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Structures Asset Management Planning Toolkit

Part A: Methodology

Version 0.6

Month 2011

This document is supported, endorsed and recommended by:

Department for Transport

CIPFA The Chartered Institute of Public Finance & Accountancy

HAMFIG Highway Asset Management Financial Information Group

Note for Project Team: High definition logos required
Note for Project Team: Suggest ask the following organisations for endoresement

DfT
CIPFA
HAMFIG
UKRLG/UK Bridges Board
LoBEG
SCOTS
ADEPT
Welsh Association of Technical Officers
TfL
Local Government Association
Welsh Local Government Association

OTHERS?

Document Control

DOCUMENT DETAILS:

NAME:	Structures Asset Management Planning Toolkit – Part A: Methodology
VERSION:	0.6
OWNER:	UK Bridges Board
PREPARED BY:	Atkins
DATE OF ISSUE:	Date – Month – Year

VERSION HISTORY:

Version	Purpose Description	Date
0.1	Draft for client comment	09 October 2009
0.2	Draft for client comment	16 November 2009
0.3	Working draft for internal review	18 November 2009
0.4	Draft for client comment	01 July 2011
0.5	Draft for client comment	2 September 2011
0.6	Draft – Realised for consultation	16 September 2011

Acknowledgements

The Structures Asset Management Planning Toolkit has been developed by building on work previously undertaken by the London Bridges Engineering Group (LoBEG). The project has been undertaken by Atkins and overseen by a steering group:

Stephen Pottle (Chair)	Transport for London
Steve Berry (Project Sponsor)	Department for Transport
Andy Bailey	Department for Transport
Paul Hersey	Department for Transport
Mandy Bretherton	Chartered Institute of Public Finance and Accountancy
David Mackenzie	The Highland Council
Graham Bessant	London Underground
Neil Garton Jones	Gwynedd Council
Richard McFarlane	Royal Borough of Kingston upon Thames
Joe Figurado	London Bridges Engineering Group
Ian Sandle	Highways Agency
Liz Kirkham	Association of Environment, Economy, Planning and Transport
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Glossary of Terms

Asset — Whole system, structure or a component or part

Asset Management[1] — A strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure in order to meet the needs of current and future customers.

Asset Management Plan[1] — A plan for managing the asset base over a period of time in order to deliver the agreed levels of service and performance targets in the most cost effective way. This may be referred to as a highway asset management plan (HAMP) or transport asset management plan (TAMP) in other guidance documents and Codes if Practice.

Asset Management Planning — The activity of producing an Asset Management Plan

Asset Value[1] — The calculated current monetary value of an asset of group of assets. ‘Asset value’ in this document is synonymous with depreciated replacement cost.

Componentisation[1] — Where an asset can be broken down into identifiable components with different useful lives those components are accounted separately.

Asset Whole Life Cycle — The asset whole life cycle comprises all stages from design, construction, operation and maintenance to the end of life, including decommissioning, deconstruction and disposal.

Depreciated replacement cost (DRC)[1] — A method of valuation which provides the current cost of replacing an asset with its modern equivalent asset less deductions for all physical deterioration and all relevant forms of obsolescence and optimisation.

Depreciation[1] — The systematic allocation of the depreciable amount of an asset over its useful life arising from use, ageing, deterioration or obsolescence.

Deterioration[1] — The physical wear and tear on the asset; damage due to time, weather, etc. that can be observed and measured through condition surveys.

Discount Rate[2] — The annual percentage rate at which the present value of a future pound, or other unit of account, is assumed to decrease through time.

Discounted Cost — The resulting cost when the total costs of maintenance and renewals are discounted by the application of the discount rate.

Discounting[2] — A technique used to convert costs or benefits that occur in different time periods to ‘present values’, so that they can be compared on a consistent basis.

It is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later.

Finite life[1] — Length of life at the end of which the assets will need to be replaced.

Gross asset value — See **Gross replacement cost**

Gross replacement cost[1] — The total admissible cost of replacing either the whole of an existing highway network or some part of it with an equivalent new asset.

Heritage asset[1] — A listed asset or an asset that, due to its construction form or character, is considered to be important to the heritage and/or character of an area.

Indefinite Life[1] — Those assets that, given the necessary maintenance, will last indefinitely.

Inflation — The rise in the general level of prices of goods and services in the economy over a period of time.

Inflation Rate — A measure of inflation; it is the percentage rate of increase in the level of consumer prices or the percentage rate of decrease in the purchasing power of money.

Note: Provided that inflation for all costs included in the life cycle plan is approximately equal, it is normal practice to exclude inflation effects from a whole life cycle cost/value analysis. However, inflation should be applied when the outputs from the analysis are used for budgeting purposes.

Life Cycle Plan — A long-term strategy for managing an asset, or a group of similar assets, with the aim of providing the required performance while minimising whole life costs.

Modern Equivalent Asset — An asset that provides the same potential performance as the existing asset but takes account of up to date technology.

Net Present Cost (NPC) — The discounted 'present cost' of all future costs, e.g. work, access, track possession, etc. It is calculated as:

$$\mathrm{NPC} = \sum_{t=0}^{T} \frac{C_t}{(1+r_t)^t}$$

where

T = the time horizon in years.

t = the current year, with t = 0 in the base year.

C_t = costs incurred in year t, i.e. labour, plant and material.

r_t = the discount rate for year t, expressed as a fraction.

Net Present Value (NPV) — The discounted 'present value' (normally monetised) of all future costs, benefits and dis-benefits (e.g. service disruption, environmental impact, carbon footprint, etc.). It is calculated as:

$$NPV = \sum_{t=0}^{T} \frac{M_t}{(1+r_t)^t}$$

where

	T = the time horizon in years.
	t = the current year, with t = 0 in the base year.
	M_t = monetised costs, benefits and dis-benefits in year t.
	r_t = the discount rate for year t, expressed as a fraction.
Special structures[1]	Structures that due to a combination of their size, construction and character, are not suitable to be valued using standardised unit rates and gross replacement cost models.
Time Horizon[1]	The period covered by the analysis; typically, this is between 30 and 120 years.
Uncertainty	Lack of certain, deterministic values for the variable inputs used in a whole life cycle cost analysis of an asset.
Unit Rates[1]	The cost per unit measure (number/length/area/volume) to replace an asset or a part of an asset.
Whole Life Cost[3]	The cost of all items/activities that need to be considered in a whole life cycle cost analysis, such as the costs of acquiring (including design and construction costs), operating and maintaining an asset over its whole life cycle through to its eventual disposal. Whole life cycle costs are used to calculate a net present cost (NPC).
Whole Life Cycle Costing	A technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. Being able to compare the future costs of alternatives allows selection of the most effective overall solution and helps to plan and control the cost of ownership.
Whole Life Cycle Value[3]	A balance of the stakeholders' aspirations, needs, requirements and whole life cycle costs, i.e. a balance between risks, performance, cost of interventions and interventions. Whole life cycle value is used to calculate a net present value (NPV).
Whole of Government Accounts[1]	Full accruals based accounts covering the whole of the public sector. They consolidate the accounts of around 1300 bodies from within the central government, local government, health service and public corporation sectors.

Abbreviations

AADT	Annual Average Daily Traffic
$AADT_f$	Factor based on Annual Average Daily Traffic Flow on route
AMP	Asset Management Plan
CIPFA	Chartered Institute of Public Finance and Accountancy
CSS	County Surveyors Society (currently known as ADEPT)
CV	Commercial Vehicles
DC	Design Costs
DRC	Depreciated Replacement Cost
ECI	Element Condition Index
Ext_{Si}	Extent for Severity i
f1, f2, f3	Weighting coefficients
f_D	Uplift factor for Design Costs
f_O	Uplift factor for Other Costs
f_p	Uplift factor for Preliminary Costs
FR	Fixed Rate
f_{TM}	Uplift factor for Traffic Management Cost
GPG	Good Practice Guide
GRC	Gross Replacement Cost
LIP	Local Improvement Plan
LoBEG	London Bridges Engineering Group
LTP	Local Transport Plan
MEA	Modern Equivalent Asset
NPC	Net Present Cost
NPV	Net Present Value
OBS_f	Factor based on obstacle crossed by route
OC	Other Costs
PC	Preliminaries Cost
P_R	Prioritisation Score
Rf	Factor based on importance of route served
SC	Scheme cost
SF	Element/Structure Size Formulae
ST_f	Structure Type factor
TEoD	Total Extent of Defects
TMC	Traffic Management Cost

TMR	Traffic Management Rate
UR_C	Constant Unit Rate
UR_S	Unit Rate for Severity i
$WC_{M\ Constant}$	Works cost for *Constant* maintenance activity cost type
$WC_{M\ Fixed}$	Works cost for *Fixed* maintenance activity cost type
$WC_{M\ Variable}$	Works cost for *Variable* maintenance activity cost type
WD	Works Duration
WGA	Whole of Government Accounts
WLC	Whole Life Cost
∑WC	Total Works Cost

1. Introduction

1.1 General

1.1.1 This Good Practice Guide (GPG) constitutes one part of the *Structures Asset Management Planning Toolkit*. **To be confirmed:** The custodian of this document is the *UK Bridges Board*.

1.1.2 The Structures Asset Management Planning Toolkit comprises:

- Part A: Methodology (this GPG)
- Part B: Functional Specification
- Part C: Supporting Information

1.2 Purpose of the Structures Asset Management Planning Toolkit

1.2.1 The purpose of the *Structures Asset Management Planning Toolkit* is to support bridge engineers and managers in their management and other related activities, for example, financial planning, prioritisation of needs, lifecycle planning and asset valuation.

1.2.2 This version of the toolkit (Version x.x, Month 2011) primarily focuses on long-term asset management and financial planning and asset valuation/depreciation for highway structures.

1.3 Objectives of the Structures Asset Management Planning Toolkit

1.3.1 The objectives of the toolkit, and the requirements and principles that underpin it are:

- To clearly explain the overall methodology and supporting rationale;
- To identify the data and supporting information, i.e. rule sets and algorithms, required to support the methodology and functional specification;
- To ensure the methodology and the functional specification are standalone and independent of any computerised tool, thereby enabling the toolkit to be adopted by different commercial software/systems;
- To enable the methodology, where appropriate, to be adopted in part or in whole to suit the functionality of different commercial software/systems;
- To clearly define the minimum requirements of the methodology and functional specification;
- To enable the methodology and functional specification, where appropriate, to be applied so that the minimum requirements are met by the analysis.
- To enable the methodology and functional specification, where appropriate, to be refined to support evolving practices over time.

1.4 Background

Asset Management

1.4.1 Asset management is accepted good practice for infrastructure assets. In recent years a number of high profile publications have emphasised the importance of adopting an asset management approach for infrastructure assets, including:

- CSS Framework for Highway Asset Management [4]
- Management of Highway Structures: A Code of Practice [5]
- Maintaining a Vital Asset [6]
- International Infrastructure Management Manual [7]
- PAS 55: Asset Management [8]

1.4.2 In recognition of this, the UK Bridges Board has developed this toolkit to support asset management activities for highway structures.

Accounting Requirements

1.4.3 The UK Government introduced the Whole of Government Accounts (WGA) process to produce a consolidated set of financial statements for the UK public sector. It consolidates around 1,500 bodies, including central government departments, local authorities, devolved administrations, the health service, and public corporations. It is prepared using accounting standards (International Financial Reporting Standards), as adapted and interpreted for the public sector, and is similar in presentation to private sector accounts.

1.4.4 The aim of WGA is to enable Parliament and the public better to understand and scrutinise how taxpayers' money is spent. By presenting the public finances in a framework familiar to the commercial and accountancy professions, WGA increases transparency and accessibility of information about public finances.

1.4.5 CIPFA, on behalf of HM Government, has produced financial planning and accounting guidance for local authority transport infrastructure. CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting*[1] supports and aligns with recognised good practice in asset management, providing synergy between asset management, financial planning and accounting. The Code moves the valuation of infrastructure assets from a historic cost basis to a depreciated replacement cost valuation which is consistent with the accounting policy adopted for WGA.

1.4.6 The Structures Asset Management Planning Toolkit meets the accounting requirements presented in the CIPFA Code[1].

1.5 Purpose of Part A

1.5.1 The purpose of this document is to describe in detail the methodology that has been developed for highway structures to meet specific asset management (and financial reporting) requirements. The document sets out the assumptions, rationale, algorithms, the minimum data requirements and how the methodology can, where appropriate, be further refined.

