UK Roads Leadership Group

2026

Well-Managed Highway Infrastructure

A Code of Practice

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PART A.OVERARCHING PRINCIPLES

SECTION A.1 SCOPE OF THE CODE OF PRACTICE

A.1.1 PRINCIPLES AND CONTEXT OF THIS CODE

A.1.1.1 'Well-managed Highway Infrastructure' was first published in 2016 to replace the former Well-maintained Highways, Management of Highway Structures and Well-lit Highways. It was reviewed in 2026 and published as an updated version of the Code, with the intention that it is updated more regularly on an ongoing basis. Printed and/or downloaded versions of this Code are uncontrolled, and thus the online version should be referred to for the most recent and definitive content.

A.1.1.2 The Code is intended to apply throughout the United Kingdom. It is recognised that there are differences in approach to some matters in England, Scotland, Wales and Northern Ireland, which are not always detailed in the Code, but general principles are set out. Production of the Code has been overseen by the UK Roads Leadership Group (UKRLG) and its Boards:

- Adaptation, Biodiversity and Climate Change Board
- Asset Management Board
- Bridges Board
- Lighting and Technology Board
- Network Management Board
- Roads Board

A.1.1.3 The Code is structured to emphasise the integrated approach to managing highway infrastructure, with overarching matters dealt with in Part A and additional asset specific matters in Parts B (highways), C (structures), D (lighting) and E (tunnels).

A.1.1.4 Delivery of a safe and well-managed highway network relies on good evidence and sound engineering judgement. This is especially important given the combined challenges facing highway authorities, including ageing highway infrastructure, constrained budgets, backlogs of work, public expectations, and resource pressures. The intention of this Code is that authorities will develop their own levels of service, and the Code therefore provides guidance for authorities to consider when developing their approach in accordance with local needs, priorities and affordability.

A.1.1.5 This edition builds on the 2016 Code, retaining its key principles while incorporating additional good practice and guidance on emerging topics. Authorities should review their existing practice against the updated content and recommendations, in line with general good practice of regular review of policies, plans and procedures. This may help identify gaps and inform implementation planning appropriate to local needs.

A.1.1.6 In the interest of route consistency for highway users, all authorities, including strategic, local, combined and those in alliances, are encouraged to collaborate in determining levels of service, especially across boundaries with neighbours responsible for strategic and local highway networks. Boundaries are not usually apparent to users and authorities should be aware of the possibility of distinct changes to levels of service through a risk-based local approach, both across authority boundaries and between roads with different character within an authority.

Neighbouring authorities are not expected to have identical levels of service, but understanding where potential differences exist can help manage these appropriately.

A.1.1.7 All highway authorities should consider adoption of new and emerging technologies as part of their highway service. This should include consideration of new ideas, methods of working and innovation in order to drive greater efficiency.

A.1.1.8 Highway authorities, at national, regional and local levels, across the UK are encouraged to actively share experience, learning and good practice arising from the application of this Code. This includes contributing to sector-led forums, participating in regional groups, and engaging in peer-to peer exchanges to support continuous improvement. By openly sharing practical experiences, innovations and challenges, authorities will help improve collective maturity and capability across the UK sector.

A.1.1.9 References to third-party documents and websites are included throughout to provide further information and support on various topics but are not part of this Code. Where these external sources have been developed primarily for other organisations or network types, such as the strategic road network, authorities should apply professional judgement to determine their relevance and applicability to local circumstances. As part of the ongoing maintenance of this Code, references will be updated periodically when changes are identified and flagged to UKRLG.

A.1.1.10 Organisational change, including local government reorganisation, should not prevent authorities from applying the principles set out within this Code. Authorities should seek to maintain continuity of asset management arrangements, information, governance and decision-making processes during periods of organisational change, and use asset management information to inform future organisational structures and service delivery models.

A.1.2 STATUS OF THE CODE

A.1.2.1 This Code of Practice is not statutory but provides authorities with guidance on highways management. Adoption of the recommendations within this document is a matter for each highway authority, based on their own legal interpretation, risks, needs and priorities.

A.1.2.2 The Code may be a relevant consideration when looking at the legal obligations of authorities, and external stakeholders may look upon its contents as evidence of good practice.

RECOMMENDATION 1 – REVIEW AGAINST THE CODE
Authorities should assess their policies, processes and delivery arrangements against this Code at intervals commensurate with risk, operational needs and material change. Significant gaps should be identified and proportionate improvement actions implemented.

A.1.3 GUIDANCE HIERARCHY

A.1.3.1 The UKRLG guidance hierarchy is shown in Figure 1. It is intended that Part A of this Code should also apply to Management of Electronic Traffic Equipment.

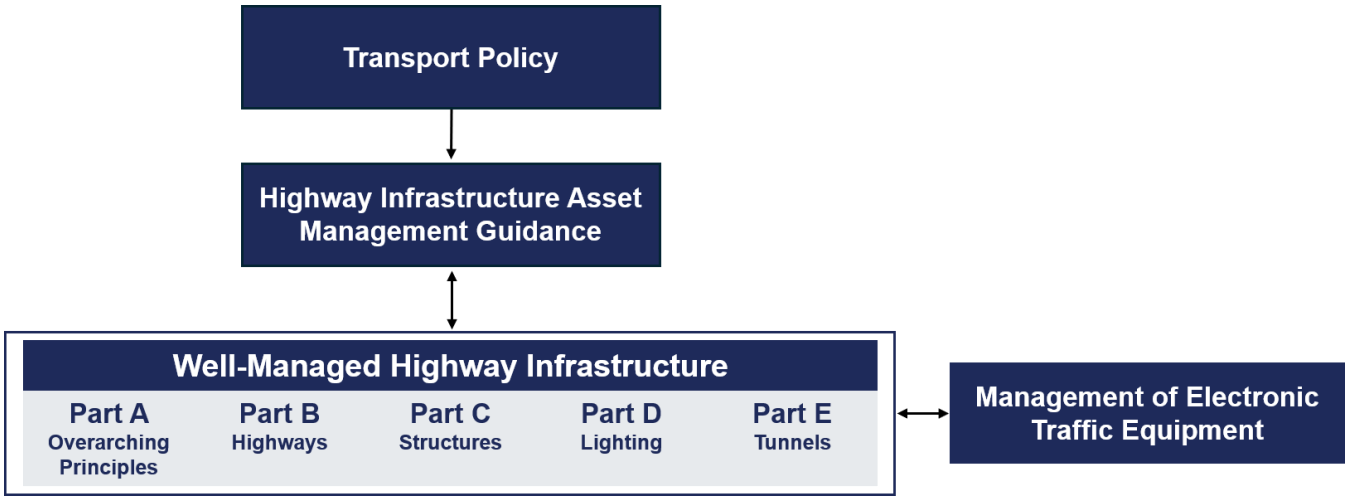


Figure 1 – UKRLG Guidance Hierarchy

A.1.3.2 The HIAMG sets out the approach to asset management. This Code refers extensively to the Highway Infrastructure Asset Management (HIAMG) and is intended to be useful additional guidance. Topics covered in the HIAMG are referred to but not repeated in this Code. Nothing in this Code supersedes the HIAMG, unless specifically stated.

A.1.3.3 The HIAMG sets out the activities that support asset management:

- the context of asset management;
- the asset management planning process; and
- enablers to support implementation of asset management.

A.1.3.4 In Scotland and Wales, the principles and recommendations of the HIAMG are accepted, however, CSS Wales and the Scottish Collaboration of Transportation Specialists in Scotland (CSSW/SCOTS) have developed practical Asset Management Guidance for use in Scotland and Wales. Topics covered in the CSSW/SCOTS Asset Management Guidance are referred to but not repeated in this Code. This Code is not intended to supersede the CSSW/SCOTS Highway Asset Management Guidance, unless specifically stated.

A.1.4 TERMINOLOGY

A.1.4.1 For the purposes of this Code publicly understood definitions are used for the major parts of the highway. There are also differences in definitions across the various legal systems in the UK that would be inappropriate to repeat at length. In such cases the English term is used. The main relevant definitions are:

- The term ‘highway’ is used to include ‘road’ and ‘street’.
- The term ‘authority’ is used to include all forms of national and local authorities having responsibility for highway infrastructure management.
- The term ‘carriageway’ is used for those parts of the highway primarily used by vehicular traffic, including motor vehicles, cycles and horses.

- The term ‘footway’ is used for that part of a highway over which the public have a right of way on foot only, e.g., segregated surfaced paths used by people walking and wheeling. ‘Footway’ includes the commonly understood use of the term ‘pavement’. The term ‘remote footway’ is used where a footway is not immediately adjoining a carriageway. The term ‘housing footway’ is used for those footways serving predominantly housing areas which may be unadopted as public highways but have established public rights of access and may be maintained separately by the housing authority. Users will make no distinction and will consider the footway network as a whole.
- The term ‘footpath’ is used for the majority of Public Rights of Way (PROW).
- The term ‘cycle route’ is used as the collective term for facilities used by people cycling. These include cycle lanes on carriageways, cycle tracks adjacent to or away from carriageways, on carriageway provision with cycle symbols and shared use facilities.

A.1.4.2 Some supporting documents use industry terms. These are not used in the Code but are referenced for completeness. The main items are:

- The industry term ‘running surface’ is used as the collective term for all hardened surfaces within the highway, including carriageways, footways and cycle routes.
- The industry term ‘pavement’ is used for the construction of running surfaces, particularly carriageways.

A.1.5 USERS AND CUSTOMERS OF HIGHWAY INFRASTRUCTURE

A.1.5.1 Highway infrastructure exists to support the movement of people, goods and services, and to enable wider social, economic and environmental outcomes. The highway network serves a diverse range of users and customers, each of whom may experience the network differently and have different needs, expectations and vulnerabilities.

A.1.5.2 Users and customers may include people walking, wheeling and cycling, disabled people, older people, users of powered two-wheeled vehicles, drivers and passengers of private and commercial vehicles, public transport users, freight and logistics operators, equestrians, businesses, public services, residents, visitors and others affected by the condition, performance and operation of the network.

A.1.5.3 Developing policies, setting levels of service and making decisions regarding highway infrastructure requires consideration of the needs of different user groups and stakeholders.

A.1.6 RELATED ACTIVITIES

A.1.6.1 There are a number of related functions that are not dealt with in detail by this Code, but which could affect and be affected by highway infrastructure maintenance activity. They have the potential for value to be added through cooperation and co-ordination. Such functions include:

- highway improvement and new construction;
- management and maintenance of Public Rights of Way;
- network management, including implementation of the network management duty, or equivalent;

- highway development control, including securing funds associated with developer obligations;
- integrated street management, including cleansing and public realm stewardship;
- town centre management, including use and operation of public space; and
- parking and enforcement functions, where restrictions and regulations can influence maintenance access and delivery.

A.1.7 LIFECYCLE ACTIVITIES FOR HIGHWAY INFRASTRUCTURE

A.1.7.1 Effective management of highway infrastructure throughout its lifecycle supports the delivery of the core objectives of safety, serviceability, sustainability and customer service. Levels of service and delivery arrangements should be established having regard to these objectives and be focussed on outcomes, rather than on inputs.

A.1.7.2 In practice, the management of highway infrastructure places significant emphasis on maintaining, preserving and renewing existing assets throughout their lifecycle. Where appropriate and practicable, authorities should seek to intervene before deterioration results in the need for more extensive repair or renewal. The timing and nature of interventions should reflect asset condition, risk, expected performance, whole-life value and available funding.

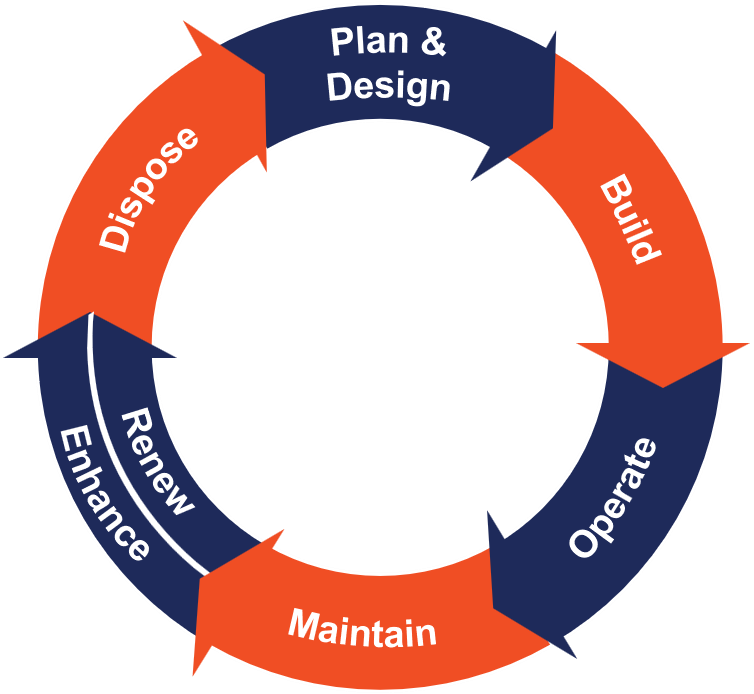


Figure 2 – Lifecycle activities for Highway Infrastructure

A.1.7.3 **Plan & Design** – identification of network needs, risks and priorities, and development of policies, strategies and investment plans to guide the management of highway infrastructure assets.

A.1.7.4 **Build** – construction of new highway infrastructure assets.

A.1.7.5 **Operate** – day-to-day management and monitoring of the network, including management of traffic, responding to incidents and emergencies, informing customers and coordinating safe access for works.

A.1.7.6 **Maintain** – inspection and maintenance of existing assets to ensure they are performing as required and to extend their service lives.

- Reactive – unplanned work undertaken in response to inspections, complaints, or emergencies.
- Routine – regular, cyclical activities required to sustain the day-to-day functioning of the network, including tasks such as vegetation control, drainage clearance, signage cleaning, and minor repairs.
- Programmed – planned schemes of work to address known issues, or proactive work to deliver preventative maintenance, e.g., preserve assets, slow deterioration and reduce the likelihood of defects developing.
- Severe weather and winter – ensuring the network operates under all weather conditions.
- Regulatory – inspecting and regulating the activities of others.

A.1.7.7 **Renew** – replacement or refurbishment of life-expired or high-risk assets.

A.1.7.8 **Enhance** – delivery of planned schemes to improve functionality of parts of the network, and also adaptation to provide assets that can better perform and respond to changing demands.

A.1.7.9 **Dispose** – removal of obsolete assets that are no longer required or fit for purpose, plus management of waste materials that are generated from other lifecycle activities.

A.1.8 SENIOR LEADER AND UKRLG RECOMMENDATIONS

A.1.8.1 In addition to recommendations made for practitioners throughout Part A, the Code also provides recommendations for senior leaders within authorities and for UKRLG, to strengthen support and accountability for the delivery of this Code.

A.1.8.2 Senior leaders may include:

- Political leaders (for example, portfolio holders, cabinet members, elected mayors and other elected office holders).
- Corporate leaders (for example, chief executives, board members, corporate directors and senior executives).
- Service leaders (for example, directors of highways and transport, heads of service, and route or regional directors).

RECOMMENDATIONS FOR SENIOR LEADERS

SENIOR LEADER RECOMMENDATION L1 – LEADERSHIP, OWNERSHIP AND ACCOUNTABILITY
Senior leaders should establish clear ownership and accountability for highway infrastructure management and provide effective governance, oversight and challenge for decision-making.

SENIOR LEADER RECOMMENDATION L2 – OUTCOMES, RISK AND RISK ACCEPTANCE
Senior leaders should define the outcomes to be achieved from highway infrastructure management and ensure that decisions regarding risk, investment and service levels are understood, considered and appropriately accepted.

SENIOR LEADER RECOMMENDATION L3 – RESOURCING AND INVESTMENT
Senior leaders should ensure that highway infrastructure management is supported by appropriate funding, resources, organisational capability and competence, taking account of current and future needs and risks.

SENIOR LEADER RECOMMENDATION L4 – COMPETENCE AND CAPABILITY
Senior leaders should maintain sufficient understanding of highway infrastructure management to provide informed leadership, decision-making and challenge.

SENIOR LEADER RECOMMENDATION L5 – LEARNING, IMPROVEMENT AND INNOVATION
Senior leaders should promote a culture of continuous improvement, learning and innovation and ensure that lessons from performance, incidents and reviews are shared and acted upon.

RECOMMENDATIONS FOR UKRLG

UKRLG RECOMMENDATION N1 – MAINTAIN AND EVOLVE THE CODE
UKRLG should maintain and periodically review the Code to ensure that it remains current, relevant and responsive to emerging challenges, opportunities and good practice.

UKRLG RECOMMENDATION N2 – DEVELOPING SUPPORTING GUIDANCE
UKRLG should identify emerging areas requiring additional guidance and coordinate the development, maintenance and dissemination of supporting documents, tools and resources.

UKRLG RECOMMENDATION N3 – FACILITATE LEARNING AND KNOWLEDGE SHARING
UKRLG should support the sharing of knowledge, innovation, research, good practice, lessons learned and case studies across the sector.

UKRLG RECOMMENDATION N4 – SUPPORT CAPABILITY DEVELOPMENT
UKRLG should support the development of capability, competence and organisational maturity across the highway sector through training, learning resources and knowledge-sharing initiatives.

UKRLG RECOMMENDATION N5 – CHAMPION INVESTMENT IN HIGHWAY INFRASTRUCTURE
UKRLG should work with government, industry and stakeholders to promote the value of highway infrastructure and support evidence-based investment in its management, maintenance and renewal.

A.1.9 FURTHER ADVICE AND GUIDANCE

A.1.9.1 Further advice, good practice and guidance can be accessed through the external links provided throughout the Code. These resources are intended to complement the principles set out in this Code by offering additional detail, examples and specialist material. In the case of misalignment, the information within this Code should be seen to take precedence.

A.1.9.2 Links are provided below to the organisations that comprised the Steering Group for the latest version of the Code, each of which holds relevant information and guidance for associated authorities:

- UKRLG – UK Roads Leadership Group
- Department for Transport - GOV.UK
- Welcome to ADEPT | ADEPT
- About SCOTS | SCOTS
- Cymdeithas Syrfewyr Sirol Cymru - County Surveyors' Society Wales
- Home | Department for Infrastructure
- National Highways - National Highways
- The Trunk Road Network in Scotland
- Roads and driving | Sub-topic | GOV.WALES

SECTION A.2 LEGAL FRAMEWORK

A.2.1 OVERVIEW

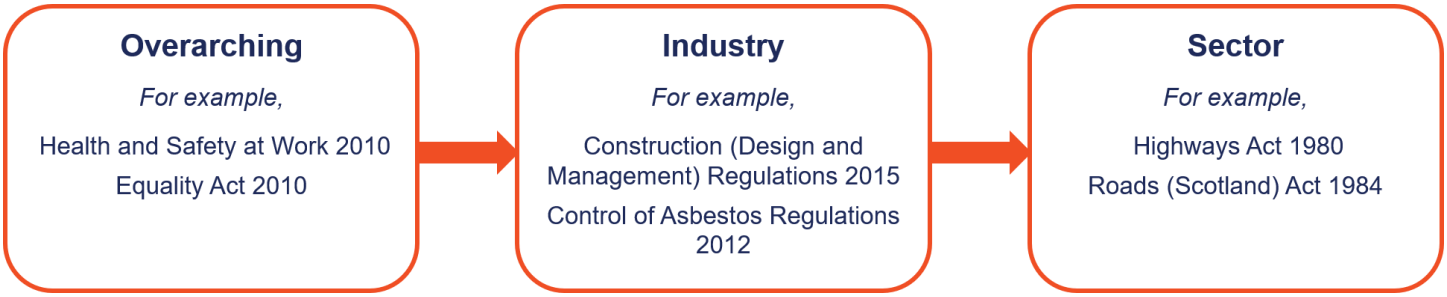


Figure 3 – Legal Framework

A.2.2 GENERAL AND SPECIFIC REQUIREMENTS

A.2.2.1 General duties and powers are dealt with in this Part of the Code. Duties and powers related to specific assets, e.g., highways, structures, lighting and tunnels, are dealt with in the relevant parts of the Code.

A.2.2.2 Much of the activity in highway infrastructure management is based upon statutory powers and duties contained in legislation and precedents developed over time as a result of claims and legal proceedings. Some important aspects of these statutory powers and duties are noted in this section. The UK Highway Liability Joint Task Group has developed guidance on Well Managed Highways Liability Risk.

A.2.2.3 All those involved in highway management, including members of authorities, should have a clear understanding of their duties and powers, their implications, and the procedures used to manage and mitigate risk.

A.2.2.4 Specific legislation mentioned is generally that for England. Scotland, Wales and Northern Ireland often have equivalent or similar legislation and the phrase ‘or equivalent’ following mention of an Act of Parliament is intended to refer to these. Nothing in or omitted from this Code can, of course, supersede the law.

HEALTH AND SAFETY

A.2.2.5 The Health and Safety at Work etc. Act 1974, or equivalent, together with the Construction (Design and Management) Regulations 2015, or equivalent, provide for a requirement for highway, traffic and street authorities to carry out work in a safe manner and establish arrangements for the management of construction works.

A.2.2.6 All those involved in the planning, management and delivery of highway infrastructure services should receive training and regular updating, as necessary, in health and safety requirements of the service.

LOCALISM

A.2.2.7 The Localism Act 2011 predominantly applies to England and confers on local authorities the power, with certain limitations, to do anything that individuals generally may do for the benefit of the authority, its area, or persons resident or present in its area. It also introduced measures such as the community right to challenge.

BEST VALUE

A.2.2.8 The Local Government Act 1999, or equivalent, provides for the general duty of best value and aims to improve local services in terms of both cost and quality.

DUTIES AND POWERS FOR HIGHWAY MAINTENANCE

A.2.2.9 There are several specific pieces of legislation that provide the basis for duties and powers relating to highway maintenance.

MAIN HIGHWAYS PROVISIONS

A.2.2.10 The Highways Act 1980, or equivalent, sets out the main duties and powers of highway authorities. In particular, it establishes the duty to maintain highways maintainable at public expense (Section 41), provides mechanisms through which the condition of highways may be challenged or considered by the courts (including Section 56), and establishes statutory defences relating to maintenance arrangements (including Section 58). Collectively, these provisions reinforce the importance of adopting, documenting and implementing a proportionate and risk-based approach to highway infrastructure management.

A.2.2.11 Applications under Section 56 of the Highways Act 1980 should be considered with regard to the authority's established risk-based approach to highway infrastructure management. The use of Section 56 to address alleged disrepair at a specific location should not be viewed as automatically overriding an authority's network wide assessment of risk, need and priority. In determining whether a highway is in such a state as to require immediate repair, due consideration should be given to the authority's inspection regimes, intervention criteria, investment plans and the consequences of re prioritising resources from higher risk locations elsewhere on the network.

A.2.2.12 Defects, deterioration or condition features should not be considered in isolation but assessed having regard to their likelihood of causing harm, the consequences of failure, the function and use of the highway, and the authority's wider network risk profile. The existence of deterioration does not, of itself, indicate a failure of the duty to maintain where the authority has identified, assessed and is managing the associated risk in a proportionate and evidence led manner.

A.2.2.13 The Roads (Scotland) Act 1984 and the Roads (Northern Ireland) Order 1993 provide specific detail for Scotland and Northern Ireland.

A.2.2.14 Responsibilities for inspection, maintenance and management may rest with different organisations depending on ownership, legal status and applicable powers or duties. Authorities should seek to ensure that information regarding ownership, maintenance responsibility and adoption status is available and communicated where appropriate.

WINTER SERVICE

A.2.2.15 The Highways Act 1980, Roads (Scotland) Act 1984 or equivalent, sets out duties and powers relating to Winter Service.

TRAFFIC MANAGEMENT

A.2.2.16 The Traffic Management Act 2004, or equivalent, sets out a number of provisions including National Highways Traffic Officers, local authority network management duty, increased oversight of utility works including permit schemes, and increased civil enforcement of traffic offences.

A.2.2.17 The Act places a network management duty on traffic authorities 'to manage their road network with a view to achieving, so far as may be reasonably practicable having regard to their other obligations and policies, to secure the expeditious movement of traffic on the authority's road network, and to facilitate the expeditious movement of traffic on road networks for which another authority is the traffic authority'. The term 'traffic' specifically includes pedestrians, and the duty requires the authority to consider all road users.

A.2.2.18 The duty is not limited to the actions of the department responsible for traffic within an authority, so authorities should consider the duty when exercising their powers under any legislation where this impacts on the operation of the road network. Authorities are required to appoint a Traffic Manager to administer the network management duty. Authorities are expected to operate the Act even-handedly, applying conditions and enforcement activity equally to their own and utilities works.

UTILITY COMPANIES

A.2.2.19 Various companies and agencies have statutory powers and obligations to work in the highway. Their activity in the highway is regulated by the New Roads and Street Works Act 1991, or equivalent, and by the Traffic Management Act 2004, or equivalent.

PUBLIC RIGHTS OF WAY

A.2.2.20 Responsibilities for Public Rights of Way (PROW) (Countryside and Rights of Way Act 2000 in England) vary considerably throughout the UK, but in general authorities are required to maintain records and ensure that ways are adequately signposted, maintained and free from obstruction. In urban areas PROW can present wider problems relating to issues such as crime. Certain legislation can facilitate closure of rights of way where deemed appropriate.

A.2.2.21 In Scotland, the Land Reform (Scotland) Act 2003 introduced the concept of Core Paths and requires local authorities to prepare and review a Core Paths Plan.

RELATED POWERS AND DUTIES

A.2.2.22 Duties and powers contained in the Highways Act, or equivalent, sit within a much broader legislative framework specifying a wider range of duties and powers. These include, or equivalents:

- Road Traffic Regulation Act 1984;
- The Traffic Signs Regulations and General Directions 2016;

- Road Traffic Act 1988 – provides a duty for highway authorities to promote road safety, including a requirement to undertake incident studies and take such measures as appear appropriate to prevent such incidents occurring;
- Road Traffic Reduction Act 1997;
- Flood and Water Management Act 2010 or equivalent
- Flood Risk Management (Scotland) Act 2009 – aims to reduce the flood risk associated with extreme weather. Provides for better, more comprehensive management of flood risk for people, homes and businesses;
- Transport Act 2000 – designation of quiet lanes or home zones;
- Active Travel (Wales) Act 2013 - legislates for the provision of routes designed for cycling and walking;
- Wildlife and Countryside Act 1981 – environmental and countryside issues with which highways operations must comply;
- Environmental Protection Act 1990 – provides the statutory basis for other environmental issues, in particular waste management, with which highway maintenance operations must comply; and
- Clean Neighbourhoods and Environment Act 2005.

A.2.2.23 There is also a framework of legislation not specifically related to highways functions, but dealing with wider community issues with which the services are involved. These include, or equivalents:

- Equality Act 2010, including the Public Sector Equality Duty - relevant to the management and maintenance of highway infrastructure, as authorities should have due regard to the needs of people with protected characteristics when developing policies, setting levels of service and making decisions relating to the operation, maintenance and improvement of the network.
- Criminal Justice and Public Order Act 1994;
- Human Rights Act 1998;
- Freedom of Information Act 2000;
- Local Government Acts; and
- Civil Contingencies Act 2004.

A.2.3 RESILIENCE, ENVIRONMENT AND BIODIVERSITY

A.2.3.1 Carriageways, footways and associated assets form the greatest part of the highway network and as such, are central to the highway authority's responsibility to manage climate change, including increasing resilience on the network and reducing impacts by promoting environmental sustainability and biodiversity wherever possible.

A.2.3.2 The Flood and Water Management Act 2010 identifies the local authority as the lead local flood authority, required to maintain a register of structures and features which are likely to have a significant effect on flood risk in their area and to promote good flood risk management. The highway authority has direct responsibility for highway drainage infrastructure which manages surface water.

A.2.3.3 The Flood and Water Management Act also requires authorities to introduce sustainable development, including drainage systems (SUDs) based around natural drainage patterns.

A.2.3.4 Legislation such as the Environment Act 2021 sets requirements for targets designed to recover the natural world in England across four priority areas: air quality, biodiversity, water and waste. The highway network can play an important part in reducing the negative impacts on nature and in increasing the positive impacts by promoting and encouraging biodiversity through the management of its green estate.

SECTION A.3 NETWORK STRATEGY

A.3.1 USING THE CODE IN THE DEVELOPMENT OF AN ASSET MANAGEMENT APPROACH

A.3.1.1 Asset management policy and strategy is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance Document, Part B. This document should be referred to and the advice below considered supplementary.

A.3.1.2 Asset management is widely accepted as a means to deliver a more efficient and effective approach to management of highway infrastructure assets through longer term planning and ensuring that levels of service are defined and achievable for available budgets. It supports making the case for funding, for better communication with stakeholders, and facilitates a greater understanding of the contribution highway infrastructure assets make to economic growth and social well-being of local communities.

A.3.1.3 Authorities have certain legal obligations with which they need to comply, and which may be the subject of claims for loss or personal injury or of legal action by those seeking to establish non-compliance by authorities. It is recognised that in such cases, the Code may be considered to be a relevant consideration. Where authorities elect in the light of local circumstances to adopt policies or approaches different from those suggested by the Code, it is essential that they are identified, together with the reasoning for such differences, be approved by the authority's Executive and published.

A.3.1.4 Authorities should also be conscious of HIAMG Recommendations 8, 9 and 14 (Leadership and Commitment, Making the Case for Asset Management and Benchmarking) in respect to asset management.

RECOMMENDATION 2 – USE OF THE CODE
Authorities should use this Code as the foundation for developing and maintaining a risk-based, outcomes-focused approach to highway infrastructure management.

RECOMMENDATION 3 – ASSET MANAGEMENT FRAMEWORK
Authorities should establish and maintain an Asset Management Framework that supports the effective delivery of highway services and long-term stewardship of infrastructure assets.

RECOMMENDATION 4 – ASSET MANAGEMENT POLICY AND STRATEGY
Authorities should maintain an asset management policy and strategy that align infrastructure management activities with corporate objectives and community outcomes, and reflect current asset needs, risks and opportunities.

LINE OF SIGHT

Asset Management Framework

Organisational Context

Corporate and external requirements that the authority is working under, including national and local transport policy, corporate vision, stakeholder expectations, legal and financial constraints

Asset Management Policy

- Describes the principles adopted in applying asset management to achieve the authority's strategic objectives.
- Demonstrates to the public and all stakeholders, including senior decision makers, elected members, practitioners and service providers, how it supports the authority's corporate policies.
- Provides a visible commitment to achieving the benefits that can be delivered through asset management and should be established at the highest level within the authority.
- It should be a one-or two-page, stand-alone document that is readily accessible.

Asset Management Strategy

- Sets out how the asset management policy is to be achieved, how long-term objectives for managing the highway are to be met and how the strategy is to be implemented, including setting targets and measuring performance.
- It sets clear direction, provides links with other relevant documents, such as corporate plans, and sets out the benefits of investing in the highway infrastructure.
- It should be a clear, public-facing message.

Asset Management Plans

- Translates the strategy into a delivery approach across the lifecycle for each key asset group.

Core Objectives of Highway Infrastructure

Safety

- Complying with statutory obligations
- Meeting users' needs for safety
- Roadworker safety
- Safety of other parties

Serviceability

- Availability
- Integrity
- Reliability
- Resilience
- Managing Condition

Sustainability

- Economic
- Social
- Environmental

Customer Service

- Communication
- Information
- Levels of service

Delivery

Lifecycle Activities	Network Activities	Ways of Working
• Design • Construction • Operation • Maintenance • Renewal • Disposal	• Integrated network management • Inter-authority coordination • Street works • Road/rail incursion • Abnormal loads	• Risk-based approach • Security-minded approach • Stakeholders and communication • Innovation • Artificial Intelligence • Designing for maintenance

Workforce Capability and Competence

- Capability
- Capacity
- Wellbeing

Figure 4 – Asset Management Approach

A.3.2 CORE OBJECTIVES OF HIGHWAY INFRASTRUCTURE

A.3.2.1 The purpose of highway infrastructure is to support the needs of people, communities, businesses and other users through the safe, reliable, sustainable and accessible movement of people and goods. The core objectives provide a framework for delivering these outcomes through effective asset management. Each of the core objectives can be affected to a different extent by various factors, and these interactions should be considered when developing and implementing plans. For example:

- Management of highway infrastructure assets affects Customer Service through a range of aspects within each of Safety, Serviceability and Sustainability.
- Network availability can be affected by weight restricted structures, resilience of improvement and maintenance works, Winter Service, regulatory activity, deficiency of drainage systems, statutory undertakers, and by planning and programming of maintenance schemes.
- Network integrity can be assisted by consistent, joined up and effective permanent and temporary signing, by ensuring consistent standards of maintenance on cycle routes between segregated and non-segregated sections, and providing consistent accessibility standards, for example through the use of dropped kerbs on key pedestrian routes, especially those used by disabled people, mobility impaired, older people, or those using prams.
- Environmental contributions can be made through verge management plans, maintaining local distinctiveness through use of local materials, reducing sign clutter, use of recycled products, noise-reducing surfacing, energy efficient light sources, and profiled street lighting levels.
- Organisational constraints such as funding or workforce will limit the scale and nature of work undertaken, and thus a risk-based approach should be applied to it.

A.3.2.2 The planning and delivery of maintenance and improvement works should balance the need to minimise disruption to users with the need to provide a safe working environment for road workers and operatives. Every aspect of the management of highway infrastructure has the potential to contribute to some extent to a number of the above objectives. For example, the contribution to the safety objective is affected by:

- the condition of the asset;
- the resilience of the asset;
- the time for attending to defects recorded in inspections and reported by users;
- the quality of management and service delivery;
- the effectiveness of materials and treatments used;
- the application of traffic management;
- the provision of suitable information to customers; and
- the effective co-ordination of programmes with works affecting the highway by utilities, developers or other local authorities.

A.3.2.3 Particular aspects of managing highway infrastructure may have wider impacts than the immediate local implementation issues. For example, the need to address carriageway defects

could compromise, at least temporarily, public transport convenience and reliability. Work at night to minimise disruption may have noise and cost implications, and bridge works may require lengthy diversions. Early identification of potential conflicts can help authorities balance competing requirements and mitigate impacts effectively.

A.3.3 CORE OBJECTIVE – SAFETY

SAFETY ON THE HIGHWAY NETWORK

A.3.3.1 Authorities should recognise the full range of individuals who may be exposed to safety risk, ensuring that their approach to managing the network is inclusive, equitable and accessible to all members of the community. Resources from across the UK nations are available to support authorities with understanding road safety.

- DfT Road Safety Strategy
- Transport Scotland Road Safety Framework to 2030
- Report on the road safety framework for Wales 2013 to 2020
- Road safety partnership plan | GOV.WALES
- Department for Infrastructure Road Safety Strategy for Northern Ireland to 2030

A.3.3.2 Highway users encompass people walking, wheeling and cycling of all ages including disabled people, mobility impaired, micromobility users where permitted, motorcyclists, drivers and passengers of private and commercial vehicles, public transport users, freight and logistics operators, and those using agricultural or specialist vehicles. Activities to improve road user safety should be informed by relevant local evidence, risk-based approaches and applicable guidance.

A.3.3.3 Road workers and operational staff also face daily exposure to risk, from a combination of traffic, site activities, and abuse from the public. This group includes maintenance and inspection personnel, winter service crews, incident response and traffic management teams, utility and street works operatives, and supply chain staff working on or near live traffic. The interface between people and moving plant, vehicles and equipment require appropriate planning, segregation, controlled movements, effective communication and safe systems of work. Controls should be proportionate to the activity, location and level of risk, taking account of road workers, highway users and others who may enter or pass through the work area. Risk to this group should be managed in accordance with the Health and Safety at Work etc Act 1974, applying the as low as reasonably practicable principle.

A.3.3.4 Measures to address road worker abuse may include public awareness campaigns, body-worn cameras, and conflict management training. Information related to incidents of road worker abuse, dangerous driving and incursions into work areas can support risk assessments, workforce briefings, service planning and safety improvement activities. Relevant information may also be shared with employees, contractors and delivery partners where appropriate. Industry groups such as Stamp It Out provide visibility of the issue and potential resources to use.

A.3.3.5 Safety responsibilities additionally extend to those who may not be users of the network but are still affected by it, such as those on adjacent transport networks such as the railways and waterways. They may also affect residents, businesses and building users adjacent to the

network, school communities, people accessing local services, users of public spaces adjoining the highway and visitors who may be affected even when not travelling on the network.

APPLICATION OF THE SAFE SYSTEM APPROACH

A.3.3.6 Application of the Safe System approach does not require authorities to establish separate inspection regimes or risk management processes. Rather, the principles can be embedded within existing policies, procedures and asset management practices to support improved road safety outcomes.

A.3.3.7 Safe roads focus on designing, managing and maintaining roads in ways that reduce the consequences of human error. Key characteristics include roads that are predictable, legible, inclusive and accessible for all users. It also recognises the importance of ensuring that maintenance activities do not introduce unmanaged hazards to either road users or workers.

A.3.3.8 Safe speeds recognise the relationship between speed, impact forces and injury severity. The approach considers how speed-management measures and speed limits can be aligned with local context, land use, user vulnerability and wider place-based objectives to reduce the risk of death and serious injury.

A.3.3.9 Safe vehicles recognise the contribution that vehicle design, technology and operation can make to reducing the likelihood and severity of collisions. Highway authorities can influence vehicle safety through their own fleets, procurement decisions and relationships with contractors, while also considering how different vehicle types interact with the highway environment. Opportunities may also exist to support the adoption of safer vehicles and emerging safety technologies.

A.3.3.10 Safe road users recognise the role that behaviour, awareness and decision-making play in road safety outcomes. Highway authorities can contribute through engagement, communication, education and behavioural insight, supported by clear and accessible information. Particular consideration may be given to user groups that are more vulnerable or exposed to risk. The approach also recognises the contribution of enforcement partners and other organisations in supporting safer road user behaviour.

A.3.3.11 Post-crash response recognises the importance of timely emergency response, effective incident management and network recovery. Highway authorities support these activities through accurate network information, emergency access arrangements and management of the highway network. Learning from incidents can contribute to future risk reduction, while recovery, diversion and reopening arrangements may take account of the needs of different users and communities.

UNDERSTANDING SAFETY

A.3.3.12 Safety risk can be informed by a range of evidence sources in addition to recorded collisions. These may include near misses, observed hazards, road worker reporting systems, customer and community feedback and intelligence from transport and fleet partners, helping to identify risks before harm occurs.

A.3.3.13 A broader evidence base can be achieved by introducing other data sources, such as connected vehicle data, telematics, public reporting tools, sensor based and automated monitoring systems and anonymised movement data.

A.3.3.14 Sharing learning across teams and partners can support continual improvement.

A.3.3.15 Within the UK, the Parliamentary Advisory Council for Transport Safety (PACTS) and Road Safety Knowledge Centre provide resources for authorities to freely access and consider:

- Parliamentary Advisory Council for Transport Safety (PACTS)
- Road Safety Knowledge Centre

A.3.3.16 Internationally, PIARC has produced an online manual and special projects covering road safety, which are available for practitioners to consider within the context of authorities in the UK:

- PIARC Road Safety Manual
- Motorcycle Protection Systems & Safety Aspects of Management of Traffic for Motorcycles – A PIARC Special Project
- Management of Road Worksites – Special Project

EMBEDDING SAFETY

A.3.3.17 Safety is most effective when supported by visible leadership and integrated into strategic planning, asset management and investment processes.

A.3.3.18 Communication channels can support two-way engagement. Information received through social media, digital platforms and other customer contact channels can provide valuable insight into network issues, customer priorities and the effectiveness of service delivery and should be considered as part of the authority's wider evidence base.

A.3.3.19 Collaboration may extend to parish councils, emergency services, public health, active travel groups, freight operators, suppliers, contractors, community and charity organisations. Authorities should recognise the role they can play in addressing wider societal issues such as suicide prevention, air quality and women's safety by taking a broader view of what safety in the highway means.

A.3.3.20 The UKRLG has published relevant documentation around suicide prevention applicable to roads and bridges: UKRLG Roads and bridges suicide prevention guidance.

A.3.3.21 Appropriate competencies and clearly defined responsibilities help ensure that all members of the workforce can undertake their roles safely.

A.3.4 CORE OBJECTIVE – SERVICEABILITY

FUNCTIONAL HIERARCHY

A.3.4.1 A network hierarchy based on the function, importance and use of routes and network links is a foundation of a risk-based management strategy. It is important in establishing levels of service and supporting the authority's statutory network management responsibilities, including the coordination and regulation of activities on the highway. Network hierarchy should primarily reflect the role a route performs within the wider network, taking into account factors such as movement, access, connectivity, resilience, user needs and the consequences of disruption.

A.3.4.2 It is important that the hierarchy adopted reflects the whole highway network and the needs, priorities and actual use of each infrastructure asset. The carriageway hierarchy, for example, may be determined by traffic volume or by local social and economic importance – perhaps a

route leading to a major hospital or industrial area, or urban, rural or busy shopping street, residential street, etc. Hierarchy may also be influenced by factors such as pedestrian, cyclist usage, or (where applicable) e-scooter trials. Collectively, these issues may be referred to as the 'functionality' of the section of highway in question.

A.3.4.3 Whilst different asset types may have their own hierarchies, all should be related such that each asset type can be considered in relation to others and to the whole highway network. Network hierarchy should take into account the desirability of continuity and of a consistent approach for walking, wheeling and cycling.

A.3.4.4 The adoption of a common hierarchy to reflect the network management duty, or equivalent, and the requirements for maintenance management based on highway functionality is desirable. This may be difficult to achieve completely, bearing in mind the differing definitions of protected streets, traffic sensitive streets, and streets with special engineering difficulties, associated with the Traffic Management duty, or equivalent. However, a high degree of compatibility between networks is desirable.

A.3.4.5 There will also be a need to define hierarchies for Resilience and for Winter Service. These should take as a starting point the hierarchy developed for general maintenance purposes but are likely to require extensive modification to accommodate local operational factors.

A.3.4.6 It is important to consider the hierarchy of neighbouring authorities for both locally and nationally maintained networks. Users will expect reasonable continuity of levels of service and collaboration in developing the network hierarchy can contribute to achieving this.

A.3.4.7 Hierarchies are a useful basis on which to consult users and the community. They are strategic but relatively easy to present and understand and not so detailed as to cause difficulties in interpreting the results. They can also address directly some of the wider policy issues, including special needs of certain groups of people.

A.3.4.8 Hierarchies should be dynamic and regularly reviewed to reflect changes in network characteristics and functionality so that management strategy reflects the current situation, rather than the use expected when the hierarchy was originally defined. For example, changes in type of traffic such as usage by e-bikes, or changes in traffic levels due to residential or business demand, will have impacts on priority.

A.3.4.9 Where major maintenance, construction or other development involves significant traffic diversion, or when congestion in one part of the network results in traffic shift to another part of the network, these changes should be reflected in the hierarchy and subsequently in the maintenance and network management regimes. There may also be seasonal influences on hierarchy.

CARRIAGEWAYS

A.3.4.10 Carriageway hierarchy will not necessarily be determined by the road classification, but by functionality and scale of use. Table 1 is intended to be used as a reference point from which to develop local hierarchies. The descriptions relate to the most usual circumstances encountered in the UK. There are likely to be, some very significant variations and authorities should take their own circumstances into account.

Table 1: Factors to Consider – Carriageways

Category	Type of Road General Description	Description
Motorway	Limited access - motorway regulations apply	Routes for fast-moving long-distance traffic. Fully grade separated and restrictions on use.
Strategic Route	Trunk and some Principal 'A' class roads between Primary Destinations	Routes for fast-moving long-distance traffic with little frontage access or pedestrian traffic. Speed limits are usually in excess of 40 mph and there are few junctions. Pedestrian crossings are either segregated or controlled and parked vehicles are generally prohibited.
Main Distributor	Major Urban Network and Inter-Primary Links. Short - medium distance traffic	Routes between Strategic Routes and linking urban centres to the strategic network with limited frontage access. In urban areas speed limits are usually 40 mph or less, parking is restricted at peak times and there are positive measures for pedestrian safety.
Secondary Distributor	B and C class roads and some unclassified urban routes carrying bus, HGV and local traffic with frontage access and frequent junctions	In residential and other built-up areas these roads have 20 or 30 mph speed limits and very high levels of pedestrian activity with some crossing facilities including zebra crossings. On-street parking is generally unrestricted except for safety reasons. In rural areas these roads link the larger villages, bus routes and HGV generators to the Strategic and Main Distributor Network.
Link Road	Roads linking between the Main and Secondary Distributor Network with frontage access and frequent junctions	In urban areas these are residential or industrial interconnecting roads with 20 or 30 mph speed limits, random pedestrian movements and uncontrolled parking. In rural areas these roads link the smaller villages to the distributor roads. They are of varying width and not always capable of carrying two-way traffic.
Local Access Road	Roads serving limited numbers of properties carrying only access traffic	In rural areas these roads serve small settlements and provide access to individual properties and land. They are often only single lane width and unsuitable for HGVs. In urban areas they are often residential loop roads or cul-de-sacs.
Minor road	Little used roads serving very limited numbers of properties.	Locally defined roads.

A.3.4.11 Assignment of a carriageway to a particular category is a matter for local discretion. However, the following issues should be taken into consideration:

- character and volume of traffic;
- current, expected and temporary usage, including the volume and nature of users and the function the route performs within the wider network;
- routes to important local facilities and to the strategic network;
- designation as a traffic sensitive route;

- designation as part of an authority's resilient network;
- forming part of a bus, tram or other public transport route;
- incident and other risk assessment;
- the significance of the route as a diversion route, including the likely scale and consequences of displaced traffic should higher priority routes become unavailable;
- special characteristic of certain assets, e.g., historic structures;
- access to schools, hospitals and medical centres;
- vulnerable road users or people with special needs, older people's homes etc; and
- ceremonial routes and special events.

A.3.4.12 Other factors should be taken into account and an on-site 'reality check' undertaken where there is any uncertainty about position in the hierarchy, for example:

- road use might be at the margin of the category but have higher than normal levels of growth. Extensive development may be taking place or planned;
- there might have been a higher-than-normal level of collisions or related incidents which would suggest unusually high levels of risk;
- although traffic flows on the carriageway might be low, there might be high numbers of people walking or wheeling, and cyclists
- the route might be the subject of promotion by the authority, for example as a 'Safer Route to School' or access to a railway station. A cycling route may be part of the National Cycle Route Network;
- the route may be temporarily being used as a diversion route around a road closure on a route at a higher level within the hierarchy; and
- traffic composition might indicate unusually high proportions of particular users, for example motorcyclists or cyclists for whom surface condition is of particular importance.

FOOTWAYS

A.3.4.13 Footway hierarchy should be determined by functionality, priority within local walking and wheeling networks, such as those identified in Local Cycling and Walking Infrastructure Plans (LCWIPs), and scale of use. Table 2 is intended to be used as a reference point from which to develop local hierarchies. The detailed descriptions relate to the most usual circumstances encountered in the UK. There are, however, some very significant variations from the norm and authorities should take their own circumstances into account.

Table 2: Example hierarchy – Footways

Category	Description
Prestige Walking Zones	Very busy areas of towns and cities with high public space and street scene contribution.
Primary Walking Routes	Busy urban shopping and business areas and main pedestrian routes.
Secondary Walking Routes	Medium usage routes through local areas feeding into primary routes, local shopping centres etc.
Link Footways	Linking local access footways through urban areas and busy rural footways.
Local Access Footways	Footways associated with low usage, such as short estate roads to the main routes, and cul-de-sacs.
Minor Footways	Little used rural footways serving very limited numbers of properties

A.3.4.14 Assignment of a footway to a particular category is a matter for local discretion. However, the following issues should be taken into consideration:

- user volume and type, e.g., pedestrian, with pushchair, mobility scooter etc;
- designation as a traffic sensitive pedestrian route;
- current usage and desired usage;
- location on a priority walking and wheeling route or area such as those identified in LCWIPs;
- contribution to the quality of public space and street scene;
- age and distribution of the population, proximity of schools or other establishments, and risk factors attracting higher than average numbers of walking and wheeling, or higher numbers of older or disabled users;
- proximity to public transport hubs and interchanges;
- incident and other risk assessment; and
- character and traffic use of adjoining carriageway.

A.3.4.15 Note that it is unlikely that an authority will have detailed walking and wheeling user count data for many of its footways, so local knowledge of inspectors and others with a local presence will be important in assessing volume of use.

A.3.4.16 The footway hierarchy should have regard to any network of ‘housing footways’, serving housing estates or related development, which may be unadopted as public highways but have established public rights of access and may be maintained separately by the housing authority. Users will make no distinction and will consider the footway network as a whole.

CYCLE ROUTES

A.3.4.17 A cycling hierarchy should be developed for the whole of an authority's network and should reflect the function and importance of routes used or intended for cycling, regardless of whether cycling

is accommodated on a carriageway, cycle lane, cycle track, shared-use facility or other form of infrastructure.

A.3.4.18 Cycling hierarchy should be determined by current and potential level of use, priority within local, regional and national cycling networks, such as those identified in Local Cycling and Walking Infrastructure Plans (LCWIPs) or the National Cycle Network (NCN), priority commuter routes etc, and other risk and importance factors. Authorities may wish to distinguish between leisure cycling and commuter and utility cycling in determining hierarchy categories.

A.3.4.19 Assignment of a cycle route to a particular category is a matter for local discretion. However, the following issues should be taken into consideration:

- user volume and type, e.g., commuter, utility, leisure
- risk factors such as the traffic character and traffic use of adjoining carriageway and whether there is physical separation between cyclists and vehicles,
- proximity to schools and other education establishments, including routes identified as safe routes to schools and school streets.
- proximity to areas of high economic activity such as industrial estates, retail centres etc;
- current usage and desired usage;
- local demographics;
- location on a priority cycling route such as those identified in LCWIPs, the National Cycle Network, and Cycle Superhighways;
- contribution to the quality of public space and street scene;
- proximity and access to public transport hubs and interchanges; and
- incident and other risk assessment.

A.3.4.20 Table 3 is intended to be used as a reference point from which to develop local hierarchies.

Table 3: Example hierarchy – Cycle Routes

Category	Possible examples
Strategic Priority Cycle Routes	Routes with very high levels of current or project cycling use or routes identified as strategic priority routes by the authority. Most or all of the routes will have dedicated provision for cyclists.
High-Priority Cycle Routes	Routes with high levels of use by utility or commuter cyclists, including some dedicated or shared infrastructure provision for cycling.
Standard Priority Cycle Routes	Other routes in urban areas and priority routes with lower usage in rural areas.
Other Cycle Routes	Routes with generally low levels of cycling use, typically without dedicated provision for cyclists, cul-de-sacs and other routes with no provision for through cycling, or where cycling is prohibited.

BRIDGES AND STRUCTURES

A.3.4.21 Factors affecting the management priority and criticality of structures include:

- position relative to the hierarchy of the route or routes supported;
- consequences of restriction, closure or failure;
- availability and suitability of alternative routes;
- access to communities, public transport, freight movements and emergency services;
- critical access or resilience requirements;
- co-located utilities and other infrastructure dependencies;
- heritage, statutory or operational significance; and
- asset-specific characteristics such as type, dimensions, construction, condition and vulnerability.

STREET LIGHTING

A.3.4.22 Factors affecting lighting service priority and management requirements include:

- position relative to the hierarchy of the route, place or area served;
- levels and types of night-time use, including people walking, wheeling and cycling;
- safety, accessibility and personal security considerations;
- casualty and crime data where relevant;
- environmental and community considerations, including obtrusive light;
- local operational requirements; and
- asset-specific characteristics such as equipment type, age, condition, maintainability and performance.

PUBLIC RIGHTS OF WAY

A.3.4.23 Factors affecting the function and importance of public rights of way include:

- strategic or local connectivity;
- current and expected use;
- role within walking, wheeling, cycling and equestrian networks;
- access to communities, services and destinations;
- designation as a promoted, strategic or long-distance route;
- accessibility and user needs;
- availability of alternative routes;
- consequences of closure or obstruction; and
- seasonal or recreational importance.

A.3.4.24 Some PROW may be metalled and within or on the fringe of urban areas. To recognise users' requirements for consistency, these should be considered for maintenance consistent with a similar footway and be incorporated in the footway hierarchy, irrespective of their designation.

RESILIENCE

A.3.4.25 Serviceability should take account of the consequences of loss of service, duration of disruption, dependency on particular routes or assets, and the availability of suitable alternatives. Resilience, adaptation, hazards and disruptive events can all influence network function and accessibility, particularly where impacts on communities, businesses, public services or vulnerable users may be significant. These considerations may inform hierarchy development, service levels and maintenance priorities.

A.3.4.26 Section A.6 contains further information on resilient networks.

A.3.5 CORE OBJECTIVE – SUSTAINABILITY

A.3.5.1 Sustainability covers all three pillars associated with the theme, namely environmental, economic and social considerations.

A.3.5.2 Environmental considerations include the efficient use of resources, reduction of waste and emissions, and protection and enhancement of the natural environment, applied proportionately and in accordance with local priorities and statutory duties.

A.3.5.3 Economic sustainability focuses on affordability and value for money over the long term, along with the wider benefits that highway infrastructure provides to society.

A.3.5.4 Social sustainability reflects the role of the highway network in supporting communities, safety, accessibility and wellbeing. This includes enabling inclusive movement, managing risks to users and others, and minimising adverse impacts arising from highway operation and works.

A.3.5.5 Section A.8 contains further information on sustainability in terms of managing highway infrastructure.

A.3.6 CORE OBJECTIVE – CUSTOMER SERVICE

THE PURPOSE AND ROLE OF THE CUSTOMER IN HIGHWAY SERVICES

A.3.6.1 Highway infrastructure provides an essential public service, supporting the safe and efficient movement of people, goods and services. Customers are central to the delivery of this service, and their needs, expectations and experiences help inform decision making.

A.3.6.2 Customers include all those who use or are affected by the network, including (but not limited to) road users of all modes, neighbouring communities, businesses, public services, and special interest groups. Each type of customer interacts with the network differently, bringing distinct priorities that may vary between user groups. Understanding these differences allows services to be planned and delivered in a way that supports improved outcomes.

UNDERSTANDING CUSTOMERS

A.3.6.3 Customer insight can be generated through a range of evidence sources, including surveys, behavioural data, complaints and enquiries, operational records and digital analytics. These sources provide complementary information that helps authorities understand how customers experience the network and where improvements are needed. However, it is important to ensure that insight is representative of the wider customer base, and not just the most vocal individuals.

A.3.6.4 Customer insight can support risk-based decision-making when it is proportionate to the service, sufficiently robust and reflective of current needs, expectations and experiences. Sharing and applying insight across relevant functions can help improve decision-making and service outcomes.

A.3.6.5 Different customer groups may have varying needs and expectations, for example people walking, wheeling and cycling, disabled people, people with mobility impairments, older people, children and young people, public transport users, freight operators, businesses, residents and visitors. The road user hierarchy within the Highway Code places those most at risk in the event of a collision at the top of the hierarchy.

A.3.6.6 A range of guidance and research is available to support understanding of the needs and experiences of disabled people and other users. For example, the Department for Transport's Inclusive Mobility guidance provides advice on accessibility and inclusive design, while the Walk Wheel Cycle Trust Disabled Citizens' Inquiry highlights barriers experienced by disabled people when walking and wheeling independently.

A.3.6.7 Segmentation helps authorities understand how planned works, network changes or service levels will affect different groups and enables decisions that promote fairness and accessibility across the network. DfT Guidance on personas can support an effective approach to segmentation for transport users: Transport user personas: understanding different users and their needs.

CUSTOMER EXPECTATIONS AND SATISFACTION

A.3.6.8 Customers expect the network to be safe, reliable, well maintained and supported by clear information. Expectations may vary between different users and stakeholders according to their needs, priorities and experiences. Understanding these differences can help inform service levels, maintenance planning and investment decisions, while identifying where mitigation measures may be required when expectations cannot reasonably be met.

A.3.6.9 Satisfaction should be assessed using methods that are consistent, proportionate and reflective of local needs. Surveys, complaints trends and sentiment analysis provide valuable insight into customer views. This information can identify the underlying drivers of satisfaction and address issues that affect confidence in the service.

A.3.6.10 Surveys may be conducted by specialist providers or designed and delivered by the authority, with further value being achieved through trend analysis over time and the benchmarking of scores with neighbouring authorities or nationally.

CUSTOMER COMMUNICATION

A.3.6.11 Communications with customers should be delivered in a format and language that is most appropriate for the audience, which is frequently non-technical in their nature and experience. Corporate communications teams within authorities should be engaged early in the development of communications and engagement activities, in line with internal policies regarding external communications, to ensure that messaging is compliant, accessible, clear and tailored to audience needs. Early involvement can help authorities communicate the purpose, benefits, impacts and trade-offs associated with decisions and activities more effectively.

A.3.6.12 Proactive communication provides customers with early and clear information about planned works, network changes or expected impacts. Effective communication helps customers understand the purpose of activities, the benefits being sought, the impacts that may arise and the reasons behind decisions. Communication should be accessible, timely and tailored to the needs of different users. Effective communication reduces uncertainty, helps customers plan journeys and supports trust in the service.

A.3.6.13 An example of communicating technical concepts to a non-technical audience is guidance produced by the Road Emulsion Association (REA), to support the explanation of preventative road maintenance to residents and why preventative maintenance matters: Explaining Preventative Road Maintenance to Residents

A.3.6.14 Reactive communication requires authorities to respond to enquiries, reports and complaints in a consistent and timely manner. Clear processes can support effective handling of customer requests and help identify recurring issues that may require operational or policy changes.

A.3.6.15 Authorities should provide straightforward and accessible ways for customers to report issues or provide feedback. Response times for acknowledgement of feedback and for any action to be taken should be clearly defined for the public, and these should be met to support trust and optimal user experience. Feedback should form part of ongoing monitoring and service improvement.

A.3.6.16 Digital tools such as online reporting platforms, real time information and mapping services play an important role in customer communication. These tools should, where practicable, be reliable, accessible and designed to meet the needs of all users. While digital forms of communication can provide benefits to both the customer and the authority, more traditional options should also be available to avoid issues of digital exclusion.

A.3.6.17 Digital and traditional communication channels should complement one another and be selected based on an understanding of the needs of different users and stakeholders. A combination of communication methods may be required to ensure information is accessible, inclusive and effective.

A.3.6.18 During major incidents or severe disruption, customers require accurate and timely information. Communications can support safety, enable informed choices and reflect established resilience arrangements.

CUSTOMER ENGAGEMENT

A.3.6.19 Engagement enables customers, communities and businesses to contribute meaningfully to decisions that affect them. Engagement should be proportionate, inclusive and undertaken early

enough to inform decisions. Authorities should be able to explain how engagement findings have been considered in their decision making, to provide clarity and transparency and also to develop trust with the respondents.

A.3.6.20 Resources explaining how authorities can deliver consultation and engagement include:

- Transport Scotland Engagement and Consultation
- GOV.UK Community consultation and engagement within transport schemes
- Government Functional Standard GovS 011: Communication
- Government Communication Service (GCS) guidance and resources
- CIHT Creating a Public Realm for All
- Local Government Association (LGA) - New Conversations: LGA Guide to Engagement
- Active Travel England (ATE) - Best Practice Guide to Consultation and Engagement

EMBEDDING THE CUSTOMER IN THE ASSET LIFECYCLE

A.3.6.21 Customer insight can inform strategic decisions, including setting service levels and investment priorities. Embedding customer considerations at this stage strengthens alignment between service outcomes and customer needs. Customer expectations may sometimes need to be balanced against risk, asset condition, available resources and wider organisational objectives.

A.3.6.22 Design processes should consider the needs of different users, applying inclusive design principles and the road user hierarchy. The planning of construction and traffic management arrangements should seek to minimise disruption and maintain access where possible and consider wider impacts on communities and businesses.

A.3.6.23 The planning and delivery of operational activities should seek to minimise inconvenience and maintain safe movement for all users, whilst providing clear, timely and accessible information. Customer priorities may influence scheduling, coordination and delivery of works, CIHT providing guidance on operational activities through its resource Reducing the impact of highway works on road users.

A.3.7 LIFECYCLE ACTIVITIES

A.3.7.1 Section A.1.7. outlines the key lifecycle activities associated with highway infrastructure and is applicable to all parts of the Code.

A.3.7.2 Maintenance of existing highway infrastructure is likely to be the majority of work undertaken by authorities. Preventative maintenance is well-evidenced as providing significantly greater value for money and supporting better outcomes against core objectives than reactive maintenance. However, reactive maintenance will always be needed where high risk defects require urgent response.

A.3.7.3 Parts B, C, D and E contain further information on specific activities authorities should deliver with respect to managing each asset type.

A.3.8 NETWORK ACTIVITIES – INTEGRATED NETWORK MANAGEMENT

A.3.8.1 Highway infrastructure management policy needs to be developed integrally with the overall management of the network. Transport users, whatever their mode, do not distinguish between many categories of road, or types of work, whether maintenance or improvement. It is irrelevant to them who is undertaking the work, whether local authority, contractor or utility. They expect the network to be managed and maintained holistically to provide consistent and appropriate levels of service and the ability to change modes as easily as possible.

A.3.8.2 Planning for highway maintenance should take into account and add value to other elements of local transport policy and strategy wherever possible, including supporting economic growth, regeneration, public health, resilience, emergency services, walking and cycling, bus and freight partnerships, casualty reduction and prevention, travel planning, safer routes to school, and routes to stations and other interchange facilities.

A.3.8.3 Interdependencies exist between different asset groups, including drainage, structures, lighting, trees and other highway assets, and coordinating activities across these may support improved outcomes and value for money. Authorities should consider the needs of all highway users, particularly vulnerable users, in planning and managing the network. This has special implications for maintenance, as when schemes or third-party street works are planned and programmed there may be an opportunity to incorporate added value to the safety, priority, integrity or quality of:

- footways and crossing facilities (particularly for vulnerable users);
- cycle routes and crossing facilities;
- riders of motorcycles;
- equestrians and crossing facilities;
- facilities for public transport and users (and also to influence reliability); and
- facilities for freight movement.

A.3.8.4 Planning and budgeting for highway maintenance should also recognise that integrated transport, especially in urban areas, is likely to result in a more complex and diverse street scene. Good design may limit the scale of more complex signage, but a wider range of more expensive signs, road markings, coloured surfacing and other materials may be necessary for management. When considering these features, authorities should take into account the potential cost of keeping this more complex arrangement in good order.

A.3.8.5 In areas where public transport is not regulated, routes of services may be less predictable and vary more frequently. Close liaison with operators will be necessary if works are to be co-ordinated so as to minimise disruption to public transport users. Other forms of public transport, including light rail and guided bus schemes, bring their own challenges for maintenance, especially Winter Service.

A.3.8.6 Manual for Streets 2007, provides guidance on effective street design which places greater emphasis on the movement and place functions of streets and the needs of people walking, wheeling and cycling. These principles can help authorities balance the needs of different users, reflect route function and place characteristics, and support the development of network hierarchies and maintenance strategies that are appropriate to local circumstances. Manual for

Streets 2, 2010 explains how the principles can be applied more widely. In Scotland, the relevant document is Designing Streets.

A.3.8.7 It may be appropriate for authorities to develop a series of related policies for specific assets or for specific activities:

- Core objectives, e.g., safety, serviceability, sustainability, customer service;
- Asset level policies, e.g., carriageways, footways, cycle routes, drainage, structures, lighting, trees, natural infrastructure, tunnels, etc;
- Asset management activities, e.g., inspections, skid resistance etc. ;
- Network activities, e.g., traffic management
- Ways of working, e.g., designing for maintenance;
- Associated activities, e.g., parking enforcement.

RECOMMENDATION 5 – INTEGRATED NETWORK
Authorities should manage highway infrastructure as part of an integrated transport system, recognising the needs of all users and the interdependencies between assets, modes and services.

RECOMMENDATION 6 – NETWORK HIERARCHY
Authorities should establish and maintain a hierarchy that reflects the network's functions, use, importance and characteristics and supports proportionate decision-making.

A.3.9 NETWORK ACTIVITIES – INTER-AUTHORITY COORDINATION

A.3.9.1 Users will expect reasonable continuity of safety and serviceability with neighbouring highway authorities, particularly at the strategic end of the network hierarchy and winter network / resilient network, but also at the lower levels of hierarchy where safety risks are more significant. In such cases, serious discontinuities in levels of service may be reduced through consultation and agreement.

A.3.9.2 Neighbouring authorities are not expected to have identical levels of service, but understanding where potential differences exist can help manage these appropriately.

A.3.9.3 Inter-authority co-ordination, at both the strategic and operational level, can bring other benefits in terms of cost and resource management, levels of service and user perception. Opportunities for such co-operation include:

- integrated route management;
- optimisation of cross boundary service provision;
- optimised programming and procurement;
- shared traffic management and publicity;
- avoidance of multiple user delays; and
- research, development and innovation.

A.3.9.4 Consultation will be necessary with other local, combined and strategic highway authorities, especially adjoining authorities, as part of the duty to manage the network and to ensure that users' reasonable requirements for consistency of service and integrated programming of works are considered and taken into account. Such coordination also supports the delivery of Network Management Duty responsibilities and wider network performance objectives.

A.3.9.5 Responsibility for assets on authority boundaries, e.g., river bridges, should be agreed with adjoining authorities.

A.3.9.6 It may be appropriate for authorities to enter into agreements with adjacent or other authorities for certain aspects of service to be carried out by one authority on behalf of the other.

A.3.9.7 Consultation and coordination will also be required with utilities, public transport operators and other key stakeholders.

A.3.9.8 Consultation and agreements should be recorded.

RECOMMENDATION 7 – CONSISTENCY WITH OTHER AUTHORITIES
Authorities should work collaboratively with neighbouring authorities and partners to promote consistency of approach where it benefits network users and service efficiency.

A.3.10 NETWORK ACTIVITIES – STREETWORKS

OVERVIEW OF STREETWORKS

A.3.10.1 Whilst street works are essential to the continued delivery of utility and communication services, effective management of these works is vital to safeguarding the safety, performance and resilience of the highway network.

A.3.10.2 Authorities have statutory duties to coordinate and, where appropriate, regulate street works. This includes assessing permit applications, applying conditions, inspecting works, enforcing compliance and ensuring reinstatements are to an acceptable standard.

A.3.10.3 Authorities should protect newly constructed or resurfaced assets where possible and reduce unnecessary disruption and congestion for customers. Authorities and works promoters should take reasonable steps to safeguard highway assets and third-party apparatus that may be affected by works.

A.3.10.4 Undertakers have rights to place and maintain their apparatus in the highway, accompanied by obligations to cooperate, plan effectively and ensure reinstatement quality. They must comply with permits or notices, provide accurate information, correct defects within required timescales and minimise disruption to road users and communities.

A.3.10.5 Developers, contractors, telecommunications providers and internal local authority teams may all promote works on the highway. These works should be subject to the same coordination, permitting and inspection requirements as those of statutory undertakers to ensure consistent standards and outcomes.

A.3.10.6 Effective management of street works requires engagement with a wide range of parties, including emergency services, public transport operators, freight organisations, local businesses and residents, and neighbouring authorities.

A.3.10.7 Clear and timely communication helps the public understand the purpose and timing of works. Accurate advance information, up-to-date on-site signage and effective use of digital channels can support this where available.

A.3.10.8 The Highway Authorities and Utilities Committee (HAUC(UK)) works across the UK and devolved governments to drive improvements to the management of works and the street and road network and publishes supporting information on its website: Home | HAUC(UK).

A.3.10.9 Primary legislation for lane rental is set out in section 74A of the New Roads and Street Works Act 1991 (NRSWA). The relevant regulations, made under that section, are the Street Works (Charges for Occupation of the Highway) (England) Regulations 2012 (the 2012 regulations).

ACCESS TO THE NETWORK

A.3.10.10 Promoters must notify or seek permission for works in accordance with the relevant local requirements. Applications should include clear information on timing, duration, location, traffic management requirements, reinstatement methods potential risks to highway assets and any proposed mitigation measures. Authorities should assess applications promptly, ensuring conditions are applied where necessary to manage safety, maintain access and coordinate with other activities.

A.3.10.11 Certain routes or locations may require additional restrictions because of safety, accessibility or operational importance. Measures may include working-hour limitations, embargoes during events, restrictions following resurfacing or designations for protected or traffic-sensitive streets. Where restrictions apply, these should balance the need to maintain network availability with the importance of enabling essential works.

A.3.10.12 Emergency works may proceed without advance notice but must still be managed to ensure safety and minimise disruption. Promoters should provide required information as soon as reasonably practicable after starting work and reinstate openings in accordance with relevant standards.

A.3.10.13 Street works must be carried out with appropriate traffic management that ensures the safety of workers and all road users, including people walking and wheeling, cyclists and people with mobility impairments. Continuity of public transport services and active travel routes, and the cumulative effect of multiple works in the same area are important considerations during planning.

COORDINATION OF WORKS

A.3.10.14 Coordination helps to minimise disruption, reduce repeated excavations and ensure the efficient use of road space. Authorities should maintain forward programmes of their own works and encourage utilities and other promoters to share planned activities. Coordination should seek to minimise disruption and deliver the best possible outcomes for road users, communities and businesses.

A.3.10.15 Early engagement and regular communication between promoters and authorities encourage collaborative working and help reduce avoidable disruption. Joint working may include shared trenches, coordinated timing or combined reinstatement activities.

A.3.10.16 Where works impact adjacent authorities or the strategic network, coordination may extend beyond local boundaries. This is particularly important for long distance diversions, major utility interventions or regional programmes of work.

REINSTATEMENTS

A.3.10.17 Reinstatements must be completed in accordance with the relevant national specification, including the Specification for the Reinstatement of Openings in Highways (SORH), or equivalent requirements. Standards cover materials, workmanship and performance characteristics, including compaction, ironwork setting and skid resistance. Reinstatements should be durable, compatible with surrounding pavement and support long-term asset resilience.

A.3.10.18 During resurfacing and reconstruction works, appropriate arrangements should be in place for the adjustment, re levelling or renewal of statutory undertakers' frames and covers to agreed specifications. Where required, established agreements with undertakers may be used to facilitate timely delivery of works, while retaining clear ownership and long-term maintenance responsibility with the asset owner.

A.3.10.19 Guarantee periods apply to reinstatements to ensure promoters remain responsible for defects attributable to their works. Monitoring compliance, identifying defects related to reinstatements, engaging with promoters to confirm defect status, and verifying that defects are addressed promptly can support effective management of guaranteed obligations.

A.3.10.20 Authorities may inspect a representative sample of works to assess compliance and identify promoters requiring targeted support or enforcement. Joint audits and shared learning can help drive improvements in reinstatement quality and application of good practice.

ENFORCEMENT

A.3.10.21 Authorities should take a proportionate approach to enforcement. Penalties or charges may be applied where promoters fail to comply with permit conditions, exceed agreed durations or deliver substandard reinstatements. Cost recovery mechanisms should be used to address additional authority expenditure arising from non-compliant works.

A.3.10.22 The use of available technologies and information sources, including artificial intelligence and reports from network users and local communities, can improve awareness of activities on the highway network and support risk-based inspection, monitoring and enforcement activities.

A.3.10.23 Performance reporting promotes transparency and improves accountability. Authorities can use performance information over time to highlight strengths, emerging issues and opportunities for improvement.

A.3.10.24 Information about reinstatement condition and performance can help authorities manage associated risks. Where defects are identified, authorities should seek to ensure that appropriate action is taken using the powers and processes available to them, having regard to the nature of the defect, the risks presented and the potential impacts on highway users. Particular consideration may be required where defective reinstatements, surface irregularities, loose material or similar defects present disproportionate risks to certain users of the highway network.

DATA AND SYSTEMS FOR STREETWORKS

A.3.10.25 Digital systems help authorities and promoters plan, coordinate and manage works more effectively. Noticing and permitting systems provide real-time information on road space occupation, support public communications and enable more consistent data recording.

A.3.10.26 DfT have provided the Street Manager platform for authorities, utilities and contractors in England to plan, manage and record street and road works. It provides improved visibility of works and publishes open data to reduce disruption and support better journey planning: Plan and manage roadworks - GOV.UK

A.3.10.27 Underground asset data is available through shared platforms that assist in planning and safe digging, although physical verification remains essential. Authorities and promoters should seek to ensure that data supplied is accurate, timely and retained in line with local requirements.

A.3.10.28 The National Underground Asset Register (NUAR) provides a secure and standardised map of buried infrastructure, based on data from authorities and utility providers.

INNOVATION FOR STREETWORKS

A.3.10.29 Innovative methods and materials can reduce excavation, shorten occupation, improve reinstatement quality and lower environmental impact. Promoters and authorities should remain open to emerging technologies and opportunities to trial or adopt new approaches where appropriate.

A.3.10.30 Lane rental schemes allow an authority to charge works promoters for the time that street and road works occupy the highway. It can help to minimise disruption and charges apply to works promoted by both utility companies and highway authorities. The DfT have published guidance for English authorities, and schemes need to be approved by the Secretary of State for Transport before they can become operational.

A.3.11 NETWORK ACTIVITIES – ROAD/RAIL INCURSION

A.3.11.1 Highway authorities should work with relevant organisations to identify road/rail interfaces where a risk of incursion of road traffic onto a railway is present. The Department for Transport publication Managing the accidental obstruction of the railway by road vehicles details a risk ranking process to be followed at each road over rail and road/rail site. Higher risk locations are then subject to a secondary assessment where the outcome is jointly agreed between highway and rail authorities and will determine any necessary improvements of other mitigation measures. The process is to undertake a joint assessment if required. It also sets out what highway authorities, rail infrastructure authorities and other organisations need to do to identify how the risk of road vehicle incursion to the railway can be jointly managed and a protocol for apportioning responsibility and costs of improvement and mitigation measures.

A.3.11.2 Highway authorities should ensure that appropriate warning signs, road markings and visibility requirements, including vegetation management where necessary, are maintained such that they remain effective and clearly visible to road users.

A.3.11.3 Where material changes are made to highway layout, operation or speed environment at locations with potential road vehicle incursion risk, authorities should consider whether relevant rail organisations need to be informed so that risks can be reviewed where appropriate.

A.3.11.4 The following are recent links to RAIB reports which authorities will wish to note the recommendations and to ensure that action is taken where applicable:

- Oxshott, August 2011;
- Stowmarket, November 2012;
- Aspatria, June 2014;
- Froxfield, January 2016;
- Coltishall, April 2022; and
- Redcar, April 2025.

A.3.12 NETWORK ACTIVITIES – ABNORMAL LOADS

A.3.12.1 The movement of abnormal loads on highways needs to be carefully managed so that large and/or heavy vehicles only use those parts of the network that can safely accommodate them. An abnormal load is considered to be a vehicle that is outside the classification of normal permitted traffic by virtue of its gross weight, length, width or axle configuration according to current road vehicle regulations. Authorities have powers to direct movement of abnormal loads and submission of a notification by the haulier enables the movement to take place legally.

A.3.12.2 The movement of abnormal loads should be managed in such a way as to ensure that the load effects induced by the abnormal loads do not exceed the load bearing capacity of structures on the route. The suitability of a specific abnormal load to cross a particular structure should be checked broadly in accordance with the procedures recommended in CS 454 – Assessment of highway bridges and structures or CS 458 – Assessment of highway bridges and structures for the effects of STGO and Special Order vehicles, or equivalent. Where an initial assessment shows that the load effects induced by an abnormal load marginally exceed the capacity of a bridge on the route, it may be possible for the abnormal load to safely cross the bridge provided other normal traffic is kept clear of the bridge when the abnormal load crosses it.

A.3.12.3 The suitability of an abnormal load to travel along the proposed route should be checked by the haulier in relation to any height restrictions from overbridges and restrictions on manoeuvrability along narrow roads and sharp bends etc. Consideration should be given to the placing and specification of street furniture on regularly used/defined abnormal load routes, e.g., bollards and pedestrian guard rails which may need to be removed to allow passage of abnormal vehicles.

A.3.12.4 In certain cases, e.g., vehicles wider than the traffic lane, abnormal loads should be escorted to provide appropriate warning to other traffic. Escorting may be undertaken by the police or by the haulier concerned as allowed for in the Code of Practice – Self Escorting of Abnormal Loads and Abnormal Vehicles, or equivalent.

A.3.12.5 Where road works are restricting the availability of regularly used abnormal load routes, consideration should be given as to how hauliers can be made aware of this.

A.3.12.6 The management of abnormal loads requires coordination between:

- Abnormal Loads Officer – person responsible for receiving notifications of movements from hauliers, ensuring that such notifications are assessed and that the haulier is advised if there is any reason why a proposed movement should not take place.

- Structures Advisor – a civil or structural engineer with appropriate competence in highway structure assessments to whom the Abnormal Loads Officer should refer decisions relating to vehicle movements which fall outside the agreed guidelines which otherwise determine whether or not particular vehicle movements should be accepted.
- Traffic Manager – the person responsible for the coordination of all traffic management on the highway network. All owners or managers of highway structures should establish and maintain a system to receive notifications from hauliers in respect of abnormal load movements. The system should enable hauliers to be advised within the statutory time limits if there is any reason why the movement should not proceed.

A.3.12.7 The Electronic Service Delivery for Abnormal Loads (ESDAL) system, or equivalent, provides a process for managing abnormal load movements.

A.3.13 WAYS OF WORKING – RISK-BASED APPROACH

A.3.13.1 Authorities should adopt a risk-based approach and a risk management regime for all aspects of highway management policy. This will include investment, setting levels of service, operations, including safety and condition inspections, determining repair priorities and replacement programmes, and organisational issues. It should be undertaken against a clear and comprehensive understanding and assessment of the likelihood of risk occurrence and the consequences involved.

A.3.13.2 There are no prescriptive or minimum standards in this Code. Adoption of a risk-based approach, taking account of the advice in the Code, will enable authorities to establish and implement levels of service appropriate to their circumstances.

A.3.14 WAYS OF WORKING – SECURITY MINDED APPROACH

A.3.14.1 Authorities should adopt a security-minded approach to their assets, information and people through understanding and routine application of appropriate and proportionate security measures to deter and/or disrupt hostile, malicious, fraudulent and criminal behaviours or activities. To support such an approach, the National Protective Security Authority has published Passport to Good Security. The National Cyber Security Centre has also produced cyber security advice for public sector organisations and the UK Government has published a suite of cyber security codes of practice for further support. Authorities should remain aware of relevant protective security and counter-terrorism legislation and guidance, including the Terrorism (Protection of Premises) Act 2025 (Martyn's Law), and consider any implications for the management of highway infrastructure, public spaces and associated activities.

A.3.14.2 Hostile Vehicle Mitigation (HVM) is a protective security discipline focussing on reducing risks associated with vehicle borne threats posed by terrorists and criminals. The National Protective Security Authority has published guidance on HVM measures, including public realm design guidance.

A.3.14.3 UKRLG has also produced specific guidance for local highway authorities covering a security-minded approach to counter-terrorist security.

A.3.15 WAYS OF WORKING – STAKEHOLDERS AND COMMUNICATION

A.3.15.1 Stakeholder expectations and the importance of good communications and liaison are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance Document, Part A. This document should be referred to and the advice below considered supplementary.

A.3.15.2 Arrangements should be established to facilitate the involvement of all authority elected members, employees, contractors and agents in building commitment and pride in the highway maintenance service and maximising individual contributions to the process of continuous improvement.

A.3.15.3 Many aspects of the maintenance process are highly technical and may be difficult to explain, but it is important that legal duties and obligations are understood. Users' concerns may tend to focus on the short term, more visible deficiencies in the network rather than the underlying less apparent problems.

A.3.15.4 The accompanying Quick Guides to this Code are designed to support the communication of technical issues related to the management of highway infrastructure with non-technical audiences. Also, industry publications such as CIHT's note on Involving the Public and Other Stakeholders and the REA's guidance on Explaining Preventative Road Maintenance to Residents provide further guidance on engagement with non-technical audiences.

A.3.15.5 Authorities should recognise the value that local communities, parish and town councils, voluntary organisations and other local stakeholders can bring through local knowledge, issue identification, community stewardship and support for agreed activities that contribute to the management and resilience of the highway network.

RECOMMENDATION 8 – CUSTOMER AND STAKEHOLDER ENGAGEMENT
Authorities should engage with customers and stakeholders to understand needs, communicate decisions, demonstrate how feedback has been considered and support transparent and informed infrastructure management.

A.3.16 WAYS OF WORKING – INNOVATION

A.3.16.1 A well-managed highway network requires authorities to respond effectively to changing needs, expectations and pressures, for example ageing assets, funding constraints, resource challenges and the accelerating pace of technological development.

A.3.16.2 A proactive and systematic approach to innovation can provide value to the identification, assessment, trial, and, where appropriate, adoption of innovative solutions in a manner consistent with risk-based decision-making and the overarching principles of this Code. This can deliver enhanced benefits across the core objectives of safety, serviceability, sustainability, and customer service.

A.3.16.3 Innovation extends beyond simply using a new technology, and could also include the adoption of any product, service, process, model or method. The innovation does not need to be something entirely new within the sector or something that has never been done before. It may involve a novel application of existing tools or processes at the disposal of an authority or within the sector.

A.3.16.4 The BS EN ISO 56000 series of standards provide requirements and guidance for establishing, implementing, maintaining and improving an innovation management system. While an innovation

management system may be applied at an authority-wide level, the operational approach detailed in the standard is summarised below in practical steps:



Figure 5 – Practical Steps to Innovation Management

A.3.16.5 Innovation can link to an authority's asset management performance management processes, with areas of underperformance potentially being suitable for consideration at the "Identify opportunities" stage above. In any case, innovation can be managed in line with an authority's wider corporate standards and principles.

A.3.16.6 Opportunities for government funding may be tied to innovation, and authorities can explore options for financial assistance when considering innovation. This may include Transport Research and Innovation Grants (TRIG) from the DfT and the Scottish Road Research Board (SRRB) from Transport Scotland.

LEADERSHIP AND CULTURE

A.3.16.7 Curiosity, collaboration and constructive challenge can support innovation and continuous improvement. Effective leadership helps create an environment where new ideas can be tested safely, learning can be gained from both success and failure, and experimentation is undertaken in an ethical, transparent and proportionate manner. Resources found through the Local Council Roads Innovation Group (LCRIG) Knowledge and Innovation Network and LGA Transformation Capability Framework contain behaviour-change approaches and templates for authorities to consider.

IDENTIFY OPPORTUNITIES AND CREATE CONCEPTS

A.3.16.8 It is important to view innovation on a need-basis and not perform innovation for the sake of it. Opportunities should be identified first based on challenges, then a solution identified based on

the value it would bring in solving that challenge. Attempting to fit a ready-made solution into operations may not achieve as great a benefit as solving a known problem.

A.3.16.9 Challenges and opportunities that may benefit from innovative approaches can be identified through:

- Asset condition and performance data;
- Operational insights from front-line teams and supply chains;
- Customer feedback and complaints;
- Financial, carbon and resilience considerations;
- National and local policies;
- Horizon scanning for developments in materials, digital technologies, data, automation and commercial models.

A.3.16.10 Opportunities may arise across all aspects of highway management, including design, construction, maintenance, operations, inspections, information management and customer engagement. Insights from programmes such as ADEPT Live Labs 2 have already demonstrated innovations in low-carbon materials, digitalisation, and new operational models.

A.3.16.11 Learning from other authorities and wider infrastructure sectors, plus participation in knowledge-sharing forums, research programmes and partnerships with industry and academia can improve consistency and avoid unnecessary duplication of effort. Organisations such as ADEPT and LCRIG promote both innovation and the collaborative sharing of knowledge across the highways sector and provide useful up-to-date information on innovations being implemented.

A.3.16.12 Innovation opportunities should be assessed by methods that are proportionate to the scale, cost, risk and potential impact of the proposed change. Considerations may include:

- Alignment with the core objectives (safety, serviceability, sustainability and customer service);
- Deliverability; and
- Scalability.

A.3.16.13 The HM Treasury Green Book and Magenta Book provide information on proportionate appraisal and evaluation standards which authorities may apply when considering their approach to innovation.

A.3.16.14 Innovations may range from incremental improvements to more transformational change, recognising that small innovations can also deliver meaningful long-term benefits.

VALIDATE CONCEPTS

A.3.16.15 Testing should be considered where an innovation introduces uncertainty or potential risk, involves new materials, technologies or processes, or could have material impacts on safety, service levels, network users or operational practices.

A.3.16.16 Testing enables authorities to gather proportionate evidence before wider adoption, ensuring that decisions remain risk-based and aligned with this Code, and should be based on:

- Clear hypotheses and intended outcomes;
- Defined success criteria;
- Consideration of network safety, operational continuity and user impact;
- Data collection, monitoring and evaluation plans;
- Safe-to-fail environments and ethical use of data and technology.

A.3.16.17 Sharing learning from trials can support improvement across the wider sector. This may involve sharing findings or case studies with local or regional groups, presentation at industry events, or contribution to industry bodies such as LCRIG.

A.3.16.18 Innovation should be managed with a clear understanding of risk.

A.3.16.19 Authorities should seek to ensure that:

- Risks are proportionately assessed and not used to unnecessarily inhibit potentially beneficial innovation;
- Roles, responsibilities and accountabilities are explicit;
- Legal, commercial and data protection requirements are considered early;
- Supply chain partners are engaged on appropriate terms, including clarity on aspects such as warranties, intellectual property and data ownership.

A.3.16.20 Future implications on funding are also relevant at the validation stage. An authority may obtain funding to adopt an innovation, however if sufficient funding will not, or is unlikely to exist across the life of the innovation to maintain or operate it, the full benefits may not be realised.

A.3.16.21 Similarly, the risk of obsolescence may be considered during the validation stage, of both the innovation and components within it.

DEVELOPING AND DEPLOYING SOLUTIONS

A.3.16.22 Where innovations demonstrate long-term value, authorities should consider updating relevant standards, policies, processes, specifications, asset management plans, operational procedures and contractual arrangements to ensure effective adoption. Consideration should also be given to how successful innovations can be scaled and embedded within business-as-usual activities so that benefits are realised consistently across the organisation and network where appropriate.

A.3.16.23 Training, change management, and ongoing performance monitoring of an innovation to assess benefits realisation can support successful integration into business-as-usual.

CONTINUOUS IMPROVEMENT

A.3.16.24 An innovative mindset can help authorities address their priority challenges and keep pace with the continual evolution of new and existing approaches, regardless of where they sit on the adoption curve. Outcomes from trials and adopted innovations can inform future decision-making, benchmarking and reporting, supporting a culture of continuous improvement across all highway asset types.

A.3.16.25 To close the loop on innovation, authorities are encouraged to communicate their findings across the sector whether the trial was a success or not, to support the combined knowledge of practitioners. An unsuccessful trial for one authority does not necessarily mean that the innovation is inherently bad but instead may highlight a need for change with its application, operating context or support from providers.

A.3.17 WAYS OF WORKING – ARTIFICIAL INTELLIGENCE

ARTIFICIAL INTELLIGENCE

A.3.17.1 Artificial Intelligence (AI) technologies are continually evolving, with new products coming to market that may provide benefit to highway authorities with the management of their assets.

A.3.17.2 Successfully implemented, AI may provide benefits to an authority in terms of efficiency, accelerating the delivery of tasks and/or allowing constrained resources to focus on value-adding activities rather than manual processing of tasks. Additionally, AI may introduce opportunities to perform functions such as complex analysis that would not otherwise be possible; however, authorities should ensure that there is sufficient human expertise to validate this type of application.

A.3.17.3 The introduction of artificial intelligence does not alter the legal responsibilities of highway authorities under existing legislation. The Highways Act Section 41 duty to maintain highways maintainable at public expense cannot be transferred through the use of contractors, suppliers or AI. Authorities therefore remain accountable for decisions and outcomes affecting the management and maintenance of the highway network, regardless of the technologies used to support those activities. The deployment of AI should be viewed as a tool to assist decision-making and service delivery, rather than as a substitute for the authority's legal responsibilities.

A.3.17.4 The evidential value of AI-enabled technologies should also be considered in the context of statutory defences available to highway authorities. AI applications, including condition assessment, network monitoring and inspection support tools, may assist authorities in strengthening the evidence base supporting inspection, risk assessment and maintenance decisions as part of a Section 58 defence. However, the use of such technologies does not remove or diminish the authority's liability under Section 41, nor does it replace the need for proportionate governance, competent oversight and documented decision-making.

A.3.17.5 Authorities should stay informed of the latest advances in AI and its capabilities in relation to managing highway infrastructure and ensure that any application understands the risks associated with it and is compliant with the authority’s own corporate AI policies.

A.3.17.6 AI solutions should be considered as part of a needs-based approach, when they can demonstrably provide a benefit to an authority with respect to achieving the core objectives for highway management. Benefits and costs should be assessed across the whole lifecycle of the assets and of the AI technology.

A.3.17.7 Authorities are encouraged to identify opportunities to provide lessons learned if tools are adopted or trialled early, to support others in understanding the practicalities of using AI. This may be done through regional or sector groups, case studies or presentations.

A.3.17.8 The scope of this section applies to AI used by highway authorities and their delivery partners across the asset lifecycle. This may include but is not limited to data pre-processing and quality

checks, demand and deterioration forecasting, safety risk modelling, defect triage and scheduling, optimisation, computer vision for inspections, natural language assistants and agents for knowledge retrieval, and automation that augments routine tasks. It covers AI embedded in off the shelf products, custom models, and agentic AI that uses multiple tools.

A.3.17.9 Agentic AI is defined by the Future Highways Research Group (FHRG) as "AI systems that can be delegated defined tasks and objectives, even operating semi-autonomously within guardrails. The AI can also interact with other systems, data, and humans and escalate decisions or exceptions when thresholds are breached". Agentic AI differs from other AI tools which may typically provide an output for a person to review and act upon, and instead agentic AI can coordinate multiple tasks and decisions in pursuit of a defined goal.

A.3.17.10 The FHRG began a project in 2026 titled "Agentic AI in Highways", covering what agentic AI means for asset management practice, what governance frameworks are needed, and what a realistic adoption pathway looks like for local highway authorities. As part of the project, FHRG research outputs will be made freely available and be signposted in this Code when launched.

GUIDING PRINCIPLES

A.3.17.11 Authorities should only consider AI where it meets a clearly defined service need or addresses an identified performance gap. Any proposal should follow the authority's risk-based approach, with expected benefits and outcomes identified before development or procurement.

A.3.17.12 Authorities should comply with internal policies on information technology (e.g. procurement, intellectual property, assurance etc) and apply recognised UK AI governance principles. These include ensuring that systems are safe and secure, outcomes can be explained, decisions are fair, responsibilities are clear, and decisions can be challenged. These requirements should be applied in a proportionate way, reflecting the purpose, scale and risk of the AI use.

A.3.17.13 Authorities should understand the legal, governance and accountability implications associated with the intended AI application before deployment. The allocation of responsibility and liability for AI-assisted decisions remains an evolving area and may depend on organisational, contractual and legal arrangements. Where AI is intended to support or influence safety-critical, regulatory, financial or otherwise legally consequential activities, authorities should seek specific legal advice before deployment.

A.3.17.14 Authorities should assess whether their available data is sufficient for the intended AI application and understand any limitations that could influence outcomes. Whilst AI may offer opportunities to improve information management and derive value from existing datasets, authorities should recognise that some applications may require improvements in data quality, coverage or governance before they can be implemented with confidence. Data requirements should be proportionate to the intended use and associated risks.

A.3.17.15 The UK Government has developed a playbook that offers guidance on using AI safely, effectively and securely for civil servants and people working in government organisations.

A.3.17.16 AI systems should be designed, developed and operated in line with good practice for secure digital services. Security should be considered across the full lifecycle, from early design and testing through to deployment, operation and eventual retirement.

A.3.17.17 The National Cyber Security Centre has produced guidelines for providers of any systems that use artificial intelligence (AI), whether those systems have been created from scratch or built on top of tools and services provided by others.

A.3.17.18 Where personal data is used, authorities should assess data-protection risks and ensure compliance with relevant legislation and good practice. Authorities should also consider the potential for unequal impacts or unintended bias when selecting data or using AI models.

A.3.17.19 The Information Commissioner's Office has produced guidance on AI and data protection, risk assessment, communication and analytics.

A.3.17.20 Where AI plays a material role in decisions or service delivery, authorities should integrate it within their existing management systems. This may include aligning with recognised AI management standards to support consistent improvement and learning over time.

A.3.17.21 Authorities should use independent assurance or recognised assessment techniques where risks or impacts are higher. Assurance should be proportionate to the use case and support confident and transparent decision-making.

A.3.17.22 Authorities should ensure that people remain accountable for decisions that affect safety, legality or significant service outcomes. AI should support professional judgement by improving consistency, efficiency or insight, rather than replacing human responsibility.

IDENTIFICATION AND IMPLEMENTATION WORKFLOW

A.3.17.23 Authorities should follow a simple and repeatable workflow when identifying and implementing AI technologies.

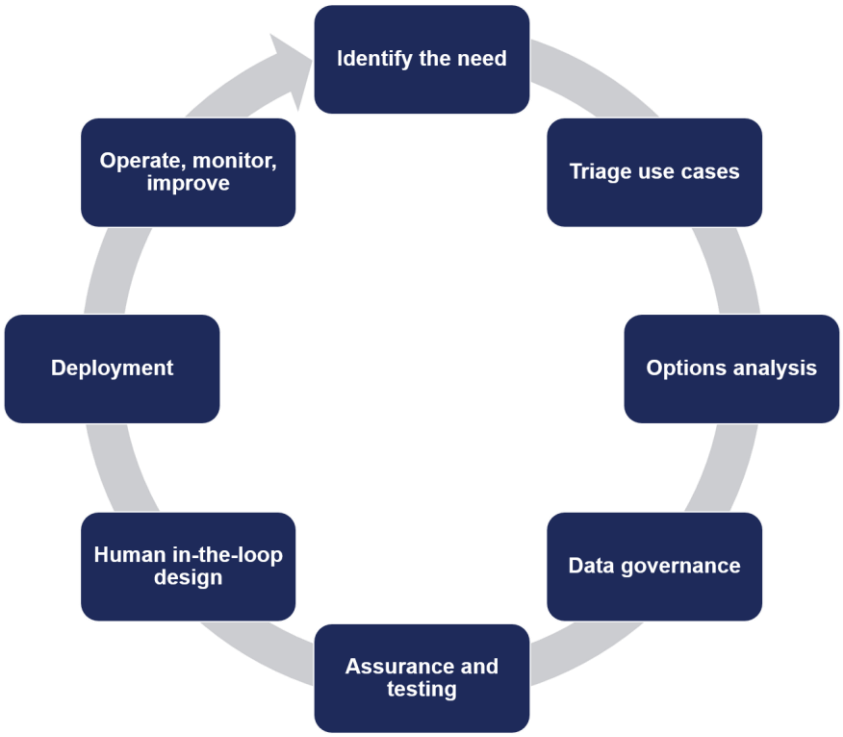


Figure 6 – Workflow for Identifying and Implementing AI Technologies

A.3.17.24 Authorities should begin by clearly defining the need the AI is intended to address. This includes describing the problem, the assets affected, the current limitations, and the outcomes sought. Authorities should also identify the relevant risks and consider how AI could reduce the likelihood or consequence of those risks, or how it might automate routine tasks to release staff time for higher-value activities.

A.3.17.25 Authorities should then assess potential use cases to determine which are most suitable. This triage should consider the scale of the risk or expected benefit, the readiness of data, the level of organisational change required, and the complexity of governance arrangements. Priority should be given to cases where AI clearly supports a recommendation in the Code, helps meet a statutory duty, or strengthens a safety-related control.

A.3.17.26 When developing options, authorities should consider whether an off-the-shelf solution is sufficient, whether existing tools can be configured to meet local needs, or whether a bespoke development is necessary. Off-the-shelf options are generally most appropriate for common outcomes where risks are low to medium, although configuration may be appropriate where multiple tools need to work together. Bespoke development should be reserved for cases where needs are unique, risks are high, or control of the technology is essential. In all cases, authorities should apply recognised AI governance principles and good security practice, in line with their wider corporate policy and guidance.

A.3.17.27 Where AI-enabled products or services are procured from third parties, authorities should ensure that relevant procurement, legal, information governance and IT professionals are involved as appropriate. Existing organisational policies and procedures relating to technology procurement remain applicable. Authorities should recognise that the pace of development of AI technologies may create additional risks and opportunities and should consider factors such as supplier support arrangements, intellectual property, data ownership, model performance, contractual flexibility and ongoing governance when assessing potential solutions.

A.3.17.28 When implementing AI systems, authorities should:

- Consider whether they have sufficient understanding of the associated risks, data that is suitable for the intended application, and access to competent personnel who can validate, challenge and oversee the outputs. These considerations should inform decisions on whether a proposed application can be deployed with confidence.
- Put appropriate data governance in place. This includes defining data sources, understanding how data has been collected and processed, ensuring there is a lawful basis where personal data is involved, and setting out controls for data retention and sharing. Authorities should document data and model characteristics using recognised approaches so that suitability, limitations and known biases are clearly understood.
- Set out a proportionate assurance and testing approach. This may include risk assessment, impact assessment, and testing for bias, robustness and security. Independent assurance may be needed for higher-risk applications. Security testing and adversarial evaluation should be completed before any system is put into live use.
- Design the system so that people remain appropriately involved. This includes defining decision rights, escalation points and situations where human review is required. Where staff rely on AI outputs, authorities should provide clear explanations or confidence indicators consistent with transparency principles.

- Apply a formal decision point before deployment. This should confirm that the value case remains valid, that required data-protection and equality assessments have been completed, that security and licensing arrangements are in place, and that staff training and support are available.

A.3.17.29 Once in operation, authorities should monitor performance, model drift, safety incidents, equality impacts and user feedback. Incidents and corrective actions should be recorded within the authority's established risk framework and reviewed through existing management processes. Where appropriate, authorities may draw on recognised AI management standards to support continual improvement.

A.3.17.30 ISO/IEC 42001 is an international standard that specifies requirements for establishing, implementing, maintaining, and continually improving an Artificial Intelligence Management System (AIMS) within organisations.

A.3.17.31 Authorities should maintain proportionate records of AI applications to support transparency, continuity, governance and organisational learning while meeting legal requirements. The level of documentation should reflect the complexity, risk and intended use of the application. The records and documentation should contain a proportionate level of detail for the AI use case or implemented solution and may contain items such as a problem statement and value case, assurance and test records, an operating manual, or monitoring and incidents logs.

PRIORITISING AI USING A RISK-BASED APPROACH

A.3.17.32 When considering where AI can add value, authorities should map potential investments to their risk profile and identify areas where AI can support highest value improvements. AI may help manage safety risks by enabling near real-time identification of hazards through imagery or sensor data, supporting detection of works clashes, and helping target inspections based on risk. Where such deployments relate to higher-risk activities, authorities should apply stronger assurance, security measures and human oversight to maintain safe operation.

A.3.17.33 AI can support improvements in asset performance and lifecycle management by helping forecast deterioration, optimise whole-life costs and predict failures, with potential benefits for both serviceability and sustainability.

A.3.17.34 Examples of support to customer service objectives includes triaging customer reports more efficiently, summarising records to support quicker responses, and providing assistants that retrieve standards and historical decisions to improve consistency.

A.3.17.35 AI may also improve efficiency and build capacity by automating repetitive or low-value tasks. This can release professional time for engineering judgement, inspections and other activities with higher safety or legal importance.

A.3.17.36 PIARC has produced a report on international applications and lessons learned on the use of AI within road administrations.

MANAGING AI RISKS

A.3.17.37 Authorities should apply controls proportionately to AI. An example baseline is set out below, including examples of controls that could be used at each risk level:

- Tier 1: Low risk – Internal productivity tools with no safety, legal or equality impact, and no personal data. Controls may include a basic risk note, usage policy, user training and periodic review.
- Tier 2: Medium risk – May include operational decision support or have access to limited personal data. Controls may include a Data Protection Impact Assessment (DPIA), bias checks, model and data documentation, security review, explicit human in the loop procedures, a monitoring plan, and transparency to users.
- Tier 3: High risk – Safety-related decisions, significant service impacts, or sensitive data. Controls may include all Tier 2 plus formal algorithmic impact assessment, independent assurance, staged pilots, red team testing, incident response playbooks, and AI management system style oversight aligned to ISO/IEC 42001.

A.3.17.38 In agentic workflows, the risk classification is determined by the highest-consequence action that system can undertake autonomously, rather than the most common or average risk level, or intended function. The governance, assurance and oversight requirements outlined in A.3.17.28 must also reflect the highest level of risk within the workflow.

A.3.17.39 The level and timing of human oversight should be proportionate to the intended application of AI and associated risks. Authorities should recognise that some operational or time-critical applications may require different oversight arrangements to strategic, planning or administrative activities. Where greater reliance is placed on automated or AI-assisted decision-making to support timely operational responses, authorities should ensure that the performance, limitations and risks of the system are understood, and that appropriate monitoring, assurance and review arrangements remain in place.

A.3.17.40 Where AI systems undertake a sequence of linked tasks, recommendations or decisions, authorities should ensure that appropriate review, escalation and intervention points are identified so that human oversight can be applied at suitable stages within the process, in line with the Highways Act.

A.3.17.41 AI systems must be secured against model theft, data exfiltration, prompt injection, supply chain compromise and abuse. Authorities should apply National Cyber Security Centre (NCSC) guidelines across secure design, development, deployment and operations, and follow government AI cyber security advice and codes of practice as they evolve.

A.3.17.42 Authorities should conduct Data Protection Impact Assessments (DPIA) where processing personal data, explain what data is used and why, and ensure routes for subject access, correction and objection aligned to ICO guidance. Equality impacts should also be considered, including the potential for indirect discrimination from training data or deployment context.

A.3.17.43 Authorities retain accountability for decisions affecting safety, service levels and statutory duties. Governance should define senior responsible owners for each AI system, decision logs, and redress routes consistent with the UK AI regulatory principles on accountability and contestability. Contracting should allocate responsibilities for training data, model performance, security, and updates.

