REVIEW OF NATIONAL HIGHWAYS' WHOLE-LIFE COST APPROACH

Contents

Executive Summary 5
1 Scope and Objectives 7
2 Approach and Timescales 8
3 Terminology 9
4 Abbreviations 10
5 Licence Requirement 5.12 12
6 Scope Item 1 – Examine National Highways' WLC Approach related to OMR Investments 12
6.1 Summary 12
6.2 Existing Guidance and Tools 14
8 Scope Item 2 – Research External WLC Best Practice 15
9 Scope Item 3 – Highlight National Highways WLC Best Practices and Share Across the Business 21
10 Scope Item 4 – Assess WLC Approaches taken by National Highways against Industry Best Practice 21
11 Scope Item 5 – OMR Investments that do not have a WLC Approach 24
11.1 Renewal 24
11.2 Operate 25
11.3 Maintain 25
11.4 Relationship between Operate, Maintain and Renewals 26
12 Scope Item 6 – OMR Investments that do have an established WLC Approach 26
13 Scope Item 7 – Barriers to WLC 27
14 Scope Item 8 – Learning Lessons 28
15 Scope Item 9 – Recommendations for Improvement 28
15.1 Ownership 28
15.2 Governance Capability 29
15.3 Information 30
16 Scope Item 10 – Recommendations for Monitoring WLC 31
17 Conclusion 32

Appendix A Best Practice Examples from Other Sectors Regarding Change Management 34
Appendix B List of Evidence 41
Appendix C Scope Item 2 - Expanded review of WLC Best Practice 45
Appendix C.1 Parameters of analysis 45
Appendix C.2 Processes and tools 47
Appendix C.3 Data 49
Appendix C.4 Ownership 51
Appendix C.5 Change management and closing the gap 52
References 54

List of Tables

Table 1 Headline Findings and Recommendations 5
Table 2 Existing Guidance and Tools 14
Table 3 Key External Good Practice Learnings 16
Table 4 6-point colour grading classification for National Highways' WLC evidence of existing Models 22
Table 5 Scoring for Renewals Investment Decision Making 23
Table 6 Scoring for Operate Investment Decision Making 23
Table 7 Scoring Maintain Investment Decision Making 24
Table 8 Dimensions of Analysis 45

List of Figures

Figure 1 Assignment Methodology 8
Figure 2 Shamrock Diagram of competing influences on asset value (IAM SSG: Lifecycle Value Realisation [2]) 47
Figure 3 Whole-Life Tool Process – Built Environment [5] 48
Figure 4 United Utilities – Approach for development of TotEx plans [7] 49
Figure 5 Example - ALP Dashboard [4] 50
Figure 6 RACI Governance from LifeCycle Cost Manual - Network Rail 52
Figure 7 Asset Management Capability enablers 53

Executive Summary

This report presents the findings and recommendations on how National Highways is progressing with its Licence commitment 5.12; to adopt a Whole-Life Cost (WLC) approach to managing its assets, with a specific focus on Operate, Maintain and Renewal (OMR) activities. This report was initiated as a collaboration between the Office of Rail and Road (ORR) and National Highways between December 2024 and March 2025.

It is recognised that there is inconsistent interpretation of this specific Licence requirement, in particular, how WLC principles are applicable in the context of OMR activities. One of the outcomes of this review was to clarify the underlying intent of the clause as being: ***to promote well-informed decision making and drive best value to road users over the long term, within the constraints of resources available***. A key learning point was the need to consider **Whole-Life *Value (WLV)***, and not just ***cost***, for the License clause to become meaningful to OMR activities.

It is observed that National Highways makes robust, conscientious decisions for OMR activities; balancing performance and risk to deliver best value from the funding available. There are several examples of existing good practices within National Highways that can be built upon. However, National Highways is not always able to provide evidence that whole-life decisions are undertaken systematically or consistently made across the Regions. A summary of the findings and recommendations is provided in *Table 1*, below. The detailed recommendations can be found in section 15 (Scope item 9).