1.6 Layout of the Good Practice Guide

1.6.1 The layout of the Good Practice Guide is summarised in Table 1.

Table 1 – Layout of the Report

Section	Contents Description
2. Asset Management Planning	Provides a detailed description of the Structures Asset Management Planning Process along with it component parts.
3. Calculating Gross Replacement Cost	Provides guidance for calculating gross replacement cost
4. Calculating Depreciation	Provides guidance for calculating depreciation
5. References	List relevant documents referred to for the purpose of this study
Appendices	Provide supporting information

2. Asset Management Planning

2.1 General

2.1.1 Asset Management Planning is used to assess current and future needs of a stock of structures, enabling 'what-if' analyses to be performed, for example, impact of different levels of spend on performance. The methodology uses standard inventory, inspection and work programme data, alongside data on deterioration rates, service lives and treatment types/effects.

2.2 Hierarchy of Asset Management Functions

2.2.1 *Management of Highway Structures: A Code of Practice* [2] recommends that the asset management functions within an organisation should align with integrated planning and decision-making at the three management processes typically categorised into three levels in large organisations, namely: Strategic, Tactical and Operational.

2.2.2 The scope of the asset management functions in the three levels is illustrated in Figure 1 and summarised below.

- ***Strategic: Where are we going and Why?*** – At the strategic level organisations establish, in consultation with stakeholders, the overall long term direction for transport, e.g. policy, goals and objectives, vision, mission statement and performance targets. The strategic vision is often encapsulated in the Business Plan, e.g. Strategic Transport Plan (e.g. LTP and LIP), and/or Asset Management Policy.
- ***Tactical: What is worth doing and When?*** – At the tactical level the overall Strategic Transport Plan (goals and objectives) is translated into specific plans, objectives and performance targets for individual asset types. The tactical level involves undertaking a performance gap analysis and adopting and implementing a formal asset management planning process to identify the required, most beneficial and cost effective activities and when they should be carried out. Particular emphasis is drawn to the role of asset management planning which although a tactical programming activity, it is heavily relied upon to support strategic planning, i.e. informs budget setting and can be used to demonstrate the delivery of performance targets.
- ***Operational: How to do the right things?*** – At the operational level detailed work plans and schedules that have a short term outlook but take account of the work volumes and phasing arising from tactical planning are developed and implemented. Engineering processes include inspection, structural assessment, routine maintenance, scheme design, work scheduling and implementation. Their focus is on choosing the right techniques, Value Engineering of schemes and carrying out the work in the most efficient way.

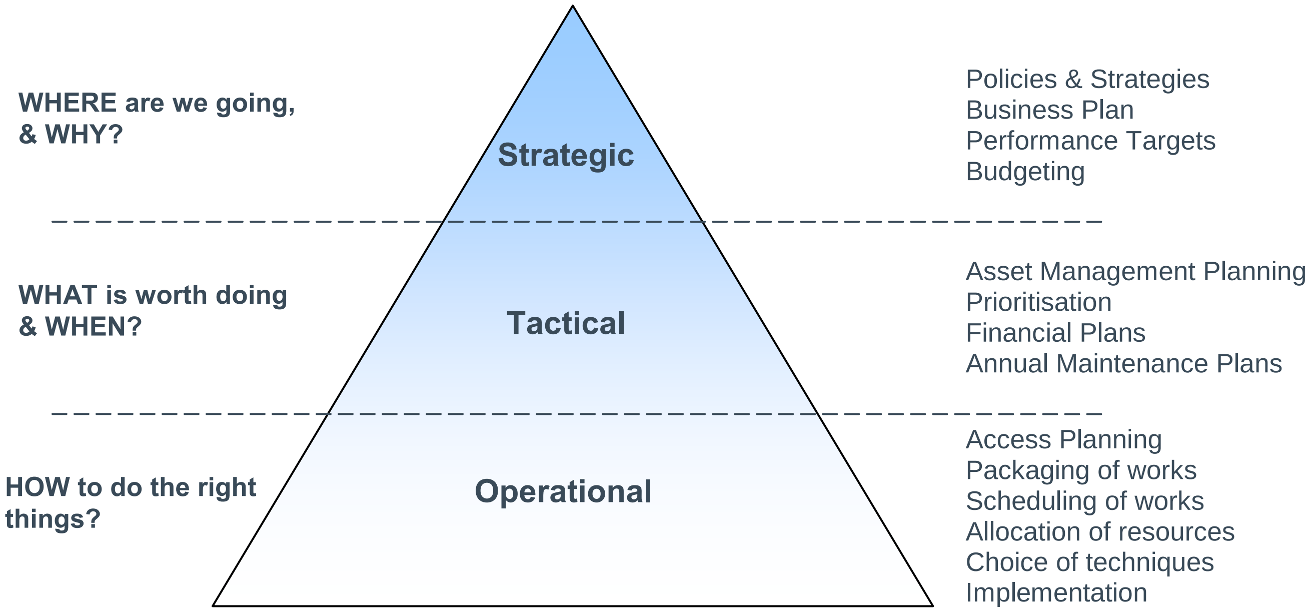


Figure 1 – Hierarchy of Asset Management Functions[5]

2.3 Overview of Asset Management Planning Process

2.3.1 The approach is based on that described in *Management of Highway Structures: A Code of Practice* [5]; extending and refining steps 5 to 9 to provide a detailed step-by-step methodology for asset management planning. Figure 2 provides an overview of the asset management planning process for structures; the main steps in the process are:

- ***Inventory Data and Groups*** – e.g. structure type, dimensions, materials elements and the criteria used to group similar structures;
- ***Condition Data*** – element level condition and defect data, i.e. a standardised severity and extent ratings are used for highway structures.
- ***Programmes of Work*** – defined programmes of work that typically address specific needs or issues, e.g. strengthening, parapet upgrade, scour susceptible bridges.
- ***Identification of Needs*** – identify maintenance needs based on defined intervention levels, triggers and programmes of work.
- ***Select Treatments and/or Strategies*** – select the appropriate treatment, and/or long-term strategy, to address the need.
- ***Calculate Costs and Penalties*** – evaluate the costs (e.g. labour, plant, material, access etc.) and penalties (e.g. traffic disruption) of doing or not doing work.
- ***Prioritise Identified Needs*** – prioritise competing maintenance needs using an appropriate set of weighted criteria;
- ***Maintain and/or Deteriorate*** – improve/restore the condition of those structures or elements that have been treated and deteriorate others.
- ***Evaluate Expenditure and Condition*** – evaluate the total annual expenditure and the condition of the structure stock after maintenance.
- ***Outputs*** – the key outputs from the lifecycle planning process, across the full analysis period (i.e. time horizon) and for each scenario analysed (e.g. Do Minimum, defined budget and target condition), include:
  - Expenditure, condition and backlog profiles;
  - The expected life of each finite life component;

- The treatment cycle/life of each indefinite life component;
- The timing, cost and effect of each intervention (be it a replacement of a finite life component or capital maintenance of an indefinite life component).

2.3.2 The following sections provide a detailed description of each step in the process.

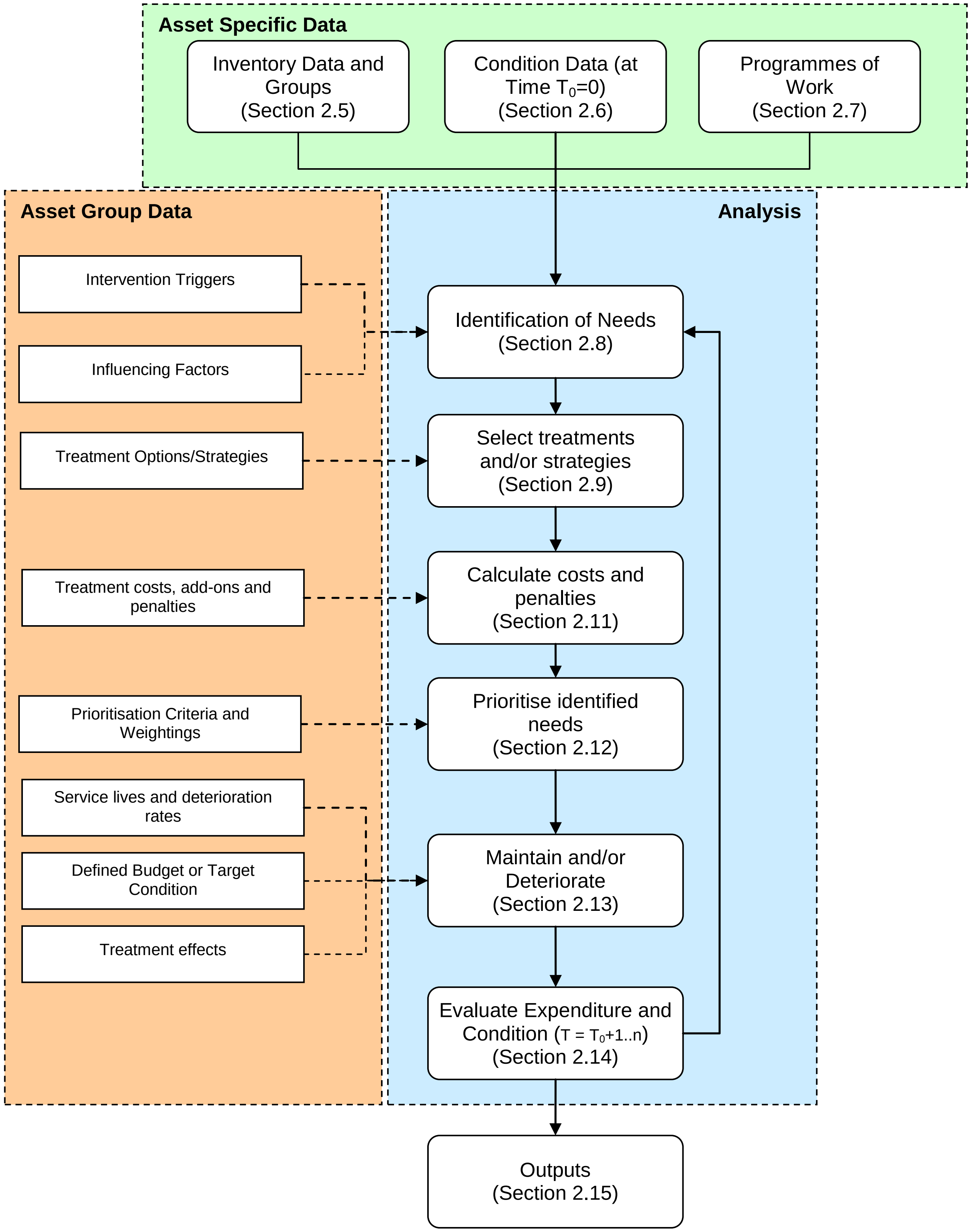


Figure 2 – Overview of Structures Asset Management Planning Process

2.4 Process Logic

Time Dependant Deterioration

2.4.1 Deterioration of highway structures may trigger specific maintenance needs and expenditure. Therefore, the appropriate representation of deterioration through time is a fundamental part of the asset management planning process. This requires service lives and deterioration rates to be defined which inform the analysis and support profiling of deterioration through time in the following sequence of events:

(1) Starting condition is provided for time T_0=0
(2) Needs are identified and/or prioritised before available funding is allocated
(3) Structures and/or elements that have been allocated funding, are maintained/treated and their condition is reset for use in the following year (T= T_0+1) of the analysis
(4) Structures and/or elements that have not been allocated funding are deteriorated further. Their deteriorated condition is used to support the analysis undertaken for the following year (T= T_0+1) in the evaluation period.
(5) Repeat steps 2 – 4 for each year in the evaluation, i.e. from T= T_0+1 to T_0+n.

Homogeneous Groups

2.4.2 Asset management planning for a stock of structures can be a highly involved and time consuming exercise if lifecycle data needs to be defined for each individual structure and its associated elements and components, e.g. deterioration rates, service lives, intervention options, cost, etc. For strategic level asset management planning it is not necessary to define detailed lifecycle planning information for every single structure (although there may be some unique/special structures that do require this level of attention).

2.4.3 Asset management planning can be streamlined by categorising the assets into homogeneous groups. A homogeneous group is a collection of assets that are considered to have similar attributes and behave in a similar manner, e.g. rate of deterioration. However, where this categorisation is not possible, i.e. due to the unique characteristics of some structures, lifecycle data and information should be defined on an individual structure basis.