WORKFORCE, SKILLS AND ORGANISATIONAL CHANGE

A.3.17.44 Authorities should use AI to help manage workforce-related risks by automating routine or repetitive tasks, improving access to knowledge, and supporting new analytical capabilities.

These approaches can help authorities make better use of limited capacity and ensure that professional time is focused on activities where human judgement is most important.

A.3.17.45 Authorities should invest in targeted training so that engineers, inspectors and managers understand where AI is strong and where it may fail, what levels of transparency are expected, and when issues should be escalated for human review. Training should support confident and safe use of AI and reinforce the authority's overall approach to risk.

A.3.17.46 Authorities should also recognise that, while AI can improve efficiency and release professional time, increased automation may reduce opportunities for practitioners to routinely apply and maintain the technical knowledge, professional judgement and critical evaluation skills required for effective asset management. Authorities should therefore consider how professional competence will be maintained alongside AI adoption, including ensuring that personnel remain capable of understanding, challenging, validating and taking responsibility for AI-enabled outputs and decisions.

A.3.17.47 Authorities should consider the potential impact of AI adoption on recruitment, early-career development and succession planning. As AI increasingly automates activities that have traditionally provided entry points into highways and asset management professions, authorities should ensure that sufficient opportunities remain for individuals to develop the practical experience, technical understanding and professional judgement needed to progress into future specialist and leadership roles.

A.3.17.48 The Local Government Association has created a series of short explainer videos designed to provide officers and councillors who are new to AI with a starting point for understanding and engaging with key concepts.

A.3.18 WAYS OF WORKING – DESIGNING FOR MAINTENANCE

A.3.18.1 Although much maintenance activity is undertaken on highway construction of long standing, new and improved highway schemes and facilities form an increasing proportion of the network over time. The future maintenance costs of such new infrastructure are therefore a prime consideration.

A.3.18.2 Scheme development (both for planned maintenance schemes e.g., renewals, and public realm schemes e.g., improvements), should focus on delivering the objectives whilst minimising network disruption and lifecycle costs and without compromising other important aspects such as access arrangements, environmental and sustainability issues, worker safety or maintainability. Design decisions can influence risks during construction, maintenance, operation and renewal activities. Where it is not possible to minimise both disruption and lifecycle costs, compromise may need to be sought.

A.3.18.3 There are many cases where careful consideration of maintenance implications at the design stage would have provided an equally effective outcome, but without maintenance complications either increasing costs or introducing practical difficulties which may compromise the effectiveness of the feature. Examples include:

- materials requiring a disproportionately high frequency of maintenance;
- access difficulties for routine maintenance such as drain clearance and cleansing;
- inappropriate use of bridge expansion joints rather than integral bridges;

- inappropriate treatments and planting on central reservations or narrow verges;
- maintenance requiring disproportionate traffic management and associated user disruption costs;
- traffic calming and safety features with high rates of deterioration;
- creating non-essential confined spaces; and
- operatives exposed to working close to live carriageways or at height.

A.3.18.4 Disproportionately costly or inconvenient maintenance requirements may inhibit or prevent programmed maintenance taking place. Failure to provide the specified maintenance regime could have serious consequences for the potential liability of the authority and its employees.

A.3.18.5 Given that works of highway improvement and significant maintenance will usually be funded from capital and that subsequent maintenance works will often be funded from revenue, the potential financial impact is greater than might be first perceived. The benefits of whole life designs and treatments should always be considered. The balance between capital and revenue expenditure could be different in certain forms of public private partnership.

A.3.18.6 This is not to say that creativity should be inhibited. High quality or relatively expensive materials may provide appropriate, low maintenance and cost-effective treatments in terms of their contribution to wider regeneration objectives, for example in improving the quality of public space and streetscape. It may also be appropriate to use environmentally sensitive materials in certain locations, despite the possibility of higher future maintenance costs.

A.3.18.7 Co-ordination of design and specifications between highway maintenance and highway improvement schemes can be improved through formal and informal liaison and co-operation between those involved to ensure that the whole life costs of schemes are optimised. These could involve formal consultation, value management and/or engineering, or a system of maintainability audits for a sample of schemes to establish local good practice.

A.3.18.8 Unusual maintenance requirements and costs associated with schemes or materials brought forward for approval should be identified so that they can be taken into account at the time. This is particularly important where new highways are being assessed for adoption and may be reflected in commuted sums for any higher than usual future maintenance costs sought from developers. The Association of Directors of Environment, Economy, Planning and Transport (ADEPT) has published guidance that aims to provide advice on the commuted sums mechanism through which developers are required to contribute to future maintenance of areas adopted by local authorities.

A.3.18.9 Tables 4 and 5 provide factors to consider by designers during the design process, to ensure that adequate consideration is given to future maintenance requirements of schemes. The list is not exhaustive but includes a number of key issues that may need to be addressed.

Table 4: Factors to Consider for Future Maintenance

Issue	Check	Action
Scope and Scale		
Intended life of scheme	Is the scheme long life or 'temporary' and likely to be affected by future redevelopment?	Choose materials and products relevant to the life of scheme.
Nature of scheme	Is the scheme a 'unique' prestige project or a 'routine' standard one?	Choose materials and products relevant to the type of scheme.
Scope of scheme	Has the scheme been 'value-managed' to consider all possible marginal benefits?	All 'significant' schemes should be value managed.
Use of scheme	Is the scheme likely to be subjected to particularly 'heavy duty' traffic use with high rates of wear?	Select design and materials to mitigate these affects so far as possible.
Cost of scheme	Have the costs of future maintenance been calculated and included in future budgets?	Identify any extraordinary maintenance costs and report these alongside construction costs.
Design Aspects		
People walking and wheeling and cyclists	Do footways and cycle routes follow established desire lines?	Redesign to reflect desire paths to avoid erosion and later replacement.
Vehicle overrun and parking	Is footway paving likely to be over-ridden or used by vehicles that were not considered in the design, including heavy goods vehicles, loading activity and pavement parking?	Where necessary use more robust construction, provide physical protection, or modify the design to reduce premature deterioration, accessibility issues and future maintenance costs.
Grassed and planted areas	Are grassed and planted areas of a size and position to be effectively maintained?	Redesign or remove where necessary to avoid future poor appearance and later redesign.
Trees	Have trees been selected and positioned to avoid future problems with roots, obstruction or leaf fall?	Reselect or reposition where necessary to avoid potentially expensive future problems.
Traffic signs	Have the future maintenance requirements of signs and associated infrastructure been considered, including illumination, cleaning, visibility, vegetation management and the removal of redundant assets?	Select solutions that minimise future maintenance requirements and ensure safe and effective operation throughout their lifecycle.

Table 5: Factors to Consider for Future Maintenance

Maintenance Operations		
Maintenance regime	Does the scheme require specialist maintenance regime?	Identify cost of specialist regime and, where appropriate, consider cheaper alternatives.
Cleansing	Does the scheme require specialist cleansing regime?	Identify cost of specialist regime and, where appropriate, consider cheaper alternatives.
Traffic management	Will maintenance require special traffic management?	Identify traffic management costs and minimise wherever possible, possible through co-ordination with other works.
Maintenance access	Is there safe and convenient access for plant and personnel?	Redesign scheme to provide safe and convenient access.
Materials and products		
Specialist materials	Are the materials used for the scheme of standard or specialist nature?	If specialist materials used ensure availability of future replacements.
Durability of materials	Does the durability of the materials provide substandard, oblique, sufficient or excessive life?	Select materials relevant to the intended life and nature of the scheme.
Failure mechanism	How will material/product approach the failure condition – slowly/quickly?	Programme safety and service inspections on basis of risk assessment.
Life extension	Are there any processes which could be used to extend useful service life at economic cost?	Investigate cost benefit of using life extension products.
Replacement practicability	Are there likely to be any difficulties in replacing failed sections?	Undertake risk assessment and plan for the likely difficulties.
Replacement cost	Is the cost of replacement likely to be disproportionately high?	Consider alternative materials or products.
Environmental impacts	Do the materials, products or processes have environmental implications that could affect future maintenance activities or require specific permits, controls or mitigation?	Consider whole-life environmental impacts and future maintenance requirements when selecting materials, products and processes.
Reuse and Recycling		
Practicability of reuse	If the scheme is a short-life scheme what is the scope reusing materials and products?	Choose re-useable materials and products wherever possible.
Practicability of recycling	What is the scope for recycling materials and products?	Where re-useable materials and products are not appropriate, use recyclable wherever possible.

RECOMMENDATION 9 – PLACE, ACCESSIBILITY AND USER EXPERIENCE
Highway authorities should manage highway infrastructure to support the quality, accessibility, character and functionality of places whilst reducing unnecessary clutter and barriers to movement.

A.3.19 WORKFORCE CAPABILITY AND COMPETENCE

A.3.19.1 The effective management of highway infrastructure depends upon the capability, capacity and performance of the workforce delivering it. People are not only a critical asset, but a key factor in achieving the core objectives over short, medium and long term.

A.3.19.2 Authorities should take a structured approach to workforce planning that integrates wellbeing, development, retention and recruitment. This should be considered across both the authority and its supply chain, recognising the alignment between organisational capability, workforce resilience and delivery outcomes.

A.3.19.3 The UK highways sector continues to face long-standing challenges, including skills shortages, an ageing workforce, increasing service demands, competition for specialist expertise, changing technical requirements, and reorganisation of authorities and functions within them. These challenges are compounded by changing expectations around working practices and workforce wellbeing. A planned and balanced approach is therefore required to ensure that the workforce remains sustainable, competent and able to meet current and future service requirements.

A.3.19.4 The Local Government Technical Advisers' Group has produced People, the key Highway Asset – Find them, train them, keep them, a toolkit of innovative practices being used in the industry.

RECOMMENDATION 10 – CAPABILITY AND COMPETENCE
Authorities should develop, retain and support a competent and resilient workforce, recognising the importance of succession planning and asset management competence.

WELLBEING

A.3.19.5 Workforce wellbeing is a key contributing factor to performance, safety and retention. Poor wellbeing can lead to reduced productivity, increased absence, higher turnover and greater risk in operational environments.

A.3.19.6 Wellbeing is part of effective workforce management and organisational practices; leadership behaviours and working environments can support the physical and psychological health of employees and contractors.

A.3.19.7 This may include:

- Promoting supportive leadership and management capability
- Ensuring workloads and expectations are realistic and manageable
- Providing access to relevant support mechanisms
- Creating an environment where individuals feel able to raise concerns

A.3.19.8 Consideration of wellbeing should extend across the supply chain, recognising that delivery outcomes are influenced by the collective workforce.

DEVELOPMENT

A.3.19.9 Authorities should ensure that all staff involved in the planning, delivery and management of highway services are appropriately trained and competent for the roles they undertake. This includes maintaining awareness of evolving standards, technologies and good practice relevant to highway asset management through Continuing Professional Development.

A.3.19.10 Where contractors or agents are engaged, authorities should require assurance that personnel undertaking work on their behalf are suitably qualified, trained and competent.

A.3.19.11 The Engineering Council, as the UK regulatory body for the engineering profession, sets and maintains standards of professional competence and ethics that govern the award and retention of the titles Chartered Engineers (CEng), Incorporated Engineers (IEng) and Engineering Technicians (EngTech). The Engineering Council holds details of degree programmes that partially or fully satisfies the education requirement for CEng and IEng registration and of programmes that professional engineering institutions have approved as contributing towards EngTech registration.

A.3.19.12 Development should extend beyond technical competence to include leadership, management and behavioural capability, particularly for those responsible for decision-making, service delivery and people management.

A.3.19.13 Investment in these areas supports more effective organisations and contributes to improved workforce engagement and performance.

RETENTION

A.3.19.14 Retention of skilled staff supports service continuity and organisational stability, retains institutional knowledge, and improves cost efficiency. Conversely, high turnover creates delivery risk, undermines capability, and increases reliance on external resources.

A.3.19.15 Leadership, culture, workload, development and wellbeing collectively influence retention. A proactive approach to retention can reduce operational risk and support long-term workforce sustainability.

A.3.19.16 Providing clear career pathways, access to professional development, supportive management and opportunities to contribute to wider industry activities can help maintain job satisfaction and engagement.

SUCCESSION PLANNING

A.3.19.17 Authorities face risks arising from the potential loss of experience and institutional knowledge due to retirement, staff turnover, organisational change and wider workforce pressures. Authorities should therefore consider succession planning and knowledge management as part of their approach to risk management. This may include documenting key processes, sharing knowledge across teams, mentoring early-career staff and planning for the gradual transition of responsibilities. Proactive steps of this nature can reduce risks to service disruption and enhance long-term organisational resilience.

A.3.19.18 Without effective succession planning, authorities risk losing critical knowledge and weakening organisational resilience. Succession planning is an important strategic risk management activity rather than an optional administrative exercise.

RECRUITMENT

A.3.19.19 Authorities should consider a range of recruitment approaches to secure the skills and experience they require. These may include direct recruitment, redeployment and upskilling of existing staff, apprenticeships, degree apprenticeships and early-career programmes, and attracting entrants with transferrable skills, e.g., from the armed forces.

A.3.19.20 Different recruitment routes offer different strengths and limitations. For example, internal development may help retain organisational knowledge and provide continuity, while external recruitment can bring new perspectives and specialist skills. Partnerships with educational institutions, professional bodies and training providers can support more sustainable recruitment pipelines and help address structural skills gaps.

A.3.19.21 Organisational reputation, culture and employee value proposition can influence authorities' ability to attract talent in a competitive market.

A.3.19.22 Positioning the highways sector as a career that delivers visible, real-world impact can support attraction, particularly those at the start of their careers and individuals transitioning from other sectors.

COLLABORATION

A.3.19.23 Authorities may not always be able to maintain all necessary skills and capacity in-house. Collaboration with neighbouring authorities, industry partners and other organisations can help access specialist expertise, share learning and make more effective use of limited resources.

A.3.19.24 Collaboration can also support workforce resilience by reducing pressure on individual organisations and enabling access to shared expertise.

A.3.19.25 Such arrangements should be managed to ensure that accountability remains clear and that the authority retains sufficient understanding and control to act as an informed client.

PROCUREMENT

A.3.19.26 Where authorities have shortfalls in capacity, capability and/or competence internally, or where an organisational decision is made regarding resourcing policy, then services can be procured from third party organisations.

A.3.19.27 Authorities should ensure that suppliers demonstrate workforce capability, including competence, capacity and an approach that supports a sustainable and resilient workforce.

A.3.19.28 Chapter A.9 contains further information on procurement and delivery models to support the management of highway infrastructure.

SECTION A.4 RISK-BASED APPROACH

A.4.1 WHAT IS A RISK-BASED APPROACH?

A.4.1.1 A risk-based approach is a systematic, evidence-based way of managing highway infrastructure in the context of local objectives, network characteristics, statutory duties, affordability and risk appetite. It provides a defensible basis for decision-making and prioritisation where no national minimum standards exist. The approach aligns with ISO 55000 principles and corporate risk management frameworks.

A.4.1.2 The effectiveness of a risk-based approach depends not only on the maturity of an authority's asset management practices, but also on its ability to implement decisions through appropriate resources, capability, governance and delivery arrangements. Authorities should recognise the potential impact of financial, organisational and capacity constraints when managing risks and establishing priorities.

A.4.1.3 It applies at the strategic, tactical and operational levels, addressing risks that may affect delivery of the authority's objectives, including local priorities and the core objectives of:

- Network safety
- Network serviceability
- Network sustainability
- Customer service

A.4.1.4 It is important to recognise that risk is not limited to safety-related matters. Risks may affect any aspect of service delivery, the achievement of organisational objectives, or the fulfilment of statutory duties and local priorities.

A.4.1.5 An effective risk-based approach considers risks at multiple levels:

- Assets, the routes that they support, and the network as a whole
- The requirements and perspectives of all users of the highway network
- Organisational factors that impact on the ability to manage the network
- External influences on the organisation, the service it needs to provide, and its ability to deliver.

A.4.1.6 Risks may change over time as network use, travel behaviour, vehicle technology, climate conditions and both national and local priorities evolve.

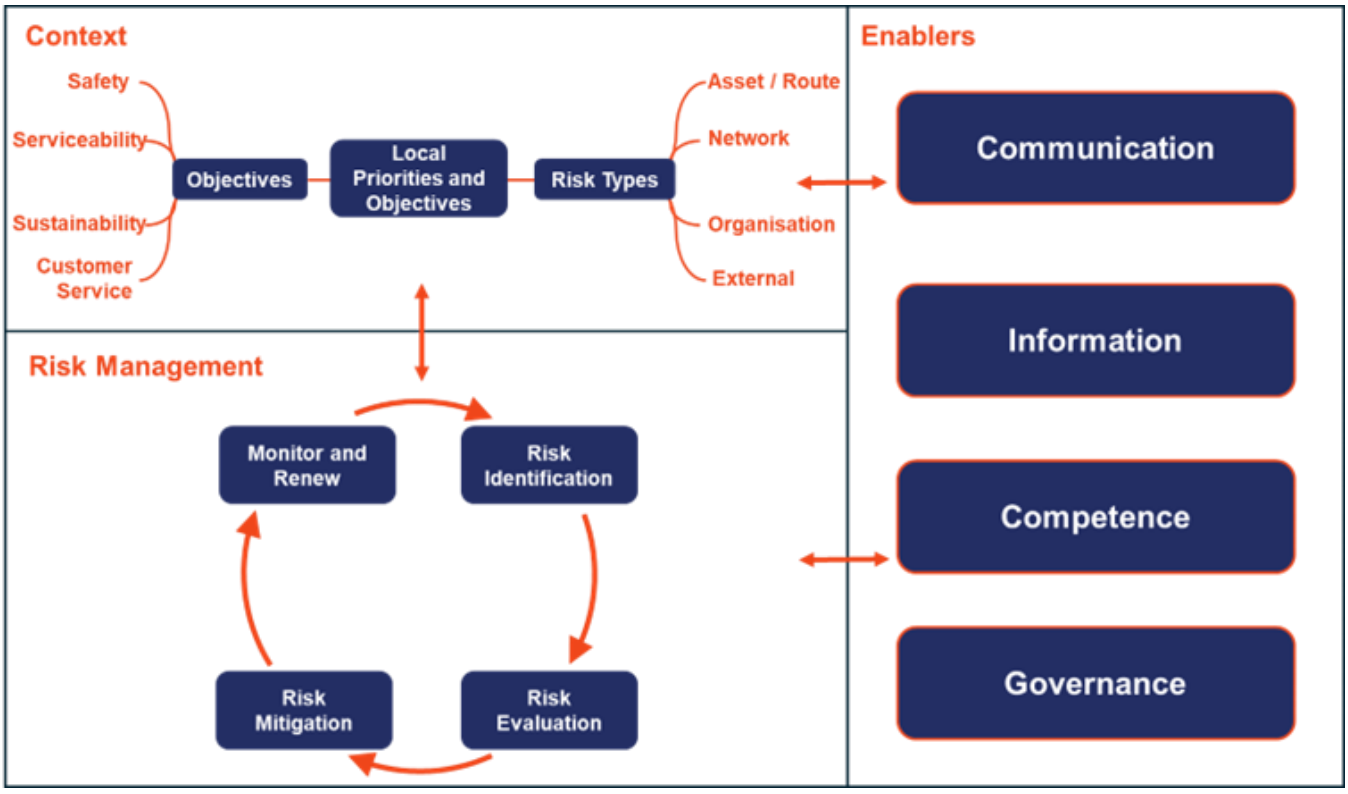


Figure 7 – Risk-based approach framework

A.4.2 THE BENEFITS OF A RISK-BASED APPROACH

A.4.2.1 A risk-based approach supports objective, transparent and appropriate prioritisation of resources and interventions. Key benefits include:

- A more intelligent allocation of effort to where there is greatest value
- Defensible decisions on priorities and levels of service
- Better understanding of current and emerging risk exposure
- Visibility of how controls, including inspections, maintenance, data and interventions reduce risk
- Insight into how risk exposure changes under different funding and investment scenarios
- Better understanding of risks and impacts on safety, service provision, sustainability, resilience and user experience
- Clarity regarding cost of action against cost of inaction
- Stronger business cases and enhanced accountability
- Support for the discharge of statutory responsibilities
- Improved ability to respond to changing demand, including active travel, public transport, freight, electric vehicles, changing demographics and climate-related impacts

A.4.3 ELEMENTS OF A RISK-BASED APPROACH

A.4.3.1 The following table describes common elements of an effective risk-based approach:

Table 6: Elements of an effective risk-based approach

Strategic alignment	The approach should clearly link to the Core Objectives and local priorities, reflecting the authority's overall risk appetite – the level of risk it is willing to tolerate in pursuit of its objectives. Risk appetite is influenced by the authority's statutory duties, available resources, corporate priorities and wider organisational objectives.
Understanding of risks and impacts	Relevant risks should be considered and evaluated at the appropriate level, taking account of the quality, completeness and limitations of available information. Authorities should consider how risks may affect different users of the highway network in different ways. This may take account of factors such as safety, accessibility, equality of access, network availability, reliability, user experience and the specific needs and vulnerabilities of particular user groups. Consideration should also be given to the wider implications of risks for service delivery, resilience, sustainability, reputation, finance and the achievement of organisational objectives.
Implementation of controls or other treatments	Appropriate controls or other treatments should be identified to manage risks. Clear ownership of risks and controls helps support effective risk management, including within partnerships.
Continual improvement	Monitoring risk exposure and the effectiveness of controls, together with actual outcomes, can help authorities identify and understand changing risk profiles. Where incidents, claims, complaints or other new information suggest that risk exposure may have changed, authorities should consider whether reassessment of existing risk evaluations, controls or responses is required. Findings should lead to proportionate corrective action and wider learning where required.

A.4.3.2 Effective risk management depends on the availability and use of relevant information. Risk-based decision-making may draw on information from a wide range of sources such as asset registers, inspection records, condition data, maintenance histories, incident reports, complaints and claims. An authority's information systems and records can support identification of changes in risk exposure, planning and decision-making.

A.4.3.3 Roles and responsibilities for identifying, evaluating and managing risks and controls should be defined, communicated and understood at all levels, including within partnership arrangements.

A.4.3.4 Regular monitoring and review of the approach can help to ensure it remains fit for purpose. Reviews may consider network changes or emerging challenges that may affect delivery of the Core Objectives or other organisational goals.

RECOMMENDATION 11 – DEVELOPMENT OF THE RISK-BASED APPROACH
Authorities should develop their risk-based approach using appropriate technical, operational, legal, financial, customer and stakeholder inputs.

A.4.4 RISK MANAGEMENT

A.4.4.1 A risk-management process will commonly involve stages such as those illustrated below, which are aligned with ISO 31000. The precise process, level of documentation and arrangements adopted should be proportionate to the nature and significance of the risks being managed:

Table 7: Stages of an effective risk-management process

Stage 1: Identify risks	Identify relevant risks that may impact the authority's objectives, including asset, route, network, organisational and external risks. Risk identification may include consideration of challenges or impacts to each of the Core Objectives and any further goals the organisation has established.
Stage 2: Evaluate risks	Evaluate likelihood, consequence, proximity and impact. Assign ownership at the appropriate level.
Stage 3: Manage risks	Determine appropriate treatments which may include the use of control measures to reduce the likelihood or impact of the risk. Understand residual risks and determine how they will be managed and recorded. Clear ownership of control measures, at an appropriate level, helps support implementation.
Stage 4: Monitor and review	Monitor risks, controls, residual risk and outcomes using current operational information. Assess and respond proportionately to newly identified risks, incidents, collisions, near misses, claims, complaints, trends and evidence of control failure. Where new information indicates that the nature or level of risk may have materially changed, authorities should consider whether reassessment is required. Take corrective action, apply interim controls where necessary, maintain appropriate records and feed lessons learned back into the risk-based approach. Assess the effectiveness of the approach and take further corrective action where appropriate.
All stages: Communication	Engage internally (across authority functions) and externally (stakeholders and public, to include all user groups).

A.4.4.2 Risk-based frameworks are a tool to help authorities make consistent, transparent and defensible decisions. They should not be used mechanistically or in isolation. Authorities should develop and apply local criteria that reflect their network, statutory duties, risk appetite, levels of service, available evidence, local priorities and the needs of different users of the highway network.

A.4.4.3 Authorities may make use of a risk register, or equivalent system, to support the process of risk management, reporting and escalation where appropriate. A risk register, or equivalent, typically records key risks and associated attributes such as controls, ownership, review dates and residual risk.

A.4.4.4 The following table gives an example of how risks could be evaluated. This is illustrative only, and authorities should establish locally appropriate risk criteria and responses; a risk rating does not of itself prescribe the action required:

Table 8: Example risk rating framework

Risk Rating	Definition	Possible response
Low	Acceptable	Monitor
Medium	Tolerable with controls	Planned mitigation
High	Significant risk requiring consideration	Prioritised intervention
Very High	Significant exposure	Prompt consideration of further controls
Extreme	Exceptional exposure	Immediate action

A.4.4.5 Approaches to risk treatment may include:

- **Avoidance**: Remove the source of risk where feasible.
- **Reduction**: Implement inspections, maintenance or other controls to reduce likelihood or impact.
- **Transfer**: Use contractual or insurance arrangements to transfer risk.
- **Acceptance**: Accept residual risk within risk appetite.

A.4.4.6 When prioritising asset risks and interventions, authorities should consider both the likelihood of an event occurring and the range of possible consequences. Consequences may vary significantly depending on factors such as location, duration, exposure, route function, availability of alternatives and the characteristics and needs of affected users. Consequences evaluated may include impacts on the Core Objectives and any other organisational goals.

A.4.4.7 Different users may experience significantly different consequences from the same defect, hazard or service disruption. Risk assessments should therefore take account of the circumstances, vulnerabilities and likely consequences for all of the user groups affected.

A.4.4.8 Additional guidance on risk management is provided in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C.

A.4.4.9 Specific technical guidance on the management of asset-specific risks is provided in Parts B, C, D and E.

A.4.4.10 Further guidance on risk appetite and risk tolerance can be found through the Institute of Risk Management (IRM), while specific guidance on the application of risk-based approaches in the highways sector, including claims and liability considerations, can be found through the Institute of Highway Engineers (IHE) guidance document Well Managed Highway Liability Risk.

RECOMMENDATION 12 – RISK MANAGEMENT
Authorities should use a documented and evidence-based risk management process to support infrastructure management decisions and prioritisation.

A.4.5 RANGE OF RISKS AND IMPACTS TO BE CONSIDERED

A.4.5.1 Risks should be considered at the strategic, tactical and operational level and may cover safety, service continuity, resilience, legal compliance, finance, data, suppliers, reputation, public confidence and the ability to deliver the authority's objectives. Authorities may use a consistent local framework for categorising and evaluating risks.

A.4.5.2 Authorities should consider how asset risks may affect different users of the highway network in different ways.

A.4.5.3 Authorities should consider not only current use but reasonably foreseeable changes in use or demand. This is particularly important where highway assets have long service lives, and where investment decisions may influence future risk exposure.

A.4.5.4 Examples of risks, impacts and potential control measures are included in the following Table 9. These examples are illustrative and are neither exhaustive nor intended to prescribe particular controls or levels of service.

Table 9: Risks, impacts and potential control measures

Example Risks and Controls			Example Impacts			
Type of Risk	**Example Risks**	**Example Control(s)**	**Safety Impact**	**Serviceability**	**Sustainability**	**Customer**
Asset / Route Risks *Risks affecting individual highway assets or specific routes*	Pavement deterioration (potholes, rutting)	Asset inspections and condition surveys, reactive maintenance, preventative maintenance	Fatality, personal injury accident	Reduced ride quality, speed restrictions, vehicle damage	Higher whole-life cost repair if untreated Reduced network resilience Reduced use of sustainable modes (active travel, public transport)	Disruption, delays, complaints Compensation claims Community severance Economic impacts
	Structures deterioration (corrosion, fatigue)	Asset inspections and condition surveys, reactive maintenance, planned maintenance	Risk of structural failure or falling debris	Weight restrictions, closures	Higher whole-life cost repair if untreated Reduced network resilience	Disruption, delays Community severance Economic impact
	Street lighting outages	Night scouting, routine maintenance	Reduced visibility at night	Reduced network serviceability	Reduced energy efficiency	Perceived increase in crime due to reduced lighting Reluctance to travel at night
	Defects affecting vulnerable users	Asset inspections and condition surveys, reactive maintenance, planned maintenance. Investigatory levels that consider	Risk of loss of control or fall	Reduced user comfort and confidence	Reduced uptake of alternative/active travel modes	Increased claims, complaints and reputational damage, poorer user experience and reduced accessibility/inclusivity

Example Risks and Controls			Example Impacts			
Type of Risk	**Example Risks**	**Example Control(s)**	**Safety Impact**	**Serviceability**	**Sustainability**	**Customer**
		location and user exposure				
	Drainage system failure	Cyclical gully cleansing	Flooding and surface water leading to accidents	Lane closures leading to delays Reduced network capacity Consequent damage to other highway assets	Water pollution, higher whole-life cost repair if untreated Reduced network resilience Reduced use of sustainable modes Damage to trees and green estate	Disruption, delays Damage to property
Network Risks *Risks affecting performance or resilience of the wider highway network*	Simultaneous works causing network disruption	Network management, street works co-ordination. collaborative planning	Increased collision risk	Delays	Increased air pollution Reduced asset life due to excessive interventions	Complaints Reputational damage
	Failure of ITS systems (signals, VMS, CCTV)	Redundancy systems, cybersecurity controls	Delayed incident detection	Reduced traffic flow efficiency	Increased air pollution	Reduced travel information quality Economic impact
	Changing vehicle types and demand	Monitoring of traffic and user data, forward-looking asset strategies, review of design and maintenance assumptions,	Conflicts between users	Accelerated asset deterioration	Increased maintenance demand, carbon and air quality impacts	Changed risk exposure, reduced user satisfaction.

Example Risks and Controls			Example Impacts			
Type of Risk	**Example Risks**	**Example Control(s)**	**Safety Impact**	**Serviceability**	**Sustainability**	**Customer**
	Inadequate resilience to extreme weather	Resilient / Winter Network definition and management plans	Increased accident risk	Network closures	Higher whole-life cost of repair due to asset deterioration Reduced use of sustainable modes	Community severance Economic impact
Organisational Risks *Risks internal to the highway authority or managing organisation*	Funding shortfalls	Long-term funding settlements, risk-based prioritisation, alternative funding models	Deferred maintenance	Reduced network condition leading to delays	Asset backlog growth Unable to implement sustainable solutions	Reduced service quality
	Skills shortages in workforce	Apprenticeships, CPD programmes, increased supervision	Poor quality works	Reduced service delivery	Rework / waste Sub-optimal long-term decision making	Reduced service quality
	Inadequate asset data quality	Digital asset management systems, regular data audits	Missed critical defects	Inefficient maintenance planning	Sub-optimal longer-term solutions Unable to implement sustainable solutions	Reduced service quality
	Poor contractor performance	Robust contract management, KPIs, audits	Poor quality works	Reduced network condition leading to delays	Rework / waste Increased costs	Reduced service quality Reputational damage
External Risks *Risks largely outside direct*	Extreme weather (flooding, heatwaves, storms)	Asset upgrades, cyclic maintenance activities,	Collision risk, infrastructure collapse	Road closures leading to delays	Water pollution	Disruption, delays Damage to property

Example Risks and Controls			Example Impacts			
Type of Risk	**Example Risks**	**Example Control(s)**	**Safety Impact**	**Serviceability**	**Sustainability**	**Customer**
organisational control		emergency preparedness			Higher whole-life cost of repair due to asset deterioration	Community severance Economic impact
	Legislative or policy changes	Policy monitoring, adaptive strategy	Compliance gaps	Operational disruption	Cost of change	Changes in service
	Supply chain disruption	Framework agreements, supplier diversification	Delayed repairs	Operational disruption Reduced material quality	Rework / waste	Reduced service quality Reputational damage

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A.4.5.5 The proximity and timing of risks and impacts should also be considered, including seasonal and event-based risks and any trends or patterns in the frequency of risk events.

A.4.5.6 Risks may also cascade or be compounded, so that one risk may create further or subsequent risks.

A.4.6 GOVERNANCE

A.4.6.1 A structured risk-based approach covers the following elements:

- Development – the risk-based approach should be developed by competent individuals with appropriate skills, experience and/or qualifications. Communication of the approach in a way that is accessible to non-technical stakeholders, with trade-offs between risk, cost and service outcomes transparently presented, can support informed decision-making across the authority.
- Approval – the approach should then be reviewed and approved by individuals with appropriate authority. Significant residual risks should be understood, acknowledged and managed within the authority's governance arrangements.
- Delivery – implementation should be carried out by competent practitioners and align with the approved strategy and methodology. Sufficient records should be maintained to support decision-making, accountability and review. Establishing agreed escalation procedures can assist where concerns or potential changes are identified.
- Monitoring, Review and Continuous Improvement – monitoring and review provide a means of assessing the effectiveness of the risk-based approach and incorporating lessons learned from its application and delivery. Periodic reviews help to confirm that the approach remains appropriate to the organisation and the network it manages. Review may also be prompted by significant internal or external change, such as changes in the risk profile or use of the highway, organisational restructuring, changes in political leadership, funding levels or other constraints, and evolving corporate priorities or risk appetite. Where review identifies a need for change, the risk-based approach can be further developed and implemented through the preceding stages of the process.

A.4.6.2 Roles, responsibilities and levels of authority should be clearly defined and cover not only highways practitioners but also corporate risk management, financial oversight, executive decision-making, and legal and insurance functions.

A.4.6.3 Highway infrastructure should be appropriately considered within corporate governance and risk management arrangements, including the corporate risk register where appropriate. Consideration should be given not only to direct impacts on highway services, but also to potential legal, financial and reputational consequences and the effect that highway-related risks may have on the delivery of wider organisational objectives, e.g. economic growth, public health, resilience, community wellbeing etc.

RECOMMENDATION 13 – RISK GOVERNANCE
Authorities should establish clear governance, ownership and accountability arrangements for the development and application of their risk-based approach.

RECOMMENDATION 14 – ASSURANCE AND COMPLIANCE
Authorities should review and assure the application of their risk-based approach at intervals that capture governance cycles, material changes to risk, changing technologies and changing user behaviours, and be able to demonstrate that decisions are consistent with their adopted policies and processes.

A.4.7 INFORMATION NEEDS

A.4.7.1 Good quality information is essential to inform a risk-based approach. Key categories may include:

Table 10: Example information needs for effective risk management

Asset and condition data	• Asset records • Inspection and survey data • Condition trends and deterioration rates
Operational and maintenance data	• Collision, injury incident and near-miss records • Claims, complaints and notifications of potential hazards • Contractor performance information • Defect records and response times • Maintenance records • Records of utility works • Traffic information and user-exposure information • Records of investigations, interim controls, escalation and lessons learned
Corporate and financial data	• Statutory and legal obligations • Corporate priorities • Budget information • Resources and workforce information • Planned network development and future demand
External and environmental data	• Flooding incidents • Weather records • Climate projections • Land-use change and development growth • Freight, logistics and electric vehicle infrastructure trends • Demographic change and accessibility needs
Customer and stakeholder data	• Third party claims • Customer complaints • Customer surveys • Consultation feedback • Feedback from user-group and stakeholder representatives

A.4.7.2 Authorities should understand the quality, completeness and limitations of the information used to support risk-based decisions. Consideration should be given to data quality, confidence levels, known gaps and uncertainties when evaluating risks and determining appropriate actions.

A.4.7.3 The level of detail should be proportionate and focused on what is necessary to support effective, defensible risk-based decisions. Information should be actively managed, which may include defining responsibilities and timescales for review, criteria for escalation, and determining the need for further investigation or action, as appropriate, where the information indicates a material change in risk or potential liability.

A.4.7.4 Inspection and survey regimes should reflect a risk-based approach. Asset-specific survey and inspections are addressed in Parts B, C, D and E.

A.4.7.5 Information systems can support analysis, transparency, monitoring and legal defensibility, and may enable relevant information to be routed promptly to those with authority to investigate, escalate and respond. Use of systems to link incidents, claims, complaints, defects and control failures with assets, locations, routes and user groups can help to identify patterns and emerging issues. A security-minded approach should be adopted for sensitive and personal data in accordance with data protection legislation.

A.4.7.6 Authorities should consider how emerging technologies and digital systems may influence risk exposure, decision-making processes and service delivery. The use of such technologies should be supported by appropriate governance, assurance, competence and accountability arrangements.

A.4.8 COMPETENCE

A.4.8.1 Competence is essential to ensure that risk-based decisions are consistent, defensible and aligned with statutory duties.

A.4.8.2 Authorities should ensure that staff and contractors are competent for their roles. Those involved in risk-based decision-making may require knowledge of legal duties, technical standards, corporate risk frameworks and relevant information. Periodic review of training needs helps maintain knowledge as current and relevant.

A.4.8.3 It is not expected that a single individual needs to be competent in all aspects required to develop and deliver a risk-based approach within a highway authority. Instead, the process benefits from bringing together different roles with different skills and knowledge, for example input from corporate functions and the authority's insurers complements the understanding from the highways team of the infrastructure itself and the service it provides.

A.4.9 COMMUNICATION

A.4.9.1 Effective two-way communication and stakeholder feedback can inform risk-based decisions. Stakeholders include residents, businesses, elected members, neighbouring authorities, supply-chain partners, utilities, transport bodies and emergency services.

A.4.9.2 Authorities should be able to explain clearly how risks are identified, evaluated and managed. They should also be able to explain how different impacts, including safety, serviceability, sustainability and user experience, have been considered in reaching decisions.

SECTION A.5 NETWORK KNOWLEDGE

A.5.1 OVERVIEW

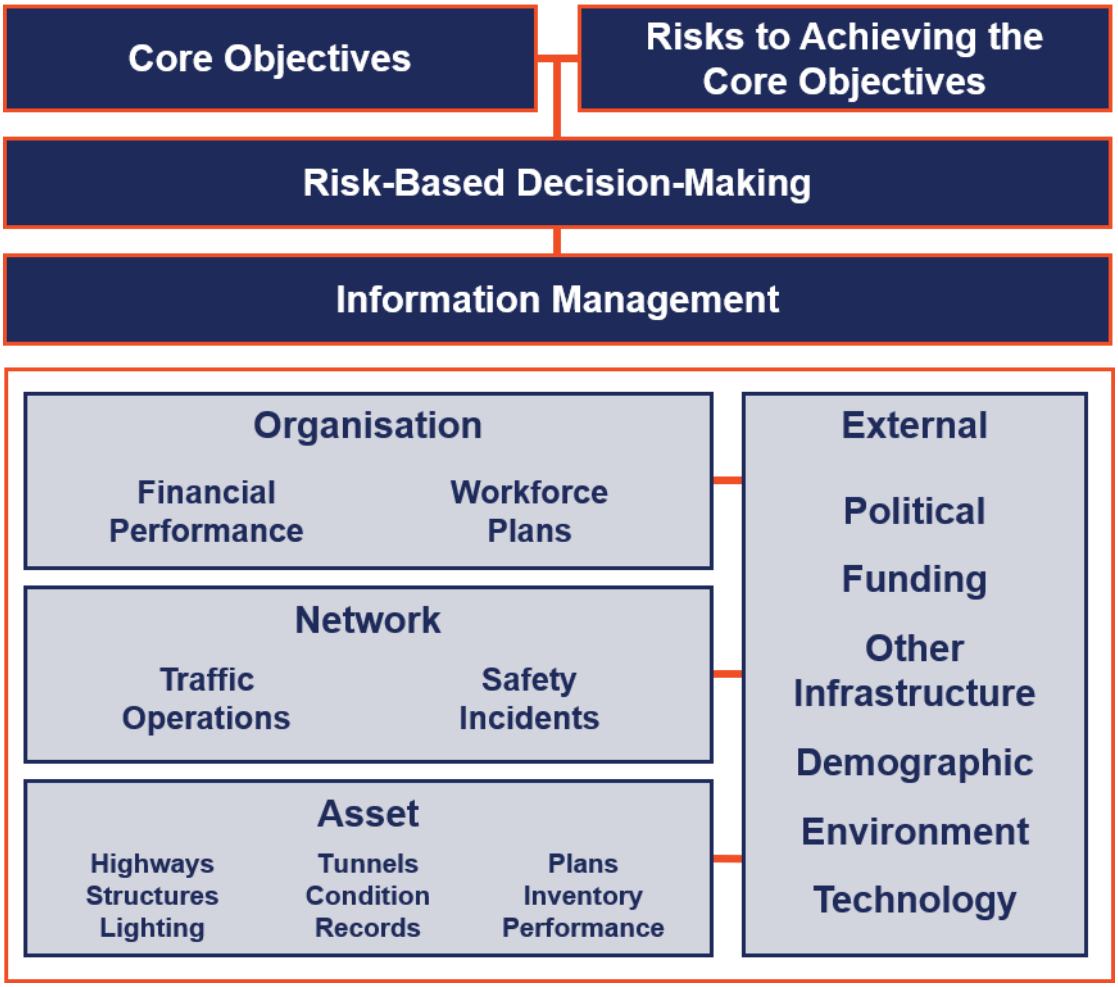


Figure 8 – Network Knowledge

A.5.2 APPROACH TO INFORMATION AND KNOWLEDGE

A.5.2.1 Network knowledge extends beyond data on assets. It includes understanding how the network performs as a whole, organisational issues across the authority, and external factors that influence risks both now and in the future.

A.5.2.2 Authorities should ensure that they have sufficient and appropriate information to support risk-based decision making, centred on achieving the core objectives of safety, serviceability, sustainability and customer service.

A.5.2.3 Prioritisation of essential information against these objectives and associated risks helps ensure that the cost of data collection remains proportionate while still supporting sound decisions.

A.5.2.4 Authorities should periodically review their information needs to reflect changes in terms of infrastructure, authority context and external factors, and the resulting impact this has on risks.

A.5.2.5 Effective asset knowledge is not static and requires continued investment to maintain the accuracy, completeness and reliability of asset information over time.

RECOMMENDATION 15 – INFORMATION REQUIREMENTS
Authorities should understand the information required to support a risk-based approach, decision-making, planning and delivery, and the achievement of organisational objectives.

A.5.3 INFORMATION MANAGEMENT

A.5.3.1 Information is fundamental to the development of infrastructure management policy and to the ability to communicate effectively with stakeholders. Effective and sustainable management of that information, which is likely to arise from many sources, and the distribution of that information to stakeholders and network users is crucial.

A.5.3.2 Authorities should maintain effective arrangements for the collection, storage, maintenance, assurance and use of information. Information should be accurate, current and complete to the extent needed for risk-based decision-making. Systems and processes should support accessibility, security and appropriate sharing across functions. Responsibilities for information stewardship should be clearly defined, ensuring that information is managed throughout its lifecycle and remains usable for analysis and decision-making.

A.5.3.3 The effective management of information relies on the availability of appropriate data. Authorities should seek to ensure that data is collected, maintained and governed in a way that enables reliable information and knowledge to be generated, shared and used to support highway infrastructure management.

A.5.3.4 Records of construction and maintenance treatments should be kept informing lifecycle plans. Information on mobile electronic devices used by practitioners in the field can support their decision making and reporting of asset condition and defects in real time.

A.5.3.5 Bringing together information from a range of sources can help build a coherent understanding of risks, performance and future needs. Integration requires authorities to identify relationships between datasets, interpret conflicting evidence and apply sound judgement when information is incomplete or uncertain.

A.5.3.6 Structured methods such as trend analysis, modelling, dashboards and forecasting can support decision-making, along with effective knowledge sharing across asset management, operations, planning, finance and delivery functions.

A.5.3.7 Authorities should understand and communicate the limitations, assumptions and uncertainties associated with the information used to support decision-making. This may include consideration of incomplete data, unknown asset condition, survey coverage and confidence in performance information, together with the implications these may have for risk assessment and investment decisions.

A.5.3.8 Authorities should be aware of the need to identify and protect information which could impact on the safety and security of individuals, sensitive assets and systems and the benefits which the sensitive asset or system exist to deliver, through the adoption of a security-minded approach to the handling and management of data and information.

A.5.3.9 From time to time, governments may require specific information to be reported, either to themselves or publicly, e.g., on authorities' websites, and authorities' information systems should facilitate this.

A.5.3.10 The Building Information Modelling (BIM) approach, sometimes known as Better Information Management, involves supply chain collaboration in the creation and use of intelligent three-dimensional models and accompanying data and information to drive efficiency, aid communication and facilitate better management of assets over their lifecycle. The Department for Transport and UKRLG have produced BIM Guidance for Infrastructure Bodies.

A.5.3.11 The British Standards Institution has published a series of Standards: BS 1192:2007, PAS 1192-2:2013, PAS 1192-3:2014, BS 1192-4:2014, PAS 1192-5:2015 and BS 8536-1:2015.

A.5.3.12 PIARC has produced guidance on Road Related Data and How to Use it, which provides examples of different organisational approaches to data from international road administrations, alongside examples of specific applications of data-led solutions.

A.5.3.13 Authorities should seek to continually improve the quality, coverage, accessibility and usefulness of information used to support highway infrastructure management. This may include improving data quality and governance, enhancing integration between systems and datasets, adopting common standards where appropriate, and learning from good practice and innovation across the sector. Improvements should be prioritised on the basis of business need, risk, value and available resources.

RECOMMENDATION 16 – INFORMATION MANAGEMENT
Authorities should establish and maintain arrangements for the effective collection, storage, update, management, protection, quality assurance, governance and use of information for a risk-based approach, decision-making, planning and delivery.

A.5.4 MANAGEMENT SYSTEMS, RECORDING AND MONITORING

A.5.4.1 Managing the safety and wide range of other risks associated with the delivery of highway infrastructure maintenance will require effective and co-ordinated information systems. Record systems should include all user contact information, records of inspection and condition and records of all maintenance activity. They should also be co-ordinated with other relevant record systems, for example road safety database.

A.5.4.2 The efficiency, accuracy and quality of information and records maintained by authorities will be crucial both to the effective management of the service and to the defence of claims against the authority for alleged failure to maintain. The management system should support compliance with standards of evidence provision.

A.5.4.3 Where information systems hold sensitive and/or personally identifiable information, a security minded approach, appropriate to the level of risk, should be adopted in relation to the capture, creation, processing, storage, distribution and use of relevant data and information in accordance with the Data Protection Act 2018.

A.5.4.4 All information obtained from inspections and surveys, together with the nature of response, including nil returns, should be recorded consistently to facilitate analysis. Such analysis should enable the data from inspections and surveys to be reviewed independently, but also in

conjunction with other information to enable a holistic view to be taken of likely future maintenance need, asset condition and trends related to network characteristics and use.

RECOMMENDATION 17 - MANAGEMENT SYSTEMS AND CLAIMS
Authorities should maintain records and evidence capable of supporting effective governance, performance management and the defence of claims where appropriate.

A.5.5 ASSET KNOWLEDGE

ASSET DATA

A.5.5.1 Asset data is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance, Part B. This document should be referred to and the advice below considered supplementary.

A.5.5.2 Authorities should maintain an understanding of the extent, status and characteristics of the highway network. This may include statutory records, such as the List of Streets maintained under Section 36(6) of the Highways Act 1980, or equivalent, together with asset inventories and other supporting records.

A.5.5.3 There is also a requirement to maintain information for the purpose of:

- identifying streets described as traffic sensitive, where work should be avoided at certain times of the day;
- identifying structures and other features described as special engineering difficulty, which need special consideration when work is planned; and
- identifying reinstatement categories used by statutory undertakers in the reinstatement of their street works.

A.5.5.4 Accurate inventory information supports a range of functions, including statutory and national reporting requirements, asset valuation, financial planning, performance monitoring and wider asset management activities.

A.5.5.5 The above requirements can be satisfied with fairly basic information, much less detailed than that required for maintenance management purposes. An appropriately detailed highway inventory or asset register or database is however an essential prerequisite of establishing a cost effective and adequate maintenance regime.

A.5.5.6 Some highway authorities are required to keep the definitive map and statement, or equivalent, for Public Rights of Way (PROW) that forms the legal record of the position and status of PROW. Certain parts of the network could be recorded both on the register of roads and the definitive map. Authorities in Scotland are required to keep records of ‘Core Paths’.

A.5.5.7 Authorities should seek to understand the effectiveness and durability of maintenance interventions over time. Information from inspections, condition surveys, maintenance records, customer reports and other relevant sources can be used to assess whether treatments are achieving expected outcomes and to inform future lifecycle planning, investment decisions and intervention strategies.

ASSET DATA COLLECTION

A.5.5.8 Establishment of an effective regime of inspection, survey and recording is an important component of highway infrastructure management. The characteristics of the regime, including types and frequency of inspection, items to be recorded and nature of response, should be defined following an assessment of the relative risks associated with potential circumstances of location, agreed level of service and condition. These should be set in the context of the authorities' overall asset management strategy.

A.5.5.9 It will also provide the basic condition data for the development of maintenance programmes. All elements of the inspection and survey regime should be applied systematically and consistently. This is particularly important in the case of network safety, where information may be crucial in respect of legal proceedings. It is important to recognise that all information recorded, even if not primarily intended for network safety purposes, may have consequential implications for safety and may therefore be relevant to legal proceedings. It is also important to recognise that records may have to be made available for public inspection and reference.

A.5.5.10 Opportunities for data collection through existing activities, such as by operatives following completion of maintenance activities, can provide efficiencies in terms of time, effort and cost spent on dedicated inspection activities. Also, data collection should be aligned with maintenance strategies, for example there may be limited need for this where particular asset types are to be maintained on a reactive basis.

ASSET MANAGEMENT SYSTEMS

A.5.5.11 Asset management systems are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance; Part C. Additional detail is provided below.

A.5.5.12 An asset register may be used by authorities to record inventories of asset types for which they have liability. This register may in practice be a combination of several asset specific systems and will form the basis of identifying which asset items safety and serviceability inspections should cover.

A.5.5.13 The asset register should also provide for recording service requests, complaints, reports or information from users and other third parties. These may require immediate action, special inspection, or influence future inspection or monitoring arrangements. The nature of response, including nil returns, should also be recorded. All inspections should record as a matter of course: time, weather conditions, any unusual circumstances of the inspection and the person conducting the inspection.

A.5.5.14 Arrangements should be made to review the inspection, assessment and recording regime at intervals to consider:

- changes in network characteristics and use;
- completeness and effectiveness of data collected;
- effectiveness of data analysis; and
- the need for changes to the inspection regime derived from risk assessment.

A.5.5.15 The frequency of such reviews should have regard to the extent and nature of changing circumstances. The analysis will also be helpful for other purposes, however, and these might also influence the frequency of review, which could include the following:

- ensuring compliance with legal obligations;
- measuring network serviceability and condition performance;
- establishing extent of outstanding work;
- seeking continuous improvement; and
- monitoring service delivery arrangements.

RECOMMENDATION 18 - INSPECTIONS AND CONDITION SURVEYS
Authorities should undertake inspections and condition surveys sufficient to understand asset performance, manage risk and support evidence-based decision-making.

A.5.6 NETWORK PERFORMANCE KNOWLEDGE

A.5.6.1 Authorities should maintain a clear understanding of how the network is performing in day-to-day operation and over time. This can support monitoring of core objectives whilst identifying trends and changes and thus inform review of the authority's risk-based approach.

A.5.6.2 Datasets that support an understanding of network performance are likely to exist within authorities, although they may not be readily visible or accessible to all practitioners. Engagement across the authority can help identify and access these datasets before any new data collection or acquisition activities are initiated, particularly where additional costs may be incurred.

A.5.6.3 Authorities should maintain an understanding of how highway infrastructure management contributes to the delivery of service outcomes. This should draw on a range of information, which may include asset condition, network performance, operational delivery, customer insight, sustainability, cost and efficiency information, as appropriate to local circumstances and business needs.

CORE OBJECTIVES

A.5.6.4 Authorities should have access to suitable datasets related to the core objectives of safety, serviceability, sustainability and customer service. Further information on potential data for each of these objectives is provided in Section A.3.

A.5.6.5 Performance information provides insight not only into the condition and performance of highway assets, but also into how effectively the service supports safety, reliability, accessibility, resilience, customer experience, value for money and wider organisational objectives.

NETWORK USAGE

A.5.6.6 Information on traffic flows, speeds, congestion, journey times, routeing patterns and freight movements can provide insight into how the network is used and how effectively it operates, which supports operational decisions and investment planning.

A.5.6.7 Changes in traffic type and traffic behaviours can influence network performance, maintenance needs and investment priorities. For example, changing consumer patterns may lead to

corresponding changes in LGV and HGV movements on the network, which may prompt review of network hierarchies. Also, transitions to electric vehicles, particularly buses and freight, may create increased loading on carriageways and result in increased levels of deterioration that need to be reflected in maintenance strategies.

A.5.6.8 Authorities may use information on incidents, events and planned works that affect the network and use this knowledge to optimise network availability.

EMERGENCY AND INCIDENT KNOWLEDGE

A.5.6.9 Information on incidents and hazard events that affect network operation or safety can contribute to understanding network performance, resilience and risk. This includes extreme weather events, flooding, drainage failures, geotechnical incidents, winter service activities and major operational disruptions.

A.5.6.10 Information on claims, liability trends, business continuity issues, disruption data, response records, recovery costs, asset performance and customer impacts can also contribute to the authority's knowledge base. This helps identify vulnerabilities, understand system behaviour under stress, inform risk assessment, and improve resilience planning and organisational preparedness.

RECOMMENDATION 19 - SERVICE PERFORMANCE AND BENCHMARKING
Authorities should monitor, review and benchmark whole-service performance, using evidence from asset, operational, financial and customer outcomes to support continuous improvement.

A.5.7 ORGANISATIONAL KNOWLEDGE

ASSET MANAGEMENT PERFORMANCE

A.5.7.1 Performance management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Parts B and C. Performance management provides an understanding of how effectively asset management activities contribute to the delivery of organisational objectives, levels of service and desired outcomes, rather than focusing solely on the condition or performance of assets.

A.5.7.2 As part of their asset management strategy, authorities should establish a performance management framework, including performance measures and targets, to enable monitoring of delivery of the strategy and of performance, and to identify the cost of meeting the strategy in the short, medium and long term.

A.5.7.3 An effective framework provides a clear and data-driven link between strategy and core objectives, associated risks, decision-making and planning, operational delivery, and the outcomes and value delivered by the service.

A.5.7.4 Performance measures should be proportionate, clearly defined and transparent, and aligned to local objectives and priorities.

A.5.7.5 Performance information can be used to identify underperformance and emerging risks, inform improvement planning and investment strategies, support innovation and efficiency, recognise and acknowledge strong performance, and improve long-term asset management outcomes.

A.5.7.6 Performance management can also support an integrated understanding of how highway infrastructure management contributes to the delivery of service outcomes. Performance measures can reflect the relationship between strategy, investment, asset condition, operational delivery, customer experience and desired outcomes.

A.5.7.7 Performance measures may include information relating to asset condition, service performance, network availability, operational effectiveness, safety and risk, sustainability, customer experience, financial performance, efficiency and value for money, as appropriate to local circumstances and objectives.

A.5.7.8 A continuous feedback loop can help ensure that evidence from service delivery, customer insight, operational performance and other sources informs future strategy, levels of service, investment planning and improvement activity.

A.5.7.9 Benchmarking and comparative performance information can support continuous improvement, transparency and evidence-based decision-making. Benchmarking may include consideration of asset performance, service performance, customer insight, operational effectiveness, cost, efficiency and outcomes, taking account of differences in local context.

A.5.7.10 Benchmarking and comparative performance information can assist with the identification of strengths, areas for improvement, emerging risks and opportunities for shared learning across the sector.

CAPABILITY, CAPACITY AND COMPETENCE

A.5.7.11 Authorities should understand their capability to manage and operate the network effectively. This includes resources, skills and experience both within the authority and across supply chain partners. Workforce Capability and Competencies are covered in more detail in Section A.3.19.

A.5.7.12 Authorities should identify the competencies required for staff and delivery partners involved in preparedness, response and recovery from hazard events. This should include understanding of hazard impacts, triggers and thresholds, structured impact assessment, decision-making under uncertainty, escalation, communication, workforce safety and recovery learning.

A.5.7.13 Training and exercising should include both directly employed staff and contractors who may be required to support operational response. Significant events and exercises may provide opportunities to review competence requirements.

A.5.7.14 Authorities should recognise the value of local knowledge and experience held by practitioners, inspectors, managers and other stakeholders who understand how the network operates, how assets perform and deteriorate, and how risks manifest in local circumstances. This knowledge can provide important context for the interpretation of data, the identification of emerging issues and the selection of appropriate interventions. Mechanisms to capture, retain and share such knowledge can be valuable, particularly when experienced staff leave, retire or change roles.

A.5.7.15 Retention of this knowledge, together with other critical organisational knowledge, supports continuity during organisational change, staff turnover or emergency situations. Effective documentation, handover processes and information-sharing practices can support this.

A.5.7.16 Understanding of supply chain capacity, capability, resilience and performance can inform procurement, contract management and risk assessment. Procurement and delivery are covered in more detail in Section A.9.

WIDER AUTHORITY FACTORS

A.5.7.17 Teams responsible for the management of highways infrastructure should be aware of policies, plans and activities that are being undertaken across relevant parts of the authority, for example where transport planning is undertaken as a separate function.

A.5.7.18 More broadly within authorities, understanding strategic direction such as changes in political leadership, priorities, policies and plans, or changes in corporate finances, will help to inform the refinement of the asset management approach.

A.5.8 EXTERNAL CONTEXT KNOWLEDGE

A.5.8.1 Awareness of evolving national policies, legislation, standards and funding arrangements can help authorities anticipate future requirements, and minimise impacts of such changes on funding, operations or other activities.

A.5.8.2 Wider economic trends, behavioural shifts in travel and changes in local or national demand may influence future service levels or investment priorities.

A.5.8.3 Highway networks interact with utilities, public transport, telecommunications and freight systems. Awareness of these interdependencies can support risk management and coordinated planning.

A.5.8.4 Changes in land use and economic activity influence patterns of travel, pressure on assets and future investment needs. Knowledge of local development plans, housing growth areas, regeneration schemes, employment clusters and logistics hubs can help ensure that asset management plans reflect emerging demands.

A.5.8.5 Information on population change, demographic trends and the distribution of key services provides insight into current and future use of the network. Authorities may also consider the needs of vulnerable road users, school communities and those accessing healthcare and transport hubs.

A.5.8.6 Environmental factors such as drainage catchments, flood risk, land stability, coastal influences, air quality management areas and protected natural assets can all affect the performance and management of the network. Knowledge of environmental constraints and appropriate liaison with relevant bodies can support effective network management.

A.5.8.7 Long-term climate projections and environmental assessments help authorities prepare for changes in weather patterns, asset deterioration and risk exposure. This information can support risk-based decision making and resilience planning.

A.5.8.8 Digital technologies, automation, data systems and new operational tools may change how networks are used and managed. These developments can influence operations, maintenance and customer expectations.

SECTION A.6 RESILIENCE AND ADAPTATION

A.6.1 OVERVIEW

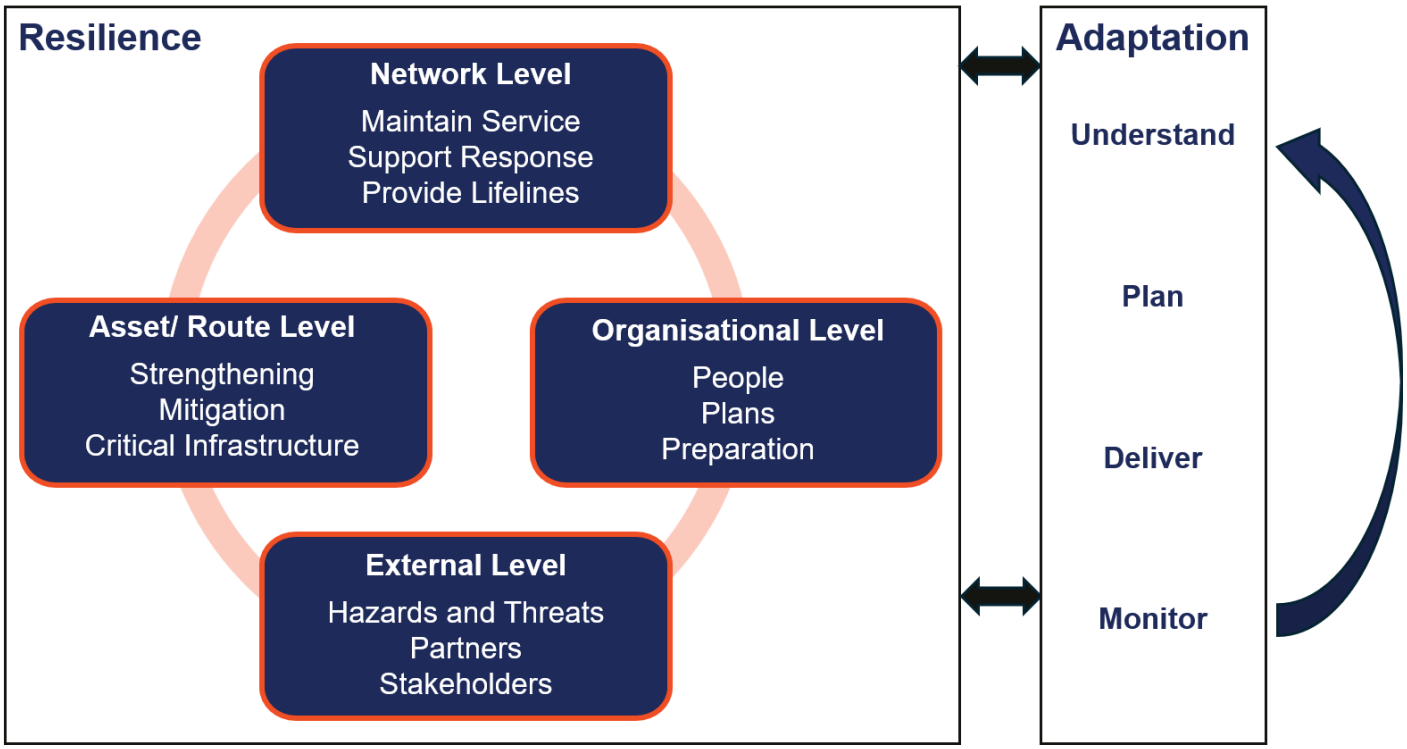


Figure 9 – Resilience and Adaptation

A.6.1.1 The UK's road network is an important part of our national infrastructure, enabling the successful operation of many social and economic activities and the continued availability and operation of these routes is a vital part of keeping our towns, cities and regions running.

A.6.1.2 Resilience is defined by the UK Government Resilience Framework and Action Plan as "the ability to anticipate, assess, prevent, mitigate, respond to, and recover from natural hazards, deliberate attacks, geopolitical instability, disease outbreaks, and other disruptive events, civil emergencies or threats to our way of life", which reflects the Code's all-hazards approach to highway management. There are six components to resilience and highway authorities are likely to draw on a combination of these in reducing risk of failure, especially on their Resilient Networks:

- Resistance / robustness – preventing damage to design standards (e.g., a flood wall);
- Reliability – operation under a range of conditions (e.g., effective fleet maintenance);
- Redundancy – availability of backups or spare capacity (e.g., a suitable diversion route);
- Resourcefulness – the ability to apply material (e.g., monetary, physical, technological, and informational) and human resources to meet established priorities and achieve goals;
- Rapidity – meet priorities and achieve goals in a timely manner, enabling a fast response and recovery (e.g., temporary bridging)
- Recovery – Reinstating, rebuilding and adapting in ways that do not reproduce vulnerabilities

A.6.1.3 This approach fits well with the guidance given in this Code and provides an overview of what an all-hazards approach to network resilience should aim to deliver.

A.6.1.4 The National Security Risk Assessment (NSRA) informs risk assessment in the UK. The National Risk Register (NRR), published biennially, is the NSRA's public-facing variant, with Community Risk Registers produced by all Local Resilience Forums representing the applied local interpretation of those assessments. Together these documents help frame the significant risks that may manifest on a two-to-five-year timescale. Interaction between highway authorities, their emergency planning teams and all contractor, supply chain, and responder-partner organisations will be key to understanding and aligning risk management approaches with these documents. This includes, where relevant, any contractor-led contingencies for emergencies and major incidents that are delivered by contractors on behalf of their local authority clients.

A.6.1.5 Current risks especially pertinent to the Code are:

- **human diseases** – especially with regard to their impact on business continuity;
- **flooding** – including high-impact, wide-area pluvial, fluvial, groundwater and coastal, as experienced in many locations within the last few years;
- **severe space weather** – such as solar flares, which may disrupt terrestrial power, and communication infrastructure and space-based services (e.g., GPS);
- **severe weather** – both in the context of chronic conditions (e.g. drought) and sudden high-impact events;
- **major industrial incidents** – especially where they touch the road network;
- **widespread electricity failure** – impacting on technology resilience;
- **major transport incidents** – including where this may involve high-consequence dangerous goods;
- **disruptive industrial action** – often with an impact on network operation and usage;
- **state threats, terrorist, malicious or criminal attacks, or civil protest** – in a variety of forms, linked to operations and security;
- **cyber security** (encompassing computer and computer network security) – a burgeoning risk with a specific impact on intelligent systems, automated systems and systems comprising a computational aspect and physical aspect working together to accomplish a task or function;
- **water infrastructure failure or loss of drinking water** – support of road haulage and logistics;
- **collapse of major government contractor;** and
- **major fires (inc. urban and wildfire).**

A.6.1.6 The "worst plausible" Reasonable Worst-Case Scenarios (RWCS) described for these risks include the potential for up-to catastrophic level impacts, which would require a whole-of-system response (e.g. pandemic, national power outage, water infrastructure failure, and civil nuclear accident)

A.6.1.7 The 2026 NRR also lists common consequences against each risk. Common consequences are the similar outcomes that can result from different risks, regardless of the specific trigger. Effects

on transport systems are listed as a common consequence for over 50% of the national risks. The exact nature of these consequences is not described in detail, but these would include significant traffic disruption, loss of IT, loss of critical assets, and cascade loss of interdependent infrastructure, routes or services. As a result, well-considered and tested generic emergency plans are important for authorities because whilst some risks require specific capabilities, other capabilities can be applied across a wide range of risks. Common capabilities that generic plans can describe include interoperability, rapid impact assessment, diversion route planning, and mutual aid.

A.6.1.8 In respect to the longer-term, the Government's Chronic Risk Analysis provides an assessment of emerging risks that may impact the network over the lifespan of assets, programmes and contracts and which should be used to inform both resilience and adaptation strategies. These risks include those related to climate change, the use of artificial intelligence, and impacts on global supply chains.

A.6.1.9 DfT has produced a set of useful transport hazard summaries to assist those developing plans and contingencies for a range of natural hazards, but it should be understood that the application of an all-hazards approach should strengthen resilience against the spectrum of hazards, threats and other risks.

A.6.1.10 The resilience measures implemented to manage risks are likely to include physical works, staff training, customer information, management plans and procedures, and adoption of an appropriate and proportionate security minded approach. These measures should include contingencies to deliver impact stabilisation (e.g., technical inspection and civils capability), situational awareness (e.g., rapid impact assessment, communications), and mutual aid support. There is also a need for training to embed interoperability principles (i.e., JESIP), to empower staff to coordinate effectively with multi-agency partners when required.

A.6.1.11 If failure of an asset could lead to major consequences, it should be identified as a critical asset and assessed in greater detail, as defined in HIAMG Section 13.4.

A.6.1.12 Tools that are developed to assess, improve and manage network resilience can provide information about parts of the highway infrastructure, its modal and functional interdependencies (e.g., roads to ports, access to schools) and colocation interdependencies with other related assets (e.g. buried utilities), which are critical from a community lifeline or security perspective. Where this is the case, the adoption of a security minded approach in relation to use of the chosen tool and the information and intelligence it generates will be essential. Technologies to support this type of interdependency assessment include the National Underground Asset Register (NUAR) and its Scottish equivalent the Community Apparatus Data Vault (Vault).

A.6.1.13 Resilience contributes to the Code's objectives through a consequence-led approach, where decisions are informed not only by asset condition but by the impact of disruption on communities, critical services and the wider economy. In this sense, the term impact should be understood through the formula:

$$\text{Impact} = (\text{Damage} \times \text{Consequences}) \times \text{Duration of effect}$$

A.6.1.14 A structured approach to prioritising risks and to developing measures to effectively manage impacts when they occur can help reduce local vulnerabilities and increase preparedness and inform any future change, delivered through both operational planning and long-term investment decisions.

A.6.1.15 Both resilience and adaptation planning activities should be ongoing, iterative processes informed by monitoring, event experience and changing climate conditions, rather than a one-off programme of interventions.

A.6.1.16 Resilience should be considered as a service-level capability rather than solely a property of individual assets. It requires a coordinated approach across the authority and should not be considered solely a responsibility of highway asset management teams. Highway authorities should work with relevant internal and external partners, including emergency planning functions, Lead Local Flood Authorities, Local Resilience Forums and climate adaptation teams, to develop a shared understanding of risks, vulnerabilities, interdependencies and resilience priorities.

A.6.1.17 Authorities may wish to refer to Local Partnerships' Strategic Resilience and Adaptation Guidance for Local Highways Authorities, which provides a framework for embedding resilience and adaptation within asset management, service delivery, governance, preparedness and investment decision-making.

A.6.2 INDUSTRY REVIEWS

A.6.2.1 The Transport Resilience Review was published in 2014, covering how transport systems could be made more resilient so as to reduce the disruption from extreme weather in the future. It made 63 recommendations, a number of which related to the management of the highway network.

A.6.2.2 More specific reviews related to highways have since been undertaken. In 2021, the Department for Transport and Local Government Technical Advisers Group produced Emergency Preparedness, Response, & Recovery: Identifying lessons learned by the UK highway sector from extreme-weather emergencies.

A.6.2.3 UKRLG has more recently published Emergency Preparedness, Response, & Recovery, which was a three-year retrospective on the 2021 report, and included analysis of UKRLG's Hazards Survey from 2024.

A.6.2.4 Some of the recommendations from these reviews have been incorporated directly into the guidance in this Code.

A.6.3 RESILIENT NETWORK

A.6.3.1 The Transport Resilience Review recognised that an economically rational approach should be taken to spending on resilience, "ensuring that enough is invested, with the right prioritisation, and avoiding wasteful and economically unjustified expenditure".

A.6.3.2 There are a wide variety of highway types, functions and uses across the UK and it is not practicable to either assess or build all-hazards resilience across all of the highway authority networks. There is a need to focus resilience risk assessments and plans on a subset of each network, defined as the "Resilient Network", which will receive priority through maintenance and other measures in order to maintain economic activity and access to key services during disruptive events.

A.6.3.3 It should be developed and reviewed periodically as necessary to ensure that it provides:

- connectivity between major communities;

- lifeline connectivity for smaller communities (e.g., sole access/egress);
- links to the strategic highway network;
- connectivity across authority boundaries where appropriate;
- links to transport interchanges;
- access to emergency facilities including Fire and Rescue, Police, Ambulance Services and hospitals;
- links to critical infrastructure (ports, power stations, water treatment works, etc);
- principal public transport routes, access to rail and bus stations, and to bus garages and other depots; and
- support of defence mobility requirements, including access to military establishments and other locally important facilities.

A.6.3.4 When defining the Resilient Network, consideration should be given to engaging with the Local Resilience Forum, or equivalent, key businesses, and interest groups to jointly identify routes and assets (e.g., bridges) which are critical to the economic and social life of the area (i.e. lifelines). Neighbouring highway authorities should also be consulted to ensure continuity of the Resilient Network at a regional level.

A.6.3.5 The risk of specific asset failure, to the extent that it leads to closure or restriction of the Resilient Network, should be assessed. This should take into account the likelihood of failure due to the asset's physical attributes and its location (e.g., design capability / capacity, condition, geology, catchment characteristics). The socio-economic consequences of failure should also be considered and include the potential for community severance, the access to respond to further emergencies, the suitability and length of any diversion route, typical traffic types and volumes, repair / recovery cost and timescale, and damage to statutory utility plant.

A.6.3.6 Taking an all-hazards, six-domain resilience approach also supports the development of contingencies for 'surprise' failures. These occur where whatever the calculated probability of failure, there is always the possibility that a failure will occur sooner or more dramatically than expected. Here, plans that include mutual aid provisions and contingencies for accessing niche capabilities (e.g., sonar survey, temporary bridging capability) allow authorities to be more prepared for such events.

A.6.3.7 A minimum Winter Service network should also be defined. This network may relate to the Resilient Network and should be a subset of the normal winter treatment network. It should provide a minimum essential service to the public, including links to the strategic network, access to key facilities and local communities, and other transport needs. It is important that there is continuity across boundaries. It is recognised that authorities may have difficulty in treating all public and school bus routes, however, where practicable, arrangements should be made to enable bus operators to run minimum services.

A.6.3.8 Issues to consider when defining resilient and minimum Winter Service networks are:

- What is the key infrastructure access to be maintained? To this end, the authority's emergency planning department should be consulted. Consideration should be given to a wide range of services, including consideration for private asset infrastructure. For example, water treatment works may require chemical deliveries to ensure continuity of water supply but may not be on the primary treated road network. Such examples illustrate the importance

of collaboration with the LRF and partner organisations to identify where bespoke contingencies may be particularly effective in delivering resilience (e.g., a farmer contract to clear a side road to a key water treatment facility)

- How will specific assets such as carriageways, cycle routes and footways be prioritised across the authority's network?
- How will the networks interface with other authorities? There is little point expending effort to keep a route open if it may be unusable in a neighbouring authority. Existing relationships between highway authorities for Winter Service delivery indicate how this can work in practice.
- Has the resilient network been assessed against a range of hazards and failure scenarios? A route that is resilient during winter weather may be vulnerable to flooding, landslip, coastal erosion, high winds or other disruptive events. Authorities should consider whether alternative routes, contingencies and operational arrangements remain effective where parts of the resilient network become unavailable due to multiple concurrent, or compounding, or cascading hazard effects.

RECOMMENDATION 20 - RESILIENT NETWORK
Authorities should identify and manage resilient networks that support the continued movement of people, goods and services during disruptive events.

A.6.4 CRITICAL HIGHWAY INFRASTRUCTURE

A.6.4.1 Critical highway infrastructure is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance, Part A.

A.6.4.2 Critical highway infrastructure comprises highway assets whose failure would result in significant impacts on network operation, communities, service delivery or the local (and potentially national) economy. Having identified critical highway infrastructure assets, it may be appropriate to consider their position within the asset hierarchy differently from similar non-critical assets. For example, a critical asset may be assigned a higher category or managed separately.

A.6.4.3 Highway authorities should consider dependencies and interdependencies between highway assets and designated Critical National Infrastructure (CNI). These may extend beyond direct access to a particular site and include routes that support the movement of people, goods, utilities, services and emergency response between infrastructure assets and across wider networks.

A.6.4.4 Where such dependencies or interdependencies exist, authorities should consider whether additional resilience, business continuity and security measures are required. This should include consideration of a range of hazards and disruption scenarios to support continuity of access and service delivery.

A.6.5 CLIMATE CHANGE AND ADAPTATION

A.6.5.1 Under the Climate Change Act 2008, public bodies and infrastructure operators may be required to assess and report on the risks and opportunities arising from climate change through the Adaptation Reporting Power (ARP) process. Recent developments in climate adaptation reporting place greater emphasis on climate risk assessment, adaptation planning and resilience outcomes across a wider range of public bodies and infrastructure providers. In England, this includes proposals to expand reporting requirements to Strategic Authorities, building on experience

gained through previous reporting rounds. Whilst reporting arrangements differ across the UK and not all highway authorities may be subject to mandatory reporting requirements, all authorities should consider undertaking proportionate climate risk assessments, gathering relevant climate resilience data and integrating adaptation into asset management, investment and service planning processes. Authorities are encouraged to align their approach with relevant adaptation reporting guidance and good practice, and to contribute voluntarily to adaptation reporting where appropriate.

A.6.5.2 The key projected climate changes for the UK, identified through the UK Climate Projections (UKCP) programme and reinforced by the findings of the Fourth Climate Change Risk Assessment – Independent Assessment (CCRA4-IA), include:

- all areas of the UK are projected to become warmer, with greater warming in summer than in winter, and more frequent and intense heatwaves;
- winters are projected to become wetter overall, with an increase in the frequency and intensity of heavy rainfall events;
- summers are projected to become drier on average across much of the UK, increasing the risks of drought and wildfire, although short-duration, high-intensity rainfall events are also expected to become more severe, increasing the risk of surface water flooding;
- sea levels are projected to continue rising around the UK coast, with generally greater increases in the south than in the north, increasing the risks of coastal flooding and erosion;
- climate change is expected to increase the risks of flooding, coastal change, slope instability and deterioration of infrastructure assets, together with wider disruption to interconnected infrastructure networks.

A.6.5.3 It is important to acknowledge that these changes are not solely projections. Many are already evident within the observed climate record, including rising temperatures, sea-level rise and an increase in the frequency and severity of extreme weather events.

A.6.5.4 The Government published the first UK Climate Change Risk Assessment (CCRA) in 2012, analysing 100 potential impacts of climate change across 11 sectors. For the transport sector, the assessment identified flooding, landslides, heat damage and bridge scour as important risks. Subsequent assessments have built on this evidence.

A.6.5.5 This has been followed up by the latest UK Climate Change Risk Assessment (CCRA3), published in 2022, which highlighted increasing risks to transport infrastructure from flooding, extreme temperatures and other severe weather impacts. It concluded that climate risks are increasing faster than adaptation measures are being implemented and emphasised the importance of embedding climate resilience within the planning, design, operation and maintenance of infrastructure assets.

A.6.5.6 The Government released the first National Adaptation Programme (NAP) in July 2013 (last updated in 2023). Each NAP contains a series of objectives and associated actions to tackle risks identified in the CCRA.

A.6.5.7 The Scottish Climate Change Adaptation Programme addresses the risks identified for Scotland in the UK Climate Change Risk Assessment.

A.6.5.8 The Department for Transport has developed a Climate Adaptation Strategy for Transport which sets out the strategic direction for adapting the transport sector to the impacts of climate change.

A.6.5.9 Adaptation is the process of modifying policies, plans, assets, operational practices or behaviours in response to current or anticipated changes in risk, vulnerability or operating conditions. Adaptation may be undertaken to address climate change impacts, changing patterns of demand and service delivery, emerging threats, lessons learned from incidents, technological developments or other factors affecting the operation and management of highway networks. Effective adaptation supports the long-term resilience of highway infrastructure assets, networks and services.

A.6.5.10 Guidance on the adaptation of local highway networks has been published by ADEPT in the form of the Local Highways Climate Adaptation Guide. The guidance provides a practical framework for highway authorities to assess climate-related risks, review resilient networks and integrate climate adaptation into asset management plans, policies and maintenance strategies. Highway authorities should consider the guidance when developing their approach to climate resilience and adaptation.

A.6.5.11 Highway authorities should assess how weather variables, such as heavy or prolonged rainfall; hotter temperatures, higher wind speeds, and combinations of hazards (e.g., high winds alongside heavy rainfall) will impact on the type of highway assets that they manage and the implications of these events occurring more frequently and/or with greater intensity. By doing this the most likely common consequences of these risks (e.g., network closure or restrictions) can be identified. These are likely to be:

- flooding (pluvial, fluvial, groundwater, coastal, and flooding resulting from reservoir, canal or other water-retaining infrastructure failures); landslips;
- bridge scour;
- widespread tree fall;
- heat damage to assets;
- falling power and communications lines;
- falling temporary structures where they may impact on the highway; and
- disruption at interchanges with other transport modes such as rail and tram.

A.6.5.12 Climate change may also increase pressures on the highway soft estate through the combined effects of extreme weather, pests, diseases and invasive species, increasing the need for proactive management, maintenance and replacement planning.

A.6.5.13 Highway authorities should review and apply the latest UK Climate Projections, as developed by the Met Office and Environment Agency, when assessing future risk and vulnerability. Local Authorities may also consider using the Met Office Local Authority Climate Service (LACS), which provides essential climate information that is tailored to the local area and easy to use for climate risk assessments, developing adaptation plans, and building climate resilience.

A.6.5.14 Highway authorities should consider using the Department for Transport's Climate Risk Assessment Guidance for the Transport Sector when undertaking climate risk assessments. The guidance provides a structured methodology for identifying, assessing and prioritising climate-related risks and adaptation measures and includes supplementary resources relevant to local

highway authorities. Climate risk assessments should be undertaken using appropriate and proportionate methodologies and supporting evidence. Authorities may wish to use the Local Partnerships Climate Adaptation Toolkit and associated Climate Risk Matrix and Risk Register to support climate risk assessment, the identification and prioritisation of climate-related risks, adaptation option appraisal, implementation planning and ongoing monitoring and review.

A.6.5.15 The projections for future changes to both average climatic conditions and the frequency of extreme weather events allow for an understanding of where risk levels may change, and the identification of new risks which may emerge as the climate changes. When applied alongside records of past incidents, and other information sources (such as flood maps), climate projections may also help to identify when and what action should be taken to adapt to the risks, e.g., it is likely that existing hazard hotspots (e.g., regular flooding sites) are an indicator of where hazard effects may increase most.

A.6.5.16 The locations where there is potential for these events to occur on the Resilient Network should be identified. This can be done using the highway asset inventory and records of past incidents of weather-related damage or incidents such as flooding or landslips. The local Flood Risk Management Plans, as prepared by the Lead Local Flood Authority, should also be used to identify areas prone to flooding. Where possible, local knowledge should be used to validate the findings. It is important that all hazard and impact data is collected in consistent formats to ensure it can be effectively utilised by all relevant local authority departments and teams (e.g., highways, Lead Local Flood Authority, adaptation)

A.6.5.17 Some of the risks may have the potential to be reduced by risk mitigations. Such actions could range from improved routine inspection or maintenance regimes to major asset improvement or replacement works where risk assessments indicate that operational, maintenance or contingency measures alone would not provide an appropriate level of resilience. Options for mitigating the greatest risks should be explored with a view to prioritising those measures that will provide the greatest return on investment in terms of reduced risk. These measures should be integrated with the asset management plan with an appropriate weighting.

A.6.5.18 Effective resilience arrangements connect preparedness, operational response, recovery and long-term adaptation, covering defined triggers and thresholds, situational awareness, structured impact assessment procedures, clear decision-making authority and processes for using learning from events to inform future investment and service design.

A.6.5.19 Authorities should adopt a proportionate and risk-based approach, recognising that retrofitting resilience across existing networks, particularly extensive rural networks, may present significant technical and financial challenges. Investment decisions should therefore reflect local risks, consequences of failure, affordability and the benefits delivered through improved resilience, across the six resilience domains, and recovery.

RECOMMENDATION 21 - CLIMATE CHANGE ADAPTATION
Authorities should assess and plan for the impacts of climate change and incorporate adaptation into infrastructure management, investment and service delivery.

A.6.6 PLANNING FOR RESPONDING TO NETWORK DISRUPTIONS

A.6.6.1 Resilience planning is not just about the physical robustness of the highway infrastructure but also about how disruption is managed and the speed of recovery. Climate change and other evolving risks may increase the frequency with which highway authorities will have to respond to

severe weather emergencies. Authorities should establish, in consultation with others—including service providers, emergency services and relevant agencies such as the Environment Agency, or equivalent—operational plans and interoperable procedures to enable timely and effective action to mitigate the effects of such emergencies as they affect the highway network. There will also be other weather conditions, such as fog or heavy rain, which, although potentially causing danger and operational difficulties, would not normally be considered emergencies or declared as multi-agency major incidents. Nevertheless, authorities should ensure that appropriate contingencies and operational procedures are in place for such events in order to minimise disruption to network users and reduce the risk of reputational harm.

A.6.6.2 The content of operational plans and procedures could be based on those developed for Winter Service, adapted to suit the particular risks involved. However, it is essential that these plans are written so that they fully integrate with the multi-agency interoperability procedures described in the respective LRF plans. It will also be essential to address the common and the specific health and safety issues relevant to each emergency risk (e.g., decision making in respect to essential operations during high winds, where reducing the risk-to-life to the public justifies deployment, albeit there is also a risk-to-life to operatives).

A.6.6.3 There are a number of potential emergency situations which could affect the highway, including those resulting from subsidence, landslip or collapsed walls, oil spills, and wildfire. Although the risk of some such occurrences can be reduced through a risk-based inspection regime, there are likely to be occasional unpredicted occurrences, for which contingency planning should be undertaken in collaboration with partner agencies where appropriate.

A.6.6.4 As illustrated in the NRR, there are also a wide range of other civil emergencies in which the highway service may need to become involved due to common consequence effects. In such cases, plans, procedures and responsibilities will generally be defined within the highway authority's Civil Emergency Plan, maintained by the authority's Emergency Planning function, and linked to other risk-specific plans and those maintained by the Police, Fire and Rescue Service, Ambulance Service and other responder organisations. Effective emergency planning requires active engagement across local authority services, partner organisations and contractors, both in the development of plans and in exercising and reviewing them, to ensure interoperability is achieved through a coordinated and effective response.

A.6.6.5 Requirements placed on authorities for emergency planning are set out in the Civil Contingencies Act 2004, and associated documents. Local authorities are Category 1 responders under this Act. This status places seven statutory duties on the authority: cooperating and sharing information with other responders, assessing local risks, planning for emergencies, communicating with the public, ensuring business continuity and supporting business continuity planning within the wider community.

A.6.6.6 Operational resilience capability is key to supporting effective preparedness, response, stabilisation, and recovery across a range of hazards, including:

- clearly defined leadership, roles and decision-making authority, supported by suitably qualified and empowered personnel, and interoperability principles,
- predefined triggers and thresholds that enable timely mobilisation and escalation,
- arrangements for maintaining situational awareness, including consistent, structured and phased impact assessment procedures (i.e. initial rapid impact assessment, followed by technical structural investigation),

- the ability to prioritise activity based on the impact on network functions, and
- arrangements to suspend or reprioritise business-as-usual activities where required.

A.6.6.7 Operational capability should be scalable to the severity and duration of events and aligned with wider organisational and multi-agency response arrangements. They should also be structured to mesh with regional and national emergency structures (e.g. COBR).

A.6.6.8 Pre-agreed and documented arrangements for the temporary suspension or reprioritisation of business-as-usual activities can be highly effective during major incidents, civil emergencies and other disruptive events. For this reason, a Suspension of Business as Usual protocol has been agreed by UKRLG, which supports authorities with the local definition of decision-making responsibilities, trigger thresholds, escalation procedures, and communication and review requirements that should inform such an action. The purpose of such arrangements is not to remove statutory responsibilities, but to support the defensible reallocation of limited resources towards the highest-priority safety, resilience and recovery activities during extreme events.

A.6.6.9 To support the prioritisation of response and recovery activities, and to inform any decision to suspend normal service, authorities should also establish arrangements for the rapid assessment of network impacts (i.e. where impact = (damage x consequences) x duration of effect). These arrangements should be periodically reviewed and aligned with wider emergency planning and business continuity arrangements. Authorities should also develop these procedures in collaboration with their neighbours, as this will safeguard interoperability during wide-area emergencies (e.g. by using common metrics to inform shared situational awareness).

A.6.6.10 Authorities should also consider the role of local communities and voluntary organisations in supporting resilience, preparedness, response, and recovery activities. Engagement with parish and town councils, community groups, charities and other local organisations may help improve local resilience, support vulnerable communities and assist in maintaining access to essential services and facilities during disruptive events. Where appropriate, such arrangements should be developed in advance and aligned with wider emergency planning and partnership arrangements (e.g. Flood Wardens).

A.6.6.11 Given their increasing role in the delivery of many highway functions, it is important that local authorities work closely with their term contractors to ensure that business continuity arrangements and emergency management contingencies align with relevant Local Resilience Forum multi-agency plans. Authorities should also ensure that contracts clearly define the contractor's responsibilities during emergencies and other disruptive events, including those activities required to support the authority in meeting its statutory duties. Whilst statutory responsibilities remain with the highway authority, contractual arrangements should provide clarity regarding roles, resources, response times, decision-making responsibilities and mobilisation requirements to support an effective response and recovery.

A.6.6.12 Operational plans and procedures for severe weather and other emergencies should be regularly tested and validated for effectiveness against a range of risk scenarios relevant to the authority's area. Consideration should also be given as to whether specific staff training is needed to support people undertaking incident management, either due to the emergency situation itself or the role being a change from their normal duties. Training and exercising should be undertaken in accordance with the Authority's emergency plan. For greatest effect, exercises should include the substantive testing of highways capabilities and competencies, which go beyond the most basic 'close the road' scenarios.

A.6.6.13 Recent experiences and consequences of flooding have increased the importance placed by local communities on flood protection measures and the need for effective action by authorities in planning and responding to extreme weather conditions. The Flood and Water Management Act 2010, or equivalent, aims to improve both flood risk management and the way that water resources are managed. The Act creates clearer roles and responsibilities and instils a more risk-based approach. This includes a lead role for local authorities and local highway authorities in managing local flood risk (from surface water, ground water and ordinary watercourses) and a strategic overview role for all flood risk for the Environment Agency, or devolved equivalent: these will be the key agencies in respect of responding to flood emergencies, and authorities should work closely with them.

A.6.6.14 The CIHT has published guidance titled All hazards operational guidance: responding to climate disruption, and six practitioner checklists designed to support local highway authority teams to proactively manage network disruptions from risks outlined in the DfT Transport hazard summaries. The purpose of the guidance is to support authorities in establishing an operational framework to structure a response to disruption, including leadership, governance, situational awareness, prioritisation, escalation, and learning arrangements required for a consistent and defensible response.

A.6.6.15 In planning for increased flood risk, including pluvial, fluvial, groundwater and coastal flooding, authorities should:

- undertake a risk assessment to determine vulnerable highways and assets;
- define alternative routes and progressively bring them up to appropriate standards of maintenance and signing;
- consider promotion of improved flood defences by infrastructure owners;
- consider installation of improved flood protection;
- prepare contingency plans in consultation with other authorities;
- assess underpasses, bridge openings and culverts against predicted future flood conditions and consider whether physical improvements, operational measures or contingency arrangements are required;
- consider if any critical infrastructure on vulnerable routes could be bypassed by a suitable new route.

A.6.6.16 The contribution of authorities in dealing with flood conditions will depend upon the circumstances but could include:

- signing hazards to mitigate risk-to-life (e.g., at flood-vulnerable underpasses and river fords)
- signing and maintaining diversions, including communication/publication of details of roads closed/alternative routes (e.g., via use of permits/systems such as one.network)
- inspection, clearance and maintenance of drainage systems, including outfalls.
- provision and operation of transportation services, such as buses to evacuate people to rest centres;
- encouraging property owners to protect their own property;
- provision and installation of temporary flood protection measures, where appropriate and in accordance with published policies;

- general support to emergency services (remembering interoperability principles); and
- liaising with and mutually supporting utility suppliers.

A.6.6.17 Sustainable drainage systems (SuDS) can play an important role in managing surface water runoff and reducing pressure on conventional drainage infrastructure. As well as helping to reduce flood risk, SuDS can contribute to climate resilience while providing environmental, water quality and amenity benefits. Comprehensive guidance on the planning, design, construction, operation and maintenance of sustainable drainage systems is available in CIRIA's SuDS Manual (C753).

A.6.6.18 The implications of high winds within an authority area are much less predictable, although weather information can help to assess the risk. Authorities should, as part of highway inventory and inspection arrangements, identify those parts of the network most at risk of obstruction due to fallen trees. Any limited sections, not already considered as part of the Resilient Network assessment, where obstruction could have particularly serious consequences for safety or serviceability should be identified. These could include accesses to relatively isolated communities. It may be appropriate to consider, with arboricultural advice, planned removal (e.g., of senile, diseased or disease-vulnerable trees) and replacement with more suitable trees in some cases, whilst retaining contingencies for extreme events.

A.6.6.19 In planning for increased risk of damage from increased wind speeds, local highway authorities should also:

- undertake a risk assessment to identify structures at greatest risk and/or consequences; and
- undertake structural appraisal and consider implications for strengthening or removal.

A.6.6.20 The Scottish approach to high winds is set out in the High Wind Strategy & National Wind Management Guidelines.

A.6.6.21 Advice from weather warnings should be taken into account in considering a particular response, e.g., to safeguard the health and safety of operatives, which may limit the extent to which any direct assistance can be provided until conditions have eased. However, consideration should be given to life-at-risk situations, where the authority may need to respond whilst managing risks through the application of As Low as Reasonably Practicable (ALARP) risk principles. The contribution of authorities and their contractors to dealing with the consequences of high winds will then depend upon the circumstances, but could include:

- signing and maintaining temporary closures and diversions;
- clearance of fallen and potentially dangerous trees;
- clearance and removal of debris;
- assistance with temporary support and repair of buildings;
- general support to emergency services (remembering interoperability principles); and
- liaison and collaboration with energy and communication suppliers where it is necessary to restore community lifelines.

RECOMMENDATION 22 - DRAINAGE MAINTENANCE
Authorities should manage and maintain drainage assets to support safety, serviceability, sustainability, resilience and adaptation objectives.

RECOMMENDATION 23 - RESILIENCE CAPABILITY AND PREPAREDNESS
Authorities should maintain the organisational capability, competence, partnerships and resources necessary to support preparedness, response, recovery and adaptation activities.

A.6.7 COLLABORATION

A.6.7.1 An integrated approach to the management of severe weather and civil emergencies forms the basis of the UK's approach as defined by the Cabinet Office and should be adopted by highway authorities.

A.6.7.2 Working with the community, partner organisations and all parts of the highway authority at planning, response and recovery stages, including across boundaries, has been shown to enhance resilience and help to mitigate the impact of threats to network operation. Examples of this approach are agreement of diversion routes, use of community flood wardens and provision of mutual aid between authorities. Lines of communication with other asset owners situated across, over, or under the highway would also be useful, particularly where significant co-location and/or functional interdependencies exist with other services.

A.6.7.3 Collaboration with the Local Resilience Forum, or equivalent, can help in developing a common understanding of the risk environment, by linking to other responding agencies and sharing good practice. Depending on the authority this might be facilitated by an Emergency Planning Officer and engagement with these experts should be part of standard procedure in plan development. As a Category 1 responder, local and highway authority plans, and training should comply with interoperability principles to ensure effective coordination can be achieved with multi-agency partners (i.e., JESIP)

A.6.7.4 Neighbouring property owners can have an impact on the resilience of a highway if they fail to adequately discharge their responsibilities as landowners. Trees from neighbouring land blown over in high winds are a frequent cause of blocked roads and associated disruption. Similarly, poorly maintained neighbouring drains or surface water run-off from adjacent fields are a common cause of road flooding and landslips. Neighbouring poles, masts and power lines may also create potential risks. Contact should be made with owners where the network is vulnerable to disruption emanating from their property to advise them of their responsibilities and liability.

A.6.7.5 Authorities may explore the potential for sharing depots as this can provide opportunities for efficiencies and resilience (e.g., mutual aid). Other areas where collaboration should be considered include decision support services for weather particularly where authorities have similar resources, facilities and climatic conditions.

A.6.8 COMMUNICATIONS

A.6.8.1 Forecasts of extreme weather and flood events have steadily improved in accuracy over recent years and this is helpful in ensuring that adequate resources can be in place and warnings given to highway users of potential disruption e.g., the Met Office Hazard Manager tool and associated Natural Hazards Partnership Daily Hazard Assessment product.

A.6.8.2 Authorities should ensure that they have clearly agreed channels for receiving weather and flood forecasts. These should be monitored in real time during periods when extreme weather is expected.

A.6.8.3 Weather forecast information is crucial and the Met Office will issue severe weather warnings and send messages to authorities, other emergency services, and the media. These messages may be issued for single hazards or multiple hazards affecting an area concurrently or consecutively. The warnings are based on colour coded descriptions and an impact matrix:

- Yellow – Be aware, there is the small chance of…;
- Amber – There is an increased likelihood of impacts from severe weather, which could potentially disrupt your plans. This means there is the possibility of travel delays, road and rail closures, power cuts and the potential risk to life and property […] and
- Red – Dangerous weather is expected […] you should take action now to keep yourself and others safe from the impact of the severe weather. It is very likely that there will be a risk to life, […]

A.6.8.4 The Flood Forecasting Centre, along with the Environment Agency and its devolved-administration equivalents have established a three-stage system of flood warning procedures, together with audible warnings in certain areas (exact wording varies):

- Flood alert – flooding is possible
- Flood warning – flooding is expected and immediate action is required
- Severe flood warning – flooding could be a significant risk to life and destruction of properties

A.6.8.5 Highway users judge how well disruption is handled principally by the information they receive from authorities, either directly or via the media. Providing timely, credible and useful information to allow people to make informed decisions before they travel and give advanced indication of what they can expect if they decide to travel, is central to this. Highway authorities should consider providing real time information using the internet and social media as well as the press, radio and TV to maximise coverage. During periods of disruption, authorities should consider giving prominence to the latest travel information on their websites. Planning should include contingencies for highways participation in a Multi-Agency Information Cell (MAIC) if it is activated during an emergency.

A.6.8.6 Authorities should communicate with passengers and other stakeholders as clearly as possible (avoiding technical jargon) to explain what is happening and how services are being affected by the weather or as a result of weather induced damage to infrastructure. Achieving this with maximum effect requires an understanding of the available information channels and how those are being used by travellers and freight customers. Openness and honesty in communication helps build confidence. Even if little information is available, or reinstatement operations will clearly be complex and inevitably protracted, letting people know when they can expect an update is helpful. Photographs on the internet or distributed by social media could be used when appropriate, to improve highway users' understanding of the reasons for the disruption. Passengers and users who have confidence in the information they are being given are more likely to act on advice, potentially helping to relieve rather than add to the situation. An effective communications strategy and plan should also include options for effectively countering any inaccurate information being shared about highway operations (i.e. myth-busting).

RECOMMENDATION 24 - COMMUNICATIONS DURING DISRUPTION
Authorities should communicate effectively with users, stakeholders and partners before, during and after disruptive events.

A.6.9 LEARNING FROM EVENTS

A.6.9.1 Authorities should regularly review their responses to severe weather, emergency rehearsals and actual responses, to identify potential improvements to their severe weather and emergency operational plans and procedures. Where appropriate reviews should be carried out in consultation with other responding organisations and public and businesses affected by the event, with findings informing future plans, processes and arrangements.

A.6.9.2 Authorities should maintain records of significant weather-related incidents and make use of evidence from flood investigations, including Section 19 investigations undertaken by Lead Local Flood Authorities where applicable. The findings of such investigations should be considered when reviewing climate risks, identifying vulnerable assets and locations, and prioritising resilience and adaptation measures within asset management and investment programmes.

A.6.9.3 Relevant performance measures can provide a better understanding of resilience, and may include preparedness and response effectiveness, network recovery time, impact on network users and progress in reducing vulnerability and risks over time.

A.6.9.4 Resilience arrangements should be tested through exercises and real-event reviews to ensure that plans, roles, thresholds and triggers, and decision-making processes remain effective and understood.

A.6.9.5 Recovery activities should consider opportunities to reduce future vulnerability and risk, rather than defaulting to like-for-like reinstatement wherever practicable.

A.6.9.6 Information obtained from significant incidents, emergencies and disruptive events can provide valuable evidence to support future preparedness, risk assessment, asset management, resilience planning and adaptation measures. Examples include impact assessments (i.e. records of network damage, consequences and disruption duration), recovery status, asset performance, customer and community impacts, response and recovery costs, and the findings of any formal investigations or structured impact reviews or inquiries.

A.6.9.7 Authorities should seek to ensure that all learning from incidents, emergencies and exercises is systematically captured, learned, and embedded to improve future preparedness, operational response, recovery arrangements and long-term adaptation.

RECOMMENDATION 25 - EMERGENCY PLANNING
Authorities should establish and maintain arrangements for preparing for, responding to and recovering from network disruptions and emergency events.

RECOMMENDATION 26 - LEARNING FROM EVENTS
Authorities should capture, review, share and apply learning from incidents, exercises and disruptive events to improve future performance and resilience.

SECTION A.7 FINANCE AND INVESTMENT

A.7.1 OVERVIEW

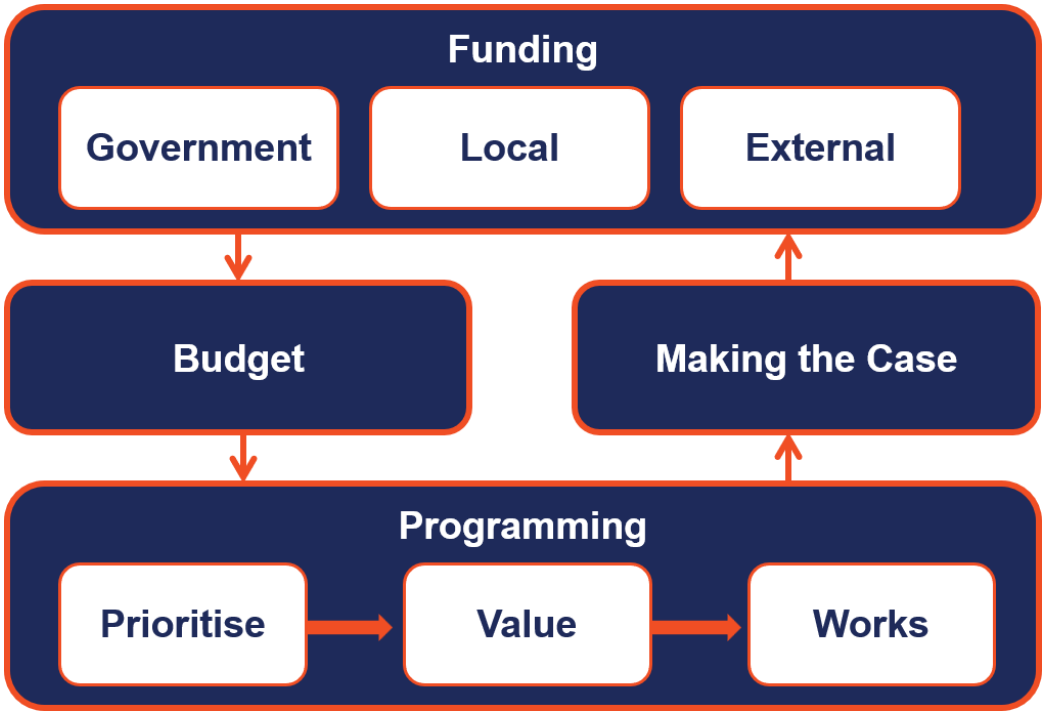


Figure 10 – Finance and Investment

A.7.2 FINANCING OF HIGHWAY MAINTENANCE

A.7.2.1 Financial constraints, lifecycle planning, making the case for investment and investment strategy are all dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Parts A, B and C. This document should be referred to and the advice below considered supplementary.