Table 1 Headline Findings and Recommendations

Finding	Recommendation
There is no clear ownership of National Highways OMR Whole-Life Value planning.	National Highways should establish a framework, across the organisation, which establishes clear ownership of OMR WLC/WLV within the business.
National Highways is not always immediately able to provide evidence that OMR Whole-Life Value decisions are undertaken systematically or consistently across the different Regions.	National Highways should produce detailed and consistent WLC/WLV governance, guidance and tools to enhance business decision making capability for OMR activities.

Finding	Recommendation
There is scope to improve the information flows that enable business decision making. For example, evaluating the disbenefit incurred from having to pursue sub-optimal OMR Whole-Life Value interventions due to funding constraints.	National Highways should capture and maintain improved data and analysis to drive more informed WLC/WLV funding discussions.

1 Scope and Objectives

This report examines National Highways' Whole-life Cost/Value approach, relating to OMR investments including:

- Processes
- Systems and models
- Governance and assurances
- Management

Research into WLC/WLV best practices from external industries was undertaken to compare National Highways approach with comparable asset intensive organisations.

The review captures evidence of where a documented approach has been applied to make OMR decisions, according to the Licence requirement, and identifies where there are gaps. National Highways' internal WLC/WLV best practice is also highlighted for sharing across the organisation.

The review includes the following asset classes:

- Flexible pavement
- Rigid pavement
- Structures
- Geotechnic
- Drainage
- Vehicle restraint systems (VRS)
- Technology
- Significant renewals (i.e. complex, high value renewals that can involve multiple assets).

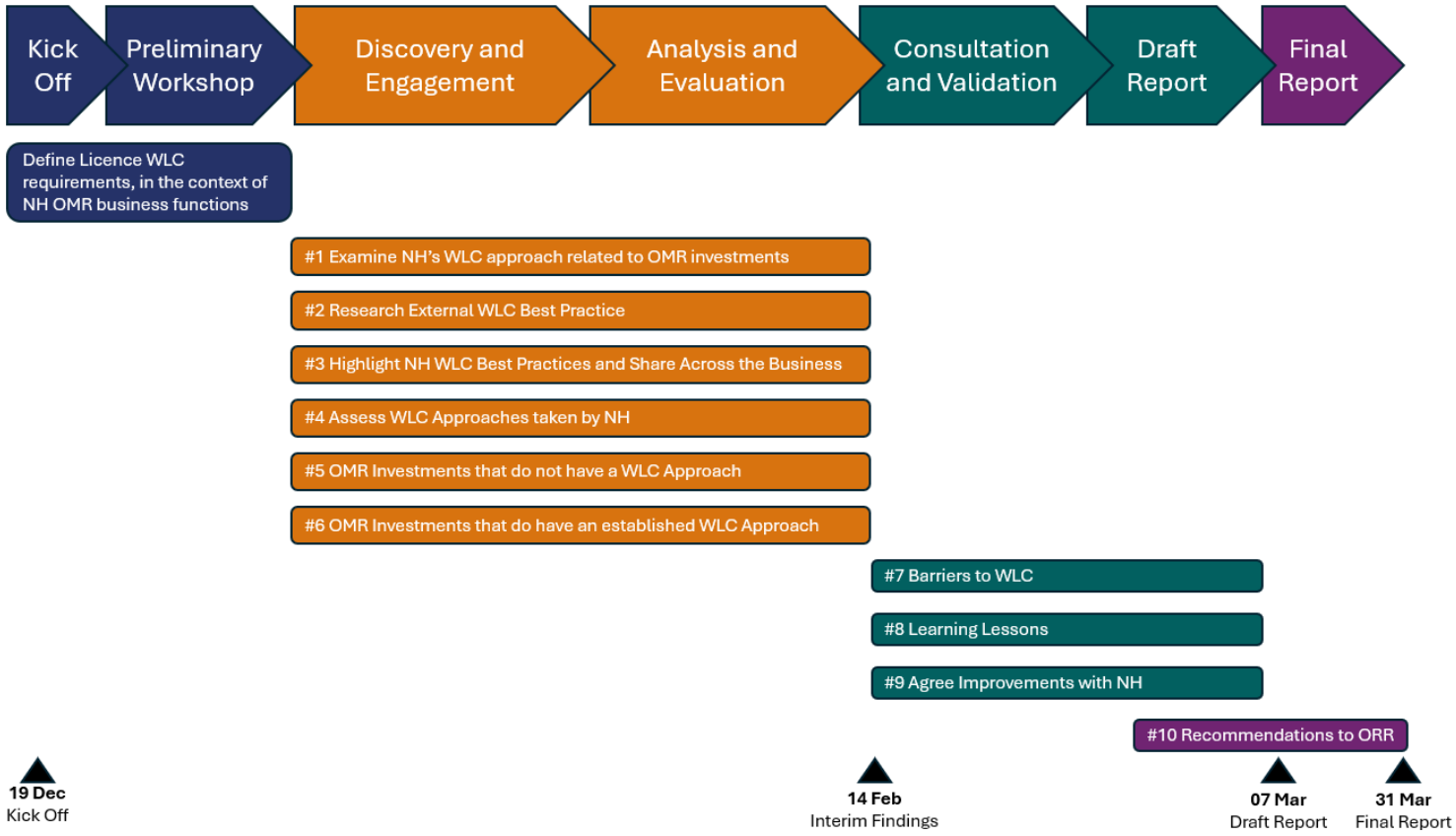
OMR investments that do have an established WLC/WLV approach, are assessed for compliance with the Licence requirement and in terms of consistency, compliance reporting and comparison with industry best practice. OMR investments that do not have an approach are identified, along with the reasons why, and recommendations provided for a practical approach.