2.4.4 The criteria used to determine homogeneous groups should be those that have a significant influence on the lifecycle behaviour or Level of Service requirements of the assets. Criteria that should be considered when defining homogeneous groups for highway structures include:

- Structure type, e.g. bridge, culvert, retaining wall, etc;
- Location, e.g. urban, rural, environmentally sensitive area, same route corridor, etc;
- Structure usage, e.g. route supported, obstacle crossed, traffic, etc;
- Construction type and material, e.g. as defined by the Bridge Type Code [9];
- Structure size, e.g. number of spans and dimensions;
- Level of Service requirements, e.g. high visual standard required, loading requirements.

Important Note: It is considered that the primary drivers for deterioration and interventions are the structure type, construction type and construction material as these would determine whether a group of structures behave in a similar or different manner with regard to deterioration. It is not recommended to group structures with different deterioration behaviour, i.e. ‘location’ should not be used as the sole or most significant criterion for grouping structures because, for example, structures on the same route corridor but of different construction and material type (e.g. a simply supported concrete bridge and a masonry arch) will not deteriorate in the same manner.

Data and Analysis

2.4.5 Figure 2 shows there are three key areas in the asset management planning process; these are:

- ***Asset Specific Data*** – Inventory, condition, etc.
- ***Asset Group Data*** – Lifecycle and other data and information typically defined at group level; and
- ***Analysis*** – Analysis performed at group, structure and/or element/component level.

2.4.6 As discussed in the previous section, for strategic asset management planning, it is only necessary to define lifecycle data at group level. However, the analysis will be performed at group, structure, element or component level, i.e. for complex structures (e.g. bridges, tunnels) the individual element or components will be analysed but for more straightforward structures (e.g. culverts, retaining walls, etc.) it will be possible to perform the analysis at either group or structure level (as element level data may not be readily available for structures such as culverts, retaining walls, etc.).

2.4.7 It is noted that the analysis is only performed for assets that are under the stewardship of an organisation.

2.5 Inventory Data and Groups

Inventory Data

2.5.1 The minimum inventory data required is:

- ***Structure Type*** – as per those listed in Table 2;
- ***Bridge Type Code*** – the four digit code that identifies the structural form and construction materials [9].
- ***Dimensions*** – the relevant dimensions for the structure type, see Table 2;
- ***Structure Breakdown*** – an appropriate breakdown of the structure, see Table 3;
- ***Structure Usage*** – the asset carried or supported (e.g. road, rail, etc.), the obstacle crossed (e.g. road, rail watercourse, etc.).
- ***Structure Location*** – Urban, rural, marine/estuarial.
- ***Traffic Category*** – a category used as an indication of levels associated with a structure, e.g. 'high', 'medium' or 'low', the actual values of AADT, CV, speed limit, traffic type, etc. are not required.

2.5.2 LoBEG published a Good Practice Guide (GPG)[10] which provides guidance and an approach for creating consistent element inventories for highway structures. It is considered that the approach supports improved Asset Management Planning and Financial Reporting and significantly aids towards meeting the requirements specified by the CIPFA Code of Practice[1]. As such authorities are encouraged to collect/record inventory data in accordance with LoBEG's Good Practice Guide[10].

Table 2 – Structures Dimensions

Structure Types	Description	Dimensional Requirements	
		Minimum	Refined
Bridge: Vehicular	A structure with a span of 1.5m or more spanning and providing passage for vehicular traffic over an obstacle, e.g. watercourse, railway, road	Number of spans Overall length (m) Average width (m)	Average height (m) Individual span lengths (m)
Bridge: Pedestrian/cycle	As for vehicular bridge, but provides passage for pedestrians and cyclists.		
Cantilever road sign	A structure with a single support that projects over the network in order to carry a traffic sign	Number	Height (m) Outreach (m)
Chamber/cellar/vault	An underground room or chamber with a plan dimension of 1.5m or more	Average length (m) Average width (m)	Average height (m)
Culvert	A drainage structure with a span of 0.9m or more passing beneath a network embankment that has a proportion of the embankment, rather than a bridge deck, between its uppermost point and the road running courses	Length (m) Average width (m)	Average height (m)
High Mast Lighting	Lighting columns over 20m in height	Number	Height (m)
Retaining Wall	A wall associated with the network where the dominant function is to act as a retaining structure (>1.35m)	Length (m)	Average retained height (m)
Sign/signal gantry	A structure spanning the network, the primary function of which is to support traffic signs and signalling equipment	Length (m)	Height (m) Width (m)
Structural earthworks - reinforced/strengthened soil/fill structure	A structure associated with the network where the dominant function is to stabilise the slope and/or retain earth. All structures with an effective retained height of 1.5m or greater.	Length (m) Plan Width (m)	Height (m)
Subway: Pipe	Subways that provide passage for utility service pipes and cabling	Length (m)	Average width (m) Average height (m)
Tunnel	An enclosed length of 150 metres or more through which vehicles passes	Length (m) Average width (m)	Average height (m)
Underpass (or subway): Pedestrian	A structure with a span of 1.5m or more that provides passage for pedestrians	Length (m) Average width (m)	Average height (m)
Underpass: Vehicular	The underpass includes approach slab, retaining walls, bridge, drainage etc.	Length (m) Average width (m)	Average height (m)
Special structure	For example, moveable bridges, Millennium Bridge, Tower Bridge	As appropriate	As appropriate

Table 3 – Component Breakdown for Asset Management Planning

Structures Type	Minimum Breakdown	Refined Breakdown
Bridge: Vehicular	CSS Bridge Inspection Elements[1]	Sub-division of major inspection elements, e.g. abutments divided into East and West
Bridge: Pedestrian/cycle		
Cantilever road sign	Structure	CSS Sign/Signal Gantry Inspection Elements[1].
Chamber/cellar/vault	Structure	CSS Bridge Inspection Elements[1].
Culvert	Structure	CSS Bridge Inspection Elements[1].
High Mast Lighting	Structure	CSS Sign/Signal Gantry Inspection Elements[1].
Retaining Wall	Structure	CSS Retaining Wall Inspection Elements[1].
Sign/signal gantry	Structure	CSS Sign/Signal Gantry Inspection Elements[1].
Structural earthworks - reinforced/strengthened soil/fill structure	Structure	-
Subway: Pipe	Structure	CSS Bridge Inspection Elements[1].
Tunnel	CSS Bridge Inspection Elements[1].	Sub-division of major inspection elements, e.g. abutments divided into East and West
Underpass (or subway): Pedestrian		
Underpass: Vehicular		
Special structure		

Finite and Indefinite Life Components

2.5.3 Lives of components can be considered in two ways:

- Finite Life – those components that typically need to be replaced at the end of their service life, for example, expansion joints, bearings, some types of parapets, paint system, etc.
- Indefinite Life – those components that, given necessary maintenance, are maintained in perpetuity, e.g. abutments, primary/secondary deck elements, foundations, etc.

2.5.4 Appendix A provides the default classification of elements into finite and indefinite life, however, it is recognised that these may differ on a case by case basis. As such, bridge engineers/managers should review and amend the default classification as appropriate.

Groups

2.5.6 Using the criteria described in Section 2.4, Paragraphs 2.4.2 – 2.4.4, homogeneous groups should be defined to reflect the key characteristics of the structure stock, enabling key drivers/influencers of lifecycle activities to be identified. It is important to bear in mind that the more refined the grouping the more effort will be involved in setting up the lifecycle data, i.e. data is required for each homogeneous group.

Example 1: Groups

‘Crude’ Group – 100 Composite Bridges

This group comprises 100 ‘concrete/steel composite bridges’ and has been formulated by interrogating only the drivers considered key to deterioration and interventions, i.e. structure type, construction type and construction material. This means that the criteria adopted for the formulation of this group are:

- Structure type = bridge; and
- Bridge Type Code = 04E 24A, i.e. a bridge composed of a reinforced concrete deck slab supported by longitudinal steel beams.

‘Refined’ Group – 5 Composite Bridges

This group comprises 5 ‘concrete/steel composite bridges’ as it has been formulated using the same criteria as the ‘Crude’ Group above as well as additional criteria as follows:

- Location = Urban
- Route supported = A road
- Obstacle crossed = Railway line
- Number of spans = 3 – 4 spans

2.6 Condition Data

2.6.1 Condition data for highway structures is primarily collated through General and Principal Inspections, typically undertaken at 2 and 6 year intervals. This data forms the foundation for all asset management planning activities and in particular acts as the starting point from which predictions on how the condition (or performance) of the assets changes though time can be made.

Group/Structure Level Analysis and/or Structures with No Condition Data

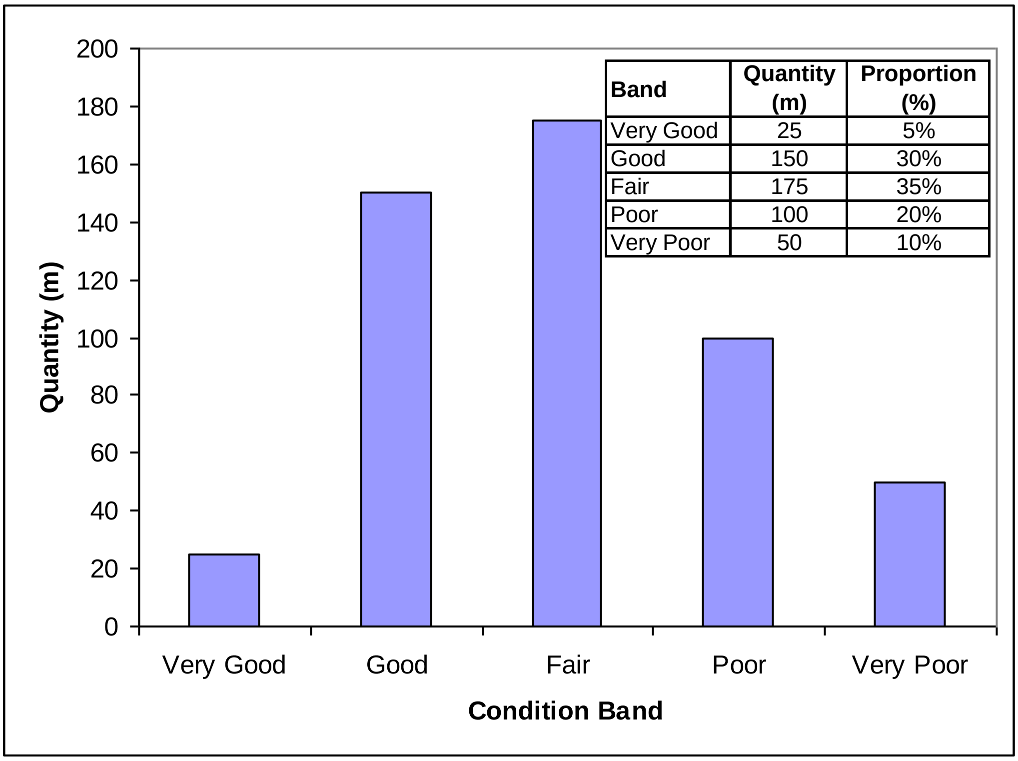
2.6.2 For certain structure types (see Table 3) the analysis can be performed at group and/or structure level as described in Section 2.4, Paragraphs 2.4.5 – 2.4.6, particularly when condition data is not held and/or systematically collected. For these structures a discrete 'condition band', representing a range of condition states/scores, is assigned at the start of the analysis. To imitate the starting position for the analysis a proportion/quantity of the group is defined against each condition band.

- Very Good, i.e. $90 \le x \le 100$
- Good, i.e. $80 \le x < 90$
- Fair, i.e. $65 \le x < 80$
- Poor, i.e. $40 \le x < 65$
- Very Poor, i.e. $0 \le x < 40$

Example 2: Group of Retaining Walls with No Condition Data

A group of retaining was has been defined and this comprises 20 reinforced concrete retaining walls of not more than 3m in height each and of total length of 500m.

As condition data is not available for this group of structures, at the start of the analysis a proportion can be assigned representing the percentage of the total length against each condition band as illustrated below.



Band	Quantity (m)	Proportion (%)
Very Good	25	5%
Good	150	30%
Fair	175	35%
Poor	100	20%
Very Poor	50	10%

2.6.3 It is noted that the aforementioned approach, i.e. the analysis being performed at group and/or structure level for structures with no condition data, is provided as a ‘stop gap’ until such time that suitable element level condition data can be collected.

Component /Element/Sub-Element Level Analysis for Structures with Condition Data – Refined Level

2.6.4 Defect code types can be used to support a more refined level of analysis. These should be in the format described in the *Inspection Manual for Highway Structures*[9]. The current methodology does not support this level of refinement.