A.7.2.2 Financial plans should be linked to asset management strategy with short-term plans covering the immediate and subsequent financial year, medium-term plans covering a 3-to-5-year rolling works programme and long-term plans may cover periods of 10 years or more (depending on asset type and typical service life). Greater certainty in longer-term funding arrangements can support more effective lifecycle planning, improved value for money, enhanced delivery efficiency and the wider adoption of preventative maintenance approaches. Financial and lifecycle planning should also consider investment required to support adaptation and resilience. This may include adaptation measures, nature-based solutions and interventions intended to reduce future disruption, risk and whole-life costs.

RECOMMENDATION 27 – LIFECYCLE PLANNING
Authorities should use lifecycle planning to inform investment decisions and seek to optimise whole-life value from infrastructure assets.

A.7.3 REVENUE AND CAPITAL FUNDING

A.7.3.1 Highway authority funding has established rules defining capital expenditure and revenue expenditure. Capital expenditure relates to works that create or enhance an asset, increase its life or add to its value. Revenue expenditure covers staff costs, day-to-day operations, inspections/surveys, reactive repairs, winter service, routine maintenance and traffic management. Whilst distinct, capital and revenue expenditure are closely related. Understanding the relationship between the two can support effective management of highway, recognising that insufficient investment in either may increase future costs, risks and maintenance liabilities.

A.7.3.2 The long-term shift in the UK from revenue to capital funding has created challenges. Many routine maintenance activities cannot legitimately be capitalised, yet revenue budgets continue to face challenges. This can lead to underfunding of essential tasks (such as drainage maintenance), increased risk exposure (e.g., increased blocked drainage assets increasing flooding) and greater reliance on short-term expensive reactive strategies (which could have been prevented through adequate revenue funding).

A.7.3.3 Capital funding offers opportunities for larger-scale renewal programmes but cannot replace the need for steady, sufficient revenue. Clear distinctions between eligible and ineligible activities, supported by consistent financial controls and appropriate application of funding definitions, help support effective financial management.

A.7.3.4 There are significant differences in both capital and revenue funding arrangements within the UK, and these may be subject to change due to political and economic factors. These are not set out in detail in this Code and reference should be made to the latest relevant government advice. Further advice is available from:

- Consolidated Budgeting Guidance 2025-26 - for publication.docx
- Must know: Capital expenditure | Local Government Association

A.7.4 SOURCES OF FUNDING

GOVERNMENT GRANT AND LOCAL FUNDING

A.7.4.1 National grant funding remains the foundation on which most highway investment is built, with local authorities also supporting this through their own sources.

A.7.4.2 Authorities should also consider the role of regional funding arrangements, including those administered through Combined Authorities and devolved transport bodies, which may provide additional opportunities to support highway investment and wider transport objectives.

PRUDENTIAL BORROWING AND INTERNAL REINVESTMENT

A.7.4.3 Borrowing can help authorities deliver major schemes and reduce long-term liabilities by smoothing expenditure and accelerating investment, but it also creates ongoing revenue commitments. When used as an invest-to-save approach, borrowing can enable maintenance that cuts reactive costs and improves network condition, provided the authority can robustly evidence the expected savings and associated risks.

INCOME GENERATION

A.7.4.4 Authorities may consider implementing measures such as a lane rental scheme to both control access to the network and also generate potential additional income. However, the requirements and implications of any such scheme should be understood before committing, to avoid unintended cost impacts and operational constraints.

PRIVATE AND ALTERNATIVE FINANCING

A.7.4.5 Legacy PFI highway contracts continue to provide long-term investment certainty, but authorities should plan effectively for successful end-of-term hand back. Newer private and alternative financing options, e.g., the UK National Wealth Fund, may support strategic objectives where robust business cases exist. Traditional development-linked contributions such as Section 106, Section 278 and community infrastructure levies remain important sources of funding for localised improvements.

A.7.4.6 Local authorities use commuted sums to fund the future maintenance of new or improved highway assets, though approaches vary widely across the UK. ADEPT has produced guidance on commuted sums that provides a consistent framework while still allowing authorities to reflect local priorities in their policies.

A.7.5 FINANCIAL REPORTING AND GOVERNANCE

BUDGETING PRINCIPLES

A.7.5.1 Effective management of highway infrastructure depends on a transparent, risk-based finance and investment strategy that links funding decisions to delivering the core objectives through the use of clear lifecycle evidence, forward-works planning, and cross-asset prioritisation.

A.7.5.2 Embedding consistent financial definitions and reporting expectations supports accountability, enables authorities to demonstrate value for money, and strengthens eligibility for additional funding.

A.7.5.3 Budgeting principles should provide the necessary level of flexibility to deliver value for money. Considerations may include:

- allocation of funds to manage risks associated with the core objectives, both at network and asset level;
- understanding the differing life expectancies of various treatments and the future implications of these for the balance of capital and revenue funding;
- the seasonal and weather sensitive nature of many treatments and the service as a whole;
- the uncertainties in prediction of out-turn costs for Winter Service and the need for financial year-end flexibility;
- the need for resilience against all hazards;
- the need to make provision for emergencies; and
- consideration of performance, not just in terms of condition but in delivering the core objectives.

A.7.6 REPORTING AND ASSURANCE

A.7.6.1 Local authorities and devolved bodies are required to follow statutory reporting frameworks, including compliance with local government financial legislation and internal audit requirements.

A.7.6.2 Section 151 Officers have a statutory duty to ensure financial propriety, sustainability and the effective stewardship of public funds. For highways, this includes:

- assurance that expenditure aligns with statutory duties and approved budgets;
- oversight of long-term investment plans;
- scrutiny of financial risks associated with asset condition; and
- ensuring that financial and asset data is reliable and transparent.

A.7.6.3 Financial reporting should consider not only asset condition and cost, but also wider core objectives and the risks associated with these. Transparent reporting supports scrutiny, enables informed decision-making and provides evidence for investment cases.

A.7.7 ASSET VALUATION

A.7.7.1 Highway infrastructure is considered to be the most valuable physical asset owned by the public sector in the UK. Effective valuation supports risk management, financial planning and decision-making. Key valuation approaches include:

- Historical cost: the original cost of constructing or acquiring the asset, with limited relevance for modern asset management.
- Gross replacement cost (GRC): the cost of replacing the asset with a modern equivalent at current prices, providing a picture of total asset value.
- Depreciated replacement cost (DRC): GRC adjusted for wear, deterioration and obsolescence, giving a clearer view of condition and remaining value.

A.7.7.2 Asset valuation can be used to highlight the financial impact of underinvestment, as deterioration and backlog growth reduce asset value and increase long-term liabilities.

A.7.8 MAKING THE CASE

A.7.8.1 A clear case for investment in highway infrastructure can help protect existing funding and support opportunities to secure additional funding.

A.7.8.2 Practitioners should be able to articulate the value of internal funding to the wider authority, in terms of the importance of managing such a vital asset and also in terms of highway infrastructure providing a key service that support virtually all other activities. Equally, practitioners should be able to demonstrate the value of investment in both revenue and capital funding, and the impact they have on one another.

A.7.8.3 Adequate funding is essential to delivering the required outcomes from an asset management approach. Authorities may develop investment scenarios to demonstrate the benefits and consequences of alternative funding allocations, in terms of risks to the core objectives and local priorities.

A.7.8.4 The HM Treasury Green Book sets out the framework for business case development. Authorities should ensure that investment proposals address the strategic, economic, commercial, financial and management dimensions required to demonstrate value for money.

A.7.8.5 Much work has been done at national level in terms of making the case for investment in highway maintenance, with a move from asset and cost-based evidence to an approach that builds on this type of evidence base by aligning it with political objectives and demonstrating social, economic and environmental benefits.

A.7.8.6 This includes work by the UK Roads Leadership Group to support the case to HM Treasury as part of the Spending Review process. The principles and structured used within this, such as the Public Value Framework, have subsequently been tailored and applied effectively at individual highway authority level.

A.7.8.7 Also, the Department for Transport has produced research into the economic benefits of highway maintenance, which authorities may refer to when making local business cases and internal funding decisions.

A.7.8.8 While proactive investment remains the most effective way to reduce long-term liabilities, financing for highways can be volatile, with inflation, supply chain pressures, revenue constraints, environmental impacts and uncertainty over wider funding creating significant budgetary risks.

A.7.8.9 Scenario planning, stress testing revenue exposure and understanding the sensitivity of budgets to shocks can support financial resilience. Digital tools, including asset information systems and analytics, can offer opportunities to optimise maintenance and reduce long-term costs.

A.7.8.10 Business cases for highway investment should consider the avoided costs and wider benefits of resilience and adaptation, including reduced disruption, reduced emergency response costs, improved network availability, protection of critical access and reduced whole-life cost.

RECOMMENDATION 28 – FINANCIAL PLANNING
Authorities should conduct financial planning with consideration to short, medium and long-term infrastructure management needs, desired service outcomes and appropriate funding scenarios.

RECOMMENDATION 29 – MAKING THE CASE FOR INVESTMENT
Authorities should understand and articulate the value, benefits, risks and consequences associated with investment and under-investment in highway infrastructure.

A.7.9 COMMUNICATION

A.7.9.1 Authorities should communicate investment needs and allocation in terms that are meaningful to each particular audience, which will help balance short-term political and public priorities with long-term stewardship. Transparent explanation of trade-offs, risks and lifecycle consequences helps maintain credibility and supports informed decision-making. Performance and benchmarking information can support this communication by helping authorities explain how investment decisions are prioritised, the outcomes being sought and how decision-making contributes to continuous improvement.

A.7.9.2 Longer-term funding arrangements provide authorities with opportunities for enhanced asset management and greater value for money in delivery. Clear communication of the impact of inflation on the purchasing power of budgets can help support realistic stakeholder expectations over time.

ELECTED MEMBERS

A.7.9.3 Clear communication supports effective political decision-making and helps elected members understand the strategic context while responding to public concerns which may be focused more on visible issues such as potholes.

A.7.9.4 Performance data, risks and investment needs are most effective when presented in accessible non-technical language, supported by visuals, dashboards and uncomplicated evidence. This can include explaining the long-term consequences of underinvestment, including increased whole-life costs, accelerated deterioration and associated impacts on corporate objectives.

SENIOR LEADERSHIP

A.7.9.5 Senior leaders require information that connects investment requirements with engineering and organisational needs and statutory obligations, which in turn are aligned with the core objectives of safety, serviceability, sustainability and customer service.

A.7.9.6 Authorities should use appropriate levels of technical detail to support this level of communication, whilst ensuring that key messages such as a return on investment and long-term liabilities are not lost in supporting evidence.

PUBLIC COMMUNICATION

A.7.9.7 Authorities should explain funding challenges, prioritisation principles and maintenance strategies in accessible and meaningful terms. Engaging early, managing expectations and showing how evidence informs decisions can improve levels of public trust and confidence.

A.7.9.8 Tools such as data portals, dashboards and interactive maps can enhance transparency, but care should be taken that these are accurate in terms of underlying information and also that any messaging is clear and unambiguous for a non-technical audience.

A.7.10 PRIORITIES AND PROGRAMMING

A.7.10.1 Priorities and programming are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

A.7.10.2 Prioritisation should be grounded in sound asset management principles aligning the works programme with delivering the core objectives and managing risks.

A.7.10.3 The highway network should be viewed as a whole when developing priorities, rather than as a series of asset groups such as carriageways, footways, structures, lighting, etc. Consideration of priorities across asset groups as well as within them, can support optimal outcomes across the wider network. Prioritisation criteria may be informed by corporate objectives, risk appetite, network characteristics, funding context and stakeholder expectations.

A.7.10.4 Authorities should communicate the rationale behind prioritisation and programming decisions where appropriate, including the implications these decisions may have for service levels, network performance and user experience. Transparent communication can support understanding of trade-offs, constraints and investment priorities.

A.7.10.5 Authorities are encouraged to share and coordinate short-, medium- and long-term programmes of work with others undertaking works on the highway for several years in advance. This will provide greater certainty for them in terms of planning and investing in staff, resources and equipment.

A.7.10.6 Authorities should consider the need to minimise long term damage from the installation, renewal, maintenance and repair of underground apparatus, e.g., use of trenchless technology.

A.7.10.7 Adaptation requirements should be included within maintenance, renewal and improvement programmes according to priority. Attention should be given to route-level resilience and network function to maximise the benefit to road users and communities from resilience and adaptation investment.

A.7.10.8 Authorities should seek to align resilience, sustainability and preventative maintenance objectives with lifecycle planning and investment decisions, recognising that these considerations are often interdependent and may contribute to improved long-term value, reduced risk and lower whole-life costs.

RECOMMENDATION 30 - CROSS-ASSET PRIORITISATION
Authorities should prioritise investment across asset groups using evidence, risk and whole- life value considerations

RECOMMENDATION 31 - FORWARD WORKS PROGRAMME
Authorities should maintain a forward programme of works that supports efficient delivery, stakeholder coordination and long-term planning.

A.7.11 VALUE MANAGEMENT

A.7.11.1 Authorities should use value management as a process to prioritise the competing needs of schemes, identified through condition and economic prioritisation. It provides a structured, consistent and quality controlled approach for assessing the benefits of undertaking maintenance and the associated risks of not undertaking maintenance. The outcome should be a prioritised programme of schemes that will be entered into the Asset Management Framework. An example of this process is summarised in Part B of the HIAMG.

A.7.11.2 Before an authority may establish a value management regime, it should identify the frequency of review and the overall approach to be adopted. It is important that this takes into consideration the corporate and transport priorities within the authority and the overall context of the Asset Management Framework. For example, the regime should identify:

- Value management frequency - it is possible that some activities would be performed on a continuous basis. However, it is anticipated that a value management review would be held annually in order to determine the programme of works to be included in the Asset Management Framework for the following years; and

- Prioritisation criteria – the criteria considered under value management to be used to prioritise needs. It is important that the prioritised needs should align with the levels of service and the volumes of work identified in the Asset Management Framework.

A.7.11.3 Each category (e.g., safety, socio-economic and environmental, value for money, risk) is assigned a weighting to represent its importance in the delivery of the objectives of the authority and the context of the Asset Management Framework. While it is recognised that safety will be of primary importance, other issues should also be addressed; otherwise, the process may focus solely on safety and fail to address serviceability, sustainability and customer service. Clearly, assigning weights to the various criteria is not an easy task, particularly when it is evident that the preference on the criteria may be conflicting. A number of systems are available to establish preferences for a number of criteria, taking into account the views of interested stakeholders. One of these is the Analytic Hierarchy Process (AHP). The system should also provide robust justifiable scores.

A.7.11.4 The value management process is usually conducted in the form of workshops with a number of interested parties from various departments within the authority. The process involves the assessment of the performance of each of the programmed maintenance schemes under the various criteria. The outcome of the value management process should be an outline programme prioritised on scores obtained from the process. The work volumes and cost estimates should align with the work volumes and the funding estimates in the Asset Management Framework. The process should also highlight the risks related to the programme.

A.7.11.5 The overall aim of the value management process is to ensure that maintenance schemes are assembled into programmes of work that align with the objectives of the authority and deliver value for money. Value of these schemes will be maximised by co-ordination with other highway improvement programmes and integrated transport schemes on related parts of the network, thus minimising disruption to users and maximising benefits to the community.

VALUE ENGINEERING

A.7.11.6 Value engineering is a refinement of the value management process. It is a second stage process that is conducted on an individual scheme, to optimise both the design and construction phases. In principle, it reduces the risk associated with unforeseen issues at the time of scheme development. Value engineering also provides the authority with a further chance to explore potential opportunities for innovation. Key individuals from works teams and specialists from each discipline should be present during this process.

A.7.11.7 Value engineering should draw upon relevant technical evidence, local knowledge and operational experience to ensure that solutions are appropriate to the characteristics and performance of the network.

WORKS PROGRAMMING

A.7.11.8 Annual and multi-year programmes should build on lifecycle plans, condition data and pre-existing banks of potential schemes. Authorities may wish to maintain a pipeline of assessed and prioritised schemes that are not currently affordable within expected funding levels but could be progressed should additional funding become available. Authorities may wish to consider developing contingency schemes that are not be affordable under expected levels of investment but could be funded by additional funds that may become available at relatively short notice.

A.7.11.9 Authorities should consider seasonal factors, such as optimal periods for surfacing, drainage works or vegetation management. Geographic sequencing can reduce mobilisation costs and network disruption. Integrating works across asset types, for example combining resurfacing with drainage upgrades, signals improvements or active travel enhancements, often delivers better value and reduces repeat interventions.

A.7.11.10 Authorities should seek to incorporate preventative maintenance activities within programmes of work where appropriate. Early intervention and preservation techniques can help extend asset life, reduce whole-life costs, minimise disruption and reduce reliance on reactive maintenance, which is often associated with higher lifecycle costs and poorer long-term outcomes. The selection of treatments should be informed by evidence such as asset condition, deterioration mechanisms, traffic loading and environmental factors to support durable and effective long-term outcomes.

A.7.11.11 Utility works should be integrated into programme planning where possible to avoid conflicts, minimise disruption and exploit opportunities for shared excavations or joint works.

A.7.11.12 Engagement with developers and planning authorities helps align developer-funded highway works with the broader highway programme. This may include:

- Section 106 agreements (Town and Country Planning Act 1990) and Section 278 agreements (Highways Act 1980) in England and Wales;
- Section 75 planning obligations (Town and Country Planning (Scotland) Act 1997) and agreements under the Roads (Scotland) Act 1984 in Scotland; and
- equivalent developer contribution and road adoption arrangements in Northern Ireland.

A.7.11.13 Authorities should also consider supply chain capacity, inflation, cost uncertainty and risk allowances when finalising programmes.

SECTION A.8 SUSTAINABILITY

A.8.1 OVERVIEW



Figure 11 – Sustainability

A.8.2 INTRODUCTION

A.8.2.1 Authorities will have their own approach to sustainability and relevant aspects should form part of their asset management strategy. This should reflect a balance of environmental, social and economic considerations (the three pillars of sustainability), and how these are embedded across the full lifecycle of highway infrastructure. Sustainability objectives can be integrated into lifecycle decision-making, recognising that choices relating to materials, treatments and interventions can influence environmental impacts, resource consumption, whole-life costs and long-term asset performance.

A.8.2.2 The United Nations Sustainable Development Goals (UNSDGs) sets out 17 goals aimed at achieving sustainable outcomes across the three pillars, and the guidance Strategic road network and the delivery of sustainable development, includes priority areas for shared action in the UK, including:

- Reduction in reliance on private car travel and location of development in sustainable places
- Promotion of walking, wheeling, cycling and public transport as the natural first choice
- Support to transport decarbonisation and future technologies
- Integration of planning decisions with wider environmental and design-quality objectives

A.8.2.3 The Well-being of Future Generations (Wales) Act 2015 describes in further detail the environmental, social and economic pillars of sustainability and how this is applied in Wales.

A.8.2.4 Authorities and their partners are pivotal to delivering sustainable communities and to provide focus. Highway infrastructure has a significant role to play, and impact to make, in the

achievement of sustainable development. Authorities may develop a policy for sustainable development in highway maintenance, forming the linkage between the strategic objectives of the authority at the highest level and the materials, practices and processes used on the highway network.

A.8.2.5 Sustainable development for highway infrastructure involves working within environmental limits whilst achieving a sustainable economy, and is encapsulated as:

- social progress which recognises the needs of everyone;
- effective protection of environment;
- prudent use of natural resources; and
- maintenance of high and stable levels of economic growth and employment.

A.8.3 ENVIRONMENTAL CONSIDERATIONS

A.8.3.1 The following environmental strategies provide high-level direction across the UK:

- England – Environmental Improvement Plan (EIP) 2025
- Northern Ireland – Environmental Improvement Plan for Northern Ireland
- Scotland – Draft Environment Strategy
- Wales – National Resources Policy and Environment (Wales) Act 2016

A.8.3.2 In England, key environmental bodies are the Environment Agency (EA), Department for Environment, Food and Rural Affairs (DEFRA), Office for Environmental Protection (OEP) and Natural England.

A.8.3.3 Natural Resources Wales is the statutory drainage and flood defence authority for Wales.

A.8.3.4 NatureScot and Scottish Environment Protection Agency are the statutory bodies in Scotland that have responsibility for the environment.

A.8.3.5 Environment matters in Northern Ireland are dealt with by several departments: Department for Communities (DfC), Department for Infrastructure (DfI) and Department of Agriculture, Environment and Rural Affairs (DAERA).

ENVIRONMENTAL MANAGEMENT

A.8.3.6 In pursuing the objective of network sustainability one of the issues will be maximising the environmental contribution made by highway infrastructure. An Environmental Management System to ISO 14000 will help address the range of relevant issues affecting the environment including:

- Carbon costs and energy reduction
- Noise
- Materials utilisation
- Waste management and recycling

- Air quality and pollution control
- Nature conservation and biodiversity
- Environmental intrusion

A.8.3.7 Environmental sustainability focuses on protecting and enhancing natural systems, reducing harmful impacts and improving resilience to long term environmental change. It includes carbon management, climate adaptation, biodiversity, natural capital, efficient resource use, nature-based solutions and minimising pollution.

A.8.3.8 Authorities should accommodate and facilitate litter picking and street cleansing activities where these are the responsibility of other authorities.

ENVIRONMENTAL CONSULTATION AND ASSESSMENT

A.8.3.9 Environmental issues cover a very wide range, each of which is a specialist area and on which experience and good practice continue to develop. There will also be a wide range of local environmental and conservation groups with specialist interests. Although engagement with such local groups will present particular challenges to highway infrastructure maintenance managers, including the management of differing points of view, perseverance is likely to bring benefits both in terms of advice and environmental competence, greater public understanding of highway maintenance issues, and opportunities to develop locally appropriate and supported solutions.

A.8.3.10 Environmental assessments may be required for certain works and authorities should be clear on the circumstances where such assessment is necessary.

ENVIRONMENTAL INTRUSION

A.8.3.11 Depots and areas for materials storage will provide the most visible evidence of the extent of environmental awareness in the service. Every effort should be made to ensure that they are located, designed, maintained and operated to the highest practicable environmental standards. In many cases these standards will be required as a condition of planning, but planning conditions are not able to address all operational issues and should therefore be considered as a minimum.

A.8.3.12 Poorly managed materials and temporary storage areas can rapidly be adopted by others as illegal waste dumps for which authorities may become liable. In any event such poorly managed storage areas would clearly be incompatible with the objective of sustainability.

A.8.3.13 Increasing emphasis on quality of public space and street scene brings increased importance to the avoidance of ‘clutter’. Excessive and redundant signs and other street furniture can contribute to environmental intrusion and adversely affect overall streetscape. Signing which is inappropriate or no longer necessary is, at best, intrusive and, at worst, a distraction and risk to users. Opportunities should be taken to remove or simplify redundant signing wherever possible in conjunction with planned maintenance works.

A.8.3.14 The Department for Transport’s Local Transport Note 1/08 Traffic Management and Streetscape aims to enhance streetscape appearance by encouraging designers to minimise the various traffic signs, road markings and street furniture associated with traffic management schemes and hence minimise clutter.

A.8.3.15 Authorities should accommodate and facilitate litter picking and street cleansing activities where these are the responsibility of other authorities.

A.8.3.16 Authorities may refer to guidance from Plantlife on the management of roadside verges.

MATERIALS, PRODUCTS AND TREATMENTS

A.8.3.17 Materials, products and treatments used for highway maintenance should meet required standards for effectiveness and durability but should also make a positive contribution to the public realm in terms of safety, functionality and aesthetics. Consideration should also be given to whole-life sustainability impacts, including embodied carbon, resource consumption and opportunities to use lower-carbon materials where appropriate.

A.8.3.18 There are a wide range of technical specifications for materials, products and treatments for highway works. Some of these are obligatory, but many provide for significant discretion in their application to particular circumstances. It is important that specifications are fit for purpose otherwise they can increase cost and may also reduce the potential for sustainability, for example by precluding the use of locally sourced materials.

A.8.3.19 The Planning (Listed Buildings and Conservation Areas) Act 1990, or equivalent, provides for the protection of conservation areas that have special historical interest. The status can influence the processes required for maintenance in such areas.

A.8.3.20 Historic England, with assistance from the Department for Transport and Chartered Institution of Highways and Transportation, has published Streets for All, which provides advice for highway and public realm works in historic places. This includes how solutions to common highway problems can be achieved without harm to the valued character of places. The underlying principles are to reduce clutter, coordinate design and to reinforce local character, while maintaining safety and accessibility for all.

A.8.3.21 Authorities may consider identifying a hierarchy of streets and spaces to prioritise the use of more expensive, natural materials. Each area should have a palette of materials appropriate to its location, which allows new and old work to relate to one another. This could be a subset of the network hierarchies referred to in Section A.4 of this Code.

A.8.3.22 SCOTS has published a Natural Stone Surfacing - Good Practice Guide on how to select the right stone materials for natural stone paving.

A.8.3.23 The Road Surface Treatments Association (RSTA) has developed numerous guidance documents that aim to raise awareness of the range and benefits of road surface treatments, and to encourage product and process innovation. Many of these have been produced in conjunction with the ADEPT Soils and Materials Design Group, and cover topics including service lives, surface dressing, innovative patching products and systems, high friction surfacing, structural road recycling, crack sealing and slurry surfacing, geosynthetics and steel meshes, asphalt preservation systems, grouted macadam, retexturing and ironwork installation.

A.8.3.24 Best Practice Guidelines for Specification of Modern Negative Texture Surfaces provides a methodology for site evaluation and material selection to ensure that the right material is installed in the right site together with a structural approach to the factors which may have a bearing on distress mechanisms.

QUALITY MANAGEMENT AND SECTOR SCHEMES

A.8.3.25 Quality management systems are intended to encourage consistent management and organisational processes. If correctly and flexibly applied, they should support a culture of competence, consistency and enable innovation to flourish.

A.8.3.26 Highway maintenance operations can be aligned to a quality assurance regime to facilitate continuous improvement, preferably based on the principles of ISO 9001 that integrates systems of client and service provider.

A.8.3.27 The quantity and cost of maintenance products and materials is relatively easy to determine, but quality can be very variable. A number of National Highway Sector Schemes (NHSS) have been developed to improve the consistency of the products and ensure that they satisfy purchaser requirements. Some sector schemes are administered by the United Kingdom Accreditation Service (UKAS).

A.8.3.28 The Highway Authorities Product Approval Scheme (HAPAS) provides a means for manufacturers and suppliers to obtain approval for the use of innovative and proprietary products within an agreed performance regime.

A.8.3.29 There are also a number of relevant documents published by the Road Surface Treatment Association and ADEPT.

MATERIALS UTILISATION

A.8.3.30 Highway maintenance consumes significant quantities of materials, and policies for materials purchasing and utilisation can make a considerable contribution to sustainability.

A.8.3.31 Authorities should consider, wherever practicable and cost effective, to maximise the use of:

- Local materials to minimise transport costs, support the local economy, and to maintain local character. This will be of particular importance for the use of visible materials in conservation areas
- Products made from recycled materials and lower-carbon alternatives, provided there is no impact on necessary performance levels or the environment.

A.8.3.32 Sustainable purchasing and materials utilisation may have cost implications and authorities should balance these against the environmental benefits. They should also consider carefully whether some limited reduction in material specification might be acceptable in order to achieve a more sustainable outcome without excessive cost.

WASTE MANAGEMENT AND RECYCLING

A.8.3.33 Authorities may have statutory or other indicators and targets relating to waste disposal and it is important that highway infrastructure maintenance provides support to these so far as practicable.

A.8.3.34 The Waste and Resources Action Programme (WRAP) is a government-funded programme established to promote resource efficiency and provide information resources such as The Quality Protocol for Recycled Aggregates.

A.8.3.35 Authorities should seek wherever practicable and cost effective to:

- Retain and reuse materials on site to avoid environmental implications of transport and disposal.
- Maximise the value of reused material through responsible reuse and recovery pathways, rather than utilising it for low-grade purposes or disposal where this can reasonably be avoided.
- Make use of 'recycle in place' processes in appropriate situations.
- Support recycled market development through the purchase of recycled products wherever possible.
- Ensure that the quantity of material that cannot be reused or recycled is minimised and disposed of at licensed sites.

A.8.3.36 Opportunities for improved sustainability through recycling, reuse and circular-economy practices are increasing. Advances in modular design, component standardisation, and more easily recoverable materials mean that emerging technologies can support more sustainable lifecycle management. Integrating these technologies into asset strategies can help assets remain adaptable, efficient, and aligned with evolving environmental expectations and industry standards.

AIR QUALITY AND POLLUTION CONTROL

A.8.3.37 Some maintenance operations have the potential to cause noise, air or water pollution and authorities should take particular account of statutory requirements. Advice from environmental health departments, the Environment Agency (EA) or equivalent, should also be sought where necessary. In some cases, environmental inconvenience to the community may be inevitable, but authorities should seek to mitigate this wherever practicable, for example by phasing and scheduling of works to avoid sensitive periods and potentially difficult weather conditions.

A.8.3.38 Storage areas for fuel, salt and other materials, both in depots and on site, have the potential for pollution and care should be taken in siting them. Permanent and temporary storage areas should be sited and managed in accordance with requirements of the Local Planning Authority and the EA. They should not be sited where they could cause damage to landscape or nature conservation or have the potential to pollute watercourses or groundwater.

NATURE CONSERVATION AND BIODIVERSITY

A.8.3.39 Highway verges and the wider 'soft estate' both have implications for conservation and biodiversity. Specialist advice should be sought on the management of these areas to achieve the correct balance between safety, amenity, nature conservation and value for money. Where landscape management plans, biodiversity action plans, or environmental databases exist they should be consulted before any work is carried out.

A.8.3.40 Authorities should also draw on wider sector guidance to strengthen biodiversity outcomes. Relevant resources include Plantlife's proposed approaches to verge and grassland management, the CIHT Green & Blue Infrastructure guidance which provides good-practice principles for integrating nature into highway environments, and, where applicable, national or devolved strategies such as the Welsh Nature Recovery Plan. These sources can support proportionate, locally-appropriate interventions that enhance ecological value while maintaining safety and serviceability.

A.8.3.41 Certain named species and habitats are protected by law, and all highway infrastructure maintenance works must comply with these requirements. Where designated sites are within or adjacent to the highway boundary, advice should be sought from Natural England, or equivalent, or local wildlife trusts, etc. Legislation requires that Natural England, or equivalent, are informed where important habitats and species may be affected, such as the removal of trees used as bat roosts. This should be done well in advance of maintenance work to allow for seasonal factors.

A.8.3.42 For England, the Biodiversity Net Gain (BNG) Requirements was introduced under the Environment Act 2021 and mandate that developers must deliver a minimum 10% biodiversity net gain, demonstrated through a biodiversity net gain plan and secured for at least 30 years.

A.8.3.43 In Scotland, Wales and Northern Ireland, the BNG requirements do not apply, however biodiversity is protected by law, and it remains best practice to have a positive effect on biodiversity. The following legislation and frameworks across the UK embed biodiversity protection and net gain:

- Scotland: Scottish Biodiversity strategy to 2045: Tackling the Nature Emergency in Scotland
- Wales: Planning Policy Wales and the Environment (Wales) Act 2016
- Northern Ireland: Wildlife and Natural Environment Act (Northern Ireland) 2011

A.8.3.44 Authorities should also recognise that trees, vegetation and other nature-based solutions can contribute to climate adaptation, surface water management, biodiversity enhancement and improvements to the wider environment. In urban areas roadside trees have a particular landscape value, are often highly regarded by the community, and should be carefully managed. Authorities may develop a policy for the installation, subsequent condition inspection and maintenance of highway trees. Care should be taken to avoid damage to trees during highway infrastructure maintenance and improvement works and guidance for the planning, installing and maintenance of utility services in proximity to trees issued by NJUG should be followed.

A.8.3.45 The Tree Design Action Group (TDAG) has produced a range of good practice guidance including Trees in Hard Landscapes.

RECOMMENDATION 32 - MATERIALS AND TREATMENTS
Authorities should select materials and treatments that are appropriate to asset needs and support whole-life value and sustainability objectives.

RECOMMENDATION 33 - ENVIRONMENTAL IMPACT AND BIODIVERSITY
Authorities should seek to minimise environmental impacts associated with both existing and future highway infrastructure and support biodiversity enhancement where appropriate.

A.8.4 FACTORS TO CONSIDER FOR SUSTAINABILITY

A.8.4.1 Tables below provides factors for consideration when undertaking a sustainability appraisal either of individual services or schemes or of managing the highway network as a whole. Actions to be taken to address each of the issues are not specified but should be determined locally taking into account local priorities and constraints. The list is not exhaustive but includes several of the key issues that may need to be addressed.

Table 11: Factors to Consider for Sustainability

Issue	Check
Local Economy	
Viability and vitality	Does the service or scheme affect the vitality and viability of the local community?
Local employment	What contribution is made to local employment by the service or scheme?
Local materials	Does the service or scheme fully make use of opportunities to use local materials?
Community Value	
Community engagement	Does the service engage well with all sections of the local community?
Meeting community needs	Does the service or scheme meet the needs of all sections of the local community?
Quality of public space	Does the scheme make an effective contribution to the quality of public space?
Noise Pollution	
Offices and depots	Are all opportunities realised to minimise noise pollution at offices and depots?
Works sites	Are all opportunities realised to minimise noise from vehicles and plant at works sites?
Traffic	Are locations of high traffic noise identified, and mitigation measures included in schemes where appropriate?
Air Pollution	
Vehicles	Are there a policy and programme for vehicle replacement and modification to minimise air pollution (with targets)?
Plant and machinery	Are there a policy and programme for plant replacement and modification to minimise air pollution (with targets)?
Water Management	
Offices and depots	Are there arrangements in all offices and depots to minimise water use (with targets)?
Works sites	Are there arrangements in all works sites to avoid water wastage (with targets)?
Pollution control	Are there policies and procedures in place at all depots and works sites (with targets) to avoid water pollution especially from oil spills and salt leachate?
Flood management	Are locations of high flood risk identified, and mitigation measures included in schemes where appropriate?
Visual Intrusion	
Depots	Are all depots located and designed to minimise visual intrusion?
Works sites	Are all works sites located to minimise visual intrusion?

Materials Utilisation	
Location	Do the materials selection criteria give priority to local sources?
Design	Does the design process include consideration of minimum materials?
Performance	Do the design criteria allow for reduced specification to mitigate environmental affects?
Lower-carbon materials	Have opportunities to use lower-carbon materials been considered where appropriate, taking account of performance, durability and whole-life outcomes?
Waste Management	
Minimisation	Do the design process and criteria facilitate the designing out of waste?
Reuse	Does the design process encourage the use of re-used materials as the first option?
Recycling	Does the design process encourage the use of recycled materials as the second option?
Energy Management	
Offices and depots	Are there policies and procedures in place at all offices and depots (with targets) to minimise energy usage?
Works sites	Are there policies and procedures in place at all offices and depots (with targets) to minimise energy usage?
Schemes	Do all work and schemes maximise the use of cold rather than hot technology?
Fuel sources	Are opportunities being considered to improve sustainability through the selection of appropriate fuels, alternative energy sources and more efficient plant, vehicles and equipment?
Biodiversity	
Policies	Has the service adopted biodiversity policies and procedures?
Trees and landscaping	Are all policies and practices for maintenance of trees and landscaping designed to maximise nature conservation value?
Works programmes	Are works programmes adjusted to assist biodiversity requirements?
Nature-based solutions	Have opportunities for nature-based solutions been considered where appropriate?

A.8.5 CARBON MANAGEMENT

PURPOSE AND SCOPE

A.8.5.1 Management of carbon can support authorities in not only reducing emissions but also increasing efficiency, reducing the use of resources, generating energy savings, realising cost savings and contributing to wider environmental outcomes.

A.8.5.2 Authorities may maintain corporate carbon reduction commitments in response to national legislation on achieving net zero emissions. The approach should be proportionate and transparent and applied in a manner consistent with the authority's wider objectives.

A.8.5.3 Whole life carbon management addresses this across the strategy, planning, design, construction, maintenance and operation of highway infrastructure. The source of carbon emissions should also be considered:

- Scope 1 cover activities controlled directly by the authority
- Scope 2 relate to purchased electricity or energy
- Scope 3 cover wider supply chain and outsourced activity.

A.8.5.4 Authorities should recognise that the distribution of emissions between Scope 1, Scope 2 and Scope 3 can vary significantly depending on delivery models, organisational arrangements and the extent of outsourced activities. Directly delivered services may have proportionately higher Scope 1 emissions, whereas outsourced models may have a greater proportion of emissions captured within Scope 3. These differences should be considered when comparing carbon performance between authorities.

A.8.5.5 PAS 2080 provides a common framework for all infrastructure sectors and value chain members on how to manage whole life carbon when delivering infrastructure assets and programmes of work:

- PAS 2080:2023 Carbon Management in Infrastructure
- PAS 2080 Guidance Document

A.8.5.6 Further guidance on whole life carbon management is available from the National Infrastructure and Service Transformation Authority (NISTA), which has published a Whole Life Carbon Management handbook to support the assessment and management of carbon emissions across the lifecycle of infrastructure assets and programmes.

SOURCES OF CARBON EMISSIONS ACROSS THE HIGHWAY LIFECYCLE

A.8.5.7 Carbon emissions arise from a range of activities associated with the lifecycle of highway assets. Understanding these sources enables authorities to plan interventions effectively, identify and prioritise opportunities for carbon reduction and consider the wider life cycle implications of their decisions.

A.8.5.8 Network operation can influence emissions through road user behaviour, congestion and temporary traffic management. Although authorities do not control vehicle movements directly, operational decisions can affect user related emissions depending on how works are sequenced and managed. Authorities can influence user emissions though through the management of active travel infrastructure and highway infrastructure related to sustainable transport (e.g. buses or EVs).

A.8.5.9 Construction, renewal and maintenance activities generate emissions from plant and equipment, materials processing, energy use on site and the effects of mobilisation. Reactive and emergency works can increase emissions where activity is unplanned or requires repeated visits.

A.8.5.10 Materials contribute significantly to lifecycle emissions, particularly where extraction, processing and transport are energy intensive. Material choices, recycled content, opportunities for reuse and the management of waste and surplus material influence total emissions. Supply chain logistics, including haulage distance and vehicle type, also strongly influence carbon impacts of materials.

A.8.5.11 Energy use within depots, workshops, offices and infrastructure contributes to operational emissions. Lighting, signals and other electrical assets may represent a substantial proportion of an authority's footprint. Fleet emissions arise from operational vehicles, winter service activity and on-site plant and can be affected by fuel type, vehicle selection and available infrastructure.

A.8.5.12 Authorities may choose to include other organisational functions within their carbon reporting scope where this aligns with wider objectives.

CARBON ASSESSMENT AND QUANTIFICATION

A.8.5.13 Carbon assessment supports decision making, business case development and programme planning by helping to understand and quantify emissions arising from Scope 1, Scope 2 and Scope 3 activities across the asset lifecycle. Assessments should be proportionate to the activity in question and presented clearly so that assumptions and limitations can be interpreted with confidence.

A.8.5.14 The scope of an assessment may include the activities, lifecycle stages and time horizons being considered. Methodologies may involve calculators, datasets or tailored approaches. Emission factors, assumptions and any known limitations should be identifiable so that results can be interpreted appropriately. Tools vary in coverage and may not represent local conditions or specialist materials, so results should be viewed as indicative. Depending on the scope of the carbon assessment, it is likely that data will be required from designers, suppliers, contractors or other sources, which need to be identified early in the process.

A.8.5.15 Greater consistency can be achieved by recording assumptions, comparing outputs with benchmarks or alternative approaches where feasible and applying similar methods across comparable activities. It is important 'not to let perfect be the enemy of the good'. Using carbon assessment to identify the decisions that have the largest carbon impact will help prioritise actions and identify where the best quality data are required. As data quality improves, authorities can refine methodologies and adopt updated information.

A.8.5.16 A whole life perspective helps ensure that decisions do not favour short-term gains at the expense of increased impacts over time. Choices relating to materials, interventions or treatments should take account of both immediate and longer-term implications.

A.8.5.17 Local Transport Quantifiable Carbon Guidance (QCG) has been produced by the Department for Transport, which describes methods of carbon analysis and how these can inform local transport strategies and schemes.

A.8.5.18 Additional guidance on assessment methodologies is available through the Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment Standard, which supports a consistent approach to the quantification and assessment of whole life carbon impacts.

CARBON REDUCTION: PRINCIPLES AND HIERARCHIES

A.8.5.19 Authorities may adopt a structured approach to identifying opportunities to reduce carbon. Avoiding emissions is often the most effective means of reduction and may involve minimising unnecessary interventions, aligning works to reduce repeated visits or managing network impacts to avoid extended delays.

A.8.5.20 Where works proceed, emissions may be reduced by improving design efficiency, selecting durable materials, optimising logistics and ensuring efficient use of plant and equipment. Coordinated programming can reduce the cumulative impact of multiple interventions. Although carbon hotspots will exist, significant long-term reductions will probably require action to be taken on many fronts, including Scope 1, 2 and 3 emissions across the full life cycle.

A.8.5.21 Substitution offers further opportunities by replacing higher carbon products, fuels or energy sources with lower carbon alternatives. This may include selecting materials with lower embodied carbon, increasing the use of recycled content, transitioning fleet and plant to alternative fuels or sourcing renewable energy for depots and lighting.

A.8.5.22 Offsetting may be applied where residual emissions remain and where such measures align with organisational policy. These are most effective when applied transparently and following consideration of reasonable opportunities to reduce emissions.

A.8.5.23 Nature-based solutions may provide opportunities to support carbon reduction, climate adaptation, biodiversity enhancement, water management and wider environmental outcomes. Their application should be proportionate to the intended outcomes and informed by the expected environmental benefits.

GOVERNANCE, PEOPLE AND CULTURE

A.8.5.24 Authorities can strengthen carbon management by aligning it with existing governance arrangements so that carbon considerations form part of routine decision making. Embedding carbon expectations within strategy development, scheme approval and programme oversight helps ensure consistent application across the organisation.

A.8.5.25 Capability can be supported through training on carbon literacy, lifecycle assessment, data management and sustainable material selection. This helps staff interpret information consistently and apply carbon considerations within their roles.

A.8.5.26 Available sector resources and collaborative initiatives can support capability development and carbon reduction. Examples include the ADEPT Carbon Leadership Programme, ADEPT Live Labs 2 and the Centre of Excellence for Decarbonising Roads (CEDR).

A.8.5.27 The Department for Transport has published updated carbon management plan guidance, a supporting template and new transport infrastructure carbon benchmarks to assist with the development of proportionate approaches to carbon management.

A.8.5.28 Within authorities, carbon management may require input from across highways teams, corporate functions such as procurement, and senior leadership including members.

A.8.5.29 Externally, collaboration with consultants, contractors, materials suppliers, academic institutions and relevant industry bodies can support the evaluation of emerging materials and technologies,

improve data availability and contribute to more efficient working practices. Collaboration with other highway authorities may help with carbon benchmarking, sharing risk in trialling low carbon innovations, and developing economies of scale through larger markets for suppliers of low carbon offerings.

COMMERCIAL AND CONTRACTUAL CONSIDERATIONS

A.8.5.30 Commercial arrangements influence the ability of authorities to reduce carbon. Specifications, tender evaluation criteria and contract requirements can reflect expectations for carbon reporting, data sharing, product information and reduction proposals. Authorities may also make use of sector guidance and procurement tools that support the integration of carbon reduction objectives within commercial arrangements, such as Liverpool City Council's Sustainable Procurement and Contracting Toolkit.

A.8.5.31 Requirements should be developed with a clear understanding of potential cost implications for the authority, and thus the impact this may have on delivery of other core objectives. This may be in the form of efficiencies that lead to reduced costs (e.g., reduced energy consumption), a premium on top of more traditional ways of working (e.g., certain new materials), or a mixture of these across the wider services and/or products being procured.

A.8.5.32 Suppliers may be required to provide carbon information for materials or activities to demonstrate alignment with the authority's objectives.

MONITORING AND REPORTING

A.8.5.33 Integrating carbon within established processes allows impacts on the network and its users to be assessed alongside the wider core objectives. Choices may require authorities to balance different outcomes, for example where a material with lower embodied carbon may have a shorter service life or where actions that reduce operational emissions influence initial investment or risk profiles. Considering these implications over the whole life of the asset and documenting the reasoning can support transparency and alignment with organisational objectives.

A.8.5.34 Incorporating reporting and review within existing governance arrangements supports the identification and application of lessons learned from completed works and helps refine practice and improve future outcomes.

RECOMMENDATION 34 - WHOLE-LIFE CARBON
Authorities should consider whole-life carbon emissions associated with the management of highway infrastructure and options to reduce these.

A.8.6 SOCIAL CONSIDERATIONS

A.8.6.1 Social sustainability is about making sure that communities and societies can thrive and continue to exist in a healthy, fair, and equal way focussing on community wellbeing, safety, accessibility and social value. Social sustainability is essential for resilient, thriving societies and long-term economic growth.

A.8.6.2 Highway infrastructure should support safe and healthy environments, including contributions to local identity and placemaking to support communities.

A.8.6.3 Authorities should consider accessibility and inclusivity in planning, design, maintenance and operation. Barriers should be identified and removed wherever possible. Effective engagement with users provides greater understanding and helps ensure the needs of vulnerable users are addressed.

A.8.6.4 Community engagement is essential for proportionate, transparent decision making. Engagement with specialist interest groups, community organisations and local bodies can improve public understanding, shape priorities and enhance communication effectiveness

A.8.6.5 Authorities should promote safe, fair and skilled workforce practices, including responsible supply chain management, good employment practices and long-term skills development.

SOCIAL VALUE

A.8.6.6 Social Value is a key consideration in procurement, in line with the Procurement Act 2023, which came fully into force in February 2025. Alongside the Act, Procurement Policy Note 002 (published February 2025) introduced a new Social Value Model for central government bodies. Critically, PPN 002 sets a minimum 10% weighting for social value in central government contract evaluations. In practice, many contracting authorities already exceed this. Social value outcomes may be monitored and reported in line with contract requirements to ensure that projects deliver wider societal benefits beyond their technical function.

A.8.6.7 Beyond this, highway activities can support social value outcomes such as employment opportunities, skills development, environmental enhancement, public realm improvements and strengthened community cohesion.

A.8.6.8 Social value objectives can be considered alongside the procurement and delivery principles set out in Section A.9 Procurement and Delivery. Social value considerations may also inform asset management decision-making where appropriate, including investment planning and scheme prioritisation. Decisions may take account of the balance between social value, cost, risk, safety, affordability and other organisational objectives.

HISTORIC ENVIRONMENT

A.8.6.9 There are currently 25 World Heritage sites within the UK designated by UNESCO (United Nations Educational, Scientific and Cultural Organization).

A.8.6.10 Although these sites have no greater legislative protection, local planning authorities are encouraged to have management plans in place. Planning applications for works in these areas are likely to require greater consultation with Historic England and thus lengthier programmes should be accommodated. Details of the sites in England are provided on the Historic England website.

A.8.6.11 In Scotland, Historic Environment Scotland has been set up by the Scottish Government to undertake a similar role to that of Historic England for ancient monuments. The same legislation is applicable for ancient monuments, except for listed buildings. They are covered by Planning (listed buildings and conservation areas) (Scotland) Act 1997

A.8.6.12 Cadw, created in 1984, is the historic environment service within the Welsh Government and deals with the preservation of ancient monuments in Wales.

A.8.6.13 The Department for Communities, Historic Environment Division, established in May 2016 is the authority in NI for determining conservation matters.

RECOMMENDATION 35 - SOCIAL SUSTAINABILITY
Authorities should consider the impacts of decisions on accessibility, inclusion, health, wellbeing and community outcomes.

RECOMMENDATION 36 - HERITAGE ASSETS
Authorities should recognise and appropriately manage the historic, cultural and environmental significance of heritage assets.

A.8.7 ECONOMIC CONSIDERATIONS

A.8.7.1 Economic sustainability ensures that infrastructure supports long-term economic growth, productivity and public value, whilst balancing environmental responsibility and social factors.

A.8.7.2 Authorities should articulate the socio-economic value of the network to support strategy and investment decisions. This includes the contribution of infrastructure to employment, goods movement, services, education and social opportunities.

A.8.7.3 The DfT report Economic appraisal for investing in local highways maintenance provides a broad review of the economic case for maintaining local highways, supported by recommendations to better support future funding decisions.

A.8.7.4 Whole life costing can help inform and communicate the medium- and long-term impacts of decision making, alongside short-term considerations, by taking account of factors such as materials selection, treatments, and procurement and considering the costs associated with emissions, disruption and safety.

A.8.7.5 Productivity improvements can be supported through improved operational processes and lean principles, innovative delivery models, and appropriate use of technology such as digital tools and automation.

A.8.7.6 Sustainable and resilient supply chains can be supported through the use of small-to-medium enterprises and local sourcing where feasible, together with longer-term supplier relationships that encourage innovation and resilience.

A.8.7.7 Economic sustainability and resilience also depend on having the right skills in the right roles. Staff availability, competence and training needs can influence service delivery, particularly as new technologies and carbon assessment methods emerge. Investment in upskilling and professional development can help teams deliver services efficiently and interpret carbon data effectively. Where specialist expertise is limited, tasks may be allocated across internal teams or external providers to support continuity and value for money.

A.8.7.8 Resilience and adaptation form an important component of economic sustainability. Disruption can affect access to employment, freight, public services, supply chains and business continuity, creating wider economic impacts. Investment decisions can therefore take account not only of asset condition, but also of its contribution to maintaining network function and reducing future disruption.

RECOMMENDATION 37 - ECONOMIC SUSTAINABILITY
Authorities should consider whole-life value and the short, medium and long-term economic impacts on both the authority and the communities it serves during decision-making, planning and delivery.

SECTION A.9 PROCUREMENT AND DELIVERY

A.9.1 OVERVIEW

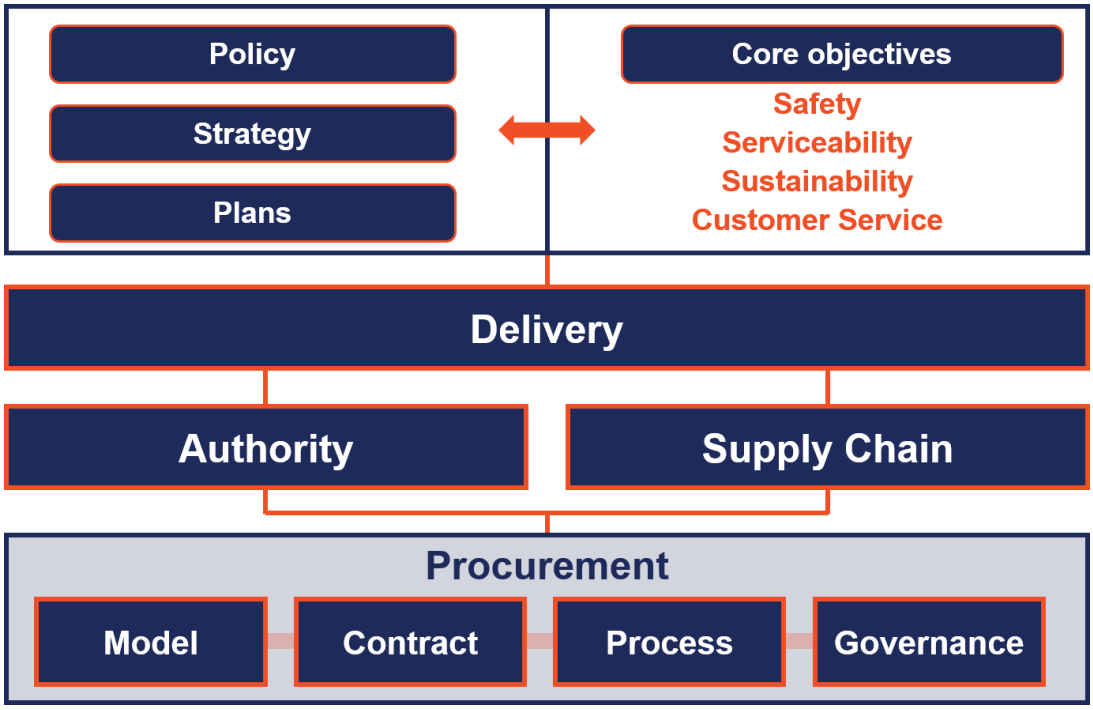


Figure 12 – Procurement and Delivery

A.9.2 CONTEXT FOR PROCUREMENT

A.9.2.1 Commercial decisions should be informed by local transport plans, asset management strategies and corporate priorities, helping to ensure that procurement and delivery support the outcomes authorities seek to achieve. Funding profiles, including the balance of capital and revenue budgets and the level of certainty over future funding, also influence contract design and duration.

A.9.2.2 Authorities must comply with applicable procurement legislation, including the Procurement Act and associated regulations, as well as any retained elements of the Public Contracts Regulations where legacy contracts remain relevant. These frameworks set out the rules for competing, awarding and managing public contracts and emphasise fairness, transparency, equal treatment and value for money.

A.9.2.3 The Procurement Act 2023 established a new framework for public procurement, placing greater emphasis on transparency, public benefit, value for money, integrity and the removal of barriers to participation. Procurement and delivery arrangements should reflect both the requirements and the principles of the legislation.

A.9.2.4 The Government's Transforming Public Procurement programme provides supporting guidance on implementing procurement reform and promotes a simpler, more flexible and transparent procurement regime that encourages innovation, improves commercial outcomes and delivers greater public value. Authorities may wish to consider this guidance when developing procurement and delivery strategies.

A.9.2.5 Procurement and delivery must support compliance with duties contained in highways, traffic management and street works legislation. This includes maintenance responsibilities, network management requirements, coordination with statutory undertakers and obligations relating to traffic regulation.

A.9.2.6 Procurement and delivery should reflect broader legal obligations, including but not limited to social value considerations as highlighted in A.8.6, equality duties, preventing modern slavery, maintaining high standards of health and safety, protecting the environment, supporting resilience, and complying with data protection and cyber security regulations.

A.9.2.7 Clear governance arrangements, including financial approvals, audit trails, assurance procedures and risk and probity controls, can support compliant, defensible procurement activity and the delivery of public value.

A.9.2.8 Organisational change can affect contractual arrangements, asset information, governance, service delivery and supplier relationships. These factors may be relevant to procurement, transition and mobilisation planning.

A.9.3 DELIVERY AND OPERATING MODELS

A.9.3.1 Authorities may choose from a range of delivery models, depending on their needs, capabilities and risk appetite. Selection of delivery models should reflect the scale, complexity, duration, risk profile and objectives of the service or programme being delivered. Factors such as organisational capability, market maturity, stakeholder requirements, desired allocation of risk and opportunities for collaboration should be considered when determining the most appropriate delivery model.

A.9.3.2 Delivery may be affected by local operating conditions, including utilities activity, traffic management requirements, limited access windows, stakeholder expectations, adjacent developments and the need to coordinate with other interventions. Delivery models should be sufficiently flexible to manage these constraints whilst supporting the efficient delivery of highway services.

A.9.3.3 Delivery and operating models should support resilience and adaptation. In-house, outsourced, alliance and term service models should provide sufficient capability, flexibility and authority to prepare for, respond to and recover from hazard events.

IN-HOUSE DELIVERY

A.9.3.4 Direct labour organisations and in house professional services teams may deliver works, inspections, technical services or customer service functions. This model offers control and flexibility but depends on internal capability, resources and cost competitiveness.

LOCAL AUTHORITY TRADING COMPANIES

A.9.3.5 Teckal compliant bodies, where authorities exercise control similar to that over their own departments and which operate predominantly for those authorities, and local authority trading companies may deliver services while maintaining local control and enabling wider commercial activity where appropriate.

PROFESSIONAL SERVICES CONTRACTS

A.9.3.6 Consultants may provide design, asset management, advisory, digital and/or programme support services.

TERM MAINTENANCE CONTRACTS

A.9.3.7 Traditional maintenance contracts supported by standard forms may be adopted. Variants include measure and value, lump sum, target cost and performance-based arrangements. Authorities may adopt different variants depending on the balance of risk, certainty and flexibility required.

HYBRID MODELS

A.9.3.8 Authorities may combine in house capability with outsourced services, which in turn may use a combination of options, e.g., professional services contract plus term maintenance contract. Specialist frameworks may provide further reach and access to additional services where required.

ALLIANCES, PARTNERSHIPS AND COLLABORATIVE MODELS

A.9.3.9 Collaborative models, including alliances and integrated teams, may be suitable where multi-party working, shared incentives and joint governance could deliver improved outcomes. These models may be beneficial for complex or long-term programmes. Shared services and combined procurements can support market resilience and greater efficiency.

A.9.3.10 The ICE has produced an overview of collaborative delivery arrangements used in UK infrastructure, highlighting how cooperation improves outcomes across different project types.

PFI AND DBFO MODELS

A.9.3.11 Legacy long term contracts, including PFI and DBFO arrangements, remain in operation for some authorities. These involve transfer of risk from the authority to the operator, and require specific commercial management, performance oversight, technical compliance and structured hand back planning.

A.9.3.12 Future contracts of this nature may be developed to provide a route for private investment in UK highway infrastructure. If so, then lessons learned from existing contracts should be applied to inform their design, procurement and delivery.

A.9.3.13 For PFI or DBFO delivery models, authorities should consider hand back and transition requirements at an early stage. Arrangements should support the transfer of asset information, operational knowledge and stewardship responsibilities, whilst helping to ensure that asset condition and service outcomes are maintained throughout the contract term.

A.9.4 PROCUREMENT STRATEGY AND PROCESS

A.9.4.1 A forward commercial strategy and procurement pipeline can help align procurement activity with local objectives, risk appetite and financial planning. Authorities should engage with the market at an appropriate stage in the procurement process to understand capability, capacity, innovation opportunities, potential barriers to participation and delivery risks. Such engagement should help inform procurement strategies and delivery models whilst maintaining fairness and transparency.

A.9.4.2 Structured options appraisal can help determine the most suitable delivery model. Cost drivers, risk allocation, internal capability and strategic priorities can inform this assessment.

A.9.4.3 Clear definition of service scope, asset classes, expected outcomes, performance requirements and customer service commitments can support effective procurement and subsequent delivery. Requirements for technology, digital capability and data standards should be communicated clearly.

A.9.4.4 Procurement and delivery strategies should be aligned with the authority's risk-based approach, taking account of factors such as service criticality, asset risk, organisational capability, market conditions and the allocation of risk between contracting parties.

A.9.4.5 Procurement strategies should support the authority's asset management objectives and be developed using a risk-based approach. Consideration should be given to whole-life value, resilience, sustainability, social value, innovation, market capability, service outcomes and the allocation of risk between parties, rather than focusing solely on lowest initial cost.

A.9.4.6 Market engagement may include soft market testing, consultation, data sharing and assessment of market readiness. This can help ensure that procurement design is informed by market knowledge and that requirements remain relevant and deliverable.

A.9.4.7 Procurement procedures should be appropriate to the complexity and risk of the requirement. Selection and award criteria should be structured, proportionate and capable of assessing technical competence, past performance, financial standing, sustainability and innovation.

A.9.4.8 Tender documentation should be comprehensive and clear. Evaluation frameworks should consider whole life value rather than simply immediate cost and use transparent weighting strategies to provide the balance required between quality and commercial submissions. Authorities should ensure appropriate clarification and dialogue where permitted.

A.9.4.9 Authorities should comply with standstill requirements, finalise contractual terms and plan for mobilisation, including workforce transfer under TUPE regulations (where applicable), data handover, system access, onboarding and communication with stakeholders.

A.9.4.10 The Local Government Association has produced guidance for councils on best value, commercial strategy, benchmarking, Procurement Act compliance, and ethical/sustainable procurement (including modern slavery).

A.9.4.11 The UK Construction Playbook provides a framework for planning, procuring and delivering public works contracts and programmes. It incorporates principles relating to early market engagement, whole-life value, collaborative delivery, effective risk allocation, innovation, sustainability, client capability and long-term supplier relationships, including recommendations arising from the Constructing the Gold Standard review of public sector construction frameworks.

A.9.4.12 Procurement and contracting approaches can influence market capability, capacity, resilience and innovation. The Competition and Markets Authority's Civil Engineering Market Study identified the benefits of providing greater certainty of future work, improving client capability and supporting a competitive and sustainable supply chain. These considerations can inform procurement and delivery strategies where appropriate.

RECOMMENDATION 38 - PROCUREMENT AND DELIVERY MODELS
Authorities should ensure procurement and delivery arrangements align with risk appetite and asset management principles and objectives.

A.9.5 COMMERCIAL FRAMEWORKS AND CONTRACTING

A.9.5.1 Contractual arrangements should be appropriate to the authority's objectives, the nature of the services being delivered, the chosen delivery model, the allocation of risk and the desired outcomes. Authorities should also consider any sector-specific requirements, standards or accreditation schemes relevant to the services being procured.

A.9.5.2 Payment mechanisms should reflect the delivery model and risk allocation. Options include cost reimbursable, target cost, lump sum and performance linked arrangements. Considerations may include indexation, inflation, cost control, customer service measures and incentivisation.

A.9.5.3 Authorities should adopt balanced risk sharing principles that support collaboration, whole life value and sustainable delivery. Effective risk management throughout the contract lifecycle can support the identification, allocation and mitigation of risk.

A.9.5.4 As well as delivering routine service requirements, procurement and delivery arrangements should support preparedness, response, recovery and long-term adaptation activities. Authorities should consider how contractual arrangements address emergency response obligations, workforce competence, business continuity, collaboration with partner organisations and resilience to future risks and changing operating conditions.

A.9.5.5 Contractual performance measures and incentive mechanisms should support the delivery of the authority's desired outcomes, including safety, serviceability, sustainability, resilience, customer service and social value.

A.9.5.6 Social value commitments can be defined, assessed and monitored throughout the procurement and contract lifecycle where appropriate. Social value outcomes may be reflected within contract management arrangements where relevant.

A.9.5.7 Authorities should avoid disproportionate transfer of risk to lower tiers of the supply chain, ensuring that terms remain fair, deliverable and supportive of a resilient market.

A.9.5.8 Authorities may use local, regional or national frameworks to procure services. Authorities should understand the benefits and risks of framework use, including speed, market access, pricing control, cost to the authority, and potential limits on competition. Call-off strategies, including direct awards and mini competitions, can provide flexibility in terms of accessing services.

A.9.5.9 Long-term contractual arrangements should include appropriate mechanisms for managing changes in legislation, regulation, policy, standards and service requirements. Associated risks, responsibilities and commercial implications should be clearly understood and allocated in a transparent and proportionate manner.

A.9.6 CONTRACT MANAGEMENT

A.9.6.1 Effective contract management is essential to achieving the intended outcomes of procurement and delivery arrangements. Contract management should maintain alignment between service delivery, asset management objectives and organisational priorities throughout the contract term.

A.9.6.2 Suitable mobilisation, transition and, where appropriate, demobilisation arrangements can support continuity of service, effective transfer of information and knowledge, clear allocation of responsibilities and the development of productive working relationships between all parties involved in service delivery.

A.9.6.3 Contract management arrangements should promote collaborative working between the authority, delivery partners and the wider supply chain. Authorities and suppliers should work together to develop a shared understanding of service objectives, delivery priorities, risks and opportunities, and to support effective medium and long-term planning of activities and investment.

A.9.6.4 Continuous improvement opportunities can be identified, evaluated and implemented through suitable contract management arrangements. Improvement activities should be evidence-based, address clearly identified needs and challenges, and draw upon the knowledge, experience and innovation capability of both delivery partners and their supply chains.

A.9.6.5 Contractual arrangements should support innovation and continuous improvement throughout the life of the contract. Benefits arising from improvements in performance, productivity, resilience, customer outcomes, sustainability or efficiency may be measured, realised and, where appropriate, shared in a manner that incentivises collaborative behaviours and long-term value creation.

A.9.6.6 Ongoing review of service delivery requirements, risks, opportunities and evolving operational needs can help ensure that delivery arrangements remain relevant and effective.

A.9.7 GOVERNANCE AND ASSURANCE OF DELIVERY

A.9.7.1 Governance arrangements may include clearly defined roles, responsibilities, delegated authorities, reporting requirements and assurance processes. These should be proportionate to the scale, complexity, value and risk profile of the services being delivered.

A.9.7.2 Performance management frameworks can provide visibility of supplier performance, delivery outcomes, risk management, innovation, social value and customer impacts. Performance information can support decision-making, continuous improvement, future procurement and delivery strategies, the management of long-term delivery relationships, and the assessment of whether contractual arrangements, performance measures and incentives are delivering the intended outcomes.

A.9.7.3 Clear and proportionate arrangements for managing contractual change can support assessment of impacts on scope, cost, programme, risk, performance and service outcomes. Such arrangements can provide transparency, maintain appropriate control and support effective decision-making throughout the contract lifecycle.

A.9.7.4 Structured approaches can support the management of issues, disputes, early warnings and compensation events. Escalation procedures may help resolve matters collaboratively and at the earliest practicable opportunity where appropriate.

A.9.7.5 Procurement and delivery arrangements should include appropriate provisions for contract expiry and service transition. Particular consideration should be given to asset information, knowledge transfer, workforce transition and, where applicable, asset hand back arrangements associated with long-term delivery models such as DBFO and PFI contracts.

A.9.7.6 Insurance requirements should be aligned with the services being delivered and the risks involved. These may include public liability, professional indemnity, motor fleet, environmental and other forms of insurance relevant to the delivery arrangement.

A.9.7.7 Arrangements relating to intellectual property rights, data ownership, licensing, information security, retention of records and access to information should be clearly defined. These should support effective asset management throughout the contract lifecycle and facilitate any future transition of services.

A.9.7.8 Financial stability, supply chain resilience and insolvency risk can influence service delivery throughout the contract lifecycle. Consideration of these factors, together with appropriate contingency arrangements can help reduce the risk of disruption and protect the authority's interests.

A.9.7.9 Periodic review of governance arrangements, strategic risks and assurance activities can help ensure that procurement and delivery arrangements remain effective, proportionate and aligned with organisational objectives, asset management priorities and changing operating circumstances.

A.9.8 RESOURCING AND CAPABILITY FOR PROCUREMENT AND DELIVERY

A.9.8.1 Appropriate client-side capability supports the identification of suitable delivery models, the procurement process and then ultimately service delivery. This includes, but is not limited to, leadership, commercial and procurement skills, technical knowledge, contract management and data literacy. The scale, nature and complexity of client-side capability should be proportionate to the complexity, value, duration and risk profile of the procurement and delivery arrangements being implemented.

A.9.8.2 Authorities should retain sufficient capability to act as an informed client and provide effective governance and oversight throughout the contract lifecycle.

A.9.8.3 Workforce management, training and succession planning should be built into delivery arrangements. Authorities may specify contract requirements for knowledge transfer from suppliers, to support development of internal staff.

A.9.8.4 Authorities should understand supplier capacity, specialist subcontractor availability, equipment requirements, skills and accreditation. Providers should have sufficient competent resources to deliver services effectively, both within their immediate organisation and through their supply chain. Where appropriate, this may be supported by clear contractual obligations and warranties from key supply chain partners.

A.9.8.5 Appropriate digital tools, asset management systems, mobile working solutions and data analytics can support improved service efficiency, quality and transparency. Contracts can support innovation and continuous improvement while supporting safe and resilient service delivery.

RECOMMENDATION 39 - INTELLIGENT CLIENT CAPABILITY
Authorities should maintain sufficient capability to act as an informed client irrespective of the delivery model adopted.

RECOMMENDATION 40 - SUPPLIER ENGAGEMENT AND FORWARD VISIBILITY
Authorities should engage with suppliers and delivery partners and provide forward visibility of planned programmes where practicable to promote innovation, investment, collaboration and long-term capability.

PART B. HIGHWAYS

SECTION B.1 SCOPE OF PART B – HIGHWAYS

B.1.1 INTRODUCTION

B.1.1.1 Part B of Well-managed Highway Infrastructure addresses specific highway-related issues and themes, covering a range of highway assets, including but not limited to the following:

- carriageways;
- footways;
- cycle infrastructure;
- highway drainage systems;
- embankments and cuttings;
- landscaped areas and trees;
- fences and barriers;
- non-illuminated traffic signs and bollards;
- road markings and studs;
- hostile vehicle mitigation;
- public rights of way; and
- relevant street furniture.

B.1.1.2 The types of assets maintained may differ across authorities. Legal adoption records, asset registers and definitive maps may be used to identify assets within their responsibility. This may include unsealed highways and green lanes, such as byways open to all traffic and other routes with public vehicular rights, where these are maintained by the highway authority.

B.1.1.3 There may be assets located within the highway boundary that are not the responsibility of the highway authority to maintain, for example, statutory undertakers' apparatus, privately owned structures or third-party installations.

B.1.1.4 The overarching principles and common themes of maintaining highway infrastructure are covered within Part A. Asset specific guidance for structures, lighting and tunnels are covered in Part C, Part D and Part E respectively.

B.1.1.5 In developing and implementing asset management practices, authorities may draw upon DMRB standards where relevant, while retaining flexibility to adopt alternative approaches that best reflect local circumstances and organisational requirements.

B.1.1.6 Guidance on general best practice and recommendations can be found on the following websites:

- Active Travel England
- Local Transport Notes (LTNs)
- Design Manual for Roads and Bridges (DMRB) | Standards for Highways
- Manual of Contract Documents for Highways Works (MCHW)

- Association of Directors of Environment, Economy, Planning & Transport
- The Chartered Institution of Highways and Transportation (CIHT)
- The Roads Surface Treatments Association (RSTA)
- UKRLG | A Code of Practice | Management of Electronic Traffic Equipment
- HMEP LCP Toolkits Quick Guidance
- Prevention and a better cure: Potholes Review
- Planning for Walking
- Active Travel Act Guidance
- Cycle infrastructure design (LTN 1/20) - GOV.UK
- Sustrans Greenway Management Handbook | 2016
- Manual for Streets
- Inclusive Mobility. A Guide to Best Practice on Access to Pedestrian and Transport Infrastructure
- Cycling by Design 2026 | Transport Scotland
- Roads for All: Good Practice Guide 2013 | Transport Scotland
- Climate adaptation strategy for transport - GOV.UK

SECTION B.2 LEGAL FRAMEWORK – HIGHWAYS

B.2.1 INTRODUCTION

B.2.1.1 General duties and powers are dealt with in Part A of this Code. This section contains information on duties and powers specifically related to highways.

B.2.2 HIGHWAY SPECIFIC LEGAL CONSIDERATIONS

B.2.2.1 The Highways Act 1980 sets out the main responsibilities of highway authorities in England and Wales. It includes the authority's maintenance duty, powers to make additions or changes to the network, permissions for certain activities and enforcement powers.

B.2.2.2 In particular, Section 41 imposes a duty to maintain the public highway: *'the authority who are for the time being the Highway Authority for a highway maintainable at the public expense are under a duty.'* This duty is subject to the statutory exceptions, qualifications and transitional provisions set out in subsection 2 and 4 in Section 41.

B.2.2.3 Section 58 provides for a defence against action relating to alleged failure to maintain on grounds that the authority has taken such care as in all the circumstances was reasonably required to ensure that the part of the highway in question was not dangerous for traffic.

a) the character of the highway, and the traffic which was reasonably to be expected to use it;

b) the standard of maintenance appropriate for a highway of that character and used by such traffic;

c) the state of repair in which a 'reasonable person' would have expected to find the highway;

d) whether the highway authority knew, or could reasonably have been expected to know, that the condition of the part of the highway to which the action relates was likely to cause danger to users of the highway;

e) where the highway authority could not reasonably have been expected to repair that part of the highway before the cause of action arose, what warning notices of its condition had been displayed.

B.2.2.4 In Scotland, the key road maintenance legislation is contained in the Roads (Scotland) Act 1984, Section 1, which provides a duty for local roads authorities to keep a list of 'public roads' and to maintain and manage them. There is no direct equivalent of the Highways Act 1980 Section 58 providing defence against alleged failure to maintain, although case law will have established some basis for this.

B.2.2.5 In Northern Ireland, under Article 8 of The Roads (Northern Ireland) Order 1993 the Department for Infrastructure has a statutory duty to maintain all public roads in a safe and serviceable condition[1].

B.2.2.6 The duty to maintain has been further clarified by case law relating to highway claims regarding the standard or condition and what constitutes a breach of Section 41. Although guidance can be taken from previously decided cases, the courts have stated that highway claims are fact

[1] Throughout this Code, when reference is made to the Highways Act 1980, this legislation does not apply in NI, where instead, the Roads (NI) Order 1993 applies.

sensitive, and each case will be decided on its own facts. More information on this is contained in Highway Risk & Liability.

B.2.3 PUBLIC RIGHTS OF WAY

B.2.3.1 The requirements for Public Rights of Way will be determined as part of each highway authority's Rights of Way Improvement Plan (ROWIP), developed in consultation with the Local Access Forums established by the Countryside and Rights of Way Act 2000.

B.2.3.2 Public Rights of Way are not a highway authority function in Scotland and Northern Ireland.

B.2.4 MOVEMENT OF TRAFFIC AND REGULATORY FUNCTIONS

B.2.4.1 The Traffic Management Act 2004, Road Traffic Regulation Act 1984, Road Traffic Act 1988, New Roads and Street Works Act 1991 (NRSWA) and associated Codes of Practice provide for regulatory functions of the highway authority.

B.2.4.2 Examples of regulatory functions are given below, but this list is not exhaustive:

- maintenance of Highway Register and Definitive Map;
- co-ordination of road and street works (responsibility of Traffic Manager or equivalent);
- charging schemes and permits for highway occupation (responsibility of Traffic Manager or equivalent);
- traffic regulation, speed limits, temporary traffic orders; and
- other regulatory functions – encroachment, illegal signs, parking, skips, scaffolds and other placements on the highway.

B.2.4.3 The Traffic Management Act 2004 places a network management duty on all local highway authorities in England. It requires authorities to do all that is reasonably practicable to manage the network effectively to keep traffic moving. This Act states that the needs of all users of the public highway must be met.

B.2.4.4 In meeting the network management duty, authorities should establish resilience and contingency plans for dealing promptly and effectively with unplanned events, such as unforeseen weather conditions, as far as is reasonably practicable.

B.2.4.5 Northern Ireland does not apply the Traffic Management Act 2004; instead, the Department for Infrastructure operates under the Traffic Management (Northern Ireland) Order 2005. This Order centres on enforcement of parking and specific traffic controls, without placing a network management duty.

B.2.4.6 The Road Traffic Act 1988 does not extend to Northern Ireland. Northern Ireland's primary road traffic framework comes from The Road Traffic (Northern Ireland) Order 1995 and other Northern Ireland specific Orders.

B.2.4.7 Northern Ireland does not apply the NRSWA; instead, the Department for Infrastructure operates under the Street Works (Northern Ireland) Order 1995. This Order applies to all public streets and requires proper coordination of works, responsibility for reinstatement, and the maintenance of a street works register.

B.2.4.8 Authorities also have wider statutory emergency planning responsibilities under the Civil Contingencies Act 2004, including participation in Local Resilience Forums, multi-agency planning and response arrangements, and maintenance of business continuity plans. Practitioners should refer to the relevant emergency planning requirements described in Part A and to highway authority emergency planning frameworks.

B.2.5 WINTER SERVICE

B.2.5.1 The overarching principles and delivery of Winter Service are covered in the NWSRG Practical Guidance Documents.

B.2.5.2 The statutory basis for Winter Service in England and Wales is addressed through Section 41 (1A) of the Highways Act, as amended by Section 111 of the Railways and Transport Safety Act 2003 reads:

- 'In particular, a Highway Authority is under a duty to ensure, so far as is reasonably practicable, that safe passage along a highway is not endangered by snow or ice'.

B.2.5.3 Section 150 of the Highways Act 1980 also imposes a duty upon authorities to remove any obstruction of the highway resulting from 'accumulation of snow or from the falling down of banks on the side of the highway, or from any other cause'.

B.2.5.4 Given the scale of financial and other resources involved in delivering the Winter Service, it is not considered reasonable either to:

- provide the service on all parts of the Network; and
- ensure carriageways, footways and cycle routes are kept free of ice or snow at all times, even on the treated parts of the network.

B.2.5.5 In Scotland, statutory responsibilities are defined by Section 34 of the Roads (Scotland) Act 1984 which requires that "a road authority shall take such steps as it considers reasonable to prevent snow and ice endangering the safe passage of pedestrians and vehicles over public roads".

B.2.5.6 In Northern Ireland, statutory responsibilities and powers are defined by Articles 9 and 10 of the Roads (NI) Order 1993. Under Article 10, the Department for Infrastructure has a statutory duty to "remove snow, soil etc which has fallen on a road". Article 9 of the Order enables the Department to "take such action as it considers reasonable to prevent snow or ice interfering with the safe passage of persons and vehicles using the road". This means, however, that unlike other parts of the UK, there is no statutory duty to salt roads or footways in Northern Ireland. Nevertheless, funding is sought each year to ensure that the main traffic routes can be treated as part of a winter service programme.

SECTION B.3 ASSET STRATEGY – HIGHWAYS

B.3.1 INTRODUCTION

B.3.1.1 A Highway Asset Management Strategy sets out the authority's approach for managing highway assets across the network to deliver value for money, minimise risk and support strategic goals.

B.3.1.2 Asset management systems are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C. This document should be referred to and the advice below considered supplementary.

B.3.2 PRINCIPLES AND CONSIDERATIONS

B.3.2.1 The Highway Asset Management Strategy should clearly set out its context in relation to the authority's goals and priorities, relevant legislative, regulatory and policy requirements, and stakeholder expectations (e.g., the public, regulators and service providers).

B.3.2.2 It should also reference links to other strategic documents, such as the broader Network Strategy, relevant strategic plans, transport objectives and wider capital investment, regeneration and resilience programmes where appropriate, to support coordinated planning and delivery.

B.3.2.3 A description of the highway asset portfolio may be included, covering asset quantities and distribution, condition, age profile, and service criticality (e.g., high, medium, or low importance). Prioritising highway assets according to network importance ensures that resources are directed towards the most critical locations.

B.3.2.4 A Highway Asset Management Strategy defines clear and measurable objectives that reflect the specific needs of the network. The examples below illustrate the types of objectives that may be considered:

- **Network Performance:** Maintain highway assets to continue to provide the required level of service to support a safe and reliable network. Performance should be monitored using appropriate measures, targets and condition data to support decision making and continuous improvement (see Section A.3 Network Strategy for more information on network performance)
- **Stakeholder Engagement:** Understanding the needs of users, communities and stakeholders can support effective highway asset management. (see Section A.3.6 for more information on stakeholder engagement)
- **Lifecycle Planning:** Apply lifecycle planning principles to manage highway assets over the short, medium and long term (see Section B.7 Finance and Investment for more information on lifecycle planning)
- **Safety:** Maintain a safe network by addressing defects and deterioration that may affect users, contractors, and other stakeholder safety. Safety considerations should underpin inspection, maintenance, and investment decisions across the network. (See Section A.3.3 for more information on safety)
- **Asset and Data Information:** Maintain accurate and reliable asset information to support planning, performance monitoring, risk assessment and investment decisions (see Section B.5 Asset Knowledge for more information on asset data and information)

- **Risk Management:** Identify, assess, and manage risks associated with highway assets. Refer to section Section B.4 Risk-Based Approach for more information on a risk-based approach for highway assets.
- **Climate Change Adaptation and Resilience**: Manage highway assets to improve network resilience to current and future climate-related hazards and other disruptive events. Asset management decisions can contribute to adaptation, long-term network resilience and maintain long-term network performance (see Section A.6 Resilience and Adaptation for more information).
- **Carbon Reduction and Environmental Sustainability**: Manage highway assets in a manner that supports carbon reduction, efficient use of resources and environmental sustainability, taking account of wider authority objectives and statutory requirements where applicable (see Section A.8 Sustainability for more information).

B.3.2.5 Clearly defined roles, responsibilities, required competencies and governance structures support consistent and effective decision making. The strategy should lay out how the authority manages highway assets to deliver value, minimise risk, and support strategic goals. Whilst the exact structure will vary by authority, typical core elements may include:

- Why assets are managed the way they are;
- What the organisation wants to achieve;
- How assets will be managed, maintained and invested in;
- Who is responsible for delivery;
- How success will be measured.

B.3.3 MAINTENANCE AND MANAGEMENT OF ACTIVE TRAVEL INFRASTRUCTURE

B.3.3.1 National policy throughout the UK aims to promote increased levels of walking, wheeling and cycling; the associated benefits are well established, and include physical and mental health and well-being, cost savings, carbon reduction, local economic benefits, improved air quality, noise reduction, reduced congestion community cohesion amongst others.

B.3.3.2 Well-maintained active travel infrastructure, comprising highway footways and cycle facilities is key to the delivery of the benefits associated with increased levels of walking, wheeling and cycling. The high benefit-cost-ratios associated with the provision of new active travel infrastructure can be significant and are well-evidenced and widely acknowledged but these benefits are contingent on new infrastructure being maintained and operated over its whole life at a level of service that meets the needs of users and potential users and that encourages walking, wheeling and cycling.

B.3.3.3 Poorly maintained infrastructure is frequently cited by users and potential users as a barrier to their walking, wheeling and cycling more and disproportionately affects older people, disabled people and other vulnerable groups.

B.3.3.4 Claims against highway authorities for trips and other incidents by pedestrians and other users can represent a significant cost, and the wider societal costs for health and social care are assessed as being significantly higher, although they are not a direct cost to the highway authority. Active Travel England have identified cycling surface and walking/wheeling surface and

maintenance defects as two of their sixteen critical safety issues for people walking, wheeling and cycling.

B.3.3.5 Maintenance of active travel infrastructure encompasses activities beyond the maintenance of the condition of the paved surface and contributes to the quality and safety of the user experience and to the attributes of good infrastructure which influence decisions on whether to use active modes:

- Safety
- Directness
- Comfort
- Coherence
- Attractiveness

B.3.3.6 Maintenance interventions may also provide opportunities to deliver local accessibility and active travel capital improvements. This may include addressing local accessibility barriers and renewing or upgrading crossing facilities, signs and road markings as part of, or alongside, planned maintenance works. Such improvements can support wider transport objectives and enhance the experience of people walking, wheeling and cycling.

B.3.3.7 Highway authorities are encouraged to develop local levels of service on a risk basis, making use of maintenance hierarchies for footways/walking wheeling infrastructure and for cycle networks (including cycling on the carriageway as well as on dedicated infrastructure such as cycle lanes, cycle tracks, greenways, cycle superhighways etc).

B.3.3.8 Part A covers the definitions of these risk-based maintenance hierarchies which, in addition to current and potential level of use should also take into account importance to strategic active travel routes/networks (NCN, LCWIP etc), local demography, routes, integration with other modes etc.

B.3.3.9 Highway authorities are encouraged to engage with stakeholders and local groups representing walkers, wheelers, cyclists and disabled users in developing risk-based levels of service for active travel infrastructure and to establish mechanisms for users of active travel infrastructure to report issues and to receive feedback on responses.

B.3.3.10 Highway authorities should ensure that inspectors and engineers involved in assessing risk to users and in determining responses to defects on active travel infrastructure are trained to ensure that they understand how defects impact those walking, wheeling and cycling.

B.3.4 COMPETENCE

B.3.4.1 Competence of staff is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C. This document should be referred to and the advice below considered supplementary.

B.3.4.2 The Institute of Highway Engineer's (IHE) guidance document Well Managed Highway Liability Risk also provides information on training and the assessment of competence. This includes the different requirements of various personnel involved in delivering the highway service, the

importance of maintaining training plans and records to evidence the training provided, and the need to periodically refresh and update training to ensure the continued competence of staff.

B.3.4.3 Competence and training plans may include, for example, health and safety, asset inspection and condition assessment, risk management, data and information management, the use of asset management systems and associated tools.

B.3.4.4 Authorities should consider competence across all highway asset maintenance functions, including asset managers, engineers and those involved in planning and delivery. Staff require the skills, knowledge, experience and training needed to carry out their roles effectively, including an understanding that different road users, such as pedestrians, cyclists and motorcyclists, may experience the same highway asset or defect differently. Maintaining this competence supports authorities in discharging their responsibilities consistently and effectively. Maintaining competence supports informed decision-making, good asset management practice and the safe, efficient operation of the highway network.

HIGHWAY INSPECTORS

B.3.4.5 The UK Roads Leadership Group Asset Management Board, with support from the Department for Transport, the Highway Inspectors Board, the Midlands Highway Alliance and the Midlands Service Improvement Group, has produced a revised Highway Inspector Competence Framework to outline the high-level requirements for this role.

B.3.4.6 The framework has built on previous good practice established through the IHE framework, considers subsequent guidance such as Well-managed Highway Infrastructure, and provides scope for authorities to tailor their risk-based approach to highway inspections to align with local risk appetite and needs. It also includes a degree of flexibility through the inclusion of core sensitive information competences and optional competences, which individual authorities can align to the scope of their locally defined inspector role.

B.3.4.7 The objectives behind the framework are to:

- Outline the role of the highway inspector;
- Raise the importance of the highway inspector role and provide a framework to help role progression;
- Recommend a set of competence areas and associated competences for the highway inspector role;
- Suggest evidence to demonstrate each specific competence;
- Outline review cycles for assessing the competences within the Framework; and
- Support highway authorities in aligning the highways inspector role with the latest Code of Practice for risk-based highway inspections.

B.3.4.8 The UKRLG Highway Inspector Competence Framework is intended to be used by professional bodies in helping to support the development of appropriate qualifications/training for highway inspectors, helping to professionalise this role.

B.3.4.9 The Highway Inspectors Board was established on behalf of UKRLG in 2011, to administer training and certification requirements for the role. The Highway Inspectors Board has subsequently overseen updates in 2017 and 2019, the latter seeing the introduction of the new

Highway Inspector Competence Framework. Candidates who successfully complete the courses run by an approved centre are eligible for inclusion on the National Register of Highway Inspectors for a period of five years

B.3.4.10 Registration with the Highway Inspectors Board can contribute positively to risk management and defence of compensation or liability cases.

B.3.4.11 Where authorities adopt their own or alternative approach to training, engagement with risk, legal and insurance departments can help ensure that the chosen approach to training and assessment of highway inspection competence is sufficiently robust for local corporate requirements, as this might need to be justified in any legal action taken against an authority.

SECTION B.4 RISK-BASED APPROACH – HIGHWAYS

B.4.1 INTRODUCTION

B.4.1.1 The overall risk-based approach principles are dealt with in Part A of this Code. This section contains information on the risk-based approach specifically related to highway assets. Risk management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C.

B.4.2 HIGHWAYS RISK-BASED APPROACH FRAMEWORK

B.4.2.1 Highway authorities should adopt the principles outlined in Part A of this Code to develop and maintain a documented, evidence-based approach to highway asset management. The approach should reflect local needs and priorities and support the effective assessment, management and prioritisation of risks associated with highway assets throughout their lifecycle.

B.4.2.2 The approach should be subject to regular monitoring and review to ensure it remains fit for purpose. Reviews may consider network changes, emerging risks, service performance, operational effectiveness, organisational change, trends in defect volumes and maintenance activities, and the impact of different investment levels on risk exposure, service outcomes and network resilience.

B.4.2.3 Examples of risks, impacts and potential control measures are included in Table 12 for illustrative purposes.

Table 12: Example risks, mitigations and impacts affecting Highways

Example Risks and Mitigations			Example Impacts			
Type of Risk	**Example Risks**	**Example Mitigation**	**Safety Impact**	**Serviceability**	**Sustainability**	**Customer**
Asset / Route Risks - Risks affecting individual highway assets or specific routes Asset / Route Risks - Risks affecting individual highway assets or specific routes	Deterioration of carriageway and footway surfaces Defects can create hazards for all users, including pedestrians, motorcyclists, cyclists, and mobility impaired users	Routine and safety inspections aligned to network hierarchy Condition surveys Reactive defect repairs and patching Programmed maintenance	Increased risk of collisions due to loss of control on damaged carriageways Slips, trips and falls on defective footways Heightened risk to cyclists and motorcyclists from surface defects Increased likelihood of vehicles swerving to avoid potholes, creating secondary hazards	Reduced ride quality and comfort Speed restrictions and temporary traffic management to manage deteriorated sections Increased journey times due to reactive repair activity Impaired accessibility for pedestrians, wheelchair users, prams Accelerated deterioration of adjacent assets (verges, drainage, markings)	Higher whole-life cost and carbon impact if deterioration is left untreated Reduced network resilience to weather events Increased maintenance frequency leading to greater material use and waste Reduced uptake of sustainable modes if routes are perceived as unsafe or uncomfortable	Disruption and delays from repeated reactive repairs and lane closures Vehicle damage claims and increased compensation liability Complaints regarding poor footway condition and trip hazards Economic impacts from reduced accessibility and network reliability
	Drainage system failure (blocked gullies, silted grips, defective pipes, collapsed culverts) leading to ineffective surface water management	Cyclical gully cleansing based on risk and network hierarchy, surveys of critical drainage assets, vegetation management around inlets and outlets, upgrade of drainage capacity in	Flooding and surface water leading to incidents or collisions Reduced visibility and driver uncertainty during heavy rainfall Higher pedestrian motorcyclist and cyclist risk due to hidden	Lane closures leading to delays Reduced network capacity Consequent damage to other highway assets Increased reactive maintenance demand and associated disruption	Water pollution from uncontrolled runoff entering watercourses Higher whole life carbon and cost due to accelerated carriageway deterioration Reduced resilience of the network to	Disruption, delays, and diversions during or after flooding events Damage to properties, vehicles, and adjacent land Increased complaints, negative perception of network management,

Example Risks and Mitigations			Example Impacts			
Asset / Route Risks - Risks affecting individual highway assets or specific routes Asset / Route Risks - Risks affecting individual highway assets or specific routes		known flooding hotspots	defects or splash and spray		climate-driven extreme weather events Potential harm to trees, landscaped areas, and green estate due to prolonged waterlogging	and potential compensation claims
	Vegetation growth obstructing traffic signs or reducing sight lines at junctions, bends or pedestrian crossings, including unintended growth from organic contamination	Scheduled vegetation maintenance, safety critical sight line inspections, targeted clearance, management of invasive species	Increased collision risk due to reduced sign visibility or impaired driver, motorcyclist, cyclist and pedestrian sight lines	Reduced network efficiency, slower traffic at constrained locations, increased reactive maintenance	Increased long term maintenance burden if unmanaged vegetation damages assets; reduced biodiversity quality if interventions become reactive rather than planned	Complaints regarding p oor visibility, perceived neglect of the network, reduced confidence in network safety
	Faded or worn road markings (lane lines, give-ways, crossings) reducing visibility for both human drivers and autonomous/ assisted d riving systems	Road marking refresh programmes, use of high-durability thermoplastic long-life markings, enhanced retro-reflective beads, prioritisation of strategic and autonomous vehicle de pendent routes	Increased collision likelihood due to lane drift, unclear priority, and reduced machine-vision detection accuracy for autonomous or driver-assistance systems	Reduced network efficiency; impaired performance of lane-keeping, adaptive cruise, and other automation features requiring clear lane delineation	Increased long-term carbon and material use if frequent renewals are needed due to sub-optimal product specification	Confusion, complaints, reduced legibility for both human drivers and automated systems, motorcyclists, cyclists and e-scooters. Decreased confidence in network management

B.4.3 ASSET SPECIFIC GUIDANCE

B.4.3.1 Authorities should apply appropriate risk levels when assessing and prioritising highway assets. The example risk rating framework in A.4 Risk Based Approach illustrates the different risk levels that may be applied within a risk-based approach.

B.4.3.2 When applying a risk-based approach, the range of users and their respective needs should be considered as per Part A.15.

CARRIAGEWAYS

B.4.3.3 Carriageway assets carry the highest volumes of everyday use and present significant safety and liability risks, a risk-based approach supports authorities in making the best use of resources.

B.4.3.4 In the context of a risk-based approach to carriageways, relevant factors may include:

- Usage levels and user vulnerability, including powered two-wheelers, alongside the functional importance and hierarchy of the route.
- Vehicle type, loading and traffic composition, including the potential impact of higher axle loads and heavier vehicles (e.g., HGVs, buses and electric vehicles) on rates of deterioration and defect formation.
- Likelihood and consequence of deterioration or defects (surface breaking, potholes, unevenness, rutting, fretting, joint failures) on safety, accessibility and network operation.
- Effectiveness of different repair types (e.g., patching vs. resurfacing vs. surface treatments).
- Practicality and risk associated with carrying out maintenance (traffic management, worksite constraints, pedestrian management, frontage access, operational safety).
- Compatibility with adjacent assets (drainage, kerbs, markings).
- Consideration of national specifications, such as those in the Manual of Contract Documents for Highway Works (MCHW).
- Where surface defects, loose material, standing water, ironwork, road markings or changes in skid resistance may present disproportionate risk to users of powered two-wheeled vehicles.

ACTIVE TRAVEL INFRASTRUCTURE

B.4.3.5 Active travel infrastructure (including cycle routes and footways) maintenance, asset management and operation includes the following activities:

- Surface condition maintenance (potholes, ride quality, reinstatement quality, skid resistance, ironwork)
- Footway condition
- Management of vegetation
- Drainage maintenance
- Winter Service

- Maintenance and operation of lighting
- Cleansing
- Road marking and sign maintenance
- Management of temporary works
- Obstructions and enforcement
- Maintenance and operation of traffic signals and technology
- Inspections and data collection

B.4.3.6 It is recommended that inspections and surveys for safety and serviceability of active travel infrastructure cover all aspects that affect the user experience, rather than focusing solely on surface condition.

B.4.3.7 Footways and cycle routes remote from carriageways, particularly those forming part of a route to encourage greater use, should be inspected at least annually.

DRAINAGE SYSTEMS

B.4.3.8 Drainage systems play a critical role in preventing surface water hazards, protecting carriageway and footway life, and supporting network resilience. Drainage failure is a significant safety, serviceability and liability risk for authorities, and effective management often demands substantial ongoing resource investment.

B.4.3.9 In the context of a risk-based approach to drainage, relevant factors may include:

- Flood risk, topography & weather exposure: includes known low spots, historical flooding, runoff patterns, and vulnerability to intense rainfall or climate-driven events.
- Drainage asset condition: includes structural condition (e.g., blockage, collapse, siltation), repeated failures, CCTV findings, and areas requiring frequent reactive interventions.
- Capacity: assess whether gullies, pipes, culverts and outfalls can handle expected flows, considering upstream catchments, sediment accumulation, and system bottlenecks.
- Drainage safety impact: consider how drainage defects contribute to standing water, skidding risk, concealed potholes, splash zones affecting pedestrians and cyclists, and impacts on vulnerable users.
- Environmental considerations: includes pollution pathways, SuDS opportunities, downstream impacts, and compliance with responsibilities for watercourse discharge or interactions with utility/sewer systems.

LANDSCAPED AREAS AND TREES

B.4.3.10 Landscaped areas and tree forms are an integral part of adoptable highways. However, visibility and sight-line risk include the potential for vegetation to obscure traffic signs, signals, road markings, lighting, junction visibility, pedestrian crossings, bends, and cycle route sight lines.

B.4.3.11 Encroachment risk should consider vegetation growth affecting footway and cycle route widths, overhanging branches reducing headroom, and vegetation obstructing drainage assets such as gullies, grips or ditches.

B.4.3.12 Condition and species risk includes fast-growing, invasive, or structurally unstable species; tree health and likelihood of limb failure; root systems affecting pavements and kerbs; or vegetation contributing to surface deterioration.

B.4.4 DESIGN FOR MAINTENANCE

B.4.4.1 Equipment used in highway asset maintenance is selected, installed, maintained and operated to support durable and efficient performance. Assessment of each item can take account of expected service life, availability, cost of spares and replacements, ease of maintenance, recycling and disposal requirements, and compatibility with other components were used in combination. Initial cost is an important consideration, but whole-life costs are a key factor in the final selection of equipment. These may include:

- ongoing maintenance;
- traffic management;
- carbon;
- disposal costs;
- performance of existing equipment; and
- initial capital procurement costs.

B.4.5 BALANCING PRIORITIES BY TYPE

B.4.5.1 The broad priorities for the respective types of highway maintenance will largely be determined by the outcome of safety and asset specific inspections and condition surveys, assessed against local risks and policies specified by the authority in the light of this Code. In general, it will be important to establish priorities and programmes for each of the following:

- emergency / reactive maintenance – attending to defects and other safety matters that require urgent action arising from inspections or user information;
- routine maintenance – providing locally defined levels of service;
- planned maintenance – attending to defects and other less urgent matters that may benefit from further planning leading to permanent repairs;
- programmed maintenance – providing lifecycle / road condition-based work streams;
- regulatory functions – regulating occupation, interference or obstruction of the network; and
- Severe weather and winter – ensuring the network operates under all weather conditions, for example by delivering salting and clearance of ice and snow.

B.4.5.2 The determination of priorities and programmes for items within the categories of regulatory functions and Winter Service will tend not to require any special consideration and will largely arise out of the design of the services. For the other four categories listed above, emergency/reactive, routine, planned and programmed, it will be helpful to establish a more structured approach as outlined in the following paragraphs.

B.4.5.3 Priorities for the various types of highway maintenance should be determined at a highway authority level, reflecting locally adopted risk assessments, service standards, operational practices, and asset condition. This allows authorities to balance safety, serviceability and

long-term asset management in a manner appropriate to their networks. While this Code provides the overarching framework, the detailed prioritisation of maintenance actions should remain locally defined.

B.4.5.4 The ADEPT & DfT: Potholes - A Repair Guide (2019) guidance emphasises a proactive approach to network resilience, encouraging authorities to prioritise preventative maintenance wherever feasible to minimise deterioration and reduce long-term defects.

B.4.5.5 The guidance also emphasises the importance of a risk-based approach to the identification and treatment of potholes. Authorities should select repair techniques that reflect local circumstances, including road structure, traffic demands, environmental conditions, defect severity, clustering, and safety considerations, ensuring that treatments are proportionate and effective.

B.4.5.6 In 2012, the Potholes Review was published by HMEP and provides guidance on areas including preventative maintenance and delivering “right first time” repairs:

B.4.5.7 The Potholes Review also recommended that authorities should consider the guidance provided in the ADEPT report Potholes and Repair Techniques for Local Highways and adopt as appropriate to their local circumstances.

B.4.5.8 The Scottish Roads Research Board have also published a Best Practice guide for the selection of pothole repair options.

B.4.5.9 Post-work inspections may be undertaken where appropriate, reflecting the nature, scale and risk of the works. Further information on right-first-time principles is provided in Section B.8.5 Economic Sustainability.

B.4.6 PRIORITIES FOR EMERGENCY / REACTIVE MAINTENANCE

B.4.6.1 Emergency / reactive maintenance involves attending to the rectification of defects and other safety matters that require action arising from inspections or user information in accordance with the locally determined levels of response. Although all such matters will by definition have a degree of urgency, some may have potentially even more serious consequences, and priorities will usually be determined exclusively on the basis of risk assessment.

B.4.6.2 The option selected, together with relevant follow up, will largely be determined by operational practicalities and also whether the site is already part of a programme for more comprehensive treatment, in which case a temporary repair may be an appropriate course of action.

B.4.6.3 Authorities may use ‘Highway Wardens’, ‘Community Wardens’ or ‘Care Teams’ to provide an integrated service of safety inspection, signing and temporary repair. In some cases, these are also extended to provide ‘Integrated Street Management’ services, and teams will need clear guidance on the application of priorities as well as appropriate training to ensure competency.

B.4.6.4 Examples of emergency / reactive maintenance are given below:

- all assets – sign and make safe for safety purposes;
- all assets – provide initial temporary repair for safety purposes; and
- all assets – provide permanent repair for safety purposes.

B.4.6.5 Definitions of temporary and permanent repairs are determined at local levels, reflecting each authority's operational practices, materials, and service standards.

B.4.6.6 Authorities should adopt permanent repairs as the first choice. Temporary repairs are only appropriate where safety cannot be managed using alternative approaches in emergency circumstances, or where funding constraints prevent permanent measures from being implemented immediately.

B.4.7 PRIORITIES FOR PROGRAMMED MAINTENANCE

B.4.7.1 Programmed maintenance is undertaken primarily in the interests of providing for a sustainable outcome, seeking to minimise cost over time and to add community value to the network or to the environment. It can also be for safety purposes by, for example, improving skidding resistance or contributing to serviceability by, for example, improving ride quality.

B.4.7.2 It will be necessary to develop priorities and programmes for the structure, surface and edge of carriageways, footways and cycle routes, using data such as age, condition, hierarchy and lifecycle planning.

B.4.7.3 Lifecycle planning tools and methods can support authorities in developing planning-level decision information, including:

- assessing the impact of different levels of funding on asset performance and asset maintenance needs;
- investigating current and future levels of funding required to sustain or improve the condition or performance of the asset;
- identifying the level of funding required to minimise whole life costs;
- identifying the role of preventative maintenance and timely intervention in extending asset life and optimising whole-life cost outcomes; and
- allocating resources to assets and treatments that provide the best whole life costs.