The review explores barriers to the use of WLC/WLV decision making in the company and assesses and evidence how National Highways is learning lessons and embedding these lessons to improve its approach. Recommendations on how to improve National Highways WLC/WLV processes, management, governance, and assurances are agreed with National Highways and presented to Office of Rail and Road (ORR), including suggestions on how to monitor National Highways approach.

2 Approach and Timescales

The assignment was carried out in four stages over a period of three months. These stages are shown in *Figure 1*. The report findings and recommendations are based on evidence provided by the different teams in National Highways during this period. There may exist further evidence of WLC application which wasn't available to the team within the project execution window. A full list of the evidence received is provided in Appendix B *List of Evidence*.

Figure 1 Assignment Methodology



3 Terminology

Assurance	Providing confidence that business governance controls are functioning effectively and the systems in place ensure the organisation is on track to meet its goals. Assurance activities include audits, performance reviews, and reporting.
Governance	The framework of rules, practices, and processes by which an organisation is directed and controlled. Key components include roles, policies, guidelines, decision-making processes, and risk management.
Lifecycle	This is the period from the design of an asset through its creation, maintenance through to disposal.
Maintain	Planned cyclical maintenance (including works agreed within the Annual Maintenance Requirement Plans (MRP) – includes Service Added Value and Asset Added Value)
Operate	Reactive maintenance for asset defects (safety and other)
Portfolio	Consideration for all assets, within a specific asset class, for the Strategic Road Network (SRN)
Programme	The combination of multiple individual schemes into an overarching delivery plan, with consideration for their independencies such as timing, scope, and location.
Renewals	Planned whole asset and/or asset component renewal/replacement. Includes Minor Capital Interventions (MCI)
Sub-optimal interventions	Sub optimal intervention is where there is a restriction to delivering the optimal, restrictions can be varied and include access, restricting time, delay impacts, costs, etc
Sub-optimal treatment	A sub-optimal treatment would be one that would be a step away from the optimal which would provide the best outcome
Sub-optimal WLV	A sub-optimal WLV would be a step away from the ideal and would not offer the same value from the investment.
Scheme	Individual capital project to renew the condition of an existing asset, such as pavement resurfacing.
Whole-Life-Value (WLV)	Balancing cost, risk, and performance over the entire lifecycle of the asset to deliver organisational objectives, considering tangible and intangible benefits as well as costs.
Whole-Lifecycle Cost (WLC)	The total cost of ownership over its entire lifecycle. This will change depending on investments/interventions through the asset life.