Currency of Condition Data

2.6.5 The use of ‘out of date’ data should be avoided because the analysis does not support the updating of condition data where this is deemed to be ‘out of date’. Condition data is considered to be current and appropriate for the analysis when an inspection regime in accordance with *Management of Highway Structures: A Code of Practice*[5] is identified and implemented. If organisations do not comply with the data collection recommendations provided in *Management of Highway Structures: A Code of Practice*[5] they should fully document the assumptions and rationale to justify that the condition data used for the analysis is suitable.

2.7 Programmes of Work

2.7.1 Programmes of work provide details (i.e. work type, cost, etc.) of activities scheduled to address specific needs or issues. These should be used, where possible, to inform the analysis and may include the following:

- ***Routine maintenance regime schedules*** – minor work carried out on a regular or cyclic basis that helps to maintain the condition and functionality of the structure and reduce the need for other, often more expensive, maintenance works.
- ***Inspection programme*** – inspections, e.g. General Inspections and Principal Inspections, that are undertaken for the purpose of providing the most-up-to-date and comprehensive data on the condition of structures.
- ***Assessment programme*** – structural assessments that are undertaken in order to identify sub-standard structures.
- ***Upgrade programmes*** – work that brings an existing structure up to the appropriate current standard, e.g. strengthening, upgrading parapets, waterproofing, etc.
- ***Improvement programmes*** – work that entails changing certain features of an existing structure e.g. increasing the width or headroom of an existing structure.
- ***Lifecycle plans*** – Long-term strategies for managing an asset, or a group of similar assets, with the aim of providing the required performance while minimising whole life costs.

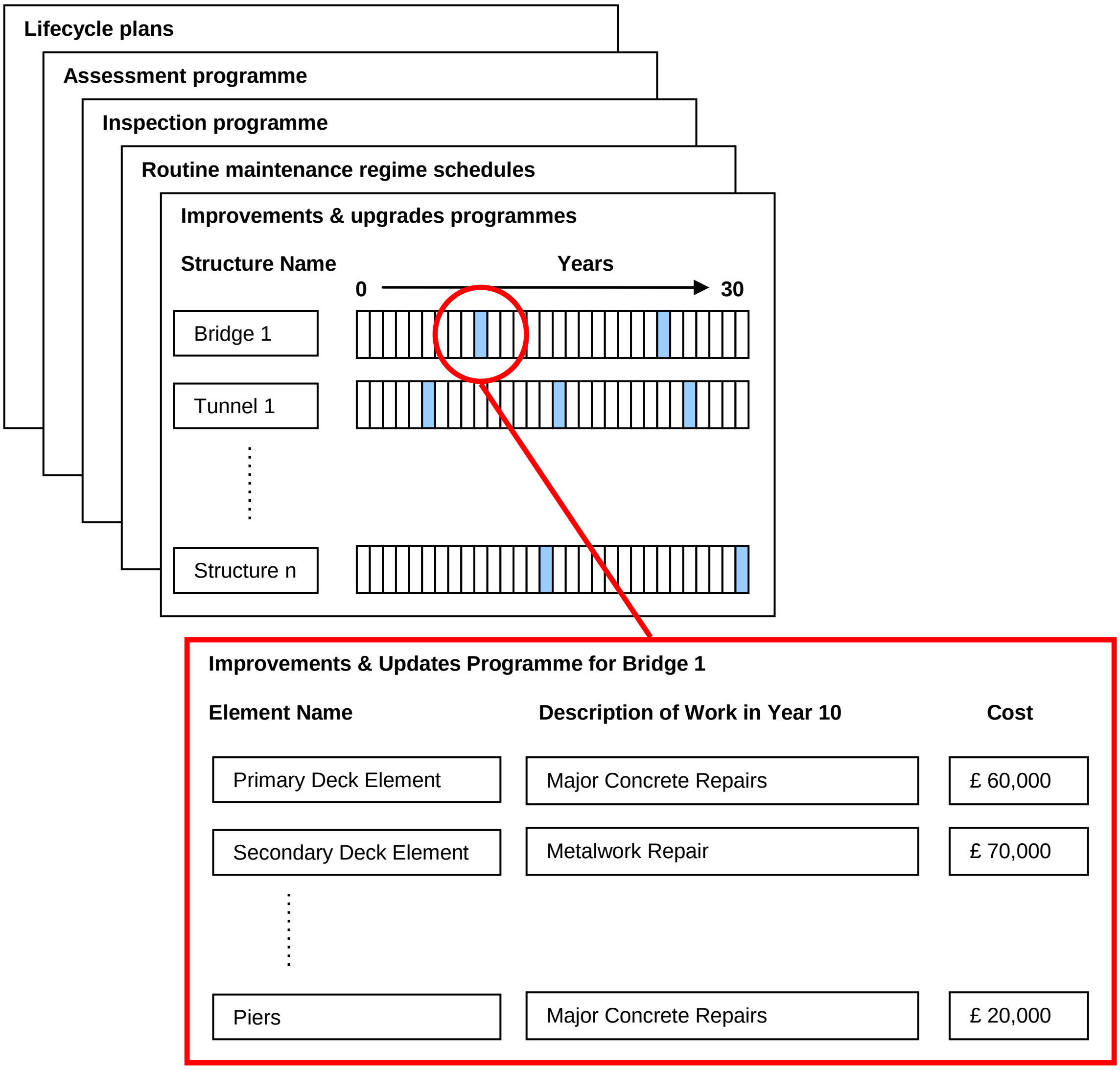
2.7.2 Further information on the classification of work types is provided in *Management of Highway Structures: A Code of Practice* [5].

2.7.3 When programmes of work are used to inform the analysis work types should be clearly classified into either Capital or Revenue expenditure. It is noted that Capital or Revenue expenditure relates to the type of maintenance/work activity and not to the source of funding. Further guidance on costs that maybe capitalised is provided in:

- CIPFA’s Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting[1]; and in
- CIPFA’s Practitioners’ Guide to Capital Finance in Local Government[11].

Example 3: Programmes of Work

Programmes of work are generated for structures that have specific maintenance and/or other needs identified to provide schedules and details of when and how these needs will be addressed as depicted below. For example ‘Bridge 1’ has a 30 year ‘Improvements and upgrades’ programme; in year 10 of this programme several treatments (i.e. concrete repairs and metalwork repairs to the deck elements, concrete repairs to the piers, etc) are planned and costed. Other activities are also planned on specific elements on the bridge for subsequent years. Similarly ‘Improvements and upgrades’ and other programmes are created for other structures in the stock.



2.8 Identification of Needs

2.8.1 Maintenance needs per group and/or individual structures are identified using intervention levels, triggers and programmes of work. These are typically the condition/performance levels that trigger the need for work, the setting of which is driven by the level of service required (at group/structure and component level) both now and in the future. The following issues are considered key drivers for the setting of intervention triggers:

- Condition – are there any specific condition/aesthetic requirements that need to be satisfied?
- Loading – what loading regime needs to be satisfied?
- Height – what vehicle height clearance is required?
- Width – what width clearance is required (e.g. a single vehicle or number of lanes provided)?
- Users – what facilities are required for users (vehicular and pedestrian)?
- Safety – what safety criteria need to be satisfied, e.g. condition to prevent concrete spalling?

Condition Intervention Triggers

2.8.2 The default pre-defined condition based intervention levels and triggers that can be used in the analysis are contained in Section 6a and Section 6b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

2.8.3 The intervention levels and triggers are influenced by factors such as the starting condition, the traffic and the exposure environment. These are defined in Section 1 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

2.8.4 For structural elements the default/initial exposure classification can be determined by considering the factors that relate to the element type, element location and usage, i.e.

- Associated Element Failures
- Route supported
- Obstacle crossed and/or proximity to the traffic spray zone

2.8.5 For groups/structures the default/initial exposure classification can be determined by considering the factors that relate to the structure type, location and usage, i.e.

- Location, e.g. urban, rural, marine/estuarial
- Route supported and/or proximity to traffic spray zone
- Obstacle crossed and/or proximity to the traffic spray zone

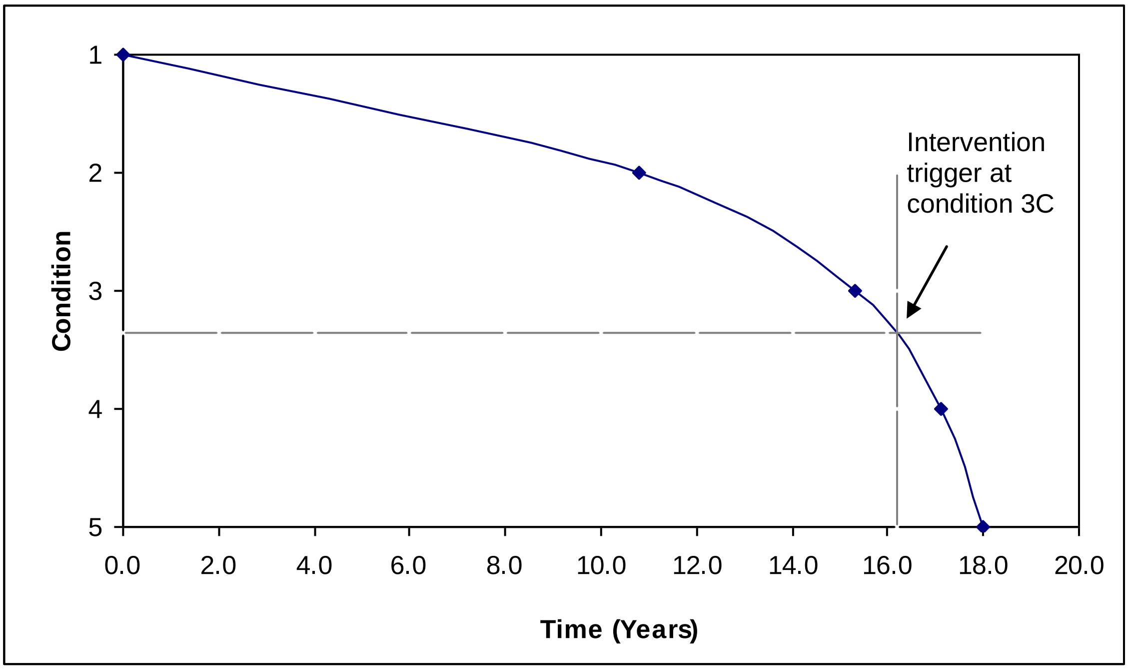
2.8.6 The default exposure classifications are presented in Section 2 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

Performance Intervention Triggers

2.8.7 Performance intervention triggers, i.e. relating to loading carrying capacity, minimum height/width, safety and other similar requirements, are addressed through the use of appropriate programmes of work (See Section 2.7).

Example 4: Intervention Triggers

A buried joint exposed to 'Moderate' traffic (see Section 1 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]) has the deterioration profile shown below. One intervention type, i.e. expansion joint replacement, is triggered when this type of component reaches condition 3C[9].



2.9 Select Treatments and/or Strategies

2.9.1 To address the identified needs (see Section 2.8), appropriate maintenance treatments and/or strategies need to be assigned to groups, individual structures and/or elements of structures.

Treatment Options

2.9.2 Different treatment options are appropriate for different structures types and different elements. A list of suitable treatment options that are currently used for the maintenance of highway structures is provided in Section 5 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]. Maintenance activities are classified into either Capital or Revenue expenditure. Guidance on costs that maybe capitalised is provided in:

- CIPFA's Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting[1]; and in
- CIPFA's Practitioners' Guide to Capital Finance in Local Government[11].

2.10 Treatment Selection

2.10.1 Treatment selection depends on which treatment options are deemed to be appropriate or can be suitably applied depending of the construction material, exposure environment and condition threshold of a group, individual structure and/or elements of structures.

2.10.2 The default treatment application triggers are provided in Section 6a and Section 6b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

Strategies

2.10.3 A minimum of three strategies should be analysed:

- ***'Planned Do Minimum' Strategy*** – the minimum required to sustain safety across the analysis period, e.g. infrequent/irregular but major interventions to satisfy/meet the minimum safety and performance targets.
- ***'Planned Preventive' Strategy*** – regular and frequent minor interventions that slow down the rate of deterioration.
- ***'Planned Targeted' Strategy*** – interventions aimed towards delivering a required target condition.

2.10.4 Although default intervention triggers associated with the aforementioned strategies are provided in Section 6a and Section 6b of the Structures Asset Management Planning Toolkit, Part C: Supporting Information [12], organisations should review/revise these based on local targets/knowledge and engineering judgement.