B.4.7.4 Lifecycle planning approaches may be applied across different asset groups, including carriageways, footways, cycle routes and ancillary assets. Authorities may select or develop lifecycle planning methods that meet their local requirements, data availability and asset-management practices. Such approaches support long-term planning by enabling authorities to analyse deterioration, forecast maintenance needs and evaluate treatment strategies across their asset portfolios.

B.4.7.5 Three different versions have been published, namely for carriageways, footpaths and ancillary assets. The carriageway model incorporates work that was carried out to develop default deterioration models for bituminous carriageways suitable for the local road network in England. The lifecycle planning toolkit, together with a user guide and information on the carriageway deterioration models, may be downloaded from the UKRLG website.

B.4.7.6 In Scotland and Wales, guidance and lifecycle planning tools are available to members of the SCOTS/CSSW Roads Asset Management Project group via the RAM Knowledge Hub. Cost projection tools are available for carriageways, footways, street furniture and other asset types.

B.4.7.7 Programmed maintenance schemes may be more expensive than routine or reactive treatments in initial cost but should be designed to have a lower whole life cost, therefore providing value for money. The determination of priorities between competing schemes needs to be based more objectively, utilising processes such as Value Management.

B.4.7.8 One method of identifying programmed maintenance schemes for carriageways, footways and cycle routes is as follows:

- The information obtained from condition surveys can be processed through an appropriate asset or pavement management system, consistent with the principles set out in PAS 2161.
- The preliminary programme should then be developed into individual schemes that meet the levels of service in the Asset Management Framework. The schemes may then be prioritised using a process of Value Management. Schemes may not necessarily be prioritised on a 'worst first' basis, as this does not always represent best value for money. A whole-life cost approach can deliver improved value by optimising the timing and type of intervention.

B.4.7.9 Examples of programmed maintenance are given below; this list is not exhaustive:

- carriageways – minor works, resurfacing, surface treatments, skid resistance improvement or reconstruction;
- footways – minor works, resurfacing, surface treatments or reconstruction;
- cycle routes – minor works, resurfacing, surface treatments or reconstruction;
- drainage systems – gully cleansing programmes, renewal or repair;
- embankments and cuttings – slope stabilisation works, vegetation management;
- landscaped areas and trees – planned arboricultural works, and disease management;
- fences and barriers – renewal of safety fencing, replacement of posts and panels;
- non-illuminated traffic signs – renewal of sign faces, replacement of aged or damaged posts;
- street furniture – refurbishment or replacement; and
- road markings and studs – refresh of road markings and renewal of worn or missing studs.

B.4.8 PRIORITIES FOR ROUTINE MAINTENANCE

B.4.8.1 Routine maintenance is primarily for the purpose of providing defined levels of network serviceability, maximising availability, reliability, integrity and quality. The priorities and programmes will be determined largely, but not exclusively, from non-urgent defects identified during asset specific inspections together with items from safety inspections not requiring urgent attention and user requests.

B.4.8.2 Priorities and programmes should be defined for all routine maintenance categories. Routine maintenance for each category may be undertaken separately, according to the frequency defined in each case, but it will usually be more efficient to combine a number of operations into a co-ordinated programme. It may also be convenient in central urban areas to consider coordination with other related street activities.

B.4.8.3 For rural areas, it would be beneficial, to support operational efficiency, to establish a regular programme of visits to local areas to undertake the widest possible range of routine maintenance

activities, with advance notification provided to the community; similar arrangements may also be appropriate for neighbourhoods within urban areas.

B.4.8.4 Examples of routine maintenance are given below, but this list is not exhaustive:

- carriageways, footways and cycle routes – minor works and patching;
- drainage systems – cleansing and repair;
- embankments and cuttings – drainage and stability;
- landscaped areas and trees – management;
- verges – grass cutting;
- fences and barriers – tensioning and repair;
- non-illuminated traffic signs and bollards – cleansing and repair; and
- road markings and studs – replacement.

SECTION B.5 ASSET KNOWLEDGE – HIGHWAYS

B.5.1 INTRODUCTION

B.5.1.1 The general principles applicable to asset knowledge are outlined in Section A.5 of this Code, with this section covering guidance relating specifically to highway assets.

B.5.1.2 This section sets out the highway assets' contributions to the core objectives of the Code, guidance for each category of inspection relating to highway assets and asset data. Authorities may refer to UKRLG Highway Infrastructure Asset Management Guidance (HIAMG) Part B for further guidance.

B.5.2 PRINCIPLES AND CONSIDERATIONS

B.5.2.1 Each highway asset type could have different condition requirements, a minimum one to satisfy the need for safety, and higher ones, designed to meet local requirements for serviceability or sustainability, as part of the asset management strategy adopted by the authority. These different higher levels have previously been given a range of names including 'warning levels', 'intervention levels' and 'investigatory levels'.

B.5.2.2 In this Code, the term '**investigatory levels'**, refers to a failure to reach the defined level that in most cases could give rise to a range of responses each of which needs to be further investigated, prior to action being taken.

B.5.2.3 The term '**intervention level'** has been retained only for use with the automatic treatment selection criteria used in UKPMS, as the system does actually 'intervene' at the defined level of condition. It will, however, always be referred to as system intervention level (SIL) for the avoidance of confusion.

B.5.2.4 An investigatory level is a threshold that prompts further assessment and consideration of risk. It is not an intervention level and does not automatically require repair or other action. Authorities should determine appropriate responses based on the outcome of the investigation, taking account of location, users, consequences, local circumstances and the authority's wider risk-based approach.

B.5.2.5 Local network knowledge, understanding of network characteristics, maintenance history and user needs can support effective inspection and asset management activities. These considerations are important regardless of whether inspections are undertaken by in-house teams, consultants or contractors.

B.5.2.6 The approach adopted locally should be documented fully and approved by the appropriate senior decision makers within each authority. All inspection and assessment results should also be recorded and accessible, preferably via a suitable asset management system.

B.5.2.7 The cost of inspections and condition surveys can form part of a proportionate risk-based approach. The frequency and extent of data collection can be influenced by both cost and the value of the information obtained.

B.5.2.8 The following section outlines how each element of the highway network contributes to the core objectives of safety, serviceability, sustainability, and customer service.

B.5.2.9 Each element of the network will contribute differently to the objective of customer service and possibly within different timescales. For example, good surface condition or signing will have an immediately positive effect, whilst the effect of good quality drainage will probably be imperceptible for most of the time.

B.5.2.10 Further to the contributions to the core maintenance objectives, guidance for each category of inspection is then detailed by asset type.

B.5.3 INSPECTION AND SURVEY CATEGORIES

SAFETY INSPECTIONS

B.5.3.1 A safety inspection for a highway authority is a routine check of the highway network to identify defects or hazards that could pose a risk to users, so that appropriate action can be taken to reduce the likelihood of injury or damage.

B.5.3.2 Authorities should determine the most appropriate way to undertake inspections in order to clearly observe any defects for each asset type. This may include inspections from a vehicle or, in busy urban areas, and particularly when inspecting footways, it may be difficult to obtain the necessary level of accuracy from vehicle-based inspections and walking should be used. It would seem logical for cycle routes to be inspected by cycle, although inspection of parts of some shared routes may be possible by walking or by vehicle as appropriate.

B.5.3.3 The inspection methodology adopted should be determined by each highway authority, taking account of local circumstances, asset characteristics, network users and the level of accuracy required to identify and assess defects effectively.

B.5.3.4 Authorities may choose to carry out combined inspections including safety, obstruction and all network management functions. These may be planned or responsive following user complaints.

B.5.3.5 Frequencies of safety inspections should be derived using the principles outlined in Section A.4 this Code (categorising the network into an appropriate hierarchy) and Section A.5 (covering risk-based approach for inspections).

B.5.3.6 In regard to safety related defects, defects should be rectified in accordance with the timescales appropriate to their risk and local policy.

B.5.3.7 The consequences of defects can vary significantly between different user groups. Consideration may be given to the nature and location of the defect, the users likely to be affected and the potential consequences for those users.

B.5.3.8 In urban areas, it may be desirable to combine footway and carriageway inspections to mitigate against problems associated with heavy traffic and parked cars.

B.5.3.9 Risk assessments should consider the reasonably foreseeable use of the highway, including manoeuvres and road space that may be used lawfully and routinely by different classes of user.

B.5.3.10 Where carriageway and footway hierarchies intersect, for example at pelican or zebra crossings, bollards, or other defined crossing points at junctions, the higher inspection frequency should take precedence in determining inspection frequency, defect definition and responses. The same

principle applies to intersections between carriageways and cycle routes, and between cycle routes and footways.

B.5.3.11 Where footways or cycle routes remote from carriageways form part of an integrated route or network intended to encourage walking and cycle use, or are promoted by the authority, consideration should be given to adopting a consistent safety inspection frequency for the route or network as a whole.

B.5.3.12 Safety inspections should incorporate highway trees, including those outside but within falling distance of the highway. For trees off highway limits inspections can only be made so far as can be seen without trespassing. Owners' permission should be obtained to enter property where suspect trees are observed. Inspections take account of any encroachment, visibility obstruction, obvious damage, signs of ill health, or trip hazards.

B.5.3.13 Landscaped areas and trees will be inspected as part of the scheduled Highway Safety Inspection regime for the highway network with particular cognisance of safety, visibility and vegetation growth. Any specific queries that arise related to trees that require specialist input will be referred to the relevant party.

B.5.3.14 Authorities have not generally established specific systems for safety inspections for public rights of way based on hierarchy. The Statement of Action required by ROWIPs provides the opportunity for authorities to consider the relevance of a more formal system of safety inspections, for at least some parts of the network.

B.5.3.15 Section A.4 of this Code advises where certain public rights of way are considered part of the footway hierarchy, safety inspections should be carried out accordingly.

B.5.3.16 Information from all inspections and surveys, together with any immediate or programmed action, including nil returns, should be accurately and promptly recorded, monitored, and utilised with other relevant information in regular reviews of maintenance strategy and practice. This is particularly relevant in the case of safety inspections.

B.5.3.17 Developments in safety inspection technology can be found in B.5.21.

CONDITION SURVEYS

B.5.3.18 Condition surveys identify the current condition of the network and from this condition, both long-term and short-term maintenance funding decisions can be made. Repeatable condition surveys allow trend analysis to be used to confirm the original decisions or allow for changes as a result of the changing network condition and inform lifecycle planning.

B.5.3.19 As part of developing their asset management regime, authorities may develop individual risk assessments for each asset specific inspections by following a similar procedure to that identified for safety inspections.

B.5.3.20 Developments in condition survey technology can be found in B.5.21.

ASSET SPECIFIC INSPECTIONS

B.5.3.21 Highway asset specific inspections are focused on ensuring that the highway assets on the network meet the needs of the users and the levels of service defined within the Highway Asset Management Strategy.

B.5.3.22 Asset specific inspections should be strongly focused on ensuring that the network meets the needs of users and comprise more detailed specific inspections of particular highway elements, to ensure that they meet the levels of service defined within the Asset Management Framework. These surveys are dependent upon the asset management regime adopted by the authority to determine programmes of work. Any safety defects encountered during asset specific inspections should be assessed and dealt with in accordance with the requirements of the safety inspection regime.

B.5.3.23 This category also includes inspections for regulatory purposes, including NRSWA, which are also primarily intended to maintain network availability and reliability, and inspections for network integrity.

B.5.3.24 The risk assessments for asset specific inspections should consider network reliability, integrity and the ability of the network to meet the needs of users. Risks are assessed by reference to the Asset Management Framework by taking due consideration of levels of service, relative priorities and available budget.

B.5.3.25 A risk-based approach to asset specific inspections, together with any condition surveys, will contribute to identifying the need, frequency and period for remedial action for each of the asset specific inspections items.

Table 13: Inspection Types

Aspect	Safety Inspections	Asset specific Inspections	Condition Surveys
Purpose	To identify defects or hazards that could pose a risk to users, so action can be taken to reduce the likelihood of injury or damage.	To ensure highway assets meet user needs and defined levels of service within the Highway Asset Management Plan.	To identify and record the current physical condition of the network to support maintenance and lifecycle planning.
Primary focus	Safety related defects and hazards.	Serviceability, functionality, reliability and network integrity.	Asset condition and deterioration.
Typical method	Walking, slow moving vehicle, cycle or combined inspections, as appropriate to asset type and location.	Targeted, more detailed inspections of specific highway elements.	Structured, repeatable surveys, often technology enabled.
Typical outputs	Safety defect records, reactive repairs, temporary measures.	Planned maintenance programmes, prioritised interventions, service performance evidence.	Condition data, trends, lifecycle planning inputs, funding justification.

B.5.4 CARRIAGEWAYS

B.5.4.1 The condition of the carriageway fabric can contribute to the core objectives as follows:

Table 14: Contribution of Carriageways to Core Objectives

Network Safety	nature, extent and location of surface defects; surface deterioration that may affect vehicle stability, braking or manoeuvrability; condition of carriageway edges where these affect the safe use of the carriageway; and surface characteristics that contribute to the safe operation of vehicles.
Network Serviceability	condition and performance of the running surface; ride quality and user comfort; availability of the network; structural condition and integrity; and suitability for its intended function
Network Sustainability	convenience and ease of use; nature extent and location of surface defects;
Customer Service	journey quality and user experience; reliability and availability of the network; minimisation of disruption arising from carriageway defects and maintenance activities; public perception of carriageway condition; and consistency of maintenance standards across the network.

CONDITION SURVEYS

B.5.4.2 The most significant financial investments in highway maintenance will be in repairing, reconditioning and reconstructing carriageways, and to a lesser degree, footways and cycle routes. Condition monitoring information can support asset management decision making, lifecycle planning, risk assessment and investment prioritisation. There are a number of established types of condition survey, each providing information from a differing perspective, and which in combination can provide a comprehensive picture of the condition of the asset. These surveys may broadly be divided into network level and project level:

- Network-level surveys provide information on the current condition and performance of assets across large parts of the network and can be used to identify deterioration trends, monitor performance and highlight locations that may require further review.
- At a project level, detailed investigations may subsequently be undertaken where a greater understanding of deterioration mechanisms, structural condition or treatment requirements is needed.

B.5.4.3 At a network level, there are national reporting requirements and standards that must be met when conducting a condition survey.

- In England, this is undertaken in accordance with PAS 2161, which establishes the current DfT standard for road condition reporting of the classified road network and replaces the previously used SCANNER condition indicators. PAS 2161 allows the use of a range of approved technologies including vehicle-based, image-based and other emerging methods, provided they produce compliant outputs in a one to five scale. Authorities in England should ensure that the technologies they select deliver the requirements of PAS 2161, while also supporting local asset management needs;
- In Scotland, Wales and Northern Ireland, authorities should comply with the relevant national standards, guidance and reporting requirements applicable for their network. For example, this may include approaches aligned with SCOTS guidance such as Scottish Road Maintenance Condition Survey (SRMCS) or Welsh Government performance indicators and survey frameworks;
- The SRMCS is an annual survey which assesses the condition of the entire Scottish Local Authority road network. It provides roads authorities with performance information required for Statutory Performance Indicator 3.
- Across all UK nations, authorities should ensure that survey approaches provide consistent, repeatable and proportionate data to support asset management and national reporting objectives.

B.5.4.4 National reporting requirements represent a minimum baseline for condition data collection. Additional surveys, investigations and data collection activities may be used to support local asset management objectives, maintenance planning, risk-based decision making and investment prioritisation. Survey providers may also offer additional information beyond national reporting requirements, such as additional data types or a greater survey frequency. The need for additional condition, performance or inventory information can be determined through the authority's risk-based approach and reflected in the procurement of survey services.

Table 15: Network-Level Condition Surveys

Survey type	Example technologies / methods	Typical application and outcomes
Network and surface condition monitoring surveys	Automated or AI-enabled imaging surveys, laser-based surveys, profile measurement systems, 3D pavement surveys, sensor-based monitoring systems.	Provides network-wide condition information to support performance monitoring, deterioration modelling, lifecycle planning and investment prioritisation. Can provide rapid coverage of large networks and a screening layer to identify locations requiring further inspection or investigation.
Visual condition surveys	Coarse Visual Inspection (CVI), Detailed Visual Inspection (DVI), driven visual surveys, walked inspections, image-based surveys	Enables assessment of visible defects and condition characteristics that may not be fully captured remotely. Supports maintenance planning, defect identification and validation of survey data.
Skid resistance surveys	Sideway-force Coefficient Routine Investigation Machine (SCRIM) and equivalent skid resistance measurement systems	Identifies sites where skid resistance characteristics may require further review. Supports risk-based management of the network and treatment prioritisation at locations with higher skidding risk.
Footway and cycleway condition surveys	Visual inspections, machine-assisted surveys, image-based surveys	Supports assessment of serviceability, safety and user experience for active travel infrastructure. Assists lifecycle planning and investment prioritisation.
Asset inventory surveys	Mobile mapping, Light Detection and Ranging (LiDAR), imagery capture, sensor-based inventory surveys	Captures or validates asset inventory information, enabling authorities to understand what assets they own, where they are located and how they can be managed. Supports asset valuation, lifecycle planning and risk management.

Table 16: Detailed Investigations

Investigation type	Example technologies / methods	Typical application and outcomes
Structural assessment	Falling Weight Deflectometer (FWD), Deflectograph, Traffic Speed Deflectometer (TSD)	Investigates pavement structural condition and remaining life. Supports treatment selection, scheme design and identification of underlying deterioration mechanisms.
Pavement construction assessment	Ground Penetrating Radar (GPR)	Provides information on pavement construction, layer thickness and composition. Supports scheme development, asset knowledge and interpretation of condition data.
Material investigations	Coring, sampling and laboratory testing	Confirms pavement material properties and asset condition. Supports treatment design, root-cause analysis and validation of survey findings.
Drainage investigations	CCTV surveys and specialist drainage investigations	Identifies drainage defects, blockages and performance issues that may contribute to asset deterioration. Supports targeted maintenance and renewal planning.
Geotechnical investigations	Boreholes, trial pits, sampling and laboratory testing	Assesses subgrade, earthwork and foundation conditions. Supports slope stability assessments, pavement design and investigation of recurring failures.
Specialist defect investigations	Targeted monitoring, specialist imaging, sensor-based monitoring	Examines specific deterioration mechanisms, recurring failures or emerging risks. Supports diagnosis of root causes and selection of appropriate interventions.

B.5.4.5 CVI is a manual inspection, normally carried out from a vehicle, complemented in some cases with machine measured rut depth data. It is a fast, cost-effective survey that enables authorities to cover large parts of their road network on a regular basis. Rather than recording detailed measurements of individual defects, the survey identifies and categorises lengths of features having generally consistent defectiveness.

B.5.4.6 DVI may be used on carriageways where more detailed information is required to support and validate treatment decisions and scheme identification (supplementing CVI data), and also on a cyclical basis for those parts of the network where a more detailed routine visual assessment is required (e.g., in urban areas). DVI can also be used for concrete carriageways. Segregated cycle routes may also be surveyed by DVI.

B.5.4.7 Guidance on CVI and DVI condition surveys can be found on the UKRLG website: Section 3: measuring surface condition using manual visual surveys.

B.5.4.8 An alternative methodology is used in Scotland which Scottish Local Authority staff can access via the RAM Knowledge Hub.

B.5.4.9 Dedicated data collection vehicle surveys are traffic speed surveys that collect data for carriageways. There is now a range of data collection technologies available. They can support national requirements for reporting where applicable.

B.5.4.10 Dedicated data collection vehicle surveys and other visually based surveys only measure surface condition. Where defects have been identified by such surveys, the Deflectograph may be used at project level to augment this condition information by providing the structural condition of the defective section for flexible and flexible composite carriageways. This will assist in supporting treatment decisions. Where automated surveys and Deflectograph show that remedial works can be limited to the surface, no strengthening is required. However, where the Deflectograph shows that the structure needs to be strengthened, the Deflectograph results provide recommendations for overlay thickness or reconstruction. It should be noted that for roads which are not long-life, dedicated data collection vehicle outputs will not take into account structural condition until it has manifested itself as rutting or cracking.

B.5.4.11 Deflectograph surveys on short network lengths may not always be economic or practical. Other techniques such as FWD, GPR, coring and trial pitting may be more cost effective.

SKIDDING RESISTANCE SURVEYS

B.5.4.12 The maintenance of adequate levels of skidding resistance on carriageways, footways and cycle routes is a most important aspect of highway maintenance, and one that contributes significantly to network safety, particularly for cyclists, motorcyclists and equestrians. However, whilst the frequency of collisions is expected to increase as skidding resistance falls, the effect will be more pronounced for more ‘difficult’ sites and there is no skidding resistance boundary at which a surfacing passes from being ‘safe’ to ‘dangerous’. Difficult sites are those where the geometry, for example, bends, junctions, roundabouts, steep gradients, pedestrian crossings and traffic signals increase the risks of skidding incidents. Authorities should publish their Skid Resistance Strategy as part of their Asset Management Framework. An approach to skid resistance management may be informed by the overall risk-based approach and assessment, in addition to:

- the network to which it applies taking account of traffic flow and characteristics and incident risk;
- the test equipment to be used, e.g., SCRIM or Grip Tester. Authorities should state if they will use the Pendulum Skid Tester for detailed investigations;
- the method of survey to be used to provide an estimate of the summer skid resistance, referred to as the Characteristic SCRIM Coefficient (CSC). Authorities can choose between the Single Annual Survey Method, Mean Summer SCRIM Coefficient Method, or Annual Survey with Benchmark Method;
- quality assurance procedures for data collection;
- frequency of surveys;
- the approach to setting investigatory levels, including the range of investigatory levels which are to be used for different categories of site;

- frequency of re-assessment of investigatory levels;
- competence levels of staff authorised to set or approve investigatory levels;
- the approach to be followed in site investigation, including prioritisation of investigations, and staff competent to undertake site investigations. Each site investigation should be undertaken or led by suitably competent personnel;
- intervention criteria;
- how remedial works will be prioritised in relation to available funding in the overall context of the Asset Management Framework;
- whether they will follow existing highway design guidance (CS 228) or produce their own strategy for dealing with early life skid resistance;
- a realistic/achievable timetable for each part of the strategy;
- responsibilities for delivering each part of the strategy; and
- the documentation to be retained to enable implementation of policy to be demonstrated (in court if necessary).

B.5.4.13 The decisions taken when setting investigatory levels should be recorded, dated and signed. Significant changes to the network may influence the suitability of existing investigatory levels, for example the installation of traffic lights, a pedestrian crossing, or roundabout. The investigatory levels for each category of hierarchy of the network should be reviewed as a result of risk assessment.

B.5.4.14 Authorities need to decide whether to use SCRIM or Grip Tester for network testing and whether they will use Grip Tester or the Pendulum Skid Tester (recommended for localised investigations only). Research has been undertaken into the correlation between Grip Tester and SCRIM.

B.5.4.15 The LASR approach (Local Authority Skid Resistance) is a prioritisation method designed to help authorities identify where skid resistance treatments are likely to deliver the greatest safety benefit.

B.5.4.16 Connected vehicle data, such as real-time measurements of wheel slip, braking events and stability control activation, can be used to supplement traditional skid resistance surveys by providing continuous, network-wide insight into locations where low friction or deteriorating surface conditions may be influencing driver behaviour.

B.5.4.17 All sites where the skid resistance is at or below investigatory level should be identified as soon as is practicable.

B.5.4.18 Investigation findings may be retained where appropriate to support decision making and risk management, together with the identity of the assessor and other parties consulted.

B.5.4.19 Where the skid resistance is considerably below the Investigatory Level (an appropriate figure should be determined locally), “Slippery Road” signs should be erected as a matter of urgency.

B.5.4.20 In other cases, “Slippery Road” signs should be erected at locations where a site investigation has shown that there is a need for treatment to improve skid resistance.

B.5.4.21 "Slippery Road" signs should be removed as soon as they are no longer required. This should be after the remedial action has been taken and maintenance engineers are satisfied that skidding resistance levels have been returned to an appropriate level. In some cases, this will not be immediately after treatment, for example at sites where surface binder has to be worn off before the skid resistance becomes adequate.

B.5.4.22 Where skidding resistance is determined as being substantially below the Investigatory Level (an appropriate figure should be determined locally) and there are clear indications that improving the condition of the surfacing is likely to significantly reduce the risk of incidents and collisions occurring, remedial treatment should be prioritised as a relatively urgent task.

B.5.4.23 Priority should then be given to the following sites:

- where the skid resistance is below the investigatory level by a certain degree (an appropriate figure should be determined locally);
- where low skid resistance is combined with low texture depth or visual indicators associated with reduced texture depth, such as fatting, fretting or aggregate loss; and
- where the incident history shows there to be a clearly increased risk of wet or skidding incidents.

B.5.4.24 Where investigations show that treatment is necessary, consideration should also be given to other planned maintenance works programmes to ensure that potential efficiencies are identified and actioned where possible. Surface treatment may not always be a necessary response and other measures to reduce the collision risk of the site may be both more cost effective and consistent with local transport policy.

B.5.5 FOOTWAYS

B.5.5.1 The condition of the footways can contribute to the core objectives as follows:

Table 17: Contribution of Footways to Core Objectives

Network Safety	nature, extent and location of surface defects; trip hazards arising from uneven surfaces, cracking or settlement; defects associated with kerbs, edgings and access points where they affect pedestrian safety; and presence of obstacles that may create a hazard for footway users.
Network Serviceability	nature and extent of surface defects; extent of encroachment from vegetation; continuity and availability of the footway network; quality and condition of the walking surface; and accessibility and ease of movement for all users.
Network Sustainability	convenience and ease of use throughout the asset life; nature, extent and rate of deterioration of the footway asset; extent of damage caused by over-running and inappropriate parking; rural footways being lost through grass ingress; and effectiveness of maintenance in preserving asset life and value.

Customer Service	cleanliness and freedom from litter, leaves and other material affecting footway use; absence of obstacles or overgrown vegetation impeding movement; provision of a comfortable and accessible walking environment; maintenance of user confidence in the condition of the footway network; and support for reliable access to services, facilities and public spaces.

B.5.5.2 The safety and serviceability of footways is a key part of enabling more walking and wheeling, including as alternatives to car use for short journeys. Maintenance strategies should positively address this.

B.5.5.3 In developing maintenance strategies, highway authorities should recognise that poor footway condition, including uneven or degraded surfaces, insufficient width from overgrown vegetation, standing water and physical obstructions, can deter walking and wheeling and disproportionately impacts older people and those with mobility challenges, with pushchairs and visual impairments. Addressing these issues through a risk-based approach supports inclusive, fit-for-purpose footways and helps improve confidence in walking and wheeling.

B.5.5.4 It will also be important in determining priorities for footway maintenance to ensure that opportunities are taken to improve social inclusion, particularly improving accessibility for older people, people with disabilities and those with prams and pushchairs. This should be included as part of the Value Management process described in Section A.7 Finance and Investment. Proposed treatments may include the provision of dropped kerbs in suitable locations and textured paving adjacent to crossing points at marginal cost during the course of works. There is a statutory duty on service providers under the Equality Act 2010 to take reasonable steps to remove or alter physical features to improve access for people with disabilities or provide an alternative method of making services available.

B.5.5.5 Although ensuring the safety of footways for users will be a priority, in some cases the presence of roadside trees may complicate the provision of footway surface regularity. The radical treatment or complete tree removal necessary to ensure surface regularity may not be possible or desirable and reduced levels of surface regularity may have to be provided.

B.5.5.6 Where footways are remote from carriageways, safety and security of users will be an important consideration, both from the point of view of unauthorised vehicular use and quality of lighting. Maintenance strategy should pay particular attention to this.

CONDITION SURVEYS FOR FOOTWAYS

B.5.5.7 The Footway Network Survey (FNS) is intended to provide a cost effective, efficient and consistent approach to footway surveys, based on a linear basis. The survey is carried out by a single surveyor walking along the footway, referenced to chainage within a UKPMS section. Further details on the survey may be found on the UKRLG website.

B.5.5.8 Detailed Visual Inspections (DVI) may also be utilised to collect footway condition data. Other suitable methods may include walked or vehicle-based image surveys and automated or technology-enabled assessment, where these provide data appropriate to the authority's asset management requirements.

B.5.6 CYCLE ROUTES

B.5.6.1 The condition of cycle routes (cycle tracks and cycle lanes) can contribute to the core objectives as follows:

Table 18: Contribution of Cycle Routes to Core Objectives

Network Safety	nature, extent and location of surface defects; nature and extent of defects affecting cyclists' stability and control; condition of edges, kerbs and transitions affecting cyclist safety; and presence of hazards that may create a risk to cyclists.
Network Serviceability	nature and extent of surface defects; extent of encroachment from vegetation and weed growth; the level of friction provided by the surface; the quality and smoothness of the riding surface; and continuity and integrity of the cycle network.
Network Sustainability	convenience and ease of use; nature, extent and location of asset deterioration; extent of damage caused by over-running, parking or unauthorised use by vehicles; loss of effective width through vegetation encroachment; and maintenance of the asset to support long-term service life.
Customer Service	cleanliness and freedom from litter, leaves, debris and other material affecting cyclist safety and comfort; absence of obstacles or overgrown vegetation that impede safe and convenient use by cyclists; provision of a comfortable and attractive cycling environment; and support for reliable and accessible cycling routes.

B.5.6.2 Securing continuous improvement in the safety and serviceability of cycle infrastructure, in particular network integrity, will be a necessary component for encouraging cycling as an alternative to the car. It will be important for maintenance strategy positively to address this.

B.5.6.3 Network integrity is a particularly important consideration where cycle routes are segregated for part of their length but intermittently rejoin the carriageway. In these circumstances a reasonably consistent level of maintenance should be provided and attention paid to carriageway edge condition in the un-segregated sections.

ASSET SPECIFIC INSPECTIONS FOR CYCLE ROUTES

B.5.6.4 Asset specific inspections for cycle tracks and cycle lanes should be undertaken at locally determined, risk-based frequencies that reflect user needs and community requirements, as set out within the Asset Management Framework. These inspections may be carried out independently or alongside other inspection types.

B.5.6.5 The UKRLG and FCMG Footways and Cycle Route Research report on cycle service levels and condition assessment highlights that serviceability goes beyond condition scoring and relates to

the quality of service experienced by the user of the infrastructure. For example, this may include aspects such as safety, comfort, ease of use or visual attractiveness.

B.5.6.6 Cycle tracks should normally be inspected on foot or by cycle where their condition cannot be adequately assessed from a vehicle, and remote or segregated routes should be inspected using the most appropriate method for their location and construction. Use of video or other survey data may be appropriate where conditions allow.

B.5.6.7 For cycle lanes, surveys are typically undertaken from a slow-moving vehicle, with walked inspections used where conditions cannot be reliably assessed from the carriageway, or where specific local factors require a closer inspection. Video or similar data collection methods may also be employed when suitable.

B.5.7 HIGHWAY DRAINAGE SYSTEMS

B.5.7.1 Highway drainage systems refer to all the gullies, pipes, culverts that are under 900 mm in diameter, manholes, catchpits, headwalls, oil/petrol interceptors, soakaways and settlement ponds necessary for the removal of rainwater from the highway network (excluding any combined drainage system that is the responsibility of the water authority).

B.5.7.2 The condition of highway drainage systems can contribute to the core objectives as follows:

Table 19: Contribution of Highway Drainage Systems to Core Objectives

Network Safety	accumulation of water on carriageways, footways and cycle routes. uncontrolled discharge of water causing hazards to highway users or adjacent land.
Network Serviceability	accumulation of water on carriageways, footways and cycle routes effectiveness of drainage systems in removing surface water;
Network Sustainability	polluted effluent from clearing of highway drainage should not be directed into watercourses; authorities have a duty to prevent nuisance and danger to adjoining landowners by flooding and should also work with others in the wider community to minimise the future risk of flooding; inadequate drainage of the highway structure will reduce effective life and increase maintenance liability; and integrity of systems, root ingress, blockage / collapse, exceedance.
Customer Service	inconvenience to users caused by standing water, flooding or drainage-related disruption; increased customer reports and complaints resulting from recurring drainage issues; negative public perception where drainage problems persist or response times are delayed.

B.5.7.3 Highway drainage elements fall into five main categories:

- Gullies, grips and ditches, which may be obstructed by the growth of vegetation or damaged by traffic. In most cases the responsibility for maintenance of ditches will rest with the adjoining landowner;
- Culverts under roads which may be affected by blockage, subsidence or structural damage;

- Other piped drainage which may be affected by blockage or subsidence;
- Sustainable urban drainage systems (SuDS), including attenuation ponds, retention ponds, swales and other drainage features, which may require special maintenance attention for maximum effectiveness; and
- Surface boxes and ironwork for both drainage and non-drainage applications, which may be affected by subsidence or obstructed access.

B.5.7.4 More information on culverts can be found in Section C.2 of this Code.

B.5.7.5 Highways Maintenance Efficiency Programme (HMEP) has guidance on the Management of Highway Drainage Assets. Authorities should consider this guidance when making decisions on the management of drainage assets.

B.5.7.6 Material arising from all road drainage emptying and cleansing operations has potential implications for pollution and should be disposed of correctly in accordance with Environment Agency, or equivalent authority, requirements.

B.5.7.7 Drainage maintenance activities should take account of ecological and environmental considerations where relevant. Activities such as desilting, vegetation management and maintenance of drainage features should be undertaken in a manner that minimises impacts on protected species, habitats and watercourses.

B.5.7.8 Where despite effective maintenance operations, flooding of the highway occurs, with implications for safety or serviceability, relevant warning signs should be placed in position as quickly as possible, and users advised through the relevant communication channels. The cause of the flooding should be determined and addressed as appropriate, in order to restore the highway to a reasonable condition.

B.5.7.9 The highway may flood if the surrounding land is in flood and there are limitations to the action that can be reasonably taken. If it is subsequently determined that the flooding is attributable to deficiencies in infrastructure or the maintenance regime, given the nature of the weather conditions under which it occurred, then action to permanently relieve the problem should be considered. If the event is attributable to the actions of a third party, the matter should be taken up with them at the earliest opportunity.

B.5.7.10 Ironware comprising covers, gratings, frames and boxes set in carriageways, footways and cycle routes has the potential to compromise safety and serviceability, and in certain cases cause noise and disturbance to local residents.

ASSET SPECIFIC INSPECTIONS OF HIGHWAY DRAINAGE SYSTEMS

B.5.7.11 In general, inspection of drainage systems has proved problematic to authorities for a variety of reasons, including inaccurate records of drainage locations, uncertainty of ownership and lack of resources. In 2012, HMEP produced Guidance on the management of Highways Drainage Assets, which provides advice to highway authorities on how to prioritise ‘at risk’ areas and make interventions. It provides a baseline for authorities to review current practices against and to identify potential improvements and is freely available to download through HMEP Resources - IHE.

B.5.7.12 Where possible, drainage assets should be inspected as part of another inspection or operation on the highway on which it is located. This is a risk-based inspection dependent on the needs of the highway network, knowledge of the asset, consequences of failure and consequences of flooding. The assessment should, where relevant, consider risks to adjoining property, groundwater interaction, downstream impacts and opportunities to reduce peak flows. With regard to flooding account will be taken of the authorities' Flood Management Plan when assessing drainage inspection requirements.

B.5.7.13 Further information on nature-based solutions can be found in Section B.8 Sustainability.

B.5.8 EMBANKMENTS AND CUTTINGS

B.5.8.1 The condition of embankments and cuttings can contribute to the core objectives as follows:

Table 20: Contribution of Embankments and Cuttings to Core Objectives

Network Safety	risk of loose material falling to injure users or damage facility.
Network Serviceability	risk of damage or service interruption.
Network Sustainability	damage or loss of habitat; interruption or pollution of watercourse; extent of damage and reduced life; and integrity of structure.
Customer Service	concern or dissatisfaction caused by visible instability or debris on slopes; disruption and inconvenience to users where slope failures lead to delays or restrictions.

B.5.8.2 Failure will be affected by soil conditions and drainage. The impact of embankment or cutting failure will generally be high in all situations, but particularly so on important high-speed links, or where dwellings could be affected. In such circumstances, the condition of embankments and cuttings will require a robust regime of inspection, and possibly continuous condition monitoring.

B.5.8.3 Slips and rock-falls from embankments and cuttings are relatively infrequent but the frequency and severity of such events may be affected by climatic change. Authorities should have records of relevant locations and should establish an inspection and maintenance regime based on a local risk assessment. In higher risk locations, or where ground conditions are difficult, specialist geotechnical advice should be obtained.

ASSET SPECIFIC INSPECTIONS OF EMBANKMENTS AND CUTTINGS

B.5.8.4 Significant embankments and cuttings should be defined and an inspection regime identified based upon the geological characteristics and the potential risk of slippages or rockslides. Asset specific inspections arrangements should be based on specialist geotechnical advice but should usually be programmed wherever possible to follow periods of extreme or severe weather, including heavy rain, severe frost or prolonged dry weather. A risk-based approach should be adopted to identify any issues critical to network performance, after which an enhanced asset specific inspections regime should be adopted.

B.5.9 LANDSCAPED AREAS AND TREES

B.5.9.1 The condition of landscaped areas and trees can contribute to the core objectives as follows:

Table 21: Contribution of Landscaped areas and trees to Core Objectives

Network Safety	obstruction to user visibility and legibility of non-illuminated traffic signs; fallen trees or overgrown vegetation that physically obstructs part of the highway; falling branches from trees; leaf fall from trees causing slippery surface; and root growth affecting surface regularity.
Network Serviceability	potential for service interruption; and quality of user experience.
Network Sustainability	landscape conservation; mitigation of climate change effects; support for habitat and biodiversity; problems of root growth for surface, structure and highway drainage; and maintaining healthy trees, root severance, ivy clearance.
Customer Service	reduced satisfaction due to overgrown or poorly maintained landscaped areas; negative perception of the network where untidy or unmanaged planting affects overall amenity.

B.5.9.2 The probability of landscaping and tree failure will generally be low but is likely to increase as a result of climate change and during periods of severe weather. Probability of failure will increase with a rise in the incidence of disease such as ash dieback. The impact will generally be related to safety or damage to road surfaces or property, and will increase on higher speed roads, areas with higher pedestrian levels and the proximity to property. The inspection and maintenance regime should identify high risk locations.

B.5.9.3 The condition of landscaped areas and trees has implications for all core objectives and requires careful consideration to achieve an appropriate balance. It is also a highly visible aspect of the highway and can demonstrate sensitivity and flexibility in maintenance policy.

B.5.9.4 Vegetation can obstruct street lighting, traffic signs, visibility and other highway infrastructure. Authorities should adopt a risk-based inspection and maintenance approach to identify and manage such issues, while maintaining the form and health of trees wherever practicable. Further information on street lighting and illuminated traffic signs is provided in Section D.5.

B.5.9.5 The soft estate includes areas of land with various functions, for example habitat, nature conservation interests, screening, planting, and wildflower diversity. The verge serves a safety and refuge function and to a lesser extent and in certain situations an amenity. The soft estate can be included in highway maintenance strategy, but it requires a specialist expertise.

B.5.9.6 Vegetation should not restrict visibility at junctions, access points and bends. Many highways have evolved rather than being formally designed and visibility and sight lines do not always exist.

However, where they do, these should be kept clear and signs, lights, and marker posts should not be obstructed. Vegetation may also need to be managed to enable inspections and surveys.

B.5.9.7 Authorities should apply judgement flexibly in urban and rural areas, taking account of local character rather than relying solely on speed limit considerations.

B.5.9.8 The growth of weeds in footways and cycle routes, hardened verges, central reserves filter drains and along kerb lines, may cause structural damage, drainage issues and is also a source of significant community interest and service requests. In circumstances weeds have been considered to have implications for pedestrian safety. Weed treatment should be undertaken according to traffic and pedestrian usage and to a level of usage that takes account of local concerns. The use of weed killers should be the minimum compatible with the required results and arrangements for weed spraying should, where appropriate, be coordinated with street cleansing activities, which may be the responsibility of other authorities.

B.5.9.9 Cutting of trees should be considered where there are special requirements in visibility areas or across central reserves, and owners of private hedges should be requested to adopt similar levels of cutting. Significant pruning or felling of trees, even for safety reasons, can be the subject of significant local concern and should only be undertaken with specialist advice and support. BS8545 demonstrates that if the right trees are properly planted and given correct structural pruning at the right time, the trees should not need any further significant pruning.

B.5.9.10 The requirements for tree maintenance can be greatly reduced through the careful selection of trees when planning planting or replacement operations. Trees requiring pollarding should generally be avoided as they can be costly and time consuming to maintain. Expert advice should be sought in the management of trees within the highway environment. Proposed tree planting should consider proximity to existing or planned street lighting to minimise the risk of shrouding streetlights or casting shadows on the highway.

B.5.9.11 Trimming of hedges should ensure that visibility sight lines and road signs are not obscured and will often be the responsibility of adjoining landowners. Any trimming should, as far as possible, be undertaken in late winter to avoid the bird-nesting season and to allow birds and mammals the maximum opportunity to take advantage of any fruits or seed present and in line with the European Birds Directive (2009).

B.5.9.12 Specialist environmental guidance should be adhered to regarding the materials used for weed spraying and the frequency of application, in the light of developing levels of usage. Noxious weeds should be dealt with on an ad hoc basis. Authorities should undertake tree, hedge, verge and weed management activities in accordance with relevant legislation, standards and guidance, including:

- Control of Pesticides Regulations 1986;
- Plant Protection Products (Sustainable Use Regulations) 2012;
- UK Pesticides National Action Plan 2025 - UK-wide approach to the sustainable use of pesticides in amenity and public-space settings;
- Integrated Weed Management Reference Guide Second Edition (Parks for London, 2026) - practical guidance on integrated and non-chemical weed control approaches;
- BS8545 - Trees: From Nursery to Independence in the Landscape;

- Wildlife and Countryside Act 1981; and
- Highway Tree Management: Operations Note 51 for good practice in the management of trees within the highway boundary.

ASSET SPECIFIC INSPECTIONS OF LANDSCAPED AREAS AND TREES

B.5.9.13 The landscaped areas asset management plan should define the inspection regime for various types of trees. A risk-based approach may be considered to develop the relevant inspection regime.

B.5.9.14 Trees are important for amenity, biodiversity and nature conservation reasons and should be preserved where practicable. However, they can present risks to highway users, adjoining land users and highway infrastructure if they become unstable, shed branches, cause obstruction, restrict visibility, interfere with signs or lighting, damage highway assets through root growth, or otherwise affect the safe operation of the network.

B.5.9.15 In England and Wales, it is the common law duty of the landowner to take reasonable care to ensure that trees outside the highway boundary, but within falling distance, are safe. However, highway authorities may become aware of trees, hedges or shrubs which are not safe. Section 154 of the Highways Act 1980 empowers the authority to deal, by notice, with hedges, trees and shrubs growing on adjacent land which overhang the highway, and to recover costs. Similarly, in Northern Ireland, Article 50 of the Roads (NI) Order 1993 gives the DFI the discretionary power to serve a Notice on the owner of the tree or hedge, or on the occupier of the land on which such tree or hedge is growing, requiring him to remove the tree or hedge or to lop the tree or cut back the hedge to such an extent as will remove the obstruction or remedy any other matter to which the notice relates.

B.5.9.16 In Scotland, Sections 88 and 92 of the Roads (Scotland) Act 1984 gives highway authorities the responsibility to remove projections which impede or endanger road users and provide restrictions on planting of trees near carriageways.

B.5.9.17 Authorities should include some basic arboricultural guidance in training for inspectors, but it is important that arboricultural specialists should advise on the appropriate frequency of inspections and works required for each individual street or mature tree that is considered to hold a high risk to users of the network. A separate programme of inspections for such trees, should also be undertaken by arboricultural advisors. LANTRA have produced a training course for professional tree inspection.

B.5.9.18 Extensive root growth from larger trees can cause significant damage to the surface of footways, particularly in urban areas. A risk assessment should therefore be undertaken with specialist arboricultural advice on the most appropriate course of action, if possible, to avoid harm to the tree. In these circumstances, it may be difficult for authorities to reconcile their responsibilities for surface regularity, with wider environmental considerations and a reduced level of regularity may be acceptable.

B.5.9.19 Overhanging branches may present a risk to high vehicles and also buildings adjoining the highway. In such circumstances, the necessary comprehensive consideration of respective risks and liabilities of the authority and landowner will require specialist technical, arboricultural and legal advice to determine the most appropriate course of action.

B.5.10 FENCES AND BARRIERS

B.5.10.1 There are different types of fences and barriers used on the highway network. These include vehicle restraint systems (safety barriers), terminals and end terminals (including crash cushions where appropriate), removable barrier sections, pedestrian guard rail (pedestrian restraint systems), boundary fencing, environmental barriers and associated posts, fixings and ancillary components.

B.5.10.2 The condition of fences and barriers can contribute to the core objectives as follows:

Table 22: Contribution of Fences and Barriers to Core Objectives

Network Safety	integrity, condition and location of safety barriers and fences; effectiveness in containing and redirecting errant vehicles; protection of pedestrians, cyclists and other road users from hazards; segregation of highway users from adjacent hazards, land or infrastructure; and prevention of unauthorised access to the highway where safety risks may arise.
Network Serviceability	prevention of livestock, wildlife and unauthorised users entering the highway; maintenance of safe and efficient operation of the highway network; protection of highway assets and infrastructure from accidental damage; and minimisation of disruption arising from failure or damage to fencing and barriers.
Network Sustainability	condition, durability and service life of fencing and barrier assets; resistance to deterioration from weather, impact damage and environmental conditions; effectiveness of maintenance interventions in preserving asset value; and resilience of fencing and barriers to future operational demands.
Customer Service	appearance and visual condition of fencing and barriers; public confidence in the safety and management of the highway network; minimisation of complaints arising from damaged, missing or poorly maintained assets; and contribution to a safe, well-maintained and attractive highway environment.

B.5.10.3 The impact of vehicle safety on fence failure will be higher with increasing difference in vertical level between the road and the adjacent land. It will be particularly so adjacent to railways and at approaches to bridges over railways. The DfT publication Managing the Accidental Obstruction of the Railway by Road Vehicles provides further guidance. Impact will also be higher on higher speed roads. Impact of failure to pedestrian barriers will increase with volumes of vehicles and pedestrians, especially children, and again where railways, rivers and similar high-risk features are concerned.

B.5.10.4 All high-risk assets will require a robust inspection regime with a commensurate high level of condition. Road restraint systems should be maintained in a condition that allows them to perform their intended function and not present a hazard to road users or pedestrians.

B.5.10.5 All fences and barriers, whether for safety purposes or general use, are potentially important features and their overall appearance is an environmental consideration. They should be cleaned and painted when necessary and where safety fencing is provided with chevron markings, these should be dealt with in accordance with the cleaning regime for non-illuminated traffic signs.

ASSET SPECIFIC INSPECTIONS OF FENCES AND BARRIERS

B.5.10.6 Steel and wire road restraint systems should be inspected at intervals determined through risk assessment in respect of mounting height, surface protective treatment and structural condition, to ensure that they remain fit for purpose. Tensioning bolts of tensioned safety fences should be checked and reset to correct torque at intervals determined by risk assessment. Safety barriers adjacent to bridges should be inspected as part of the highway asset, as well as part of General and Principal Inspections for structures.

B.5.10.7 Inspection and testing of safety barriers with respect to mounting height and integrity should be undertaken at a frequency determined locally using a risk-based approach.

B.5.10.8 BS 7669-3 provides recommended inspection frequencies for routine and detailed inspections of safety barriers, which may be considered when developing a risk-based approach.

B.5.10.9 Pedestrian guard rail, boundary fences and environmental barriers for which the authority is responsible, should be also inspected in respect of integrity, and where appropriate stock proof qualities, during the course of asset specific inspections of carriageways, footways and cycle routes. A higher frequency may be necessary in some locations (e.g., in areas with known higher incidence of vandalism). Inspections of structural condition and protective treatment should be carried out at regular intervals. All inspection intervals should be determined using a risk-based approach.

B.5.10.10 Vehicle restraint systems should be inspected in accordance with an authority's strategy based upon the UKRLG/DfT October 2011 document – Provision of Road Restraint Systems for Local Authorities.

B.5.10.11 Safety barriers and fences adjacent to railway lines should be inspected by the highway authority irrespective of liability, with inspection intervals determined using a risk-based approach. The DfT publication Managing the accidental obstruction of the railway by road vehicles provides more guidance on this (see Section A.4 of this Code).

B.5.10.12 The Road Restraint Risk Assessment Process (RRRAP) has been developed to allow the need for a vehicle restraint system to be established for individual sites or schemes and, where required, to determine its performance requirements. Further information and access to RRRAP can be found at: Road Restraint Risk Assessment Process

B.5.11 NON-ILLUMINATED TRAFFIC SIGNS

B.5.11.1 The condition of non-illuminated signs can contribute to the core objectives as follows:

Table 23: Contribution of non-illuminated traffic signs to Core Objectives

Network Safety	identification and communication of hazards, restrictions and regulatory requirements to road users; separation and management of potential traffic conflicts; provision of clear and consistent information to support safe user decisions; and maintenance of sign visibility, legibility and correct positioning.
Network Serviceability	contribution to the efficient movement of traffic; support for ease of navigation and route finding; contribution to the integrity and operation of the highway network; and provision of information that assists road users in reaching destinations efficiently.
Network Sustainability	support for sustainable transport modes through appropriate signing; contribution to local economic activity by facilitating access to destinations and services; support for effective route management, including the routing of heavy vehicles where appropriate; and maintenance of asset condition to maximise service life and value.
Customer Service	provision of clear, accurate and accessible information to road users; reduced user confidence where signs are unclear, damaged, missing or obscured; support for a positive user experience through consistent and reliable signing; and reduction in confusion, unnecessary delays and navigation errors.

B.5.11.2 The impact of failure can be greater for regulatory signs than for warning signs, the impact of which will be greater than direction signs; however, this will depend on the nature of the information conveyed and the consequences arising from sign failure. The probability of sign failure is generally low, although it will be higher in areas subject to vandalism. However, the probability of sign illegibility, defectiveness or clutter is much higher.

B.5.11.3 Non-illuminated traffic signs and bollards represent a highly visible component of the highway network, highly valued by users. At best they can significantly affect both network efficiency and the convenience of users. At worst they can be intrusive, confusing and capable of detracting even more significantly from the local environment, if in poor condition.

B.5.11.4 Although in many circumstances illuminated signs are essential, the use of high-reflectivity, non-illuminated signs can bring benefits in terms of sustainability. This should be a consideration where legally permitted, both for new signs and on replacement, and should also be considered during any network integrity inspections.

ASSET SPECIFIC INSPECTIONS OF NON-ILLUMINATED TRAFFIC SIGNS

B.5.11.5 Non-illuminated traffic signs are one of the most visible elements of the highway network, highly valued by users, and contribute significantly to network serviceability through facilitating efficient and effective use of the network.

B.5.11.6 The primary objective is to keep all non-illuminated traffic signs legible, visible and effective as far as possible at all times in relation to the road use and traffic speeds. The following defects in signs and bollards should be considered as factors in a local risk assessment. The speed of permanent repair will depend on the degree of danger, but important warning and regulatory signs should be replaced as a matter of urgency:

- Matters affecting the legality of important warning and regulatory signs;
- Damage, deterioration, or vandalism to signs leaving either the sign or situation to which it applies in a dangerous condition; and
- Missing traffic cylinders across gaps in central reserve fence at emergency crossing points.

B.5.11.7 Vegetation potentially obscuring non-illuminated traffic signs should be recorded during safety inspections and asset specific inspections of carriageways, footways and cycle routes, and treated accordingly. The level of risk associated with such vegetation may change during periods of maximum growth.

B.5.11.8 Special signing schemes, for example blockwork chevron treatments at roundabouts and traffic calming schemes using special signing may deteriorate more quickly than conventional signing. They are also likely to have been installed to improve network safety. Inspection arrangements should reflect this via risk assessment.

B.5.11.9 The condition of non-illuminated traffic signs should be inspected in daylight, and also at night for degradation of colour, retro-reflectivity, deteriorating fittings, legibility distance, and average surface luminance, after cleaning. The frequency of cleaning required will be influenced by the risk of soiling in local areas.

B.5.11.10 Inspections should initially be visual and condition assessed. Any suspect areas identified by the visual inspection should be noted and further testing instigated. The coefficient of retro-reflection of sign face sheeting is a specialist site test that may require the services of a specialist organisation. Authorities should choose sign performance levels depending on the overall risk assessment and road hierarchy. National Highways have published CS125 which contains more information on the inspection and maintenance of traffic signs.

B.5.11.11 Inspection of “Stop and Give Way” signs at minor roads should be included in the inspections of signs on the major road to which they control entry.

B.5.11.12 Asset specific inspections should ideally identify signing that is inappropriate or no longer necessary and may be a distraction to users, or detrimental to the street scene. Such signing should be noted for removal or replacement either as part of future programmed works or more urgently, if necessary. Examples may include:

- Non-illuminated traffic signs or markings may be poorly sited, or the legend may be either incorrect, confusing or not reflect current priorities;
- Non-illuminated traffic signs or markings may be redundant;
- Sign posts, poles, mounting structures or other sign support equipment that no longer serve a highway purpose following the removal, loss or redundancy of the associated sign.

B.5.11.13 The Department for Transport published advice in Chapter 1 of the Traffic Signs Manual regarding reducing sign clutter. It emphasises that designers should use their engineering

judgement and local knowledge to complement guidance to ensure signing solutions are effective.

B.5.12 STREET FURNITURE

B.5.12.1 The condition of street furniture can contribute to the core objectives as follows:

Table 24: Contribution of Street Furniture to Core Objectives

Network Safety	risk to users from damaged, unstable or obstructive street furniture;
Network Serviceability	obstruction or reduced accessibility caused by poorly positioned or degraded items;
Network Sustainability	poor condition and material degradation affecting long-term maintenance and environmental quality;
Customer Service	dissatisfaction caused by unsightly, damaged or poorly maintained street furniture.

B.5.13 ROAD MARKINGS AND STUDS

B.5.13.1 The condition of road markings and studs can contribute to the core objectives as follows:

Table 25: Contribution of Road Markings and Studs to Core Objectives

Network Safety	route delineation, particularly in darkness and poor weather; and
	potential for damage and injury if loose.
Network Serviceability	ease of use, particularly in darkness and bad weather.
Network Sustainability	support of sustainable transport modes;
	edge delineation to reduce edge damage; and
	movement of wheel tracking to reduce localised damage.
Customer Service	dissatisfaction caused by unclear or poorly maintained markings.

B.5.13.2 The impact of failure will be greater for regulatory markings than for other markings, the probability of marking wear increases with traffic volume.

B.5.13.3 Many road markings are used to give effect to regulatory provisions, and it is important that their legal status is not affected by undue wear or damage. A high proportion of road markings are essential for road safety or fundamental to the implementation of integrated transport policy, for example traffic calming schemes, bus priority measures and the delineation of cycle routes. If such markings are not kept in good order, the measures may lose effectiveness and the success of transport integration compromised. Where road markings become obscured by mud or spillages action should be taken to clean the road surface.

B.5.13.4 All regulatory road markings existing before resurfacing or surface dressing should either be masked during treatment or replaced as soon as reasonably practicable after the completion of work. If it is not possible to restore immediately in permanent materials, temporary markings should be used at sites where their absence is likely to give rise to dangerous conditions, considering the type of new surface laid. During resurfacing ‘No Road Markings’ boards should be displayed until all markings have been replaced.

B.5.13.5 Road studs that are either missing, or have become defective, should be replaced individually or by a bulk change, depending on the individual highway circumstances. Displaced road studs lying on the carriageway, hard shoulders or lay-bys, and loose studs if considered to be a hazard, should be removed immediately if reasonably practicable.

ASSET SPECIFIC INSPECTIONS OF ROAD MARKINGS AND STUDS

B.5.13.6 Inspections in respect of wear, spread, colour, skid resistance and retro-reflectivity should be undertaken for paint markings and for thermoplastic markings, at frequencies determined by risk assessment. Inspections for reflective conspicuity should be carried out during the hours of darkness and programmed to enable maintenance works to be completed before the onset of winter.

B.5.14 THIRD PARTY INFRASTRUCTURE

B.5.14.1 Responsibility for defective infrastructure, e.g., ironwork, cabinets and poles, where this is part of the apparatus installed by a utility company, lies with the company.

B.5.14.2 Defects identified during inspection or from users should be formally notified to the utility, with a follow up procedure to ensure that dangerous defects are remedied within a specified timescale. However, authorities need to be mindful of their duty to maintain and the circumstances in which they can be held liable for defective privately owned infrastructure.

B.5.14.3 In Northern Ireland, water utility assets are publicly owned within the Department for Infrastructure (DfI).

B.5.15 PUBLIC RIGHTS OF WAY

B.5.15.1 Local authorities in England and Wales should hold a 'Definitive Map', a legal record that identifies the location and status of public rights of way providing the foundation for determining responsibility and ensuring routes are kept open and in suitable condition.

B.5.15.2 This should be accompanied by a 'Definitive Statement' which describes the types of right of ways in an area and could include further details as needed.

B.5.15.3 In Scotland, public access is based on statutory responsible access rights established under the Land Reform (Scotland) Act 2003. Local authorities and National Park authorities act as access authorities, with duties to uphold access rights and to plan, develop and manage core paths. Public rights of way in Scotland arise under common law and are distinct from statutory access rights and the core paths framework. Public rights of way are not managed as part of the adopted roads network, and there is no equivalent to the definitive map system used in England and Wales.

B.5.15.4 Public rights of way are not a roads authority function in Northern Ireland.

B.5.15.5 While public rights of way are defined and recorded differently across England and Wales, Scotland and Northern Ireland, highways authorities across the UK should manage them through a clear, auditable end-to-end process that:

- Maintains the legal record of routes;

- Keeps routes open and safe by inspecting, prioritising and maintaining the network;
- Prevents and resolves access problems by responding promptly to reports, investigating issues, and securing the removal of obstructions or hazards (including taking proportionate enforcement action where required), and
- Supports consistent usability through appropriate signposting/waymarking, coordinated work with landowners and communities, and transparent communication on when works or maintenance will be taken and when.

B.5.15.6 In some cases, the condition of public rights of way can be impacted by unclear responsibility for inspection and maintenance, particularly where responsibilities are shared between different authorities.

B.5.15.7 Where responsibility for a public right of way has been established, authorities should take account of the route's recorded status, physical character, location and use when determining proportionate inspection, maintenance and response arrangements. Decisions should be evidence-based and recorded.

B.5.15.8 Public Rights of Way can contribute to the core objectives as follows:

Table 26: Contribution of Public Rights of Way to Core Objectives

Network Safety	trips/slips from poor surfaces; unsafe bridges/steps; conflict with vehicles at crossings.
Network Serviceability	overgrowth and obstructions; missing waymarks/signs; closures/diversions not clearly signed.
Network Sustainability	damage from illegal/unsuitable use (e.g., motor vehicles); barriers affecting accessibility.
Customer Service	complaints from unclear route status/permissions; inconsistent enforcement; poor communication of diversions/restrictions.

B.5.16 PRIVATE & UNMAINTAINED ROADS

B.5.16.1 Private and unmaintained roads commonly include roads within newer developments awaiting adoption, as well as older roads that have remained unadopted for historical reasons and are roads that are not maintainable at public expense. Responsibilities can often be unclear, particularly where roads appear similar to those maintained by the authority.

B.5.16.2 These roads generally fall outside the authority's routine maintenance responsibilities and can generate user enquiries, safety concerns and requests for intervention. Authorities should therefore maintain clear information on the status of such roads and the responsibilities associated with their maintenance and potential adoption.

B.5.16.3 Authorities should refer to the DfT's Advice Note on the Adoption of Roads into the Public Highway and Section 37-40 of the Highways Act 1980 for further guidance on the adoption of private and unmaintained roads.

B.5.17 NETWORK INTEGRITY

B.5.17.1 Although each element of each component within each category of network hierarchy might be well maintained within the framework of an overall asset management strategy, the network might

still not deliver best value, as the assets may not be performing to optimum efficiency. Operational efficiency is primarily a network management consideration but aspects of it are closely related to the maintenance function, for example:

- Assets such as traffic signs may need to be updated, or deemed no longer be required as a result of a renewal and/or third-party scheme
- Facilities for walking, cycling or public transport might be discontinuous or poorly defined.
- Opportunities for installation of dropped kerbs or tactile paving should be taken; and
- Opportunities might be taken to modify layout as part of future relevant maintenance schemes.

B.5.17.2 Such network deficiencies are unlikely to be noted as part of safety, or condition inspections, but are nevertheless relevant to network efficiency. Authorities may undertake asset specific inspections of network integrity at intervals determined by risk assessment, or prior to planning of network maintenance and improvements.

B.5.18 REGULATORY FUNCTIONS

B.5.18.1 Regulatory functions such as traffic orders associated with parking and vehicle movement can contribute to the core objectives as follows:

Table 27: Contribution of Regulatory Functions to Core Objectives

Network Safety	risk to users and adjoining property.
Network Serviceability	minimising and signing of obstruction.
Network Sustainability	inconvenience to disabled people; and structural damage from parked heavy vehicles.
Customer Service	dissatisfaction caused by unclear or poorly implemented regulatory controls.

B.5.18.2 In England, the statutory duty for network management introduced by the Traffic Management Act places a clear emphasis on regulatory activity. A range of Codes of Practice also provide clear guidance on required levels of service.

B.5.18.3 In Scotland, the Scottish Road Works Commissioner has a range of performance indicators for both roads' authorities and utility companies. These are generated from the Scottish Road Works Register.

B.5.18.4 A significant element of highway maintenance comprises regulation and enforcement of activities on or affecting the highway, which vary across the UK. The most significant of these involves responsibilities under the New Roads and Street Works Act 1991 (NRSWA). The Joint Authorities Group (JAG) UK website contains a range of guidance, information and assistance.

B.5.18.5 Other regulatory activities include:

- Traffic and network management:
  - Ensuring 'expeditious movement of traffic';

  - Issuing permits or permissions for utilities, skips, hoardings, temporary closures and other authorised occupation of the highway;
  - Construction of vehicle crossings;
- Highway records and legal documentation:
  - Management of the Highway Register or equivalent;
  - Management of the Definitive Map for public rights of way;
- Protection of the highway and public rights of way:
  - Dealing with encroachment on the highway including from private property;
  - Dealing with obstruction on highways or public rights of way;
  - Dealing with illegal and unauthorised signs;
  - Dealing with illegal parking on verges and footways;
- Network development:
  - Adoption of new highways.

B.5.18.6 Although each of these are separate duties and activities, many of them have wider implications for highway maintenance, for example:

- Many of these items, for example illegal signs or encroachment, may have the potential to contribute to incidents; and the details of how the occurrence was dealt with (or not dealt with) by the authority may be a material consideration in legal proceedings; and
- Encroachment from adjoining private land that extend into or over the highway which can reduce available width or headroom, restrict accessibility or visibility, interfere with drainage or maintenance activities, or affect the safe movement of highway users; and
- Inappropriate parking on verges and footways, especially by heavy vehicles, could cause considerable damage and where this has occurred it might be relevant to increase inspection frequency and consider new materials or prevention.

B.5.18.7 Regulatory activities can be informed by risk assessment and local priorities.

B.5.19 RELIABILITY OF DATA

B.5.19.1 UKPMS is the national standard for pavement management systems. In UKPMS, the term ‘pavement’ is used in its technical sense, meaning the collective term for all hardened surfaces within the highway, including carriageways, footways and cycle route.

B.5.19.2 Asset management systems that operate outside the UKPMS accreditation system can also provide suitable functionality and value for highway authority users. The specification and performance of such systems can be considered against user requirements and areas where consistency is desirable.

B.5.19.3 PAS 2161 approval applies to the survey technology and data outputs used for national reporting, whilst UKPMS accreditation applies to the systems used to process and manage that data. Authorities should ensure that PAS 2161-compliant data can be integrated effectively within UKPMS-accredited systems, or within equivalent asset management systems, to support consistent, reliable and auditable asset management processes.

B.5.19.4 Systems that are accredited to the UKPMS standard have successfully demonstrated that they meet the current national standards with respect to:

- Loading network, inventory and condition data, including data collected by:
  - Visual surveys (CVI and DVI);
  - SCANNER and TRACS Type Surveys (TTS);
  - PAS 2161 compliant technologies
  - Footway Network Surveys (FNS);
  - SCRIM;
  - Grip Tester; and
  - Deflectograph.
- Data processing
- Condition reporting, including national reports for England, Northern Ireland, Scotland and Wales and local reports for unclassified roads and footways
- Financial reporting to support asset management, including
  - Inventory reports;
  - Accumulated and annual depreciation of carriageways; and
  - Supporting information for footways, cycle tracks and paved verges.

B.5.19.5 UKPMS accreditation is governed by the Road Condition Management Group (RCMG) on behalf of the UK Roads Board. More information about UKPMS, including a current list of accredited systems, is available from the RCMG page on the UKRLG website.

B.5.19.6 Asset data management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

B.5.19.7 Asset management systems are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance, Part C. This document should be referred to and the advice below considered supplementary.

B.5.19.8 A highway asset management system is essential to deliver an effective and efficient approach to asset management. This should typically have the capacity to cover all of the asset types outlined in Section B.1,with the actual data collected aligning to the authority's own asset data management strategy and condition data aligned to national reporting requirements.

B.5.19.9 Authorities will require a system to suit particular local needs and responsibilities, procurement arrangements and other factors. It may include specialist applications indirectly related to highway maintenance, for example traffic and incident analysis.

B.5.19.10 Where appropriate, authorities should utilise specialist systems for particular asset groups, such as trees, to support asset inventory, inspection, risk assessment and maintenance.

B.5.19.11 Compatibility between highway asset management systems and those for structures and lighting will support a holistic approach to managing the network.

B.5.19.12 Opportunities to ensure quality and reliability of data occur at a number of levels including:

- survey instructions and documentation;
- selection and appointment of inspectors;
- training and accreditation;
- specification and procurement of surveys;
- audit procedures;
- survey procedures;
- data capture software;
- processing software;
- maintenance and calibration of equipment; and
- record keeping.

B.5.19.13 Considerable care should be taken in the derivation of locally enhanced versions of surveys to ensure that data can be extracted, without bias from the survey.

B.5.19.14 In the case of machine surveys, where these are used, such as SCANNER, Deflectograph, SCRIM, FWD, GPR, Grip Tester, or any PAS2161 accredited technology, these should be carried out by accredited surveyors using accredited software. Further information on accreditation can be found on the UKRLG website.

B.5.19.15 Care should also be taken in the specification of surveys when deciding whether these are to be carried out in house or by contract, to ensure that appropriate quality provisions are included in the specification that address:

- Selection and training of inspectors;
- Survey procedures and documentation; and
- Quality management procedures, audit and error correction.

B.5.19.16 Authorities may retain information relating to training and professional development in accordance with local requirements. All training, experience and other forms of staff development should be recorded and documented.

B.5.19.17 Audit and quality control procedures are essential, and where highways staff change role within an authority, competence for the new position should be reviewed and any required training or development should be provided if necessary.

B.5.19.18 Authorities should ensure that hazardous materials within the highway, including asphalt waste containing coal tar, are accurately identified, recorded and maintained as live information in accordance with UK regulatory requirements. Guidance such as RPS 157 sets out the need for proper recording of information for asphalt waste containing coal tar, including retaining compliance records for inspection by the Environment Agency. SEPA's Position on recycling, treatment, storage and use of asphalt waste containing coal tar further reinforces the importance of maintaining clear, reliable and traceable hazardous-materials information for highway assets. These records should be made available to authorised parties to support the safe planning and coordination of works within the highway. Further guidance on identifying, managing and

recording asphalt waste containing coal tar can be found in Managing Reclaimed Asphalt - ADEPT (2024).

B.5.20 ADDITIONAL DATA SOURCES

B.5.20.1 Telemetry or telematics data could be considered as a supporting information source to supplement other datasets. This information should not be relied upon as evidence of asset condition but may provide useful insight when considered alongside primary condition and inspection data.

B.5.20.2 User and community responses can make a significant indirect contribution both to safety and serviceability by ensuring that service requests and complaints are dealt with appropriately and converted into actions. Adequate provision of information will also enable users to obtain better serviceability from the network. Authorities may consider whether community action and self-help might be encouraged and promoted.

B.5.20.3 Highway authorities may use a range of digital technologies as additional sources of asset information, including sensors, monitoring systems, digital platforms, digital twins and other emerging technologies. These sources can supplement asset inventories, condition information, inspection records and performance data, supporting improved asset knowledge and decision-making. The usefulness of additional data sources will depend on their quality, reliability and suitability for the intended purpose.

B.5.20.4 Authorities may consider road roughness, longitudinal profile and International Roughness Index (IRI) data as supplementary sources of information on ride quality, surface performance and deterioration, where appropriate to local asset management requirements.

B.5.21 DEVELOPMENTS IN TECHNOLOGY FOR DATA COLLECTION

B.5.21.1 Technology may be used to support the collection, recording and management of data to inform highway management activities, including inspection and assessment. Where technology is deployed, consideration may be given to its suitability for the intended purpose and the competence required to use it effectively. Whilst there are options to utilise dedicated survey runs; there may be opportunities to capture data alongside routine operations through existing fleet movements.

B.5.21.2 The risks and liabilities associated with the use of technology for data collection, including limitations of accuracy, validation, data security and the potential impact on legal duties, are discussed in more detail within the Risk and Liability Guidance published by UKRLG.

DEVELOPMENTS IN CONDITION SURVEY TECHNOLOGY

B.5.21.3 Whilst traditional survey methods remain valid, authorities should consider using proven technology and systems for the effective identification and management of condition. Developments in technology may influence future survey approaches and methods. Proven technology should include the use of in-vehicle location and communications systems to record the position of condition information. The use of such technology should also provide opportunities to change the number, type and quantity of inspections and should therefore generate efficiencies.

B.5.21.4 New survey techniques may offer opportunities to improve efficiency and data quality. PAS 2161 allows different technology types to be used by authorities following an approvals process. Technology types used through this process should include vehicle-based and image-based approaches, and other emerging technologies such as remote sensing or satellite inspections.

B.5.21.5 AI-enabled survey technologies have the potential to support highway condition assessment and data collection. Cameras and sensors should be used to capture high-resolution imagery at traffic speed, allowing large extents of the network to be assessed quickly and consistently. Automated image analysis should then be applied to identify and classify deterioration, such as cracking and rutting, providing early warning of emerging risks.

DEVELOPMENTS IN SAFETY INSPECTION TECHNOLOGY

B.5.21.6 Recent developments in highway safety inspection technology include vehicle-mounted, high-resolution cameras and sensors that capture real-time images at normal driving speeds.

B.5.21.7 When combined with automated image analysis and AI, these systems can rapidly identify defects, obstructions and emerging risks, supporting timely, risk-based inspection and maintenance decisions.

SECTION B.6 RESILIENCE AND ADAPTATION – HIGHWAYS

B.6.1 INTRODUCTION

B.6.1.1 The definitions and overall principles for resilience of highway infrastructure are dealt with in Part A of this Code. This section contains information on resilience and adaptation related to highway elements not associated with structures, lighting or tunnels.

B.6.1.2 In the previous Code of Practice, the main focus on resilience planning and management has centred around Winter Service, specifically providing specialist operational services for prevention and clearance of snow and ice. Increasingly, however, highway assets are exposed to a wider range of hazards, environmental stresses, including flooding, extreme temperatures, severe weather events, protests, and other risks, e.g. unexploded ordnance disposal operations, which can affect safety, serviceability, sustainability, and customer service.

B.6.1.3 Specific operational considerations for Winter Service can be found in Section B.9 Winter Service

B.6.2 RESILIENCE AND THE CORE OBJECTIVES

B.6.2.1 Resilient highway assets contribute significantly to each of the core objectives set out in this Code as described below:

SAFETY

B.6.2.2 Safety is a consideration even though statutory obligations and users' needs vary in different parts of the UK. Highway assets contribute to safe network operation by supporting navigation, maintaining visibility, reducing the risk of flooding, and helping to manage the impacts of disruption.

SERVICEABILITY

B.6.2.3 Resilient highway assets including carriageways, road markings and drainage systems, ensure the network continues to function, or can be restored rapidly during unforeseen events.

SUSTAINABILITY

B.6.2.4 Resilience measures support long term sustainability by reducing the environmental and financial impacts of frequent repairs, replacements, and emergency interventions caused by unforeseen events. Effective resilience can contribute to a reduction in whole life costs and minimise damage to the environment. Intense and/or severe weather events can cause serious damage to the fabric of carriageways, footways and cycle routes and accelerated damage of the network.

CUSTOMER SERVICE

B.6.2.5 Demonstrating preparedness for a range of risks and disruptions, such as the common consequences in the NRR, builds confidence and improves customer satisfaction, showing the service is capable, responsive, and dependable. Highway assets contribute to reliable journeys by helping to maintain access, continuity of movement and network connectivity during disruption.

B.6.3 HIGHWAY SPECIFIC HAZARDS

B.6.3.1 There are a large number of hazards that can affect highway assets, the information below provides indicative, illustrative examples of some of the risks that may arise with possible mitigation measures, with the DfT Transport Hazard Summaries providing additional information.

B.6.3.2 The examples below are not exhaustive and should not be interpreted as prescriptive or mandatory actions. In practice, highway authorities may determine their own appropriate mitigations subject to the funding levels, strategic aims and objectives.

WEATHER & CLIMATE

B.6.3.3 Highway assets are increasingly affected by weather and climate variation. Extreme heat, intense rainfall and colder and wetted winters can influence the operational performance of highway assets. Increasingly intense and severe weather conditions can increase surface deterioration, reduce skid resistance and increase the need for temporary restrictions on highways. Weather and climate related hazards create operational challenges and can impact journey reliability and increase the need for maintenance interventions.

B.6.3.4 Authorities should consider appropriate mitigation measures to manage the impacts of weather and climate hazards. Examples include but are not limited to, the use of resilient surfacing materials, proactive weather monitoring and operational responses during adverse conditions. Longer term adaptation, including enhanced drainage and climate resilient design to support the resilience of highway assets.

B.6.3.5 Authorities may refer to:

- CIHT's Delivering a Resilient Transport Network report for additional guidance on managing weather and climate impacts, including flooding and water related hazards affecting highway assets.
- CIHT's Responding to Climate Disruption for guidance on preparing for, responding to and learning from climate-related disruption.
- Local Highways Climate Adaptation Guide | ADEPT for guidance on climate adaptation for the highway network.
- Rapid Adaptation Pathways Assessment Toolkit | ADEPT for guidance on identifying climate risks, exploring adaptation options and developing adaptation pathways.

B.6.3.6 Further guidance for the planning and delivery of Winter Service activities can be found in Section B.9 Winter Service.

Table 28: Illustrative risk and mitigations for weather and climate related hazards.

Assets	Risk	Mitigation
Carriageways, Footways, Cycle Routes	Surface softening	Apply resilient surfacing materials, gritting and dusting
Non-illuminated Signs & Bollards	Loss of visibility or clarity	Weather-resistant sign faces and reinforced mounting

Trees & Vegetation	Stress or decline	Monitoring and targeted pruning

FLOODING & WATER

B.6.3.7 Flooding presents significant risks across highway assets, with standing water, runoff and overloaded drainage systems reducing safety and potentially affecting the structural condition of carriageways, footways and verges. Severe or repeated flooding can have compounding effects, resulting in more closures, reduced usability and increased intervention requirements.

B.6.3.8 Authorities should establish appropriate inspection, monitoring and maintenance regimes to manage the impacts of flooding and other water-related hazards. This may include routine drainage maintenance, asset inspections, condition monitoring, and the identification and prioritisation of drainage defects or constraints that could affect the safe and efficient operation of the highway network.

B.6.3.9 Authorities should consider appropriate mitigation and adaptation measures to improve network resilience to flooding and water-related hazards. Examples may include increasing drainage capacity, implementing targeted flood protection measures, using flood-resilient materials, and other interventions that support the continued safe operation of the network during and following water-related events.

Table 29: Illustrative risk and mitigations for flooding and water related hazards

Assets	Risk	Mitigation
Carriageways, Footways, Cycle Routes	Loss of skid resistance or surface damage	Improve surface drainage and waterproofing
Drainage Systems	Blockage or surcharge	Routine maintenance, assess inspection regime, increase drainage capacity
Embankments & Cuttings	Slope destabilisation	Enhance slope drainage

GROUND INSTABILITY AND GEOTECHNICAL HAZARDS

B.6.3.10 Ground instability can influence the performance and safety of highways through settlement, heave or lateral movement affecting carriageway and footway levels, verges and adjacent earthworks. Instability of surrounding slopes can also introduce debris hazards or create the need for operational restrictions to ensure user safety.

B.6.3.11 Authorities should consider appropriate mitigation measures to manage the impacts of ground instability and geotechnical hazards. Examples include but are not limited to, geotechnical monitoring, early identification of changes in ground behaviour and the implementation of stabilisation or remedial works where required. Regular inspection of earthworks and vegetation supports early intervention and helps maintain network resilience.

B.6.3.12 Authorities may refer to CD 622 Managing Geotechnical Risk for further information on risk and mitigation regarding geotechnical hazards.

Table 30: Illustrative risk and mitigations for ground instability and geotechnical related hazards

Assets	Risk	Mitigation
Carriageways, Footways, Cycle Routes	Settlement, heave or lateral movement resulting in uneven surfaces or loss of serviceability	Geotechnical monitoring, surface condition assessment and timely remedial or stabilisation works
Drainage Systems	Ground movement or erosion undermining drainage assets, leading to failure or loss of capacity	Inspect supporting ground conditions and undertake structural repair or renewal where instability is identified
Landscaped areas and Trees	Slope instability, erosion or failure resulting in debris on the carriageway or loss of support	Slope monitoring and stabilisation measures as required

ENVIRONMENTAL/ECOLOGICAL

B.6.3.13 Environmental and ecological factors may impact highway assets through organic material, vegetation encroachment or exposure to pollutants. Such conditions can obstruct drainage, reduce visibility or contribute to surface deterioration, with implications for user safety and long-term asset condition.

B.6.3.14 Authorities should consider appropriate mitigation measures to manage the impacts of environmental and ecological hazards. Examples include but are not limited to, routine cleansing, vegetation management and targeted inspection regimes to identify and address areas where environmental factors accelerate deterioration. These actions support the reliability and safe functioning of the network.

Table 31: Illustrative risk and mitigations for environmental/ ecological related hazards

Assets	Risk	Mitigation
Carriageways, Footways, Cycle Routes	Organic fouling affecting surface condition	Implement regular surface sweeping and cleansing
Landscaped areas and Trees	Decline or obstruction due to natural growth or ecological stress	Structured tree-health management and vegetation control

ASSET/INFRASTRUCTURE FAILURE

B.6.3.15 The performance of highway assets may reduce over time as a result of ageing, material degradation or underlying defects. Pavements, barriers, drainage features and roadside equipment are susceptible to performance decline if issues are not managed through timely intervention and structured asset management processes.

B.6.3.16 Authorities should consider appropriate mitigation measures to manage the impacts of asset and infrastructure failure. Examples include but are not limited to, regular inspection, condition-based assessment and prioritised maintenance or renewal activity. Temporary operational controls may be applied where necessary, while longer term planning supports effective lifecycle management

of the asset base. Consideration should also be given to the availability of alternative routes to maintain connectivity and support recovery following disruptive events.

Table 32: Illustrative risk and mitigations for assets/ infrastructure related hazards

Assets	Risk	Mitigation
Carriageways, Footways, Cycle Routes	Structural deterioration	Targeted structural repairs
Drainage Systems	Mechanical or pump failure	Upgrade system components
Fences & Barriers	Loss of structural integrity	Replace or repair damaged sections

OPERATIONAL AND TRANSPORT-RELATED INCIDENTS

B.6.3.17 Operational incidents such as collisions, spillages, breakdowns or increased vehicle loading can affect highway surfaces, drainage features and roadside equipment. These incidents may disrupt traffic, compromise safety or necessitate emergency interventions to maintain network functionality.

B.6.3.18 Authorities should consider appropriate mitigation measures to manage the impacts of operational and transport related incidents. Examples include but are not limited to, coordinated incident response, resilient maintenance practices and design approaches that reflect evolving vehicle characteristics. Effective liaison with emergency services and rapid response arrangements help minimise disruption and maintain safe operation.

Table 33: Illustrative risk and mitigations for operational and transport related hazards

Assets	Risk	Mitigation
Carriageways, Footways, Cycle Routes	Surface damage from fire or collision events	Repair damaged surfacing and restore functionality
Fences & Barriers	Impact damage resulting from vehicle collisions	Replace or replace impacted barrier sections
Non-illuminated Signs & Bollards	Structural damage due to vehicle or object impacts	Repair or replace affected posts and sign faces

HUMAN/SOCIAL DISRUPTION

B.6.3.19 Human behaviour can influence highway performance where activities result in obstruction, damage or unsafe interactions with the network. Examples include vandalism, unauthorised access, debris placement or protest actions that disrupt traffic flow, creating safety risks and operational burdens.

B.6.3.20 Authorities should consider appropriate mitigation measures to manage the impacts of human and social disruption. Examples include but are not limited to, surveillance, targeted enforcement and operational procedures designed to deter unsafe behaviour. Coordinated responses with partners and other agencies, and communication strategies help reduce the impact of human related incidents and maintain the safe functioning of the network.

Table 34: Illustrative risk and mitigations for human/ social disruption related hazards.

Assets	Risk	Mitigation
Carriageways, Footways, Cycle Routes	Accelerated deterioration	Regular maintenance and inspection
Drainage Systems	Blockage or reduced performance	Regular drainage clearing and maintenance activities

SECURITY/MALICIOUS ATTACKS

B.6.3.21 Highways may be affected by malicious actions such as deliberate damage, tampering with roadside equipment or interference with safety critical features. Such acts can compromise asset performance, introduce safety risks and trigger unplanned maintenance demands.

B.6.3.22 Authorities should consider appropriate mitigation measures to manage the impacts of security risks and malicious attacks. Examples include but are not limited to, coordinated intelligence assessment with partner agencies, securing vulnerable components, restricting access to critical areas and using monitoring systems at higher risk locations. Protective measures, including hostile vehicle mitigation, tamper resistant fixings and reinforced housings, support asset reliability and enable effective incident response.

Table 35: Illustrative risk and mitigations for security/ malicious related hazards

Assets	Risk	Mitigation
Fences & Barriers	Deliberate tampering	Strengthen security features and reinforce fixings
Landscaped Areas and Trees	Wilful damage such as illegal felling or fire	Replace damaged vegetation and enhance monitoring
Non-illuminated Signs & Bollards	Vandalism	Remove graffiti and repair damaged sign equipment

SECTION B.7 FINANCE AND INVESTMENT – HIGHWAYS

B.7.1 INTRODUCTION

B.7.1.1 Finance and investment principles and considerations are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

B.7.1.2 The general principles relating to finance and investment at a network level are set out in Part A of this Code. The guidance below provides additional detail specific to highway assets.

B.7.2 LIFECYCLE PLANNING

B.7.2.1 Asset management adopts a long term, whole life approach to managing highway assets, seeking to optimise asset performance while making best use of available funding and resources. This approach considers the full lifecycle of assets and is covered in detail in the UKRLG Highway Infrastructure Asset Management Guidance.

B.7.2.2 Lifecycle modelling helps to formulate asset management strategy, by testing out different scenarios over a long time period in order to understand the different outcomes and options, and to make decisions about the way forward. It is an ongoing process of obtaining and modelling data on the current and historic condition of highway assets and about the factors that affect deterioration to predict future performance.

B.7.2.3 Lifecycle modelling is particularly relevant for high value, critical assets such as carriageways and footways. A number of factors may be considered as part of carriageway and footway lifecycle modelling, including but not limited to:

- Construction type
- Composition
- Condition data
- Traffic volumes
- Rate of deterioration

B.7.2.4 For assets such as traffic signs and drainage systems, consideration may be given to factors including the age of the asset, reactive defects and expected service life.

B.7.2.5 The lifecycle modelling approach accounts for the long-term costs of managing the condition and level of service and is an important part of highway service planning for the following reasons:

- The majority of benefits from annual maintenance programmes are realised over a long period of time (30 years and beyond). Lifecycle modelling forecasts highlight the long-term implications of current maintenance strategies and funding allocations.
- Decisions on how to prioritise annual programmes also have an inherent impact on long-term financial sustainability, recognising that delivery may be influenced by local budgetary constraints and shorter-term funding cycles.

- Lifecycle modelling can support strategies for achieving Net Zero Carbon in highway service delivery. Strategic lifecycle models typically produce estimates of total CO2 emissions from long-term capital programmes.

B.7.3 INCOME GENERATION

B.7.3.1 There are opportunities to generate income by permitting commercial advertising on roundabouts, poster displays, and other suitable highway assets. Controlled advertising opportunities provide a low impact revenue stream that can support the maintenance and improvement of highway infrastructure. Further information is available in Outdoor Advertisements and Signs: A Guide for Advertisers. Any advertising proposals should be assessed to ensure they do not adversely affect highway safety, network operation, accessibility, amenity or the wider street scene.

B.7.3.2 Income generating arrangements should align with the authority's wider highway asset management strategy and commercial policies, ensuring that revenue opportunities are balanced with long term highway asset integrity, public safety, and service performance.

SECTION B.8 SUSTAINABILITY – HIGHWAYS

B.8.1 INTRODUCTION

B.8.1.1 The principles of sustainability for highway infrastructure can be found in Part A of this Code. This section contains information on sustainability specifically related to highway elements not associated with structures, lighting or tunnels.

B.8.2 PRINCIPLES AND CONSIDERATIONS

B.8.2.1 Highway infrastructure plays a key role in an authority's environmental ambition. There is a need to reduce the environmental impact of all highway activities where practical, while balancing sustainability objectives with safety, asset condition, affordability, local priorities and available funding in the ambition to reach net zero.

B.8.2.2 Reducing the environmental impact of highway works and operations is an important and essential focus for meeting sustainability goals. There are many areas that an authority may consider. For the purposes of this Code, the areas have been categorised as environmental, social and economic sustainability.

B.8.2.3 Sustainable solutions should be considered alongside an authority's core responsibilities for safety, serviceability, asset condition and network resilience. Decisions should balance environmental benefits with whole-life cost, affordability, deliverability, local priorities and the need to maintain a safe and effective highway network.

B.8.2.4 Authorities may refer to relevant UK guidance on value for money, climate and environmental appraisal, and carbon management when assessing options:

- HM Treasury Green Book and supplementary guidance — for appraisal of policies, programmes and projects, including costs, benefits, risks, climate impacts, environmental valuation and value for money.

B.8.3 ENVIRONMENTAL SUSTAINABILITY

HAZARDOUS WASTE REMOVAL

B.8.3.1 Authorities should ensure that hazardous materials arising from highway works are identified, classified and managed in accordance with the relevant regulatory guidance. This includes the safe handling, storage, treatment and movement of asphalt waste containing coal tar, and the controlled removal of asbestos were present within highway assets. These materials should be segregated from non-hazardous arisings, handled only by competent and appropriately authorised contractors, and transported and disposed of through permitted facilities.

B.8.3.2 Further information on the correct handling, treatment and reuse of these materials can be found within the guidance below:

- Storing, treating and using asphalt waste: RPS 157
- Movement and Use of Treated Asphalt Waste Containing Coal Tar | Department of Agriculture, Environment and Rural Affairs

- GG 105 - Asbestos management
- Managing Reclaimed Asphalt - ADEPT (2024)
- Waste Classification: Guidance on the Classification and Assessment of Waste (WM3)
- Street Works UK Material Classification Protocol

NOISE REDUCTION

B.8.3.3 Road traffic noise is a major environmental consideration, both for those living close to heavily used inter-urban highways and also within urban areas. Legislation is progressively seeking to reduce road noise from vehicles but noise from running surfaces can also be intrusive.

B.8.3.4 Where running surfaces are renewed or resurfaced, the opportunity exists to mitigate the effects of traffic noise. Whenever major maintenance schemes of this type are being planned, authorities should consider the option of a lower noise alternative. Further information on selecting surface dressings that can help achieve quieter surfaces is provided in Road Note 39.

B.8.3.5 The statutory duty to 'secure the expeditious movement of traffic' imposed by the Traffic Management Act 2004, or equivalent, could place greater emphasis on night working. Lane Rental schemes may also encourage works to be undertaken at less disruptive times. Close consultation with residents and Environmental Health Officers, particularly in urban areas, is necessary.

NATURE BASED SOLUTIONS

B.8.3.6 Nature-based solutions may contribute to wider environmental and resilience objectives in appropriate circumstances. Nature-based solutions use natural processes to reduce the impact of increasing extreme weather (such as extreme heat and wetted winters), support climate adaptation, and deliver wider environmental benefits. Nature based solutions to support highway maintenance can be cost-effective methods at improving the resilience of highway asset systems. Examples of nature-based solutions on highways include:

- Sustainable Drainage Systems (SuDS) mimic natural water movement to manage runoff and reduce flood risk.
- Using trees and shrubs to reduces heat stress on highway assets, mitigates wind exposure and offers carbon and biodiversity benefits.

B.8.3.7 In managing environmental considerations, reference should also be made to CIRIA's SuDS Manual, which supports the incorporation of drainage solutions that work with natural processes and wider ecological objectives.

B.8.3.8 Authorities may refer to the following guidance for more information on the application of nature-based solutions, including sustainable drainage systems:

- National Standards for Sustainable Drainage Systems (SuDS)
- SUDS for Roads

NATURE CONSERVATION AND BIODIVERSITY

B.8.3.9 Certain named species and habitats are protected by law, and all highway infrastructure maintenance works must comply with these requirements. Where designated sites are within or adjacent to the highway boundary, advice should be sought from Natural England, or equivalent, or local wildlife trusts, etc. Legislation requires that Natural England, or equivalent, are informed where important habitats and species may be affected, such as the removal of trees used as bat roosts. This should be done well in advance of maintenance work to allow for seasonal factors.

B.8.3.10 Authorities should recognise the contribution that trees make to the economic, social and environmental well-being of the community. In urban areas roadside trees have a particular landscape value, are often highly regarded by the community, and should be carefully managed. Authorities should develop a policy for the installation, subsequent condition inspection and maintenance of highway trees. Care should be taken to avoid damage to trees during highway infrastructure maintenance and improvement works and guidance for the planning, installing and maintenance of utility services in proximity to trees issued by NJUG should be followed.

INVASIVE PLANTS AND INJURIOUS WEEDS

B.8.3.11 The Wildlife and Countryside Act 1981 makes it an offence to plant or otherwise cause to grow any plant in the wild at a place outside its native range. This can cause restrictions on verge and other maintenance operations. The Wildlife and Natural Environment (Scotland) Act 2011 has brought in new provisions governing the introduction of non-native species in Scotland.

B.8.3.12 The Noxious Weeds Act 1959 places a responsibility on the authorities to take action to inhibit the growth and spread of injurious weeds growing within the highway.

B.8.3.13 Where injurious weeds on highway land are a nuisance to adjacent landowners, it is advisable to work with the landowner to ensure that weed control measures are undertaken simultaneously to avoid recontamination across the highway boundary. The prescribed injurious weeds are:

- ragwort;
- broad leaved dock;
- curled dock;
- creeping thistle; and
- spear thistle;

B.8.3.14 Authorities with low baseline biodiversity on highway verges should consider whether a more targeted approach to managing injurious weeds is appropriate, recognising that certain species can deliver significant nectar/pollen resources and are associated with greater pollinator visitation and diversity than some recommended pollinator seed mixes.

B.8.3.15 Ragwort in particular is extremely hard to eradicate, and some authorities have bylaws to control it. The seed can survive 20 years in the soil before germinating and any root left behind when dug up will re-grow. It is also highly toxic to horses, cattle and sheep. It is normally biennial producing small rosettes in the spring and flowers in its second year from July onwards. Cutting is used by many authorities for control to prevent the plant flowering and seeding, and two full cuts of the verge by the end of June every year for five years will inhibit seeding and spreading.

B.8.3.16 Ragwort can only be completely eradicated by digging out before it flowers, which in most cases will be impractical for authorities with large areas of verge, or by spraying an appropriate weed killer. On ungrazed land such as roadside verges, unselective weed killer use could also destroy many desirable wild species, and labour-intensive spot treatment may be preferable.

B.8.3.17 Authorities may refer to the guidance listed below for further information on dealing with invasive plants and injurious weeds:

- How To Stop Invasive Non-Native Plants from Spreading
- Invasive Non-Native (Alien) Plant Species: Rules in England and Wales
- The Weed Control Handbook: Guidance on the use of herbicides on nature conservation sites (2025)
- Integrated Weed Management Reference Guide Second Edition

URBAN LANDSCAPED AREAS AND TREES

B.8.3.18 Highway trees contribute to amenity and nature conservation and in urban areas can enhance the space between buildings, reinforcing the area's character and appeal. Close co-operation between arboriculturists, highway engineers, landscape architects and urban designers is essential to preserve and enhance the range and quality of street trees, ensuring that a considered approach has been taken to supporting sufficient species diversity to make the overall town or neighbourhood tree population more robust to the advent of disease and/or more resilient to climate change. Avenues, boulevards, town squares and formal spaces, and informal rural locations all require the application of different planting principles. Trees and planting may reflect the history, architecture and tradition of places. Small pockets of poor-quality planting can undermine the quality of the streetscape.

B.8.3.19 Street trees and planting are not appropriate in every instance. Trees and planting should always form part of the overall urban context and not be added or preserved without question. Trees may be planted where trees have not been planted previously particularly in urban areas that have changed use (e.g., warehousing to residential) or in areas where historically they were considered unworthy of tree planting.

B.8.3.20 Authorities should develop, with advice from arboriculturists, landscape architects and urban designers, a local policy for the installation, management, removal and replacement of highway trees and landscaping. The policy should recognise the amenity and nature conservation value of trees, along with benefits such as air pollution removal, carbon storage or stormwater attenuation, and also seek constructively to manage ongoing risk to the authority. The policy should include the approach to asset specific inspections, to be undertaken by arboriculturists, including frequency, for various types of trees.

MATERIALS, PRODUCTS AND TREATMENTS

B.8.3.21 The principles for materials, products and treatments are set out in Section A.8 Sustainability.

B.8.3.22 When selecting materials and treatments for highway assets, authorities should consider whole-life performance, durability, resilience, embodied carbon, resource use and the disruption associated with future maintenance interventions.

B.8.3.23 Material and treatment selection should consider environmental impacts over the expected service life rather than at installation alone. Authorities should consider opportunities to preserve assets and intervene at an appropriate stage to extend service life. A material or treatment with a higher initial carbon impact may provide a lower whole-life impact where improved durability reduces repeat interventions, traffic management, resource use and disruption to network users.

B.8.3.24 Suitable low-carbon materials, recycled content, preservation techniques and emerging technologies may contribute to reduced whole-life environmental impacts where appropriate to the asset, location and operating conditions. This may include lower-temperature asphalt, recycled asphalt, in-situ recycling, preservation treatments and materials designed to improve durability and resilience.

B.8.3.25 Appropriate technical knowledge can assist the assessment of materials and treatments proposed by suppliers. Decisions should be supported by appropriate evidence and should consider local conditions, expected performance, whole-life value and compatibility with existing highway assets.

- Further information is available from the following guidance: DfT Local Transport Quantifiable Carbon Guidance - Guidance on assessing carbon impacts in local transport strategies and schemes.
- RSTA Carbon Emissions for Road Surface and Other Maintenance Treatments for Asset Management Purposes - Carbon information for comparing highway maintenance materials and treatments.
- ADEPT Guidance on Resilience of Surfacing Materials - Selecting bituminous materials and treatments to improve resilience to changing climatic conditions.

B.8.4 SOCIAL SUSTAINABILITY

ACTIVE TRAVEL

B.8.4.1 Active travel plays a vital role in social sustainability by ensuring that the management and maintenance of highway assets support safe, inclusive, and accessible routes that enable people of all ages and abilities to move freely, access to other forms of transport and participate fully in their communities.

TRANSPORT SAFETY

B.8.4.2 Highway infrastructure can influence both actual and perceived safety. Authorities should consider the safety and personal security needs of all users when planning, designing, maintaining and operating the network. This should include consideration of vulnerable users and those with protected characteristics, recognising that different groups may experience the network in different ways. Measures may include good asset condition, appropriate lighting, clear sightlines, management of vegetation, wayfinding, accessible infrastructure and the provision of an environment that encourage safety in transport and public spaces.

B.8.4.3 To improve and support safety for road users' highways authorities should as far as reasonably practicable:

- Maintain footways and cycle routes so they remain clear, direct easy to use and well lit;

- Maintain landscaped areas and trees to preserve visibility and avoid enclosed or hidden spaces;
- Recognise that poor maintenance and inaccessibility can have a greater effect on vulnerable users;
- Maintaining accessible, legible and usable walking routes during temporary works.

TRANSPORT SAFETY FOR VULNERABLE USERS

B.8.4.4 Some users may be more vulnerable to the impacts of poor maintenance, inaccessible infrastructure or disruption caused by highway works. These impacts can be particularly significant for disabled people, older people, children and young people, and others who may face barriers to using the highway network safely, confidently and independently.

TRANSPORT SAFETY FOR WOMEN AND GIRLS

B.8.4.5 While authorities should consider the safety and personal security needs of all users, women and girls can experience distinct safety and security concerns when using transport networks and public spaces. These may include concerns relating to harassment, intimidation, personal security, isolation, accessibility and confidence when travelling. Such concerns can influence travel choices and perceptions of safety, particularly for disabled women who may face additional barriers when travelling independently.

B.8.4.6 Authorities may wish to consider the following factors when seeking to improve transport safety for women and girls:

- Provide clear information on how safety concerns and incidents can be reported;
- Consider feedback and reported concerns when prioritising network improvements;
- Engage with women and girls to understand local safety concerns and barriers to travel;
- Consider the impacts of temporary works, diversions and network disruption on personal safety;
- Recognise the additional challenges that may be experienced by disabled women and girls when travelling; and
- Work with relevant partners to identify and address transport safety concerns where appropriate.

B.8.4.7 Additional information on transport safety for women and girls can be found at:

- Assessing How to Grow the Market for Interventions to Improve Transport Safety for Women and Girls - Overview of evidence relating to transport safety, violence against women and girls, interventions and recommended actions.
- Transport Safety for Young Women - Research highlighting the experiences, concerns and travel behaviours of girls and young women.
- Enhancing Transport Safety for Disabled Women - Research identifying the specific challenges and barriers faced by disabled women when travelling.
- Findings from the Transport Safety for Women and Girls - For an overview of types of interventions to improve safety for women and girls.

PUBLIC TRANSPORT ACCESSIBILITY

B.8.4.8 Public transport accessibility is a key component of social sustainability. Highway authorities play a critical role in ensuring that the design, maintenance and operation of highway assets support safe, inclusive and reliable access to public transport, particularly for disabled people and those with sensory impairments.

B.8.4.9 When managing and maintaining highway assets, authorities should consider how infrastructure supports access to bus services and other forms of public transport, including the needs of people with visual, mobility, cognitive and sensory impairments.

B.8.4.10 Potential measures that highway authorities may consider include:

- Maintaining accessible routes to bus stops, ensuring footways are level, well-drained, unobstructed and suitable for wheelchair users, people who walk with aids, and people with pushchairs;
- Providing and maintaining raised kerbs, bus stop clearway markings and appropriate carriageway geometry to support step-free boarding where required;
- Ensuring bus stops, shelters and waiting areas are well lit, visible and feel safe, particularly during hours of darkness;
- Maintaining tactile paving, detectable kerbs and consistent footway layouts to support people with visual impairments;
- Ensuring colour contrast, signage and street furniture placement support legibility and wayfinding for people with sensory or cognitive impairments;
- Maintaining real-time passenger information equipment, timetables and signage so that information is accurate, legible and reliable;
- Ensuring temporary works do not remove or reduce access to public transport without suitable alternative arrangements, particularly for disabled users.

B.8.4.11 Authorities should recognise that poor maintenance, obstructions, or inconsistent layouts can disproportionately affect disabled people and those who rely on public transport, reducing independence and access to employment, education and services.

B.8.4.12 For further guidance authorities may refer to:

- Inclusive mobility: making transport accessible for passengers and pedestrians
- Guidance on the Use of Tactile Paving Surfaces

B.8.5 ECONOMIC SUSTAINABILITY

B.8.5.1 Highway authorities face rising pressures from constrained budgets, ageing infrastructure, increasing network usage, and public expectations for reliability. Right first-time repair practices are essential for delivering economically sustainable management of highway assets including carriageways, footways, drainage systems, traffic signs, fences and barriers, and road markings.

B.8.5.2 Examples of right first-time principles in the context of highway assets include, but are not limited to:

- Carriageways and footways: consider the repair methods based on the defect type, scale and underlying condition.
- Drainage systems: consider the root cause, e.g., blocked outlet, prior to undertaking repairs.
- Road markings: ensure surface preparation and curing times are adhered to for maximum durability.

B.8.5.3 By focusing on the durability and quality of each intervention across all highway asset types, authorities may reduce costs and improve service levels.

SECTION B.9 WINTER SERVICE – HIGHWAYS

B.9.1 INTRODUCTION

B.9.1.1 Winter Service should be regarded as an integral part of the authority's wider resilience planning. It plays a key role in maintaining network safety and availability during adverse weather conditions and should be considered alongside other resilience and emergency planning activities, as set out in Sections A.6 and B.6 of this Code.

B.9.1.2 Although sometimes referred to as "Winter Maintenance", the activities undertaken during winter are not maintenance in the traditional asset management sense, but specialist operational services. For clarity and consistency, the term "Winter Service" is adopted throughout this Code.

B.9.1.3 Winter Service is a significant aspect of network management, both in terms of financial commitment and its perceived importance to users. It can also have environmental impacts. The way in which Winter Service is organised may have implications for the procurement, coordination and management of other highway maintenance and operational services. Winter Service should therefore be developed in conjunction with the authority's wider highway management and asset management arrangements.