4 Abbreviations

Abbreviation	Expansion of the Abbreviations
AIP	Approval In Principle
ALP	Asset Lifecycle Plans
AM	Asset Management
BCR	Benefit Cost Ratio
BREEAM	Building Research Establishment Environmental Assessment Method
CapEx	Capital Expenditure
CDMT	Capital Delivery Management Tool
CPI	Capital Programme Integration
CSC	Customer Strategy and Communications
DSBP	Draft Strategic Business Plan
FWI	Fatalities and Weighted Injuries
GHG	Green House Gases
GHLS	Generic High-Level Solution
IAM	Institute of Asset Management
IEPS	Improved Estimating Processes and Systems
KPI	Key Performance Indicator
MCI	Minor Capital Interventions
MI	Maintenance Integration
MPI	Major Projects Integration
MRP	Maintenance Requirement Plans
NH	National Highways
OD	Operations Directorate
Ofwat	The Water Services Regulation Authority
OMR	Operate, Maintain, and Renew
OpEx	Operational Expenditure
ORR	Office of Rail and Road
P-AMS	Pavements Asset Management System
PCF	Project Control Framework
PDEM	Project Delivery Estimating Module
PEAT/LITE	Programme for Economic Appraisal Tool
PV	Present Value
PVc	Present Value of cost
QUADRO	Queues And Delays at Roadworks
RACI	Responsible, Accountable, Consulted, and Informed

RICS	Royal Institution of Chartered Surveyors
RIS	Road Investment Strategy
SAMPT	Structures Asset Management Planning Toolkit
SES	Safety, Engineering and Standards
SID	Solutions Identification and Development
SIDM	Sustainable Investment Decision Making Transformation
SIT	Structures Investment Tool
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
SRN	Strategic Road Network
SuDS	Sustainable Drainage Systems
SWEEP	Software for Whole-Life Economic Evaluation of Pavements
SWOT	Strengths, Weaknesses, Opportunities, Threats
TotEx	Total Expenditure
UCD	Unit Cost Database
URC	Unit Rate Calculator
VM	Value Management
WLC	Whole-Life Cost
WLCA	Whole-Life Cost Assessment
WLV	Whole-Life Value
WWW	Way We Work

5 Licence Requirement 5.12

Licence requirement 5.12 states that National Highways must:

i. Adopt a Whole-Life Cost approach to managing its assets.

ii. When presented with a significant choice between bearing short-term costs and increasing long-term costs, appraise the different options in line with relevant government policy and guidance to determine which represents the best overall value for money.

iii. Ensure that it has in place robust internal arrangements to achieve, and to demonstrate how it has achieved, value for money.

iv. Have due regard to circumstances in which it may be appropriate to carry out additional work as part of proposals where these can reduce or eliminate long-term costs or disruption to the network.

6 Scope Item 1 – Examine National Highways' WLC Approach related to OMR Investments

6.1 Summary

The business was requested to supply relevant data and examples of application WLC approaches related to OMR investments, to demonstrate the current position. It is recognised that timescales may have restricted evidence provided.

At the strategic level, National Highways states its intent to adopt a WLC approach within its Asset Strategies. There is clear, documented guidance available for Structures assets in CD355 (Application of Whole-Life Costs for Design and Maintenance of Highway Structures). This guidance outlines the assessment process, evidence is available from each of the Regions to demonstrate this is being adhered to. There is a consistent approach for Maintenance too where a standardised process, decision support tool and governance are applied.

For all other asset classes, there is insufficient guidance to evidence *how* WLC commitments are being fulfilled for Operate and Renewal investments. This gap is recognised by National Highways staff and improvements are being actively sought to define OMR assessment criteria.

Operate investment decisions are based upon safety and risk approaches given their real-time, reactive nature. The front-line inspectors and traffic officers will seek guidance and assurance of a technical approach from experts within the business for technical solutions as and when required, e.g. Defects related to Structures, Drainage, Geotechnical, etc.