2.10.5 Furthermore, and despite the fact that this would be a very unlikely situation in practice, an **'Unplanned Re-active' Strategy** can also be analysed for the purposes of demonstrating the consequences of a zero-budget. It is anticipated that, if no funding is available, the stock condition and value would decline over the evaluation period, while restrictions and traffic delay would increase (See 'Calculating Penalties' in Section 2.11).

Example 5: Treatment Selection Strategies

The elements listed below are present (amongst other elements) on a reinforced concrete bridge. Given the exposure and/or traffic and the material type of each element, the treatment types listed below have been identified as suitable treatment options. The selection of specific treatment options depends on the maintenance strategy (see descriptions above) for which the analysis will be performed and the predefined condition based intervention triggers also listed below.

							Intervention triggers			
Element	Exposure	Material	Treatment Type	Applicable to Condition Band			Preventive	Targeted	Do minimum	Do Nothing
01 - Primary deck element	Moderate	Concrete	Concrete repairs	2B	-	5E	3C	3C	4D	-
			Element replacement	3B	-	5E	-	-	-	-
08 - Abutments	Mild	Concrete	Concrete repairs	2B	-	5E	3C	3C	4D	-
			Element replacement	3B	-	5E	-	-	-	-
13 - Bearings	Severe	Roller	Bearings: Replacement	2B	-	5E	3C	3C	4D	-
18 - Expansion Joints	High	Asphaltic Plug	Expansion joint: Replacement	2B	-	5E	3C	3C	4D	-

2.11 Calculate Costs and Penalties

2.11.1 Once a suitable treatment has been selected, costs are derived for:

- ***Maintenance activities*** – the actual cost for doing work on a specific element/structure;
- ***Add-ons*** – costs associated with work enablers, i.e. traffic management, design costs, access, preliminaries, etc.
- ***Penalties*** – an indicative monetary value representing the risks and penalties associated with not undertaking and/or significantly delaying intervention(s).

Maintenance Activities Cost

2.11.2 Each identified work activity is assigned a base unit rate (i.e. rates for works only). For the purpose of this, a set of typical unit rates should be compiled for each of the interventions. A set of default unit rates are presented in Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12] against each work activity along with the following:

- ***Unit*** – the unit against which base cost is defined, e.g. item, m, m^2;
- ***Maintenance Activity Cost Type*** – cost types can be set as Fixed, Constant or Variable where these are defined as:
  - Fixed – a unit rate applied under specified conditions and/or a point in time. The activity has a fixed cost per item/time period.
  - Constant – a unit rate that remains the same regardless of condition and is normally applied to the full size of the structure/element/component, e.g. element replacement, application of impregnants, etc.
  - Variable – a unit rate that is dependant on the condition/severity of the structure/element to which a maintenance activity is applied, e.g. concrete repairs, masonry repairs, metalwork repairs.
- ***Unit Rates*** – the rates for the cost types listed above; see Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12] for the default rates which are base lined to the second quarter of 2010. Guidance on indexation is provided in Section 13 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

2.11.3 The work cost for a maintenance activity that may be required for each component and/or element at a given time is evaluated based on the quantity of work required, i.e. taking into account the component(s)/element(s) dimensions and the severity/extent of the defect, and the maintenance activity cost type and unit rates as follows. When the analysis is undertaken for groups/or structures that do not have condition data at element level, a structure, e.g. a retaining wall, a culvert, etc., is regarded to be an 'element' for the purposes of calculating works costs.

1. When the maintenance activity cost type is *Fixed*, the works cost is evaluated using the following equation:

$$\mathbf{WC_{M\ Fixed} = FR}$$

Equation 1

Where:

$WC_{M\ Fixed}$ = Works cost for *Fixed* maintenance activity cost type

FR = Fixed Rate (see Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

2. When the maintenance activity cost type is *Constant*, the works cost is evaluated using the following equation:

$$WC_{M\ Constant} = SF \times UR_C$$

Equation 2

Where:

$WC_{M\ Constant}$ = Works cost for *Constant* maintenance activity cost type

SF = Element/Structure Size Formulae (see Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

UR_C = Constant Unit Rate (see Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

3. When the maintenance activity cost type is *Variable*, the deterioration sequence defined in Table 4 is applied. This describes the expected percentage of the element/structure in each severity band, for example, when a structure is in 'Fair' condition or an element is in condition 3C, it is assumed that 7.5% of the structure/element is in Severity 3 and 12.5% is in Severity 2. These percentages are used along with the corresponding maintenance activity unit rates listed in Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12] to calculate the works cost.

Table 4 – Extend of Severity

Structure Condition	Primary Condition		Lesser Conditions Also Present						Total Extent of Defects (TEoD)
Very Good	1A	0.00%	-		-		-		0.00%
-	2B	2.50%	-		-		-		2.50%
Good	2C	7.50%	-		-		-		7.50%
-	2D	12.50%	-		-		-		12.50%
-	3B	2.50%	2D	12.50%	-		-		15.00%
Fair	3C	7.50%	2D	12.50%	-		-		20.00%
-	3D	12.50%	2E	10.00%					22.50%
-	4B	2.50%	3D	12.50%	2E	10.00%	-		25.00%
Poor	4C	7.50%	3D	12.50%	2E	10.00%	-		30.00%
-	4D	12.50%	3D	12.50%	2E	10.00%	-		35.00%
-	5B	2.50%	4D	12.50%	3D	12.50%	2E	10.00%	37.50%
Very Poor	5C	7.50%	4D	12.50%	3D	12.50%	2E	10.00%	42.50%
-	5D	20.00%	4D	12.50%	3D	12.50%	2E	12.50%	57.50%
-	5E	50.00%	4D	20.00%	-		-		70.00%

This information is used to calculate the Works Cost using the following equation:

$$WC_{M\ Variable} = SF \times [(UR_{S2} \times Ext_{S2}) + (UR_{S3} \times Ext_{S3}) + (UR_{S4} \times Ext_{S4}) + (UR_{S5} \times Ext_{S5})]$$

Equation 3

Where:

$WC_{M\ Variable}$ = Works cost for *Variable* maintenance activity cost type

SF = Element/Structure Size Formulae (see Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

UR_{Si} = Unit Rate for Severity i (see Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

Ext_{Si} = Extent for Severity i (Table 4)

Add-ons

2.11.4 A scheme is a combination of all the activities undertaken on all components and/or elements of each structure at a specific time step. Thus the total scheme cost will be a summation of all the works cost undertaken within the time step. This cost can be significantly influenced by the following:

- ***Traffic Management Cost*** – the Traffic Management Costs associated with doing the work.
- ***Preliminaries*** – include items such as establishment of site facilities for the employer/overseeing organization and the contractor.
- ***Design Costs*** – planning the scheme, i.e., programming the works, and preparation of designs/drawings.
- ***Other Costs*** – includes activities such as access costs, site clearance, minor earthworks, fencing, retaining wall repairs, etc.

2.11.5 The cost associated with the above factors is calculated by applying a suitable default percentage or uplift factor to the total works cost of each maintenance activity and for each structure, component and/or element at a given time. The scheme cost can then be calculated using the equations below.

$$SC = \sum WC + TMC + PC + DC + OC$$

Equation 4

$$TMC = WD \times TMR$$

Equation 5

$$WD = SF / WDR \text{ (for } WC_{M\ Constant}) \quad \text{or} \quad WD = (SF \times TEoD) / WDR \text{ (for } WC_{M\ Variable})$$

Equation 6

$$PC = f_P \times \sum WC$$

Equation 7

$$DC = f_D (\sum WC + TMC + PC + OC)$$

Equation 8

$$OC = f_O \times \sum WC$$

Equation 9

Where:

SC = Scheme cost

∑WC = Total works cost in a given time step, i.e. the sum of all individual maintenance activities works cost for a structure calculated as described in the previous section.

TMC = Traffic Management Cost

P_C = Preliminaries Cost

DC = Design Costs

OC = Other Costs

WD = Works Duration

TMR = Traffic Management Rate

SF = Element/Structure Size Formulae (see Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

WDR = Works Duration Rate (see Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

TEoD = Total Extent of Defects (from Table 4 in this document)

f_p = Uplift factor for Preliminary Costs

f_D = Uplift factor for Design Costs

f_O = Uplift factor for Other Costs

2.11.6 The aforementioned default rates and uplift factors are listed in Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

Example 6: Calculation of Work Cost and Add-ons

Consider a 2 span bridge carrying and an A class road and crossing a watercourse. The total length of the structure is 17m and the average width is 8m. The spans are supported on elastomeric bearings and the central pier is located in the river bed. The clearance of the bridge to water surface is 4.7 m. Given their condition and exposure environment, the following elements require maintenance (in a single year):

Pier – 'Scour Protection Measures' were identified through fixed programmes of work as the river bed next to the pier experiences high water velocities and turbulence flow.

Bearings – the reported condition of the bearings is 3C and they are in a severe exposure environment (assuming that the expansion joints on the structure are not functioning). 'Bearings Replacement' is triggered as an appropriate intervention under a preventive maintenance strategy.

Expansion Joints – the reported condition of the nosing joints is 4C and they operate in a low traffic category (i.e. AADT < 10,000 vehicles per lane). 'Expansion Joint Replacement' is triggered as an appropriate intervention.

Abutments – the reported condition of the reinforced concrete abutments is 3C and they are in a severe exposure environment (assuming that the expansion joints on the structure are not functioning). 'Concrete Repairs' are triggered as an appropriate intervention under a preventive maintenance strategy.

The work cost (WC) for each of identified elements is calculated below:

<u>Piers Scour Protection Measures – Works Cost</u>

Maintenance Activity Work Type = Fixed (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

Therefore Equation 1 is used $\mathbf{WC_{M\ Fixed} = FR}$

The Fixed Rate (FR) for Scour Protection Measures is £11,920 (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

Therefore the Works Cost for Scour Protection Measures is: $\mathbf{WC_{M\ Fixed} = FR = £11,920}$

Bearings Replacement – Works Cost

Maintenance Activity Work Type = Constant (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

Therefore Equation 2 is used $\mathbf{WC_{M\ Constant} = SF \times UR_C}$

The Element Size formula (SF) for Bearings is **SF = Average Width x (Number of Spans + 1)** (see Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

SF = Average Width x (Number of Spans + 1) = 8 x (2 + 1) = 24m

The Constant Unit Rate (URc) for bearing replacement is £894 per meter (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

Therefore the Works Cost for Bearings Replacement is:

$\mathbf{WC_{M\ Constant} = SF \times UR_C = 24m \times £894/m = £21,456}$

Expansion Joints Replacement – Works Cost

Maintenance Activity Work Type = Constant (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

Therefore Equation 2 is used $\mathbf{WC_{M\ Constant} = SF \times UR_C}$

The Element Size formula (SF) for Expansion Joints is

SF = Average Width x (Number of Spans + 1) (see Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

SF = Average Width x (Number of Spans + 1) = 8 x (2 + 1) = 24m

The Constant Unit Rate (URc) for expansion joint replacement: nosing joint is £658 per meter (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

Therefore the Works Cost for Expansion Joints Replacement is:

$\mathbf{WC_{M\ Constant} = SF \times UR_C = 24m \times £658/m = £15,792}$

Abutments Concrete Repairs – Works Cost

The Maintenance Activity Work Type = Variable (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

Therefore Equation 3 is used $\mathbf{WC_{M\ Variable} = SF \times [(UR_{S2} \times Ext_{S2}) + (UR_{S3} \times Ext_{S3}) + (UR_{S4} \times Ext_{S4}) + (UR_{S5} \times Ext_{S5})]}$

The Element Size formula (SF) for Abutments is:

SF = Average Critical Headroom x Average Width x 2 (see Section 8 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12]).