B.9.1.4 Authorities should develop locally appropriate service levels for Winter Service. These should define, as a minimum, the Overall Winter Period, the Core Winter Period, the required level of resilience, and the extent of treatment networks.

B.9.2 PRINCIPLES AND CONSIDERATIONS

B.9.2.1 Winter Service addresses regular, frequent and reasonably predictable winter conditions such as low temperatures, ice and snow, as well as less frequent but more severe events. The potential effects of climate change, including changes to the frequency and severity of winter weather, should be taken into account in Winter Service planning.

B.9.2.2 Winter Service should be subject to the same structured approach as other elements of the highway management regime, including planning, delivery, performance review and continuous improvement. Clear policies and plans support effective decision-making and proportionate deployment of resources.

B.9.2.3 Policies and plans developed for Winter Service are likely to have wider relevance to emergency planning for extreme weather conditions, including flooding, high winds and high temperatures. They may also support preparedness for non-weather-related incidents that affect the operation of the highway network.

B.9.2.4 Given its operational importance, cost and visibility to users, Winter Service should be considered alongside environmental impacts, resilience objectives and wider service delivery considerations. Decisions relating to Winter Service should align with the authority's broader highway management strategies and organisational priorities.

B.9.2.5 Authorities should apply the overarching principles in this Code alongside the more detailed operational guidance provided in the NWSRG Practical Guides. Authorities may also refer to the Department for Infrastructure's Winter Service RSPPG E022 for Northern Ireland-specific guidance on Winter Service policy, planning and delivery arrangements.

B.9.2.6 Authorities should refer to the relevant sections of the NWSRG Practical Guides listed below for further guidance on the planning and delivery of the Winter Service:

- Planning for Winter Service Delivery for guidance on winter service planning, policy, service levels, resilience, resources, communications, information and publicity, and overall delivery arrangements.
- De-Icer Types for guidance on the types of de-icers available, how they work, their effective temperature ranges, when alternative de-icers may be appropriate, and the factors affecting their use.
- Salt Storage for guidance on salt storage, stock management, salt condition, moisture control, stock resilience, restocking arrangements, supply-chain resilience and related lead-time considerations.
- Treatment Methodologies and Technologies for guidance on treatment methods, spreading technologies and the principal approaches available for winter treatment operations.
- Spreader Management for guidance on spreader standards, calibration, distribution testing, maintenance and performance monitoring.
- Winter Service Decision Making for guidance on the winter service decision-making process, the use of decision support systems, and the role and competence of winter service decision makers.
- Spread Rates for Precautionary Salting for guidance on precautionary salting spread rates and the operational factors that influence those rates in practice.
- Treatments for Snow and Ice for guidance on the treatment of snow and ice conditions, including advance treatment, ploughing and operational response during severe winter weather.
- Treatments for Extreme Cold for guidance on winter service during extreme cold conditions, including mutual aid, alternative de-icers, storage, handling and treatment strategies.
- Winter Service on Footways and Cycleways for guidance on the treatment and prioritisation of footways and cycle routes, including route selection, equipment and operational considerations.
- Weather Forecasting and Road Weather Information Systems for guidance on forecasting services, road weather information, monitoring systems and the use of weather information in winter service decision-making.
- Route Selection and Optimisation for guidance on the selection, justification, review and optimisation of winter treatment routes.

PART C. STRUCTURES

SECTION C.1 SCOPE OF PART C – STRUCTURES

C.1.1 INTRODUCTION

C.1.1.1 Part C of Well-managed Highway Infrastructures has been drawn up specifically for highway structures associated with the adopted road network which meet the dimensional criteria defined in CG 300 Technical approval of highway structures. In addition, the general principles apply to structures associated with all other highways that are used by the public, e.g. segregated footpaths and cycle routes, and the Public Right of Way network. The types of highway structure covered by the Code are those within the boundaries of the highway or which otherwise materially affect it and include:

- bridges including footbridges, cycle route bridges, bridleway bridges, accommodation bridges, occupation bridges, subways, underpasses, and culverts;
- retaining walls;
- sign/signal gantries;
- cantilever road signs;
- moveable bridges, and
- minor structures (such as high masts, catenary lighting, noise barriers).

C.1.1.2 Note that the structure types listed above differ from those listed in CG 300. The structure types listed above are those typically found on Local Authority networks, although if an asset owner wishes to adopt the coverage in CG 300 this is permissible (see also C.1.1.6 and C.1.1.7).

C.1.1.3 It is becoming commonplace for structural earthworks to be constructed and demonstrates a need for Highway Structures Managers to be aware of their location and construction type, and the impact these assets have on the network. The role of the Highway Structures Manager is covered in further detail in section C4.6.

C.1.1.4 The term ‘highway structures’ is used throughout the Code to refer collectively to all of the above structure types.

C.1.1.5 The overarching principles and common themes of maintaining highway infrastructure are covered within Part A. Asset specific guidance for highways, lighting and tunnels are covered in Part B, Part D and Part E, respectively.

C.1.1.6 The definitions used for highway structures should follow those set out in the Design Manual for Roads and Bridges (DMRB). Whilst the DMRB classifies smaller assets (such as bridges with spans or internal diameter of greater than 0.9m) as structures, asset owners may adopt a different approach. In developing and implementing asset management practices, authorities may draw upon DMRB standards where relevant, while retaining flexibility to adopt alternative approaches that best reflect local circumstances and organisational requirements. Any such decisions should be clearly recorded as part of a Risk Based Approach to demonstrate that the level of management is appropriate and risk informed.

C.1.1.7 Highway Structures Managers should refer to CG 300 in the DMRB for the current requirements governing the technical approval of highway structures. CG 300 sets out the processes,

responsibilities, and documentation needed for the technical approval, checking, and certification of structures.

C.1.1.8 Highway Structures Managers must ensure that structures falling within the dimensional thresholds defined in CG 300, such as those with clear spans or internal diameters above the relevant limits and retaining walls exceeding the height criteria, are managed and approved in accordance with the procedures specified in that document.

C.1.1.9 It is important to note that not all asset owners will follow the same model when it comes to which department manages different assets. Larger asset owning organisations may have dedicated teams and resources capable of managing geotechnical assets or high masts, for example, whereas smaller asset owning organisations (or where organisations have a low number of a particular asset type) it may be more appropriate for another team or function to have primary responsibility for those assets. In either case it is important to define the roles and responsibilities within an organisation so that no asset is left unmanaged, or that effort is duplicated elsewhere within the organisation.

C.1.2 THE ROLE OF HIGHWAY STRUCTURES

C.1.2.1 Bridges and other highway structures are fundamental to transport infrastructure because they form essential links in the highway network. It is not therefore in the public interest to allow highway structures to deteriorate in a way that compromises the functionality of the highway network, be it through restrictions or closures caused by unsafe structures or the disruption of traffic due to extensive works needed as a result of repeated deferred renewal works (sometimes referred to as a ‘maintenance holiday’) rather than completing renewal works on a ‘little and often’ basis which typically involve shorter periods of disruption. When structural failures occur, replacement works often involve long lead times due to the need for design, approvals, procurement, and construction. These delays can result in prolonged disruption to communities and significant economic impacts, and they typically affect communities and the wider network for a longer period than if work had been carried out at an earlier opportunity. It is therefore vital that authorities intervene early, undertaking timely repair, strengthening, or renewal activities to prevent deterioration from reaching a point where full replacement becomes necessary.

C.1.2.2 The importance of timely intervention to address deterioration of assets is a key theme of this Code of Practice and for structures is covered in more detail in sections C.3, C.4, and C.7. It is also important to look to coordinate maintenance activities with other asset groups, even though structures maintenance tends to take a longer period.

C.1.2.3 Highway structures represent a significant national investment, with most being publicly owned and many being prominent features in the local environment. In the UK, the management of highway structures is undertaken by a variety of owners/agencies. In the Code they are collectively referred to as ‘owner’ or ‘authority’ as appropriate. Given the long programme durations required to replace failed assets, owners should ensure they have effective monitoring, prioritisation, and forward planning processes in place. Proactive management and timely intervention help safeguard structural performance, minimise disruption, and ensure that resources are used efficiently by avoiding the far greater costs and impacts associated with unplanned failure and major replacement schemes.

SECTION C.2 LEGAL FRAMEWORK – STRUCTURES

C.2.1 INTRODUCTION

C.2.1.1 General duties and powers are dealt with in Part A of this Code. This section contains information on duties and powers specifically related to highway structures.

C.2.1.2 Most highway structures are readily accessible to the public and support a wide range of highway types, including roads, footways, cycle routes, bridleways, and other public rights of way. Responsibility for these structures rests with the relevant highway authority, who should apply a risk-based approach to determine the appropriate standards to be met. This includes considering whether DMRB requirements are applicable or whether alternative, proportionate standards are more suitable for the specific type and use of the structure.

C.2.1.3 Structure owners should be aware of their responsibilities under the Control of Asbestos Regulations 2012 in relation to any asbestos-containing materials within highway structures. Owners should refer to the relevant DMRB guidance for advice on identifying and managing asbestos risks.

C.2.2 STRUCTURES SPECIFIC LEGAL AND PROCEDURAL REQUIREMENTS

C.2.2.1 In England and Wales, the Highways Act 1980[2] sets out the main duties of highway authorities. Section 41 imposes a duty to maintain highways that are maintainable at public expense. Where a highway passes over a bridge, Section 328(2) vests the bridge as part of the highway and the normal duty to maintain under Section 41 of the 1980 Act applies under these circumstances. However, this does not preclude bridges under highways being in private ownership and rightly the responsibility of the private owner. Issues regarding retaining walls are covered below. Where such ownership arrangements fall outside the typical model, it is recommended that they are clearly recorded through formal legal documentation tied to the relevant land title, so that ownership and maintenance responsibilities can be traced accurately in future years.

C.2.2.2 In Scotland, the equivalent provisions are contained in the Roads (Scotland) Act 1984. Section 1 requires a local roads authority to manage and maintain roads entered in its list of public roads, while Sections 75 to 82 contain specific provisions relating to bridges, tunnels, and the diversion of watercourses. These include the construction of bridges over, and tunnels under, navigable waters; the reconstruction and improvement of privately maintained bridges; and agreements for the transfer of responsibility for private bridges. Section 90 separately addresses structures or apparatus placed over a road. In applying this Code in Scotland, references to a 'highway authority' should be read as references to a 'roads authority.'

C.2.2.3 In Northern Ireland, the relevant legislation is the Roads (Northern Ireland) Order 1993. Article 2 defines a road as including any bridge or tunnel over or through which the road passes and defines a bridge as including a footbridge. Article 4 contains provisions for the construction of bridges and tunnels in relation to navigable waters, Article 8 places a duty on the Department to maintain public roads, and Article 12 addresses road bridges over railways.

[2] Throughout this Code, when reference is made to the Highways Act 1980, this legislation does not apply in NI, where instead, the Roads (NI) Order 1993 applies.

C.2.2.4 It should also be noted that the legal information within this Code is a guide only, and asset owners would benefit from seeking legal advice for individual cases where there is any ambiguity.

BRIDGES

C.2.2.5 The majority of bridges are maintainable at public expense unless they were built under an Act of Parliament for the construction of the canal and railway networks or built by private owners under the authority of a Royal Charter or an Act of Parliament in consideration for being allowed to charge tolls. Where a bridge carries a road but is not maintainable by the highway authority (e.g. Network Rail), it is important for the highway authority to have an agreement with the owner of the bridge to clarify the demarcation of maintenance responsibilities. In some cases, individual bridges have their own dedicated Act of Parliament, which may specify particular requirements that can differ from duties under the Highways Act 1980. Highway authorities should identify any site-specific legislative provisions and ensure these are understood and documented when determining responsibilities and management requirements.

C.2.2.6 Authorities may wish to refer to the additional guidance document 'Definition of asset management responsibilities for bridges and structures'.

C.2.2.7 Other possible exceptions are bridges built by private landowners as a means of access over or under the highway. These are often covered by agreements with the highway authority. Section 176 of the Highways Act covers licences for bridges over the highway, whilst bridges under the highway are generally covered by agreements under the general provisions of the Highways Act and Section 111 of the Local Government Act 1972.

C.2.2.8 Section 7 of the Trunk Roads Act 1946 and later Section 55 of the Highways Act 1980 led to the adoption by the strategic highway authority of all private bridges when a road was trunked. These bridges have generally been passed to the local highway authority if the road was subsequently de-trunked in accordance with Section 2 of the Highways Act 1980.

C.2.2.9 Between 1989 and 1999 as the result of a European Directive, authorities were charged by Central Government with assessing the strength of bridges carrying the adopted road network and, where appropriate, with strengthening to ensure adequacy for the introduction of the 40-tonne European Standard to roads in the UK on 1 January 1999.

C.2.2.10 The British Railways Board, the London Board, Scottish Canals, and the Canal & River Trust (or their successors in title) are referred to as "the Boards" throughout the following section. Note that other waterways exist that are not owned by these boards and as such may not be described as 'successors in title.'

C.2.2.11 In the case of bridges owned by the Boards and their successors, an initial assessment was required to BD 21/01 (which is now CS 454 The Assessment of Highway Bridges and Structures) and its successive developments and, in the event of the assessment indicating inadequate strength, a further assessment generally to BE4, to determine whether or not the owner's load bearing obligation for the structure was met. A programme of strengthening was implemented to deal with any shortfalls of strength with cost sharing determined on the degree of shortfall, the form of strengthening and the desired loading requirements for the route. Schemes are progressed under national templates for works agreements prepared by the Boards and ADEPT Bridges Group. Further details are provided in Strengthening of rail track owned highway structures published jointly by CSS (now ADEPT) and Railtrack (now Network Rail), March 1999.

C.2.2.12 BS EN 1991-2 defines models of traffic loads for the design of road bridges, footbridges, and railway bridges.

C.2.2.13 References to the London Board are to be construed as reference to Transport for London. See also the Channel Tunnel Act 1987, s6(3), Sch.2, Pt III, para 21(4) for the application of this section to the concessionaires as defined by that Act. Other enabling legislation has been introduced to empower replacement organisations, such as London Underground Limited, to retain similar powers.

C.2.2.14 National variations apply in Scotland and Northern Ireland as mentioned above.

RAILWAY AND CANAL BRIDGES

C.2.2.15 The Transport Act 1968 (Part VIII Bridges and level Crossings etc) sought to clarify responsibilities for maintaining the structures that carry highways over the railways of the British Railways Board or the London Board, and over waterways of the British Waterways Board, now the Canal & River Trust and replaced by Scottish Canals in Scotland (or their successors in title).

C.2.2.16 Part VIII of that Act states that where, at that time, any of the above Boards were responsible for maintaining the highway on the bridge or giving access to the bridge, they remain responsible for all but the surfacing of the highway which from that time becomes the responsibility of the highway authority as highway maintainable at the public expense. The Act provides that the authority is not responsible for any defect in the surface that is attributable to the failure of the Boards to discharge their responsibility. There are similar obligations on the authority to afford access to the Boards to carry out their maintenance work and to seek the consent of the Boards to works which might affect the loading and/or parapet height on the bridge.

C.2.2.17 The Transport Act 1968 imposed upon the Boards the need to provide bridges with the required load-bearing capacity and to maintain or improve their bridges as appropriate. Except for special cases where standards are specified by a Minister, the capacity was defined as the weight of traffic which ordinarily uses or may be reasonably expected to use the highway carried by the bridge on or about the day on which the section of the Act came into force for existing bridges or, if the bridge is constructed subsequently, when it is opened to traffic. This was stated in the Motor Vehicles (Construction and Use) Regulations 1969. In the case of railway bridges this was further defined by The Railway Bridges (Load Bearing Standards) (England and Wales) Order 1972 (SI 1072 No. 1705) where five standards of loading are applied depending on the age of the bridge or when it was reconstructed (special provision is made for specific bridges listed in Schedules 2 and 3 to this order). The five standards of loading are:

- Technical Memorandum (Bridges) No. BE4 The Assessment of Highway Bridges for Construction and Use Vehicles;
- Type HA (equivalent lane loading) standard;
- HA and 37.5 units of HB (abnormal loading);
- HA and 45 units of HB; and
- for bridges that were or were about to be weight restricted, the load bearing obligation was limited to the weight restriction.

OVERBRIDGES

C.2.2.18 Bridges carrying railways or waterways over highways are usually owned by the respective Boards or their successors. Adequate consultation and liaison should take place before either the other owner or the highway authority does any work that could impact upon the interests of the other.

C.2.2.19 Bridge strikes can result in fatalities, significant disruption, and substantial economic impacts. While railway overbridges are particularly vulnerable due to the need to verify structural integrity before rail services can resume, bridge strikes also affect highway and waterway structures. Strikes can range from minor damage to complete structural failure and may occur even where the available headroom exceeds the minimum required clearance.

C.2.2.20 Authorities, bridge owners, and infrastructure operators should adopt a proactive approach to reducing the risk of bridge strikes. This may include appropriate signing, route management, stakeholder engagement, monitoring of strike locations and the application of lessons learned from previous incidents.

C.2.2.21 The Bridge Strike Prevention Group (BSPG) was established to improve awareness of bridge strike risks and promote good practice across the UK. BSPG includes representatives from highway authorities, bridge owners, transport operators and government bodies, including DfT, ADEPT, SCOTS Bridges Group, Network Rail, TfL (LUL and Surface), LoBEG, Railways Inspectorate/HSE, Freight Transport Association, Road Haulage Association, Association of Chief Police Officers, National Highways, Transport Scotland, Welsh Government, Department for Infrastructure Northern Ireland and others. As part of the BSPG activities, ADEPT in collaboration with Network Rail have developed a protocol for highway managers and bridge owners to minimise the risk of bridge strikes.

PRIVATELY MAINTAINABLE BRIDGES

C.2.2.22 In England and Wales, there are provisions in Sections 93 to 95 of the Highways Act 1980 (Sections 80 and 81 of the Roads (Scotland) Act 1984) which allow the highway authority to enter into agreements with the owners of private bridges for the transfer of ownership of the structure and responsibility for its improvement and maintenance. These agreements normally contain financial provisions or commuted sums to cover any outstanding liabilities. Section 271 of the Act also provides for agreement of transfer of tolls and subsequent compensation if necessary. In Northern Ireland, ownership and maintenance responsibilities for privately maintained bridges should be determined in accordance with the Roads (Northern Ireland) Order 1993 and any relevant agreements, title provisions, or statutory arrangements.

C.2.2.23 Where agreement cannot be reached in England and Wales, either party may apply to the Secretary of State for an order under Section 93 of the Act. Such an order can require the owner or highway authority to reconstruct or improve the bridge, determine who should maintain/operate the bridge in the future and require the transfer of ownership. Similar provisions apply in Scotland under the Roads (Scotland) Act 1984.

LOW, NARROW, OR WEAK BRIDGES

C.2.2.24 The Traffic Signs Manual contains guidance on the signing of low, narrow, and weak bridges. Chapter 4 provides guidance on warning signs, including those associated with low bridges,

whilst Chapter 3 provides guidance on regulatory signs and restrictions, including width and weight restrictions.

C.2.2.25 All bridges with less than 5.03 m clearance above the carriageway should be treated as low bridges for signing purposes and signed in accordance with the Traffic Signs Manual, Chapter 4.

C.2.2.26 In England, Wales and Scotland, Sections 1 and 2 of the Road Traffic Regulation Act 1984, as amended, may be used by a highway authority to make a TRO (called a "Weight Restriction Order" although actually a TRO) prohibiting certain vehicles from using a bridge which has a load bearing capacity less than that required to safely carry all vehicles permitted under The Road Vehicles (Construction and Use) Regulations 1986 or The Road Vehicles (Authorised Weight) Regulations 1998. "Weak Bridge" warning signs should be erected in accordance with Traffic Signs Manual Chapter 4 using guidance in CS 454 to determine the appropriate weight restriction with appropriate advance signing. Further guidance on the management of substandard structures can be found in CS 470.

C.2.2.27 National variations apply in Northern Ireland. Traffic restrictions, signing, and traffic regulation powers are governed by Northern Ireland-specific legislation, including the Roads (Northern Ireland) Order 1993 and associated road traffic and traffic-sign regulations. Authorities should ensure that any restrictions relating to low, narrow, or weak bridges are implemented in accordance with the relevant Northern Ireland requirements.

C.2.2.28 Load Mitigation Interim Measures should be imposed on weak structures to reduce the effects of the loading on the structure to an acceptable level, either by reducing the magnitude of the loading or by altering the response of the structure. These include weight restrictions, lane restrictions, propping, use of a temporary structure and closure.

C.2.2.29 Bridges with the members supporting central reserves, outer verges, and footways, which are not protected from vehicular traffic by an effective barrier, should be assessed for accidental wheel or vehicle loading in accordance with CS 454, and if necessary appropriate mitigating solution, e.g. 'effective barriers', should be implemented.

C.2.2.30 Bridges can often create narrow pinch points along the highway network. These pinch points create hazards with an increased risk of collision. "Road Narrows" signs (Sign 516 and 517 from Traffic Signs Manual Chapter 4) should be used. At sites where the bridge parapets are subject to repetitive impact damage the use of speed control measures and bollards including additional hazard signage to highlight the presence of parapets/bollards (sign 528.1) should be considered as risk reduction measures.

CULVERTS

C.2.2.31 Culverts, if constructed as part of a highway scheme, are maintainable by the highway authority. In doing this the authority may have interfered with the natural capacity of the watercourse upstream and might as a result have some responsibility if flooding occurs because the culvert is not large enough to take all the flow. Depending upon the size of storm causing the flooding, this may be an actionable nuisance, as in the case of Bybrook Barn Centre v Kent CC, and should be duly considered, where relevant. This is also relevant to bridges over watercourses. As this is a complex issue, it is suggested that a highway authority produce and maintain a guidance note to clarify how the matter of flooding should be considered. Where appropriate, relevant environmental, flood-risk and drainage authorities, including the Environment Agency or equivalent, Lead Local Flood Authority (LLFA) or Internal Drainage Board (IDB), should be

consulted when producing the guidance note and when undertaking work on culverts/bridges that may interfere with the natural capacity of a watercourse.

C.2.2.32 National variations apply in relation to flood-risk management and watercourse regulation. In England, authorities may need to engage with the Environment Agency, Lead Local Flood Authorities, or Internal Drainage Boards, as appropriate. In Scotland, relevant bodies may include the Scottish Environment Protection Agency (SEPA) and local authorities, with activities undertaken in accordance with the Environmental Authorisation (Scotland) Regulations 2018 and other applicable legislation. In Northern Ireland, authorities should engage with the relevant departments and agencies responsible for watercourses, drainage, and flood-risk management. Asset owners should ensure that the appropriate regulatory bodies are consulted when undertaking works to culverts or bridges that may affect the hydraulic capacity of a watercourse.

RETAINING WALLS

C.2.2.33 Most retaining walls, which directly support the highway or support land carrying the highway ("highway retaining walls") and are within the highway boundary, are maintainable at public expense. Occasionally such retaining walls have been built by adjoining landowners to create a more level site and so afford more usable space, e.g. for a mill, these are generally owned by, and should be maintained by, the landowner. Whilst this cannot be insisted upon by the highway authority unless covered by an agreement or is included in the land title, the highway does have a right of support under Common Law, and this can be used if the wall starts to collapse.

C.2.2.34 The responsibility for the maintenance of retaining walls which support property adjacent to the highway ("property retaining walls") is more difficult to determine. These walls may have been built as part of the highway and as such are maintainable at public expense unless built as accommodation works for the adjoining landowner with an agreement that the landowner would maintain them in the future. Some retaining walls may have been built by the adjoining landowner to create a more useable area and as such are maintainable by the landowner.

C.2.2.35 In England and Wales, if an existing wall is liable to endanger highway users, the relevant Local Authority has the primary power under Section 167 of the Highways Act 1980 to serve notice on the owner or occupier requiring them to carry out the necessary repair works to remove the danger. If the Local Authority chooses not to exercise this power, the highway authority may then serve notice instead. This can be a protracted process, and the authority needs to consider their general duty of care to the public. Serving of such a notice imposes a duty on the highway authority to act in default of action by the owner. Section 167 also states that no new retaining wall shall be built of height greater than 4 feet 6 inches (approximately 1.37m) within 4 yards (approximately 3.66m) of a street unless it is approved by the local council following consultation with the highway authority.

C.2.2.36 National variations apply in Scotland and Northern Ireland. In Scotland, responsibilities relating to roads are governed by the Roads (Scotland) Act 1984. While there is no direct equivalent to Section 167 of the Highways Act 1980, roads authorities retain responsibilities for the management and maintenance of public roads under Section 1 of that Act and may need to rely on statutory powers, title conditions, agreements or common law principles when addressing risks arising from retaining walls adjoining roads. In Northern Ireland, responsibilities are governed by the Roads (Northern Ireland) Order 1993, including the duty to maintain roads under Article 8. Ownership, maintenance responsibility, and powers relating to retaining walls should be established in accordance with the relevant national legislation and any applicable agreements or land title provisions.

C.2.2.37 The ownership and maintenance of retaining walls can be complex, particularly where ownership, support rights or maintenance responsibilities are not clearly documented. Authorities should seek to establish and record responsibilities wherever reasonably practicable. For new roads and developments, authorities should consider requiring any retaining wall supporting the highway to be subject to a formal agreement or deed, linked where appropriate to the title of the land, setting out ongoing ownership and maintenance responsibilities. Asset owners should seek legal advice where ownership or responsibility is unclear.

CELLARS AND VAULTS

C.2.2.38 The majority of cellars and vaults associated with the highway are privately owned and their maintenance and management are largely outside the remit of the authority. Nevertheless, when a private cellar or vault collapses it is frequently the responsibility of the authority's Highway Structures Manager to oversee initial investigation and subsequent repairs. To minimise the risk to the public and the length of time taken to return the highway to public use, the Highway Structures Manager may wish to implement procedures or protocols to mitigate the risk of collapse and deal with subsequent investigation and repair. Guidance is provided in the following paragraphs on developing such a protocol.

C.2.2.39 In England and Wales, Sections 179 and 180 of the Highways Act 1980 give procedures for the control of the construction of cellars and vaults under the street, of the provision of openings under the street, and of pavement lights and ventilators. The duty to maintain and repair a cellar or vault is on the owner or occupier, whereas the highway authority has a right of support of the highway and has powers to enter and maintain existing structures if the owner or occupier fails to act. The Act does not necessarily impose an obligation on the owner or occupier to carry out works that enhance or improve, e.g. strengthening to carry current accidental wheel loads or vehicle loading, if the carriageway needs to be extended over the cellar or vault.

C.2.2.40 In Scotland, similar provisions are contained in Section 66 of the Roads (Scotland) Act 1984, which places duties on owners to maintain and repair vaults and cellars beneath roads and provides powers for the roads authority to require such works to be undertaken.

C.2.2.41 Authorities should implement a procedure for dealing with cellars and vaults that reflects the nature and number of cellars and vaults associated with their highway. The procedure should take into account current data and knowledge (e.g. number of recent failures), the resources needed to collect further data (e.g. a survey to identify all cellars and vaults) and the benefits provided by this data. The following approaches should be considered:

- ad hoc approach – after a collapse, the authority liaises with the owner/occupier regarding the repair. There is no set protocol for dealing with collapse/repair, but the principles outlined within Section 6 (Network Resilience) of Part A should be followed.
- re-active protocol – after a collapse, the authority follows a set protocol.
  - The protocol may include:
  - secure the site, e.g. site safety, traffic management, initial inspection, and structural analysis;
  - identification of relevant parties, e.g. owner, occupier, highway, and other authorities;
  - investigation, e.g. nature of the cellar/vault, extent and cause of damage, scope and cost of works required and constraints; and

- repairs, e.g. establish who will carry out the repairs, identify work required to meet current standards and agree how costs will be shared between the parties.
- This approach may be suitable for authorities that have a large number of cellars and vaults associated with their highway but have had few collapses in the past and the risk of collapses in the future is assessed to be small.

- Pro-active protocol – based on the re-active protocol but add to this a pro-active approach to collapse mitigation using risk assessment. The authority, in agreement with cellar/vault owners, develops a risk assessment procedure that identifies those cellars and vaults most at risk. These structures should be inspected/assessed by the authority or the owner's engineering representative (as agreed) and the need for repairs and strengthening identified. Identification, inspection and assessment of all cellars and vaults are likely to be difficult and expensive tasks. This approach should be justified based on minimum whole life costs (to the owner and authority) and may be suitable for authorities that have a large number of cellars and vaults associated with their highway and have had a significant number of collapses in the past.

PARTY WALL ACT

C.2.2.42 The Party Wall Act 1996 applies to England and Wales and requires the issue of statutory notices when work affects adjacent properties within three metres of any construction works or within six metres if affecting foundation support. The Act is generally only applicable where the authority is acting as a landowner rather than solely in its capacity as highway authority. Authorities nevertheless retain obligations relating to the support of the highway under common law. Condition surveys should be undertaken prior to any major works and in some instances the processes prescribed within the Party Wall Act may prove beneficial. The process may lead to an affected party appointing an Independent Party Wall Surveyor to act on their behalf and thus later disputes may be avoided. Further information may be obtained from the website of the Pyramus and Thisbe Club, which is the organisation for professionals specialising in party wall matters.

C.2.2.43 There is no direct legislative equivalent to the Party Wall etc. Act 1996 in Scotland or Northern Ireland. In Scotland, matters relating to shared walls and support are generally governed by common law, title conditions and, where relevant, the Tenements (Scotland) Act 2004. In Northern Ireland, similar matters are generally governed by common law and property title provisions.

TUNNELS

C.2.2.44 Tunnels are covered in Part E of this Code of Practice. The Road Tunnel Safety Regulations (2007, amended 2009) apply to tunnels over 500 metres in length that form part of the trans-European road network. For all other road tunnels, the applicable Design Manual for Roads and Bridges (DMRB) standards should be followed, specifically CM 430 and CS 452, and for new road tunnels, CD 352.

OTHER HIGHWAY STRUCTURES

C.2.2.45 Other structures, such as gantries and cantilever traffic signs, constructed as part of a highway, are also maintainable at public expense and are usually managed by the Highway Structures Manager of the authority.

C.2.2.46 If a highway runs along a river or the seashore then an embankment, river wall, seawall, and/or groynes may be necessary for protection. They will therefore need to be maintained by the highway authority as part of their duties to maintain under the Highways Act 1980, (see the case of Sandgate UDC v Kent County Council 1898). However, each case should be considered on its merits depending on the circumstances, as maintenance could be the responsibility of or shared with the Coast Protection Authority. More information on embankments can be found in Section B.5 of this Code.

C.2.2.47 Reinforced earthworks and engineered slopes are becoming increasingly prevalent on the network. It is important that either the Highway Structures Manager or the Geotechnical Team agree to take responsibility for the asset and are aware of its existence on the network.

IMPROVEMENTS AND RECONSTRUCTION

C.2.2.48 In England and Wales, Sections 62 to 105 of the Highways Act 1980 give general powers to the authority to improve the highway be it widening, junction improvements or safety aspects. Improvements can include highway structures. Section 75(2) requires consent of the railway, canal, inland navigation, dock, or harbour undertakers concerned, if affected.

C.2.2.49 Sections 91 and 92 of the 1980 Act respectively state that an authority can construct a bridge to carry the highway and that a bridge can be reconstructed either at the site or within 200 yards (approximately 183m) of the existing one. Section 93 of the Act permits the authority to apply to the Minister of State for an order to provide for reconstruction, improvement, or maintenance of privately maintained bridges if they are considered dangerous or unsuitable for the requirements of road traffic.

C.2.2.50 The authority has the power under the 1980 Act, Section 110 to divert non-navigable watercourses if necessary or desirable as part of improvement or alterations.

C.2.2.51 Construction of bridges over, and of tunnels under, navigable waterways, requires an order from the Minister under Section 106 of the Highways Act 1980. If the waterway is also tidal, consent is required under the Coast Protection Act 1949 as amended by Section 36 of the Merchant Shipping Act 1988. If material is to be deposited in the tidal waterway, consent is also required in accordance with the Food and Environmental Protection Act 1985 Part II. Part E of this Code provides guidance for tunnels.

C.2.2.52 In Scotland, powers relating to the construction, reconstruction and improvement of bridges, tunnels and associated works are contained within Sections 75 to 82 of the Roads (Scotland) Act 1984. Requirements relating to works affecting navigable waters, marine areas and watercourses may also require consultation with, or consent from, the relevant statutory bodies, including Marine Scotland, the Scottish Environment Protection Agency (SEPA), and local authorities, as appropriate.

C.2.2.53 In Northern Ireland, equivalent powers are contained within the Roads (Northern Ireland) Order 1993, including provisions relating to bridges and tunnels associated with navigable waters. Authorities should ensure that all necessary national statutory approvals and consultations are obtained before undertaking improvement or reconstruction works.

C.2.2.54 Each of these processes involves a statutory consultation process which includes the Environment Agency, Marine Management Organisation, navigation authorities, Northern

Lighthouse Board, for Scotland, etc as necessary. For works required on highway structures within areas covered by a “Harbour Order” permission is required from the Harbour Authority.

STRUCTURES OVER OR ADJACENT TO WATERCOURSES OR FLOOD DEFENCES

C.2.2.55 If highway structure works are required in, over, under or near a watercourse or flood defences (including sea defences), it is essential to contact the appropriate agency, for consent to work in watercourses. Consents can take a minimum of two months to obtain and should therefore be sought as early in the planning process as feasible. Consents to cover both temporary and permanent work are required. Where a structure interacts with a waterbody in such a way that it may also act as a dam, early consideration must be given to whether the requirements of the Reservoirs Act 1975, Reservoirs Act (Northern Ireland) 2015 or Reservoirs (Scotland) Act 2011 apply.

C.2.2.56 Watercourse and flood-risk consents are the means of meeting requirements that the works do not endanger life or property by increasing the risk of flooding or cause harm to the water environment. Consents are given by the Environment Agency under the Water Resources Act 1991 in England for main rivers and by the lead local floods authority under the Land Drainage Act 1991 for works on or near ‘Ordinary Watercourses’. In some areas there are Internal Drainage Boards who deal with these matters on behalf of the Environment Agency.

C.2.2.57 In Scotland, watercourse regulation is undertaken by the Scottish Environment Protection Agency (SEPA) and local authorities. Relevant requirements include the Environmental Authorisation (Scotland) Regulations 2018 (EASR). Works within or adjacent to marine areas may require a Marine Licence issued by Marine Scotland, and early engagement is recommended as consents can take significant time to obtain. Other bodies, such as Fisheries Boards, may also require consultation where relevant.

C.2.2.58 In Northern Ireland, authorities should engage with the relevant departments and agencies responsible for watercourse management, drainage, flood-risk management, and environmental regulation, as appropriate to the nature and location of the works. Any necessary statutory approvals should be secured before works commence.

C.2.2.59 Where a structure falls within the scope of the Reservoirs Act 1975, Reservoirs Act (Northern Ireland) 2015 or Reservoirs (Scotland) Act 2011, additional statutory duties may apply, including inspection and supervision by suitably qualified reservoir panel engineers and adherence to prescribed safety and monitoring requirements. These duties operate alongside, and do not replace, any watercourse consent requirements.

ENVIRONMENTAL REQUIREMENTS

C.2.2.60 Maintenance work and inspections on highway structures should be undertaken giving due consideration to the environment. Highway structures provide habitats for some species, such as reptiles, nesting birds, bats, and plants especially lichens, mosses, and liverworts. They are often situated in and over key biodiversity corridors – i.e. rivers, streams, and estuaries. Whilst they facilitate the passage of vehicles, cycles, and pedestrians, over or under obstacles, bridges can also be a barrier to the migration of animals, which can result in conflict with traffic. Brief details of the requirements are given in Section 8 of Part A of this Code.

C.2.2.61 In England, key environmental bodies are the Environment Agency (EA), Department for Environment, Food and Rural Affairs (DEFRA), Office for Environmental Protection (OEP), and Natural England.

C.2.2.62 On 1 April 2013, the Environment Agency Wales was merged with the Countryside Council for Wales and Forestry Commission Wales into a single environmental body, Natural Resources Wales, which is the statutory drainage and flood defence authority for Wales.

C.2.2.63 In Scotland, the principal environmental bodies include the Scottish Environment Protection Agency, Marine Scotland and NatureScot. These organisations have responsibilities relating to environmental regulation, biodiversity, protected species, watercourses, marine licensing, and the protection of the natural environment.

C.2.2.64 In Northern Ireland, environmental matters are primarily administered through the Department of Agriculture, Environment and Rural Affairs (DAERA), together with the Department for Infrastructure (DfI) and Department for Communities (DfC), depending on the nature of the asset and the environmental issue concerned.

CONSERVATION REQUIREMENTS

C.2.2.65 The Planning (Listed Building and Conservation Areas) Act 1990 requires each authority to compile a list of buildings of special architectural or historic interest. Listed building consent is required to demolish such a structure, or to alter or extend it in a manner affecting its architectural or historic interest. The Act also provides for the protection of conservation areas that have special historical interest. The status can influence the processes required for structure maintenance in such an area.

C.2.2.66 There are different grades of listing, depending on the historical or architectural importance of the structure, ranging from Grade 2 through Grade 2* to Grade 1, with a further level of Scheduled Ancient Monument, which is covered by The Ancient Monuments and Archaeological Areas Act 1979. Secretary of State (Department of Culture, Media, and Sport) approval of proposals for work on a Scheduled Ancient Monument is required before any works are carried out, except emergency works. The Ancient Monuments (Class Consents) Order 1994 gives consent in Class 5 for works which are urgently necessary in the interests of safety or health, provided that the works are limited to the minimum measures immediately necessary and notice in writing justifying in detail the need for the works is given to the Secretary of State as soon as reasonably practical. This would allow the replacement of the odd damaged stone or realignment of a displaced parapet but not repair of more extensive damage.

C.2.2.67 The Secretary of State relies heavily on the advice of Historic England and any proposals for work on such structures should involve early consultation with the local representative of Historic England. Proposals for works on structures recorded at the lower (listed) levels are usually approved by the planning department of the local authority. However, if the work will require complete or partial demolition, or if the work will alter or extend a Grade 1 or 2* structure in any manner which would change its character as a building of special architectural or historical interest, the planning department of the local authority has to consult Historic England.

C.2.2.68 Authorities may also enter into agreed repair frameworks with Historic England for specific or repeat repair methods on certain assets. These agreements allow predefined works to proceed without repeated consent, provided they fall within the approved scope, and should be considered early in the planning process.

C.2.2.69 Although these sites have no greater legislative protection, local planning authorities are encouraged to have management plans in place. Planning applications for works in these areas are likely to require greater consultation with Historic England and thus lengthier programmes should be accommodated. Details of the sites in England are provided on the Historic England website.

C.2.2.70 As the requirements for the conservation of historic structures are specified in a number of disparate documents and there was a need to bring them together in a bridge-orientated publication, National Highways sponsored the publication of Conservation of Bridges and issued CG 304 - Conservation of highway structures. Both these publications should be consulted before work is proposed on historic structures. The website Maintain our Heritage, although primarily for historic buildings, has information on various aspects of maintaining these structures.

C.2.2.71 England, Wales, Scotland, and Northern Ireland maintain statutory systems for the designation and protection of historic assets. The categories, consenting arrangements and responsible bodies vary between nations. Scheduled monuments throughout the UK remain subject to the Ancient Monuments and Archaeological Areas Act 1979, whilst listed building legislation differs between nations.

C.2.2.72 In Scotland, Historic Environment Scotland performs a role broadly comparable to Historic England in relation to the historic environment and scheduled monuments. Listed buildings and conservation areas are governed by the Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997. Authorities should engage with Historic Environment Scotland at an early stage were maintenance, alteration or reconstruction works may affect designated heritage assets.

C.2.2.73 In Wales, Cadw, is the historic environment service of the Welsh Government and is responsible for the protection and management of scheduled monuments, listed buildings and other elements of the historic environment. Authorities should engage with Cadw where works may affect designated heritage assets.

C.2.2.74 In Northern Ireland, responsibility for heritage and conservation matters rests with the Historic Environment Division of the Department for Communities. Authorities should engage with the Historic Environment Division where works may affect listed buildings, scheduled monuments, or other designated heritage assets.

C.2.2.75 World Heritage Sites designated by UNESCO (United Nations Educational, Scientific and Cultural Organization) occur across all parts of the United Kingdom. Although designation does not provide additional statutory controls beyond existing planning and heritage legislation, authorities should have regard to World Heritage Site management plans and engage with the relevant heritage and planning bodies when proposing works that may affect the Outstanding Universal Value of the site.

SECTION C.3 ASSET STRATEGY – STRUCTURES

C.3.1 INTRODUCTION

C.3.1.1 A Structures Asset Management Strategy sets out the authority's approach for managing structures assets across the network to deliver value for money, minimise risk and support strategic goals. More specifically, the Strategy sets out how the Asset Management Policy will be implemented.

C.3.1.2 Asset data management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

C.3.1.3 Asset management systems are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C. This document should be referred to and the advice below considered supplementary.

C.3.2 PRINCIPLES AND CONSIDERATIONS

C.3.2.1 The Structures Asset Management Strategy should clearly set out its context in relation to the authority's goals and priorities, relevant legislative, regulatory and policy requirements, and stakeholder expectations (e.g., the public, regulators, and partners). It should also reference links to other strategic documents, such as Part A of this code (Network Strategy), the Corporate Plan, the Climate Strategy, and other related frameworks. In doing so, this will provide a clear 'line of sight' between the higher-level documents.

C.3.2.2 A strategic approach to Structures Asset Management is important and requires a long-term plan that takes into account a number of considerations such as condition, criticality, intervention timings, and whole life cost/whole life carbon. The approach should also take into account how structures assets contribute to maintaining resilience at network level and avoiding excessive disruption associated with delayed interventions. These factors are considered in more detail throughout Part C.

CROSS ASSET/CROSS PARTY CONSIDERATIONS

C.3.2.3 Key risks to the network are outlined in A.3 Network Strategy of this Code. Those particularly relevant to structures assets and therefore should also be considered here include:

- scour,
- flooding,
- diversion routes,
- collision damage
- abnormal loads (including high, wide, and heavy loads); and
- gritting policy.

C.3.2.4 Although these risks are primarily managed by network managers and addressed in A.3 Network Strategy, their relevance to structures emphasises the need for strong and effective

communication across asset disciplines to ensure coordinated risk management and might be considered as part of the structure's asset management strategy.

C.3.2.5 The wider approach to route criticality and network resilience will need input from the Highway Structures Manager, as it is likely that there will be highway structures located on, or near, key routes. Consideration will need to be given to how these key structures will be maintained in order to maintain safety and functionality of the highway network. Resilience and adaptation are discussed in more detail in Section C.6 Resilience and Adaptation.

C.3.2.6 Effective communication and understanding of responsibilities between councils, structures teams, other asset teams and police is essential in managing critical routes and abnormal loads. To understand these responsibilities, refer to the most recent National Police Chiefs' Council (NPCC) guidance on abnormal load movements.

C.3.2.7 Local characteristics of the network are likely to influence the structures asset strategy. Certain structures may be critical for maintaining access to power stations, for example, or may be critical to maintaining an abnormal/indivisible load corridor. Whilst they may not fall on the same routes as the network-wide route criticality, it is important that structure-specific criticality is captured in the strategy, alongside the approach to managing those assets.

C.3.2.8 Similarly, structures that interact with other infrastructure such as railway crossings should be considered in the structure's asset strategy. Liaison with other asset owners will be critical to understand the requirements and restrictions that are in place when managing those assets.

NON-BRIDGE STRUCTURE FAILURE

C.3.2.9 Collapses of retaining walls, pipe subways and other non-bridge structures are becoming increasingly common, and consideration should therefore be given to non-bridge structures to ensure they are appropriately addressed and proactively planned for.

C.3.2.10 One of the key considerations in this area is being aware of the location and maintenance responsibilities of non-bridge assets. The structures asset strategy should acknowledge the risk these assets pose and identify how that risk will be mitigated. Mitigations could include a proactive response such as undertaking a comprehensive survey to locate and inspect these assets aligned with route criticality, or a reactive 'fix on failure' approach (noting that the reactive approach also carries associated risk and uncertainty).

SLOW DETERIORATION

C.3.2.11 Structures deteriorate differently from other asset classes. Their deterioration can remain hidden for long periods without noticeably affecting service levels. However, if not properly maintained, failure can occur suddenly, often requiring substantial funding to address the issue. Such failures can also create significant knock-on impacts for the wider network, including reduced resilience, the introduction of lengthy diversion routes, safety risks to road users, damage to utility pipes and the potential closure of the affected section. These impacts can lead to increased journey times, disruption to local communities and businesses, heightened congestion on alternative routes, and reputational consequences for the authority responsible for the network.

C.3.2.12 The increasing use of fibre optic cable presents further challenges, as the replacement of this cable is often complex and more costly than older types of cable. This in addition to other critical,

non-highway purposes (such as military fuel lines and water mains) may impact the criticality of a structure and increase the impact to local and wider stakeholders.

C.3.2.13 Slow structural deterioration is not always visible from network-level performance measures, such as network availability. Authorities should therefore use appropriate engineering condition measures for structures alongside network-level performance measures to understand the state of the network.

C.3.2.14 Early identification of structural issues that require remediation will often result in lower whole life costs and less disruption. Delaying renewal works will lead to more extensive work being required at a later date, at a greater cost and longer duration to rectify, therefore intervention at the optimum time is essential. Carrying out renewal works on a 'little and often' basis, where works are well planned to minimise disruption where possible, is preferable to delaying works.

C.3.2.15 It is important to note the role of the Traffic Manager in accordance with the Traffic Management Act 2004, and the role the Highway Structures Manager can play in making the Traffic Manager aware of the impact of structure failure/unavailability on the network as a whole. Typically, when a structure fails or becomes unavailable the route on which it is located will be compromised. Other asset failures may still allow the route to function (depending on the nature of the failure) as other mitigation measures may be able to be implemented.

C.3.2.16 Whilst structures generally deteriorate slowly, there are some elements that can exhibit rapid deterioration, such as hidden critical elements. These can lead to sudden, unpredicted failure which can result in significant disruption. Further guidance on the management of hidden critical elements can be found in CS 450 and CIRIA guide C764, *Hidden defects in bridges.*

C.3.3 MANAGEMENT OF ASSET INFORMATION

C.3.3.1 Maintaining an up-to-date asset inventory is fundamental to effective asset management and underpins informed decision-making across the network. Asset owners are expected to ensure that asset information is accurate, complete, and routinely updated following inspections, maintenance activities, renewals, or changes in asset condition, to support network decision making. A reliable inventory supports risk management, lifecycle planning, long-term investment planning, prioritisation of interventions, and the delivery of value for money. This is all the more important considering structures maintenance is disruptive and takes longer than most roads interventions. Further guidance on the fundamental importance of having good data, its specific requirements, data standards, and processes for managing asset information is provided in C.5 Asset Knowledge.

C.3.3.2 For high-value or high-risk structures, more thorough lifecycle plans should be created in line with guidance in Section C.7 Finance and Investment. The use of a digital twin for these structures can support Highway Structures Managers with predictive maintenance by forecasting potential failures before they happen, supporting the scheduling of maintenance activities.

C.3.4 COMPETENCE

C.3.4.1 A fundamental principle of this Code is that the management of highway structures, including maintenance planning, structural review and assessment, is undertaken by suitably qualified and experienced civil or structural engineers. Personnel undertaking these roles should hold appropriate professional qualifications and demonstrate the necessary experience to make

engineering judgements that affect the safety, operation, serviceability, and longevity of highway structures.

C.3.4.2 This Code strongly encourages structure owners to ensure that the key roles involved in structures management, such as the Highway Structures Manager, are fulfilled by a chartered engineer with structures design/maintenance/management experience (CG 300 states CEng MICE, CEng MIStructE or equivalent). Where this cannot be achieved within the organisation, arrangements should be put in place to secure appropriate access to such expertise through alternative means.

C.3.4.3 Structural inspection activities, while forming a critical component of structures management, require a distinct but complementary set of competencies. Inspectors are not required to be Chartered Engineers; however, they must possess sufficient knowledge, training and practical experience of inspection processes, defect identification, and safe working practices. Their competence should be aligned with recognised industry benchmarks and independently assessed certification schemes, such as the Bridge Inspector Certification Scheme (BICS), to ensure that inspections are carried out consistently and effectively.

C.3.4.4 To support effective implementation of the practices set out in this Code, organisations should establish and maintain structured programmes of Continuing Professional Development (CPD) and training for Highway Structures Managers, engineers, inspectors, and associated staff. These programmes should enable personnel to understand and apply the processes and requirements described in the Code, commensurate with their roles and responsibilities.

C.3.4.5 In addition, it is recommended that agents and contractors are required to demonstrate that their personnel are competent for the work they undertake in relation to highway structures. This should include appropriate qualifications, training and relevant experience for both engineering and inspection roles. Competence should be subject to independent verification, such as audit and/or formal assessment, and supported by evidence of continued professional engagement in relevant work activities.

HIGHWAY STRUCTURES MANAGER COMPETENCE

C.3.4.6 As outlined above, ensuring key personnel have the right skills and attributes to enable them to manage a highly complex and challenging asset class is essential. One of the key roles mentioned throughout Part C is the Highway Structures Manager.

C.3.4.7 The Highway Structures Manager should have all the competencies described for a Bridge Inspector (see following sections) and in addition to those competencies, be competent and have experience in:

- Asset Management
- Structural Strength Assessments
- Highway structure design and construction
- Financial management
- Project management
- Contract management
- CDM and other relevant construction legislation

- DMRB and MCHW

C.3.4.8 The skills and competencies described above can be supported by the formal qualifications described in C.3.4.2.

BRIDGE INSPECTION COMPETENCE

C.3.4.9 The accurate and consistent capture of condition data is essential to effective highway structures management. The increasing use of asset management systems and decision-support tools has further reinforced the need for high-quality, reliable inspection information. International bridge failures in recent years have highlighted the importance of robust inspection regimes and assured inspector competence.

C.3.4.10 Competencies that a bridge inspector should have include the following:

- Structure types and elements/behaviour of structures.
- Inspection process
- Defect descriptions and causes.
- Investigation and testing
- Repair techniques.

C.3.4.11 Bridge inspectors should be able to demonstrate their competence. The level of competence and experience will dictate the complexity of structure they are able to inspect without supervision.

C.3.4.12 The Bridge Inspector Certification Scheme (BICS) has been developed to provide a structured and consistent framework for the competence assessment of bridge inspectors. The scheme has been established collaboratively by the UK Bridges Board and Transport Infrastructure Ireland, with oversight from key industry stakeholders including ADEPT, the Department for Transport and the UK devolved administrations. BICS is intended to operate as part of the National Highway Sector Schemes framework.

C.3.4.13 BICS provides an independently verified approach to assessing competence that is aligned with established inspection and examination guidance across transportation networks. The scheme assesses capability across all stages of the inspection process, including planning, safe delivery, and reporting, with a strong emphasis on health and safety and risk management.

C.3.4.14 The benefits of the scheme include:

- An increase in the profile of bridge inspectors via the introduction of a recognised certification scheme across the UK and Ireland.
- An increase in the quality of bridge inspections due to improved levels of consistency and reporting from competent inspectors leading to a greater level of confidence.
- A reduction in risk for bridge owners due to evidence of competence and best practice.
- Cost savings as a consequence of minimised rework and the ability to better prioritise limited maintenance budgets.
- Increased flexibility for organisations in moving inspection staff around and sharing them with other sectors.

C.3.4.15 The scheme comprises three levels of certification, reflecting progressive levels of knowledge, responsibility, and practical experience. This structure enables inspectors to demonstrate competence appropriate to their role while supporting career progression within the discipline.

C.3.4.16 Adoption of BICS supports a consistent approach to the inspection of structures and the recording of condition data. However, it should be recognised that certification forms part of a broader competence framework. Complementary training remains essential to develop underpinning knowledge of structural behaviour, defect identification, investigation techniques, inspection technologies, and condition assessment.

C.3.4.17 Structure owners should consider how BICS certification, alongside other training, and competency measures, can be integrated within their organisational competence management systems to support the delivery of safe, consistent, and high-quality inspection outcomes. It is important to note that various alternative BICS schemes have been developed by area groups of ADEPTS in order to demonstrate the competencies of bridge inspectors.

SECTION C.4 RISK-BASED APPROACH – STRUCTURES

C.4.1 INTRODUCTION

C.4.1.1 The general principles to be applied to risk-based approach are detailed in Part A, with this section covering guidance relating to highways structures assets. Risk management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C.

C.4.1.2 Although this section is concerned with structures, it is imperative that a consistent approach is developed for other highway assets too, such that competing demands for limited funding can be assessed on an equal basis.

C.4.2 RISK MANAGEMENT PRINCIPLES FOR HIGHWAY STRUCTURES

C.4.2.1 Examples of risks, impacts and potential mitigation measures are included in table 36 for illustrative purposes.

Table 36: Examples of risks, impacts, and potential mitigation measures

Example Risks and Mitigations			Example Impacts			
Type of Risk	**Example Risks**	**Example Mitigation**	**Safety**	**Serviceability**	**Sustainability**	**Customer**
Asset - Risks affecting individual structures assets	Structural deterioration of elements causing reduced functionality or closure of a structure.	Condition inspections Reactive defect repairs Planned preventative maintenance	Increased risk of structure failure and potential harm to road users, property, or nearby assets.	Increased maintenance activities. Need to impose restrictions on weight, height, width.	Higher whole-life cost. Increased maintenance frequency leading to greater material use and waste.	Disruption and delays from repeated reactive repairs, or disruption due to remediation or replacement works and diversion routes.
	Water ingress leading to element corrosion.	Routine inspections Preventative maintenance	Reduced capacity, increased risk of element/structure failure.	Premature element/ asset failure and increased maintenance costs.	Higher whole-life cost. Increased maintenance frequency leading to greater material use and waste.	Disruption and delays from repeated reactive repairs, or disruption due to remediation or replacement works and diversion routes.
Service – Risks affecting how assets work	Extreme weather – scour causing structure collapse/closure	Scour susceptibility assessment Scour protection works for vulnerable structures Resilience planning Temporary structure/propping	Fatality, personal injury accident. Risk of structure failure.	Weight restrictions. Structure closure leading to delays.	Water pollution. Higher whole life cost due to repair or replacement.	Disruption and delays due to remediation or replacement works and diversion routes.

C.4.2.2 Undertaking risk assessment and developing management strategies from assessments, should allow for funding to be prioritised in areas where the need is greatest. This can support practitioners in managing the deterioration of their bridge stock in a more proactive integrated manner. It should be noted that the risk assessment approach should be undertaken with caution. This process should not be used to justify a 'Do Nothing' approach unless it can be shown that 'Do Nothing' is not adversely affecting the condition of the structure. Care should also be given to ensure that bridge owners do not place themselves at an excessive/unacceptable level of risk. Authorities should develop risk-based policies to manage and coordinate decision making from risk management/assessment.

C.4.2.3 An integrated management approach is required. The assessment of a structure's performance (or lack of) needs to be assessed with a strong reference to the criticality of the structure's location on a network.

C.4.2.4 The LoBEG Good Practice Guide - Risk-based Inspection of Highway Structures provides examples of detailed risk-based methodologies specifically for the inspection of highways structures.

C.4.2.5 DMRB provides a variety of risk-based technical standards, those specific to highways structures relate to inspection, post-tensioned structures, half-joints and hinge joints, piers, parapets, sub-standard structures, and scour susceptibility, amongst others.

C.4.2.6 User needs should be considered as per Part A.15.

DETERMINING CRITICALITY

C.4.2.7 When determining the relative importance of a structure within the wider network, authorities should consider a range of operational, social, and economic factors to support a consistent, risk-based approach. Practitioners should apply professional judgement to assess local circumstances. Key considerations include:

- Risk of single points of failure, where the loss of a structure could sever communities and utility services, force long diversions, or remove essential links relied on by neighbouring authorities or National Highway Authorities, with knock-on impacts for local businesses, schools, and other key services.
- Authorities should also consider how loss of access may affect local and emergency services, particularly where alternative routes are limited or constrained.
- Anticipated duration of works and how far a structure or route would be inaccessible, recognising the resulting disruption to users.
- Consider the degree of integration with other infrastructure such as rail or strategic highways, to ensure partner organisations' priorities and operational needs are reflected when assessing criticality.

C.4.2.8 A small structure/culvert on a critical network link may warrant more attention than a much larger structure on a remote unclassified road. Alternatively, a small structure on an unclassified road (with no local diversion routes possible) that provides the only local link between adjacent villages could be assessed as being more important than a much larger structure on a more significant road (where simple diversions are possible). Hence bridge owners should consider the hierarchy of their structures relative to the hierarchy of the road network, coupled with local factors and

constraints to ensure that by applying an integrated asset approach, more efficient management strategies with a reduced impact for users can be realised.

C.4.3 PROGRAMMING AND PRIORITIES

C.4.3.1 A well-designed risk-based cyclic maintenance programme will help prevent the performance of a structure from falling below its intended level; identify any physical, structural or durability-related work needed to maintain or extend the life of the asset; reduce the likelihood of unexpected faults or failures; and ensure that the structure continues to operate safely and as intended.

C.4.3.2 A well-structured maintenance programme should be underpinned by a well-defined inspection programme. Inspections should be recognised as key points at which condition information is refreshed and priorities can be reassessed. DMRB document CS 450 defines the minimum, or baseline inspection frequency as every two years for General Inspections, and every six years for Principal Inspections, however authorities may need to visit structures more frequently where risk, criticality or emerging deterioration trends indicate that additional monitoring or interim inspections are appropriate. CS 450 provides a methodology for changing the frequency of Principal Inspections, whilst Transport for London and LoBEG have developed a risk-based approach to assessing the frequency of General Inspections. Using inspection findings supports a more responsive and risk-based approach to programming work.

C.4.3.3 Given the potentially significant financial and operational consequences associated with structural failure, it is essential that maintenance programmes balance immediate needs with early, preventative action. Even relatively small-scale failures can incur substantial costs, generate prolonged disruption, and place considerable pressure on already constrained budgets. Embedding a “little and often” approach where regular, low-cost activities such as drainage clearance, vegetation management and minor defect repairs are carried out proactively can slow deterioration, reduce cumulative risk, and minimise the likelihood of more intensive and expensive interventions being required later in the asset’s life.

C.4.4 DETERMINE CURRENT PERFORMANCE

C.4.4.1 The asset inventory, condition and performance data should be used to determine the current performance of the highway structures in a way that supports the identification of needs and Value Management. Inspection data is particularly important, as it provides the most current and detailed understanding of asset condition and forms the foundation upon which other condition and performance information is interpreted. Much of the information should be in a format that can be readily used for identifying needs, for example element condition data and assessed capacity. Some data may require manipulation in order to provide information that assists identification and Value Management, for example, structure specific Performance Indicator values.

C.4.4.2 The current performance should be determined for individual elements and/or structures using absolute measures, e.g. severity and extent of a defect or assessed capacity of a structure. The description of current performance should be commensurate with the level of detail required for short term maintenance planning. This implies a greater reliance on absolute measures that describe current condition and performance in detail rather than performance measures. Performance measures are more suited to determining performance in the long-term asset management planning process.

C.4.4.3 There is no industry-wide benchmark or minimum acceptable level of performance for highway structures other than the structure being 'safe and serviceable.' Levels of desired performance may be focussed around the BCI scores, how many interim measures are in place and so on, or the target condition for the structure stock could be set within a particular range (based on the five condition bands very poor to very good). Alternatively, some authorities have developed a State of Good Repair score, which takes into account BCI scores and deck area to determine whether a structure is in a good state of repair or not.

C.4.5 IDENTIFICATION OF NEEDS

C.4.5.1 The purpose of this task is to identify and document all maintenance required on highway structures and the associated cost estimates. The documented maintenance needs and costs are referred to as the structures workbank, which forms the basis of the subsequent Value Management and Value Engineering processes. Long-term asset management should also be considered at this stage, as visibility of needs beyond the typical 3–5-year planning horizon is essential for effective budget management and for anticipating periods where multiple high-cost interventions may coincide.

C.4.5.2 General Inspections provide the most frequent opportunity to review outstanding workbank items and confirm whether previously identified priorities remain appropriate. Where a Principal Inspection has highlighted work likely to be required within the next five years, the GI should be used to validate whether deterioration has accelerated or slowed, enabling the priority and timing of interventions to be adjusted accordingly. This approach ensures that the workbank remains current, risk-based, and reflective of the latest condition information.

C.4.5.3 A formal approach to the identification of needs should be developed but the Highway Structures Manager should be aware that maintenance needs can arise due to a wide range of factors, some of which may not be covered by a formal approach. Common criteria that should inform the identification of needs are:

- assessment of condition and performance data by a suitably qualified and experienced engineer to identify needs;
- development of lifecycle plans to identify maintenance cycles and intervention thresholds; and
- identification of regular maintenance needs (e.g. inspections, structural reviews and assessments and routine maintenance) and planned improvement/development schemes.

C.4.5.4 Non-standard factors may also influence prioritisation beyond the formal methodology for example, where assets form part of a prominent streetscape or urban environment that requires a higher standard of presentation for reasons unrelated to function.

C.4.5.5 The following sections describe the above criteria in more detail. Some modern structures also have Maintenance Manuals as required by Appendix A of CG 302 As Built, Operational and Maintenance Records for Highway Structures. These should also be used to inform the identification of needs.

C.4.6 CONDITION AND PERFORMANCE DATA

C.4.6.1 The condition and performance data should be reviewed periodically by a suitably qualified and experienced engineer to identify maintenance needs. It is recommended that General Inspection

pro forma are reviewed and signed off by the inspection team no longer than two months after the inspection, but preferably within one month. Thereby the signing off and identification of needs are combined. Some authorities may also wish to combine data entry with these tasks. Acceptance of the inspection report by the asset owner/Highway Structures Manager may also be required thereafter, depending on individual organisational requirements.

C.4.6.2 This exercise is heavily dependent on the engineer's knowledge of the elements/structures and the appropriate methods for dealing with the needs. As a minimum, the engineer should have knowledge of a range of appropriate maintenance techniques, and in which circumstances the techniques should be applied.

C.4.6.3 The Highway Structures Manager may wish to define some generic rules/guidelines, which define when a particular maintenance method should be used. These rules/guidelines are normally defined in the lifecycle plans (see below) but may need to be defined separately for situations that the lifecycle plans do not cover, e.g. when elements deteriorate below the intervention thresholds defined in the lifecycle plans and may require alternative maintenance techniques.

C.4.7 LIFECYCLE PLANS

C.4.7.1 Lifecycle plans provide a structured method for forecasting future maintenance needs for existing structures by bringing together the various work types outlined in this section, including regular maintenance, preventative maintenance, component renewal, and other programmed activities. These plans should be informed by known performance and deterioration trends wherever possible, drawing heavily on inspection data as the most current and detailed source of condition information. Where local deterioration data is limited, industry-standard profiles may be used as an interim basis until more reliable evidence becomes available.

C.4.7.2 Given the size and complexity of many structures' portfolios, most authorities will not have individual lifecycle plans for every structure. A risk-based approach should therefore be adopted, with priority given to structures identified as critical to the operation of the network. Grouping similar structures can also help in developing standardised lifecycle plans that can be applied across multiple assets, improving consistency and reducing resource demand.

C.4.7.3 Lifecycle plans should be reviewed following each cycle of inspection to ensure they reflect the latest understanding of deterioration rates and emerging needs. Inspection findings that indicate accelerated or reduced deterioration should prompt updates to anticipated intervention timings, enabling authorities to manage budgets more effectively and avoid clusters of high-cost interventions.

C.4.7.4 Authorities may also consider developing route-level lifecycle plans, which assess maintenance needs across multiple structures within a corridor. Coordinating interventions at this level can generate efficiencies, reduce repeated disruption, and ensure that works are delivered in a way that optimises both resource use and network performance.

C.4.8 WORKS PRIORITISATION

C.4.8.1 A risk-based approach to works prioritisation enables authorities to make informed decisions on how resources are allocated across their structure's portfolio. Prioritisation should consider the relative risk, cost, and consequence of undertaking or deferring different types of work, supported by up-to-date condition information, inspection findings, and network criticality.

C.4.8.2 A well-developed portfolio will also take into account factors that cannot be readily seen, or are independent from inspection data, such as actions arising from scour assessments, management of sub-standard structures (where replacement may be a viable option), parapet replacement or pier protection. Prioritisation of the entire workbank should take into account network (and therefore structure) criticality.

APPLYING A RISK-BASED FRAMEWORK

C.4.8.3 Across all work types, prioritisation should be informed by:

- structural condition and deterioration rates
- outcomes of assessments separate from inspection data (see C.4.8.2)
- network criticality and the consequences of restriction or failure
- health and safety considerations
- whole-life costs and value for money
- opportunities to coordinate works or minimise disruption
- sustainability considerations, including opportunities for preventative intervention.

C.4.8.4 By applying these principles consistently, authorities can ensure that maintenance, repair, strengthening, and replacement activities are undertaken in a manner that optimises safety, performance, value, and long-term resilience.

REPAIR, STRENGTHENING AND REPLACEMENT PRIORITISATION BASED ON CS 470

C.4.8.5 Routine and preventative maintenance should also be prioritised within a risk-based framework. well-timed, low-cost interventions can significantly reduce the likelihood of more extensive and expensive works in the future. Authorities should consider adopting a “little and often” approach where appropriate, recognising the whole-life savings that arise from regular minor interventions such as drainage clearance, vegetation control, joint replacement, and joint cleaning. Prioritising these activities can help slow deterioration and reduce long-term demand for essential maintenance and strengthening schemes. Involving the Traffic Manager through consultation can help an authority to demonstrate it is meeting its statutory duties.

C.4.8.6 CS 470 Management of Sub-Standard Highway Structures lists the factors which should be taken into account in any prioritisation of strengthening work. These include:

- risk of structure collapsing;
- traffic delay costs caused by interim measures;
- other social, environmental, and economic consequences caused by interim measures;
- the negotiability of alternative routes;
- the cost-effectiveness of the strengthening (ratio of costs and benefits);
- joint replacement; and
- other benefits from scheme.

C.4.8.7 Factors that should be considered for other interventions include:

- risk of increase rate of deterioration
- reduction of safety performance in use

C.4.8.8 A Good Practice Guide on Risk-based Prioritisation and Value for Money: Phase 1 has been published by London Bridges Engineering Group (LoBEG).

SECTION C.5 ASSET KNOWLEDGE – STRUCTURES

C.5.1 INTRODUCTION

C.5.1.1 This section covers the knowledge required for effective asset management of structures assets, including inspections, assessments, and recording. For guidance on structural inspection, assessment, and testing of lighting assets. Refer to Part D of this Code.

C.5.2 ASSET MANAGEMENT – DATA AND SYSTEMS

C.5.2.1 A structures asset management system should provide/support the following list of functions.

- collection, storage and retrieval of inventory data and condition data;
- works management and prioritisation;
- asset valuation – both gross replacement and depreciated replacement cost to support Whole of Government Accounting requirements;
- production and reporting of national and local performance data;
- deterioration modelling and life cycle planning; and
- management and storage, in electronic format, of drawings, photographs and reports.

C.5.2.2 The UK Bridges Board has developed a methodology for Structures Asset Management Planning, known as the Structures Asset Valuation and Investment tool (SAVI). New versions are published annually via the UK Roads Leadership Group website and may be used to produce annual valuation figures where needed.

C.5.2.3 Commercial software systems should implement the methodology of the valuation module in a consistent manner, in order that the valuation figures produced by any one system are comparable and auditable regardless of the system used.

C.5.2.4 Asset data should be held in a format that allows it to be easily entered, analysed and manipulated during the planning process, preferably in a computerised format. Data entry may be performed by administration staff or engineers. In the latter case data entry, especially for General Inspections, should be combined with the identification of needs in order to produce a more time and cost-efficient approach. The highway structures stock should be divided into groups and sub-groups that have similar deterioration characteristics and maintenance.

C.5.2.5 Consistency is vital to current and developing Bridge Management Techniques and to ensure that these are suitably supported, it is essential that element inventories are created and maintained in a consistent manner.

C.5.2.6 The London Bridges Engineering Group (LoBEG) has published a Good Practice Guide on Creating Consistent Element Inventories for Highway Structures. This describes the approach for creating consistent element inventories and provides guidance on the consistent evaluation of Bridge Condition Indicators.

C.5.2.7 The extent of data held depends on the particular requirements of the authority, but the following should be considered:

- **basic inventory data** – the basic information about each highway structure, including structure name/reference, structural type, location, route carried, obstacle crossed (where relevant) and key dimensions;
- **legal data** – details of contracts, licences, legal agreements, letters, etc. that define who is responsible for management, e.g. authority, another owner, third party, maintaining agent;
- **condition data** – an up-to-date General Inspection pro forma should be held for all structures as a minimum. Holding additional more historic condition data will assist in monitoring and developing trends;
- **structural assessment and review data** – the assessment rating, date of latest structural review, details of a planned assessment, or details of why the structure is excluded from the review/assessment programme; and
- **Health and Safety File** – an H&S file should be maintained for each highway structure as construction work is carried out.

C.5.2.8 The data collected and managed by authorities may depend also on imposed requirements arising from government/corporate policy and targets (current and future, if known) relating to the environment and sustainability, resource accounting and budgeting, Best Value, asset valuation etc.

INVENTORY DATA

C.5.2.9 The inventory should hold the basic data and information on the stock of highway structures in terms of descriptive parameters such as structural type, form, construction material, and geometry (dimensions, span, width, skew etc). Attributes held in the inventory should enable management to operate at a number of levels, e.g. stock, groups, or individual structure.

C.5.2.10 Suggested fields for a highway structures inventory are listed below:

- structure type, e.g. bridge, culvert, retaining wall;
- owner and, where appropriate, management, maintenance, and inspection responsibilities;
- structure identifier – reference, name, key number, etc;
- route carried, e.g. Principal A road, Broad, footway;
- structure location, e.g. map reference (easting and northing), GPS, section of road, local position reference;
- year of construction/reconstruction, designer, and design code;
- location of drawings, photographs, design details, etc;
- headroom envelopes, minimum headroom, navigation clearance;
- historic listing or scheduled ancient monument;
- special access requirements, including details of confined space working, permit to entry or work, maintenance access needs etc;
- details, including date, of major upgrades and/or modifications, e.g. widening or strengthening;

- presence of utility services (stats) – a field indicating 'yes' or 'no' may be sufficient rather than specific details. This is for information only and a live search should be carried out to confirm stats prior to any works;
- external considerations and/or constraints, e.g. social, geographical, environmental, conservation, etc;
- structure arrangement, e.g. number and location of widenings, number of spans/panels, skew;
- structural form, e.g. arch, beam, and slab;
- general material of construction, e.g. masonry, steel, concrete;
- obstacle crossed, e.g. road, watercourse, railway;
- dimensions, e.g. length, width, height;
- list of components, e.g. primary deck element, joints, bearings. The inspection pro forma developed by CSS (now ADEPT) provides an appropriate list;
- materials of construction;
- year of construction/installation;
- manufacturer and unit specifications, e.g. for parapets, bearings, and joints;
- presence of asbestos; and
- capacity rating/abnormal load rating.

INSPECTION, CONDITION AND PERFORMANCE DATA

C.5.2.11 General and Principal Inspections provide the majority of condition data. These are supplemented by Special Inspections, testing, and monitoring, as appropriate, where the data sought is often focussed on a particular part of the structure or aspect of performance. Such data is often obtained on a "one-off" basis and may include measurements which cannot be conveniently entered into a paper based or electronic system. The database should indicate the location of the full report in such instances.

C.5.2.12 Condition data from previous inspections should be retained as the evolution of this data over time gives a clear indication of the rate of deterioration and residual service life. This data can be used to estimate deterioration rates for different element and structure types which may be used to develop lifecycle plans.

PERFORMANCE MEASUREMENT FOR HIGHWAY STRUCTURES

C.5.2.13 Setting targets and measuring performance are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

C.5.2.14 The following should be considered when identifying performance measures for use in asset management planning:

- performance measures for highway structures that are already in use, e.g. Condition PI;
- performance measures that have been developed, or are under development, for highway structures; and

- additional performance measures that may be needed to reflect the levels of service for the overall network and for measuring the effectiveness and efficiency of the planning and delivery processes.

C.5.2.15 The Government paper on Choosing the Right Fabric: A Framework for Performance Measurement provides useful further guidance for the identification, development, and use of performance measures.

C.5.2.16 Performance Measures for Highway Structures: Part A provides guidance on performance reporting, although it is recognised that the data requirements to drive these performance measures can be onerous.

C.5.2.17 In determining performance measures, it is important to distinguish between those that reflect asset performance (such as number of structures with restrictions or are sub-standard) and those that reflect management performance (such as inspection completion rates). Given the long timescales associated with structure deterioration, the most useful indicators indicate changes over time, such as overall condition levels and the numbers of structures that are sub-standard, or restricted. Similarly, short-term indicators such as inspection completion rates and expenditure only report on a small aspect of structures management that may not reflect the overall performance of the structure stock. It is therefore important for asset owners to identify indicators that provide value and contribute to management of structures and the wider network.

C.5.2.18 In setting performance metrics, it is important to understand the required level of performance, so that current metrics can be measured against the required levels. It is not pragmatic to set the target condition of a BCI_{av} or BCI_{crit} of 100, for example, so a more appropriate target should be selected that ensures the structures can still operate in a safe and serviceable manner yet can be more readily tracked and monitored.

C.5.3 ASSET CONDITION AND INVESTIGATORY LEVELS

INTRODUCTION

C.5.3.1 An asset management strategy is the mechanism by which authorities deliver their asset management policy in practice.

C.5.3.2 Asset condition information and proportionate investigatory levels provide the evidence base for informed, risk-based decisions. Early identification of defects and deterioration enables timely interventions that maintain safety and functionality, ensuring structures continue to operate reliably for customers and support a resilient network. Clear and consistent condition data also preserves asset value through well-timed, cost-effective maintenance, reducing whole-life impacts and supporting sustainable use of resources. Applying investigatory levels according to asset importance ensures that effort is targeted where it delivers the greatest serviceability and public benefit, aligning fully with a risk-based approach.

MAINTENANCE STANDARDS

C.5.3.3 All maintenance work should preferably be designed to current standards, although there may be situations where lesser standards are acceptable, e.g. repair of part of an element, repair of accident damage. Where lesser standards are adopted, this should be formally recorded as a departure from standard and held within the asset records so that future maintainers can understand the basis for the decision. Guidance on managing departures is provided in CG300.

C.5.3.4 Each case should be considered on its merits. Where lesser standards are accepted, the designer should check that the load carrying capacity of the structure at both serviceability and ultimate limit states and the durability of the repaired area are not less than that of the rest of the structure. Lesser standards may be unavoidable, e.g. maintenance of a listed bridge or scheduled monument. In this situation it is recommended that a safety audit or risk assessment is carried out. This documentation should be kept with the structure file for the structure in question. Where unacceptable risks or hazards are identified, the Highways Structure Manager should look for alternative mitigation measures.

C.5.3.5 It is important that the implications for future maintenance are a prime consideration in the design and implementation of all maintenance schemes. A strategic approach should also be applied at each maintenance intervention to minimise future maintenance needs. This includes considering whether existing components can be replaced with options that offer greater durability or are easier to maintain in the long term. Reducing the frequency of future interventions helps limit operational disruption and reduces the carbon impacts associated with diversion routes, traffic management, and repeated site visits. These future maintenance implications should therefore be a key consideration when planning and designing maintenance works.

C.5.3.6 The DMRB and the Manual of Contract Documents for Highway Works (MCHW) are maintained by National Highways on behalf of all Overseeing Organisations (Trunk Road or strategic road authorities in England, Scotland, Wales, and Northern Ireland).

C.5.3.7 The DMRB provides detailed guidance in the form of standards for most aspects of highway structure design and assessment. The guidance includes criteria for structural loading, analysis, material properties, element design, or assessment, in addition to geometrical requirements and best practice for design for durability. The MCHW provides model contract documents, specifications, notes for guidance and standard details. Care is required to remain fully aware of changes and additions to the DMRB and the MCHW.

TECHNICAL APPROVAL

C.5.3.8 All structural design and assessment should be subject to a formal Technical Approval procedure such as those used by the Overseeing Organisations [CG 300 Technical Approval of Highway Structure] or Network Rail [GC/RT5101 Technical Approval Requirements for Changes to the Infrastructure]. Authorities should have such a procedure in place and have formally appointed an appropriate organisation or individual to act as Technical Approval Authority (TAA).

C.5.3.9 Both National Highways and Network Rail have a range of documents applicable to maintenance and that refer to the relevant British Standards and Eurocodes. Departures from these standards should be carefully recorded to enable an audit trail for certification.

NATIONAL VARIATIONS

C.5.3.10 The DMRB is used by authorities in Scotland with some specific variations appropriate for use in Scotland. Transport Scotland issues interim amendments (TSIA) as necessary.

C.5.3.11 Similarly, the DMRB is implemented by the Welsh Government with some specific variations appropriate for use in Wales.

C.5.3.12 The DMRB is implemented in Northern Ireland by the Department for Infrastructure (DfI) as one of the Overseeing Organisations, with some specific variations appropriate for use in Northern

Ireland. DfI issues interim amendments as DEMs (Director of Engineering Memoranda) as necessary and Northern Ireland specific policy as RSPPGs (Roads Policy & Procedure Guide).

IMPLEMENTATION OF THE EUROCODES

C.5.3.13 The *Eurocodes* are a series of European Standards developed by the *European Committee for Standardisation*, to provide a common approach for the design of buildings and other civil engineering works and construction products. The Eurocodes are currently not to be used for assessment, although assessment will be incorporated into the next generation of Eurocodes, which, as of 2026, are being updated with an anticipated release date of 2027/28.

C.5.3.14 Ten Eurocodes have been developed and published. They are organised in 58 parts, and each part is supplemented by a National Annex.

- EN 1990 Eurocode: Basis of structural design;
- EN 1991 Eurocode 1 : Actions on structures ;
- EN 1992 Eurocode 2: Design of concrete structures;
- EN 1993 Eurocode 3: Design of steel structures;
- EN 1994 Eurocode 4: Design of composite structures;
- EN 1995 Eurocode 5: Design of timber structures;
- EN 1996 Eurocode 6: Design of masonry structures;
- EN 1997 Eurocode 7: Geotechnical design;
- EN 1998 Eurocode 8: Design for earthquake resistance; and
- EN 1999 Eurocode 9: Design of aluminium structures.

C.5.3.15 On 31 March 2010, all British Standards that conflicted with the Eurocodes were withdrawn. The *Eurocodes* have therefore replaced national codes that were previously published by national standard bodies and have become mandatory for European publicly funded works. As with other European standards, the Eurocodes are used in public procurement.

PREDICT FUTURE DEMAND

C.5.3.16 Changes in demand in the future may alter how a structure should be managed, e.g. if a planned route widening will necessitate a bridge replacement in 10 years' time, then the maintenance strategy for the existing bridge should reflect this. The most cost-effective solution for the bridge may be to adopt a managed deterioration approach that provides the minimum required performance for the next 10 years but does not necessarily keep the bridge in a visibly good condition.

C.5.3.17 The prediction of future demand on highway structures should align with the network demands and are likely to include changes in vehicle weight, height and width, and traffic volume. Future demands should be predicted using available data, historical trends, and local factors. The following should be considered when developing rules for predicting future demand on highway structures:

- **vehicle weight** – current highway bridge design and assessment standards [BS EN 1991-2, CS454] use a number of loading models that allow future increases in Gross Vehicle

Weights (GVW) to be assessed. However, increases in GVW may require associated changes to the Authorised Weight (AW) regulations, i.e. limits on axle weights, numbers, and spacing. If the AW regulations change, the effect on bridges would be examined nationally and appropriate guidance provided by the DfT to highway authorities;

- **height and width** – it are unlikely that any change in specified vehicle dimension would force a national programme of bridge 'raising,' road 'lowering' or road widening. It should be sufficient to assess the vertical and horizontal clearance requirements on specific structures or structures on a route, e.g. routes/structures that currently have height/width restrictions, routes that may be reclassified as a high load route. Height is not controlled by UK legislation, unlike width, length, and weight; and
- **traffic volume** – increases in traffic volume may require highway structures to be widened or replaced as part of a larger highway widening/upgrade scheme. Also, increases in HGV movements (for example, due to a quarry or distribution centre opening) may have a significant impact on future management and maintenance. The Highway Structures Manager should seek to obtain advance warning of such schemes and use this in asset management planning.

C.5.4 INSPECTION, ASSESSMENT AND RECORDING

C.5.4.1 This section covers guidance for each category of inspection relating to structures.

C.5.4.2 Inspection, testing, and monitoring should be used to:

- provide data on the current condition, performance, and environment of a structure, e.g. severity and extent of defects, material strength, and loading. The data enables the Highway Structures Manager to assess if a highway structure is currently safe for use and fit for purpose, and provides sufficient data for actions to be planned where structures do not meet these requirements;
- inform analyses, assessments, and processes, e.g. change in condition, cause of deterioration, rate of deterioration, maintenance requirements, effectiveness of maintenance and structural capacity. The outputs inform asset management planning and enable cost effective plans, which deliver the agreed levels of service, to be developed; and
- compile, verify and maintain inventory data, e.g. structure type, dimensions, and location, for all the highway structures the authority is responsible for.

C.5.4.3 The above points illustrate that the data provided by inspection, testing and monitoring is fundamental to highway structures management and hence to good management practice. It is essential that authorities recognise the importance of inspection, testing and monitoring and seek to plan, perform, resource, and use them accordingly.

C.5.4.4 The extent of inspection, testing and monitoring of structures should be determined using a risk-based approach, as defined in Section A.5 of this Code. This should consider the position of the structure on the highway network hierarchy and hence, its importance to the overall transport infrastructure, and the characteristics of the structure itself in terms of its type, material, condition, vulnerability to closure or restriction due to component failure, flooding, impact etc.

C.5.4.5 Reducing the level of inspection or increasing the interval between inspections increases the level of risk to the manager/owner of the asset. It should be agreed with senior managers or Heads of Service and appropriately recorded and reported. This should only be carried out using good

practice and asset management techniques, such as deterioration modelling. Those responsible for asset stewardship should not be put under unacceptable pressure to reduce inspection periods for any reason that may put public safety at risk.

C.5.4.6 The Inspection Manual for Highway Structures (Volume 1 and Volume 2) was commissioned by Highways England and published in May 2007. The next revision of the Inspection Manual is expected in 2026/27. A Technical Project Board, representing UK highway bridge owners, oversaw the development; the manual is supported, endorsed, and recommended by the UK Bridges Board.

C.5.4.7 The manual contains detailed guidance which covers the following areas:

- The inspection process;
  - Scheduling inspections;
  - Planning and preparing for inspections;
  - Performing inspections;
  - Recording inspection findings; and
  - Input to maintenance planning process.
- Defects, descriptions, and causes;
  - Principal causes of defects;
  - Concrete defects;
  - Steel defects;
  - Masonry defects; and
  - Defects in miscellaneous materials.
- Investigation and testing;
  - The testing process;
  - Summary of testing techniques;
  - General testing techniques;
  - Tests on concrete;
  - Tests on metal;
  - Tests on masonry;
  - Tests on timber; and
  - Tests on advanced composites.

C.5.5 INSPECTION REGIME

C.5.5.1 An inspection, testing and monitoring regime should minimise risks to public safety, provide sufficient data for management and make effective use of resources. The mix of techniques used in the regime, and frequencies at which they are applied, should be determined by considering appropriate criteria in an objective manner, e.g. through a formal risk assessment. The criteria should include, but not be restricted to, public safety, the characteristics of the assets, the

consequence of failure, the environment the assets operate in, the services provided, typical rates of deterioration and susceptibility to damage.

C.5.5.2 The inspection, testing and monitoring techniques should be sufficient to:

- identify condition, defects and signs of deterioration that are significant to highway structure safety and management;
- identify any significant changes in condition, loading or environment that have occurred since the last observation;
- assess or provide information for the assessment of stability and serviceability;
- determine or assist the determination of the cause, extent, and rate of deterioration; and
- provide information that can be used to support highway structures management, i.e. the identification of needs and associated maintenance works.

C.5.5.3 The inspection regime should enable any defects which may cause an unacceptable safety or serviceability risk or a serious maintenance requirement to be detected in good time in order to safeguard the public and the structure and implement remedial actions. The regime should consist of a combination of Acceptance, Safety, General and Principal Inspections of the whole structure and more detailed Safety and Special Inspections (including Inspections for Assessment), as necessary, concentrating on known or suspected areas of deterioration or inadequacy. Guidance on inspections for highway structures is included in *CS 450 Inspection of Highway Structures*.

C.5.5.4 All inspections should result in a report, in a format commensurate with the inspection type, which gives a clear and accurate description of the structure's condition.

C.5.5.5 A procedure should be implemented whereby the inspector has a clearly defined duty to inform the Highway Structures Manager, at the earliest possible opportunity, of any defects that may represent an immediate risk to public safety.

ROUTINE SURVEILLANCE

C.5.5.6 All structures should be subjected to Routine Surveillance as part of regular Highway Safety Inspections carried out by highway maintenance staff. Routine Surveillance is normally undertaken from a slow-moving vehicle. Inspectors should immediately report to the Highway Structures Manager any obvious defects that are apparent from the vehicle which need urgent attention, such as damage to the superstructure and bridge supports of overbridges, damage to parapets, flood damage, insecure expansion joint plates, etc. The Highway Structures Manager should be satisfied that the frequency of Highway Safety Inspections is suitable for the Routine Surveillance of highway structures and, if unsuitable, decide how to deal with the need for additional surveillance.

C.5.5.7 All highway structure management and maintenance staff should be encouraged to always be vigilant when moving around the network and to report anything that might need urgent attention. The public should also be informed of the need to report any highway structure defects they feel may pose a risk to public safety. This is normally best achieved by providing appropriate contact details (e-mail and/or telephone) on the authority's website.

C.5.5.8 The Highway Structures Manager should make formal contact with the highway maintenance staff and, if necessary, explain the important features to observe or defects to report on highway structures during Routine Surveillance and the information that should be recorded if a defect is observed, e.g. structure location and defect description. The Highway Structures Manager's contact details, or the contact details of an appropriate member of their team, should be provided to the highway maintenance staff.

GENERAL INSPECTION

C.5.5.9 General Inspections comprise a visual inspection of all parts of the structure (that can be inspected without the need for special access or traffic management arrangements) and, where relevant to the behaviour or stability of the structure will include an inspection of the adjacent earthworks or waterways. Riverbanks, for example, in the vicinity of a bridge should be examined for evidence of scour or flooding or for conditions, such as the deposition of debris or blockages to the waterway, which could lead to scour of bridge supports or flooding. Guidance on General Inspections for highway structures is included in CS 450 Inspection of Highway Structures and CSS Bridge Condition Indicators Volume 2: Guidance Note on Bridge Inspection Reporting and Addendum to CSS Bridge Condition Indicator Volume 2.

C.5.5.10 The inspection requirements for Authorities may differ and may include specific requirements when inspections are conducted. Transport Scotland, for example, asks for a reduced scour inspection around accessible piers and abutments during General Inspections.

PRINCIPAL INSPECTION

C.5.5.11 Principal Inspections comprise a close examination, within touching distance, of all accessible parts of a structure, including, where relevant, underwater parts and adjacent earthworks and waterways, utilising suitable access and/or traffic management works, as necessary. Closed circuit television, high resolution digital photography/video or drones may be used for areas of difficult or dangerous access, e.g. obscured parts of a structure, confined spaces, and underwater inspections.

C.5.5.12 A Principal Inspection may include a modest programme of tests, when considered necessary, e.g. hammer tapping to detect loose concrete cover or half-cell and chloride measurements to enable risk of reinforcement corrosion to be assessed, tests for cement content and measurements of concrete cover and electrical resistivity of concrete (see Section 7.3 of *BA 35*).

C.5.5.13 A Principal Inspection should be of sufficient scope and quality to determine:

- the condition of all parts of the structure;
- the extent of any significant change or deterioration since the last Principal Inspection; and
- any information relevant to the stability of the structure and/or continued use in service and safety.

C.5.5.14 A Principal Inspection should establish:

- the scope and urgency of any remedial or other actions required before the next inspection;
- the need for a Special Inspection and/or additional investigations; and
- the accuracy of the main information on the structure held in the inventory.

SPECIAL INSPECTION

C.5.5.15 There are occasions when a more specific inspection, concentrating on the condition of particular parts of the structure, is required. This is known as a Special Inspection. The need for a Special Inspection normally arises due to specific circumstances or following certain events, for example:

- when a particular problem is detected during an earlier inspection of the structure or of similar structures;
- on particular structural forms or types, e.g. cast-iron structures, post tensioned structures, structures strengthened with bonded plates;
- on structures that have loading or other forms of restrictions on use, e.g., restriction of traffic on bridges;
- when the necessary frequency or access arrangements for a particular part of the structure are beyond those available for General or Principal Inspections;
- on bridges that have to carry an abnormally heavy load - inspections may be done before, during and after the passage of the load;
- following a bridge strike;
- following a flood or high river flow to check for scour or other damage;
- to check specific concerns, possibly based on new information, e.g. concerns over the quality of previously used batches of rebar or concrete; and
- where a post tensioned bridge has a regime of Special Inspections implemented as a result of an earlier investigation or a Special Inspection is required in accordance with CS465 Management of Post-Tensioned Concrete Bridges, organisation, and methods for carrying out Special Inspections.

C.5.5.16 A policy should be developed clarifying when it is appropriate to carry out a Special Inspection. Further guidance on Special Inspections is provided in CS 450 Inspection of Highway Structures.

INSPECTION FOR ASSESSMENT

C.5.5.17 This is another type of inspection, which is carried out before a structural assessment. CS 454 provides guidance on undertaking an Inspection for Assessment.

SAFETY INSPECTION

C.5.5.18 A Safety Inspection may be undertaken following Routine Surveillance or after information has been received which indicates the structure is damaged and may be unsafe. The Safety Inspection should determine the extent of the damage and whether immediate safety precautions or other action should be taken. A Special Inspection may then follow to monitor the condition and effectiveness of interim measures and to determine what repair or other actions should be undertaken in the longer-term.

C.5.5.19 Extreme unplanned events such as storms, high winds and flooding have a significant impact on infrastructure. Bridges are highly susceptible to damage from extreme events. The susceptibility of the asset owner's bridge stock should be reviewed to highlight potential structures at risk. These structures should be inspected following extreme events such as flooding to check on their

integrity. Inspecting certain 'at-risk' structures during extreme events should also be considered to allow early closure if the particular risk level warrants closure.

ACCEPTANCE INSPECTION

C.5.5.20 The need for an Acceptance Inspection should be considered when there is a changeover of responsibility for the operation, maintenance, and safety of a structure from one party to another. The purpose of an Acceptance Inspection is to provide the party taking over responsibility for the structure with a formal mechanism for documenting and agreeing the status of, and outstanding work on, a structure prior to handover. The scope of an Acceptance Inspection depends on the circumstances, e.g. handover of a new structure, transfer of an existing structure, hand back of a structure after a concession period. Acceptance responsibilities and activities depend upon the form of contract, but the Acceptance Inspection is normally carried out by the party taking over responsibility, but who may be accompanied by the other party to facilitate agreement. The Acceptance Inspection should include:

- the identification of any permanent access provisions and features affecting the safety and security of the structure. These should be discussed in detail and agreement reached before handover;
- the identification and handover of all the necessary records, maintenance and operating manuals which have an impact on the future management of the structure; and
- agreement of the date on which the authority takes over responsibility for the structure. The agreement should be recorded in the Structure File.

C.5.5.21 Acceptance Inspections on new, existing and concession structures should also include the following, as appropriate.

- Handover of a new structure:
  - An Acceptance Inspection should be undertaken for new structures about one month before the issue of the completion documentation or opening to traffic. A Principal Inspection should be used for this purpose. The inspection should identify and record any defects, developing problems and work outstanding under the contract and secure agreement on any works to be completed before handover. This should act as the benchmark for the inspection carried out at the end of the Defects Correction Period and for subsequent inspections.
  - A construction contract normally includes a Defects Correction Period (also referred to as the Period of Maintenance or Defects Liability Period) during which the contractor is responsible for making good defects that appear. The length of the Defects Correction Period should be specified in the contract.
  - An inspection should be undertaken prior to the end of the Defects Correction Period to identify all defects before the expiry of the contractual obligations. The timing of the inspection should be sufficient to allow agreement of the work to be undertaken by the contractor and, if necessary, enforcement of contractual obligations. The inspection may be a General or Principal Inspection depending upon the type and form of the structure and the length of time since handover or the last inspection.
  - Prior to adoption of a new structure, asset information should be obtained, in the appropriate format, and at the appropriate BIM level, for the authority taking over responsibility for a new structure.

- The ADEPT Bridges Group has published guidance for the calculation of commuted maintenance sums for structures to be adopted or transferred.
- Authorities may also wish to use the above, or a similar, procedure for accepting major maintenance work.

- Transfer of an existing structure:
  - An Acceptance Inspection should be undertaken prior to an authority taking over responsibility of an existing structure. A Principal Inspection should be carried out as part of the Acceptance Inspection unless the results of a recent Principal Inspection are deemed to be relevant and sufficient. Should there be areas of concern highlighted in the PI such as defects that could impact on the long-term durability of the structure then a Special Inspection should be carried out to ascertain the extent and implications of the defect(s) with respect to the structure's future lifecycle costs and commuted maintenance sums.
- Hand back after a concession period:
  - An Acceptance Inspection should be undertaken beforehand back at the end of a concession period, e.g. a PFI or PPP type contract. The inspection should compare the current condition and performance of the structure against the measures specified in the contract. This should include a Principal Inspection unless the results of a recent Principal Inspection are deemed to be relevant and sufficient. This information should be used to identify and agree items of outstanding work to be completed, to satisfy the contract measures, beforehand back. The timing of the Acceptance Inspection should be sufficient to allow agreement of the outstanding work to be undertaken by the contractor and, if necessary, enforcement of contractual obligations.

INSPECTION REQUIREMENTS OF OTHER OWNERS

C.5.5.22 Where other owners have structures within the footprint of the highway, they are responsible for ensuring the safety, integrity, and adequacy of those structures for use by the public. The inspection of other owner structures normally falls into two categories:

- **Newer structures** – an appropriate inspection regime is likely to have been recorded in the licence/maintenance agreement; and
- **Older Structures** – there is unlikely to be a statement of inspection requirements in a formal agreement. The highway authority only has the power to act to ensure safety in default of action by the other owner when the structure becomes dangerous. A highway authority cannot insist retrospectively on a regime of inspection and maintenance to be undertaken by the other owner where there is no clear statement of requirements in a formal agreement.

C.5.5.23 In certain cases, an authority can be reasonably confident based on available information that an owner is acting responsibly and has an adequate regime of inspections in place, e.g. Network Rail, Canal & River Trust, Scottish Canals, London Underground Limited. In some cases, however, this conclusion cannot be justified, and the highway authority should carry out General Inspections of such structures in the wider interests of public safety. This in no way negates the primary responsibility of the actual owner toward public safety and structural integrity.

FREQUENCY OF INSPECTIONS

C.5.5.24 When a structure is known or suspected to be subject to a rapid change in condition, consideration shall be given to reducing the interval between inspections (for General or Principal Inspection), alternatively the programming of additional Safety Inspections as noted above should be considered to manage the risk of change. Refer to C.4 Risk-based approach for further guidance on the frequency of inspection rates.

C.5.5.25 The reduced interval should be such that any significant change in condition or circumstances can be identified and assessed in time for appropriate action to be implemented. The revised inspection regime and reasons for more frequent inspections should be recorded in the Structure File. The more frequent inspection regime may be limited to a specific element or feature.

C.5.5.26 When a structure is deteriorating towards the point where it is no longer serviceable, but before it reaches that state, a management plan should be prepared for the structure, which outlines the available options to mitigate its performance, frequencies of inspection, and intervention levels, established by risk assessment, and this should be recorded in the Structure File.

C.5.5.27 Highway structures are long life assets, and their constituent components deteriorate at different rates due to a wide range of factors, e.g. material type, construction form, usage, exposure, and maintenance. The suitability of increased inspection intervals should be assessed and justified using a risk assessment, giving due consideration to the following:

- type, quality, extent and results of previous inspections, testing, monitoring, structural assessment, etc;
- accessibility of all parts of a structure, for example:
  - if the inspector can get close to all parts of a structure during a General Inspection, there may be little difference between the General and Principal Inspection. A Principal (or Special) Inspection may only be required when the need has been identified by a General Inspection; and
  - if the inspector cannot get close to all parts of the structure during a General Inspection and there is a likelihood of significant defects not being detected, there is a need for regular Principal (or Special) inspections.
- providing suitably current data for calculating the Condition Performance Indicator (Bridge Condition Indicator) and determining the extent and priority of all defects; and
- the ease of producing practical and workable inspection budgets and schedules, i.e. scheduling may become unduly complicated if different inspection intervals (especially for General Inspections) are used across the highway structures stock.

C.5.6 RISK ASSESSMENT

C.5.6.1 A risk assessment should be specific to a structure or group of similar structures. An assessment method should be developed that seeks to quantify:

- the likelihood of rapid deterioration or other incidents; and
- the consequence of unchecked deterioration/incidents.

C.5.6.2 Assessment of the likelihood of rapid deterioration or other incidents should include, but not be limited to, the following criteria where relevant:

- exposure severity, e.g. mild, moderate, or severe, and external influences which may cause rapid deterioration or failure, e.g. significant change in use (above, adjacent, or beneath), loading that exceeds existing restrictions, stray current/electrical corrosion;
- current condition and level of contamination, e.g. chlorides or carbonation, and how these conditions may influence the rate of deterioration. The age of the structure may also be considered;
- material type and the typical rate of deterioration for the observed deterioration mechanism. Many defects are known to take many years to develop to the point where they require maintenance or present a risk to structural integrity or public safety. The maintenance/repair history of the structure should be taken into consideration and structure specific characteristics such as fatigue-prone details and susceptibility to scour damage, should be considered;
- severity and extent of damage due to incidents, such as vehicle impact, scour and vandalism, and whether this is likely to lead to further deterioration before it is repaired;
- potential mode of failure, e.g. brittle or ductile failure;
- extent of failure, e.g. local or global failure;
- structural form and age; and
- visibility / access to critical elements.

C.5.6.3 Assessment of the consequence of unchecked deterioration and other incidents should include, but not be limited to, the following criteria where relevant:

- consequence of failure of the structure or its elements, e.g.
  - the likely number of fatalities and casualties based on the size of the structure and traffic volume on the route crossed and obstacle crossed;
  - traffic delay costs incurred through diversions/congestion based on the route type and availability of diversion routes;
  - loss of utility services;
  - socio-economic impact based on the location of the structure and the community served, e.g. industrial, business, or residential;
- increased costs due to unchecked deterioration/incidents resulting in more expensive maintenance work later; and
- to determine in so far as is reasonably practicable based upon the available information and interpretation, when to intervene to close the structure or the road to ensure public safety.

C.5.6.4 Assessment of the consequences of structure failure may also inform an assessment of the criticality of those structures to the wider network, as the local highway network tends to carry most of the infrastructure related to internet, power, water (including wastewater) and so on.

C.5.6.5 The risk assessment should be recorded in the Structure File and agreed by the Highway Structures Manager before the frequency of inspections is changed. The validity of the risk assessment should be re-confirmed and recorded by the Highway Structures Manager after each

Principal Inspection or when any other significant change in the condition of the structure becomes apparent.

C.5.6.6 It is important to ensure that significant risks are escalated appropriately to senior managers and are included in risk registers at a higher level. Having clear governance in place that ensures key risks are reported and understood upwards in an organisation is vital.

SCHEDULING INSPECTIONS

C.5.6.7 Inspection scheduling should seek to make the most efficient use of the resources available and minimise disturbance to the public, e.g. plan inspections to take advantage of traffic management planned for other reasons.

INSPECTION OF MECHANICAL AND ELECTRICAL EQUIPMENT (SEE ALSO PART E)

C.5.6.8 Mechanical and Electrical (M&E) equipment associated with highway structures includes, but is not limited to, lighting and ventilation in road tunnels, lighting in pedestrian underpasses and hydraulic rams on moveable bridges. The stewardship of this equipment may be the responsibility of the Highway Structures Manager. Part E of this guide provides additional guidance on tunnels.

C.5.6.9 Typically, where there is a crossover in asset responsibility it will be necessary to agree the extent to which each team will be responsible. Lighting in a pedestrian underpass, for example, may fall within the remit of the electrical team for electrical testing and replacement, but may be included in the structure's inspection only on a functional basis. As such, any outage should be raised with the electrical team as soon as practicable.

C.5.6.10 It is becoming more frequent for additional assets to be fixed to lighting columns, such as signs, CCTV equipment and the like. Whilst the management of lighting columns is set out in Part D, it is good practice to undertake an assessment of the lighting columns to ensure that any additional loading on the lighting column is acceptable. This role may differ between asset owners; however, it may be the responsibility of the Structures resource within an asset owner organisation.

C.5.6.11 An appropriate regime of inspection (and testing) of M&E equipment should be established. The inspection regime should be commensurate with the manufacturer's recommendations.

C.5.6.12 Useful guidance on the inspection and testing of M&E equipment associated with highway structures was provided in Series 7000 Mechanical and Electrical Installations in Road Tunnels, Moveable Bridges and Bridge Access Gantries MCHW prior to its withdrawal. Part E of this code provides a good template that could be adopted for best practice.

C.5.7 MONITORING

C.5.7.1 Monitoring is the periodic, or continuous, measurement of structural behaviour by visual / electronic means, or other means to record data on deterioration and performance, e.g. deflections, strains, and crack sizes. There are many instances where measurements can usefully be repeated periodically, or in rare circumstances taken continuously, so that condition and performance can be monitored over time.