$\mathbf{SF = Average\ Critical\ Headroom \times Average\ Width \times 2 = 4.7m \times 8\ m \times 2 = 75.2m^2}$

The reported condition for Abutments is 3C, therefore using Table 4 12.5% of the total area is in Severity 2 (2D), 7.5% of the total area is in Severity 3 (3C) and none in Severity 4 or 5. Therefore the Extent of Severity is:

$\mathbf{Ext_{S2}}$ = 12.5/100 = 0.125

$\mathbf{Ext_{S3}}$ = 7.5/100 = 0.075

$\mathbf{Ext_{S4} = Ext_{S5}}$ = 0

The Variable Unit Rate (URSi) (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]) for concrete repairs is:

$\mathbf{UR_{S2}}$ = £298/m^2

$\mathbf{UR_{S3}}$ = £1,192/m^2

$\mathbf{UR_{S4}}$ = £1,788/m^2

$\mathbf{UR_{S5}}$ = £2,314/m^2

Therefore the Works Cost for Concrete Repairs to the Abutments is:

$\mathbf{WC_{M\ Variable} = SF \times [(UR_{S2} \times Ext_{S2}) + (UR_{S3} \times Ext_{S3}) + (UR_{S4} \times Ext_{S4}) + (UR_{S5} \times Ext_{S5})]}$

$\mathbf{WC_{M\ Variable} = 75.2m^2 \times [(£298/m^2 \times 0.125) + (£1{,}192/m^2 \times 0.075) + (£1{,}788/m^2 \times 0) + (£2{,}314/m^2 \times 0)]}$

$\mathbf{WC_{M\ Variable} = 75.2m^2 \times [(£37.25/m^2) + (£89.40/m^2) + (0) + (0)]}$

$\mathbf{WC_{M\ Variable} = 75.2m^2 \times [£126.62/m^2] = £9{,}524}$

Total Works Cost

The Total Work Cost is equal the sum of the individual work activities costs:

$\sum$WC = £11,920 + £21,456 + £15,792 + £9,524 = £58,692

Traffic Management Cost

Given that the structure carries an A road and crosses a river Traffic Management is only required for replacing the expansion joints (See Section 7 and Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12])

Traffic Management is calculated using:

Equation 5 **TMC = WD x TMR** and

Equation 6 **WD = SF / WDR (for $\mathbf{WC_{M\ Constant}}$)**

The Work Duration Rate (WDR) for concrete repairs is 1m^2 per hour (See Section 7 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]). Therefore:

WD = SF / WDR = 75.2$\mathbf{m^2}$ / 1$\mathbf{m^2}$/hour = 75.2 hours

The Traffic Management Rate (TMR) is £233/hour, and so

TMC = WD x TMR = 75.2 hours x £233/hour = £16,770

Preliminaries Cost

Preliminaries Cost are calculated using Equation 7 **PC = $\mathbf{f_P}$ x $\sum$WC**

The uplift factor for Preliminary Costs f_p is 0.115 (See Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]). Therefore:

PC = $\mathbf{f_P}$ x $\sum$WC = 0.115 x £58,692 = £6,750

Other Costs

Other Costs are calculated using Equation 9 **OC = $\mathbf{f_O}$ x $\sum$WC**

The uplift factor for Other Costs f_O is 0.15 (See Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]). Therefore:

OC = $\mathbf{f_O}$ x $\sum$WC = 0.15 x £58,692 = £8,803

Design Costs

Design Costs are calculated using Equation 8 **DC = $\mathbf{f_D}$ ($\sum$WC + TMC + PC + OC)**

The uplift factor for Design Costs f_D is 0.2 (See Section 9 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]). Therefore:

DC = f_D (∑WC + TMC + PC + OC) = 0.2 x (£58,692 + £16,770 + £6,750 + £8,803) = £91,015

Total Scheme Cost

Equation 4 is used to calculate the Total Scheme Cost, i.e.

SC = ∑WC + TMC + PC + DC + OC = £58,692 + £16,770 + £6,750 + £91,015 + £8,803

SC = £180,030

Calculate Penalties

2.11.7 A 'penalty' refers to an indicative monetary value representing the risks and penalties associated with not undertaking and/or significantly delaying intervention(s). This typically takes account of:

- Loss of Service:
  - *Impact on availability:* In extreme circumstances, it may become necessary to close lanes and/or entire structure(s) for safety reasons. When appropriate, penalty costs associated with the structure(s) and/or lane closures could be quantified by vehicle delay costs.
  - *Impact on other routes:* Not undertaking and/or significantly delaying an intervention may impact the route supported and/or crossed by the structure, i.e. pose a risk to:
    - railways, e.g. service disruption
    - waterways, e.g. pollution
    - traffic flow (over/under the structure)
    - farm access, etc.
  - *Impact on Utilities:* Disruption of utility services, e.g. gas, water, telecommunication, etc.
- Safety Risk:
  - *Risk to public safety:* If some elements are permitted to deteriorate to an unacceptable level (e.g. expansion joints, bearings) they may cause vehicle accidents due to their impact on the running surface. When appropriate, associated penalty costs, e.g. accident/casualty costs, should be calculated and taken into consideration while developing lifecycle plans.
  - *Risk to structural Integrity:* In extreme circumstances structural failure may occur, e.g. a load bearing element reached condition 5 (failed). When appropriate, associated penalty costs, e.g. vehicle delay costs, reconstruction costs, etc., should be calculated and taken into consideration while developing lifecycle plans.
- Environmental Impacts may include pollution (air/noise) due to traffic delays, or carbon footprint cost (associated with re-construction), etc. Where, appropriate such costs should be quantified and taken into consideration while developing lifecycle plans.

2.11.8 Penalty costs can be calculated based on the following:

- ***Safety/Performance At-Risk (Bridges only)*** – A bridge's safety/performance is considered to be at risk if at least one element with a "very high importance" rating has a condition score of 4.0 or more (the Condition Performance Indicator procedure describes which elements are classified as having a very high, high, medium and low importance [13 - 15]). By definition, a condition score of 4.0 or more describes a significant loss of functionality.
- ***Traffic Delay Cost*** – Every substandard bridge incurs a traffic delay cost. If at least one element with a "very high importance" rating on a bridge has a condition score of 4.0 or more, but less than 5.0, then the traffic flow is assumed to be restricted on one lane in each direction. The length of time over which the restriction applies is dependent on bridge length:

- For bridges with a length of 10m or less, the restriction applies for 5 days.
- For bridges with a length of 10m to 20m, the restriction applies for 10 days.
- For bridges with a length greater than 20m, the restriction applies for 15 days.

However, if at least one element with a "very high importance" rating on a bridge has a condition score of 5.0 or more, the entire bridge is assumed to be closed to all traffic for 30 days.

2.11.9 The default traffic delay rates are listed in Section 10 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

Example 7: Penalties

The Primary deck element of a 15m long bridge has reached condition 4D and there are no available funds to undertake any maintenance work. The structure carries an A class road with a high traffic category, i.e. AADT > 25,000 vehicles per lane.

The bridge is flagged as having its 'Safety/Performance At-Risk' and a restriction is applied for 10 days (See Section 10 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]).

The traffic delay costs resulting from this restriction is calculated by multiplying the Daily Traffic Delay Rate given in Section 10 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information*[12] by the duration of the restriction, i.e. 10 days. Therefore:

Traffic Delay Cost = £858/day x 10days = £8,580

2.12 Prioritise Identified Needs

2.12.1 In the analysis, it is likely that a large number of elements will reach their maintenance intervention threshold simultaneously and the level of funding may not be sufficient to meet all maintenance requirements. A prioritisation process is used to allocate the budget, in a logical and consistent manner, to where it is needed most. The prioritisation method reflects a streamlined and fully automated Value Management process that operates on readily available data. The prioritisation method is based on:

- ***Element Condition Index*** – a combination of the element's/component's physical condition (severity and extent of defect) and its importance (very high, high, medium or low) to the overall structure [13, 14, 15]; where:
  - *Element Condition or Structure Condition Band* – elements/structures in poorer condition receive higher priority because they are deemed to represent a greater risk to the public and the service. Also, deferred maintenance on elements in poorer condition is considered to lead to proportionally larger maintenance costs when further deterioration occurs.
  - *Element Importance* – elements that have a greater impact on functionality, durability and/or strength receive a higher priority. When the analysis is undertaken for structures with no condition data or for groups/structures, e.g. retaining walls, culvert etc., a structure is treated as being an element and the Element Importance is set at a default value of 'Medium'.
- ***Structure Importance*** – reflects the importance of the structure to the network by taking account of the structure type (as per those listed in Table 2), the route classification, the Traffic category of the route and the type of obstacle crossed (e.g. railway, local road, watercourse or farmland). More important structures have a higher priority of maintenance because deferred maintenance work or structural failure results in greater consequences.

2.12.2 The equation used for calculating the prioritisation score is shown below:

$$P_R = f_1(ECI) + f_2(AADT_f + OBS_f + R_f) + f_3(ST_f)$$

Equation 10

Where:	ECI	=	Element Condition Index [13, 14, 15]
	$AADT_f$	=	Factor based on Annual Average Daily Traffic Flow on route
	OBS_f	=	Factor based on obstacle crossed by route
	Rf	=	Factor based on importance of route served
	ST_f	=	Structure Type factor
	f1, f2, f3	=	Weighting coefficients

NOTE TO PROJECT TEAM: The algorithm needs to be tested/amended using real data

2.12.3 The default weightings and the other factors used by the prioritisation algorithm are listed in Section 11 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

NOTE TO PROJECT TEAM: Investigate smoothing/combining works – algorithm?

2.13 Maintain and Deteriorate Components

2.13.1 Once the identified needs are prioritised, there are two possibilities:

- Structures/elements are not maintained, i.e. further deterioration is allowed to take place; and
- Structures/elements are maintained, i.e. an intervention is applied and the condition is restored to a predefined level.

2.13.2 This utilises the following, as described in subsequent sections:

- Service lives and deterioration rates
- Treatment effects
- Defined budget or target condition

Service Lives and Deterioration Rates

2.13.3 A set of deterioration rates/service lives was compiled for the analysis. The data cover all the components and materials and seek to reflect the key factors that influence the rate of deterioration or length of service life. These are listed in Sections 3, 4a and 4b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12]. It is recognised that this is not an exact science and typically the best source of information is local knowledge, especially as some defects take many years to develop to the point where they require maintenance.

2.13.4 Traffic and Exposure Environment have the two significant influences on deterioration rates and service lives of materials and components. The default exposure classifications are presented in Section 2 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

2.13.5 The appropriate representation of deterioration trough time is a fundamental part of the asset management planning process. In order to achieve this, i.e. calculate deterioration profiles through time, it is firstly necessary to define and compile data on the following:

- Factors influencing the service life and rates of deterioration of components and structural elements, e.g. exposure environment and traffic;
- Service lives and deterioration rates for components and elements, and how these may differ by material type, exposure environment and other relevant factors;

2.13.6 In general, the starting position for future deterioration would be taken as the current condition, with the rate of deterioration influenced by exposure. The analysis supports the creation of profiles, such as that shown in Figure 3; i.e. profiles that describe how condition changes over time given no maintenance intervention. Figure 3 shows a profile that describes how an element deteriorates from condition 1A to condition 5E, i.e. representing the time to failure. To represent uncertainty in deterioration rates and service lives, times to failure are defined as normal, triangular or uniform distributions.

2.13.7 A uniform distribution allowing for uncertainty of $\pm$ 20% about the mean value for time to failure is applied to the service lives and deterioration rates of all components and elements. This distribution was selected because experience indicates that diverse deterioration rates and service lives occur across the network due to the wide range of exposure environments and construction qualities present. A random time to failure is selected for each element from the respective distribution.

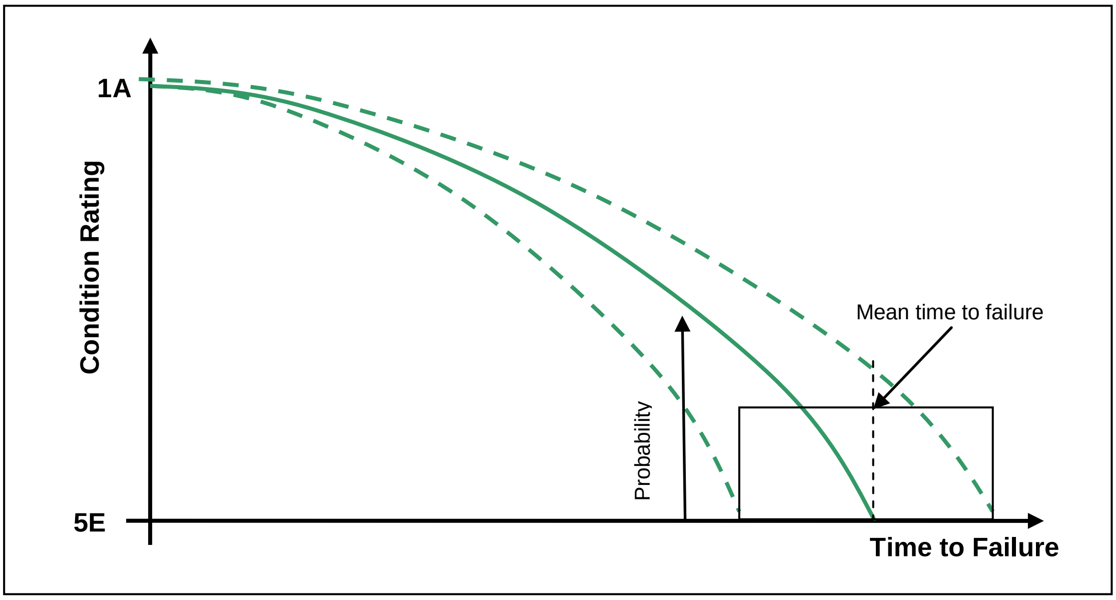


Figure 3 – Deterioration Profiling

Treatment Effects

2.13.8 Applied treatments have one or more of the following effects on elements/structures:

- Changed exposure classification (**Note for the project team:** due to work undertaken, check associated elements condition and how this impacts exposure)
- Reset condition to a defined level
- Change the time to failure
- Change the deterioration profile

2.13.9 These effects are listed in Section 6a and Section 6b of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

Define Budget or Target Condition

2.13.10 The analysis requires the annual budget and/or target condition to the defined.

2.13.11 Where an annual budget is defined the analysis enables assessing how the budget changes the condition, and future funding requirements, for the structure stock.

2.13.12 Where a target condition is defined the analysis suggests the level of funding required to achieve/maintain the target condition.

2.14 Evaluate Expenditure and Condition

2.14.1 The total annual expenditure and condition is evaluated for each element, component or structure in each year in the analysis period based on the applied maintenance activities. In addition, the number of substandard structures and associated traffic delay costs are calculated depending on whether or not maintenance activities are applied.

Backlog Volumes

2.14.2 Backlog volume refers to the financial value of the maintenance works which are required to restore to “as-new” condition all elements that have reached or exceeded their intervention threshold. Backlog volume is evaluated for each year in the analysis period for each of the structure types listed in Table 2.

Work Volumes

2.14.3 Work volume is defined as the financial value of the maintenance works carried out, as permitted by the available budget, on elements that have reached or exceeded their intervention threshold.

Work volume is evaluated for each year in the analysis period classified as capital or revenue for each of the structure types listed in Table 2.

2.15 Outputs

2.15.1 The analysis provides the following functionality and output:

1. Enables performing simple *what-if* scenarios to interrogate:
   - How the structure stock condition changes due to different levels of funding.
   - How the maintenance backlog changes due to different levels of maintenance funding; and
   - How penalties change due to different levels of funding e.g. number of propped structures, number of weight restricted structures, etc.
2. The 'optimum' level of funding to maintain the condition and functionality of the structures stock.
3. Time dependent condition and funding profiles for the structure stock and sub-groups of the stock e.g. bridges, retaining walls and culverts.
4. Routine maintenance and inspections expenditure profiles.
5. The total (discounted) WLC for each scenario including works and penalty costs
6. The expected life of each finite life component
7. The treatment cycle/life of each indefinite life component
8. Gross replacement and depreciated replacement cost profiles (also See Sections 3, 4a and 4b).

3. Calculating Gross Replacement Cost

3.1.1 The gross replacement cost is calculated as:

GRC = Dimensions x Unit rate x Adjustment factor(s)

Equation 11

Where:

Dimensions – those relevant to the structure type, e.g. m, m^2 and number (see Table 2)
Unit rate – the cost per dimension relevant to the structure type, e.g. £/m^2

Adjustment factor(s) – these reflect criteria that have a significant impact on GRC.

3.1.2 The structure types and associated subdivisions listed in Table 2 are used for calculating GRC. Unit rates were derived using the concept of modern equivalent asset (MEA) as described in CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting* [1]. Default unit rates are listed in Section 12 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

3.1.3 Heritage and special structures may require an alternative approach for deriving appropriate unit rates for GRC evaluation as described in CIPFA's *Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting* [1].

3.1.4 Unit rates are adjusted, where appropriate, to take account of criteria that have a significant impact on replacement costs. Factors that may have a significant impact and their associated values are listed in Section 12 of the *Structures Asset Management Planning Toolkit, Part C: Supporting Information* [12].

4. Calculating Depreciation

4.1.1 Depreciation for is calculated as follows:

- ***finite life structures/components*** – depreciation is based on the cost of replacing the component plus any interim capital expenditure needed to allow it to achieve its life
- ***indefinite life structures/components*** – depreciation is based on the cost of any capital treatments needed to maintain the component to the required standard over the life of the treatment, systematically spread across the defined life cycle. If a component does not normally require treatment to maintain its life indefinitely, no depreciation applies. However, should it begin to show signs of measurable deterioration that will require capital treatment to restore service potential then it needs to be re-categorised and treated from that point as a finite life asset.

4.1.2 Annual depreciation is calculated for each component/asset/group as:

$$\frac{\text{cost of all capital treatments and/or replacements in the life cycle}}{number\ of\ years\ in\ the\ lifecycle}$$

Equation 12

4.1.3 Where sufficient age data is available initial depreciated replacement cost (DRC) is calculated as:

GRC – (annual depreciation x number of years of life cycle consumed so far)

Equation 13

4.1.4 Figure 4 illustrates how depreciation is calculated and systematically spread across the total useful life (or intervention cycle).

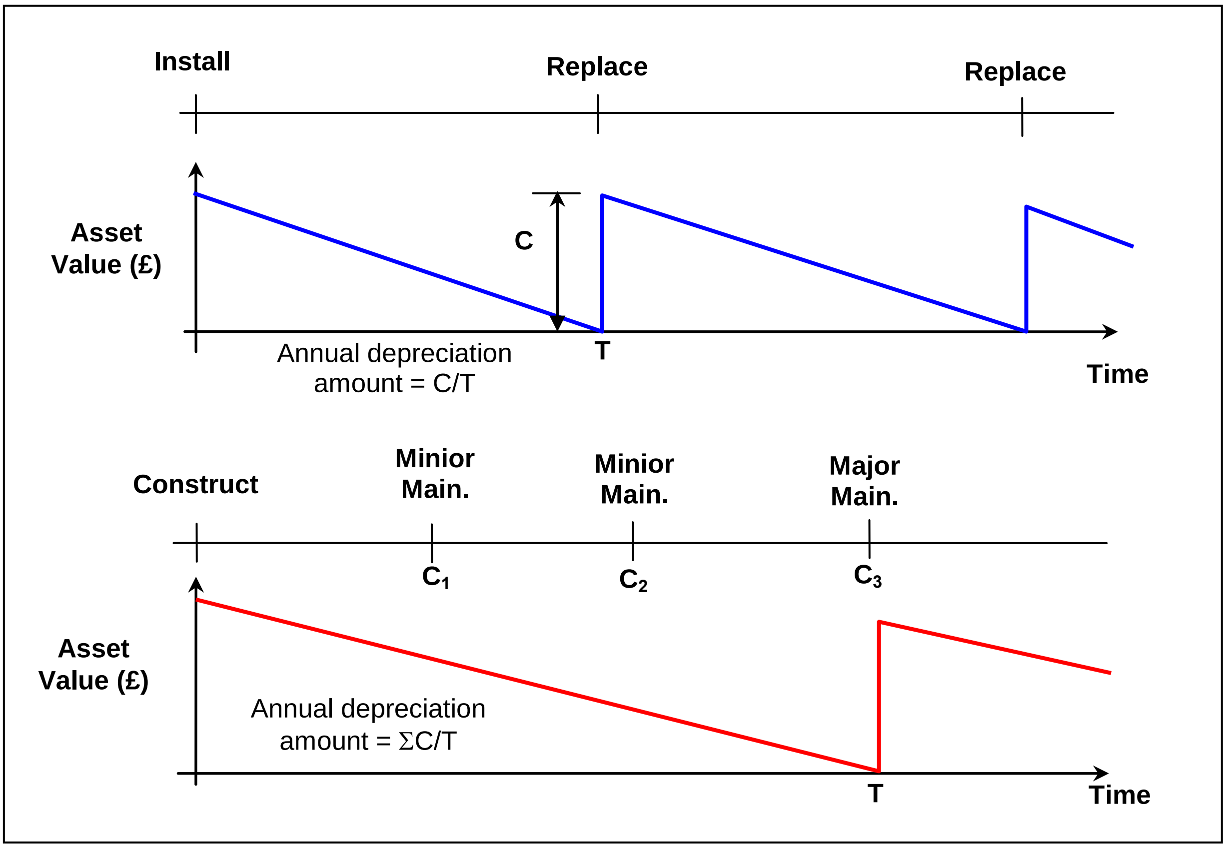
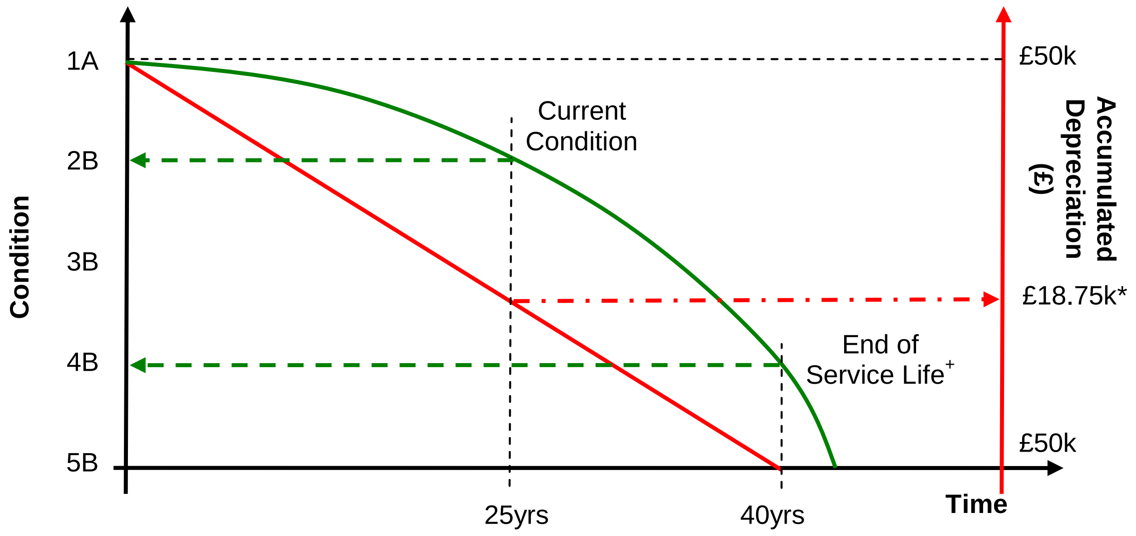


Figure 4 – Depreciation over the Lifecycle

4.1.5 In the majority of cases, the current condition and performance of a structure or component is somewhere between ‘as new’ (i.e. construct or install) and ‘end of life’ (i.e. replace or maintain), with limited, if any, information on the timing and cost of past activities. In the absence of age data, the initial DRC calculation is based on predictions of future treatment needs over the life cycle, and their timing and cost, while the current condition is used to estimate the current age of the structure/component. This is illustrated in the following component level example.

Example 8: Consider a single bridge component with the following details:
(i) component type = bearing (roller bearing);
(ii) predicted useful service life = 40 years;
(iii) current condition = 2B;
(iv) replacement cost = £50,000 (including traffic management, access, etc).
The current condition information is used to identify an assumed age for the component, as shown below in Figure 10.3. The assumed age is then used as the basis for the straight line accumulated depreciation calculation, i.e. 25 years of an expected 40 year life have been used and therefore the current DRC is £18,750.



* where £50k x [(40yrs - 25yrs)/40yrs] = £18.75k
\+ DRC at end of service life (condition 4B) = £50k

4.1.6 The life cycle approach provides this information for all defined structures/components, thereby enabling the DRC to be calculated for the stock of structures.

5. References

1. Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting, CIPFA, 2010
2. HM Treasury (2003), The Green Book: Appraisal and Evaluation in Central Government, London: The Stationery Office. Also available at http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/green_book.htm (accessed on 5 April 2011).
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4. CSS Framework for Highway Asset Management, 2004
5. Management of Highway Structures: A Code of Practice, TSO, 2005
6. Maintaining a Vital Asset, 2005
7. International Infrastructure Management Manual, 2006.
8. PAS 55: Asset Management, Specification for the Optimized Management of Physical Assets, BSi, 2008.
9. Inspection Manual for Highway Structures, Volume 1: Reference Manual, TSO, 2007.
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11. CIPFA's Practitioners' Guide to Capital Finance in Local Government, CIPFA, 2008.
12. Structures Asset Management Planning Toolkit, Part C: Supporting Information, 2011.
13. Bridge Condition Indicators: Volume 3 – Guidance Note on Evaluation of Bridge Condition Indicators, County Surveyors' Society, 2002
14. Addendum to Bridge Condition Indicators: Volume 3 – Guidance Note on Evaluation of Bridge Condition Indicators, County Surveyors' Society, 2004
15. Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Performance Indicator, Highways Agency & CSS Bridges Group, 2007.
16. Trunk Road Maintenance Manual: Volume 1 – Highways Maintenance Code, Highways Agency, 2006.