NEED FOR MONITORING

C.5.7.2 Key reasons for undertaking monitoring include:

- during construction to check behaviour;
- after construction as an aid to the future maintenance management;
- where deterioration or damage has occurred and it is necessary to check for further loss of strength, condition, or performance;
- on structures that, when assessed to modern codes, have a load-carrying capacity that is below current standards but do not appear to be suffering distress; and
- to determine safety to remain in use.

SELECTION OF MONITORING TECHNIQUES/DESIGN OF MONITORING SYSTEMS

C.5.7.3 Monitoring covers a wide range of applications, from determining the ingress of chlorides into concrete over a period of years to the transient behaviour of a structure as a heavy vehicle passes over it. Typically, monitoring systems may be put in place to determine long-term movements, crack growth, changes in strain (either long-term or short-term) or the corrosivity of the environment.

C.5.7.4 The techniques used depend on the reasons for monitoring, which should be clearly defined at the outset. The aim should be to install the simplest monitoring system that meets the objectives, providing it is sufficiently robust for the specific location. The following issues should be considered when selecting a monitoring system.

EXTERNAL FACTORS

C.5.7.5 When devising a monitoring system consideration should be given to monitoring the external factors that may influence the property being measured. Temperature, for example, has a major influence on both structural behaviour and the various deterioration mechanisms that occur in highway structures.

DATA COLLECTION FREQUENCY

C.5.7.6 Where access is difficult or more frequent measurements are required, e.g. to monitor changes due to temperature, it may be necessary to install sensors that can be connected to a data logging system. This is particularly advantageous in cases were access causes traffic disruption. It is important to consider how the data will be collected, e.g., it could be downloaded locally by visiting the site, or remotely through various wired and wireless methods.

C.5.7.7 The interval between readings depends on what is being monitored and the rate at which it is likely to change, e.g., it might be appropriate to repeat certain types of measurement, such as the determination of chloride concentration, every time a Principal Inspection is carried out. Other types of measurement might need to be repeated more frequently, e.g. monitoring crack widths might require weekly or monthly measurements. Monitoring temperatures or strains might require measurements every hour and recording transient strains might require measurements to be taken several times a second.

C.5.7.8 Most monitoring systems can collect data at regular intervals for the period of the monitoring but in other cases data is collected only when an event triggers the monitoring system. An example is the detection of wire fractures in post-tensioned structures using acoustic monitoring. The structure is monitored continuously but data is recorded only after an acoustic event is detected that has the characteristics of a wire break. Another example is the measurement of stresses under traffic loading where the monitoring system is triggered by heavy vehicles and data is collected only during their passage over the structure.

C.5.7.9 Monitoring systems can also be designed to process data as it is being collected from the instrumentation. With this setup it can be designed to act as an early warning device, automatically issuing an alarm when pre-defined limits of the parameters are reached. This type of system can be used effectively as part of a risk management strategy.

C.5.7.10 CS 470 covers wider monitoring and management strategies, including trigger levels and subsequent actions. Monitoring methods are expected to evolve significantly, and it is important that asset owners understand how monitoring systems generate and analyse results. This is of particular importance with the rise in use of AI and 'black box' systems, where the methodology and parameters being measured may not always be obvious.

SCOUR

C.5.7.11 CS 469 outlines requirements for the assessment of scour and other hydraulic actions at highway structures crossing or adjacent to waterways. It provides processes to determine the level of risk associated with scour effects. It also includes processes to assess the robustness of structures in a flood, and references to measures for reducing risk.

C.5.7.12 Advice on the monitoring of highway structures for scour is given in the CIRIA report *C742: Manual on scour at bridges and other hydraulic structure*s.

C.5.7.13 Scour monitoring and inspection is not straightforward because scour is not normally visible during a flood and scour holes often fill in during the falling stages of a flood. As a result, it can be difficult to assess in flood conditions the magnitude of scour holes and determine whether the structure is safe. CIRIA provide additional guidance on this topic.

RETAINING WALLS

C.5.7.14 Monitoring the performance of retaining walls can be carried out by measuring movements directly, but sometimes it is more appropriate to use inclinometers, or electro-levels. Loads and moments in walls can be measured using pressure cells and strain gauges. Associated behaviour of the nearby ground can be monitored using inclinometers, pressure cells, and piezometers.

C.5.7.15 Installation and monitoring of these devices is a skilled operation, and recourse should be made to a specialist.

INSTALLATION

C.5.7.16 Key issues that need to be addressed when considering the installation of a monitoring system include:

- Environment of installation;
- Maintenance and power supply;

- Data logging capacity;
- Protection against vandalism;
- Access to replace sensors in harsh environments;
- Minimising damage to the structure by installation; and
- Decommissioning.

C.5.7.17 Details of the monitoring system should be included in the Structure File and Health and Safety File, if appropriate, so that others working on the structure are aware of its presence.

MONITORING OF SUB-STANDARD STRUCTURES

C.5.7.18 Advice on the monitoring of structures that fail a strength assessment is given in CS 470 Management of sub-standard structures. Monitoring interim measures can avoid the disruptive effect of applying load mitigation interim measures.

EVALUATION OF MONITORING RESULTS

C.5.7.19 Monitoring a highway structure should not be an end in itself but part of a wider strategy for management. Monitoring shall also include the establishment of critical trigger levels to highlight when and where remedial action is required. The remedial action (diversions, communications, load mitigation and so on) should also be included as part of a proactive monitoring strategy.

C.5.7.20 Monitoring may generate large volumes of data and consideration needs to be given at the outset to its storage, analysis, and eventual presentation, to support a focus on what is needed and avoid becoming immersed in data.

RECORDING AND REPORTING OF MONITORING RESULTS

C.5.7.21 A detailed record should be kept of the monitoring system. The record should include objectives of the monitoring, the equipment used, the location and position of sensors and data logging system (where appropriate), procedures for maintaining the system and collection of data, where the data is stored and how it is analysed.

C.5.7.22 Where necessary, sensors should be calibrated before use and the calibration records maintained in the Structure File for future reference.

C.5.7.23 Action plans shall be developed as part of a proactive management approach to highlight the required interventions when trigger levels are breached.

C.5.8 ASSESSMENT OF STRUCTURES

C.5.8.1 The purpose of the assessment of a highway structure is to determine the ability or capacity of the structure to carry the loads which are imposed upon it, and which may reasonably be expected to be imposed upon it in the foreseeable future. The assessment provides valuable information for managing the safety and serviceability of highway structures.

C.5.8.2 A regime of structural reviews should be implemented whereby the adequacy of structures to carry the specified loads is ascertained when there are significant changes to the usage, loading,

condition, or the assessment standards. A structural review should identify structures which need a detailed assessment.

C.5.8.3 A prioritised programme of structural review should be put in place to establish the need to assess, or update the assessment of, all structures which have not been designed or previously assessed to current standards. Where a requirement for assessment is identified, such assessments should be carried out in accordance with national standards which are current at the time.

C.5.8.4 The results of assessments and structural reviews should be recorded, together with relevant data and assumptions, and kept up-to-date and utilised in the planning and management of future maintenance programmes on the structures.

STRUCTURAL REVIEW

C.5.8.5 A review of an individual structure or group of structures, within the structures stock, to establish or confirm the validity of its latest assessment (or its original design if there has been no subsequent assessment) is termed a 'structural review.' A structural review should consider all available current information, taking account of the known condition of the relevant structures, their inherent strengths and weaknesses and anticipated effects of any changes, including changes to assessment standards. A structural review should not normally require detailed analysis of particular structures.

C.5.8.6 Assessment and structural review are key elements of the management process for highway structures to check their safety and serviceability. All structures should therefore be assessed or reviewed against current national standards.

ASSESSMENTS

C.5.8.7 Since detailed assessments require considerable effort, an assessment should only be undertaken when a structural review has identified the need for assessment.

C.5.8.8 The assessment should take account of all available information about the structure including its service performance. In addition, an 'Inspection for Assessment' should be performed to establish the current condition of key structural elements as accurately as is practicable.

C.5.8.9 The scope of assessment and method of analysis used should be commensurate with the form of the structure, information available and the consequences of a potential shortfall in the assessed load bearing capacity. Assessment of simple structures not showing signs of distress, particularly if details of the hidden parts of the structure are unknown, may be based solely on inspection as permitted by current standards. This would include mass concrete or masonry retaining walls that did not show signs of bulging, cracking, deformation, tilting etc.

C.5.8.10 Assessment should generally be carried out initially using simple but conservative analytical methods. Where the adequacy of a structure cannot be confirmed, or falls short of requirements using simple methods, progressively more precise and advanced methods should be employed where it is judged that a desired increase in assessed load bearing capacity might reasonably be achieved.

C.5.9 STRUCTURAL REVIEW AND ASSESSMENT REGIME

C.5.9.1 CS 451 provides a system for Structural Review and Assessment of structures, which links the assessment and inspection processes.

C.5.9.2 The future management of highway structures should include a regime of ongoing structural reviews to ascertain their adequacy to support imposed loads. Such reviews should be undertaken at a frequency twice that of the Principal Inspection frequency (i.e. every 12 years for a PI interval of six years, every 16 years for a PI interval of eight years). A structural review should include the following information:

- Load capacity;
- The presence, or otherwise, of interim measures;
- The current condition of the structure;
- Accessibility of critical elements;
- The presence, or otherwise, of a monitoring regime;
- Any changes in condition since the assessment or design that are likely to detrimentally affect load capacity;
- Any increase in loading since the assessment or design;
- Any proposed increase in loading; and
- The route carried and obstacle crossed.

C.5.9.3 An annual programme of structural review should be put in place, which is guided by operational needs and the PI programme. Certain circumstances may mean some structures are a priority and would appear early in the programme of structural reviews. These include:

- Structures which have defects likely to affect their design or assessed capacity; and
- Structures which have, or are going to have, changes to their imposed loading.

C.5.10 ASSESSMENT PROCESS

INITIAL APPRAISAL

C.5.10.1 Most assessments require an initial appraisal to establish what level of assessment is required and whether any additional information in the form of further inspections or testing is needed. The form of this appraisal may vary but may include a Level 1 analysis.

C.5.10.2 When sufficient information has been obtained, the appropriate scope of the assessment should be formally agreed between the overseeing manager and the assessor and be subject to a Technical Approval process. The appropriate scope of assessment may range from a judgement based simply on the Inspection for Assessment for a small retaining wall, as allowed by CS 454 The Assessment of Highway Bridges and Structures, to a detailed structural analysis of all parts of a structure based on information from records, inspections, and investigations.

C.5.10.3 Structures that have not previously been assessed generally require an assessment of all load bearing elements. Assessments arising out of identified local damage and/or deterioration may

only require assessment of a limited number of elements that lead towards the design of a suitable repair. Depending on the circumstances, there may be variations in traffic loads that may need to be considered.

INSPECTION AND TESTING FOR ASSESSMENT

C.5.10.4 The report on the Inspection for Assessment should include the observations made and comment on the condition of the structure, giving the condition factors required by CS 454 The Assessment of Highway Bridges and Structures. If the condition has deteriorated since the previous inspection, a statement should be included on its importance and, if appropriate, how the deterioration should be taken into account in the assessment calculations. For example, a condition factor might be used, or the assessment might be based on a deteriorated (smaller) section of structural elements.

TECHNICAL APPROVAL

C.5.10.5 Technical Approval is the formal arrangement by which the Technical Approval Authority (TAA) agrees the basis on which a structural design or assessment is to be carried out. It confirms the scope and level of the assessment together with the standards to be used and the forms of analysis models that are to be used. Technical Approval extends to formal acknowledgement of completion by the acceptance of appropriate certification. Guidance on the Technical Approval process is given in CG300 Technical Approval of Highway Structures.

C.5.10.6 An appropriate system of Technical Approval should be established, and an appropriate organisation or individual should be formally appointed to act as the TAA.

C.5.10.7 The authority and the TAA should jointly maintain an up-to-date list of current design and assessment standards similar to those listed in Appendix H of CG300.

FORMAL ASSESSMENT ANALYSIS

C.5.10.8 The analysis of a structure to determine its load bearing capacity should employ an approach that is appropriate for the structural form and materials as recommended by national standards.

C.5.10.9 The three Levels of Assessment as defined in CS 470 The Management of Sub-standard Highway Structures should be considered and are summarised in the table below.

Table 37: Levels of Assessment

Requirement
Use of simple analysis methods and full partial safety factors from appropriate assessment standards to produce a conservative assessment.
Use of a more refined analysis model such as grillage or finite element models. Also allows the determination of actual characteristic strengths based on existing test data deemed to be relevant to the particular structure.
Allows the use of Bridge Specific Assessment Live Loading (BSALL). Also allows the use of characteristic strengths or worst credible strengths based on testing of samples of materials from the structure.

C.5.10.10 The level of analysis should be appropriate to the circumstances. Where initial assessment does not provide the required confidence in the structure, progressively more advanced methods should be employed, taking into account the cost of more advanced analysis and the benefits that might reasonably be gained.

C.5.10.11 Level 1 may be used for initial assessments, leading to subsequent Level 2 or 3 assessments. Level 1 should only be relied upon as a definitive assessment if it clearly demonstrates the required load bearing capacity of the structure.

C.5.10.12 Levels 2 or 3 generally provide the degree of confidence required to establish the load bearing capacities of most structures. The additional testing associated with Level 3 should be dependent on whether or not such evidence might reasonably increase the assessed load bearing capacity to a level which is considered appropriate or desirable for the particular structure.

C.5.10.13 Where practicable, assessment should include an estimate of any reserve load bearing capacity of the structure. Where there is likely to be ongoing deterioration of a structure, assessment should include the determination of critical condition factors.

C.5.10.14 Where the assessment indicates that a structure is substandard in relation to the requirements of current standards, remedial options should be considered, appraised and a final action recommended. Interim measures (including those necessary to protect the structure and the public) to be taken prior to the implementation of the recommended remedial action, including restriction of use or monitoring if appropriate, should be recommended. All decisions taken need to be appropriately documented.

C.5.11 ASSESSMENTS FOR ABNORMAL LOADS

C.5.11.1 The principles of managing abnormal loads are dealt with in Section A.4 of this Code. This section contains information specifically related to structural assessments.

C.5.11.2 Assessment for the effects of abnormal loads on bridges and other highway structures should be carried out in accordance with CS 458. This standard is based upon a series of “SV” loading models which more closely model the behaviour of real heavy vehicles than the old HB model and defines how a Reserve Factor should be calculated for each acceptable vehicle.

C.5.11.3 CS 458 also provides guidance for converting existing HB ratings to equivalent SV ratings to aid correlation of such ratings with the effects of real vehicles. However, this is necessarily conservative and reassessment to CS 458 should be considered for critical bridges.

C.5.11.4 For Special Order movements (greater than 150 tonne) and, in some special cases, for General Order movements, detailed assessments may be required for particular structures where no alternative route is readily available.

C.5.11.5 In such cases, for bridges, consideration may be given to limiting Dynamic Amplification Factors and the effects of normal traffic, which might be on a bridge at the same time as the abnormal load. Guidance for such assessments is provided in Annex D of CS 458.

C.5.11.6 Where an initial assessment shows that the load effects induced by an abnormal load marginally exceed the capacity of a bridge on the route, an authority may consider allowing the abnormal load to cross the structure provided the speed of the vehicle is restricted and other normal traffic is kept clear of the bridge. Note that this may only be achievable in exceptional circumstances

and may need a police escort (or Traffic Officers on the National Highways network) to ensure compliance with any such restrictions. As such, this may not be practical in most cases. Checks for such situations can be made in accordance with the procedures given in Appendix B of CS 458.

C.5.11.7 An engineer with good experience of Highway Structure Assessments shall undertake the role of Structures Advisor, to whom the Abnormal Loads Officer should refer decisions relating to vehicle movements which fall outside the agreed guidelines which otherwise determine whether particular vehicle movements should be accepted.

C.5.12 RECORDING OF ASSESSMENT RESULTS

ASSESSMENT REPORT

C.5.12.1 Structural assessment results should be fully detailed in a formal report which should consider providing the following information:

- the name, location, and any formal identification number of the structure;
- for bridges, details of obstacles crossed and roads carried;
- the date and reason for the assessment;
- an overview of the method of analysis including a description and diagram of any computer model used;
- any appropriate geological assumptions and parameters;
- loading details;
- level of assessment;
- overall assessed load bearing capacity;
- identification of any critical elements of the structure;
- all condition factors used and if relevant, the pavement condition or other variable factors which formed part of the assessment;
- recommendations in respect of any elements having an assessed load bearing capacity below that required or considered desirable;
- guidance on timescale for which the assessment results are expected to be valid and the date or specific circumstances for undertaking a subsequent structural review; and
- they signed AIP and accepted certification should be included in an appendix together with the assessment calculations or reference to other documents containing the calculations.

BASIC RECORDS FOR THE BRIDGE MANAGEMENT SYSTEM

C.5.12.2 The basic results of an assessment should be recorded in a standard format common to all of the structures for which the authority is responsible. Ideally the record would take the form of an electronic database.

C.5.12.3 The level of detail transcribed from the assessment report into the database should be defined by the Bridge Management System adopted by the authority. This could include basic details of each

structure including location, form of structure, details of road(s) carried, span arrangements, and designed or assessed load bearing capacity.

C.5.12.4 Where the results of the assessment are dependent on variable factors such as pavement condition, as allowed by CS 454, there should be clear feedback to the highway authority to ensure that the ongoing requirements form part of the planning process for periodic maintenance. In such cases, committing to a protocol that ensures good stewardship of the surface quality can lead to the benefit of an increased load bearing capacity rating for the bridge. However, poor condition should generally be assumed if that commitment cannot be assured.

C.5.12.5 Information on reserves in load bearing capacity with respect to both normal and abnormal traffic loading, where available, and critical condition factors for elements susceptible to deterioration should be used in the planning and management of future maintenance programmes on structures.

ADDITIONAL RECORDS FOR CRITICAL STRUCTURES

C.5.12.6 A structure that has a load bearing capacity below those of others on a particular section of road is termed a 'critical structure.' This is a technical term unrelated to the *HIAMG* definition of 'critical infrastructure.' If the load bearing capacity of a critical structure is below that required for unrestricted normal traffic (typically the 40-tonne Assessment Loading defined in CS 454), it will effectively restrict the whole section of the road to this weight limit. Alternatively, a structure may be critical with respect to the movement of abnormal loads. In either case, it is useful to record additional information from the assessment to aid consideration of what vehicles should or should not be allowed to use the road.

C.5.12.7 The additional information recorded for critical structures (particularly bridges) could include:

- details and load bearing capacities of all potentially critical elements with live load capacities up to 15% higher than the governing element/capacity;
- load ratings in terms of HB units and all relevant Reserve Factors against SV vehicles as defined in CS 458 The Assessment of Highway Bridges for the Effects of Special Types General Order (STGO) and Special Order (SO) Vehicles;
- if practicable, lane influence lines for critical effects together with the associated limiting load bearing capacities; and
- for arches, details of the bogie configurations considered and their associated maximum axle loads.

C.5.13 INTERIM MEASURES AND MANAGEMENT OF SUBSTANDARD STRUCTURES

C.5.13.1 A structure which does not meet the carriageway loading requirements given in CS 454 (or by other means) is termed a 'substandard structure'. The assessment of a substandard structure should identify the appropriate remedial action required to maintain its safety.

C.5.13.2 Prior to strengthening or replacement, all substandard structures should be considered as representing a risk to the public. Where such works must be deferred, detailed risk assessments should be undertaken and where appropriate interim measures should be implemented as soon as possible.

C.5.13.3 If there is deemed to be an immediate and unacceptable risk to public safety, CS 454 and CS 470 require that formal interim measures which would effectively mitigate the risk, be put in place until the identified remedial action is implemented. These measures may include:

- weight or width restrictions plus monitoring;
- propping or temporary bridge plus monitoring;
- closure and diversion of traffic; and
- lane restrictions.

C.5.13.4 In particular CS 470 provides guidance on the use of weight restrictions and/or the application of monitoring to appropriate structures and provides a Technical Approval framework for agreeing such measures.

C.5.13.5 CS 470 indicates that structures that satisfy all the criteria in points one, two and three below and additionally small span bridges as described in four, may be considered to be appropriate for monitoring subject to Technical Approval.

1. Structures with no significant signs of distress, or structures where distress is observed which does not appear to be recent or significant and detrimental to the safety of the structure.
2. Structures where failure is likely to be gradual over time, progressing from local signs of distress to more extensive failure before reaching the point where total collapse is precipitated. It must also be possible to predict the mode(s) of failure under traffic load with reasonable certainty.
3. Structures and situations where monitoring would be meaningful and effective.
4. Bridges of spans less than five metres where the consequences of failure are low.

SECTION C.6 RESILIENCE AND ADAPTATION – STRUCTURES

C.6.1 INTRODUCTION

C.6.1.1 The definitions and overall principles for resilience of highway infrastructure are dealt with in Part A of this Code. This section contains information on resilience and adaptation, specifically related to structures.

C.6.2 HOW RESILIENCE SUPPORTS THE CODE'S OBJECTIVES

OBJECTIVES

C.6.2.1 Resilient highways structures contribute significantly to each of the core objectives set out in this Code as described below:

SAFETY

C.6.2.2 Safety remains a key consideration across the UK, though statutory obligations and user needs differ between regions. Strengthening the resilience of highway structures helps reduce the likelihood of hazards, threats, and other risks significantly impacting them and ensures that assets remain safe, reliable, and fit for purpose for all users.

CUSTOMER

C.6.2.3 Demonstrating that structures are reliable and well-maintained improves confidence by ensuring the network remains open, predictable, and resilient. Durability of highway structures supports the continuity of movement by reducing delays and disruption and minimising unexpected closures to keep journeys dependable for all users.

SERVICEABILITY

C.6.2.4 Maintaining the availability, reliability and performance of highway structures is a key objective and one where user judgements of performance will be immediate rather than longer term.

SUSTAINABILITY

C.6.2.5 Resilience measures support the long-term sustainability of structures by reducing the environmental and financial impacts of frequent repairs, replacements, and interventions. Durable design and effective asset management help minimise whole-life material use, waste, and carbon. Intense and/or severe weather effects can affect structures and accelerate deterioration, increasing the need for unplanned interventions and reducing long-term sustainability of the network.

C.6.3 STRUCTURES SPECIFIC HAZARDS

C.6.3.1 There are a large number of risks that can affect structures, with the information below providing indicative, illustrative examples of some of the risks that may arise with possible mitigation measures.

C.6.3.2 The examples below are not exhaustive and should not be interpreted as prescriptive or mandatory actions. In practice, local highway authorities may determine their own appropriate mitigations subject to funding levels.

C.6.3.3 The table below provides brief, indicative examples of hazards, risks, and mitigations.

Table 38: Hazards, Risks and Mitigations

Hazards	Risks	Mitigations
Weather and Climate	Disruption or deterioration caused by severe weather	Planned diversion routes; climate-resilient design
Flooding and Water-Related	Collapse due to scour	Flood management measures; protections against water-related erosion
Ground Instability and Geotechnical	Ground movement and slope instability affecting structures	Monitoring of ground conditions
Environmental and Ecological	Accelerated deterioration from environmental exposure	Protective treatments
Asset/ Infrastructure Failure	Reduced performance or safety	Inspection, assessment, and intervention
Operational and Transport-Related Incidents	Structure closure, weight/width restrictions	Updated assessments, renewals, and resilience measures
Human and Social Disruption	Suicide, Protest	Deterrent measures; monitoring and incident planning
Security and Malicious Attack	Targeted iconic or strategic bridges attacks	Security measures; robust surveillance

WEATHER AND CLIMATE

C.6.3.4 Weather and climate conditions can create operational and structural challenges for bridges and other highway structures. High winds may lead to temporary closures, particularly on exposed viaducts or structures with significant deck area, resulting in network disruption. Intense or severe climate events can also accelerate the deterioration of structural components, reduce long-term performance, and increase maintenance demands.

C.6.3.5 Authorities should consider appropriate mitigation measures to manage the impacts of weather and climate risks. Examples may include implementing diversion routes for high-wind scenarios and ensuring structures are designed or managed with appropriate climate-resilience measures. These may include aerodynamic considerations, strengthened components, or adaptation strategies aligned with expected future climatic conditions.

C.6.3.6 Authorities may refer to CIHT's Delivering a Resilient Transport Network report for additional guidance on managing weather and climate impacts, including flooding and water-related hazards affecting structures.

FLOODING AND WATER-RELATED

C.6.3.7 Flooding and water-related hazards present a high risk to structures, particularly where rising water levels or fast flows may undercut foundations, reduce the effectiveness of support systems or force closures of structures. Scour is one of the most common and severe water-related hazards affecting highways structures.

C.6.3.8 Authorities should consider appropriate mitigation measures to manage the impacts of flooding and water related hazards. Examples may include improving drainage, managing water conveyance, and enhancing resilience at vulnerable locations. Scour protection measures, including pier protection or monitoring at critical points, help maintain structural stability during flood events.

C.6.3.9 Authorities may refer to CS 469 - Management of scour and other hydraulic actions at highway structures for additional guidance on the management of scour. This guidance document details a methodology to identify scour-susceptible structures and includes a prioritisation method to aid asset owners in focussing on the highest risk structures.

C.6.3.10 The methodology contained within the standard is particularly detailed, with Level 2 assessments requiring a high level of detail in order to assess the scour risk. Where undertaken, Level 1 assessments will enable asset owners to determine their Medium and High-risk structures in relation to scour susceptibility.

C.6.3.11 Scour risk mitigation may also require asset owners to identify measures upstream of the structure to minimise the impact of rising water levels and severe flooding. Debris accumulation has a significant impact on scour susceptibility, and it may be appropriate to take measures to minimise the likelihood of debris accumulation at the structure and implement prompt removal if it occurs.

GROUND INSTABILITY AND GEOTECHNICAL

C.6.3.12 Ground instability can affect the long-term performance of structures, with movement, deformation, or settlement reducing stability. Instability of slopes or embankments can introduce additional pressures or cause debris to impact structural elements. A sudden change in the carriageway level will also increase damage at deck ends and expansion joints, as well as creating a hazard for road users.

C.6.3.13 Authorities should consider appropriate mitigation measures to manage the impacts of ground instability and geotechnical hazards. Examples may include ground condition monitoring, the use of stabilisation or remedial works where required, and proactive slope management. These measures ensure that risks associated with changing ground behaviour are identified early and addressed before they influence structural integrity. Whilst these risks and mitigations have an impact on highway structures, they are likely to be managed by geotechnical experts, whilst requiring close collaboration between the structures and geotechnical roles.

ENVIRONMENTAL AND ECOLOGICAL

C.6.3.14 Environmental exposure can lead to accelerated corrosion or reduced durability of structural materials. Factors such as de-icing salts, marine environments, or other ecological conditions may speed up deterioration of key components, affecting long-term serviceability.

C.6.3.15 Authorities should consider appropriate mitigation measures to manage the impacts of environmental and ecological hazards. Examples include protective materials and targeted inspections to support the early detection and management of environmentally driven deterioration. These interventions help maintain asset condition and ensure resilience against long-term environmental pressures.

ASSET/ INFRASTRUCTURE FAILURE

C.6.3.16 Structures may experience reduced performance or safety where ageing, material degradation, or underlying defects exist. Substandard structures, assets with known weaknesses, or those with uncertain construction records can present a higher risk of failure over time. Conflicts with utilities or unclear ownership of third-party structures can further complicate maintenance or condition management.

C.6.3.17 Authorities should consider appropriate mitigation measures to manage the impacts of asset and infrastructure failure. Examples include regular inspection, structural assessment, and timely intervention. Where required, authorities may implement load restrictions or plan strengthening and renewal activities. Early coordination with utilities and clear responsibility arrangements for third-party assets support more efficient and reliable asset management.

OPERATIONAL AND TRANSPORT-RELATED INCIDENTS (SEE ALSO PART E)

C.6.3.18 Operational risks such as cyber-attacks, obsolescence of mechanical and electrical components, increased vehicle loading - particularly from EVs - and fire risks in tunnels or fires under/adjacent to structures can all affect network reliability and structural performance. In certain circumstances, emergency/temporary bridging may be required to maintain connectivity following unexpected asset issues.

C.6.3.19 Authorities should consider appropriate mitigation measures to manage the impacts of operational and transport related incidents. Examples may include cyber-security controls, planned renewals to address obsolescence, updated assessments to manage increased vehicle loads, and appropriate fire-resistant design measures. Where necessary, access to pre-identified temporary bridging options would support rapid response and continuity of service.

C.6.3.20 Temporary bridging options offer a good solution to ensure continuity of service and network connectivity is maintained. As with permanent structures, temporary bridges are subject to TAA processes and requirements, and so will need careful consideration before deployment. It should be noted that whilst called temporary bridges, they may be in place for many years whilst a permanent replacement is designed and constructed.

C.6.3.21 It is proposed to develop national lists of temporary bridges to assist in responding to emergency situations and bridge collapse. At the time of writing, the proposal is being developed, with implementation to be determined.

HUMAN AND SOCIAL DISRUPTION

C.6.3.22 Human and social behaviours can pose significant risks to highway structures, particularly bridges where individuals may attempt to gain access to parapets or areas not intended for public use. Incidents involving attempted suicide, climbing, or other unsafe behaviours can create serious safety concerns both for the individuals involved and for road users below. Such events may also lead to emergency closures, cause significant disruption, and place additional pressures on

operational teams. Protest activity, unauthorised access to structural components, or gatherings on bridges can similarly create hazards and impede the safe functioning of the network.

C.6.3.23 Authorities should consider appropriate mitigation measures to manage the impacts of human and social disruption. Clear operational procedures based on interoperability principles and liaison with emergency services help reduce the impact of incidents. Together, these measures improve safety for users and create a more resilient, well-managed environment around structures where human-related risks may be present.

C.6.3.24 Authorities may refer to the UKRLG Roads and Bridges Suicide Prevention Guidance (2025) for further detail on appropriate mitigation measures to reduce the risk of suicide on highway structures.

SECURITY AND MALICIOUS ATTACK

C.6.3.25 Security and malicious attacks present a risk to highway structures. Acts such as deliberate damage, tampering, or unauthorised access can weaken key components, compromise structural integrity, and create hazards for road users. Incidents of vandalism, attempts to interfere with bearings or expansion joints, removal of fixings, or damage to parapets can reduce the safety margins of structures and increase maintenance demands. Iconic or strategically important bridges may be at increased risk of intentional harm, requiring additional consideration.

C.6.3.26 Authorities should consider appropriate mitigation measures to manage the impacts of security and malicious attacks. Examples include physical protection of vulnerable components, locking or securing access points, and ensuring that critical structural areas such as abutments, chambers, and service ducts are protected from unauthorised entry. Installing CCTV or monitoring systems at high-risk or high-value structures can deter malicious behaviour and support incident response. Measures such as protective barriers, tamper-resistant fixings, and impact-protection solutions further help safeguard structures, maintain asset reliability, and support a safe and resilient network. There should also be general and, if necessary, specific contingency plans for the total loss/destruction of iconic, critical, or lifeline structures.

NON-STRUCTURES ASSETS

C.6.3.27 Authorities are likely to have assets such as fords or causeways in their portfolio and often have a vital role in providing access to remote locations. The effects of climate change on these assets could be severe, as the increase in rainfall and water levels leave these assets submerged for a longer period of time. Highway Structure Managers should consider mitigations to ensure that these assets can continue to function in future.

C.6.3.28 The flooding of these assets may also present a safety risk, and authorities should consider the need for monitoring the assets, supported with signing and communication methods for network users if an alternate route or travel arrangements should be used.

THIRD-PARTY STRUCTURES

C.6.3.29 Vaults, cellars, and undercrofts present a unique risk to the highway, often being out of the control of the asset owner. It is vital for asset owners to understand where there may be third-party assets that could have a direct impact on the integrity of the highway, or highway structures. Where ownership can be determined, it is important to inform the owner of such structures of their obligations and potential impact on the highway.

SECTION C.7 FINANCE AND INVESTMENT – STRUCTURES

C.7.1 INTRODUCTION

C.7.1.1 The general principles to be applied to programming and priorities are outlined in Section A.7 of this Code, with this section covering guidance relating to structures.

C.7.1.2 This section covers both information on the mechanism for structures teams in authorities to obtain funding, and the processes used to programme and prioritise the spend of this funding into forward programmes.

C.7.1.3 Securing a special or additional budget typically requires a business case, which can be supported by strong asset knowledge in line with Section C.5 that clearly outlines the need for budget and the impact this will have on the structure(s) and wider network. Being able to efficiently spend budget each year when allocated will also support an authority in demonstrating they can successfully deliver additional budget in a given period.

C.7.1.4 Highway structures are exposed to a wide range of naturally occurring and man-made factors that lead to, or directly cause, deterioration. In addition, the highway network is a dynamic system with changing user demands, some of which may be reflected in changes to codes and standards. The purpose of maintenance is to repair damage caused by deterioration, vehicle impact, or vandalism, slow down or prevent the deterioration process, meet the changing demands of users, where appropriate, and maximise safe service life.

C.7.1.5 The purpose of maintenance planning and management is to enable the Highway Structures Manager to develop and implement cost effective and sustainable maintenance plans for highway structures that support the safe operation of the network while delivering the required asset performance and levels of service. The maintenance planning and management process enables the Highway Structures Manager to deliver the authority's long-term goals and objectives by developing maintenance plans that align with and provide detail to the work volumes and phasing identified in the Asset Management Framework.

C.7.1.6 There are a variety of available tools that can facilitate planning, such as Structures Asset Valuation and Investment (SAVI) toolkit which is focused primarily on bridges. SAVI also includes functionality to allow asset owners to determine the overall valuation of their structure stock.

C.7.1.7 Maintenance planning should adequately support the safe operation of highway structures. Performance levels should be identified at which a structure or component is considered to be sub-standard and which, if left unmanaged, may result in the structure becoming unsafe. Identifying minimum safety and performance levels assists the prioritisation of needs and development of maintenance plans.

C.7.1.8 Different investment strategies may also drive the performance levels at which work is triggered on a structure. A 'Do minimum' approach would be driven by a lower condition intervention level than a 'Planned Preventative' approach, for example.

C.7.1.9 Authorities should be suitably prepared for urgent safety and stability concerns and emergencies and deal with them effectively when they occur. An emergency response procedure should be developed for this purpose and documented, and an associated emergency budget determined.

C.7.2 LIFECYCLE PLANS

C.7.2.1 Lifecycle plans should be used to identify needs on specific structures and elements. The cyclic/intervention rules established in the lifecycle plans are compared against the current condition and performance of a structure/element and the specific characteristics of the structure are assessed to determine if the lifecycle plan activity is appropriate, i.e. the lifecycle plans should be used as general guidance when identifying specific maintenance needs.

C.7.2.2 Where appropriate, lifecycle plans should be amended through the maintenance planning process because the bridge engineer is undertaking a more detailed review of needs compared to asset management planning. Such amendments should then be passed back to asset management planning to improve long term work predictions.

C.7.2.3 A lifecycle plan should be developed for each structure group/sub-group. Refinement of the groups and sub-groups may prove beneficial as it allows greater management planning control through more targeted lifecycle plans, but more knowledge of deterioration rates and mechanisms is required.

C.7.2.4 Lifecycle plans should be developed using whole life costing to establish the most cost-effective approach to structures management. Whole life costs should not be the sole consideration and other issues such as asset performance, carbon and network safety should also be considered where relevant.

C.7.2.5 A number of useful resources have been developed to support lifecycle planning. *A Good Practice Guide on Lifecycle Planning for Highway Structures* has been published by the London Bridges Engineering Group (LoBEG). This is a useful reference document providing a step-by-step approach on structure specific lifecycle planning and whole life costing. The Good Practice Guide is accompanied by a computerised Lifecycle Planning Model and associated User Guide.

C.7.2.6 Structures Asset Valuation and Investment Tool (SAVI) was developed by the Highways Asset Management Finance Information Group (HAMFIG), with ownership taken by the UK Bridges Board. SAVI is a multi-functional, condition-based tool that supports the valuation of highway structure assets, the development of prioritised maintenance and investment programmes, and the assessment of future funding requirements. The tool can be used to support lifecycle planning, investment decision-making, and long-term management of highway structures.

C.7.2.7 In Scotland and Wales, guidance and lifecycle planning tools are available to members of the SCOTS/CSSW Roads Asset Management Project group via the RAM Knowledge Hub. Cost projection tools are available for structures and other asset types.

ROUTINE MAINTENANCE REGIME

C.7.2.8 Typical routine maintenance tasks include removing graffiti, removing vegetation, clearing debris and bird droppings from components, clearing drainage systems, repairing gap sealant, cleaning sliding and roller surfaces of bearings and re-greasing, checking and, if necessary, tightening fixings on deck movement joints and removing debris and silt from culverts. These requirements are often formalised into maintenance contracts or guidance specifications, depending on the client type.

C.7.2.9 It is widely accepted that, whilst many of these tasks are minor in themselves, failure to carry them out may lead to deterioration of the structure and the need for more costly repair operations

in the future. In general, a routine maintenance regime is cost effective in whole life terms and a 'little and often' approach is often more cost effective when compared with the cost and disruption resulting from deferred maintenance. Life Cycle Planning provides a useful way of quantifying the benefits of early intervention compared with the disbenefits of deferred maintenance.

C.7.2.10 Authorities are recommended to establish an appropriate routine maintenance regime for highway structures. In doing so particular consideration should be given to the following points:

- Removal of graffiti: whilst the removal of all graffiti is commendable in improving the local environment, it can be an expensive operation if the graffiti is persistent. Some authorities have therefore decided only to remove racist or obscene graffiti (generally as soon as it is reported), unless there is little likelihood of more appearing in the medium term or there is an area-wide clean-up campaign organised by the local council or community body with the intention of keeping the area clean. Some urban authorities remove all graffiti to meet council objectives and tourist expectations; they accept this is a significant and essential expense;
- Repair of gap sealant: sealant has often been specified by designers for gaps/joints where it is not essential and as a result some authorities have decided only to repair sealant where it is required. Examples include open joints that are visually unacceptable (but are not prone to vandalism) or where replacement will help prevent ingress of water which could lead to frost damage, corrosion of metalwork or reinforcement or unacceptable staining;
- Removal of trapped debris in front of piers and abutments following river spates;
- Clearing drainage and removal of vegetation: this can prevent the build-up of water that can accelerate the deterioration of elements such as bearings and metallic components on the structure; and
- Work to bearings and removal of bird guano: cleaning bearing shelves and greasing bearings/moving parts allows bearings to move as designed and therefore reduce the stresses that can be placed on a structure. The removal of bird guano also contributes to increasing the longevity of assets, as this can cause significant damage and contribute to corrosion.

Routine maintenance activities also provide an opportunity to report and record other items, such as missing bolts in VRS or parapets, or damage to expansion joints.

STRUCTURES WORKBANK

C.7.2.11 The structures workbank is a database of all work that is currently outstanding on the network, including estimated costs for doing the work. It is recognised that certain work types by their very nature cannot be planned in detail in advance, such as for reactive maintenance, but the workbank should still reserve a volume of work for these, albeit unknown, structures based on experience and engineering judgement. A workbank format should be established that is appropriate to local, and if appropriate, national needs. The timescale for the workbank should comply with the authority's corporate planning timeframe and requirements.

C.7.2.12 The figure below highlights three possible approaches.

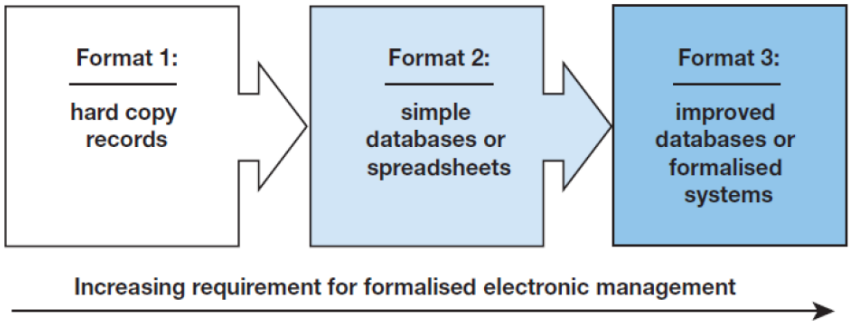


Figure 13 – Possible formats for the structures work bank.

C.7.2.13 The workbank should include a full list of all maintenance required on the structures stock. The workbank should provide the following information for each item of work and be contained within a bridge management system (BMS):

- name and identifier (structure key) of the structure;
- element where work is required;
- defect, including severity and extent (if appropriate);
- required work;
- work type;
- recommendation for when the work should be undertaken, i.e. which year;
- estimated cost;
- consequence of the work not being undertaken in the recommended timeframe.

C.7.2.14 The full list of information is taken forward to the Value Management and Value Engineering phases. Once work has been undertaken it should be identified as completed and removed from the workbank.

C.7.3 VALUE MANAGEMENT

C.7.3.1 Value Management as outlined in Section A.7 is used to prioritise the needs listed in the structures workbank. All work recorded in the workbank is subject to Value Management; however, for minor or routine activities this will be an extremely simple, light-touch process. More complex or higher-value schemes will follow the full Value Management process, including planning and, where appropriate, value engineering, as well as scheduling and delivery.

C.7.3.2 The workbank captures all required work and should be managed within the BMS. The BMS should have the capability to group related activities and adjust maintenance tasks to improve efficiency. As a result, every activity within the workbank should be managed appropriately in line with the level of Value Management required.

C.7.3.3 Value Management should be used because it provides a formalised approach for assessing the benefits of undertaking maintenance and the associated risks of not undertaking maintenance. The risks and benefits should cover hard issues, e.g. condition and assessed capacity, which can

be assessed objectively and soft issues such as local importance, customer feedback and synergies with other work that may need to be assessed subjectively.

C.7.3.4 The outcome of the Value Management process should be a prioritised list of actions in the structures workbank that is taken forward to the Value Engineering process. It should also identify where there will need to be an option appraisal in the Value Engineering process.

C.7.3.5 Value Management should not be a complex and overly involved process. It should cover the appropriate criteria in a manner that enables engineers readily to compare and identify a priority score.

C.7.3.6 The full Value Management process is only appropriate for major schemes. A simplified process should be used to deal with common types of moderate and minor maintenance.

VALUE MANAGEMENT REGIME

C.7.3.7 A Value Management regime should be established that identifies the frequency of review and the approach to be taken. The regime should identify:

- **Value Management frequency** – some activities may be performed on a continuous basis, e.g. automated prioritisation of needs based on objective criteria. Other, more subjective criteria, e.g. local importance, are best analysed at regular intervals when one or more appropriate staff can review the latest needs. Value Management reviews or workshops held at least once every year, but preferably every six months, are likely to be appropriate for most authorities;
- **Prioritisation criteria** – the criteria considered during the Value Management process to prioritise needs. They may be objective or subjective in nature; and
- **Value Management review/workshops** – the staff to be involved in the Value Management review or workshop and the format this activity should take.

C.7.3.8 The Value Management regime should be appropriate to the size and characteristics of the highway structures stock.

PRIORITISATION CRITERIA

C.7.3.9 The Value Management process should be developed by suitably qualified and experienced staff who have a sound understanding of maintenance requirements and an awareness of longer-term goals and objectives, as identified in the Asset Management Framework. The process should be transparent, encompassing the important prioritisation criteria, but it should also be flexible enough to assess a wide range of work and structure types. The sensitivity of the process to each prioritisation criterion should be fully trialled and the output assessed, possibly against predefined expectations. Prioritisation should also reflect network performance aspirations identified through any traffic and transportation manager appraisal processes.

C.7.3.10 The Value Management process should include a range of prioritisation criteria that are appropriate to the characteristics of the highway structures stock and network. As a minimum, prioritisation criteria should be considered that relate to the following three categories:

- **Safety and functionality** – criteria in this category should seek to use information from the asset inventory and database to rank the importance of the need. Examples of criteria that

could be considered are structure type, structure location, route carried, obstacle crossed, element condition, assessed capacity, height restriction, and traffic flow restrictions. The criteria considered should influence the prioritisation score in an appropriate manner, e.g. as condition deteriorates the prioritisation score increases, as route classification increases the prioritisation score increases;

- **Benefits and dis-benefits** – criteria in this category should seek to quantify in a simplified manner, the benefits and dis-benefits produced by addressing and not addressing a need. It may be more appropriate to use engineering judgement rather than an automated procedure. If the former approach is used it should be guided by a simple classification procedure, e.g. High, Medium, or Low benefit/dis-benefit. Examples of benefits/dis-benefits that should be considered include lower or higher whole life costs, reduced or increased journey times, minimisation of network disruption, and integrating work items to achieve cost savings. Life cycle planning can assist in quantifying those aspects; and
- **Socio-economic and environmental** – criteria in this category should cover the softer issues that cannot be readily quantified by an automated prioritisation process, e.g. local policies, user/customer perception, impact on local communities and businesses, environmental impact, and sustainability considerations. A formalised approach should be developed that allows the reviewer, or workshop attendees, to quantify criteria easily, e.g. High, Medium, or Low impact.

C.7.3.11 Many of the above criteria can be assessed through a formalised risk analysis and risk assessment approach.

C.7.3.12 During the development of the Value Management process, careful consideration should be given to the weighting of each criterion. While it is recognised that safety will be a motivating factor other issues should be addressed to ensure a balanced work programme, e.g. priorities of the Asset Management Framework. Weighting decisions should also take account of network performance aspirations identified through traffic and transportation manager appraisal processes. Otherwise, the process may focus solely on more apparent maintenance needs and fail to address preventative maintenance requirements. The system should also provide robust and justifiable prioritisation scores.

C.7.3.13 The level of refinement depends upon the complexity of the network and the number of issues that must be accounted for. The adopted system should allow for future development and have the ability to cope with increasingly complex situations.

VALUE MANAGEMENT REVIEW/WORKSHOP

C.7.3.14 The prioritisation criteria should be challenged in a formal Value Management review or workshop. In the context of this Code, a review is performed by one person, preferably the Highway Structures Manager, and a workshop is attended by more than one appropriately qualified and experienced person.

C.7.3.15 The review/workshop should assess each need in turn and give it a final prioritised score. The starting point for the review/workshop may be:

- **Un-prioritised workbank** – in this case the review/workshop should address all the prioritisation criteria. It is advisable to use a small number of important criteria to avoid the review becoming overly complex; and

- **Semi-prioritised workbank** – in this case an automated prioritisation would have already been performed based on the asset inventory and database information (primarily using the safety and functionality criteria). The review or workshop should therefore concentrate on the softer prioritisation issues that may not be appropriate for automation, e.g. socio-economic and environmental.

C.7.3.16 The cost estimates for the prioritised needs are compared against the 1-to-3-year funding plan. Starting at the top of the prioritised list, i.e. taking the most critical need first, the cost estimates are added together until they equal the 1-to-3-year budget.

C.7.4 VALUE ENGINEERING

C.7.4.1 Value Engineering is the process of developing an optimal solution to a maintenance need and reducing waste and inefficient aspects of design, construction, and maintenance [Achieving Excellence in Construction]. Value Engineering takes the prioritised needs from the Value Management exercise and creates cost effective schemes that can be planned, scheduled, and implemented.

C.7.4.2 An additional benefit associated with Value Engineering is that it affords an opportunity to reduce carbon impacts through consideration of different options and solutions. This may include looking at carbon emissions related to diversion routes and traffic delay, locality of construction materials as well as materials and quantities themselves.

C.7.4.3 The two key components of Value Engineering are option appraisal and scheme development. Important criteria that feed into these components include maintenance options and standards, Whole Life Costing, and synergies with other schemes. Option appraisal, scheme development, and Whole Life Costing are described below.

C.7.4.4 The full Value Engineering process is only appropriate for major schemes, but a simplified process should be used to deal with moderate and minor works, where minor works should be grouped into those of a similar type to streamline the process.

OPTION APPRAISAL

C.7.4.5 Option appraisal is necessary to identify the appropriate maintenance solution when there is more than one practical alternative for addressing the maintenance need. There may be only one practical maintenance option for many of the identified needs, and it may have already been determined from the Identification of Needs and Value Management exercises. When there is only one practical maintenance solution, option appraisal is not required, and the work item can be passed through to the scheme development process.

C.7.4.6 The Value Management phase should have flagged up needs that are suitable for option appraisal. These needs should now be assessed by suitable personnel in order to identify the practical maintenance options. Personnel suitable for assessing options may include:

- Highway Structures Manager/engineer and other suitably qualified and experienced staff within the authority; and
- external consultant and contractor staff with suitable experience and preferably a sound knowledge of the structures and network.

C.7.4.7 It is beneficial to involve the aforementioned personnel as early as possible in the exercise as this may lead to alternative proposals that benefit the network and lead to long-term savings. Early contractor involvement may enable the cost of work to be more robustly informed and effectively assessed. This process increases confidence levels and makes achievement of the planned work regime more likely.

C.7.4.8 The options should be analysed using Whole Life Costing to identify the most cost-effective solution. Larger maintenance or improvement needs may merit the use of more sophisticated analysis techniques that account for a wider range of socio-economic issues, e.g. Multi Criteria Decision analysis. Expert advice should be sought regarding the suitability of applying more sophisticated techniques.

C.7.4.9 Large upgrade or improvement schemes may require a formal public consultation exercise. In such cases, authorities should identify appropriate parties to include in the consultation, e.g. residents and businesses, and give them a suitable opportunity to comment on the options proposed.

SCHEME DEVELOPMENT

C.7.4.10 Scheme development is the effective combination of individual work items into schemes, in which each item makes best use of available funding and resources.

C.7.4.11 Procurement routes have a major effect on scheme development and out-turn costs. Senior managers, Highway Structures Managers, and budget holders should be involved in the choice of procurement routes. In choosing a procurement route due consideration should be given to obtaining value for money, monitoring quality, and rewarding or penalising good/poor quality respectively. The adoption of supply chain partners helps in the effective choice of maintenance solutions because advice can be sought at an earlier stage. Early contractor involvement is one method available. For smaller schemes or rapid-response situations, call-off contracts may offer a more suitable and flexible option, particularly where traditional procurement routes are inefficient or overly complex. In addition, obtaining early advice from consultants can support the development of appropriate solutions, especially for small elements of design work or emergency interventions.

C.7.4.12 The scheme development process should focus on the minimisation of network disruption and minimisation of whole life costs without compromising other important aspects such as appearance, access arrangements, environmental and sustainability issues, etc. It should be recognised that it may not be possible to minimise both network disruption and whole life costs and a compromise may have to be accepted. When developing schemes a number of alternative techniques are available for combining work items, each having different outcomes. Commonly used techniques include:

1. **Combine different work items on one structure** - addresses all actions on one structure thereby creating one period of longer network disruption compared to several interventions of shorter individual disruption but possibly longer total disruption. This technique may have relatively high scheme costs because the contractor has to mobilise for a range of activities and possibly more than one contractor is required;
2. **Combine similar work types** - a scheme of works that concentrate on one specific work type or similar work types. This technique should achieve cost savings by procuring the work in bulk because mobilisation fees are reduced and the contractor is provided with a steady

work stream. A disadvantage is increased network disruptions at a particular location because different contractors may visit one structure to carry out their specific activities; and

3. **Combine schemes based on route or area** - this technique is similar to technique one above except that it is extended to cover a series of schemes on a route. It should achieve cost savings by procuring the work in bulk because contractor mobilisation fees are reduced and they are provided with a steady work stream. A disadvantage is that a number of contractors are likely to be required, leading to the possibility of programme extensions, site conflicts, and continued network disruption over a short period.

C.7.4.13 The developed schemes are used to prepare the Forward Work Plan.

C.7.5 PREPARE FORWARD WORK PLAN

C.7.5.1 The Forward Work Plan is a detailed programme of work covering anything from one to five years. A longer funding period has significant benefits when it comes to forward planning as there is increased surety of funding, which can then be translated into a comprehensive structures programme. Typically, a structures scheme may cover multiple years, from feasibility, through detailed design to construction, so having multi-year settlements is ideally suited to the structures portfolio and something that should be encouraged.

C.7.5.2 The Forward Work Plan should draw together all the work that has passed thorough the Value Management and Value Engineering phases, i.e. developed schemes, and non-value managed work, e.g. inspections, structural assessments, routine maintenance, and management of substandard structures.

C.7.5.3 Efficiencies may be realised by programming similar work on nearby structures. This may not always be possible, but where this can be achieved there are benefits in reduced disruption compared to undertaking multiple interventions over a longer period.

C.7.5.4 Work that is not covered by the forward work plan, but requires funding, is added to the backlog of work. Not addressing the backlog can have serious consequences, as delaying work often results in more costly interventions later, as the condition of that structure will continue to deteriorate in that time. Timely intervention frequently offers benefits in terms of lower whole life cost, when compared to delayed interventions, where works take longer and cost much more.

C.7.5.5 The development of a comprehensive work bank and robust backlog is key to making the case for additional funding. A well-developed life cycle plan will be able to demonstrate the risks of not funding work in a timely manner and go some way to quantifying the increase in future costs as a result of deferring maintenance. It is also important to understand how this will impact the performance at network level, by understanding the likelihood of interim measures being introduced or, in the worst case, closure. Quantifying those risks may also result in the risks being highlighted at senior level within an organisation.

C.7.5.6 A growing concern is ageing infrastructure. Many concrete bridges are approaching major maintenance requirements, with pre- and post-tensioned structures, half-joint and hinge joint structures of particular concern. A proactive approach is needed to develop a robust management strategy that allows these structures to continue to function. By contrast, masonry arch structures are often some of the most resilient structures on a network – however they often present different challenges due to their construction.

C.7.5.7 Opportunities may exist to realise efficiencies through local partnerships with other, neighbouring authorities. By entering a collaborative alliance, efficiencies may be realised around procurement methods, supplier involvement and works delivery.

C.7.6 MONITORING, REVIEW AND FEEDBACK

C.7.6.1 The Annual and Forward Work Plan should be regularly monitored and reviewed to assess work delivery, i.e. planned programme and costs vs actual. Changes may be required to the planned schedule of works if it has deviated significantly from the original plan. Feedback loops should also be implemented to assess and record out-turn costs and the quality of the final solution (this data may also inform improvements).

C.7.6.2 The workbank should be continually reviewed to check that maintenance needs are being properly addressed and removed from the workbank once acted upon. It is helpful to record the dates when the scheme is included and removed from the workbank so the turnaround can be monitored.

SECTION C.8 SUSTAINABILITY – STRUCTURES

C.8.1 INTRODUCTION

C.8.1.1 This section provides sustainability guidance specific to structures, aligned to the overall principles and three pillars set out in Part A: environmental, social, and economic sustainability.

C.8.1.2 Sustainability requirements for highway structures should be embedded throughout inspection, assessment, maintenance planning, design, delivery, and reporting processes to ensure consistent, long-term environmental performance. A risk- and evidence-based approach should be applied to balance safety, serviceability, resilience, adaptation, environmental protection, and value for money across the whole life of the asset, enabling decisions that support both operational and structural needs and wider sustainability objectives.

C.8.2 ENVIRONMENTAL SUSTAINABILITY

C.8.2.1 Maintenance work and inspections on highway structures should be undertaken giving due consideration to the natural environment. Highway structures provide habitats for some species, such as reptiles, nesting birds, bats, and plants especially lichens, mosses, and liverworts, some of which are highly protected and present specific requirements. They are often situated in and over key biodiversity corridors e.g. woodland, grassland, rivers, streams, and estuaries. Whilst they facilitate the passage of vehicles, cycles, and pedestrians, over or under obstacles, bridges can also be a barrier to the migration of animals, which can result in conflict with traffic. Brief details of the requirements are given in Section A.8 of this Code.

C.8.2.2 Structures face unique environmental challenges, as they often have a direct influence on watercourses. Work to these structures often requires permission and approval from the Environment Agency (EA) or Scottish Environment Protection Agency (SEPA) before work can be carried out, with the work being completed in a sympathetic manner to balance the need for intervention against the potential impact on the watercourse.

C.8.2.3 Listed structures and those with heritage interest will also need close liaison with stakeholders such as Historic England/Historic Environment Scotland/CADW/Department for Communities. Often, only limited changes can be made to such structures, and substantial changes may only be made in exceptional circumstances. The limitations typically relate to materials used in the construction of those structures, although the appearance of materials would also need to be considered (for example, a change in colour for paint protection systems on metal bridges).

GUIDING LEGISLATION

C.8.2.4 The Climate Change Act 2008 empowered the government to set national targets for the year 2050 for the reduction of greenhouse gas emissions and to encourage energy users to meet the objectives of the act, such as reducing such emissions or removing greenhouse gas from the atmosphere.

C.8.2.5 The Carbon Budget and Growth Delivery Plan (CBGDP) 2025 is the UK Government's major Section 14 report under the Climate Change Act 2008. It sets out how the UK will meet Carbon Budgets 4, 5 and 6 (covering 2023–2037) and links climate action with economic growth: Carbon Budget and Growth Delivery Plan.

C.8.2.6 The Well-being of Future Generations (Wales) Act 2015 is a landmark Welsh law that requires public bodies to improve the social, economic, environmental, and cultural well-being of Wales.

CARBON MANAGEMENT

C.8.2.7 Section 8.5 Carbon Management in Part A describes the overarching principles and approach to managing carbon across the life of highway infrastructure. This subsection refers to the implications on structures assets and how relevant standards can be met for carbon management.

C.8.2.8 To follow the principles of PAS 2080 when managing structures assets, decisions should be underpinned by advanced assessment and proactive maintenance techniques, such as structural health monitoring, targeted investigation, testing, strengthening, and preventative interventions. These approaches reduce uncertainty around condition, help avoid unnecessary renewal, and ensure interventions remain proportionate.

C.8.2.9 CG 300 requires carbon impacts to be assessed as part of the environmental considerations for any scheme requiring an AIP, with the assessment carried out through a carbon count at one or more design stages, as defined in the carbon management plan or agreed with the TAA.

C.8.2.10 In CG 300, carbon assessments have been incorporated into the AIP for bridges designed to Eurocodes, with requirements captured in Section 3.10: “Environment and sustainability”. This section includes cultural-heritage considerations, environmental-management plans, and walking, cycling, and horse-riding assessments, and now requires designers to set out measures to manage the carbon impacts of their design, in line with Note 7 of Appendix A.

C.8.2.11 For structures designed or assessed using non-Eurocodes, carbon requirements are incorporated through Appendix B of CG 300, with carbon-management proposals included in Section 3.9: “Environment and sustainability”. A carbon count is mandatory for design work, while for assessments carbon impacts are only required where agreed with the TAA.

C.8.2.12 Given the current inconsistencies in carbon-assessment methodologies, authorities should recognise that the wider tool landscape remains fragmented and that no single national carbon tool is yet available. Local authorities are therefore encouraged to adopt a client-led, scalable approach to carbon assessment, beginning with simple and proportionate methods rather than delaying action until more advanced tools become available.

C.8.2.13 Robust assessments should also account for emissions resulting from diversion routes and traffic management, which for many maintenance schemes can exceed the embodied carbon associated with materials. Decision-making should continue to emphasise that maintaining existing structures on a ‘little and often’ basis is generally the most sustainable outcome, avoiding unnecessary renewal and the associated carbon and resource impacts. This approach may also demonstrate that with deferred maintenance, works will typically be more expensive and of longer duration, incurring greater emissions from diversion routes being in place longer.

C.8.2.14 Until such time as definitive carbon calculation methodologies are introduced, asset owners should decide whether it is reasonable to include delay and diversion carbon in their assessment.

C.8.2.15 Alongside carbon, the resource extraction and wider social impacts of new materials should be considered, as these impacts will continue even as material carbon intensities reduce. This

further reinforces that avoiding unnecessary renewal generally remains the most sustainable choice.

C.8.2.16 The Net Zero Bridges Group provides relevant sector guidance on reducing carbon and improving sustainability performance in bridge management; addressing the challenges and opportunities associated with decarbonising existing bridges.

C.8.3 SOCIAL SUSTAINABILITY

C.8.3.1 Listed structures and masonry arches require tailored and sensitive treatment, as their replacement is often unpopular or, in some cases, not feasible. Opportunities should be considered to repurpose historic bridges for active-travel use where appropriate, supporting wider sustainability and accessibility objectives. Refer to DMRB CG 304: Conservation of Highway Structures for further guidance.

C.8.3.2 The Planning (Listed Building and Conservation Areas) Act 1990 requires each authority to compile a list of buildings of special interest, either historic or architectural. Listed building consent is required to demolish such a structure, or to alter or extend it in a manner affecting its architectural or historic interest. The Act also provides for the protection of conservation areas that have special historical interest. The status can influence the processes required for structure maintenance in such an area.

C.8.3.3 The bodies responsible for listed structures in the UK are Historic England, CADW, Historic Environment Scotland and the Department for Communities. England and Wales, Scotland and Northern Ireland use different grading categories to identify listed structures, alongside a further level of Scheduled Ancient Monument, which is covered by The Ancient Monuments and Archaeological Areas Act 1979. Secretary of State (Department of Culture, Media, and Sport) approval of proposals for work on a Scheduled Ancient Monument is required before any works are carried out, except emergency works. The Ancient Monuments (Class Consents) Order 1994 gives consent in Class 5 for works which are urgently necessary in the interests of safety or health, provided that the works are limited to the minimum measures immediately necessary and notice in writing justifying in detail the need for the works is given to the Secretary of State as soon as reasonably practical. This would allow the replacement of the odd damaged stone or realignment of a displaced parapet but not repair of more extensive damage. The Secretary of State relies heavily on the advice of Historic England/HES/CADW/DoC and any proposals for work on such structures should involve early consultation with the local representative of those bodies. Proposals for works on structures recorded at the lower (listed) levels are usually approved by the planning department of the local authority. However, if the work will require complete or partial demolition, or if the work will alter or extend a listed structure in any manner which would change its character as a building of special architectural or historical interest, the planning department of the local authority has to consult the national body responsible for such decisions.

C.8.4 ECONOMIC SUSTAINABILITY

C.8.4.1 Useful guidance is available to support the application of circular economy principles in the management of structures assets. Although some research focuses on newbuild structures, the underlying principles remain directly relevant to existing assets, particularly in emphasising the value of recovering and reusing materials and components where structures are adapted, renewed, or decommissioned. In practice, “little and often” maintenance approaches are typically the most sustainable and cost-effective but are rarely supported under current capital focused

funding systems. Circular economy principles should also be embedded into reconstruction activities, encouraging the retention of materials wherever feasible and reducing waste across the asset lifecycle.

PART D.LIGHTING

SECTION D.1 SCOPE OF PART D – LIGHTING

D.1.1 INTRODUCTION

D.1.1.1 Part D of Well-managed Highway Infrastructure covers specific issues and themes regarding lighting, and includes the following asset types:

- lighting columns, attachments and foundations;
- high masts and foundations;
- lighting units attached to subways/walls/wooden poles or steel poles such as those used by Distribution Network Operators (DNO);
- heritage[3] columns;
- illuminated bollards;
- illuminated traffic signposts including associated sign faces;
- Belisha beacons;
- refuge beacons;
- feeder pillars;
- brackets;
- luminaires;
- private cable networks;
- control equipment, cables; and
- control gear, switching, internal wiring cabling (within ownership).

D.1.1.2 The overarching principles and common themes of maintaining highway infrastructure are covered within Part A, asset specific guidance for highways, structures and tunnels is covered in Part B, Part C and Part E respectively.

D.1.1.3 Technology equipment installed within the highway environment, including any power electronics required to operate the equipment will be covered in a separate Code of Practice that is in development: Management of Roadside Technology. Where technology equipment is mounted on, attached to, or powered from lighting assets, the management of risks and impacts relating to the lighting asset is within the scope of this Part. Examples of such equipment may include CCTV, Wi-Fi and electric vehicle charging infrastructure.

D.1.1.4 The objectives of this Part of the Code are as follows:

- to encourage delivery of the right quality and amount of light in the right place and at the right time;
- to support a risk-based approach for lighting management that enables authorities to make informed, proportionate and evidence-based decisions;

[3] Further considerations related to assets in heritage sites as well as decorative assets and how local policy affects them is covered in D.2.3 Conservation Areas

- to deliver value for money through the adoption of appropriate technology;
- to encourage the development, adoption, and regular review of policies for lighting operation and maintenance, consistent with the wider principles of integrated transport, crime reduction, sustainability and best value;
- to encourage harmonisation of lighting maintenance practice, where this is consistent with user expectations, whilst retaining reasonable diversity to accommodate local requirements; and
- to encourage the adoption of an efficient and robust approach in the collection, processing and recording of lighting asset inventory and condition data for the purpose of local and national needs assessment, including:
  - scenario planning and investment modelling;
  - management;
  - performance monitoring; and
  - electricity purchase.

D.1.2 FURTHER GUIDANCE

D.1.2.1 Guidance on general best practice and recommendations can be found on the following websites:

- The Institution of Lighting Professionals;
- The Institution of Engineering and Technology;
- The Highway Electrical Association;
- ADEPT;
- Energy Networks Association (ENA);
- NISTA - PFI Centre of Excellence;
- The Scottish Futures Trust;
- Manual for Streets; and
- Design Manual for Roads and Bridges.

ADAPTIVE LIGHTING

D.1.2.2 To address rising energy costs, meet climate and carbon reduction targets, reduce obtrusive light and manage increasing financial pressures, many highway authorities are implementing adaptive lighting strategies and, in some cases, removing lighting in selected areas.

D.1.2.3 Implementation of adaptive lighting or the removal of lighting should be underpinned by a risk assessment. This assessment should clearly document the decision-making process, the evidence considered, and the rationale for the chosen approach. On the strategic road network, the assessment for new and replacement lighting is undertaken in accordance with TA 501 - Road lighting appraisal.

D.1.2.4 Work funded by DfT has resulted in a detailed case study on Decarbonisation of Street lighting - ADEPT Live Lab East Riding of Yorkshire Council Low Carbon Lighting.

SECTION D.2 LEGAL FRAMEWORK – LIGHTING

D.2.1 INTRODUCTION

D.2.1.1 General duties and powers are dealt with in Part A of this Code. Guidance relating to traffic management is covered in section A.2.2.15 of this Code. This section contains information on duties and powers specifically related to lighting.

D.2.2 LIGHTING SPECIFIC LEGAL CONSIDERATIONS

D.2.2.1 There is no statutory requirement on local authorities in the United Kingdom to provide public lighting. The following statutes empower local authorities to light roads but do not impose a duty. For avoidance of doubt, there is no duty of care to provide lighting; authorities have a power, not an obligation, to light.

D.2.2.2 The ADEPT Live Labs programme provides useful material on how case law relates to lighting powers and responsibilities. It clarifies that while there is no duty of care to provide lighting, once lighting is installed the highway authority should manage it safely and take account of relevant risks when considering operation, reduction, dimming or switch-off. The level of assessment and supporting information should reflect the significance of the decision and associated risks.

D.2.2.3 In England and Wales, Section 97 of the Highways Act 1980[4] empowers a highway authority to provide lighting for any highway or proposed highway for which they are, or will be, the highway authority. District Councils and many Parish or Town Councils also have the power to provide lighting as local lighting authorities; these powers being conferred by the Public Health Act, or the Parish Councils Act. Where such councils wish to provide lighting on a highway, the consent of the highway authority is required.

D.2.2.4 In Northern Ireland, the Roads (Northern Ireland) Order, Article 44 grants the Department for Infrastructure the power to provide road lighting, where the Department considers that any road should be illuminated.

D.2.2.5 In Scotland, the Roads (Scotland) Act, Section 35, empowers a local roads highway authority to provide lighting for roads, or proposed roads, which are, or will be, maintainable by them and which in their opinion ought to be lit.

D.2.2.6 Highway authorities have a duty of care to the road user. The Highways Act 1980 sets out the principal responsibilities of highway authorities in England and Wales, with Section 41 specifically requiring the maintenance of highways that are maintained at public expense. Any loss to an individual as a consequence of the inappropriate use of these powers may result in action being taken to recover the loss. Such action could be taken on several grounds:

- negligent exercise of power (including failure to use that power). There is no blanket immunity;
- action for misfeasance of public office; and
- breach of the common law duty of care (if it can be established).

[4] Throughout this Code, when reference is made to the Highways Act 1980, this legislation does not apply in NI, where instead, the Roads (NI) Order 1993 applies.

D.2.2.7 NOTE: This duty of care does not imply any duty on the highway authority to keep the public lighting lit. However, a highway authority responsible for the maintenance of public lighting should be able to demonstrate that they have systems in place to maintain the public lighting equipment in a safe condition, including the detection of dangerous equipment and that these systems are supported by asset information and maintenance records appropriate to the nature of the asset, associated risks and operational requirements.

D.2.2.8 BS 5489 and BS EN 13201 are the current design standards for road lighting and provide recommended good practice guidance for lighting design, levels, and selection of appropriate lighting classes. While BS 5489 is guidance rather than a statutory requirement, following it demonstrates alignment with Section 41 of the Highways Act 1980 and the associated duty to maintain the highway in a safe condition. Where alternative approaches are adopted, consideration should be given to understanding the factors influencing the decision and any associated risks. The extent of supporting analysis and documentation should be proportionate to the significance of the departure and its potential impacts.

NEW ROADS AND STREET WORKS

D.2.2.9 The New Roads and Street Works Act 1991 (NRSWA) is an enabling act setting out the duties of Street Authorities to coordinate and regulate works carried out in the highway. All underground cables should be recorded in accordance with the Electricity Safety, Quality and Continuity Regulations 2002 (as amended) and the Code of Practice for Recording of Underground Apparatus in Streets.

D.2.2.10 The JAG(UK) website contains a range of guidance, information and assistance.

STATUTORY NUISANCE: LIGHTING

D.2.2.11 In England and Wales Street lighting is not specifically exempt from the legislation, but it is unlikely to qualify as a statutory nuisance as generally speaking it is not considered to be within the definition of ‘premises. Further practical guidance on managing and minimising lighting impacts is available in the Institution of Lighting Professionals Guidance Note 01 - The Reduction of Obtrusive Light, which provides recommended good practice for assessing obtrusive light and may assist Authorities in demonstrating reasonable steps to avoid nuisance.

D.2.2.12 In England and Wales, the Clean Neighbourhoods and Environment Act 2005 applies and amends the Environmental Protection Act 1990. Section 102 of the 2005 Act makes artificial light a potential statutory nuisance.

D.2.2.13 In Scotland the Public Health etc (Scotland) Act 2008 applies.

D.2.2.14 In Scotland, street lighting is more exposed to complaint of statutory nuisance, as in addition to defining ‘premises’ as a source of potential statutory nuisance the Scottish Act also includes artificial light from ‘any stationary object’. Guidance documents have been published by the Scottish Government,

NATURAL HABITATS

D.2.2.15 Authorities should be aware that under the Conservation (Natural Habitats, &c) Regulations 1994 and as amended in 2007 European Protected Species of plants and animals receive protection. Artificial lighting has the potential to adversely affect protected species and habitats, and

Authorities should therefore consider recognised best-practice guidance, including national Dark Skies guidance and principles aimed at reducing unnecessary skyglow, spill light and ecological disturbance.

D.2.2.16 One such protected species on which artificial light can have adverse effects is bats and so care needs to be taken not to disturb the animals themselves or their roosts and habitats. Guidance is available from the Bat Conservation Trust and the Institution of Lighting Professionals..

SUSTAINABILITY

D.2.2.17 The Climate Change Act 2008 empowered the government to set national targets for the year 2050 for the reduction of greenhouse gas emissions and to encourage energy users to meet the objectives of the Act, such as reducing such emissions or removing greenhouse gas from the atmosphere.

D.2.2.18 The Act introduced legally binding carbon budgets, which set ceilings on the levels of greenhouse gases that may be emitted nationally. The Carbon Reduction Commitment (CRC) Energy Efficiency Scheme applied to qualifying Authorities until its closure following the 2018–19 compliance year. There is currently no direct successor carbon pricing or reporting scheme that applies to authorities. Energy and carbon management is now undertaken through highway authority governance arrangements, carbon reduction strategies, and asset management processes aligned with national carbon objectives. The use of tools such as CIBSE TM66 can assist Authorities in demonstrating responsible energy and carbon management and supporting sustainable asset lifecycle decision making.

CRIME AND DISORDER

D.2.2.19 Section 17 of the Crime and Disorder Act 1998 states the duty to consider crime and disorder implications. In relation to lighting, this may include considering how lighting provision, maintenance and operational decisions affect perceptions of safety, the use of public spaces and wider community outcomes. The Crime and Disorder Act does not apply to Scotland or Northern Ireland.

TRAFFIC SIGNS

D.2.2.20 Traffic Signs Manual provides guidance on the use of traffic signs and road markings prescribed by the Traffic Signs Regulations and covers England, Scotland, Wales and Northern Ireland.

CONSERVATION AREAS

D.2.2.21 The introduction of the Civic Amenities Act 1967 gave legislative control to the protection of conservation areas which are defined as - ‘an area of special architectural or historic interest, the character or appearance of which it is desirable to preserve or enhance.’

D.2.2.22 Conservation Areas are designated more on local criteria than on national criteria and their designation is derived by the highway authority with support and advice from Historic England, the English Government’s lead advisory body for the historic environment, and Cadw, the Welsh Government’s historic environment service. Consideration is given to the history, building style, important views and different activities performed in the area as well as other factors of which the exterior lighting may be one. In Scotland, equivalent oversight is provided by Historic Environment

Scotland, and in Northern Ireland by the Historic Environment Division of the Department for Communities.

D.2.2.23 Highway authorities should liaise with local stakeholders including heritage bodies, community groups, local conservation officers, and relevant national organisations such as Historic Environment Scotland, Cadw, Historic England, and the Historic Environment Division (NI)—to determine what forms of exterior lighting are or are not suitable for the character and sensitivities of each Conservation Area. Stakeholder engagement should inform decisions on lighting design, equipment selection, and operational practices.

D.2.2.24 After a Conservation Area has been designated it undergoes a dynamic process of assessment to preserve and enhance the character and appearance of the Area. A conservation area appraisal document should be developed, and the maintenance and appearance of exterior lighting should be considered when an appraisal is put together.

D.2.2.25 The maintenance and/or refurbishment of heritage equipment can be a costly process, and financial constraints may have an effect on the decision as to which equipment may or may not be used. Alternatives to exact physical replacements of existing equipment which give the same 'feel' to the conservation area may be considered by the highway authority and proposals for alternative equipment should be investigated.

D.2.2.26 A grant scheme may be available for preventative maintenance and repair of historic places, some examples of which can be seen below:

- Historic England;
- The Architectural Heritage Fund;
- Heritage Lottery Fund; and
- War Memorials Trust.

SECTION D.3 ASSET STRATEGY – LIGHTING

D.3.1 INTRODUCTION

D.3.1.1 A Lighting Asset Management Strategy sets out the highway authority's approach for managing lighting assets across the network to deliver value for money, minimise risk and support strategic goals.

D.3.1.2 Asset management systems are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C. This document should be referred to and the advice below considered supplementary.

D.3.2 PRINCIPLES AND CONSIDERATIONS

D.3.2.1 The Lighting Asset Management (AM) Strategy should clearly set out its context in relation to the highway authority's goals and priorities, relevant legislative, regulatory and policy requirements, and stakeholder expectations (e.g., the public, regulators, and partners). It should also reference links to other strategic documents, such as Part A of this code (Network Strategy), the Corporate Plan, the Climate Strategy, and other related frameworks.

D.3.2.2 A lighting AM strategy will set out clear, measurable objectives such as:

- Asset Safety: Provide lighting that supports the safe movement of all road users, ensure assets are electrically safe, structurally secure, and conform to relevant standards and legislation. Reduce risks associated with location, asset condition, complexity, ageing or defective equipment through planned inspection, targeted intervention and renewal.
- Reliability and Performance: Maintain a consistent level of lighting performance that aligns with design standards, operational requirements and user needs. Accommodate variations in asset type, location, and complexity and minimise service disruption through proactive maintenance and efficient response to outages.
- Sustainability and Net Zero: Reduce energy consumption and carbon emissions through adopting efficient and adaptable technologies and removal of obsolete or inefficient assets, while supporting commitments to net zero. Manage the lifecycle of materials responsibly and support circular economy principles.
- Cost Effectiveness: Optimise investment decisions by balancing upfront costs, operational costs, risks, long-term asset performance and future adaptability. Use whole life cost analysis to guide renewal and replacement programmes. Apply proportionate, risk-based approaches to the management of standard, unique, or complex assets, including those subject to changing use or requirements.
- Stakeholder and Community Value: Enhance public confidence by providing a reliable, well maintained lighting service. Support broader placemaking, public realm, and community safety initiatives.
- Asset Knowledge: Maintain accurate, up-to-date asset information and intelligence to support evidence-based decision making including the identification of complex or non-standard assets and assessment of their suitability for future operational, technological, or functional change. Use condition surveys, fault data, and performance analytics to drive targeted interventions.

D.3.2.3 A description of the lighting asset portfolio may be included, covering asset quantities and distribution, location, condition, age profile, and service criticality (e.g., high, medium, or low importance). Lighting assets should be prioritised using a risk-based approach that considers network importance, location-specific risks, and the likelihood and consequence of asset failure to ensure that resources are directed towards the most critical locations.

D.3.2.4 Roles, responsibilities, required competencies, and governance structures appropriate to the scale, complexity and risk profile of the service should be clearly defined to ensure consistent and effective decision-making.

D.3.2.5 The Strategy approach should consider:

- Lifecycle Management: Using a structured, risk-based approach to plan, remove, maintain, renew, or replace lighting assets.
- Asset Information Management: Maintaining accurate lighting asset data throughout the asset lifecycle to support planning, inspection, maintenance, risk assessment, and investment decisions, enabling a shift from reactive and time-based maintenance to proactive, risk and condition-based asset management.
- Condition Monitoring: Identifying needs early through inspections, electrical Inspection and testing, structural inspections, tests and assessments, and performance analytics.
- Planned & Reactive Maintenance: Combining proactive programmes with efficient fault response to ensure service continuity.
- Technology Upgrades: Exploring smart technologies, data systems, and digital tools to enhance asset performance.
- Risk-Based Renewal: Replacing defective, non-compliant, or life-expired assets based on risk, condition, and strategic importance.
- Sustainable Procurement: Working with suppliers and contractors who support sustainability and carbon-reduction objectives.
- Environmental Considerations: Managing assets according to location-specific environmental conditions.
- Whole-Life Cost Assessment: Applying whole-life cost analysis to support effective decision-making.

D.3.2.6 The strategy should lay out how the highway authority manages its assets to deliver value, minimise risk, and support strategic goals. Whilst the exact structure will vary with each highway authority, typical core elements could include:

- Why assets are managed the way they are
- What the organisation wants to achieve
- How it will manage, maintain, and invest in assets
- Who is responsible for delivery
- How success will be measured

D.3.3 COMPETENCE

D.3.3.1 Competence of staff is dealt with in UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C. This document should be referred to and the advice below considered supplementary. Further guidance on competence is also contained in TD 501 - Road lighting design.

D.3.3.2 Employers of persons working on lighting installations, including client and contractor's personnel, must have a system in place to authorise and certify the level of competency of those employed and be able to demonstrate the necessary training, knowledge, skills, experience and appropriate supervision to achieve and maintain the certified level of competency.

D.3.3.3 Competence requires appropriate training, technical knowledge and experience sufficient to ensure safe and effective work on lighting assets including:

- Knowledge of lighting systems and associated equipment (including electrical, structural, optical, and control components),
- Knowledge of the specific asset or system being worked on,
- Understanding the hazards associated with lighting assets and the precautions required to manage those risks,
- Experience of working on lighting installations and associated infrastructure,
- Experience relevant to the type of system and environment; and
- Ability to recognise at all times when it is safe for work to continue.

D.3.3.4 Regulation 16 of the Electricity at Work Regulations states that: "No person shall be engaged in any work activity where technical knowledge or experience is necessary to prevent danger or where appropriate, injury, unless he possesses such knowledge or experience, or is under such degree of supervision as may be appropriate having regard to the nature of the work".

D.3.3.5 Regulation 16 applies to any work relating to electrical equipment whether or not a risk of injury is actually present at that time.

D.3.3.6 Some work, such as testing, may need to be carried out on live equipment and must only be carried out by an appropriately trained, skilled and experienced person competent in these activities.

D.3.3.7 The highway authority, its representatives, and operatives should have appropriate training, information, and instructions to ensure they understand the safety procedures relevant to their roles and activities. All parties should only undertake work or oversight activities in accordance with established instructions, procedures, and rules.

D.3.3.8 When operating or working on the DNO/DSO/IDNO cut-out the operative should be appropriately trained and, where necessary, approved by the DNO/DSO/IDNO.

D.3.3.9 In some circumstances, individuals may need to be supervised where their technical knowledge or experience is insufficient to ensure that they can carry out the work safely. Supervisors must have their responsibilities clearly explained to them by the duty holder, as defined in the Regulations, who must decide on the degree of supervision required.

D.3.3.10 Options for demonstrating on-site competence are National Highway Sector Scheme 8 (NHSS 8) and the associated Highway Electrical Registration Scheme (HERS) that sets out a reasonably practicable approach to the identification, achievement, recording and maintenance of competence. Some DNOs / IDNOs may require evidence of training and assessment to Electricity Association Engineering Recommendation G39 (which includes a reference to HERS). However, reliance solely on G39 without additional training and assessment of competence would leave the employing organisation open to failures to meet the requirements of the Health & Safety at Work etc. Act, the Management of Health and Safety at Work Regulations, the Electricity at Work Regulations and the Construction Design and Management Regulations amongst others.

D.3.3.11 By law all gas engineers in the UK must be on the Gas Safe Register. Maintenance of gas equipment in lighting units should only be carried out by gas engineers registered with Gas Safe.

SECTION D.4 RISK-BASED APPROACH – LIGHTING

D.4.1 INTRODUCTION

D.4.1.1 The general principles of a risk-based approach are detailed in Part A, with this section covering guidance relating to lighting assets. Risk management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C.

D.4.1.2 This section emphasises the use of asset condition, performance data and operational risk to inform decisions on inspection regimes, maintenance interventions and replacement strategies, rather than reliance on fixed time-based cycles alone.

Table 39: Example risks, mitigations and impacts affecting Lighting

Example Risks and Mitigations			Example Impacts			
Type of Risk	**Example Risks**	**Example Mitigation**	**Safety**	**Serviceability**	**Sustainability**	**Customer**
Asset - Risks affecting individual lighting assets	Structural deterioration of lighting columns. Defects can create hazards for all users, including pedestrians, cyclists, and motorists.	Safety inspections Condition surveys Reactive defect repairs Planned preventative maintenance	Increased risk of column failure and potential harm to road users, property of nearby assets.	Increased maintenance activities. Increased chance of blackspots.	Higher whole-life cost Increased maintenance frequency leading to greater material use and waste	Disruption and delays from the time taken to clear the asset in event of failure, or disruption due to remediation or replacement works.
	Water ingress into lit bollards leading to corrosion and electrical damage.	Routine inspections Preventative maintenance	Reduced visibility of central refuges, islands, or traffic calming features	Premature asset failure and increased maintenance costs.	Increased consumption of energy and impact to energy usage.	Increased complaints, negative perception of network management.
Service – Risks affecting how assets work	Power supply outages	Multiple feeder supplies so outages affect limited sections only	Increased risk of being unable to achieve required lighting levels or maintain integration with other assets leading to reduced visibility and the potential loss of safety-critical functions such as CCTV.	Inability to support dependent assets such as CCTV, traffic monitoring equipment, or illuminated signs where these rely on the lighting power supply	Reduced energy efficiency performance, as unplanned outages may lead to inefficient recovery measures such as temporary diesel generators or mobile lighting units with higher carbon emissions.	Increased risk of inability to meet customer expectations of consistently lit roads.

D.4.2 PROGRAMMING AND PRIORITIES

D.4.2.1 Programming and priorities are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

D.4.2.2 A lighting system requires inspection and maintenance undertaken using a risk-based approach to ensure that it is safe, operates correctly, continues to provide the designed performance and maximises its useful life. Maintenance can be divided into two aspects:

- Routine or cyclical, comprising risk based preventative maintenance carried out at appropriate intervals to help reduce or eliminate failures and to ensure the system continues operating at its intended design outputs.
- Reactive, where failures of equipment are identified, recorded and the affected equipment repaired or replaced in response to the risk and operational impact of the failure.

D.4.2.3 A well-designed risk-based cyclic maintenance programme should help to prevent the performance of the installation falling below the designed level; will identify any mechanical, structural, electrical or optical work necessary to maintain or increase the life of the installation; may reduce the incidence of faults; and check that the installation is safe.

D.4.2.4 Cyclical maintenance programmes should be determined taking account of all lighting unit variables including the lighting structure, foundation or fixing, light source, attachments and any electrical elements. Whilst it is desirable to carry out as many of these maintenance tasks as possible on a single visit, the tasks required and the competency of the workforce may limit the range of work that can be completed at one time.

D.4.2.5 The principles of maintenance applicable to lighting columns are equally applicable to high-mast lighting. However, due to the complexity of access particularly the need to lower head frames to undertake maintenance, maintenance activities should where practicable be grouped and undertaken during the same access opportunity at appropriate intervals.

D.4.2.6 Luminaire maintenance intervals may be aligned with other planned works. These intervals should be determined with reference to the required maintenance factor. Suggested luminaire maintenance factors are provided in BS 5489.

D.4.2.7 Periodic programmes of site-specific illuminance (lux level) surveys should be considered to confirm actual lighting performance and to enable comparison against the assumed maintenance factor. In addition, analysis of historic defect reports and reactive repair data should be undertaken on a periodic basis to identify trends in lighting failures, asset types, and locations, thereby informing the prioritisation and development of maintenance and renewal programmes. The scope and frequency of such activities should reflect asset criticality, operational requirements and the available information.

D.4.2.8 Cyclical maintenance for alternative power sources should take account of the manufacturers' guidance to ensure effective operation.

D.4.2.9 User needs should be considered as per Part A.15.

D.4.3 DESIGN FOR MAINTENANCE

D.4.3.1 Equipment used in lighting systems should be selected, installed, maintained and operated to ensure durable and efficient performance. Each item should be assessed for its potential life, availability, cost of spares and replacements, ease of maintenance, recycling/disposal and, when used in combination, compatibility with other components.

D.4.3.2 Initial cost is important, but it is whole life costs that should guide the final selection of equipment, including;

- planned maintenance;
- energy;
- traffic management;
- environmental impact;
- end of life costs;
- performance of existing equipment; and
- initial capital procurement costs.

D.4.3.3 LED lighting is now widely considered the standard for road lighting, offering significant energy and performance benefits. However, appropriate guidance should be consulted prior to procurement to ensure suitability and long-term performance.

D.4.4 ILLUMINATED TRAFFIC SIGN AND BOLLARD MAINTENANCE

D.4.4.1 Traffic signs should only be illuminated where required by the Traffic Signs Regulations and General Directions (TSRGD), relevant standards, or the asset owner's policy.

D.4.4.2 Cleaning of sign faces should be undertaken in accordance with the asset owner's risk assessment and policy. Optical inspection and cleaning of illuminated traffic sign luminaires should be carried out during routine maintenance activities, or more frequently if required, to ensure the continued conspicuity of the sign.

D.4.4.3 External cleaning of traffic bollards, along with the optical inspection and internal cleaning of illuminated bollards, should be undertaken in accordance with the asset owner's risk assessment and policy. In areas of heavy traffic, and particularly during winter, additional cleaning may be necessary, and this should be incorporated into the cyclic maintenance schedule. Some locations will require additional reactive cleaning during the winter months.

D.4.4.4 Solar powered equipment utilising battery storage will require a maintenance strategy that includes manufacturers' guidance to ensure effective operation throughout the night.

D.4.4.5 Further information regarding the maintenance of traffic signs can be found in Part B of this Code.

D.4.5 LUMINAIRES

LED REPLACEMENT

D.4.5.1 A risk-based approach to LED luminaire replacement recognises that LED assets do not fail in predictable cycles like traditional discharge lamps. They typically degrade slowly over time with the electronic driver being the most common point of failure. Because of this, replacement decisions should be guided by the actual condition and performance of each luminaire, combined with the operational risks associated with reduced lighting levels or outages. This approach helps highway authorities prioritise resources where they deliver the greatest safety and performance benefit.

D.4.5.2 Under the risk-based approach model, interventions are triggered by observable or measurable indicators rather than fixed time intervals. For example, a luminaire showing reduced illuminance, significant lens yellowing, or water ingress would be prioritised for replacement ahead of another asset of the same age that is still performing correctly. In areas with high safety requirements such as pedestrian crossings, junctions, subways, or conflict zones, lighting failures represent a greater risk, so luminaires may be replaced sooner, even if degradation is modest. Conversely, low risk residential areas may continue operating with ageing assets until their performance drops below required standards.

D.4.5.3 There are three main replacement strategies within a risk-based framework:

- The most common is driver replacement, as drivers are the component most prone to failure and can often be replaced without the need to replace the complete luminaire. Where a luminaire operates with Constant Light Output (CLO), care is required to ensure that any replacement driver is correctly programmed to continue from the same point on the CLO curve as the failed unit. Determining the appropriate CLO setting from a failed driver may be difficult and will typically require liaison with the luminaire manufacturer.
- In cases where luminaires are designed to be serviceable, LED module or light engine replacement may be used to restore performance or address lumen depreciation.
- Where luminaires are sealed or obsolete, full luminaire replacement becomes the most appropriate option. An example is replacing older LED luminaires that no longer meet lighting class requirements or for which compatible drivers are no longer available.

D.4.5.4 Even though LEDs can have long lifespans, highway authorities should ensure that lighting levels remain compliant throughout the asset's life. When developing a risk-based approach consideration could be given to routine inspections, nighttime performance checks, and where available, monitoring data from CMS systems to identify decreasing output, colour shift, or abnormal driver behaviour. This ensures that luminaires are replaced when the risk of degraded performance outweighs the benefit of extending their life, supporting safety, compliance, and long-term cost efficiency.

D.4.5.5 Further guidance on LED lighting such as GN05 Using LEDs, GN06 Retrofitting LED luminaires on existing lighting columns and GN11 Determination of Maintenance Factors is available from the Institution of Lighting Professionals.

LAMP REPLACEMENT

D.4.5.6 Discharge lamps remain installed within the lighting assets of some authorities. Guidance on their replacement is set out in this section.

D.4.5.7 There are two options for the replacement of discharge lamps. The asset owner should adopt a risk-based approach when determining which of these strategies is most appropriate:

- group lamp replacement; under which all lamps of a similar type and burning hours in a particular area or street are replaced at the same pre-defined time; and
- burn to extinction, under which lamps are replaced on failure.

D.4.5.8 The legal requirements for the illumination of certain mandatory traffic signs may influence whether a group lamp replacement strategy may be adopted.

D.4.5.9 A burn to extinction lamp replacement strategy will run all lamps until they eventually fail. The performance of discharge lamps depreciates over time and more significantly towards the point of ultimate failure, so just before failure the lamps will be emitting significantly lower levels of light than required by design. Best value will not be obtained from the electrical energy consumed, as at end-of-life lamps are performing well below optimal performance.

D.4.5.10 With a burn to extinction policy each individual lamp will fail at a different time to its neighbours, this may lead to a peak of replacements being required in the winter months when lamps are burning longer and the risk of failure is higher, this places peaks and troughs in the workload. Eventually each street will contain a mixture of new and old lamps, some giving more light than others and leading to patchy lighting levels. While this may not be acutely obvious, frequent changes in light levels may fatigue the driver's eye, resulting in a road safety hazard.

D.4.5.11 If a burn to extinction policy is adopted, then consideration should be given to introducing 'find and fix' night scouting. The alternative is that the highway authority will incur the financial and environmental cost of attending to widely dispersed and sporadic faults, which can be significant, both in urban and rural areas.

D.4.5.12 Burn to extinction has not been seen as good practice in the past because lamp lumen depreciation would normally be included within any designed lighting solution and this would then advise when an installation would start to drop beyond compliant design standards. Extending the lamp life until the lamp actually fails will run the risk of the lighting solution failing to deliver the illumination required for the task in hand.

D.4.5.13 The advantages of a well-planned, risk-based group replacement programme are that it minimises the likelihood of isolated lamp failures and ensures that the lighting system performance is maintained at an appropriate level throughout the life of the installation. This approach also helps to ensure that there is a reasonably uniform workload and expenditure profile within and across the years.

D.4.5.14 The lamp replacement frequency should be determined by:

- Location e.g. assets in more remote or difficult-to-access locations are likely to incur higher reactive maintenance costs than those in urban or easily accessible areas;
- the type of lamp;

- the manufacturer;
- the lamp wattage; and
- its annual hours of operation.

D.4.5.15 To take advantage of improved products, group replacement and cleaning intervals should be continually reviewed in line with guidance and specific lamp manufacturers' performance predictions.

D.4.5.16 Authorities that adopt a policy of group lamp replacement but then do not replace isolated lamp failures as they occur, should be aware that this may actually increase energy consumption and the likelihood of premature failure of the control gear, when it continuously tries to ignite a failed lamp.

D.4.5.17 Group lamp replacement is generally seen as good practice reducing the risk of lighting solutions running below design standards.

D.4.5.18 The group lamp change model generally provides owners with improved Value for Money and lowering cost through planned lamp change regimes. This maintenance approach enables service planning and accurate forecasting which supports good asset management.

COMPATIBILITY OF COMPONENTS

D.4.5.19 Compatibility of appropriate replacement components or assemblies may be an issue. Generic substitutes may not have the same visual appearance or give the same lighting performance as the original equipment. Lighting column replacement should recognise that relocation or changes to column position may affect light distribution and potentially reduce lighting performance. The main issues to be considered include:

- Lighting Performance. The original design for lighting any given road, footpath or area usually depends on optimising a number of factors, environmental, optical and functional (relating to anticipated use). From this process the optimum choice of luminaire performance and their spacing and mounting heights will be determined to achieve a specific performance in accordance with the requirements of the following:
  - BS 5489-1 Code of practice for the design of road lighting – Lighting of roads and public amenity areas;
  - https://landingpage.bsigroup.com/LandingPage/Standard?UPI=000000000030296174BS EN 13201-2 Road lighting. Performance requirements;
  - BS EN 13201-3 Road lighting. Calculation of performance;
  - BS EN 13201-4 Road lighting. Methods of measuring lighting performance; and
  - BS EN 13201-5 Road lighting. Energy performance indicators.
- It is important that maintenance repairs do not introduce components (e.g. luminaires) or carry out adjustments (reflector positions, light source positions, surge protection, control gear or drivers) that affect the designed performance. Changes in luminaire type and / or LED modules should be assessed prior to installation to confirm that the light distribution and control are at least equivalent either to that of the original installed or to the current requirements of the asset owner as set out in their policy. In addition, any such changes should be assessed for their impact on electromagnetic compatibility (EMC), interoperability

with the CMS, and thermal performance, ensuring that emissions, immunity, system communications, monitoring/control functionality, and operating temperatures remain within approved design limits and applicable standards.

- Many roads are often subject to restrictions around the times that access can be made available for maintenance activities and therefore every effort should be made to ensure that lights not working are repaired and put back into full operation in the shortest time on-site. Maintenance activities on restricted access roads have to be planned in advance and this should allow the purchase of the correct components to replace those that need replacement. Care should be taken when ordering replacement components to ensure that the performance matches those in situ on the road. Good records and knowledge of the lighting system will provide good guidance as to the quantity of units needed for maintenance purposes.
- Mechanical performance will also be affected by changes in mounting height, bracket out-reach, spigot angle and through the incorrect alignment of bracket and luminaire relative to the lit area.
- Replacement control gear and/or drivers must be capable of operating the light source no less efficiently than the original control gear. New or revised circuit wattages must be recorded in the inventory particularly as electronic ballasts have a lower consumption than wire wound ballasts.
- Operating hours. Photocells have standardised switching levels relating to a total number of operating hours per annum. The cells also have specific characteristics relating to power consumption, reliability and stability that effect the operating hours and the charging arrangements. Changes in photocell types and/or operating hours must be recorded in the inventory particularly as electronic cells have lower consumption than thermal cells and new cells typically have lower lux levels (e.g., 35/18) than those they replace.
- Increased weight and/or windage - the replacement product should be checked for suitability with the structure that it is proposed to be fitted.
- Energy consumption of CMS nodes compared to that of any photocells being replaced;
- UKCA, UKNI, and CE marking applies to lighting and associated equipment. Guidance on this is available in the HEA / HEA-HEMSA Guide to the Construction Products Regulations (CPR) and CE Marking.

D.4.6 ELECTRICAL INSPECTION, ASSESSMENT AND RECORDING

DEFECT RISK ASSESSMENT

D.4.6.1 Risk management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C, and Section 4 of Part A of this Code.

D.4.6.2 In terms of possible dangers from electricity, the Electricity at Work Regulations 1989 require all systems to be constructed, maintained, and operated, so far as is reasonably practicable to prevent danger. In any action for contravention of these duties, it is a defence to prove that all-reasonable steps and due diligence to avoid an offence had been exercised. To illustrate due diligence, it follows that periodic inspections should be undertaken to understand whether or not an electrical installation may present a danger and prove that on the day of inspection the installation was in a safe condition.

D.4.6.3 BS 7671 Requirements for Electrical Installations is the recognised standard for demonstrating compliance with the Electricity at Work Regulations 1989.

D.4.6.4 The IET Guidance Note 3: Inspection & Testing supports a risk-based approach for inspection of electrical installations, stating: "The person carrying out subsequent inspections may recommend that the interval between future inspections be increased or decreased as a result of the findings of their inspection." Inspection findings may be used to inform future inspection intervals, maintenance planning and risk management activities. Authorities should determine how this information is incorporated within local asset management arrangements.

D.4.6.5 IET Guidance Note 3: Inspection & Testing sets out how defects and observations identified during periodic inspection are to be classified, recorded, and acted upon, primarily through the Electrical Installation Condition Report (EICR) classification coding system.

D.4.6.6 The co-ordination of electrical inspection and testing with other cyclic maintenance activities or planned works, for example, a column replacement scheme or LED rollout, should be considered to help reduce disruption to the public; however, this may not be the most cost-effective means of carrying out this operation and separate personnel may be needed for this purpose.

VISUAL INSPECTION OF ELECTRICAL EQUIPMENT

D.4.6.7 The nature and location of public lighting installations is such that visual inspection of the electrical equipment and wiring is of paramount importance. The condition of the electrical equipment and wiring should be visually checked at each cyclic maintenance or repair visit and its condition reported back to the asset owner. So far as reasonably practicable, the visual inspection should verify that the health and safety of persons, animals and property is not endangered.

D.4.6.8 The general visual conditions of the electrical installation should be noted on the inspection report. However, if any particular item causes concern, it is recommended that the matter of concern is detailed on an appropriate supporting schedule.

D.4.6.9 During the visual inspection, any dangers should be identified that may arise during the testing procedure. The street lighting operative should take any necessary action and implement safety precautions to avoid danger. Where an issue is considered as dangerous, the item of equipment should be repaired immediately or taken out of service by removing the fuse from the supply termination until the fault has been rectified. Issues related to the Distributors cable or cut-out (cracked, broken fuse carrier, loose connection, exposed live conductors, etc.) should be reported to the relevant Distributor. Under no circumstances should an electrically dangerous item of equipment be left in operation.

D.4.6.10 Failure to carry out an electrical inspection must be recorded in the street lighting operative's report together with the reasons and any departure from the requirements of the regulations.

D.4.6.11 The requirement to record such limitations and departures, and the associated approach to managing incomplete inspections as well as further guidance on electrical inspections is set out in BS 7671 and its associated guidance, in particular IET Guidance Note 3.

ELECTRICAL TESTING

D.4.6.12 Testing should only be carried out by a competent person. All test equipment should be suitable for the test intended, correctly calibrated and regularly certified. For further details on electrical testing refer to BS 7671 and associated guidance including in particular Guidance Note 3.

ELECTRICAL TESTING RECORDS

D.4.6.13 The results of initial commissioning records and periodic electrical inspection and testing must be recorded.

D.4.6.14 Records of maintenance, including electrical test results, should be kept in accordance with the agreed retention period of the organisation, enabling the condition of the equipment and the effectiveness of maintenance policies to be monitored. A computerised asset management system should allow electrical test certificates to be linked to the specific individual item of equipment, thus providing an efficient maintenance system.

D.4.6.15 It should be noted that the scope of testing for highway lighting circuits and columns extends to 5th core distributor cabling in relation to the measurement of external earth fault loop impedance.

SURGE PROTECTION

D.4.6.16 The operation of electronic equipment in street lighting can be severely affected by lightning or electrical switching events. These increases in voltages (surges or transient over voltages) could possibly cause irreparable damage to equipment. A Surge Protective Device (SPD) is specifically designed to protect equipment from such events by redirecting the harmful voltage away from the equipment. Refer to ILP GN13: Surge Protection for Exterior Lighting Installations, for guidance on mitigating electrical surge risks in exterior lighting systems through correct application of SPDs.

D.4.6.17 A risk-based approach should be used to determine where SPDs are installed. Where installed, SPDs should be checked, where practicable, during the periodic electrical inspection and test that it is still in a serviceable condition (many SPDs have fault indicators that will show when the device has operated or has been damaged or destroyed by a surge).

D.4.6.18 It is important prior to applying any insulation resistance tests, to establish if the installation has any SPDs installed. SPDs should be isolated during insulation resistance testing, as the SPD could operate, by treating the test voltage applied to the system as a transient overvoltage (see BS 7671).

D.4.6.19 The type and use of SPDs varies between manufacturers and all maintenance should be carried out in accordance with the manufacturer's instructions. Further guidance can be found at the BEAMA website.

D.4.7 STRUCTURAL CONDITION INSPECTION AND TESTING, AND STRUCTURAL ASSESSMENT

D.4.7.1 The structural failure of lighting columns and traffic signposts highlights locations where under-investment in, and timely replacement of, aging assets has increased safety risks above acceptable levels, creating a legal and financial risk to the highway authority, which can be avoided by monitoring and understanding the condition of each asset.