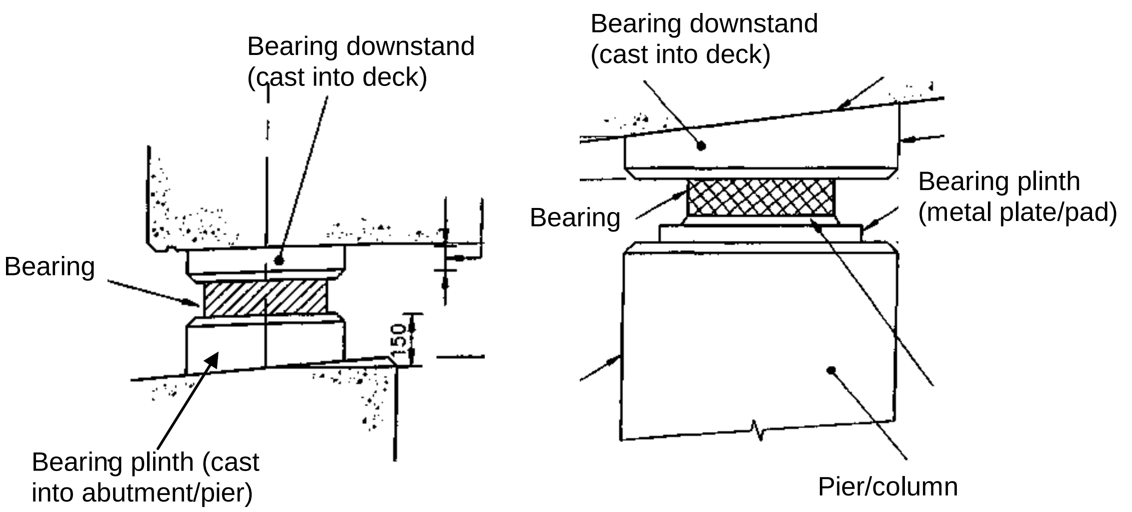
Appendix A – Finite and Indefinite Life Components

Bridges

<table>
<tr><th>CSS Element Type</th><th>Types/Comments</th><th>Finite or Indefinite Life?</th></tr>
<tr><td>01 - Primary deck element</td><td rowspan="12">These elements come in a wide range of different material types (e.g. reinforced concrete, steel, cast iron, masonry (blockwork, brickwork, prestressed concrete, FRPs, stainless steel etc.)</td><td rowspan="12">Indefinite Life - all of these element types are treated as Indefinite Life because they are normally maintained in perpetuity, i.e. maintenance activities to fix defects and or restore functionality (although in some instances the most effective management strategy is full element replacement)</td></tr>
<tr><td>02 - Transverse Beams</td></tr>
<tr><td>03 - Secondary deck element</td></tr>
<tr><td>04 - Half joints/Hinge Joints</td></tr>
<tr><td>05 - Tie beam/rod</td></tr>
<tr><td>06 - Parapet beam or cantilever</td></tr>
<tr><td>07 - Deck bracing</td></tr>
<tr><td>08 - Foundations</td></tr>
<tr><td>09 - Abutments (incl. arch springing)</td></tr>
<tr><td>10 - Spandrel wall/head wall</td></tr>
<tr><td>11 - Pier/column</td></tr>
<tr><td>12 - Cross-head/capping beam</td></tr>
<tr><td rowspan="7">13 - Bearings</td><td>Elastomeric/rubber</td><td rowspan="7">Finite Life – bearings are treated as fixed life elements as they normally have a short life (in comparison to the whole bridge) and are replaced in totality at the end of their service life.</td></tr>
<tr><td>Plane Sliding</td></tr>
<tr><td>Pot</td></tr>
<tr><td>Rocker</td></tr>
<tr><td>Roller</td></tr>
<tr><td>Spherical</td></tr>
<tr><td>Steel plate</td></tr>
<tr><td>14 - Bearing plinth/shelf</td><td>Plinth may be cast into the shelf (whereby they are the same material) or connected to the shelf (e.g. metal plate/pad bolted or fixed to shelf); see Figure 5 below this table).</td><td>Finite or Indefinite Life – suggest it is dealt with on a case by case basis and defined accordingly. The maintenance strategy will depend on the arrangement.</td></tr>
<tr><td rowspan="2">15 - Superstructure drainage</td><td>Cast into superstructure (deck)</td><td>Indefinite Life – linked to the life of the deck</td></tr>
<tr><td>Not cast into superstructure (deck); may be attached externally or attached internally, e.g. inside box beam.</td><td>Finite Life – based on life of drainage components</td></tr>
<tr><td rowspan="2">16 - Substructure drainage</td><td>Cast into substructure</td><td>Indefinite Life – linked to the life of the substructure, e.g. abutments</td></tr>
<tr><td>Not cast into substructure, may be attached externally or attached internally, e.g. inside hollow pier.</td><td>Finite Life – based on life of drainage components</td></tr>
</table>

CSS Element Type	Types/Comments	Finite or Indefinite Life?
17 - Waterproofing	Boarded Systems	**Finite Life** – life may be determined by carriageway life, poor laying, expected service life, deck repairs, traffic volume, deck liveliness etc.
	Mastic Asphalt	
	Sheet Systems	
	Spray Systems	
18 – Movement/Expansion joints	Buried Joint	**Finite Life** –expansion joints are treated as fixed life elements as they normally have a short life (in comparison to the whole bridge) and are replaced in totality at the end of their service life. However, there are a number of instances (e.g. Elastomeric in Metal Runners) where component parts are replaced at regular intervals to extend/achieve the expected service life.
	Asphaltic Plug Joint	
	Nosing Joint	
	Polysulphide seals	
	Elastomeric/Reinforced Elastomeric Joint	
	Single Element Elastomeric In Metal Runners	
	Multi Element Elastomeric In Metal Runners	
	Cantilever Comb And Tooth Joint	
	Roller Shutter	
	Sliding Plate	
19 - Finishes: deck elements	Corrosion (paint) protection system **Note**: Excludes CP and silane, these are a treatment to existing elements.	**Finite Life** - considered to be a separate element. The service life will differ depending on the maintenance regime applied and the aesthetics/ambience required.
	Cladding	**Finite or Indefinite Life** – will depend on circumstances and factors e.g. type of cladding, integrity of fixings, or condition or underlying element.
	Tiling	**Finite Life** – assumed that these would be renewed every 20 to 30 years.
20 - Finishes: substructure elements	Corrosion (paint) protection system	As per element 19
	Tiling	As per element 19
	Cladding	As per element 19
21 - Finishes: parapets/safety fences	Corrosion (paint) protection system	As per element 19
	Tiling	As per element 19
	Cladding	As per element 19.
22 - Access/walkways/gantries	-	**Indefinite Life** - normally specialist features on larger/special structure and should be maintained in perpetuity.

CSS Element Type	Types/Comments	Finite or Indefinite Life?
23 - Handrail/parapets/safety fences	Concrete	**Indefinite of Fixed Life** - depends on maintenance regime and defect types, may be appropriate to define steel, aluminium and timber as fixed life.
	Steel	
	Aluminium	
	Masonry	
	Timber	
24 - Carriageway surfacing	-	**EXCLUDED or Fixed Life** – if surfacing and waterproofing (element 17) are a combined, otherwise excluded as it is assumed to be covered by pavements.
25 - Footway/verge/footbridge surfacing	-	As per element 24
26 - Invert/river bed	May be natural material or man made	**Indefinite Life**
27 - Aprons	Man made, e.g. concrete	**Indefinite Life**
28 - Fenders /cutwaters /collision protection	Man made, e.g. reinforced concrete, metal, timber	**Indefinite Life**
29 - River training works	Man made, e.g. reinforced concrete, metal, timber	**Indefinite Life**
30 - Revetment/batter paving	Man made, e.g. concrete paving, rip-rap	**Indefinite Life**
31 - Wing walls	As per elements 1 to 12	**Indefinite Life**
32 - Retaining walls	As per elements 1 to 12	**Indefinite Life**
33 - Embankments	Natural or man made	**Indefinite Life**
34 - Machinery	Will be structure specific	**EXCLUDED –** assumed to be outside the scope of the structures financial planning
35 - Approach rails/barriers/walls	-	As per element 23
36 - Signs	-	**Finite life**
37 - Lighting	-	**EXCLUDED –** assumed to be outside the scope of the structures financial planning
38 - Services	-	**EXCLUDED –** assumed to be outside the scope of the structures financial planning



Drawings taken from the CIRIA 2001 Bridge Detailing

Figure 5 – Bearing plinth and shelf arrangements

Retaining Walls

CSS Element Type	Types/Comments	Finite or Indefinite Life?
1. Foundations	These elements come in a wide range of different material types (e.g. reinforced concrete, steel, cast iron, masonry (blockwork, brickwork, prestressed concrete, FRPs, stainless steel etc.)	**Indefinite Life** – as per element 1 to 12 for bridges.
2. Primary Element		
3. Secondary Element		
4. Parapet beam/plinth		
5. Drainage	Integral with structure	**Indefinite Life**
6. Movement/Expansion Joints	-	**Finite Life**
7. Finishes: Wall	Corrosion (paint) protection system	As per element 19 for bridges
	Tiling	As per element 19 for bridges
	Cladding	As per element 19 for bridges
8. Finishes: Handrail/Parapet	Corrosion (paint) protection system	As per element 19 for bridges
	Tiling	As per element 19 for bridges
	Cladding	As per element 19 for bridges
9. Handrail/Parapets/Safety Fences		As per element 23 for bridges
10. Carriageway: Top of Wall	-	**EXCLUDE** as it is assumed to be covered by pavements
11. Carriageway: Foot of Wall	-	
12. Footway/verge: Top of Wall	-	
13. Footway/verge: Foot of Wall	-	
14. Embankment: Top of Wall	-	**Indefinite Life**
15. Embankment: Foot of Wall	-	
16. Invert/river bed	May be natural material or man made	**Indefinite Life**
17. Aprons	Man mage, e.g. concrete	**Indefinite Life**

Sign/Signal Gantries

<table>
<tr><th>CSS Element Type</th><th>Component/Element Level Analysis</th><th>Structure Level Analysis</th></tr>
<tr><td>1. Foundations</td><td>Indefinite Life</td><td rowspan="13">Finite Life – the whole sign/signal gantry is assumed to have a fixed life (regardless if it is a concrete, steel, aluminium, etc.) driven by deterioration and technological advances. The service life is assumed to be:

• Mild Environment – 40yrs
• Moderate Environment – 30yrs
• Severe Environment – 20yrs

It is assumed to be more efficient and economic to replace metal gantries that to repaint them in-situ. Minor cyclic and repair works (e.g. replacing bolts, cleaning, replacing fixings, etc.) would be undertaken during the life of the gantry, but their cost would be low in relation to the overall replacement cost of the gantry, i.e. several hundred pounds compared to £20,000 plus for a replacement.</td></tr>
<tr><td>2. Truss/Beams/Cantilevers</td><td>Indefinite Life</td></tr>
<tr><td>3. Transverse Members</td><td>Indefinite Life</td></tr>
<tr><td>4. Columns/Supports/Legs</td><td>Indefinite Life</td></tr>
<tr><td>5. Finishes: truss/beam/cant.</td><td>Finite Life</td></tr>
<tr><td>6. Finishes: columns/supports</td><td>Finite Life</td></tr>
<tr><td>7. Finishes: other elements</td><td>Finite Life</td></tr>
<tr><td>8. Access walkway/deck</td><td>Indefinite Life</td></tr>
<tr><td>9. Access Ladder</td><td>Indefinite Life</td></tr>
<tr><td>10. Handrail</td><td>Indefinite Life</td></tr>
<tr><td>11. Base Connections</td><td>Indefinite Life</td></tr>
<tr><td>12. Support to longitudinal connection</td><td>Indefinite Life</td></tr>
<tr><td>13. Sign and signal supports</td><td>Finite Life</td></tr>
<tr><td>14. Signs/Signals</td><td>Finite Life</td><td>Finite Life</td></tr>
<tr><td>15. Lighting</td><td colspan="2">EXCLUDED – assumed to be outside the scope of the structures financial planning</td></tr>
<tr><td>16. Services</td><td colspan="2">EXCLUDED – assumed to be outside the scope of the structures financial planning</td></tr>
</table>