D.4.7.2 Highway authorities have a statutory duty to ensure that their highway networks are maintained in a safe and reliable condition. The Highways Act 1980 sets out the principal responsibilities of Highway Authorities in England and Wales, with Section 41 specifically requiring the maintenance of highways that are maintained at public expense. In the event of any alleged breach of these duties, it is a valid defence to demonstrate that all reasonable steps and due diligence were exercised to prevent an offence. In Northern Ireland, under Article 44 of the Roads (NI) Order 1993, DFI holds discretionary powers regarding street lighting rather than an absolute statutory duty to illuminate every location. Where the Department considers that any road should be illuminated or better illuminated, it has the power to act. It can provide lighting if it decides it is in the public interest for a street or footpath to which the public has access to be lit or better lit. The Department may arrange for the supply of electricity or other means of illumination from authorized persons. It is empowered to install necessary equipment, including lamps, lamp posts, cables, and supports. The Department holds the authority to operate and maintain any lighting system installed under this Article.

D.4.7.3 To demonstrate due diligence, it follows that Condition Inspection and Testing, and Structural assessment should be undertaken to determine whether a lighting column or illuminated traffic signpost may present a risk. The guidance provided within this Code of Practice represents industry best practice and supports highway authorities in meeting their due diligence obligations.

D.4.7.4 A visual and condition inspection of each lighting column and illuminated traffic signpost should be carried out at every cyclic maintenance or repair visit and a report made recording who carried out the inspection and when, the equipment's condition and any remedial works required as per ILP GN22: Asset Management Toolkit – Minor Structures. The report should include photographs to assist with record keeping and clearly demonstrate column condition. Persons undertaking these inspections should have the competence to recognise specific defects in different types, materials and constructions of lighting columns and illuminated traffic signposts and to assess severity and extent of defects.

D.4.7.5 Consideration should be given to inspecting and analysing lighting columns or illuminated traffic signposts when removed from service, due to accident damage or replacement. The general condition of the unit, particularly the root section, will give an overall guide as to the condition of other similar units in similar locations and of similar age.

D.4.7.6 Visual and condition inspections provide an opportunity to confirm whether a more specialist inspection is required, using a risk-based approach. It should be noted that requesting a specialist inspection following the recommendations of a visual and condition inspection is considered an additional activity beyond the planned testing regime an asset owner may already have in place.

RISK ASSESSMENT

D.4.7.7 A strategy for the management of the structural safety of lighting columns and illuminated traffic signposts and feeder pillars should be developed and implemented. This strategy should include risk management procedures for prioritising the inspection and testing of lighting columns and illuminated traffic signposts and the development of non-destructive testing programmes to determine the structural integrity of these items.

STRUCTURAL TESTING

D.4.7.8 Structural condition inspection and testing methods for lighting columns and illuminated traffic signs are described in ILP GN22: Asset Management Toolkit – Minor Structures.

D.4.7.9 Structural condition inspection involves visually assessing the asset to identify safety critical features that contribute to the structural safety or performance of the asset in the context of its location, surroundings, and purpose. These inspections examine the safety critical features for wear, corrosion, damage, or vandalism to identify any abnormal hazards or risks. Where access is insufficient for visual inspection, for example, inside the asset or below ground level, or where quantitative results are required then Non-Destructive Testing (NDT) is used to identify the condition of a safety critical feature. NDT may provide qualitative results (e.g. a yes/no answer) or quantitative results (providing an absolute or relative measurement). Where suitable NDT methods cannot assess condition or risk, physical testing methods, e.g. force-deflection testing or dynamic load testing methods can provide additional information but have the disadvantage of having the potential to cause catastrophic damage where the asset is close to the end of life, or cumulative damage where used repeatedly through the asset life

D.4.7.10 Structural assessment is usually a structural calculation or similar method carried out by a qualified and competent engineer, to make a judgement on the structural suitability of the asset for continued use. This is employed where the asset is found to be worn, corroded, damaged or otherwise deteriorating, or where there is a proposed "change of use", for example, the addition of attachments that would change the applied loads on the structure. The structural assessment is informed by the site inspection and testing results, as well as any other asset information available.

D.4.7.11 The asset owner should consider the results of both the condition inspection/testing and the structural assessment for each asset and should make a decision on whether to replace the asset either, urgently, in the short term, or as part of planned future works, whether the age and condition of an assets indicates that risk is increased, such that a condition inspection/testing needs to be carried out more frequently, or whether, the asset remains a low risk.

D.4.7.12 Advancements in testing methods should be adopted wherever possible, particularly where they provide higher-quality or more reliable data.

D.4.7.13 Most of the tests and in particular the destructive tests need to be carried out by specialist contractors with the correct equipment and procedures to manage the risk of asset failure.

D.4.7.14 The frequency of, and methods used for, condition inspection and testing should be determined using a risk-based approach taking into account:

- locations where the poor condition of lighting columns has been established through routine visual and condition inspections or other reports;
- assets with attachments such as banners, CCTV, Wi-Fi, hanging baskets, smart sensors;
- environmental conditions;
- complex or unusual assets;
- results of previous inspections and tests;
- age profile;
- homogeneous asset groups;
- known problematic asset types;
- luminaire conversions or retrofits;

- unusual column foundations or footings;
- columns supplied by overhead electrical cable;
- types of lighting column posing a significant risk (e.g., those fitted with unauthorised attachments; steel columns with right-angled door openings; steel columns with hot swaged joints and brackets with missing bolts or sealing gaskets; and pre-stressed concrete columns with poorly fitted or missing spacing plugs);
- non-galvanized steel columns may be more prone to failure than older steel lighting columns or newer galvanized lighting columns;
- assets located in exposed or very exposed locations for wind loading;
- assets mounted in elevated locations e.g. on over-bridges; and
- volume of traffic; motorised and/or non-motorised.

D.4.7.15 The above criteria are not exhaustive but should provide sufficient detail on which the testing of lighting columns and illuminated traffic signposts can be prioritised specific to the asset owner inventory, types and needs. However, each highway authority should establish its own priorities based on the location, types, ages and condition of their stock. The results obtained from the testing programme should be iteratively reapplied into the highway authority's asset management systems, with attribute fields as suggested within ILP GN22: Asset Management Toolkit – Minor Structures to update and refine the process and to ensure that the most appropriate priorities are being addressed.

D.4.7.16 For guidance on structural inspection, assessment and testing of other minor structures refer to Part C of this Code.

D.4.8 PROTECTIVE COATINGS

D.4.8.1 Lighting columns and illuminated traffic signposts can be protected from the effects of the weather, pollution, and other environmental elements. Steel lighting columns and illuminated traffic signposts in particular will quickly deteriorate if they are not provided with a protective system such as hot dipped galvanising. Further protection may also be given by the application of an additional protective system such as paint or powder coating.

D.4.8.2 The condition of lighting column and illuminated traffic sign post protective systems including the finishes or surface treatments applied to the various materials used in their construction should be inspected at each maintenance visit and a report on its condition submitted by the service provider to the asset owner.

D.4.8.3 Maintenance street lighting operatives should have the competence to recognise the different types of materials used in the manufacture of lighting columns and illuminated traffic signposts and the different types of protective systems applied, together with the potential defects and severity of the defects applicable to each.

D.4.8.4 The frequency for the reapplication of protective systems to lighting columns and illuminated traffic signposts should be determined on a risk-based approach taking account of the following matters:

- condition and age of equipment;

- material used to manufacture the asset;
- presence of dissimilar metals;
- condition of existing coating;
- visual inspection;
- reports from customers;
- level of atmospheric pollution;
- location of equipment, for example, protective coatings on columns located in verges may be susceptible to damage from grass-cutting activities, such as the use of strimmer's;
- type of protective system used; and
- other environmental factors.

D.4.8.5 Reapplications of protective coatings should be recorded to assist good record keeping. Further guidance on the application and maintenance of protective coatings can be found in National Highway Sector Scheme 19A and the lighting column technical forum.

D.4.8.6 Some lighting columns are particularly vulnerable to corrosion underground and consideration should be given to extra protection to the root section and proportion of column directly above the ground.

D.4.8.7 Where lighting assets incorporate dissimilar metals, consideration shall be given to the risk of bi-metallic corrosion, particularly for aluminium assets installed with copper earth electrodes or earthing components. The specification, design, and detailing of the structural asset, protective coatings, and earthing system shall minimise the potential for associated structural section loss.

D.4.9 TREES

D.4.9.1 The effect of trees on the performance of the lighting installation should be considered at the design stage and care taken to minimise the need for unnecessary pruning, damage to the tree and to the lighting asset throughout the expected life of the lighting installation. Account should be taken of the inevitable growth in height and spread of the tree and help and advice sought from an arboriculturist at the design stage.

D.4.9.2 The impact of tree growth on the performance of lighting installations throughout the asset lifecycle should be considered. Where inspections, condition surveys, customer reports or other observations identify that vegetation is significantly obstructing light output or reducing the effectiveness of the lighting installation, appropriate investigation and remedial action should be considered in accordance with the highway authority's policies and risk-based approach.

D.4.9.3 For solar powered lighting installations in particular, consideration should also be given to the potential shading effects of both existing trees and future tree growth. Reduced exposure to sunlight can significantly diminish solar panel charging efficiency, leading to lower energy storage and reduced lighting performance. Designers should assess seasonal variations in canopy density, potential future shading, and the orientation and placement of solar luminaires to ensure adequate solar access throughout the asset's lifespan.

D.4.9.4 Care should be taken to avoid unnecessary damage to roots and branches when erecting or removing lighting columns or excavating cable trenches. See NJUG Guidelines for the Planning, Installation and Maintenance of Utility Services in Proximity to Trees for further details.

D.4.9.5 More details can be found in Part B of this Code regarding siting of trees, and clearance for vehicles.

D.4.10 LIGHT MEASUREMENT

D.4.10.1 The process for measuring lighting performance is set out in BS EN 13201-2.

D.4.10.2 A risk-based approach should be used to determine whether Lighting measurements are used to verify the failure point of LED luminaires, where this is due to parametric failure (the most common failure mode), and also for non-LED lighting systems, to verify that a lamp change has taken place as part of a group lamp replacement cycle.

D.4.10.3 To verify performance, lighting level measurements should be carried out after any planned full road-replacement lighting scheme to confirm that on-site illumination meets the design specifications. It may also be beneficial to record measurements before the scheme is implemented, enabling a comparison of pre- and post-installation lighting levels should any customer concerns arise following the works.

SECTION D.5 ASSET KNOWLEDGE – LIGHTING

D.5.1 INTRODUCTION

D.5.1.1 Asset data management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

D.5.1.2 Asset management systems are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C. This document should be referred to and the advice below considered supplementary.

D.5.2 PRINCIPLES AND CONSIDERATIONS

D.5.2.1 Lighting asset management systems should provide and support the following list of functions for the assets listed in the scope in D.1.1:

- collection, storage and retrieval of inventory data and condition data;
- works management and prioritisation;
- production and reporting of national and local performance data;
- deterioration modelling and life cycle planning;
- management and storage, in electronic format, of drawings, photographs and reports;
- identify different cleaning intervals for installations with different conditions, lamp types, environmental zones, and luminaire IP ratings; and
- identify appropriate routine maintenance intervals for installations with different conditions, including for example: lamp types, LED configuration, Driver type, environmental zones and luminaire and gear compartment IP ratings.

D.5.2.2 Critical attributes that a lighting asset management system should include are:

- Charge code
- Switch regime
- Control gear type
- Manufacturer model
- Metered (yes/no)
- Asset type
- DNO/DSO/IDNO or private network
- Electrical Supply distributor
- MPAN
- Asset ID
- Asset Condition

- Luminaire optic
- Date of equipment installation
- Asset OS Coordinates
- Approved attachments
- Column height
- Column material
- Column foundation type

D.5.2.3 The asset management system should be kept up to date to ensure the currency of the data held, and responsibility for updates should be confirmed.

D.5.2.4 The National Underground Asset Register NUAR is a digital map of underground pipes and cables in England, Wales, and Northern Ireland

D.5.2.5 Accurate recording of asset data, inspection records and maintenance activities is essential. Authorities should seek to maintain asset information of sufficient quality to support operational, maintenance and investment decisions. Periodic checks of data quality may be undertaken where appropriate to the intended use of the information and the consequences of inaccuracies.

D.5.2.6 Asset data will also support the calculation of Gross Replacement Cost and Depreciated Replacement Cost for lighting associated with highway infrastructure, as required for Whole of Government Accounts. Guidance on this is available from CIPFA.

D.5.2.7 Guidance has been developed on Managing Unmetered Energy Street Lighting Inventories (MUESLI), which covers the following:

- the proper establishment and maintenance of unmetered supply inventories for unmetered supply customers;
- appropriate practices for Distribution Network Operators when checking that inventories are accurate and being properly maintained; and
- procedures for remedial actions if material irregularities or discrepancies are identified.

ADAPTIVE LIGHTING

D.5.2.8 Adaptive lighting is typically enabled through the use of Central Management Systems (CMS). CMS are digital platforms used to remotely monitor, control, and optimise street lighting networks. They provide remote visibility of each streetlight, automatic fault reporting, the ability to adjust lighting levels, and the ability to integrate with other digital platforms. Emerging technologies are increasing interoperability between CMS, Intelligent Transport Systems (ITS) assets, connected sensors and wider smart city infrastructure, providing interfaces through which lighting can respond dynamically to traffic demand, pedestrian movements, environmental conditions, and network events.

D.5.2.9 To maintain consistent and reliable records, seamless and intuitive interoperability between the inventory and the CMS database is essential Authorities may adopt different approaches to maintaining alignment based on local needs, system complexity and risk. The following represent

the recommended minimum CMS and inventory attributes that should be standard across all CMS solutions on the market:

- whether the light is operating as expected or not – e.g., faults or outages;
- circuit characteristics - current, voltage, power factor;
- switch on and off times;
- adapting levels; and
- total energy consumed (see Section D.7, trading arrangements).

D.5.2.10 In addition, it is possible to include the following:

- predictive faults based on historical performance and component characteristics, noting that on-site behaviour may differ from factory-tested performance;
- integration of additional sensors in luminaire sockets;
- breach of base compartment / door off; and
- estimate light output reporting.

D.5.3 RELIABILITY OF DATA

D.5.3.1 Asset data management is dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

D.5.3.2 Opportunities to ensure quality and reliability of data occur at a number of levels including:

- survey instructions and documentation;
- selection and appointment of staff;
- training;
- specification and procurement of surveys;
- audit procedures;
- survey procedures;
- data capture software;
- processing software;
- definition and accuracy of asset replacement components;
- maintenance and calibration of survey and measuring equipment; and
- record keeping.

D.5.3.3 Considerable care should be taken in the derivation of locally enhanced versions of surveys to ensure that data can be extracted, without bias from the survey.

D.5.3.4 The completeness and accuracy of as-built information is essential for effective asset management. Authorities should seek to maintain accurate and timely asset information from new

installations, replacements, repairs, modifications, and removals. As-built records should include relevant asset attributes, locations, component changes, and associated documentation necessary to support future maintenance, inspection, operational and investment decisions.

D.5.4 RECORDING OF INFORMATION

D.5.4.1 Information obtained from surveys, together with any immediate or programmed action, including nil returns, can be used to support maintenance planning, risk management and future investment decisions. The extent of review and analysis should reflect the significance of the information and associated risks.

D.5.5 DEVELOPMENTS IN SURVEY TECHNOLOGY

D.5.5.1 Survey strategies should be reviewed regularly to take account of emerging technologies and methods. This may include the use of in-vehicle systems and remote location and communications technology to identify and record the location of defects in real time, enabling information to be shared directly with the works gang. Recorded defects should then be reviewed, assessed, and prioritised for remedial action.

D.5.5.2 Emerging technologies, data collection methods, survey systems, and analytical tools can provide valuable information to support lighting asset management. However, these technologies should complement rather than replace professional judgement. Asset data should be subject to appropriate review, validation, interpretation, and challenge by competent personnel to ensure that decisions are proportionate, evidence based and reflect local circumstances.

SECTION D.6 RESILIENCE AND ADAPTATION – LIGHTING

D.6.1 INTRODUCTION

D.6.1.1 The definitions and overall principles for resilience of highway infrastructure are dealt with in Part A of this Code. This section contains information on resilience and adaptation, specifically related to lighting assets.

D.6.1.2 Resilience in lighting assets plays a key role in supporting the core objectives set out in this Code. Well-designed and maintained lighting infrastructure contributes to safety by maintaining visibility during normal operation and adverse conditions, while also enhancing customer confidence through a service that is reliable, responsive, and dependable.

D.6.1.3 Resilient lighting further supports serviceability by ensuring the network remains operational or can be restored quickly following disruption. It also contributes to sustainability by reducing the need for reactive maintenance, lowering whole-life costs and minimising environmental impacts. As climate pressures and network demands increase, embedding resilience within lighting assets is essential to maintaining safe, reliable, and efficient highway networks.

D.6.1.4 Authorities should incorporate resilience and climate adaptation considerations into their lighting asset management plans, integrating climate adaptation, asset condition, service reliability, emergency preparedness, and wider infrastructure resilience considerations. Particular attention should be given to locations where environmental stresses, asset ageing, dependence on electrical power supplies or communications infrastructure, and service criticality combine to create elevated risks of failure or prolonged outage. These considerations should inform the risk-based approach with respect to inspection regimes, maintenance activities and renewal programmes.

D.6.2 HOW RESILIENCE SUPPORTS THE CODE'S OBJECTIVES

D.6.2.1 Improving the resilience of lighting assets is essential to safety, customer confidence, serviceability, and long-term sustainability, particularly for Authorities managing ageing and diverse networks.

D.6.2.2 Well designed and robust lighting infrastructure helps reduce the risk of asset failures such as column collapse from high winds, corrosion of steel and concrete columns, electrical faults, ground movement, flooding of feeder pillars, and damage from vehicle strikes.

D.6.2.3 These risks are being amplified by intensifying weather hazards, including more frequent and intense storms, prolonged wet conditions, and temperature extremes, which accelerate deterioration and increase the likelihood of outages. Reliable and rapidly recoverable lighting is especially important following severe weather events, when prolonged darkness on busy roads, junctions, and residential streets can lead to safety concerns, public complaints, and reputational risk for authorities.

D.6.2.4 Resilient assets reduce unplanned interventions, emergency repairs, and resource intensive reactive maintenance, helping Authorities manage constrained budgets and limited operational capacity. Over the longer term, designing and maintaining lighting to withstand future climate

conditions supports whole life cost efficiency, reduces waste and premature replacement, and enables Authorities to balance statutory duties, risk-based maintenance, and local priorities while keeping the network safe and fit for purpose.

D.6.3 HAZARDS AND POSSIBLE MITIGATIONS

D.6.3.1 There are a large number of hazards that can affect lighting assets, the information below provides indicative, illustrative examples of some of the risks that may arise with possible mitigation measures.

D.6.3.2 The examples below are not exhaustive and should not be interpreted as prescriptive or mandatory actions. In practice, local Highway Authorities may determine their own appropriate mitigations subject to funding levels.

WEATHER AND CLIMATE

D.6.3.3 High winds pose a significant risk to lighting columns because strong gusts can cause them to sway, weaken, or fail. Over time, repeated wind movement can reduce stability and increase the likelihood of structural issues. Trees add further risks, especially during storms as falling branches or whole trees can strike lighting columns and nearby assets. Tree roots also can compromise the stability of lighting columns by disturbing surrounding ground or exerting pressure on foundations.

D.6.3.4 To mitigate against these risks, lighting columns should be designed to withstand expected wind conditions in accordance with BS EN 40 and PD 6547. Coordinating with landscaping and design teams on tree placement, species selection, root-management, and ongoing maintenance further helps prevent avoidable damage in high-wind events.

FLOODING AND WATER

D.6.3.5 Flooding is a major concern for lighting assets, especially for lighting columns, feeder pillars, and base lit bollards. Water ingress, especially when contaminated with debris, chemicals, and pollutants, can cause electrical failure, insulation breakdown, corrosion, and long-term deterioration of components even after drying, making equipment unsafe to re-energise without specialist inspection and, in many cases, replacement. Submerged electrical equipment also presents significant fire and shock hazards, with moisture and sediment severely compromising wiring, switches, and internal components.

D.6.3.6 As flood events increase in frequency and severity, lighting infrastructure becomes more vulnerable to repeated exposure and cumulative damage. Improving resilience involves elevating key components above expected flood levels, using higher specification cables, doors, or plinth mounted designs, and applying flood risk mapping when planning installations. Any equipment exposed to water must be professionally assessed, tested, and replaced where necessary, supported by long term resilience strategies for high-risk locations.

GROUND INSTABILITY AND GEOTECHNICAL HAZARDS

D.6.3.7 Ground instability can cause lighting columns to lean, creating structural weakness and placing extra strain on attached wiring and connections. Soil movement, erosion, poor compaction, or subsidence can all shift the column's foundation, gradually altering its alignment and increasing the chance of faults or failure. These issues may also misalign or tension cables, leading to further operational problems.

D.6.3.8 To reduce these risks, lighting columns should be designed with foundations, and installation methods appropriate to the site's topography and ground conditions. This includes ensuring suitable foundation depths, using stable backfill, and accounting for slopes or softer ground. Close collaboration with the teams responsible for geotechnical and geo-assets is essential, as their understanding of soil behaviour, ground movement, and local instability helps inform the design and placement of lighting assets. Regular inspections in areas prone to movement help identify early signs of lean or ground disturbance, allowing timely remedial action and preventing more serious asset failures.

ENVIRONMENTAL

D.6.3.9 Corrosion is a significant risk for lighting columns, particularly in coastal areas where air with a higher concentration of chlorides accelerates metal deterioration, and on gritting routes where repeated exposure to de-icing salts can damage column surfaces, fixings, and electrical components. Over time, this leads to weakened structures, reduced asset lifespan, and a higher likelihood of failures.

D.6.3.10 To manage these risks, Authorities should use suitable, corrosion-resistant materials and protective coatings, particularly for assets in known high-exposure areas. Identifying vulnerable locations early allows targeted inspections and planned interventions before deterioration becomes critical. Coordination with winter service planning, covered in B.5 Resilience and Adaptation, is essential to understand which routes receive frequent salting and to ensure lighting assets in these areas are specified, protected, and maintained to withstand increased corrosion exposure.

LIGHTING ASSET/INFRASTRUCTURE FAILURE

D.6.3.11 If multiple columns share similar weaknesses, such as ageing materials or hidden corrosion, there is a risk that failures may occur across a wider area rather than as isolated incidents. This can lead to sudden loss of lighting over entire routes or neighbourhoods, creating safety concerns for road users, increasing maintenance pressures, and reducing overall network resilience. Failures may develop gradually, for example through progressive deterioration at the column root, or occur suddenly if a shared defect goes undetected. This risk is further elevated where complex or non-standard lighting structures are present such as columns carrying multiple catenary cables or split root cast iron designs as these may be difficult to inspect using standard Non-Destructive Testing (NDT) techniques, increasing the likelihood of undetected defects. Identifying such assets and developing specific resilience or maintenance plans is therefore essential.

D.6.3.12 To reduce this risk, Authorities should proactively assess asset condition, prioritising the identification of vulnerable lighting assets, high-risk locations, and early signs of deterioration. These activities should be aligned with the guidance in the section D.5 Asset Knowledge and section D.4 Risk Based Approach of this Code.

HUMAN/SOCIAL DISRUPTION

D.6.3.13 Attachments to lighting columns can create significant risks when they are installed without proper approval or oversight. A lack of oversight raises direct safety concerns, as poorly fitted or unstable items can detach, fail, or expose live components, posing risks to the public and maintenance teams. Poorly installed attachments may disturb wiring routes, loosen connections, make faults harder to detect or impact the structural integrity of the asset, posing risks to both the public and maintenance teams.

D.6.3.14 To manage these risks, authorities should operate a clear licensing process for all temporary attachments, ensuring installations are assessed, recorded, and safely installed. Regular monitoring and prompt removal of unauthorised or unsafe items further reduces the likelihood of damage. Publishing guidance for third parties helps set clear expectations on what can be attached, how it must be installed, and the safety requirements that must be met to protect both the asset and the wider network.

SECURITY/MALICIOUS ATTACKS

D.6.3.15 Security and malicious attacks present a risk to lighting assets, vandalism can cause damage to columns, doors, wiring, and associated equipment. Acts such as tampering or deliberately damaging components can reduce asset reliability, create electrical hazards, and increase maintenance demands. These incidents may also compromise the safety of the surrounding area if lighting performance is affected.

D.6.3.16 To mitigate these risks, Authorities can apply security measures set out in PAS 191 or TD 501 to strengthen the physical protection and resilience of assets, install CCTV in vulnerable or high risk locations to deter malicious behaviour, and use column protectors to reduce the likelihood of impact or deliberate interference. Together, these measures help safeguard lighting infrastructure, maintain network reliability, and support a safer public environment.

ELECTRICITY AND TECHNOLOGY FAILURE

D.6.3.17 Highway lighting networks are exposed to electricity and technology failures arising from loss of power supply, failure of control equipment, and disruption to communications used by Central Management Systems (CMS). Increasing reliance on intelligent and adaptive lighting, often supported by public 4G/5G networks, introduces vulnerability to telecommunications outages, CMS platform failures, and cyber related incidents. These failures can lead to loss of lighting, loss of monitoring and fault reporting, and reduced ability to manage assets effectively. Where communications are unavailable, adaptive lighting performance and associated energy reporting may also be compromised, with potential financial impacts if energy settlement defaults to assumed full load consumption.

D.6.3.18 Authorities should adopt a risk-based and proportionate approach to managing electricity and technology failure within lighting systems. TD 501 considers how a risk assessment for outages may be approached. This can be through CMS solutions with appropriate resilience, such as mesh or star network architectures, to reduce single points of failure and maintain local operation in the absence of central communications. Systems should incorporate predefined fallback modes to ensure lighting remains available at safe operating levels during power or communications disruption. Critical locations may justify the installation of an alternative, backup power supply, such as Uninterruptible Power Supplies (UPS) to maintain continuity during short term power interruptions. Arrangements for secure local storage and subsequent transmission of energy data help minimise financial and operational impacts during outages. Proportionate cyber security controls should be applied to intelligent lighting systems to protect against accidental or malicious failure.

GAS-POWERED LIGHTING AND FUTURE FUELTRANSITION RISK

D.6.3.19 Lighting assets that rely on gas supply face an increasing long term resilience risk due to national decarbonisation objectives and potential changes to the availability, regulation, and cost of mains gas. Authorities should recognise the possible planned or unplanned cessation of gas supply as a

foreseeable risk and address this through asset management and climate adaptation planning. Where appropriate, Authorities should consider alternative low or zero carbon supply solutions that enable the reuse of existing lighting equipment helping to reduce cost, embodied carbon, and disruption. Any transition approach should be subject to appropriate safety, performance, and whole-life cost and carbon assessment.

SECTION D.7 FINANCE AND INVESTMENT – LIGHTING

D.7.1 INTRODUCTION

D.7.1.1 Finance and Investment principles and considerations are dealt with in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B. This document should be referred to and the advice below considered supplementary.

D.7.1.2 The general principles relating to finance and investment at a network level are set out in Part A of this Code. These should be referred to in the first instance, with the guidance below providing additional detail specific to lighting assets

D.7.2 MAKING THE CASE FOR INVESTMENT

D.7.2.1 A clear, evidence-based case for investment should be presented by showing how proposed lighting schemes deliver measurable benefits and support wider organisational objectives. This includes capturing, documenting and clearly explaining how Benefit–Cost Ratios (BCR) and Value for Money (VfM) assessments have been developed where applicable, as these commonly form part of the justification for funding decisions. However, it is recognised that many of the benefits associated with lighting, particularly those relating to public safety, perceptions of safety, accessibility, equality, and community confidence are difficult to quantify or assign a monetary value. Investment appraisals should therefore explicitly acknowledge and document these qualitative considerations alongside quantitative assessments. In addition, some lighting interventions may arise from strategic, policy led or community led decisions that would not, in isolation, meet conventional BCR or VfM thresholds. In such cases, the basis for investment should be clearly articulated, including the broader social, strategic, or reputational drivers. Ultimately, investment proposals should be robust enough to demonstrate their priority relative to competing service areas and clearly show how the scheme contributes to network performance, long-term sustainability, and strategic goals

D.7.2.2 Evaluating Value for Money (VfM) for lighting schemes might consider environmental benefits along with electricity or maintenance savings. Carbon-reduction impacts can significantly influence overall VfM and should be captured alongside financial metrics. Wider environmental factors including impacts on flora and fauna, which can carry recognised economic values should also be taken into account where relevant. In line with the principles set out in the HM Treasury Green Book, VfM assessments should consider these broader social, environmental, and economic benefits to ensure the full value of a lighting scheme is represented rather than relying solely on energy-reduction outcomes.

D.7.3 INCOME GENERATION

D.7.3.1 There are opportunities to generate income by enabling the use of street lighting columns and associated infrastructure to host equipment such as 4G/5G small-cell telecommunications units and CCTV enforcement cameras. While this can generate income and support better integration and targeting of council services, helping resources to be used more effectively and budgets to go further, it should be recognised that certain uses particularly enforcement-related equipment may increase the risk of vandalism or malicious damage. Such risks should be considered as part of asset management, design detailing, and maintenance planning to protect both the lighting asset and hosted equipment.

D.7.3.2 Income-generating arrangements should align with the highway authority's wider lighting asset management strategy and commercial policies, ensuring that revenue opportunities are balanced with long-term lighting asset integrity, public safety, and service performance.

D.7.3.3 There are several Electric Vehicle charging models that a highway authority can adopt. Authorities should base their model choice on the ownership and delivery approach that best fits their organisational capability, risk tolerance, and long-term objectives. IET guidance Guide to Electric Vehicle Charging Infrastructure for Local Authorities provides guidance on EV charging ownership and operation models.

D.7.4 COMMUTED SUMS

D.7.4.1 Commuted sums are capital payments made by developers or third parties to cover the long-term costs that a highway authority will incur in maintaining, repairing, and ultimately replacing new or upgraded lighting assets that are being provided, adopted or transferred into its ownership.

D.7.4.2 ADEPT's Commuted Sums for Highway Infrastructure Asset Management provides guidance on approaches to calculating commuted sums and outlines how contributions may be considered to support the future maintenance and replacement of highway infrastructure, including lighting assets, intended for adoption by authorities.

D.7.5 SERVICE AGREEMENTS

ATTACHMENTS

D.7.5.1 Where street lighting assets support co-located technologies such as electric vehicle chargers, 5G equipment, or small-cell telecommunications infrastructure, a legally binding agreement should be established with the relevant operator.

D.7.5.2 This agreement should clearly define responsibilities for installation, maintenance, energy use, access, emergency attendance, accident or malicious damage (including vandalism), maintenance and repair liabilities, and the allocation of costs, ensuring that the highway authority's interests and statutory duties are protected.

D.7.5.3 Careful assessment is required to confirm that the lighting asset can safely accommodate additional equipment. This should include consideration of structural capacity, proposed attachment methodology, electrical demand, and compliance with required clearances to the road and surrounding infrastructure, as well as any potential operational impacts such as sightline restrictions or access constraints.

D.7.5.4 Where third-party equipment is attached to lighting columns or other lighting infrastructure, the assessment should be undertaken in accordance with relevant industry guidance and standards. Consideration should be given to the requirements of:

- ILP guidance GN12 The Smart Lighting Column;
- PLG06 Guidance on Installation and Maintenance of Seasonal Decorations;
- PAS 190 Assessment of Lighting and CCTV Columns;
- PAS 191 Multi-Functional Lighting & CCTV Columns Design;
- with any requirements arising from the Telecommunications Act, and

- Electronic Communications Code.

D.7.5.5 Particular attention should be given to structural capacity, wind loading, attachment methods, drilling or modification of the existing structure, electrical interfaces, inspection requirements, and the long-term maintenance responsibilities associated with the attached equipment.

ELECTRICAL SUPPLIES

D.7.5.6 The provision of public lighting is largely dependent on the supply of electricity through the network of the DNO/DSO or an Independent DNO (IDNO). An IDNO is an embedded network within a DNO/DSO area increasingly used for new domestic or commercial developments. The obligations on IDNOs and DNO/DSO are the same. Where an IDNO supplies street lighting assets, a Service Level Agreement (SLA) should be established to ensure that attendance times, response arrangements, and general service levels meet the operational needs of the highway authority. The SLA should clearly set expectations around fault attendance, communications, and escalation procedures.

D.7.5.7 Some highway authorities own and operate private cable networks for lighting assets. These networks may provide functions beyond the electrical supply to lighting columns such as the operation of passive safety equipment disconnection systems. Highway authorities should take account of the ongoing maintenance, safety and liability implications of such networks and ensure that the associated investment requirements are reflected within asset management strategies, lifecycle planning, and long-term funding programmes.

D.7.5.8 To obtain or continue to have an unmetered supply a highway authority must comply with:

- the criteria identified in The Electricity (Unmetered Supply) Regulations;
- a Connection agreement with the respective Distribution Network Operator/ Distribution System Operator (DNO/DSO). This agreement will follow the national terms of connection; and
- the obligations described in the Balancing and Settlement Code (BSC) for unmetered supplies captured in BSCP520 and its associated documents.

D.7.5.9 For connected loads exceeding 2000W at a supply point, the DNO may request the provision of a metered connection, were reasonably practicable. Metered connections may also be required in certain circumstances, including where Elexon unmetered supply codes are not available or were indicated by the Balancing and Settlement Code (BSCP520). Authorities should take account of DNO requirements and should consider whether the provision of a metered connection represents best value, informed by an appropriate assessment such as a benefit cost review. For metered connections, including those to private or embedded networks, authorities should ensure that suitable metered connection agreements are in place with the DNO.

D.7.5.10 Ofgem have set out a minimum level of service for new connections. This is currently covered under the Guaranteed Standards of Performance (GSoPs). Departures from the GSoPs should mean that rebates for non-performance are made by the DNO/DSO / IDNO and if necessary, after exhausting the DNO/DSO / IDNO complaints procedure, recourse to Ofgem in terms of non-performance.

D.7.5.11 It should be borne in mind that following a decision in the High Court (PN Daly Ltd and United Utilities Electricity PLC v Wigan MBC, 2003), it was established that the works involved in the

connection and disconnection of street lighting and other items of street furniture to the electricity distribution system are not “street works” but are “works for road purposes”.

D.7.5.12 Competitive arrangements are in place for connections, disconnections, and transfers through the use of authorised Independent Connection Providers (ICP). DNO/DSOs / IDNOs are obliged to facilitate competition and also not to discriminate between their own business activities and that of competitors. Reference should be made in particular to the Competition in Connections Code of Practice.

PROCEDURES FOR NEW INSTALLATIONS

D.7.5.13 New installations include the following:

- new capital lighting schemes;
- road improvement schemes;
- provision of connections and/or disconnections;
- transfers; and
- new services.

D.7.5.14 The agreement or contract should detail the procedures to be followed by both parties when:

- placing orders;
- notifying that equipment is installed and ready for connection; and
- notifying that equipment has been connected.

D.7.5.15 In order for the ICP or DNO/DSO / IDNO to comply with the required response time for a new installation the highway authority will need to supply relevant information:

- an accurate location of the equipment involved including:
  - postcode;
  - asset number;
  - location, road name and, for example, side of, rear of, outside house number, etc;
  - a map of the area (minimum size 1:1250 with the apparatus highlighted); and
  - Ordnance Survey co-ordinates or GIS co-ordinates.
- a description of the work involved, and the number of points involved.

D.7.5.16 The estimate from the ICP / DNO/DSO / IDNO should include the following information:

- a plan showing the extent of the works together with any civil engineering works (for instance ducts) required from the highway authority;
- a schedule detailing the estimated costs based on the standard schedule of rates where applicable; and
- a breakdown of contestable and non-contestable works.

D.7.5.17 The highway authority may also request one or more ICPs to provide an estimate for the contestable elements. The highway authority, on accepting the estimate, shall provide an order for the works together with a programme of works.

D.7.5.18 On installation of the new equipment, or when existing equipment is ready to be disconnected/transferred, the highway authority shall advise the ICP / DNO/DSO / IDNO advising that the site is now ready for their works.

D.7.5.19 The highway authority should amend the Asset Management System accordingly as soon as practicable with all connections, disconnections, and alterations. The relevant DNO/DSO / IDNO should also be recorded.

PROCEDURES FOR REPAIRS

D.7.5.20 The agreement or contract should detail the procedures to be followed by both parties when a fault is identified.

D.7.5.21 When the Highway authority has identified a fault on a DNO/DSO / IDNO electricity service it shall notify the DNO/DSO / IDNO as soon as possible.

D.7.5.22 The DNO/DSO / IDNO shall respond to faults within or better than the timescales set out in the Electricity (Connection Standards of Performance) Regulations and the Quality of Service Guaranteed Standards

D.7.5.23 The highway authority is responsible for providing a safe enclosure for the DNO/DSO service termination equipment and reporting any concerns or faults with the cut-out or service termination equipment.

D.7.5.24 The highway authority should monitor the DNO/DSO / IDNO performance in order to validate or, if required, claim rebates. It should be noted that the DNO / IDNO is required to pay rebates for non-performance, there is no requirement for these to be claimed by the customer. Highway authorities should appreciate the necessity to ensure that DNO/DSO / IDNOs are provided with accurate and reliable information in a timely manner when they are requested to carry out work. Failure to do so may lead to a failure to enforce any remedial action or rebates.

CUT-OUTS

D.7.5.25 Most highway authorities have the ability to operate the cut-out for the purpose of connecting internal wiring, withdrawing fuse carriers during maintenance of equipment, and replacing failed fuse cartridges. This is included within ENA EREC G39 and the Competition in Connections Code of Practice.

ELECTRICITY SETTLEMENT INVENTORY

D.7.5.26 The Connection Agreement and the Balancing and Settlement Code (BSC) obligations require the Highway authority to maintain an accurate inventory of all unmetered equipment. This inventory should be submitted to each of the DNO/DSOs who have connections on a frequency agreed with the DNO/DSO. If there are frequent changes to the inventory, then this may be monthly but where few changes this may extend too annually.

D.7.5.27 The content and file structure of the inventory submission is defined in the BSC Operational Information Document. The parties may agree an alternative format.

D.7.5.28 The key data items are the Charge Code which is a 13-digit code defining the type of unmetered equipment and the Switch Regime defines the type of operation of the equipment (e.g., continuous, electronic photocell 35/18lux, or part night).

D.7.5.29 Generic LED Charge Codes and variable power switch regimes have been produced by Elexon.

D.7.5.30 The BSC website includes lists of approved Charge Codes and Switch Regimes and their associated information, such as chargeable watts. Equipment manufacturers apply for Charge Codes when they first place equipment on the market.

D.7.5.31 The asset management system should identify the relevant DNO/DSO / IDNO to which the equipment is connected and whether the connection is metered or unmetered.

D.7.5.32 Unmetered supplies are based on an assumption that the Highway authority maintains an accurate and up to date inventory. Under the Connection agreement the DNO/DSO can audit the identified street furniture and the inventory records to identify material discrepancies. The Managing Unmetered Energy Street Lighting Inventories (MUESLI) covers the audit methodology.

TRADING ARRANGEMENTS

D.7.5.33 Unmetered supplies can be traded on a Half Hourly (HH) or Non-Half Hourly (NHH) basis. Most large unmetered supplies are traded on a HH basis.

D.7.5.34 NHH trading uses the inventory to determine an Estimated Annual Consumption (EAC) using predefined annual hours which differ across 14 areas of GB.

D.7.5.35 HH trading can utilise a PECU Array and/or CMS equipment switching information to give more reflective consumption data. The highway authority should contract with a BSC approved Meter Administrator to use the inventory and switching data to calculate HH data.

- Highway authorities should procure energy through their corporate procurement arrangements who normally employ a specialist utilities procurement organisation.

SECTION D.8 SUSTAINABILITY – LIGHTING

D.8.1 INTRODUCTION

D.8.1.1 The principles of sustainability for highway infrastructure can be found in Part A of this Code. This section contains information on sustainability specifically related to lighting. Sustainability in lighting involves balancing environmental, social, and economic factors across the whole asset lifecycle to ensure efficient, resilient and responsible lighting provision.

D.8.2 ENVIRONMENTAL SUSTAINABILITY

D.8.2.1 TM66 Creating a circular economy in the lighting industry | CIBSE provides guidance on the selection and management of lighting assets to support circular economy principles. This includes consideration of luminaires designed for durability, ease of disassembly, repair, upgrade, and eventual material recovery. Where available and applicable, TM66 Circular Economy Scores and supporting product data should be considered during procurement to inform decision-making and to promote improved reuse, refurbishment, and recycling outcomes across the lighting lifecycle.

REUSE, RECYCLING AND WASTE DISPOSAL

D.8.2.2 Responsible management of materials is a core requirement for lighting assets, and particular attention should be given to repair, reuse, recycling, and appropriate waste disposal.

D.8.2.3 Luminaires should be recycled wherever possible, and where recycling is not feasible, disposal should follow approved processes. Most lamps fall under the category of hazardous waste, meaning their handling and disposal should comply with relevant regulatory frameworks.

D.8.2.4 Lamp and Luminaire Producer Schemes, funded through levies on new lamps and luminaires, provide structured and approved routes for disposal in accordance with WEEE Regulations and Environment Agency requirements. Examples of these can be found via the links below (other compliant schemes are available):

- Recolight
- WERCS

D.8.2.5 In addition to luminaire disposal, consideration should also be given to the responsible management of lighting columns and their foundations, many of which can contain recoverable materials. Steel and aluminium columns can be recycled, while concrete columns require specific handling and disposal routes, particularly where reinforcement or legacy components are present.

D.8.2.6 CMS nodes, control gear, and other electrical components may also offer opportunities for reuse or component recovery where condition allows, supporting a more circular approach to asset lifecycle management and reducing the volume of material sent to landfill.

D.8.2.7 The Street Works UK Material Classification Protocol provides guidance on the categorisation and management of waste materials generated during street works, including those related to lighting assets.

D.8.2.8 It is important to recognise the potential presence of asbestos in certain legacy street lighting assets particularly those installed or manufactured prior to the UK ban on all forms of asbestos in 1999. Where asbestos is suspected or identified, work must be carried out in accordance with the Control of Asbestos Regulations, using licensed contractors where required, and ensuring appropriate risk assessments, safe working methods and waste-handling procedures are followed.

ENERGY USE

D.8.2.9 Effective management of energy use is a central component of sustainable road lighting. Minimising energy consumption whilst maintaining required lighting performance not only reduces operational costs, but it also lowers carbon emissions and limits environmental impacts.

D.8.2.10 Sustainable approaches to energy use should be considered throughout the lifecycle of road lighting assets from initial design and equipment selection through to operation, control strategies, maintenance, and eventual asset renewal. The following should be considered:

- Whether lighting is still required
- Using appropriate luminaires with appropriate optical control.
- Selecting the correct lighting class to avoid over lighting.
- Adaptive lighting that ensures energy is used only when and where it is needed.
- Using control systems that optimise performance and identify faults early, preventing unnecessary energy consumption. It should be noted that fault identification within these systems can be limited and is not consistently reliable.
- Ensuring electrical infrastructure associated with lighting assets, such as cabling, is appropriately operated and maintained to reduce inefficiencies and minimise avoidable energy losses.
- Where site conditions allow, incorporating renewable energy solutions such as solar powered units for isolated locations or low energy installations.
- Ongoing monitoring of energy use through CMS data, metering or reporting frameworks to identify opportunities for improvement in energy use.
- Lighting asset obsolescence and the potential to adopt emerging technologies that may deliver improved energy efficiency over time.

BIODIVERSITY

D.8.2.11 Lighting assets, including during operation and replacement, should be managed in a way that minimises ecological impacts. Highway authorities should assess and mitigate the effects of light pollution, recognising that artificial lighting can alter habitats, disrupt natural behaviours, and contribute to the decline of sensitive species.

D.8.2.12 Particular attention should be given to protected species, such as bats, which are especially sensitive to artificial lighting. Where works may affect these species or their habitats, highway authorities should implement mitigation measures in accordance with relevant legislation, conservation guidance and recognised dark sky approaches. This may include adjusting light colour, timing, intensity, or direction. Designers and operational teams should minimise

unnecessary light spill, apply appropriate optical control, and ensure that lighting levels are no higher than required for operational safety.

CARBON EMISSIONS

D.8.2.13 Lighting assets play a key role in supporting carbon-reduction. Carbon emissions in lighting arise not only from the energy consumed during operation but also from the wider lifecycle of lighting assets. Other considerations for reducing carbon emissions in lighting include:

D.8.2.14 Reducing embodied carbon in materials and manufacturing through selecting materials or products with low embodied carbon, such as recycled aluminium or steel, prioritising products with Environmental Product Declarations (EPDs) or equivalent carbon data from schemes such as TM65 Embodied carbon in building services, selecting luminaires and columns with long service life to reduce frequency of replacement and working with suppliers that use low carbon manufacturing processes and renewable energy.

D.8.2.15 Selecting assets that last longer or those that can be easily refurbished and/or repaired rather than disposable ones in accordance with the circular economy principles set out in TM66 Assured Product Verification Scheme.

D.8.2.16 Ensuring modularity (e.g., replaceable drivers, removable optics) to extend the life of the luminaires in accordance with TM66 principles.

D.8.2.17 Optimising column and bracket design to reduce steel use, structural loads and foundation requirements, while maintaining long-term performance and maintainability.

D.8.3 SOCIAL SUSTAINABILITY

LISTED LIGHTING ASSETS

D.8.3.1 Where lighting is located within listed environments or heritage settings, authorities must recognise that statutory protections may extend beyond the primary structure to include supporting components such as brackets, luminaires, cabling routes, clips fixed into brickwork, and other associated fittings. In such contexts, replacement or modification may be restricted, and any intervention must be undertaken with specialist heritage advice. Tailored treatments should be prioritised to retain the character of the original installation. Reuse and refurbishment of existing components should be considered wherever feasible, as this not only preserves historical integrity but also offers environmental sustainability benefits through reduced material consumption and minimised waste.

D.8.3.2 When managing and maintaining lighting assets within Conservation Areas, UNESCO World Heritage Sites, and Areas of Outstanding Natural Beauty (AONBs), due regard should be given to the cultural, historical and landscape value of the area. Maintenance, replacement, and operational activities should be undertaken in a proportionate and visually sympathetic manner, aligned with local conservation objectives, to ensure that lighting does not detract from the special qualities that underpin the designation. Relevant guidance should be followed, including that published by Historic England, Historic Environment Scotland (HES), Historic Environment Division (HED) for Northern Ireland and Cadw for Wales.

D.8.3.3 In some locations, highway authorities should consider patterns of use and movements of people, when planning lighting provision. Lighting should support safe and intuitive navigation while

avoiding unnecessary or intrusive installations that may conflict with heritage or landscape character. Solutions should strike an appropriate balance between operational requirements, community expectations, and the preservation of historic and environmental assets.

DARK SKY PRESERVATION

D.8.3.4 The operation and maintenance of lighting assets should consider their impact on dark sky preservation, recognising its importance for community wellbeing, local heritage, and the protection of natural nighttime environments. Operational practices should minimise unnecessary upward light, avoid over-illumination, and apply precise optical control to preserve dark skies, particularly in rural or environmentally sensitive locations valued by the community. Where lighting assets are located within or may affect designated Dark Sky areas, operational and maintenance activities must comply with any specific requirements associated with those designations.

HUMAN IMPACTS OF LIGHT POLLUTION

D.8.3.5 Light pollution, particularly artificial light at night, has recognised social and human health impacts, including disruption to circadian rhythms, reduced sleep quality, and negative effects on wellbeing. Lighting operation and maintenance should therefore minimise intrusive light, avoid excessive brightness near residential areas, and ensure that lighting levels and operating hours are appropriate for actual usage. Where changes to lighting assets may affect how the surrounding environment is experienced or perceptions of safety, these impacts should be considered as part of the lighting asset management decision-making and risk assessment.

SAFETY

D.8.3.6 Safety must remain a primary consideration in the operation and management of lighting assets. Lighting should support safe movement for all road users including active travel users such as pedestrians and cyclists, enhance nighttime visibility, and contribute to secure public spaces. Operational and maintenance measures should be proportionate, avoiding over-lighting while ensuring that lighting levels remain appropriate to support community safety and meet operational requirements.

D.8.3.7 Equality impacts must also be considered in the operation and management of lighting assets, ensuring that spaces remain accessible and feel safe for all users. This should include taking account of information obtained through engagement with policing bodies and consideration of community feedback, to identify locations or conditions where equality impacts may arise. In particular, this includes recognising concerns related to Violence Against Women and Girls and the needs of active travel users by maintaining appropriate lighting along key pedestrian and cycle routes, minimising areas of concealment through effective operation and maintenance, and responding to issues identified through community or policing insight.

D.8.4 ECONOMIC SUSTAINABILITY

D.8.4.1 Effective economic sustainability in road lighting relies on evaluating costs across the entire lifecycle of lighting assets rather than focusing solely on capital cost. Highway authorities should consider installation, energy use, maintenance requirements, replacement intervals, and end of life treatment when planning or upgrading lighting infrastructure. Using whole life cost assessments supports more informed decision making and helps ensure that long term financial commitments remain manageable.

D.8.4.2 Where appropriate, the economic assessment of lighting should include consideration of alternative measures that may deliver comparable safety or operational outcomes at lower whole-life cost, ensuring lighting is retained or introduced only where it provides the most sustainable and cost-effective option.

D.8.4.3 Maintenance and asset management practices also have a major influence on long term expenditure and environmental performance. In support of circular economy principles, Authorities should prioritise durable, repairable equipment with readily available spare parts and solutions that simplify access for maintenance. Incorporating CMS can further reduce inspection visits and enable early identification of faults, minimising unplanned costs and service disruptions.

D.8.4.4 Lighting procurement strategies and material choices play an important role in economic sustainability. Standardising lighting equipment across the network, selecting suppliers who can guarantee long term support and choosing materials that offer long service life or recyclability can all improve value for money. Considering future risk such as regulatory changes, supply chain change or technology obsolescence is essential to circular economy approaches helping ensure that lighting assets can be maintained, upgraded, reused or refurbished rather than prematurely replaced, and that investments made today remain resilient, affordable and aligned with long term service plans.

PART E. TUNNELS

SECTION E.1 SCOPE OF PART E – TUNNELS

E.1.1 INTRODUCTION

E.1.1.1 Part E provides guidance for the management of highway tunnels forming part of the adopted highway network. It supplements the principles contained within Parts A to D of this Code and should be applied in conjunction with those Parts.

E.1.1.2 Highway tunnels are complex infrastructure assets comprising interdependent structural, mechanical, electrical, communications and operational technology systems. The safe operation of a tunnel depends upon the performance of these systems as an integrated whole. Unlike many highway assets, tunnels should therefore be considered and managed as integrated systems rather than collections of individual assets. Figure 14 illustrates this concept.

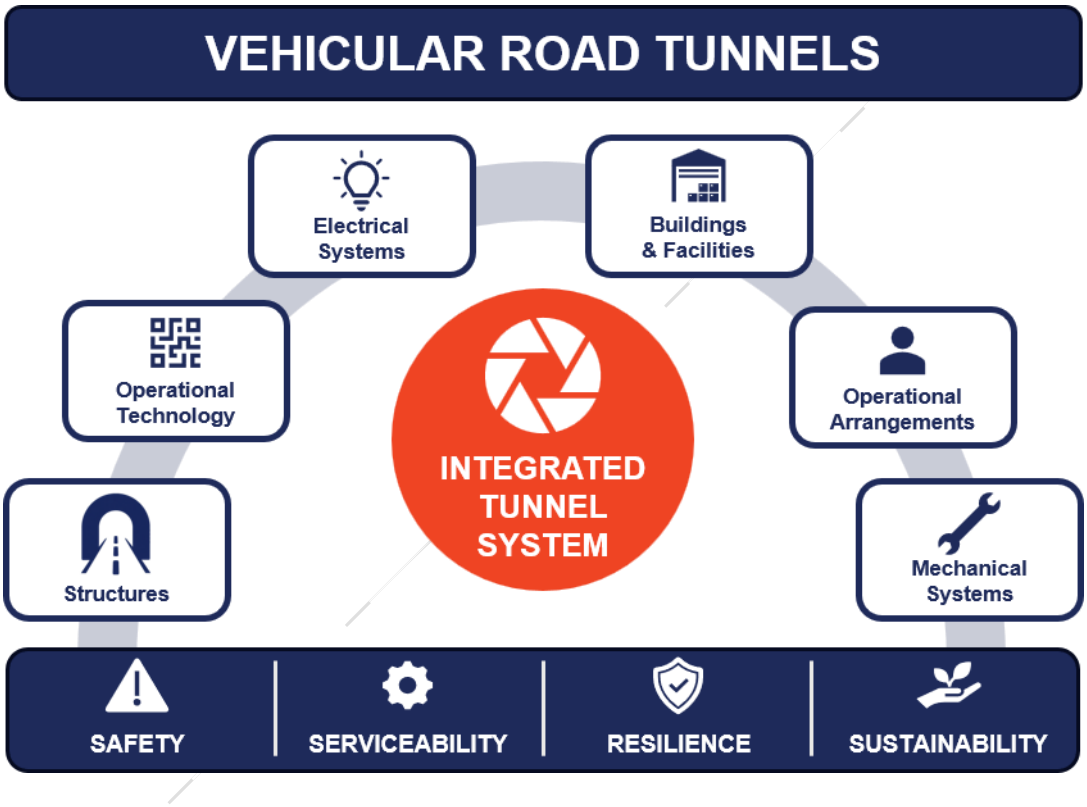


Figure 14 – Tunnel as an Integrated System

E.1.1.3 For the purposes of this Part, Operational Technology (OT) includes the hardware, software, communications infrastructure, operational networks, and control systems used to monitor, control, automate or support tunnel operations. This may include SCADA systems, programmable logic controllers (PLCs), control-room systems, operational networks, field devices and associated operational software supporting the safe operation and resilience of the tunnel.

E.1.1.4 The purpose of this Part is to support highway authorities in managing tunnel assets throughout their operational life, recognising the additional risks, system interdependencies and operational requirements associated with enclosed infrastructure. The guidance aims to support safe operation, operational resilience, serviceability, and whole-life value.

E.1.1.5 This Part focuses upon the management, operation, maintenance, inspection, and renewal of in-service tunnel assets. It is not intended to replace applicable statutory requirements, design standards, or technical approval procedures, which should continue to be applied where appropriate.

E.1.1.6 In developing and implementing asset management practices, highway authorities may draw upon Design Manual for Roads and Bridges (DMRB) standards where relevant, while retaining flexibility to adopt alternative approaches that best reflect local circumstances and organisational requirements.

E.1.1.7 For the purposes of this Code, a highway tunnel should be interpreted in accordance with the (DMRB) as a vehicular road tunnel with an enclosed length exceeding 150 metres.

E.1.1.8 Practices explained in this Part may also be transferrable to other assets with similar characteristics for hazard management purposes, such as pumping stations, long underpasses, or other assets (e.g. shorter assets than 150 metres) incorporating complex operational systems. Any such application should be undertaken in accordance with the authority's own risk management and governance arrangements.

E.1.1.9 Highway authorities may define and manage a tunnel as a wider tunnel system rather than solely the physical structure between the tunnel portals. The tunnel system may be comprised of the associated infrastructure that supports its operation, such as service buildings, control rooms, communications systems, operational technology (OT), monitoring systems, traffic management systems, power supplies, ventilation systems, and other supporting assets. Highway authorities should determine the extent of their tunnel system based on local circumstances, operational requirements, and risk, and ensure that asset management arrangements appropriately reflect those dependencies.

E.1.1.10 Highway authorities should identify interfaces and dependencies between tunnel systems and understand the consequences of their failure. Assets that support safety-critical functions should be managed as safety-critical elements where their failure could result in unsafe conditions, loss of resilience or operational restrictions, regardless of classification elsewhere within this Code.

E.1.1.11 Typical key components of this tunnel system include (not exhaustive):

- Tunnel structure;
- Tunnel buildings;
- Power supply and distribution systems;
- Fire detection and suppression systems;
- Evacuation and emergency communication systems;
- Ventilation systems;
- Lighting systems;
- Drainage systems;
- Operational Technology (OT), including SCADA systems, control systems, operational networks, and associated communications infrastructure;
- CCTV, incident detection, and monitoring systems;

- Tunnel operation and control functions; and
- Traffic control systems.

E.1.2 SCOPE AND APPLICABILITY

E.1.2.1 This Part should be applied in conjunction with the overarching asset management principles contained within Part A and relevant guidance contained within Parts B, C and D, as appropriate.

E.1.2.2 The structural elements of tunnels are addressed principally within Part C (Structures). This Part supplements Part C by addressing the management of tunnels as integrated operational systems comprising structural, mechanical, electrical, communications and operational technology assets.

E.1.2.3 General guidance relating to lighting and electrical assets is provided in Part D (Lighting). This Part supplements that guidance by addressing the tunnel-specific operational, safety, resilience and asset management considerations associated with those systems when they form part of a highway tunnel.

E.1.2.4 The guidance contained within this Part should be applied in a proportionate and risk-based manner, taking account of:

- the characteristics of the tunnel;
- network importance;
- operational complexity;
- traffic composition, usage, and associated risk;
- consequences of failure; and
- applicable statutory and regulatory requirements.

E.1.2.5 Where modifications, renewals or improvements are undertaken, highway authorities should ensure that appropriate governance, approval and change management processes are followed and that the safety, resilience, and functionality of the tunnel continue to be maintained throughout its operational life.

E.1.3 THE ROLE OF HIGHWAY TUNNELS

E.1.3.1 Highway tunnels provide essential transport links where geographical, environmental, urban development or planning constraints limit the feasibility of surface routes. They enable the movement of people and goods whilst reducing severance, supporting connectivity and maintaining continuity within the wider transport network.

E.1.3.2 Many highway tunnels form strategically important links within local, regional, and national transport networks and may have limited or no suitable diversionary alternatives. Their availability can therefore have a significant influence on network performance, journey reliability, and connectivity between communities. Figure 15 illustrates the role of tunnels within the wider transport network.

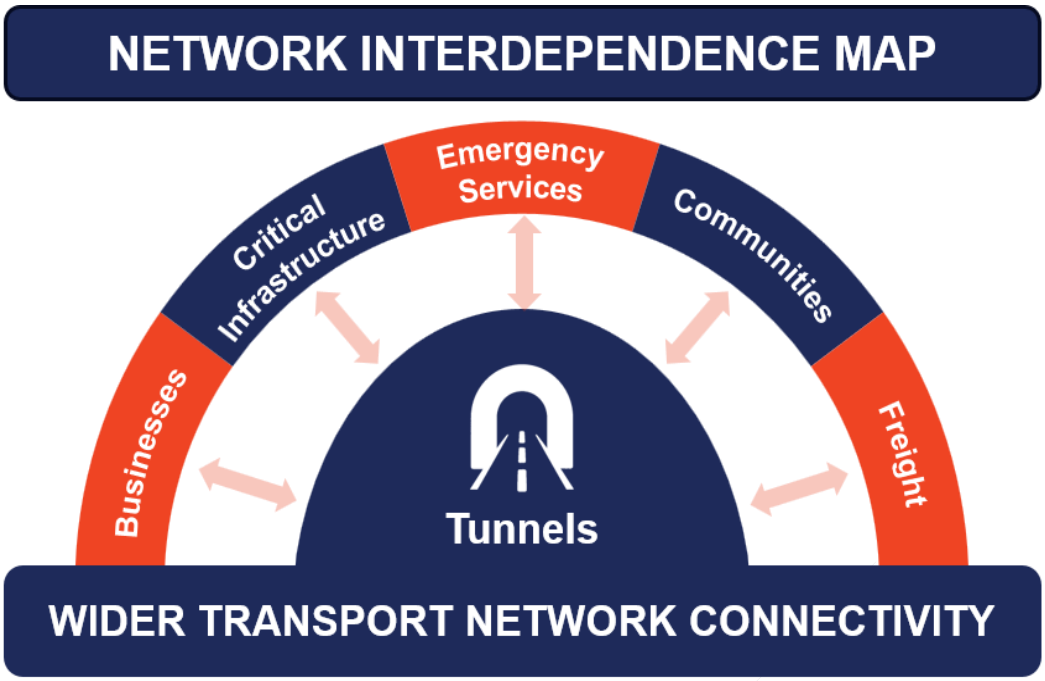


Figure 15 – Highway Tunnel Role in the Wider Network

E.1.3.3 Tunnel restrictions, degraded operation, or closure may result in significant impacts on road users, communities, businesses, and the wider economy. In some circumstances, tunnel closures may affect emergency response arrangements, freight movement, and access to critical infrastructure. Highway authorities should therefore recognise the strategic importance of tunnels within the wider highway network when establishing asset management and investment priorities.

E.1.3.4 Highway tunnels differ from many other highway assets because they operate as enclosed environments that depend upon the continued performance of multiple interconnected systems. Safe operation typically relies upon structural, mechanical, electrical, communications and operational technology systems functioning collectively as an integrated whole.

E.1.3.5 Highway tunnels compared to other infrastructure may be considered open systems in which the main hazards are introduced by road users rather than arising from the tunnel itself. Unlike many buildings or fixed transport systems, the vehicles using a tunnel may carry significant energy loads, combustible materials, hazardous substances or other risks that are largely outside the direct control of the tunnel operator, except where restrictions apply, such as those associated with ADR tunnel categories.

E.1.3.6 The principal operational hazards associated with highway tunnels generally arise from the use of the tunnel by vehicles and may include:

- fire and smoke incidents;
- hazardous goods incidents;
- toxic or hazardous spillages;
- vehicle collisions;
- vehicle breakdowns;

- flooding;
- failure of safety-critical systems.

E.1.3.7 Highway tunnels comprise integrated structural, mechanical, electrical, communications and operational technology systems which must function collectively to support safe operation and network performance. The management of highway tunnels therefore extends beyond the maintenance of individual assets and requires an understanding of the interactions and dependencies between systems.

E.1.3.8 Failure of safety-critical assets or supporting systems may result in operational restrictions, degraded operation, or tunnel closure. Highway authorities should adopt a proactive approach to asset management, inspection, maintenance, testing, renewal, operational planning, and resilience management throughout the asset lifecycle.

E.1.3.9 Highway tunnels represent significant long-term investments. Effective stewardship requires highway authorities to balance safety, operational performance, resilience, sustainability, and whole-life value when making asset management decisions.

SECTION E.2 LEGAL FRAMEWORK – TUNNELS

E.2.1 INTRODUCTION

E.2.1.1 Highway authorities have a range of statutory duties and responsibilities relevant to the management and operation of tunnels and covered infrastructure. These duties arise from general highway, traffic management, health and safety, fire safety, and emergency planning legislation, and apply to tunnels as part of the wider highway network. General duties and powers are set out in Part A of this Code; this section highlights those particularly relevant to highway tunnels and associated systems.

E.2.1.2 The legal framework applicable to highway tunnels comprises retained European law, primary legislation (Acts of Parliament), secondary legislation (regulations and statutory instruments), and common law. Highway authorities should understand how these layers interact when identifying and discharging their legal duties.

E.2.1.3 Tunnels and covered infrastructure present additional challenges due to their enclosed environment, system interdependencies, and potential consequences of failure. Highway authorities should ensure that their statutory duties are applied appropriately, taking account of the specific risks associated with tunnel operation.

E.2.1.4 Where reference is made to tunnel failure within this part, it relates to the tunnel's inability to fulfil its intended functions necessary for safe operation.

E.2.1.5 While the UK has left the European Union, many requirements derived from EU Directives remain embedded within UK law. In particular, the Road Tunnel Safety Regulations 2007 (RTSR) transpose Directive 2004/54/EC and continue to provide a key benchmark for tunnel safety.

E.2.1.6 Most highway tunnels are accessible to the public and are typically associated with road networks. Responsibility for their management rests with the relevant highway authority, which must adopt a proportionate and risk-based approach to determine appropriate standards, with due consideration of current best practice. This includes considering whether Design Manual for Roads and Bridges (DMRB) requirements are applicable, or whether alternative standards may be justified based on the asset characteristics, operational requirements, and associated risks.

E.2.1.7 Tunnel management may require compliance with a range of statutory duties, regulations, and supporting requirements. The legislation applicable to a particular tunnel will depend on its characteristics, ownership, operational arrangements, and location. Table 40 provides examples of key legislation, regulations and legal frameworks that may be relevant to the management, operation and maintenance of highway tunnels and associated infrastructure.

Table 40: Legislative and Regulatory Framework

Area	Examples
Highway Duties	Highways Act 1980[5]
Health & Safety	HSWA, CDM Regulations
Fire Safety	Regulatory Reform (Fire Safety) Order
Emergency Planning	Civil Contingencies Act 2004
Dangerous Goods	CDG Regulations, ADR
Tunnel Safety	Road Tunnel Safety Regulations 2007 (RTSR)
Environment	Environmental Permitting

E.2.2 GENERAL LEGAL DUTIES

E.2.2.1 Highway authorities should identify and comply with the legislation applicable to the ownership, operation, maintenance, and management of tunnel assets.

E.2.2.2 Relevant legislation applying to tunnels and covered infrastructure may include, but is not limited to:

HIGHWAY LEGISLATION

- Highways Act 1980 (and equivalent legislation in devolved administrations, e.g. Roads (Scotland) Act 1984 and The Roads (Northern Ireland) Order 1993), including duties relating to highway maintenance and the management of the highway network.
- Road Traffic Regulation Act 1984
- Road Traffic Act 1988
- Traffic Management Act 2004
- New Roads and Street Works Act 1991
- Road Safety Act 2006

HEALTH AND SAFETY LEGISLATION

- Health and Safety at Work etc. Act 1974
- Construction (Design and Management) Regulations
- Confined Spaces Regulations

[5] Throughout this Code, when reference is made to the Highways Act 1980, this legislation does not apply in NI, where instead, the Roads (NI) Order 1993 applies.

- Control of Asbestos Regulations 2012 (Relevant DMRB guidance should be followed for the identification and management of asbestos risks)

FIRE SAFETY LEGISLATION

- Regulatory Reform (Fire Safety) Order 2005

EMERGENCY PLANNING AND RESILIENCE

- Civil Contingencies Act 2004

EQUALITY AND HUMAN RIGHTS

- Human Rights Act 1998
- Equality Act 2010

DANGEROUS GOODS

- ADR - Agreement concerning the International Carriage of Dangerous Goods by Road
- Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009

E.2.2.3 Other legislation may apply depending on the characteristics and operation of the tunnel, including:

- Fire and Rescue Services Act
- Environmental and air quality legislation (including the Environment Act 2021, Clean Air Act 1993 and Air Quality Standards Regulations 2010)
- Pollution Prevention and Control Act 1999
- Data protection legislation relating to monitoring, surveillance, and operational systems e.g., Data Protection Act 2018

E.2.2.4 The legislation identified above collectively establishes a range of duties and responsibilities which may require highway authorities to:

- Maintain infrastructure in a safe and serviceable condition;
- Manage risks to users, employees, contractors, and others affected by their activities;
- Establish appropriate systems of inspection, maintenance, and operation;
- Plan for and respond to incidents and emergencies.

E.2.2.5 These duties apply to tunnels in the same way as they do to other highway assets, but highway authorities should give enhanced consideration due to the characteristics of enclosed environments such as tunnels, underpasses, and subways.

E.2.2.6 A range of secondary legislation, supporting regulations and technical requirements may also apply to tunnel operation and associated infrastructure, including:

- Traffic Signs Regulations and General Directions

- Building Regulations (England) and the Building Safety Act 2022 (for tunnel service buildings)
- Network and Information Systems (NIS) Regulations 2018 relating to the resilience and security of operational technology, communications, and control systems.

E.2.2.7 In addition to statutory duties, highway authorities are subject to common law obligations, including maintaining the public's right of safe passage along the highway. This includes taking reasonable steps to avoid creating hazards or obstructions and managing foreseeable risks associated with tunnel operation.

E.2.3 OWNERSHIP AND RESPONSIBILITIES

E.2.3.1 Highway authorities and other infrastructure owners are subject to statutory duties relating to the management, operation and maintenance of tunnels and associated infrastructure. In England and Wales, the Highways Act 1980 establishes the primary duties of highway authorities, including the duty under Section 41 to maintain highways maintainable at public expense. Equivalent duties and legislative frameworks apply elsewhere in the United Kingdom.

E.2.3.2 Where a tunnel forms part of the highway network, it is generally treated as part of that highway and subject to the same maintenance duties and responsibilities as the highway it supports.

E.2.3.3 Highway authorities should establish and document ownership, operational and maintenance responsibilities for tunnel assets and associated infrastructure.

E.2.3.4 In some circumstances, ownership, operation, and maintenance responsibilities may be divided between different organisations. This may include tunnels owned or operated by:

- railway undertakings;
- utility providers;
- concessionaires;
- DBFO or DBFM operators;
- private infrastructure owners; or
- other third parties.

E.2.3.5 Where ownership and operational responsibilities are shared, highway authorities should ensure that formal agreements clearly define:

- responsibilities for inspection;
- responsibilities for maintenance;
- operational responsibilities;
- emergency arrangements; and
- asset management obligations.

E.2.3.6 Most highway tunnels are maintainable at public expense. Exceptions may include tunnels constructed under private Acts, Royal Charter, or for canals, railways, or tolled infrastructure.

E.2.3.7 Highway authorities should identify and comply with any site-specific legislation, agreements, or restrictions applicable to their tunnel assets.

E.2.4 TUNNELS SPECIFIC LEGAL REQUIREMENTS

E.2.4.1 Certain tunnels may be subject to specific legislative and regulatory requirements. Highway authorities should also identify and document any site-specific legislation that may apply.

E.2.4.2 Additional arrangements may apply where tunnels have been constructed to provide private access beneath highways. These are typically governed by agreements under the Highways Act 1980 and Section 111 of the Local Government Act 1972.

E.2.4.3 Highway authorities responsible for tunnels falling within the scope of Road Tunnel Safety Regulations 2007 (RTSR) should ensure that the requirements of those Regulations are implemented and maintained appropriately.

E.2.4.4 Such requirements may include:

- appointment of defined tunnel safety roles;
- maintenance of tunnel safety documentation;
- establishment of operational and emergency arrangements;
- inspection and assurance activities;
- incident reporting; and
- tunnel safety governance arrangements.

E.2.4.5 Highway authorities should understand whether tunnel-specific legislation applies to their assets and ensure that compliance arrangements remain current throughout the life of the tunnel.

E.2.4.6 Where restrictions relating to dangerous goods apply, highway authorities should ensure that appropriate operational controls, signage, and enforcement arrangements are established and maintained.

E.2.4.7 Additional legislative requirements, governance arrangements, and technical frameworks may apply to certain tunnels depending on their ownership, classification, location, or operational characteristics. Highway authorities should identify and comply with all applicable requirements and ensure they are reflected within asset management, operational, emergency planning and resilience arrangements.

E.2.4.8 Highway authorities should identify and comply with the legislative and regulatory requirements applicable to their tunnel assets. Where technical standards, guidance and good practice are applied, highway authorities should ensure that implementation is proportionate to the characteristics, complexity, and risk profile of the asset.

E.2.5 STANDARDS, GUIDANCE AND GOOD PRACTICE

E.2.5.1 Highway authorities should consider relevant standards, guidance and recognised good practice when managing tunnel assets.

E.2.5.2 Relevant standards, publications, and sources of recognised good practice may include:

- Design Manual for Roads and Bridges (DMRB): The primary standard for the design, operation, and maintenance of highway tunnels in the UK, including requirements for inspection, safety systems, and lifecycle management (e.g. CD 352, CS 452, CM 430);
- Road Tunnel Safety Regulations 2007 (RTSR) and associated guidance;
- IET Wiring Regulations (BS 7671);
- PIARC Road Tunnels Manual;
- recognised industry guidance;
- manufacturer recommendations; and
- authority-specific governance requirements.

E.2.5.3 DMRB standards remain mandatory where required by the relevant overseeing organisation. Other highway authorities may choose to adopt DMRB requirements, in whole or in part, where considered appropriate to the characteristics, risks and operational requirements of their tunnel assets.

E.2.5.4 Highway authorities should ensure that management arrangements reflect current good practice and take account of emerging knowledge, technological developments, and operational experience.

E.2.6 APPLICATION ACROSS DIFFERENT TUNNEL TYPES

E.2.6.1 The legislative and regulatory requirements applicable to a tunnel will depend upon its characteristics, ownership, location and whether it falls within a specific regulatory regime.

E.2.6.2 Some tunnels may be subject to the Road Tunnel Safety Regulations 2007 (RTSR), whilst others may be managed through broader highway, health and safety, fire safety, and emergency planning requirements. Highway authorities may nevertheless choose to adopt relevant principles, processes and practices derived from the RTSR as recognised good practice were considered appropriate to the characteristics, complexity and risks associated with their tunnel assets.

E.2.6.3 Tunnel classification and ownership do not necessarily determine the applicable regulatory framework. For example, a tunnel may be managed by a strategic highway authority, local authority or other infrastructure owner and may also be subject to the RTSR where the relevant criteria are met.

E.2.6.4 Highway authorities should identify the requirements applicable to their tunnel assets and ensure that management arrangements are proportionate to the scale, complexity, and risk profile of the asset.

E.2.7 PROPORTIONATE AND RISK-BASED APPLICATION

E.2.7.1 In line with the principles set out in Part A of this Code, highway authorities should apply a proportionate, risk-based approach when determining how legal duties are implemented.

E.2.7.2 This includes:

- Identifying hazards associated with the tunnel environment
- Assessing the likelihood and consequences of failure
- Implementing appropriate control measures
- Reviewing and updating arrangements as necessary

E.2.7.3 Highway authorities should ensure that management arrangements remain proportionate to:

- the characteristics of the tunnel;
- the consequences of failure;
- network importance;
- operational complexity; and
- statutory requirements.

E.2.7.4 For tunnels that fall outside formal regulatory regimes, highway authorities should use relevant standards and good practice to inform their approach, ensuring that risks are appropriately managed.

E.2.7.5 Tunnel assets present particular challenges owing to their enclosed environment, the potential for incidents to escalate and the constraints associated with evacuation, access, and emergency response.

E.2.7.6 Highway authorities should establish arrangements that:

- Assess and manage risks to users, employees, and others;
- Establish safe systems of operation and maintenance;
- Support emergency planning and incident response; and
- Maintain compliance with applicable legal duties.

E.2.7.7 Highway authorities should ensure that arrangements for operation, inspection, maintenance, and emergency planning are appropriate to the level of risk associated with the asset and its use.

E.2.8 ENVIRONMENTAL, PLANNING AND HERITAGE CONSIDERATIONS

E.2.8.1 Highway authorities should identify and comply with environmental, planning and heritage requirements that may affect tunnel assets.

E.2.8.2 Relevant considerations may include:

- Environmental permits and discharge consents;
- Air quality obligations;
- Drainage and pollution-control requirements;
- Firewater containment, collection, treatment, and disposal requirements associated with tunnel incidents and fire-fighting activities;
- Listed structures and conservation areas;

- Planning and consent requirements for certain works, including modifications, upgrades, or the installation of new equipment;
- Archaeological considerations; and
- Statutory approvals associated with maintenance or improvement activities.

E.2.8.3 Highway authorities should ensure that relevant approvals, permissions, and environmental controls are identified and complied with, and that any constraints are appropriately reflected in asset management and operational planning.

SECTION E.3 ASSET STRATEGY – TUNNELS

E.3.1 INTRODUCTION

E.3.1.1 The Tunnel Asset Strategy should define the authority's approach to the management of tunnel assets throughout their operational life. The strategy should support the safe operation of the tunnel, delivery of required levels of service, operational resilience, and the achievement of whole-life value.

E.3.1.2 The Tunnel Asset Strategy should support and align with the authority's wider Asset Management Policy, organisational objectives, network management objectives, statutory duties, legal obligations, and applicable regulatory requirements.

E.3.1.3 The Tunnel Asset Strategy may be supported by a range of subordinate strategies, plans and processes, including those relating to investment, maintenance, inspection, technology, resilience, sustainability, procurement, and lifecycle management. These should collectively support the authority's asset-management objectives and operational requirements.

E.3.1.4 Effective asset strategies are dependent upon reliable asset information and asset knowledge. Highway authorities should recognise that asset data alone does not provide sufficient understanding to support effective decision-making. Asset knowledge is developed through the combination of asset information, inspections, testing, monitoring, operational experience, and engineering judgement. This knowledge provides the foundation for risk-based decision-making, operational assurance, lifecycle planning, resilience management, and investment prioritisation throughout the operational life of the tunnel.

E.3.1.5 Effective asset management depends upon more than the collection of asset data. Data requires interpretation and context before it can support informed decision-making. Figure 16 illustrates the relationship between asset data, asset information, asset knowledge, and asset-management decisions.

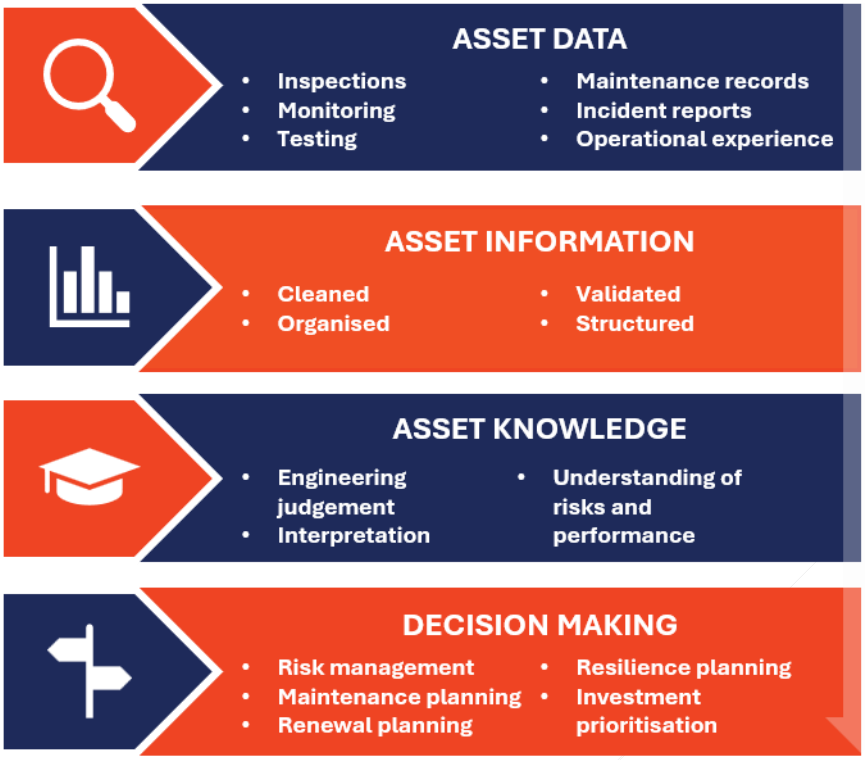


Figure 16 – Relationship between Asset Data, Asset Information, Asset Knowledge, and Decision-Making

E.3.1.6 Asset management systems are covered in the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part C. The requirements set out here should be read as supplementary.

E.3.1.7 Tunnel asset strategies should be informed by recognised asset management principles, including those contained within the ISO 55000 series of asset management standards (particularly ISO 55000, ISO 55001 and ISO 55002), and should support whole-life management, risk-based decision-making, continuous improvement, value creation and the achievement of a sustainable state of good repair throughout the asset lifecycle.

E.3.2 ASSET STRATEGY PRINCIPLES AND CONSIDERATIONS

E.3.2.1 The Tunnel Asset Strategy should reflect the authority's objectives, stakeholder expectations, and statutory responsibilities whilst maintaining clear alignment with wider strategies such as the Network Strategy (Part A), organisational strategies and plans, and legal duties and obligations.

E.3.2.2 Highway authorities should seek to ensure that tunnel asset-management activities are based upon the following principles:

- Protection of tunnel users, workers, emergency responders and wider public;
- Delivery of safe and reliable tunnel operation;
- Risk-based decision-making;
- Whole-life asset management and lifecycle optimisation;
- Evidence-based decision-making informed by asset knowledge;

- Resilience and operational continuity;
- Sustainability and efficient use of resources;
- Effective management of technology and obsolescence risks;
- Collaboration between relevant stakeholders; and
- Continuous improvement.

E.3.2.3 Highway authorities should recognise that capital expenditure (CAPEX) and operational expenditure (OPEX) are interdependent. Deferred investment in asset renewal, replacement or modernisation may increase maintenance requirements, fault response activities, specialist support needs, operational risks, obsolescence pressures, and whole-life costs. Asset strategies should consider the long-term consequences of investment decisions and seek to optimise value through an appropriate balance of CAPEX and OPEX throughout the asset lifecycle.

E.3.2.4 Lifecycle planning should consider not only maintenance and renewal activities but also refurbishment, upgrade, replacement, obsolescence management, and eventual decommissioning requirements where applicable. Repeated reliance on increased maintenance activity, temporary repairs or compensatory measures may indicate a need for renewal, replacement, or wider asset investment.

E.3.3 INTEGRATED TUNNEL ASSET MANAGEMENT

E.3.3.1 Tunnel strategies should recognise network-wide risks and dependencies, including flooding, diversionary routes, and wider network impacts. Highway tunnels should be managed as integrated systems rather than collections of individual assets. Tunnel asset strategies should recognise the interdependencies that exist between:

- structural assets;
- mechanical systems;
- electrical systems;
- communications systems;
- fire-life-safety systems;
- operational technology systems;
- traffic-management systems; and
- operational procedures.

E.3.3.2 Highway authorities should identify and understand the interfaces and dependencies between these systems and the consequences of asset or system failures.

E.3.3.3 Tunnel systems are highly interdependent, and the performance of individual assets should not be considered in isolation. Figure 17 provides an illustrative example of typical dependencies between tunnel systems and supporting infrastructure.

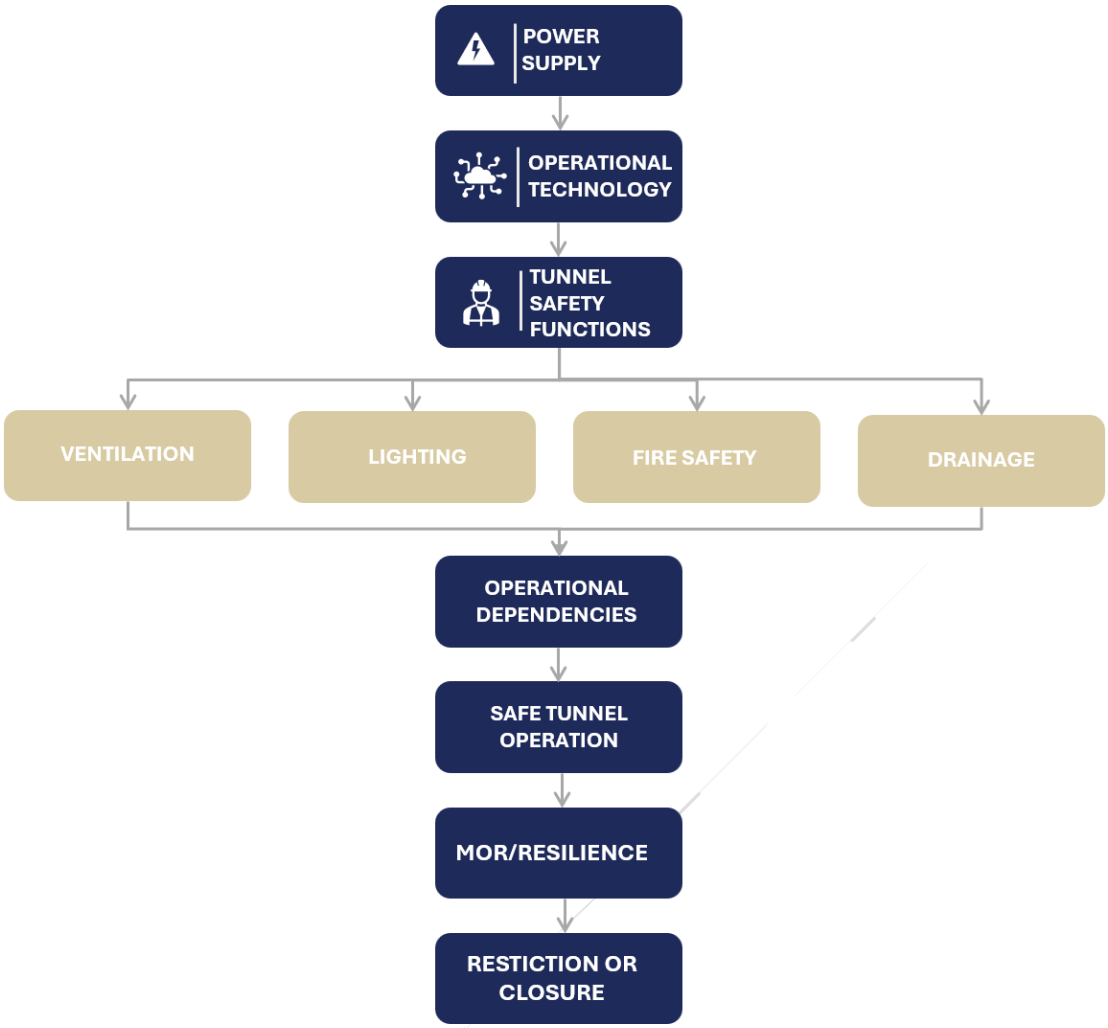


Figure 17 – Example Tunnel System Dependencies

E.3.3.4 Tunnel strategies should take account of any tunnel classifications, restrictive envelopes, dangerous-goods restrictions, vehicle restrictions, route restrictions, emergency-service access requirements, operational requirements, and the potential operational impacts associated with the tunnel.

E.3.3.5 Tunnel asset strategies should also consider supporting infrastructure beyond the tunnel itself, including:

- tunnel service buildings;
- control buildings;
- plant rooms;
- substations;
- ventilation buildings;
- pumping stations;
- drainage infrastructure;

- associated operational facilities and utility infrastructure; and
- emergency-access and evacuation routes.

E.3.3.6 Failures of supporting infrastructure may affect the tunnel's ability to deliver safety-critical functions, maintain resilience, or comply with Minimum Operating Requirements (MOR).

E.3.3.7 Tunnel systems are typically designed with defined levels of resilience and redundancy, such as duty/standby arrangements and alternative system configurations. Asset management, maintenance, and renewal activities should seek to maintain these capabilities throughout the operational life of the tunnel.

E.3.3.8 Minimum Operating Requirements (MOR) should be considered when developing asset-management strategies, resilience arrangements, and lifecycle plans.

E.3.3.9 Defined Minimum Operating Requirements (MOR), or equivalent authority-defined operational thresholds, provide an important reference point for understanding whether tunnel systems continue to deliver the operational capability, resilience and safety functions necessary to support safe operation.

E.3.3.10 Repeated breaches of Minimum Operating Requirements (MOR) may indicate underlying asset, resilience, maintenance, or investment deficiencies and should be considered when reviewing asset strategies, life cycle plans, and investment priorities.

E.3.3.11 Highway authorities should also consider dependencies on external infrastructure and services, including power supplies, communications networks, digital infrastructure, traffic-management systems, and emergency-response arrangements.

E.3.3.12 Tunnel-specific criticality should be identified, particularly where tunnels support emergency-service routes, healthcare facilities, strategic transport links, or other infrastructure of regional or national importance.

E.3.3.13 The consequences of asset deterioration, failures, obsolescence, loss of resilience and service interruptions should be understood and considered when developing asset-management strategies, maintenance programmes, and investment plans.

E.3.4 GOVERNANCE, ROLES, AND RESPONSIBILITIES

E.3.4.1 Highway authorities should establish clear governance arrangements to support the safe and effective management of tunnel assets throughout their operational life.

E.3.4.2 Responsibilities for tunnel management, operation, maintenance, inspection, assurance, emergency planning, and asset stewardship should be clearly defined and documented.

E.3.4.3 The scale and complexity of governance arrangements should be proportionate to the risks, complexity, and operational importance of the tunnel.

E.3.4.4 Roles and responsibilities may include, as appropriate:

- Tunnel Manager or equivalent duty holder;
- Operations Manager;

- Maintenance Manager;
- Tunnel Safety Officer or equivalent safety role;
- Engineers and technical specialists;
- Control-room or operational personnel;
- Asset-management personnel; and
- Inspection Entity, independent assurance provider, or equivalent assurance function.

E.3.4.5 Where Inspection Entities, independent reviewers or third-party assurance providers are utilised, highway authorities should clearly define responsibilities, reporting arrangements and interfaces with operational and maintenance organisations.

E.3.4.6 Inspection Entities or equivalent independent assurance functions may provide independent assessment of tunnel condition, asset performance, safety-critical systems, maintenance effectiveness, and compliance arrangements. Such activities can provide additional confidence in asset knowledge, operational assurance, risk management, and investment decision-making, particularly where tunnels contain complex or safety-critical systems.

E.3.4.7 Independent inspection and assurance activities can support:

- asset knowledge;
- operational assurance;
- risk management;
- condition assessment;
- asset performance evaluation;
- resilience planning; and
- investment decision-making.

E.3.4.8 Highway authorities should ensure that governance arrangements support effective communication and decision-making between asset managers, operators, maintainers, emergency responders, and other stakeholders.

E.3.4.9 Governance arrangements should support the management of operational risks throughout the lifecycle of the tunnel. This may include the establishment of operational procedures, risk registers, incident-response arrangements, emergency planning, multi-agency coordination, and return-to-service processes appropriate to the characteristics and operational requirements of the tunnel.

E.3.4.10 Emergency planning arrangements should be developed collaboratively with emergency services, Local Resilience Forums, and other relevant stakeholders, as appropriate to the characteristics, risks, and operational requirements of the tunnel.

E.3.5 COMPETENCE

E.3.5.1 Tunnel management requires competent personnel possessing appropriate knowledge, skills, and experience relevant to their responsibilities.

E.3.5.2 Highway authorities should ensure that personnel involved in tunnel operation, maintenance, inspection, management, and decision-making possess competence appropriate to the complexity and criticality of the systems they manage.

E.3.5.3 Competence requirements should be considered for:

- asset managers;
- tunnel managers;
- operators;
- maintainers;
- inspectors;
- designers and technical advisors;
- operational technology specialists; and
- those responsible for safety-critical decisions.

E.3.5.4 Inspection and assurance activities should be undertaken by personnel possessing appropriate technical knowledge, inspection capability and understanding of tunnel hazards and operating environments.

E.3.5.5 Highway authorities should recognise that different inspection, assurance, and approval activities may require different levels of competence and independence. Where independent assurance functions or Inspection Entities are utilised, appropriately qualified, and experienced personnel should be appointed in accordance with the authority's governance arrangements.

E.3.5.6 Highway authorities should recognise that competence requirements may vary according to the nature of the inspection, assessment or assurance activity being undertaken. Activities requiring independent assurance, technical approval or statutory compliance may necessitate higher levels of competence, professional registration, or independence than routine inspection and maintenance activities.

E.3.5.7 For tunnels subject to specific statutory requirements, highway authorities should ensure that competence, independence, professional registration, and approval requirements are consistent with the applicable legislation and governance arrangements.

E.3.5.8 Where specialist assets or systems are involved, highway authorities should ensure that competence requirements reflect the specific knowledge necessary to assess, maintain or manage those assets.

E.3.5.9 Highway authorities should support ongoing training, professional development, competency assessment, and knowledge transfer to ensure organisational capability is maintained throughout the lifecycle of the tunnel.

E.3.5.10 Appropriate access to chartered engineering expertise and specialist technical support should be available where necessary.

E.3.5.11 Highway authorities may wish to consider recognised industry competency schemes, training programmes, qualifications, and accreditation routes when developing competence frameworks. Examples may include National Highways Sector Schemes (NHSS), vocational qualifications

such as the ProQual NVQ Level 3 in Road Tunnelling Operations, and other sector-recognised competency frameworks relevant to tunnel operations, maintenance and inspection.

E.3.6 ASSET INFORMATION AND KNOWLEDGE

E.3.6.1 Effective tunnel asset strategies depend upon reliable asset information and asset knowledge.

E.3.6.2 Highway authorities should recognise the distinction between:

- asset data;
- asset information; and
- asset knowledge.

E.3.6.3 Asset knowledge provides the understanding necessary to support inspection planning, maintenance, operational assurance, resilience planning, lifecycle forecasting, and investment decision-making.

E.3.6.4 Asset strategy, asset knowledge, risk assessment, and lifecycle planning are closely linked activities that collectively support effective tunnel management. The relationship between these processes is illustrated in Figure 18.

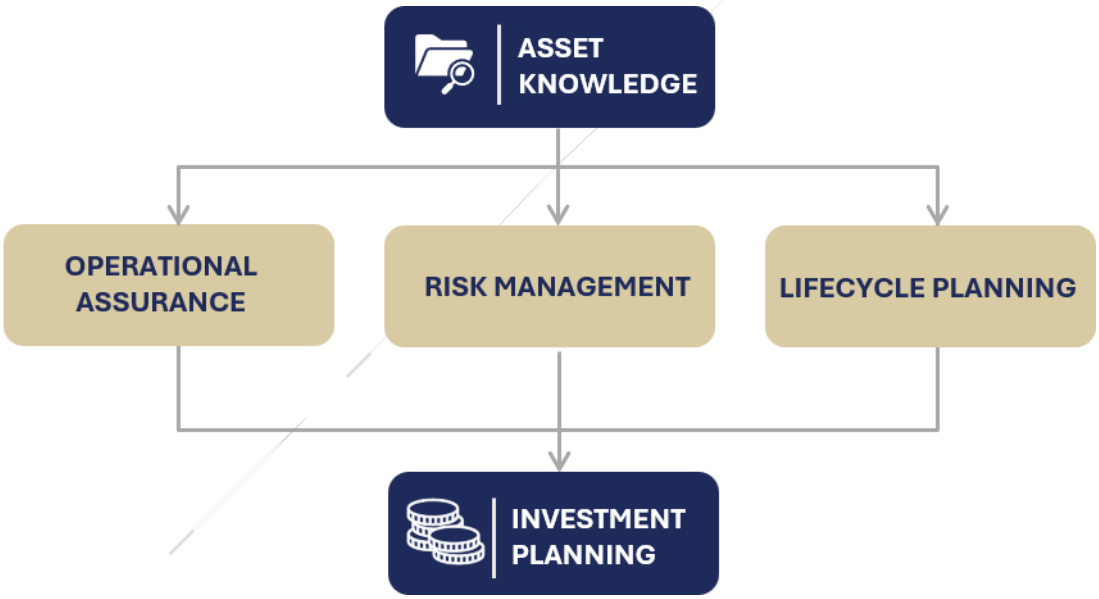


Figure 18 – Asset knowledge as an enabler of risk-based asset management and decision-making.

E.3.6.5 Highway authorities should maintain appropriate arrangements for the collection, management, storage, protection, and retrieval of asset information throughout the lifecycle of the tunnel.

E.3.6.6 Digital information-management systems should be used where practicable to support the effective management, protection, and retrieval of asset information.

E.3.6.7 Highway authorities should establish appropriate asset-management systems, processes, and procedures to support asset identification, information management, maintenance planning, defect management, lifecycle planning, and decision-making.

E.3.6.8 Highway authorities should maintain an appropriate asset inventory and asset hierarchy to support the identification, classification, and management of tunnel assets throughout their lifecycle.

E.3.6.9 Asset information should be:

- accurate;
- current;
- accessible to authorised users;
- appropriately protected;
- subject to change control; and
- maintained through suitable version-control processes.

E.3.6.10 Highway authorities should also consider arrangements for retaining organisational knowledge and operational experience to reduce the risk of knowledge loss arising from personnel changes, contractor changes, or organisational restructuring.

E.3.6.11 Particular consideration should be given to tunnel safety documentation and other records necessary to support safe operation, operational assurance, maintenance planning, and statutory compliance.

E.3.6.12 Asset information may include, as appropriate, asset inventories, asset hierarchies, as-built records, operation and maintenance manuals, inspection reports, statutory test records, maintenance records, failure records, renewal records, change records, closure programmes, action plans, and other records necessary to support safe operation and effective asset management.

E.3.6.13 Further guidance relating to asset information, asset management systems and asset knowledge is provided in Section E.5.

E.3.7 MAINTENANCE, INSPECTION AND ASSURANCE

E.3.7.1 Highway authorities should establish maintenance, inspection, and assurance strategies appropriate to the characteristics, complexity, and operational requirements of their tunnel assets.

E.3.7.2 Maintenance strategies may include:

- preventative maintenance;
- predictive maintenance;
- corrective maintenance;
- condition-based maintenance; and
- renewal activities.

E.3.7.3 Inspection and assurance strategies should be risk-based and proportionate to asset criticality, operational importance, and consequences of failure.

E.3.7.4 Tunnel inspection activities may comprise a range of disciplines, including structural inspections and inspections of mechanical, electrical, communications and operational technology systems. Highway authorities should recognise that different inspection approaches, competencies, standards, and frequencies may be required for different asset types. Inspection and management of structural assets should be undertaken in accordance with the requirements of Part C of this Code, together with any other applicable standards and guidance.

E.3.7.5 Highway authorities should ensure that maintenance and inspection activities support:

- safety;
- operational performance;
- resilience;
- asset condition management;
- lifecycle planning; and
- compliance with Minimum Operating Requirements (MOR).

E.3.7.6 Inspection, testing, monitoring, and assurance activities should be coordinated where appropriate and should support the development of reliable asset knowledge and informed decision-making.

E.3.7.7 Highway authorities should consider the use of condition monitoring techniques, such as thermography, vibration analysis, performance monitoring, and other diagnostic methods, where appropriate to support asset knowledge, predictive maintenance, and lifecycle planning.

E.3.7.8 Highway authorities should recognise that safe tunnel operation depends not only upon the condition of individual assets, but also upon the performance of integrated tunnel systems and the effectiveness of operational arrangements.

E.3.7.9 Further guidance relating to inspection, monitoring, testing, and assurance activities is provided in Section E.5.

E.3.8 IDENTIFICATION OF NEED AND LIFECYCLE PLANNING

E.3.8.1 Intervention requirements should be identified using information derived from:

- inspections;
- monitoring;
- testing;
- maintenance records;
- condition assessments;
- performance assessments;
- operational experience;
- risk assessments;

- incident investigations; and
- obsolescence reviews.

E.3.8.2 Highway authorities should develop lifecycle plans that support the long-term management of tunnel assets and systems.

E.3.8.3 Lifecycle planning should consider:

- asset condition;
- asset performance;
- remaining life;
- asset criticality;
- operational requirements;
- system dependencies;
- resilience objectives;
- obsolescence risks;
- software and technology support requirements; and
- Minimum Operating Requirements (MOR).

E.3.8.4 Highway authorities should recognise that operational technology (OT) systems, including associated software, may require significantly different support, investment, and replacement cycles from structural, mechanical, and electrical assets.

E.3.8.5 Lifecycle planning should consider the availability of supplier support, software maintenance, licensing requirements, cyber-security obligations, critical spares, and technology obsolescence risks.

E.3.8.6 Lifecycle planning should consider opportunities to reduce whole-life carbon emissions through maintenance, refurbishment, renewal, replacement, and operational interventions. Highway authorities should seek to balance safety, performance, resilience, environmental impacts, and whole-life value when evaluating intervention options.

E.3.8.7 Lifecycle planning should support:

- maintenance planning;
- renewal planning;
- investment prioritisation;
- resilience improvement;
- operational continuity; and
- long-term asset stewardship.

E.3.8.8 Highway authorities should periodically review lifecycle plans to reflect changing asset condition, operational requirements, emerging risks, technological developments, and evolving network needs.

E.3.8.9 Asset knowledge supports identification of intervention needs throughout the asset lifecycle. Information obtained through inspection, testing, monitoring and operational experience should be used to inform risk assessments and intervention planning. Figure 19 illustrates this relationship.



Figure 19 – Relationship between asset knowledge, risk assessment, and lifecycle intervention planning.

E.3.8.10 Where planned inspection, maintenance, testing, or renewal activities cannot be completed as programmed, highway authorities should assess and manage any resulting risks, implement appropriate mitigation measures where necessary, record the deferment and reprogramme the activity for completion at the earliest reasonably practicable opportunity.

SECTION E.4 RISK-BASED APPROACH – TUNNELS

E.4.1 INTRODUCTION

E.4.1.1 Highway authorities should apply a proportionate and risk-based approach to the management of tunnel assets, taking account of the characteristics, complexity, strategic importance, and operational requirements of the tunnel.

E.4.1.2 Risk management should support:

- Safe operation;
- Operational resilience;
- Network performance;
- Environmental protection; and
- Long-term asset stewardship.

E.4.1.3 Highway authorities should ensure that risk management activities are informed by appropriate asset, operational and safety information, including inspection records, condition data, maintenance records, performance information, tunnel safety documentation, and operational experience.

E.4.2 TUNNELS RISK-BASED APPROACH FRAMEWORK

E.4.2.1 A risk-based approach should be applied to the management of tunnel assets to support proportionate, evidence-based, and prioritised decision-making.

E.4.2.2 Highway authorities should establish a risk-management framework that reflects the characteristics, complexity, strategic importance, and operational requirements of their tunnel assets.

E.4.2.3 Risk assessments should consider a range of factors including:

- Safety risks;
- Operational risks;
- Asset risks;
- Maintenance risks;
- Obsolescence risks;
- Network performance risks;
- Environmental risks; and
- Resilience risks.

E.4.2.4 Tunnel risks may arise from a combination of safety, operational, asset and external factors. Table 41 provides examples of risk categories that may be considered within tunnel risk assessments.

Table 41: Tunnel Risk Categories

Risk Category	Examples
Safety	Fire, evacuation issues
Operational	Restrictions, closures
Asset	Deterioration, integrity
Obsolescence	Unsupported systems
Resilience	Flooding, power loss, loss of redundancy
Environmental	Pollution incidents
Cyber-security and OT	OT vulnerabilities, cyber-attack, software compromise

E.4.2.5 These categories are not intended to be exhaustive and highway authorities may identify additional risks relevant to the characteristics and operating environment of their assets.

E.4.2.6 User needs should be considered as per Part A.15.

E.4.2.7 Tunnel risk management should consider both individual asset failures and the performance of integrated tunnel systems. Further guidance on system dependencies and integrated performance is provided in Section E.4.5.

E.4.2.8 Highway authorities should ensure that risks associated with tunnel assets and operations are reduced so far as is reasonably practicable through appropriate design, operational, maintenance and resilience measures.

E.4.2.9 Where safety-critical risks are identified, authorities should ensure that decisions concerning risk-control measures are supported by appropriate justification demonstrating that risks have been reduced so far as is reasonably practicable, taking account of applicable legal duties, recognised good practice and the principle of gross disproportion.

E.4.2.10 Highway authorities should ensure that identified risks, mitigations, responsibilities, and review arrangements are appropriately recorded and maintained. Examples may include tunnel risk registers, operational risk registers, safety documentation, or equivalent authority-defined systems used to record risks, controls, actions, and review arrangements. Such arrangements should support the recording of risk ownership, status of mitigation measures, review dates, and escalation requirements where appropriate.

E.4.2.11 Highway authorities may utilise recognised methodologies and industry guidance to support structured and auditable risk assessments where appropriate. Examples may include GG 104 Requirements for Safety Risk Assessment, organisational risk-management frameworks, and other recognised industry approaches.

E.4.2.12 Highway authorities should identify the operational thresholds at which mitigation measures, operational restrictions or closure may become necessary to maintain safe operation. Minimum Operating Requirements (MOR), or equivalent authority-defined operational thresholds, provide

an important mechanism for supporting risk-based decision-making, operational resilience, and asset management planning.

E.4.2.13 Risk assessments should consider the relationship between identified risks, system performance, and MOR.

E.4.2.14 Further guidance relating to MOR is provided in Sections E.4.8 and E.6.

E.4.3 PROGRAMMING AND PRIORITIES

E.4.3.1 Highway authorities should use risk assessments, inspection findings, condition information, performance monitoring, and operational experience to inform the prioritisation and programming of maintenance, renewal, and improvement activities.

E.4.3.2 Programming decisions should take account of:

- Asset condition;
- Asset performance;
- Asset integrity;
- System performance;
- Asset criticality;
- Likelihood and consequence of failure;
- Operational requirements;
- Governance and approval processes;
- Resilience objectives; and
- Minimum Operating Requirements (MOR).

E.4.3.3 Asset condition relates to the physical state of an asset and the extent and severity of deterioration or defects.

E.4.3.4 Asset performance relates to the ability of an asset or system to fulfil its intended operational function.

E.4.3.5 Condition and performance assessments should, where practicable, be supported by objective and measurable information, such as defect severity, defect extent, assessed capacity, performance indicators, and compliance with operational requirements.

E.4.3.6 Asset integrity relates to the continued safety and suitability of an asset, including structural stability, safety-critical fixings, containment systems, and other features necessary to support safe operation.

E.4.3.7 Prioritisation should also consider whole-life costs, sustainability objectives, which are covered in Section E.8, and opportunities to undertake preventative interventions that reduce future maintenance demands, disruption, and resource consumption.

E.4.3.8 Highway authorities should recognise that:

- Deterioration may introduce future safety, reliability or resilience risks before operational performance is affected;
- Assets in satisfactory physical condition may not necessarily achieve the level of performance required to support safe tunnel operation, operational resilience, or compliance with Minimum Operating Requirements (MOR); and
- Systems may not achieve the required operational outcomes even where individual assets continue to operate satisfactorily in isolation.

E.4.3.9 Inspection findings, condition assessments, performance monitoring, and operational experience should be used to identify emerging risks, support timely intervention, and optimise the allocation of resources.

E.4.3.10 Highway authorities should establish appropriate measures and indicators to support risk-based decision-making and monitor the effectiveness of asset management activities. Examples may include:

- Availability and reliability of safety-critical systems;
- Compliance with MOR;
- Frequency and severity of faults or failures;
- Number and duration of operational restrictions or closures;
- Response and recovery times following incidents or failures;
- Asset condition trends and deterioration rates;
- Integrity-related findings associated with safety-critical assets; and
- Performance of integrated tunnel systems.

E.4.3.11 Inspection findings, performance testing, and operational monitoring should be used not only to assess asset condition, but also to evaluate system performance, support remaining-life assessments, inform lifecycle planning and assist investment prioritisation.

E.4.3.12 Prioritisation should consider risks and consequences at network, tunnel, system, and asset level, including both individual asset risks and the wider consequences of failure.

E.4.3.13 When assessing asset criticality and determining priorities, highway authorities should consider the consequences of reduced availability or loss of the tunnel and associated systems.

E.4.3.14 Consideration should be given to:

- The potential for single points of failure where loss of the tunnel could sever communities, force lengthy diversions or remove important network links;
- Impacts on neighbouring highway authorities, strategic highway networks, and other transport operators;
- Effects on businesses, freight movements, education facilities, healthcare facilities, and other key services;
- Impacts on emergency-service access and response where alternative routes are limited or constrained;

- The anticipated duration of restrictions, maintenance activities, closures, or recovery periods;
- The availability, suitability, and resilience of diversion routes; and
- Dependencies on, or interactions with, other critical infrastructure, including railways, ports, airports, power infrastructure, utility networks, and strategic transport corridors.

E.4.3.15 Highway authorities should ensure that these considerations are reflected within risk assessments, prioritisation processes, maintenance planning, resilience arrangements, and investment decisions.

E.4.4 OPERATIONAL AND SAFETY RISKS

E.4.4.1 Highway authorities should identify and assess operational risks that may affect the safe and effective operation of the tunnel and its associated systems.

E.4.4.2 Examples may include:

- Fire and smoke incidents;
- Hazardous goods incidents;
- Toxic or hazardous spillages;
- Flooding;
- Power loss;
- Communications failures;
- Traffic management failures;
- Operational technology (OT), software and cyber-security related failures, threats, or vulnerabilities;
- Deterioration of safety-critical assets;
- Insufficient availability of competent operators, maintenance personnel, and supply chain partners, including risks associated with succession planning and workforce continuity;
- Loss of monitoring, supervisory or control functions; and
- Failure of supporting infrastructure.

E.4.4.3 Highway authorities should establish appropriate controls, mitigation measures and contingency arrangements to manage identified risks and support continued operational resilience.

E.4.4.4 Risk assessments should consider both normal operating conditions and incident-response scenarios, recognising the interdependencies between tunnel systems and the potential consequences of degraded operation.

E.4.4.5 Where appropriate, highway authorities should engage relevant stakeholders, including emergency services, tunnel operators, infrastructure owners, and operational partners when assessing significant operational risks, resilience arrangements, and emergency-response procedures.

E.4.5 SYSTEM DEPENDENCIES AND INTEGRATED PERFORMANCE

E.4.5.1 Tunnel assets should be assessed both as individual components and as parts of integrated operational systems.

E.4.5.2 Highway authorities should identify interfaces and dependencies between structural, mechanical, electrical, communications, operational technology, and fire safety systems.

E.4.5.3 The performance of individual assets should not be considered in isolation. Risk assessments should consider the ability of systems to operate collectively during both normal operation and incident response conditions.

E.4.5.4 Figure 20 illustrates how dependencies between tunnel assets and systems can amplify the consequences of individual asset failures. Unlike many conventional highway assets, tunnel components function as part of integrated safety and operational systems. The failure of a single critical asset may degrade a safety function, affect compliance with minimum operating requirements (MORs), and ultimately result in operational restrictions, tunnel closure, and wider network impacts.



Figure 20 – Relationship Between Asset Failure, Safety Functions and Operational Consequences

E.4.5.5 Particular consideration should be given to:

- Single points of failure;
- Cascading failures;
- Operational technology (OT) dependencies;
- Supporting infrastructure dependencies;
- Resilience arrangements; and
- Recovery following asset or system failures.

E.4.5.6 Highway authorities should ensure that the consequences of individual and multiple asset failures are understood and appropriately managed.

E.4.6 DESIGN INFORMATION AND SAFETY DOCUMENTATION

E.4.6.1 The management of in-service tunnel risks should be informed by an understanding of the tunnel's original design intent, safety assumptions, and subsequent modifications.

E.4.6.2 Highway authorities should take account of relevant design, construction, commissioning, and operational documentation where these continue to influence:

- Safe operation;
- Maintenance activities;
- Emergency response arrangements;
- Resilience planning; or
- Minimum Operating Requirements (MOR).

E.4.6.3 Relevant information may include:

- Tunnel safety documentation;
- Fire and life-safety strategies;
- Design assumptions and constraints;
- Commissioning and acceptance records;
- Maintenance and inspection records;
- Records of modifications and asset changes;
- Operational procedures;
- Emergency response documentation; and
- Other records required to support safe operation and risk assessment.

E.4.6.4 Highway authorities should ensure that such information remains accessible and is updated as necessary throughout the operational life of the asset.

E.4.6.5 Where documentation is incomplete or unavailable, highway authorities should consider the implications for risk assessment and establish appropriate measures to address any resulting uncertainty.

E.4.6.6 Relevant guidance may include:

- GG 104 Requirements for Safety Risk Assessment;
- CM 430 Maintenance of Road Tunnels;
- CS 452 Inspection and Records for Road Tunnel Systems;
- CD 352 Design of Road Tunnels;
- CG 300 Technical Approval of Road Structures (including service tunnels where applicable); and

E.4.6.7 other applicable statutory, regulatory, and organisational requirements.

E.4.7 RISK-BASED MAINTENANCE AND INTERVENTION PLANNING

E.4.7.1 Highway authorities should use risk assessment outcomes to support inspection, monitoring, maintenance, renewal, and improvement activities.

E.4.7.2 The risk-based framework should support a proactive approach to asset management, using condition, performance, and inspection data to inform lifecycle planning, identify emerging risks and prioritise timely interventions that reduce the likelihood and consequence of failure.

E.4.7.3 Maintenance programmes should reflect:

- Asset criticality;
- Consequences of failure;
- Condition and performance information;
- Operational requirements;
- Resilience objectives; and
- Minimum Operating Requirements (MOR).

E.4.7.4 Highway authorities should consider the wider consequences of failure, including impacts on users, network performance, emergency-service access, and other dependent infrastructure.

E.4.7.5 Highway authorities should establish appropriate maintenance strategies for tunnel assets and systems, including preventative, predictive, corrective and renewal interventions where appropriate.

E.4.7.6 Maintenance and intervention planning should consider the availability of spare parts, asset obsolescence risks, supplier support arrangements, and opportunities to reduce reliance on unsupported or obsolete systems.

E.4.7.7 Examples may include operational technology systems, communications systems, control systems, and other specialist tunnel equipment.

E.4.7.8 Inspection, servicing, testing, and maintenance activities provide important opportunities to refresh asset information, identify emerging risks, and review intervention priorities. Highway authorities may determine that more frequent inspection, monitoring, or maintenance activities are required where asset criticality, operational importance, deterioration trends, or changing risk profiles indicate additional assurance is necessary.

E.4.7.9 Highway authorities may utilise predictive maintenance techniques, condition monitoring, performance trending and other data-driven approaches to identify emerging risks, anticipate failures and optimise intervention timing.

E.4.7.10 Performance monitoring should consider both individual asset performance and the performance of integrated tunnel systems. Highway authorities should recognise that degradation may not always be apparent from condition information alone and that performance monitoring can provide early indication of emerging failures, loss of resilience or deterioration affecting operational capability.

E.4.7.11 Examples may include monitoring of:

- Ventilation system performance;
- Lighting performance and illumination levels;
- Power supply resilience and availability;
- Communications systems;
- Operational technology (OT) systems;
- Fire and life-safety systems;
- Drainage and pumping systems; and
- Other safety-critical tunnel systems.

E.4.7.12 Where appropriate, highway authorities should consider testing and assessment of integrated tunnel-system performance and operational outcomes, rather than relying solely on assessment of individual assets or components in isolation.

E.4.7.13 Information derived from inspections, performance testing and operational monitoring may also be used to support:

- Remaining-life assessments;
- Lifecycle planning;
- Financial forecasting;
- Investment planning; and
- Risk-based decision-making.

E.4.7.14 Highway authorities should ensure that maintenance arrangements support compliance with MOR and, where appropriate, restore degraded assets or systems before operational thresholds are exceeded.

LIFECYCLE PLANNING

E.4.7.15 Highway authorities should develop lifecycle plans to support the long-term management of tunnel assets and systems.

E.4.7.16 Lifecycle plans should consider:

- Inspection findings;
- Condition information;
- Performance monitoring;
- Deterioration trends;
- Asset criticality;
- Operational requirements; and
- Minimum Operating Requirements (MOR).

E.4.7.17 Lifecycle plans should support the identification and prioritisation of maintenance, renewal and improvement activities and should be reviewed periodically to reflect the latest asset information and operational experience.

E.4.7.18 Where local deterioration and performance data is limited, highway authorities may use available industry experience, relevant standards, and engineering judgement to support planning activities.

E.4.7.19 Highway authorities should seek to coordinate maintenance, renewal, and improvement activities where appropriate to:

- Optimise resource use;
- Minimise disruption;
- Improve operational resilience; and
- Maximise network performance.

E.4.8 MINIMUM OPERATING REQUIREMENTS (MOR)

E.4.8.1 Highway authorities should establish arrangements for determining the operational thresholds below which mitigation measures, operational restrictions or closure become necessary to maintain safe operation.

E.4.8.2 Minimum Operating Requirements (MOR), or equivalent authority-defined operational thresholds, provide an important mechanism for supporting operational risk management, resilience planning, and decision-making.

E.4.8.3 Risk assessments should consider the consequences of assets or systems degrading below MOR and the actions necessary to maintain safe operation.

E.4.8.4 MOR should inform:

- maintenance prioritisation;
- resilience planning;
- incident response;
- operational decision-making;
- recovery planning; and
- investment planning.

E.4.8.5 Highway authorities should understand the operational, network and safety consequences associated with the loss of MOR and ensure that appropriate arrangements are in place to restore safe operation within acceptable timescales.

E.4.8.6 Further guidance relating to MOR is provided in Section E.6.

SECTION E.5 ASSET KNOWLEDGE AND INFORMATION MANAGEMENT – TUNNELS

E.5.1 INTRODUCTION

E.5.1.1 This section covers the information, records, documentation, and knowledge required for the effective management of tunnel assets, systems and associated Operational Technology (OT). This includes structural, mechanical, electrical, communications and OT systems together with the inspection, testing, monitoring, and records necessary to support their management. For guidance on the inspection, assessment and testing of tunnel structural components refer to Part C of this Code.

E.5.1.2 Asset knowledge may be understood as the understanding developed through asset information, inspections, testing, monitoring, operational experience, and engineering judgement, which together support the effective management of an asset throughout its lifecycle. Effective asset knowledge supports informed risk-based decision-making and provides an important foundation for operational assurance, safety management, resilience planning, and investment decision-making.

E.5.1.3 Highway authorities should also consider arrangements for retaining and transferring organisational knowledge and experience to reduce the risk of losing critical asset knowledge through personnel or organisational changes.

E.5.1.4 Highway authorities should maintain appropriate arrangements for the collection, storage, control, maintenance, and retrieval of asset information. Asset knowledge should be accessible to all who have a legitimate need to use it and should be maintained in a manner that ensures information is accurate, current, traceable, and appropriately protected. Information should be subject to suitable governance arrangements, including version control, change management and retention processes. Digital systems and common data environments may assist in providing a reliable and auditable source of information.

E.5.1.5 Particular consideration should be given to the management of tunnel safety documentation and associated records required by the Road Tunnel Safety Regulations 2007 (RTSR).

E.5.1.6 Tunnel safety documentation may include design information, safety assessments, inspection and testing records, operational procedures, emergency planning arrangements, fire safety documentation, modification records, and other information necessary to demonstrate the safe management, operation and maintenance of the tunnel throughout its operational life.

E.5.2 ASSET MANAGEMENT – DATA AND SYSTEMS

E.5.2.1 Highway authorities should establish and maintain appropriate asset management systems and processes to support the collection, storage, management, analysis and reporting of tunnel asset information.

E.5.2.2 Asset management systems should support the effective management of structural, mechanical, electrical, communications, operational technology (OT), software, and other tunnel-related assets throughout their lifecycle.

E.5.2.3 Asset management systems should support, as appropriate:

- collection, storage, and retrieval of asset information;
- inventory, condition, performance, and configuration management;
- inspection, monitoring, and testing records;
- maintenance planning and work management;
- lifecycle planning and investment decision-making;
- performance reporting and analysis;
- spares and obsolescence management;
- defect management, reactive maintenance recording;
- management of drawings, photographs, models, and technical documentation; and
- management of tunnel safety documentation and associated records.

E.5.2.4 The asset management system should provide and maintain a single source of truth for asset information. Asset inventory, condition, performance, maintenance, and configuration information should be held within, or synchronised with, an authoritative system of record and kept updated following inspections, maintenance activities, asset modifications, and renewals.

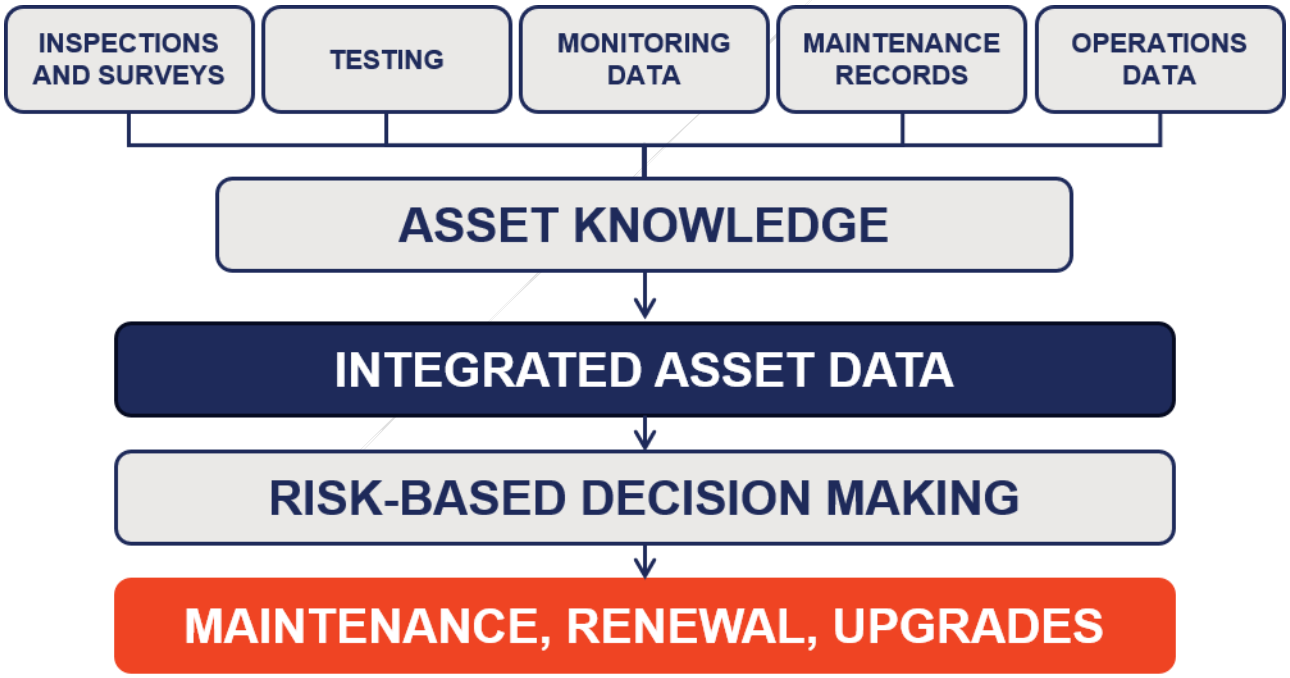


Figure 21 – Asset Information Ecosystem (Concept)

E.5.2.5 Appropriate governance, change control and quality assurance procedures should be implemented to ensure the accuracy, completeness, consistency, and currency of asset data throughout the asset lifecycle.

E.5.2.6 Asset information should be held in a format that supports efficient updating, analysis, reporting, and decision making.

E.5.2.7 Highway authorities should ensure that information derived from inspections, monitoring, testing, maintenance activities, and operational experience can be used to support:

- risk-based decision-making;
- maintenance planning;
- lifecycle forecasting;
- performance assessment;
- obsolescence management; and
- future investment decisions.

E.5.2.8 Associated buildings and facilities that support the operation and maintenance of highway tunnels (e.g. control buildings, plant rooms, ventilation buildings, pump stations, and substations) should be included within the asset management regime.

E.5.2.9 Highway authorities should ensure that the condition, performance and availability of associated buildings and facilities are appropriately considered where they support tunnel operation or the delivery of safety-critical functions.

E.5.2.10 Such facilities may also be subject to separate statutory, regulatory, or organisational requirements and should be managed accordingly.

E.5.2.11 Consistency in the collection, structuring and management of asset information is important to support reliable analysis, comparison, and long-term planning.

E.5.2.12 The extent and level of detail of information captured should be proportionate to asset importance, criticality, operational requirements, and associated risks.

E.5.2.13 The information requirements of individual highway authorities may vary. Highway authorities should maintain sufficient information to support the safe management, operation and maintenance of tunnel assets and systems. Information may include, but is not limited to:

- asset inventory and configuration information;
- ownership, governance, and responsibility information;
- inspection, monitoring, testing, and condition records;
- performance and operational information;
- maintenance and renewal records;
- tunnel safety documentation and associated records required under the Road Tunnel Safety Regulations 2007 (RTSR);
- health and safety information required to support construction, maintenance, and operational activities;
- records of modifications, upgrades, and asset changes; and
- emergency planning, operational and safety-related documentation.

E.5.2.14 Further guidance on tunnel records and inventories is provided in CS 452.

The extent and nature of information collected should be proportionate to the authority's statutory obligations, operational requirements, organisational objectives, and asset-management needs. Information may be required to support activities such as sustainability reporting, resilience planning, financial forecasting, performance monitoring, and investment decision-making.

E.5.2.15 Asset information may be structured using a hierarchical framework (e.g. asset group, system, sub-system, and element) to support consistency in recording, reporting, and lifecycle management.

E.5.2.16 Where appropriate, parent-child relationships between assets should be established to support management of system dependencies and integrated tunnel systems.

E.5.2.17 Asset inventory information should be sufficient to support management at network, tunnel, system, and asset level. Inventory records should contain the information necessary to identify, locate and manage tunnel assets and systems, together with the associated attributes and relationships needed to support inspection, maintenance, lifecycle planning, and investment decision-making.

E.5.2.18 Information may include, but is not limited to:

- unique asset identifiers;
- ownership and responsibilities;
- location information;
- tunnel configuration and arrangement;
- principal asset characteristics;
- installation and renewal dates;
- manufacturer and model information;
- design and operational constraints;
- safety-critical attributes;
- asbestos and other regulated materials;
- inspection and maintenance requirements; and
- references to associated technical documentation.

E.5.2.19 Highway authorities should recognise that tunnels comprise interdependent systems with differing service lives, deterioration characteristics, and replacement needs.

E.5.2.20 Asset management systems should support the identification and management of:

- asset deterioration;
- performance trends;
- remaining life;
- renewal requirements;
- obsolescence risks;

- cyber-security risks;
- software and configuration changes; and
- replacement or refurbishment requirements associated with safety-critical assets and systems.

E.5.3 ASSET CONDITION, PERFORMANCE AND ENGINEERING ASSESSMENT

E.5.3.1 Asset condition, performance, and engineering assessment information provides an important evidence base for informed, risk-based decision-making. Early identification of deterioration, defects and performance issues enables timely interventions that support safety, operability, resilience, and long-term asset stewardship.

E.5.3.2 Highway authorities should ensure that asset condition, performance and engineering assessments are proportionate to asset criticality, operational importance, associated risks, and the potential consequences of failure.

E.5.3.3 Assessment information should be used to support:

- risk-based decision-making;
- maintenance and renewal planning;
- lifecycle forecasting;
- performance monitoring;
- resilience planning;
- investment prioritisation; and
- compliance with operational requirements, including Minimum Operating Requirements (MOR) where applicable.

E.5.3.4 Highway authorities should recognise that condition, performance, and integrity are related but distinct concepts:

- Condition relates to the physical state of an asset and the extent of deterioration or defects;
- Performance relates to the ability of an asset or system to fulfil its required operational function; and
- Integrity relates to the continued suitability and safety of an asset to support its intended purpose.

E.5.3.5 Condition, performance and engineering assessment information should be recorded and maintained within the asset records and used to support future inspections, maintenance planning, lifecycle assessments, and investment decisions.

E.5.3.6 Highway authorities should consider the implications for future maintenance when planning and implementing maintenance, renewal, and improvement work.

E.5.3.7 Consideration should be given to opportunities to improve durability, maintainability, resilience, and operational performance, including the use of components, systems or materials that reduce future maintenance requirements and whole-life impacts.

E.5.3.8 Where appropriate, highway authorities should seek to minimise operational disruption, resource consumption and environmental impacts associated with future interventions.

E.5.3.9 Maintenance, renewal, and modification activities should normally be undertaken in accordance with applicable standards, specifications, and organisational requirements.

E.5.3.10 There may be circumstances where full compliance with current standards is not reasonably practicable or proportionate, for example where works involve partial repairs, accident damage, existing constraints, or heritage assets.

E.5.3.11 Where departures from current standards or alternative approaches are adopted, highway authorities should ensure that:

- the basis for the decision is appropriately documented;
- associated risks are identified and assessed;
- suitable mitigation measures are implemented where necessary; and
- relevant records are retained within the asset information and safety documentation.

E.5.3.12 Where appropriate, highway authorities may undertake additional engineering assessments, safety reviews, or risk assessments to support decision-making.

E.5.3.13 Highway authorities should ensure that relevant engineering assurance and approval procedures are applied where required.

E.5.3.14 Where applicable, tunnel design, assessment, modification, and renewal activities should be subject to appropriate technical approval and governance arrangements, such as those described in CG 300.

E.5.3.15 Highway authorities should maintain awareness of relevant standards, specifications, and guidance applicable to tunnel assets and systems, including those relating to design, assessment, maintenance, testing, and renewal activities.

E.5.3.16 Highway authorities should consider future operational and network demands when assessing tunnel assets and planning future interventions.

E.5.3.17 Consideration may include:

- changes in traffic volumes;
- vehicle dimensions and weights;
- freight movements;
- alternative fuel and propulsion technologies;
- changes in user behaviour; and

- other emerging transport trends that may influence tunnel operation, maintenance, or safety requirements.

E.5.4 INSPECTION, ASSESSMENT, TESTING AND MONITORING OF TUNNEL SYSTEMS

E.5.4.1 This section covers inspection, assessment, testing, and monitoring activities associated with tunnel assets and systems.

E.5.4.2 Inspection, testing and monitoring should be used not only to assess asset condition, but also to verify system performance, validate safety functions, support operational readiness, demonstrate compliance with statutory and operational requirements, support cyber-security and operational technology assurance activities, and provide confidence that tunnel systems continue to operate as intended.

E.5.4.3 Highway authorities should recognise that asset condition alone may not provide sufficient information to determine tunnel safety, resilience, or operational readiness. Inspection, testing and monitoring activities should therefore assess both the condition of individual assets and the performance of integrated tunnel systems.

E.5.4.4 For inspection of structural components of a tunnel, refer to Part C of this Code together with applicable structural inspection standards and guidance, including CS 450 where relevant. Tunnel systems inspections should be undertaken in accordance with applicable tunnel-specific guidance such as CS 452.

E.5.4.5 Inspection, testing and monitoring should be used to:

- provide information on the condition, performance and operational readiness of tunnel assets and systems;
- identify deterioration, defects, faults, and emerging risks;
- verify that safety-critical assets and systems continue to perform in accordance with operational requirements and design intent;
- assess compliance with operational requirements, including Minimum Operating Requirements (MOR), where applicable;
- identify emerging risks that may affect continued compliance with MOR;
- validate the performance of tunnel systems during both normal operation and incident response conditions;
- support maintenance, renewal, and lifecycle planning;
- support statutory, regulatory, and organisational assurance requirements;
- support assessment of communications systems, operational technology (OT), software, and other digital assets where appropriate; and
- compile, verify and maintain asset information and inventory records.

E.5.4.6 Highway authorities should recognise that the performance of integrated tunnel systems cannot always be determined from asset condition information alone.

E.5.4.7 Inspection, testing and monitoring activities should therefore consider both individual asset condition and the performance of the wider tunnel system, including interactions and dependencies between structural, mechanical, electrical, communications, fire-life-safety, and operational technology systems.

E.5.4.8 Inspection, testing, and monitoring information is fundamental to the effective management of tunnel assets and systems. Highway authorities should ensure that sufficient resources, competence, and arrangements are in place to support these activities and that resulting information is used to inform decision-making. Highway authorities should ensure that actions arising from inspections, monitoring activities, testing and assessments are appropriately prioritised, implemented and recorded.

E.5.4.9 Records should demonstrate how findings have been reviewed and what actions have been taken in response.

E.5.4.10 Inspection, testing and monitoring records should form part of the tunnel asset records and, where applicable, tunnel safety documentation.

E.5.4.11 Testing may include:

- functional testing;
- commissioning and re-commissioning activities;
- integrated system testing;
- operational validation;
- failover and resilience testing;
- communications testing; and
- cyber-security assurance activities appropriate to the criticality and operational importance of the tunnel systems.

E.5.4.12 Testing undertaken following installation, maintenance, renewal, or modification works should demonstrate that affected assets and systems continue to perform as intended.

E.5.4.13 The extent and frequency of inspection, testing and monitoring should be determined using a risk-based approach, taking account of:

- asset criticality;
- operational importance;
- consequences of failure;
- tunnel characteristics;
- system dependencies;
- safety requirements;
- resilience requirements; and
- network impacts associated with restrictions or closure.

E.5.4.14 Where inspection intervals are varied from established practices or guidance, highway authorities should ensure that decisions are supported by appropriate engineering judgement, risk assessment and available performance, condition, and deterioration information.

E.5.5 INSPECTION REGIME

E.5.5.1 An inspection, testing and monitoring regime should minimise risks to public safety, support effective management of tunnel assets and systems and make efficient use of available resources.

E.5.5.2 The inspection, testing and monitoring techniques should be sufficient to:

- identify condition, defects and signs of deterioration that are significant to highway tunnel safety, operation, and management;
- identify any significant changes in condition or environment or system performance that have occurred since the last observation;
- assess the safety, functionality, performance and operational readiness of tunnel assets and systems;
- determine or assist the determination of the cause, extent, and rate of deterioration; and
- provide information to support maintenance, renewal, and investment planning.

E.5.5.3 Inspection activities should consider both individual assets and integrated tunnel systems.

E.5.5.4 Inspection regimes may include Acceptance, Safety, General, Principal and Special Inspections, as appropriate. Special Inspections may be undertaken to investigate known or suspected defects, performance issues, incidents, emerging risks, or other circumstances requiring more detailed examination.

E.5.5.5 Different inspection types provide different levels of information and assurance. Some inspections focus on identifying immediate hazards and safety concerns, whilst others support detailed assessment of condition, performance, deterioration, resilience, and future intervention requirements. Highway authorities should establish inspection regimes appropriate to the characteristics of the tunnel and its constituent systems. Typical inspection types and their purpose are summarised in Table 42.

Table 42: Common Inspection Types and Purpose

Inspection Type	Typical Purpose
Acceptance	New or modified assets
Safety	Identify immediate hazards
General	Routine condition review
Principal	Detailed assessment
Special	Specific defect investigation (e.g. following an incident such as fires, serious RTC)

E.5.5.6 Principal inspections should consider not only asset condition but also the ability of the tunnel systems to continue to support safe and effective operation. Assessment should be informed by inspection, testing, monitoring and operational performance information, recognising that deterioration in tunnel systems may not always be identifiable through visual inspection alone.

E.5.6 INSPECTION REPORTING

E.5.6.1 All inspections should result in an appropriate record or report commensurate with the inspection type.

E.5.6.2 Records should provide a clear and accurate description of the condition, performance, deficiencies and, where relevant, operational implications associated with the tunnel assets and systems.

E.5.7 ESCALATION OF CRITICAL DEFECTS

E.5.7.1 Highway authorities should establish arrangements requiring inspectors to notify relevant responsible persons promptly where defects, failures or deficiencies may represent an immediate risk to public safety, tunnel operation, resilience, or continued compliance with operational requirements.

E.5.8 SCHEDULING INSPECTIONS

E.5.8.1 Highway authorities should comply with applicable requirements for highway tunnel inspections contained within CS 452. Inspection of structural tunnel components should also be undertaken in accordance with Part C of this Code and relevant structural inspection standards, including CS 450 where applicable. Where alternative inspection intervals, scopes or approaches are adopted, these should be supported by a documented risk assessment, undertaken by suitably competent persons, and approved in accordance with the authority's governance and accountability arrangements.

E.5.8.2 Guidance relating to testing and maintenance activities is provided within documents such as CM 430 and CS 452.

E.5.8.3 Guidance and compliance management frameworks developed for building services may provide useful reference material for associated tunnel facilities and operational buildings where appropriate. Examples of compliance-management guidance that may assist highway authorities include BSRIA Statutory Compliance Inspection Checklist (BG 80/2025) noting that tunnel-specific requirements should also be considered.

E.5.8.4 Particular consideration should be given to inspection and testing of tunnel mechanical, electrical, communications, fire-life-safety, and operational technology systems.

E.5.8.5 Inspection frequencies should take account of applicable standards, manufacturer recommendations, asset criticality, operational requirements, and risk.

E.5.8.6 Acceptance Inspections should be undertaken following the construction, refurbishment or significant modification of tunnel assets and systems in accordance with applicable guidance.

E.5.8.7 Highway authorities should maintain records necessary to support safe operation and demonstrate compliance with relevant standards, regulations, and organisational requirements.

E.5.8.8 Inspection arrangements should consider safety-critical fixings, supports and associated infrastructure used to support tunnel equipment and systems.

E.5.8.9 Responsibilities for their inspection and maintenance should be clearly defined and coordinated with structural inspection activities where appropriate.

E.5.8.10 An appropriate regime of inspection and testing should be established for tunnel M&E, communications, fire-life-safety, and operational technology systems.

E.5.8.11 Previous guidance relating to tunnel M&E inspection and testing was provided within MCHW Series 7000. Although this series has been withdrawn, highway authorities should establish inspection, maintenance and testing requirements using applicable documents such as CS 452 and CM 430, together with manufacturer guidance, works-specific requirements and other relevant standards and industry good practice.

E.5.9 EMERGENCY PREPAREDNESS AND INSPECTION ACTIVITIES

E.5.9.1 Highway authorities should ensure that inspection, testing, operational validation, and emergency-preparedness activities are appropriately coordinated where practicable.

E.5.9.2 Lessons learned from incidents, faults, emergency exercises, and operational events should be considered when reviewing inspection, testing, and monitoring regimes.

E.5.10 MONITORING

E.5.10.1 Monitoring is the periodic or continuous observation, measurement or collection of information used to assess asset condition, system performance, and operational capability.

E.5.10.2 Unlike many highway structures, tunnels often contain extensive mechanical, electrical, communications and operational technology systems capable of generating continuous

performance information that can support proactive asset management and operational decision-making.

E.5.10.3 Highway authorities should maintain appropriate records for safety-critical fixings associated with tunnel assets and systems. Processes for asset installation, modification, replacement, and removal should ensure that safety-critical fixing records remain current and that responsibilities for inspection, maintenance and assurance are clearly defined. Further guidance is provided in Part C and CIRIA C778.

E.5.10.4 Tunnel operators should make appropriate use of information generated by tunnel control, monitoring and operational technology systems to support fault identification, performance trending, predictive maintenance, asset assurance, and operational decision-making.

E.5.10.5 Monitoring may be used to assess:

- deterioration;
- asset performance;
- system performance;
- operational readiness;
- environmental conditions;
- resilience;
- energy consumption;
- fault trends; and
- compliance with operational requirements.

E.5.10.6 Examples may include monitoring of:

- ventilation flow rates and fan performance;
- lighting performance and illumination levels;
- drainage and pumping systems;
- power supply systems;
- fire detection, fire mains, and fire-life-safety systems;
- communications systems;
- CCTV, incident detection, and control systems;
- operational technology systems;
- environmental conditions;
- vibration, temperature, pressure, and structural movements; and
- asset fault and alarm information.

E.5.10.7 Monitoring of operational technology (OT) and associated digital systems should include consideration of:

- software performance;
- configuration management;
- software backup management;
- obsolescence monitoring;
- cyber-security;
- personnel access management and permissions, including physical access controls;
- system dependencies; and
- digital asset health.

E.5.10.8 Monitoring information may also be used to verify continuing compliance with key design assumptions relating to structural performance, ventilation, lighting, drainage, fire-life-safety systems, and operational performance.

E.5.10.9 The monitoring approach adopted should be proportionate to risk, asset criticality, and operational requirements.

E.5.10.10 Monitoring systems may also provide alarm, warning or decision-support functions that support risk management, resilience, and operational control.

E.5.10.11 Monitoring arrangements should consider dependencies between systems and identify potential single points of failure that may affect tunnel operation, resilience, or compliance with operational requirements.

E.5.10.12 Monitoring arrangements should also consider facilities supporting tunnel operation, including control buildings, plant rooms, substations, ventilation buildings, and associated fire-safety systems where these support tunnel operation.

E.5.10.13 Monitoring information should be analysed, interpreted, and presented in a manner that supports decision-making and avoids unnecessary accumulation of unused data.

E.5.10.14 Information from incidents, faults, emergency exercises, and operational events should be considered alongside monitoring information where relevant.

E.5.10.15 Highway authorities should establish trigger levels, thresholds, and response arrangements, including actions to be taken where monitoring indicates:

- deterioration;
- performance degradation;
- loss of resilience;
- emerging system failures;
- cyber-security concerns; or
- increased operational risk.

E.5.11 EXTERNAL FACTORS

E.5.11.1 Monitoring arrangements should consider external factors that may influence the parameter being measured or the interpretation of monitoring results. Examples may include weather conditions, traffic patterns, environmental conditions, tunnel orientation, groundwater conditions, and interactions with adjacent infrastructure.

E.5.12 MONITORING FREQUENCY

E.5.12.1 The frequency of monitoring should be proportionate to the parameter being measured, the associated risks and the rate at which conditions may change.

E.5.12.2 Monitoring may be undertaken periodically, continuously or on an event-triggered basis depending on operational requirements and the purpose of the monitoring activity.

E.5.13 ALARM AND WARNING FUNCTIONS

E.5.13.1 Monitoring systems may be configured to provide alarms, alerts, or automated responses when predefined thresholds are exceeded. Such arrangements can provide early warning of deterioration, performance degradation or emerging operational risks and support proactive intervention.

E.5.14 INSTALLATION

E.5.14.1 When implementing monitoring systems, highway authorities should consider:

- environmental conditions;
- reliability and resilience of the monitoring system;
- power supplies;
- communications arrangements;
- cyber-security requirements;
- access for maintenance and inspection;
- calibration requirements;
- data logging and storage capacity; and
- protection against damage, vandalism, or unauthorised interference.

E.5.14.2 Details of the monitoring system should be included in the tunnel Operation and Maintenance Manual and Health and Safety File, if appropriate, so that others working on the tunnel are aware of its presence.

E.5.15 EVALUATION OF MONITORING RESULTS

E.5.15.1 Monitoring may generate large volumes of data and consideration needs to be given at the outset to its storage, analysis, and eventual presentation, to support a focus on what is needed and avoid becoming immersed in data.

E.5.16 MONITORING DOCUMENTATION

E.5.16.1 Highway authorities should maintain information relating to monitoring systems, including monitoring objectives, equipment details, sensor locations, calibration records, data collection arrangements, maintenance requirements, data storage arrangements, and analysis methods.

E.5.16.2 Monitoring system information should be maintained within relevant asset records, operation, and maintenance documentation and, where appropriate, tunnel safety documentation.

E.5.16.3 Where monitoring equipment requires calibration, calibration intervals and records should be maintained in accordance with manufacturer recommendations and organisational requirements.

E.5.16.4 Action plans should be developed as part of a proactive management approach to highlight the required interventions when trigger levels are breached.

E.5.17 OPERATIONAL ASSURANCE

E.5.17.1 Operational assurance activities provide confidence that tunnel assets, systems, operational arrangements, and emergency-response arrangements continue to support safe and effective tunnel operation throughout the asset lifecycle.

E.5.17.2 Operational assurance should consider the effectiveness of arrangements involving tunnel operators, maintainers, emergency responders, local highway authorities, and other relevant stakeholders where these contribute to the safe operation, management, and recovery of the tunnel.

E.5.17.3 Assurance activities may include operational reviews, emergency exercises, incident debriefs, audits, inspections, testing and validation activities that demonstrate the continued effectiveness of safety, operational and emergency-response arrangements. Assurance activities should demonstrate that tunnel systems, operational arrangements and emergency-response measures continue to function collectively in accordance with their intended purpose and design assumptions.

E.5.17.4 Emergency exercises should support not only validation of procedures and emergency plans, but also familiarisation of emergency responders and other stakeholders with the tunnel environment, safety systems, access arrangements, evacuation strategies, communications arrangements, and incident-management processes.

E.5.17.5 Operational assurance should support:

- statutory compliance;
- operational readiness;
- system performance verification;
- risk management;
- resilience;
- maintenance and renewal planning; and
- the maintenance of tunnel safety documentation.

E.5.17.6 Operational assurance may be supported through inspection, assessment, testing, monitoring, commissioning, re-commissioning, operational validation, and emergency preparedness activities.

E.5.17.7 Highway authorities should ensure that information arising from operational assurance activities is recorded, reviewed, and used to inform decision-making, maintenance planning, operational procedures, and risk management activities.

E.5.17.8 Records arising from operational assurance activities should form part of the tunnel asset records and, where appropriate, tunnel safety documentation.

E.5.17.9 Further guidance relating to inspection, testing, monitoring, and operational assurance activities is provided in Sections E.5.4 and E.5.10.

E.5.18 FIRE SAFETY MANAGEMENT

E.5.18.1 Highway authorities should ensure that fire safety risks are assessed and managed throughout the operational life of the tunnel and associated facilities. Fire risk assessments should be undertaken by competent persons, reviewed periodically, and updated following significant changes to the asset, its operation, traffic characteristics, or use.

E.5.18.2 In developing fire safety arrangements, highway authorities should consider relevant fire safety legislation, including the Regulatory Reform (Fire Safety) Order 2005 (as amended), together with applicable tunnel-specific requirements, guidance, and operational risk assessments. Fire risk assessments should form part of the overall safety management arrangements for the tunnel and associated facilities.

E.5.18.3 Fire risk assessments should consider:

- tunnel design assumptions;
- fire-life-safety systems;
- operational procedures;
- emergency response arrangements;
- condition and performance of safety-critical systems;
- foreseeable fire scenarios; and
- risks to tunnel users, workers, and associated infrastructure.

E.5.18.4 Associated operational buildings, including control buildings, plant rooms, substations and ventilation buildings, should also be considered where relevant.

E.5.18.5 Highway authorities should ensure that actions arising from fire risk assessments are prioritised, implemented and recorded.

E.5.18.6 Highway authorities should engage relevant emergency services and enforcing highway authorities, as appropriate, when determining fire safety arrangements, emergency response planning, and familiarisation activities.

E.5.19 OPERATIONAL DOCUMENTATION AND KNOWLEDGE MANAGEMENT

E.5.19.1 Highway authorities should maintain operational documentation necessary to support the safe operation, maintenance and management of tunnel assets and systems.

E.5.19.2 Documentation may include:

- Operation and Maintenance (O&M) Manuals;
- tunnel safety documentation;
- operating procedures;
- maintenance procedures;
- emergency response procedures;
- asset records;
- testing and inspection records;
- configuration information; and
- software and system documentation.

E.5.19.3 The scope of tunnel safety documentation will vary between highway authorities and tunnel types. Table 43 provides illustrative examples of documentation that may support safe tunnel operation and management.

Table 43: Examples of Tunnel Safety Documentation

Documentation	Purpose
O&M Manuals	Operation and maintenance
Safety Documentation	Safety governance
Emergency Plans	Incident response
Asset Records	Asset management
Inspection Records	Condition history
Change Registers	Configuration control
Test Records	Operational assurance

E.5.19.4 Highway authorities should ensure that documentation is:

- accessible;
- appropriately protected;
- subject to version control;

- maintained following asset changes; and
- retained in accordance with organisational requirements.

E.5.19.5 Where assets, software, procedures, or operational arrangements are modified, associated documentation should be updated accordingly.

E.5.19.6 Highway authorities should maintain appropriate change-control records for operational documentation. Where documents are revised, an auditable change log, revision history or equivalent record should be maintained to support governance, operational assurance, version control, and review of changes by authorised persons.

E.5.19.7 Changes to documentation should be considered when reviewing:

- maintenance regimes;
- inspection regimes;
- operational risk assessments;
- emergency procedures; and
- minimum operating requirements.

E.5.20 SPARES, OBSOLESCENCE AND CONFIGURATION MANAGEMENT

E.5.20.1 Highway authorities should establish arrangements for the management of critical spare parts, consumables, and replacement components necessary to support tunnel operation and resilience.

E.5.20.2 The requirement for spare parts should be determined using a risk-based approach taking account of:

- asset criticality;
- failure consequences;
- supplier lead times;
- availability of alternative equipment;
- historical failure, if available;
- operational requirements; and
- minimum operating requirements.

E.5.20.3 Highway authorities should consider the risks associated with asset obsolescence throughout the lifecycle of tunnel assets and systems.

E.5.20.4 Obsolescence management should include consideration of:

- operational technology (OT) hardware and systems;
- associated software and licences;
- version control and configuration management;

- communications infrastructure and networks;
- supplier support arrangements; and
- cyber-security implications.

E.5.20.5 Where critical spares are stored, highway authorities should ensure that storage, preservation, inspection, and maintenance arrangements are appropriate to maintain fitness for use.

E.5.20.6 Configuration information, software versions, licences, security patches, and system settings should be controlled and recorded to support asset management, cybersecurity, and operational assurance.

E.5.20.7 Highway authorities should assign responsibility for the management of configuration information, software versions, licences, operational technology (OT) system changes, and cybersecurity-related changes. Responsibilities should include maintaining configuration records, change histories, version-control information and associated technical documentation.

E.5.20.8 Where equipment, components or control systems are no longer manufactured, supported, or maintained by the original supplier, highway authorities should implement appropriate mitigation measures. Such measures may include holding critical spare parts, identifying alternative suppliers, refurbishing existing components, maintaining software support arrangements, or planning for asset replacement and upgrade.

E.5.20.9 Highway authorities should maintain records of spare-part usage and stock levels to support replenishment planning and operational resilience. Where maintenance activities are undertaken by others, appropriate arrangements should be established to ensure spare-part consumption and inventory records remain current and accurate.

SECTION E.6 RESILIENCE AND ADAPTATION – TUNNELS

E.6.1 INTRODUCTION

E.6.1.1 The definitions and overall principles for resilience of highway infrastructure are dealt with in Part A of this Code. This section contains information on resilience and adaptation, specifically related to tunnels assets.

E.6.1.2 Resilience in tunnels encompasses both physical systems and operational procedures. This includes the ability to support coordinated incident management, including the safe evacuation of road users during planned and unplanned events, maintaining effective communication and interoperability, and ensuring that emergency services can gain timely access to all areas of the tunnel. Appropriate arrangements for emergency response, recovery and business continuity are therefore important components of tunnel resilience.

E.6.1.3 Tunnel resilience depends not only upon physical assets and systems but also upon organisational capability, including competent personnel, governance arrangements, operational procedures, emergency planning, availability of resources and effective coordination and interoperability between tunnel operators, maintainers, emergency responders, and other stakeholders.

E.6.1.4 Within this wider context, tunnel mechanical, electrical, communications, software and operational technology systems play a fundamental role in supporting the safe operation of tunnels. These systems deliver critical safety functions including detection, control, communication, ventilation, user information, and fire-life-safety support. They enable many of the operational resilience measures associated with tunnel operation, including evacuation, incident management, and emergency service response.

E.6.1.5 The performance of these safety functions may be assessed against defined Minimum Operating Requirements (MORs), where adopted by the authority, to support decisions regarding tunnel operation during periods of degraded performance. Well-designed and maintained systems support resilience by maintaining critical safety functions during both normal and degraded operating conditions.

E.6.1.6 Resilient tunnel systems support serviceability by enabling continued operation, or managed degraded operation, during disruptive events and by facilitating rapid recovery following incidents. This may be achieved through appropriate robustness, redundancy, maintainability, monitoring, and operational response arrangements. Authorities should consider whether risk-assessed contingency measures could permit limited or controlled use of a tunnel during certain disruptive events, where this supports emergency response, network resilience or access to critical services. Where possible, any such arrangements should be agreed in advance with relevant duty holder, documented within operational and emergency plans, and supported by appropriate controls and governance.

E.6.1.7 Resilience also contributes to sustainability by reducing unplanned interventions, supporting effective whole-life asset management, and enabling adaptation to evolving risks such as climate change, changing traffic demands and technological developments. Resilience can also create

opportunities through the adoption of more adaptable, interoperable, and future-compatible technologies.

E.6.1.8 Resilience is not a condition that is achieved and maintained indefinitely. Resilience may be eroded by asset deterioration, technology obsolescence, inadequate maintenance, cyber threats, and failure to address performance degradation. Highway authorities should therefore periodically review safety functions, system availability, operational arrangements, and resilience measures to ensure that they remain effective and appropriate.

E.6.1.9 As tunnels frequently form critical links within transport networks, highway authorities should consider hazards that may affect resilience, including flooding, groundwater ingress, air-quality issues, changing climatic conditions, extreme weather events and other risks identified through risk assessment and resilience planning activities.

E.6.1.10 Tunnel resilience should also be considered within the context of the wider transport network. Stakeholders and highway authorities should recognise that disruption affecting a tunnel may have significant consequences for network operation, diversion routes, freight movements, emergency response arrangements, access to critical services and wider societal resilience.

E.6.1.11 Authorities responsible for road tunnels should have regard to relevant statutory and technical requirements applicable to the tunnel. This may include the Road Tunnel Safety Regulations 2007 for tunnels falling within their scope, and the Design Manual for Roads and Bridges (DMRB) or other relevant technical standards where these apply or have been adopted by the authority.

E.6.1.12 Emergency planning, contingency arrangements and incident-response procedures should be developed collaboratively with emergency responders and other relevant stakeholders and should be periodically exercised, tested and reviewed. For tunnels that are not subject to the Road Tunnel Safety Regulations 2007 or applicable DMRB requirements, proportionate emergency-planning and incident-response arrangements should nevertheless be established, taking account of the tunnel's characteristics, risk profile and operational context. Such activities may include desktop, simulation-based and live exercises, as appropriate, to support operational readiness, interoperability and continuous improvement.

E.6.1.13 Resilience planning should therefore consider interactions with adjoining infrastructure, strategic diversion routes, traffic-management systems, and other assets that support continued operation of the transport network during periods of disruption.

E.6.1.14 As critical infrastructure, tunnels should also be resilient to cyber-security incidents affecting operational technology, communications, and control systems.

E.6.1.15 Assessment of tunnel resilience should make use of information derived from Asset Knowledge, inspection, testing, monitoring, operational assurance, and risk-management activities described elsewhere within this Code.

E.6.2 HOW RESILIENCE SUPPORTS THE CODE'S OBJECTIVES

E.6.2.1 Resilience supports the core objectives of this Code by helping to ensure that tunnel assets, systems and operational arrangements continue to provide safe and reliable service under normal, degraded and emergency operating conditions. Resilience contributes to safety, serviceability, sustainability, and effective asset management throughout the lifecycle of the tunnel.

E.6.2.2 Tunnel resilience contributes directly to safety by maintaining the performance of critical safety functions that support tunnel operation. These functions may include incident detection, ventilation and smoke management, communications, user information, fire-life-safety systems, operational control systems and support for self-rescue and emergency response activities.

E.6.2.3 Highway authorities should identify the safety functions necessary to support safe operation of the tunnel. These safety functions may provide a practical basis for assessing resilience, operational capability, and the effects of system degradation.

E.6.2.4 Assessment of resilience may include consideration of the availability, reliability and performance of safety functions under normal, degraded and emergency operating conditions. Measures may include system availability, operational performance, recovery times, fault trends, and the ability to maintain safe operation during disruptive events.

E.6.2.5 Industry guidance relating to functional safety, safety functions, and risk reduction, including standards such as IEC 61508 where applicable, may assist highway authorities in defining resilience objectives and assessing operational capability. Safety functions may provide a useful basis for assessing resilience by enabling highway authorities to evaluate the availability, reliability and performance of systems that support safe tunnel operation. The extent of application should be proportionate to the tunnel, its associated risks, operational requirements, and organisational arrangements.

E.6.2.6 Where system performance degrades, resilience measures may support continued operation through managed degraded modes of operation, the implementation of compensatory measures, or other operational controls. Where operational capability falls below acceptable levels, resilience arrangements support safe and controlled restriction, partial closure, or full closure of the tunnel where necessary.

E.6.2.7 A key characteristic of resilience is the ability to continue operating safely during periods of degraded performance and to recover efficiently following disruption. Effective monitoring, fault detection, operational procedures, availability of resources and maintenance arrangements support the restoration of safety functions and operational capability whilst minimising disruption to tunnel users and the wider network.

E.6.2.8 Tunnel systems are highly interdependent, both internally and with external infrastructure. Dependencies associated with power supply, communications networks, operational technology, software systems, drainage systems, control systems, and supporting facilities should be considered as part of resilience planning, as the failure in one system may affect multiple safety functions.

E.6.2.9 Resilience supports serviceability by enabling continued operation, or managed degraded operation, during disruptive events whilst limiting the severity and duration of disruption. Maintaining operational capability wherever reasonably practicable helps support user confidence, network efficiency, and continuity of service.

E.6.2.10 Resilience also supports sustainability by reducing the likelihood of unplanned failures, minimising reactive maintenance and supporting efficient whole-life asset management. By maintaining system performance and reducing disruption, resilience can contribute to improved environmental, social, and economic outcomes.

E.6.2.11 Adaptation is an integral part of resilience. Highway authorities should consider future changes in climate, evolving traffic demands/characteristics, vehicle technologies, energy systems, digital technologies, and user requirements when planning future interventions and resilience measures.

E.6.2.12 Continuous improvement is an important aspect of resilience. Information derived from operational experience, incidents, inspections, monitoring, testing, emergency exercises, and risk assessments should be used to review and improve resilience arrangements throughout the lifecycle of the tunnel.

E.6.3 TUNNEL RESILIENCE HAZARD CATEGORIES

E.6.3.1 Tunnel resilience may be affected by a range of hazards, vulnerabilities and disruptive events. Due to the safety-critical nature of tunnel operation, such events may have significant consequences for tunnel users, emergency responders, asset integrity, operational continuity, and network availability. The resilience risk categories described below provide indicative examples of factors that may affect tunnel resilience and the associated measures that may support prevention, preparedness, response, recovery, and adaptation.

E.6.3.2 Highway authorities should apply a proportionate, risk-based approach to identify relevant resilience risks and determine appropriate mitigation measures, taking into account the tunnel characteristics, operational requirements, traffic profile, wider network dependencies, and local circumstances. Consideration should be given not only to the likelihood and consequences of disruptive events, but also to the extent and duration of service disruption, the effectiveness of response and recovery arrangements, and the ability of the tunnel and associated systems to continue operating safely under degraded conditions.

E.6.3.3 Resilience planning should be supported through appropriate preparedness measures, including staff training, operational exercises, and continuous improvement activities. Desktop exercises, simulation-based exercises, digital-twin environments, and live exercises may assist in understanding system behaviour, testing operational arrangements and improving response capability.

E.6.3.4 Live multi-agency exercises should replicate, so far as reasonably practicable, realistic emergency and operational conditions relevant to the tunnel. Lessons learned from incidents, emergency exercises, faults, and operational events should be recorded and used to improve resilience arrangements, operational procedures, and emergency response plans.

E.6.3.5 Highway authorities should recognise that tunnels form part of a wider transport network. Resilience planning should therefore consider interactions with adjoining infrastructure, diversion routes, traffic-management systems, emergency-response arrangements, and other external factors that may influence tunnel operation or affect the consequences of disruptive events. This may include changes in traffic demand, diversionary routing, restrictions associated with dangerous goods movements, or circumstances that affect emergency-service access and response. Where appropriate, emergency-services may be permitted access through a tunnel by emergency service vehicles responding under “blue-light” conditions, where the relevant duty holders, emergency responders and other affected parties have assessed that it is safe to do so.

E.6.3.6 Tunnel resilience may be affected by a wide range of hazards and disruptive events. Table 44 provides examples of resilience hazard categories and associated considerations. These categories are further expanded below.

Table 44: Tunnel Resilience Hazard Categories

Hazard Category	Examples
Weather & Climate	Flooding, groundwater ingress, extreme weather
Fire & Operational Incidents	Fires, collisions, breakdowns, spillages
Power Failure	Loss of mains supply, standby power failure
Control, Communications & Digital Systems	OT failure, software faults, telecoms outages
Asset Condition, Ageing & Maintenance	Deterioration, obsolescence, inadequate maintenance
Security & Malicious Acts	Cyber-attack, vandalism, unauthorised access
External Dependencies	Utilities, traffic-management systems, supporting infrastructure
Dust, Contamination & Deposited Materials	Dust, particulates, hazardous residues

WEATHER AND CLIMATE

E.6.3.7 Weather, climate, and environmental conditions may present risks to tunnel resilience throughout the asset lifecycle.

E.6.3.8 Highway authorities should consider factors such as:

- flooding;
- groundwater ingress;
- extreme rainfall/wind;
- elevated temperatures;
- severe weather events;
- air-quality considerations; and
- other environmental influences that may affect tunnel operation.

E.6.3.9 Such events may affect drainage and pumping systems, power supplies, communication systems, control equipment, and other safety-critical assets. Flooding at tunnel portals or within the tunnel may affect multiple systems simultaneously and result in degraded operation or loss of availability.

E.6.3.10 Resilience measures may include flood mitigation, resilient drainage systems, protection of critical equipment, environmental monitoring, climate-risk assessment, and adaptation planning.

FIRE AND OPERATIONAL INCIDENTS

E.6.3.11 Tunnel resilience should consider incidents arising from normal use of the highway, recognising that tunnels are open transport systems used by road vehicles and that many significant resilience challenges arise from vehicle-related events.

E.6.3.12 Examples may include:

- fires;
- collisions;
- vehicle breakdowns;
- spillages;
- dangerous goods incidents;
- congestion; and
- other operational incidents.

E.6.3.13 Fire remains one of the most significant hazards affecting tunnel resilience because of its potential to rapidly compromise tenability, user safety, asset condition, and tunnel availability.

E.6.3.14 Resilience arrangements should support maintenance of critical safety functions including incident detection, smoke management, user information, communications, and emergency response arrangements.

E.6.3.15 Highway authorities should ensure that operational and emergency-response arrangements reflect interoperability principles (i.e., JESIP) and are coordinated with relevant emergency services and other stakeholders. Roles, responsibilities, and response arrangements should be clearly defined, understood, and regularly reviewed to support effective incident response and recovery.

E.6.3.16 In the event of fire, the maintenance of tenable conditions and the ability of tunnel users to reach a place of relative or ultimate safety are key resilience objectives. Resilience arrangements should take account of the characteristics of tunnel users and support evacuation, emergency response, and recovery activities appropriate to the tunnel design and operating strategy.

POWER AND ELECTRICAL FAILURE

E.6.3.17 Tunnel systems are highly dependent on reliable power supplies. Loss of electrical power may affect multiple safety-critical systems simultaneously and result in degraded operation or loss of availability.

E.6.3.18 Consideration should be given to the consequences of loss of:

- primary power supplies;
- standby power supplies;
- emergency power systems;
- power-distribution systems; and

- associated infrastructure.

E.6.3.19 Resilience/mitigation measures may include redundancy, backup power supplies, standby generation, uninterruptible power supplies, and contingency operating procedures.

CONTROL, COMMUNICATION AND DIGITAL SYSTEM FAILURE

E.6.3.20 Control and communication systems are central to tunnel operation, incident management, and operations resilience.

E.6.3.21 Highway authorities should consider:

- operational technology (OT) systems, including control, monitoring and communications functions;
- associated software, digital infrastructure, and networks; and
- supporting infrastructure beyond the tunnel itself.

E.6.3.22 Failures of these systems can reduce situational awareness, limit operational control, and affect the ability to respond effectively to incidents.

E.6.3.23 Consideration should also be given to traffic-management, monitoring and user-information systems located on the approaches to the tunnel where these support tunnel operation, incident management, traffic control, evacuation, or resilience objectives.

E.6.3.24 Increasing reliance on digital infrastructure introduces additional risks associated with telecommunications outages, software failures, operational technology (OT) failures, system faults, and cyber-related incidents.

E.6.3.25 Preparedness measures, including regular training, exercises and periodic review of system performance, should support effective management of system failures and assist highway authorities in maintaining safe tunnel operation during periods of disruption.

SYSTEM INTERDEPENDENCIES AND CASCADING FAILURES

E.6.3.26 Tunnel systems operate as an integrated system of interdependent assets, technologies, and operational arrangements. Disruptive events may result in cascading effects whereby failure of one asset, system or service contributes to failures elsewhere, increasing the overall impact on safety, resilience, and operational continuity.

E.6.3.27 In addition to internal dependencies, tunnels may rely on external infrastructure and services including:

- power supplies;
- communications networks;
- operational technology;
- software platforms;
- traffic-management systems;
- associated buildings and facilities; and

- other infrastructure supporting tunnel operations.

E.6.3.28 Failures affecting these systems may result in widespread disruption or reduction in operational capability.

E.6.3.29 The potential for simultaneous or sequential events, including those occurring during recovery activities, should be considered in the design, operation, testing, maintenance, and resilience planning of tunnel systems, together with associated contingency arrangements and multi-agency incident-response plans based on interoperability principles.

E.6.3.30 Highway authorities should identify and manage system interdependencies to ensure that critical safety functions can be maintained despite individual failures or disruptive events.

E.6.3.31 Resilience measures may include:

- avoiding common-mode failures;
- identifying single points of failure;
- provision of redundancy;
- contingency arrangements;
- monitoring of critical dependencies;
- recovery planning; and
- operational strategies that prioritise the maintenance of safe conditions and minimisation of service disruption.

ASSET FAILURE, CONDITION, AGEING AND MAINTENANCE

E.6.3.32 Asset failure, deterioration, ageing, inadequate maintenance, and declining system performance may reduce resilience and increase vulnerability to disruptive events. Failures may occur suddenly or develop progressively over time and may affect the availability, reliability and operational performance of tunnel assets and systems, reducing their ability to maintain critical safety functions during normal, degraded or emergency operating conditions. Progressive degradation may affect the reliability, availability and operational performance of tunnel assets and systems, reducing their ability to maintain critical safety functions during normal, degraded or emergency operating condition.

E.6.3.33 The effects of asset failure, deterioration or ageing may be particularly significant where assets perform safety-critical functions or where failure may affect multiple systems, operational activities, or resilience measures. Reduced system performance may increase the likelihood and consequences of disruptive events and may affect the ability of the tunnel to recover effectively following incidents.

E.6.3.34 Highway authorities should use asset knowledge, inspection, testing, monitoring, maintenance, and lifecycle-planning activities to support resilience and reduce the likelihood of avoidable failures. Proactive identification of vulnerable assets and timely intervention can help maintain performance, extend service life, and support rapid recovery following disruption.

E.6.3.35 Highway authorities should recognise that asset resilience may also be affected by technology obsolescence, software support arrangements, and supply-chain constraints. Obsolescence and

supportability should be considered as part of lifecycle planning and resilience management activities.

E.6.3.36 Further guidance relating to condition assessment, monitoring, obsolescence management, spares management, software support and configuration management is provided in Section E.5.

SECURITY AND MALICIOUS ACTS

E.6.3.37 Tunnel infrastructure may be exposed to risks associated with vandalism, theft, unauthorised access and malicious acts, including cyber security incidents and other forms of deliberate interference that may affect tunnel operation, safety functions, or resilience.

E.6.3.38 Such events may affect asset availability, operational capability, user safety, information security, and confidence in tunnel operation. The consequences may include disruption to critical systems, loss of operational control, reduced situational awareness or degradation of safety-critical functions.

E.6.3.39 Highway authorities should implement proportionate physical-security and cyber-security measures appropriate to the risks associated with the tunnel, its operation and the criticality of the systems involved.

E.6.3.40 Security and resilience measures may include:

- physical access controls;
- digital access controls;
- monitoring and surveillance systems;
- asset and configuration management;
- cyber-security controls;
- incident-detection and reporting arrangements;
- backup and recovery procedures; and
- periodic review of security risks and vulnerabilities.

E.6.3.41 Particular consideration should be given to operational technology (OT), communications systems, software platforms, monitoring systems, control systems and other digital infrastructure used to support tunnel operation and incident management.

E.6.3.42 Where applicable, highway authorities should consider relevant cyber-security legislation, regulatory obligations and organisational requirements affecting operational technology, communications, and information systems.

E.6.3.43 Preparedness arrangements should include appropriate incident-response procedures, recovery arrangements, and periodic review of security risks to support continued operation and rapid recovery following security-related events.

DUST, CONTAMINATION AND DEPOSITED MATERIALS

E.6.3.44 The enclosed nature of tunnel environments may result in the accumulation of dust, respirable particulates, soot, silica-containing dusts, deposited contaminants and other potentially hazardous

residues on tunnel surfaces, equipment, and associated facilities. Such materials may arise from traffic emissions, brake and tyre wear, maintenance and construction activities, flooding events, fire incidents, and other operational activities. In some circumstances, deposited materials may contain substances with carcinogenic or other harmful properties that present risks to personnel undertaking inspection, cleaning, maintenance, or emergency-response activities. Highway authorities should consider the management of dusts, deposited contaminants and hazardous residues within inspection, maintenance and health-and-safety arrangements, including appropriate monitoring, cleaning, risk assessment, and control measures where necessary.

OPERATIONAL READINESS AND RISK MANAGEMENT

E.6.3.45 Highway authorities should maintain arrangements to understand and manage operational risks associated with tunnel assets and systems.

E.6.3.46 Operational risk information should consider risks arising during:

- normal operation;
- maintenance activities;
- incidents and emergencies;
- planned closures; and
- degraded modes of operation.

E.6.3.47 Highway authorities should also consider risks associated with commissioning, handover into operation, return-to-service activities and significant changes to tunnel assets, systems, or operational arrangements. Appropriate assurance, testing, validation, and operational readiness activities should be undertaken to support safe transition into operation.

E.6.3.48 Highway authorities should maintain appropriate operational procedures and emergency response arrangements relevant to the tunnel.

E.6.3.49 Emergency Planning Groups (EPGs), TDSCGs or equivalent arrangements should be used where appropriate. Such arrangements should be used to support coordination between tunnel operators, emergency services, and other relevant stakeholders.

E.6.3.50 Emergency exercises may include desktop, simulation-based and live exercises and should be undertaken at frequencies appropriate to the tunnel, its risks, and operational requirements. Exercises should support not only validation of operational procedures and emergency response arrangements, but also familiarisation of emergency responders and other stakeholders with the tunnel environment, safety systems, access arrangements, communications protocols, evacuation procedures, and incident-management responsibilities.

E.6.3.51 Highway authorities should work with emergency services and other relevant stakeholders to ensure that emergency exercises support the development and maintenance of competence, coordination, operational readiness, and interoperability throughout the lifecycle of the tunnel.

E.6.3.52 Lessons learned from exercises, incidents and operational events should be reviewed and used to improve:

- operational procedures;

- emergency response arrangements;
- training programmes;
- risk assessments; and
- tunnel safety documentation.

E.6.3.53 Operational risk assessments should consider the potential impacts on tunnel users, workers, emergency responders, local communities, infrastructure, and network operation.

E.6.3.54 Risk information should be reviewed periodically and following significant changes to tunnel assets, systems, operational procedures, traffic characteristics, incidents, or emergency exercises.

MINIMUM OPERATING REQUIREMENTS (MOR)

E.6.3.55 Highway authorities may establish Minimum Operating Requirements (MORs) to support decisions regarding tunnel operation during periods of degraded asset, system, or operational performance. MORs should not necessarily be regarded as equivalent to normal design or operational performance requirements. MORs may define the minimum acceptable operational capability below which additional restrictions, compensatory measures or closure may be required.

E.6.3.56 MORs should define the minimum acceptable operational capability necessary to maintain safe operation of the tunnel.

E.6.3.57 MORs may be developed with reference to:

- safety functions;
- tunnel characteristics;
- traffic characteristics;
- emergency response arrangements;
- operational procedures;
- system dependencies;
- compensatory measures;
- operational risks; and
- consequences of restriction or closure.

E.6.3.58 MORs should consider both:

- tunnel-user safety; and
- wider societal, economic and network impacts, recognising that tunnel closures may affect emergency-service response, diversion routes, freight movements, and network resilience.

E.6.3.59 Where system performance falls below normal operating requirements, highway authorities may implement compensatory measures were justified by risk assessment in order to maintain safe operation until normal capability is restored or further restrictions become necessary.

E.6.3.60 Compensatory measures may include:

- speed restrictions;
- lane restrictions;
- enhanced monitoring;
- enhanced inspections;
- additional operational resources;
- traffic-management measures;
- other risk-control measures.

E.6.3.61 The compensatory measures adopted should be proportionate to the nature of the degradation, the safety functions affected, the associated risks and the operational requirements of the tunnel. Table 45 provides illustrative examples of compensatory measures that may be considered where system performance is degraded.

Table 45: Example Compensatory Measures

Degraded Function/System	Example Compensatory Measures
Lighting systems	Reduced speed limits, lane restrictions, enhanced monitoring where appropriate.
Incident detection systems	Increased operator monitoring, additional patrols, temporary operational controls
Communications systems	Alternative communication methods, increased operational staffing
Ventilation systems	Traffic restrictions, reduced tunnel throughput, enhanced monitoring of environmental conditions
CCTV or monitoring systems	Additional inspections, increased operator presence, temporary traffic-management measures
Power systems	Operation on standby supplies, prioritisation of critical safety functions
Operational technology (OT) systems	Fall-back operating procedures, manual intervention, enhanced operational oversight
Multiple degraded systems	Combined compensatory measures, partial restriction or temporary closure where required

E.6.3.62 Where MORs cannot be achieved, highway authorities should consider whether partial restriction, temporary closure or full closure is necessary.

E.6.3.63 Highway authorities should ensure that utility providers and other external infrastructure owners are aware of the criticality of services supporting tunnel operation, including power, water, wastewater, and communications connections where loss of service could affect tunnel safety, resilience, or availability.

E.6.3.64 Highway authorities should maintain documented arrangements describing:

- assessment of degraded conditions;
- operational decision-making responsibilities;
- compensatory measures;
- escalation processes; and
- restoration criteria.

E.6.3.65 Figure 22 provides an illustrative example of how Minimum Operating Requirements (MORs) may be applied when tunnel assets, systems or operational arrangements are degraded. The process supports structured operational decision-making by assessing whether critical safety functions continue to meet the minimum capability required for safe operation. Depending on the outcome of the assessment, highway authorities may continue operation, implement compensatory measures, undertake remedial actions, apply restrictions, or consider partial or full closure until the required level of operational capability is restored.

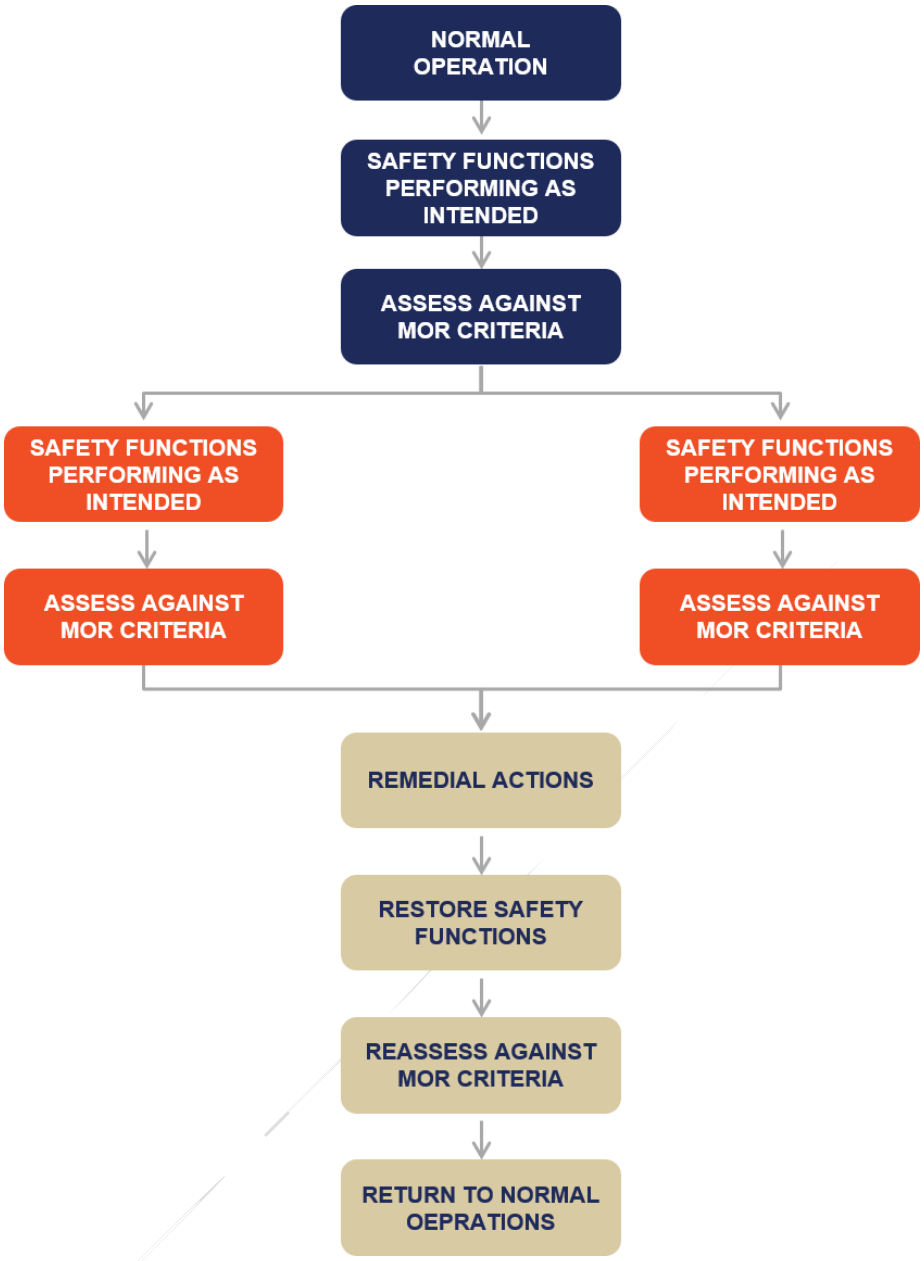


Figure 22 – Example Application of MOR

E.6.3.66 MORs should be reviewed periodically and following significant changes, incidents, exercises, or operational events.

E.6.4 ADAPTATION AND CONTINUOUS IMPROVEMENT

E.6.4.1 Highway authorities should periodically review tunnel resilience arrangements.

E.6.4.2 Reviews should consider:

- operational experience;
- incidents;

- exercises;
- monitoring information;
- inspection findings;
- technology changes;
- cyber-security threats;
- climate change; and
- changes in network demand.

E.6.4.3 Resilience planning should support continuous improvement and adaptation throughout the lifecycle of the tunnel.

SECTION E.7 FINANCE AND INVESTMENT – TUNNELS

E.7.1 INTRODUCTION

E.7.1.1 The principles of financial planning, lifecycle management, investment planning, and value management are described within Part A of this Code and the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG). This section provides supplementary guidance relating to the specific financial and investment considerations associated with highway tunnels.

E.7.1.2 Highway tunnels comprise complex, integrated systems with differing asset lives, renewal cycles, operational requirements, and risk profiles. Investment decisions should support the continued safe operation of the tunnel, maintenance of operational resilience, achievement of statutory obligations and delivery of whole-life value.

E.7.1.3 This section covers both the mechanisms by which tunnel teams obtain funding and the processes used to programme and prioritise expenditure within forward investment programmes.

E.7.1.4 Highway authorities should recognise that tunnel investment requirements may differ significantly from those associated with other highway assets due to the presence of safety-critical systems, operational technology, communications infrastructure, service buildings, and Minimum Operating Requirements (MOR).

E.7.1.5 Financial planning should be aligned with the Tunnel Asset Strategy, lifecycle plans, risk assessment arrangements, and resilience objectives described elsewhere within Part E. Highway authorities should consider short-, medium- and long-term investment horizons appropriate to the characteristics, service lives and operational requirements of their tunnel assets and systems. For Structural elements of Tunnels, refer to Part C of this Code.

E.7.1.6 Highway authorities should recognise that tunnel investment requirements may vary significantly between assets due to differences in tunnel age, construction, condition, traffic characteristics, operational requirements, associated buildings, supporting infrastructure, and installed technology. Investment planning should therefore be based upon the specific characteristics, risks, operational needs, and stock control management of each tunnel.

E.7.2 LIFECYCLE INVESTMENT DRIVERS AND FUNDING PRIORITIES

E.7.2.1 Investment decisions should be informed by asset knowledge, risk assessments, inspection findings, lifecycle assessments, operational requirements, and resilience objectives.

E.7.2.2 Investment needs may arise from:

- asset deterioration;
- declining asset performance;
- obsolescence;
- statutory or regulatory requirements;
- resilience improvements;
- interventions in advance of renewals;

- changes in operational requirements;
- changes in traffic demand;
- cyber-security requirements;
- supplier support limitations;
- safety improvements; and
- the need to maintain Minimum Operating Requirements (MOR).

E.7.2.3 Investment requirements may arise from different drivers throughout the tunnel lifecycle. Table 46 provides examples of common investment drivers and their potential implications.

Table 46: Lifecycle Investment Drivers examples

Driver	Example
Deterioration	Renewal required
Obsolescence	Unsupported equipment
Compliance	Legislative changes
Resilience	Flood mitigation
Cyber-security	OT upgrades
MOR	Restoration of safety functions
Operational Need	Traffic growth or reduction, increased number of HGVs, Dangerous Goods Vehicles (DGVs), or abnormal loads.

E.7.2.4 Highway authorities should recognise that tunnel investment priorities may differ from those associated with other highway assets due to the potentially significant safety, operational and network consequences of tunnel restrictions, degraded operation, or closure.

E.7.2.5 Funding priorities should consider:

- safety and statutory compliance;
- operational performance;
- resilience;
- asset criticality;
- network importance;
- consequences of failure;
- effects on emergency-service access;

- impacts on users and communities;
- environmental performance; and
- whole-life value.

E.7.2.6 Highway authorities should recognise that financial constraints do not remove statutory responsibilities relating to tunnel safety, operation, and maintenance. Where risks cannot be managed within acceptable limits, restrictions, compensatory measures, or closure may become necessary.

E.7.3 LIFECYCLE PLANNING AND INVESTMENT

E.7.3.1 Lifecycle planning principles should support the identification of future maintenance, renewal, replacement, and improvement requirements throughout the operational life of the tunnel.

E.7.3.2 Highway authorities should recognise the significant differences in asset service life, deterioration characteristics, renewal cycles and investment horizons between the tunnel structures, mechanical systems, electrical systems, communication systems, operational technology, and associated infrastructure. Structural assets may remain in service for many decades, whilst mechanical, electrical, communications, operational technology and software systems may require more frequent renewal, replacement, or upgrade. Lifecycle planning should consider software support arrangements, licensing requirements, interoperability, cyber-security obligations, supplier support, and technology obsolescence.

E.7.3.3 Tunnel asset groups may exhibit significantly different service lives and intervention cycles. Table 47 provides an illustrative comparison.

Table 47: Differing Asset Lifecycles

Asset Group	Relative Lifecycle Characteristics
Structure	Long-term
Buildings	Long-term
Mechanical	Medium-term
Electrical	Medium-term
Operational Technology Systems	Short-medium to Short

E.7.3.4 Asset age alone should not be used as the sole basis for determining intervention or replacement requirements. Lifecycle decisions should be informed by asset condition, performance, operational requirements, resilience needs, Minimum Operating Requirements (MOR), obsolescence risks, maintenance history, and engineering judgement.

E.7.3.5 Tunnel service buildings, substations, plant rooms, control buildings, communications infrastructure, and associated facilities should be considered alongside tunnel assets where they support tunnel operation or the delivery of safety-critical functions.

E.7.3.6 Highway authorities should also consider opportunities to reduce whole-life costs, carbon emissions, disruption and resource consumption through appropriate maintenance, refurbishment, renewal, and replacement strategies.

E.7.3.7 Highway authorities should seek to coordinate lifecycle interventions with wider highway and utility programmes where appropriate to minimise disruption and optimise value.

E.7.3.8 Guidance relating to investment prioritisation, programming, funding scenarios, and lifecycle planning is provided within the UKRLG Highway Infrastructure Asset Management Guidance (HIAMG), Part B, and should be read in conjunction with this section. The requirements below are intended to supplement that guidance with tunnel-specific considerations.

E.7.3.9 Investment planning should support the achievement of Minimum Operating Requirements (MOR), resilience objectives, and the continued delivery of safety-critical functions. Funding priorities should be linked to operational risk, statutory compliance and tunnel availability and the wider consequences of restrictions, degraded operation, or tunnel closure, including impacts on users, freight movements, emergency response arrangements, and wider network performance.

E.7.3.10 The upgrading and refurbishment of operational tunnels may require detailed consideration of system interdependencies, interoperability, commissioning requirements, operational constraints, regulatory obligations, and construction impacts. Highway authorities should recognise that interventions affecting one system may influence the performance or operation of other tunnel systems, with implications on design, construction, scheduling, regulatory compliance, and costs.

E.7.3.11 Highway authorities should consider the impact of legislative, regulatory, and market changes on the availability, supportability and replacement requirements of tunnel assets and systems. One example is the September 2023 withdrawal of certain T5 and T8 fluorescent lighting tubes, following changes made by the EU Commission to the RoHS Directive, which created replacement and upgrade considerations for some tunnel operators.

E.7.4 VALUE MANAGEMENT AND INVESTMENT PRIORITISATION

E.7.4.1 Value Management should be used to support transparent, evidence-based, and risk-informed investment decisions.

E.7.4.2 Highway authorities should maintain a forward work bank or equivalent process containing identified maintenance, renewal, replacement, and improvement requirements.

E.7.4.3 Prioritisation should take account of:

- safety;
- system performance;
- resilience;
- asset condition;
- asset criticality;
- network importance;
- operational impacts;

- consequences of failure;
- statutory compliance;
- environmental impacts;
- sustainability objectives; and
- whole-life costs.

E.7.4.4 In addition to direct asset impacts, highway authorities should consider wider consequences including:

- tunnel availability;
- user delays;
- freight movements;
- emergency-service access;
- network resilience;
- community impacts; and
- economic impacts.

E.7.4.5 Particular consideration should be given to tunnels that provide strategic links or where alternative routes are limited or unavailable. Prioritisation should consider both objective factors, such as condition, performance and resilience, and wider considerations such as stakeholder requirements, local impacts, and opportunities to coordinate works.

E.7.4.6 The outcome of the Value Management process should be a prioritised programme of interventions that can be progressed through investment planning and delivery processes.

E.7.4.7 Highway authorities may apply proportionate Value Management processes, with simpler approaches for routine maintenance activities and more detailed assessment for major renewal, replacement, or improvement schemes.

E.7.5 SPARES, OBSOLESCENCE AND TECHNOLOGY INVESTMENT

E.7.5.1 Tunnel systems frequently rely upon specialist equipment, operational technology systems and associated software that may become obsolete or unsupported before the end of their physical asset life.

E.7.5.2 Highway authorities should implement proactive arrangements for the management of:

- critical spares;
- equipment obsolescence;
- software support;
- software licences;
- hardware support;
- communications systems;

- operational technology;
- cyber-security requirements; and
- supplier support arrangements.

E.7.5.3 Investment planning should recognise that timely replacement of obsolete systems may be necessary to maintain resilience, operational capability, and cyber-security compliance.

E.7.5.4 Highway authorities should assess the availability of replacement components, manufacturer support, software support arrangements, and supply-chain risks when determining investment priorities.

E.7.5.5 Tunnel components may be bespoke, highly specialised, or subject to limited supplier availability. Highway authorities should recognise that the procurement timescales for replacement components may be significantly longer than those associated with conventional highway assets.

E.7.5.6 Strategic holding of critical spare parts may provide a cost-effective means of maintaining operational capability, extending asset life, and reducing the risk of prolonged restrictions or tunnel closures.

E.7.5.7 Where Minimum Operating Requirements (MOR) indicate that failure of a single asset or component could result in operational restrictions, degraded operation or tunnel closure, highway authorities should consider whether the holding of critical spare parts would support operational resilience, recovery, and continued delivery of safety-critical functions.

E.7.5.8 Critical spares assessment should consider assets located within the tunnel and within associated service buildings, control buildings, substations, plant rooms, and other facilities that support tunnel operations.

E.7.5.9 Where critical spare parts are held, appropriate storage, inspection, maintenance, and testing arrangements should be implemented to ensure that components remain fit for their intended purpose.

E.7.5.10 Highway authorities should maintain appropriate records, governance arrangements, and visibility of critical spare assets, including those held by service providers, contractors, or third-party organisations. Responsibilities for ownership, storage, maintenance, inspection, and replacement should be clearly defined.

E.7.5.11 Where manufacturers withdraw support or spare parts become unavailable, highway authorities should assess whether refurbishment, upgrade or asset replacement represents the most effective long-term solution.

E.7.5.12 Highway authorities should recognise that replacement is not always the preferred response to obsolescence. Refurbishment, life extension, repair, reuse, strategic spares holdings and other risk-based interventions may provide appropriate alternatives where consistent with operational, safety, resilience, and whole-life value objectives.

E.7.5.13 Particular consideration should be given to operational technology, communications networks, software-based systems, and other technology assets whose support arrangements may change more rapidly than those associated with traditional infrastructure assets.

E.7.6 VALUE ENGINEERING AND SCHEME DEVELOPMENT

E.7.6.1 Value Engineering should be used to identify the most effective means of delivering required asset outcomes whilst maintaining safety, resilience, and whole-life value.

E.7.6.2 Where multiple intervention options exist, highway authorities should undertake proportionate option appraisal to identify appropriate solutions.

E.7.6.3 Assessment criteria may include:

- whole-life costs;
- safety outcomes;
- resilience benefits;
- operational impacts;
- constructability;
- maintainability;
- environmental impacts;
- programme implications; and
- future flexibility.

E.7.6.4 Particular consideration should be given to the constraints associated with working in operational tunnels, including:

- restricted access;
- traffic management;
- tunnel closures;
- temporary loss of resilience;
- effects on safety systems;
- emergency-response arrangements; and
- impacts on users and the wider network.

E.7.6.5 Highway authorities should recognise that maintenance, renewal, and upgrade works may temporarily affect tunnel safety systems, resilience measures or operational arrangements and should ensure that appropriate mitigations are implemented throughout the works period.

E.7.6.6 Highway authorities should ensure that scheme development and option appraisal are informed by suitably competent personnel with appropriate knowledge of tunnel systems, operations, and associated risks.

E.7.6.7 Highway authorities should seek opportunities to coordinate maintenance, renewal and improvement works to minimise disruption and improve efficiency and optimise tunnel closures.

E.7.7 FORWARD WORK PROGRAMMES

E.7.7.1 Highway authorities should maintain forward work programmes that support short-, medium- and long-term planning.

E.7.7.2 Forward work programmes should be informed by:

- lifecycle plans;
- inspection findings;
- condition assessments;
- performance information;
- risk assessments;
- resilience requirements;
- obsolescence reviews; and
- available funding.

E.7.7.3 Programmes should recognise that many tunnel interventions require extended planning periods due to:

- operational constraints;
- closure requirements;
- stakeholder engagement;
- specialist procurement;
- technology integration; and
- commissioning and testing requirements.

E.7.7.4 Highway authorities should seek to coordinate tunnel closures, maintenance activities and renewal programmes with other highway, utility and infrastructure works whenever practicable in order to minimise disruption and optimise network performance. Opportunities should also be considered to integrate works across multiple tunnel assets and systems in order to minimise repeat interventions, reduce disruption and improve overall value.

E.7.7.5 Where funding constraints prevent delivery of all identified needs, highway authorities should maintain visibility of deferred interventions and understand the associated risks and consequences.

E.7.7.6 Due to the restricted operating environment and interdependent systems within tunnels, some interventions may require temporary operational restrictions or mitigating measures during implementation. Highway authorities should consider the associated operational, safety, programme and cost implications when developing forward work programmes.

E.7.8 MONITORING, REVIEW, AND CONTINUOUS IMPROVEMENT

E.7.8.1 Highway authorities should periodically review investment programmes to assess delivery, performance, and outcomes.

E.7.8.2 Review activities should consider:

- delivery against programme;
- expenditure against forecast;
- changes in asset condition;
- changes in asset performance;
- emerging risks;
- resilience performance;
- operational experience;
- lessons learned from incidents;
- lessons learned from maintenance activities; and
- changing operational requirements.

E.7.8.3 Highway authorities should seek to understand whether investment decisions are delivering the intended benefits relating to:

- safety;
- resilience;
- reliability;
- operational performance;
- sustainability;
- availability; and
- whole-life value.

E.7.8.4 Feedback from lifecycle planning, inspections, monitoring, operational assurance, incident investigations, and resilience activities should be used to improve future investment decisions, programme development, and operational outcomes.

SECTION E.8 SUSTAINABILITY – TUNNELS

E.8.1 INTRODUCTION

E.8.1.1 The principles of sustainability for highway infrastructure are provided in Section A.8 of this Code. This section identifies additional sustainability considerations specific to the operation, maintenance and management of highway tunnel infrastructure and associated systems.

E.8.1.2 Tunnel infrastructure represents a high-risk, energy-intensive asset with significant operational demands. Highway authorities should seek to minimise the environmental impact of tunnel operations and maintenance whilst maintaining safety, reliability, and service performance.

E.8.1.3 Sustainability considerations for tunnel infrastructure should be considered alongside the environmental, social, and economic principles set out in Sections A.8.2, A.8.5 and A.8.6, respectively.

E.8.1.4 Sustainability in tunnel infrastructure should seek to balance environmental performance, social value and economic efficiency whilst maintaining the safety, resilience, and operational requirements necessary for tunnel operation.

E.8.2 ENVIRONMENTAL SUSTAINABILITY

E.8.2.1 Additional guidance on carbon management is provided in Section A.8.4. Tunnel operations are typically energy intensive, and highway authorities should seek to minimise energy consumption associated with lighting, ventilation, pumping, operational technology (OT), whilst maintaining compliance with operational and safety requirements.

ENERGY USE

E.8.2.2 Opportunities to improve energy efficiency should include:

- adaptive lighting systems linked to ambient conditions and traffic flow;
- demand-led ventilation control based on air quality monitoring;
- use of high-efficiency plant and equipment;
- optimisation of operational regimes through monitoring and control systems.

E.8.2.3 Lighting, ventilation, and pumping systems frequently represent the largest contributors to operational energy consumption and associated carbon emissions within tunnel infrastructure. Highway authorities should consider optimisation of control strategies, monitoring systems, maintenance activities, and technology upgrades to improve energy efficiency whilst maintaining required safety functions and operational performance.

WASTE DISPOSAL

E.8.2.4 Maintenance activities should seek to minimise waste generation. Opportunities should be considered to refurbish, reuse, remanufacture or recycle tunnel equipment and components where this can be achieved without compromising safety, reliability, or performance. General

guidance on materials utilisation, waste management and recycling is provided in Sections A.8.2.31 to A.8.2.37.

E.8.2.5 Highway authorities should ensure that hazardous materials arising from tunnel maintenance activities are identified, classified, and managed in accordance with relevant regulations. This includes, but is not limited to:

- contaminated drainage residues (e.g. hydrocarbons, heavy metals);
- hazardous electrical or mechanical components;
- asbestos-containing materials within tunnel structures or equipment.

E.8.2.6 Such materials should be segregated, handled by competent personnel, and transported and disposed of via appropriately permitted facilities.

BIODIVERSITY AND LAND USE

E.8.2.7 Highway authorities should consider the potential impacts of tunnel operation and maintenance activities on biodiversity and surrounding land uses. General guidance on biodiversity, nature conservation and protected species is provided in Section A.8.2.

E.8.2.8 Particular consideration should be given to:

- tunnel portals, ventilation shafts and service buildings located within or adjacent to environmentally sensitive areas;
- drainage outfalls, attenuation features, and associated watercourses;
- habitats that may support protected species, including bats, nesting birds, and other wildlife; and
- maintenance activities that may affect designated sites or ecological corridors.

E.8.2.9 Where maintenance or renewal works have the potential to affect protected habitats or species, highway authorities should obtain appropriate ecological advice and comply with relevant environmental legislation and consenting requirements.

E.8.2.10 Opportunities to enhance biodiversity through the management of tunnel approaches, portal landscaping, sustainable drainage systems, and associated land should be considered where practicable and consistent with operational and safety requirements.

INCIDENT MANAGEMENT AND RESILIENCE

E.8.2.11 Highway authorities should consider the environmental impacts of incidents and emergency response activities as part of tunnel operational planning. General guidance on carbon management is provided in Section A.8.4.

E.8.2.12 Incident response and recovery arrangements should, where practicable, seek to minimise:

- the duration of tunnel closures;
- traffic congestion and associated vehicle emissions;
- unnecessary operation of energy-intensive systems; and

- the generation of waste and contaminated materials.

E.8.2.13 Procedures should be established for the management of environmentally hazardous incidents, including vehicle fires, fuel spillages, hazardous goods incidents, and contaminated fire-fighting water. Particular consideration should be given to fire-fighting water associated with alternative fuel vehicles such as electric-vehicle fires, hazardous-goods incidents and other events that may generate environmentally harmful residues.

WATER AND DRAINAGE MANAGEMENT

E.8.2.14 Tunnel drainage systems play a critical role in environmental protection, operational resilience, and fire safety. Highway authorities should ensure that drainage systems are maintained to:

- prevent the uncontrolled discharge of pollutants;
- manage wash water and runoff effectively;
- maintain interception systems (e.g. oil separators).

E.8.2.15 Where practicable, water-efficient maintenance techniques should be adopted, and opportunities for water treatment and reuse should be considered.

E.8.2.16 Activities should comply with applicable environmental permitting requirements, including the Environmental Permitting (England and Wales) Regulations, where relevant.

E.8.2.17 Highway authorities should also consider relevant guidance published by the Environment Agency, Natural Resources Wales, the Scottish Environment Protection Agency (SEPA), the Northern Ireland Environment Agency (NIEA) and other relevant environmental regulators, where applicable.

E.8.2.18 Highway authorities managing older tunnel assets should recognise that historical environmental obligations, drainage arrangements, discharge consents, and contamination risks may not always be fully documented. Appropriate investigations and risk assessments should be undertaken where uncertainties exist.

AIR QUALITY AND EMISSIONS

E.8.2.19 Highway authorities should maintain tunnel ventilation systems to ensure safe air quality within the tunnel and minimise environmental impacts at portals.

E.8.2.20 Highway authorities should also manage emissions, dust and noise arising from maintenance activities to minimise environmental impact on surrounding areas.

E.8.2.21 This should include:

- regular inspection and calibration of air quality monitoring systems;
- optimisation of ventilation strategies to balance air quality and energy consumption;
- minimisation of unnecessary ventilation operation.

CLIMATE RESILIENCE AND ADAPTATION

E.8.2.22 Tunnel asset managers should recognise the close relationship between sustainability and resilience. Climate-adaptation measures should be integrated into maintenance, renewal, and asset-management activities to improve long-term operational reliability and reduce whole-life environmental impacts.

E.8.2.23 Highway authorities should ensure that monitoring and control systems remain capable of supporting adaptation to changing environmental and operational conditions.

E.8.2.24 Highway authorities should assess and manage risks to tunnel infrastructure arising from climate change, including:

- increased rainfall, groundwater ingress, and flooding risk;
- rising temperatures affecting equipment performance;
- extreme weather events impacting tunnel operations.

E.8.2.25 Maintenance strategies should incorporate resilience measures such as enhanced drainage capacity, equipment cooling, and protection of critical systems.

E.8.2.26 Particular consideration should be given to portal flooding, drainage system capacity, resilience of pumping systems and the effects of elevated temperatures on safety-critical equipment.

ENVIRONMENTAL INTRUSION

E.8.2.27 Tunnel portals, ventilation shafts, service buildings, and associated infrastructure should be designed, maintained, and operated to minimise visual, noise and environmental impacts on surrounding areas.

E.8.2.28 Equipment such as fans, generators and plant should be maintained to minimise noise and vibration were reasonably practicable.

E.8.2.29 Storage areas, compounds, and maintenance facilities associated with tunnel operations should meet high environmental standards and avoid creating sources of pollution or visual intrusion. General guidance on environmental intrusion is provided in Section A.8.2.

E.8.3 SOCIAL SUSTAINABILITY

USER SAFETY AND EXPERIENCE

E.8.3.1 Tunnel users are in a confined environment where safety, comfort and perception are critical. Highway authorities should ensure that tunnel operation and maintenance support:

- safe and reliable passage through the tunnel;
- clear visibility and legibility (lighting, signage, and markings);
- acceptable air quality conditions;
- minimised disruption during maintenance activities.

PERSONAL SECURITY

E.8.3.2 Tunnels may present heightened concerns regarding personal safety, particularly for vulnerable users. Highway authorities should, as far as reasonably practical:

- maintain lighting levels to support visibility and perception of safety;
- ensure emergency egress routes are clearly identifiable and accessible;
- avoid creating concealed or poorly visible areas within pedestrian-accessible tunnel environments or approaches.

COMMUNITY IMPACT

E.8.3.3 Highway authorities should consider the impact of tunnel operation and maintenance on local communities, including noise, air quality, traffic disruption, and planned closures, and should take reasonable steps to minimise adverse effects.

E.8.3.4 Highway authorities should communicate significant tunnel closures and maintenance activities to affected stakeholders and coordinate, where appropriate, with local highway authorities, emergency services, and network operators.

WORKFORCE HEALTH AND SAFETY

E.8.3.5 Tunnel maintenance activities present unique risks, including confined spaces, live traffic, and hazardous atmospheres. Highway authorities should ensure compliance with:

- ISO 45001 – Occupational Health and Safety;
- confined space and tunnel-specific safety procedures.

E.8.3.6 Personnel should be appropriately trained and competent in both safety-critical and sustainable practices.

E.8.4 ECONOMIC SUSTAINABILITY

E.8.4.1 Tunnel infrastructure typically represents a significant long-term investment requiring ongoing operation, maintenance, inspection, testing, and renewal. Economic sustainability should seek to optimise whole-life value whilst maintaining safety, resilience, and operational performance.

E.8.4.2 Highway authorities should consider:

- whole-life costs;
- asset lifecycle management;
- energy consumption;
- maintenance efficiency;
- operational availability;
- resilience to disruptive events; and
- replacement and renewal planning.

E.8.4.3 Maintenance, renewal, and operational interventions should seek to minimise unnecessary whole-life costs arising from unplanned failures, emergency repairs, prolonged closures, and reduced service availability.

E.8.4.4 Highway authorities should recognise that tunnel closures may result in significant economic impacts affecting users, freight movements, emergency services, and wider transport networks. Sustainable asset management should therefore consider both direct asset costs and wider network consequences.

E.8.4.5 Maintaining operational availability through effective asset management may contribute to sustainability by reducing disruption, congestion, diversionary traffic, and the associated environmental, social, and economic impacts.

E.8.4.6 General guidance on economic sustainability and whole-life costing is provided in Section A.8.6. For tunnel infrastructure, highway authorities should consider the whole-life performance, reliability and maintainability of safety-critical systems when determining maintenance and renewal strategies.

EFFICIENT MAINTENANCE AND OPERATIONS

E.8.4.7 Efficient maintenance is essential to minimise both cost and disruption. Highway authorities should adopt:

- condition-based and risk-based maintenance approaches;
- predictive maintenance using monitoring data;
- planned interventions to reduce unplanned failures.

E.8.4.8 Lifecycle maintenance strategies should seek to minimise whole-life cost, carbon emissions, and disruption. Planned maintenance and timely asset renewal may reduce resource consumption, avoid premature asset replacement, and minimise the impacts associated with emergency interventions and tunnel closures.

RIGHT FIRST-TIME PRINCIPLES

E.8.4.9 Right first-time principles should be applied to all safety-critical and operationally critical tunnel systems, including:

- ventilation plant repairs and replacement;
- electrical and control systems maintenance;
- drainage system interventions addressing root causes;
- safety systems (fire detection, communications, power supply).

E.8.4.10 By ensuring that interventions are robust and durable, highway authorities can reduce repeat interventions, minimise closures and improve overall service reliability.

RESOURCE AND ENERGY EFFICIENCY

E.8.4.11 Highway authorities should seek to maximise the service life and reliability of tunnel assets through effective use of maintenance resources, operational data, and asset management systems.

E.8.4.12 Highway authorities should seek to optimise the use of energy, materials, and labour across tunnel operations, identifying opportunities to reduce operational costs while maintaining safety and compliance, including through the effective use of digital tools and operational data.

INNOVATION AND DIGITAL SYSTEMS

E.8.4.13 Highway authorities should consider innovative technologies, monitoring techniques and digital tools that improve safety, operational efficiency, asset reliability, environmental performance, and resource efficiency, whilst reducing maintenance interventions and operational disruption.

E.8.4.14 Highway authorities should encourage innovation and adoption of low-carbon technologies where practicable, ensuring tunnel infrastructure remains efficient, resilient, and adaptable to future requirements.