Maintenance investment process is clearly defined, focusing on the development of a Regional Maintenance Requirements Plan. This plan utilises a standard Safety Engineering and Standards (SES) support tool, with governance provided by SES. The output identifies the lowest risk programme within budget constraints. This approach is a pragmatic adaptation of WLC principles. It considers Whole-Life Value and offers the lowest risk with available budget. This is an appropriate approach for National Highways' context and aligns with the intent of Licence requirement 5.12.

National Highways does need to ensure feedback loops to check-review whether actual work delivered meets what was originally planned. For example, there is no evidence of lessons learned from understanding whether an intervention gave rise to subsequent reactive work. Evaluation of the reduced asset life due to a constrained maintenance approach would be strategically valuable information to demonstrate the reduced whole-life asset value due to imposed underfunding. There is evidence that some Regions produce a risk assessment of a financially constrained approach. However, overall, this constitutes an area to improve compliance with the Licence requirement.

Individual Renewals investment appraisal is inconsistent by asset and Region and in some cases limited analysis is carried out. Structures asset investments are the only exception to this with CD355 ensuring a consistent approach across all Regions.

For all other asset classes, Regions are broadly adopting a risk-based approach to prioritising Renewal investments while managing within a constrained budget. There are some misconceptions amongst staff that financial constraints reduce the value of WLC analysis. However, if analysis is carried out, the business can better demonstrate the reduced asset life from the sub-optimal treatments and whole-life benefits that can be achieved if the upfront funding is available.

Operations and SES confirmed that WLC analysis is being conducted using tools that have not been updated for a decade and need revalidation. For example, Project Economic Appraisal Tool (PEAT/LITE) and Software for whole-life Economic Evaluation of Pavements (SWEEP) tools, which are being used, but inconsistently. These tools are unsupported, and no formal training is available. Regional operations teams are self-training based on local knowledge retained from previous service provider staff.

SES has introduced a new pavement tool, called Pavements Asset Management System (P.AMS) that can model pavement life and include WLC analysis. Regional staff are currently being trained in its application (at the time of writing this report). This presents an opportunity for National Highways to enhance its WLC governance for flexible pavement assets, however it is not clear how, when and where this data will be used in the decision making for Renewals.

From discussions with National Highways' SES teams, WLC analysis used to be a key part of regional service providers' justification for Renewals. There was a structured Value for Money (VfM) process, including WLC, with rigorous checks and challenges from Operational regional teams and SES, supported by technical experts. The reviewed schemes then formed the delivery programmes of works. However, following the insourcing, via the 'Asset Delivery' reorganisation during in RIS1, this WLC function was no longer mandatory.

6.2 Existing Guidance and Tools

Table 2 below summarises the existing guidance and tools that National Highways has in place for renewal scheme appraisal. These represent good practice that have been built upon in this report's recommendations.

Table 2 Existing Guidance and Tools

Sub-Asset	Existing Approach
Significant Renewals	PCF/BCR, scheme business case examples
Pavement (structural, complex)	SWEEP/P-AMS, SES review
Pavement (non-structural, standard)	Asset Handbook
Structures	CD335
All other assets	PEAT/Lite, Asset Handbook

8 Scope Item 2 – Research External WLC Best Practice

A review was undertaken of WLC/WLV assessment guidance, models, tools, and frameworks used in various sectors, especially rail, water, and the built environment. The rail sector provides good alignment with roads, with both involving the management of linear, ageing, and interdependent assets with similar asset intervention needs. Since the rail sector has been through more investment cycles compared to roads, its approaches are more structured and embedded in planning processes, therefore providing several learnings in application. Similarly, the water sector has also been through more investment cycles. It has made considerable progress to improve decision making through transformation frameworks for sustainable investment decision making. The built environment sector provides detailed guidance for whole-life appraisals tools to achieve WLV. The methodologies consider broader criteria than just initial capital costs. It provides a good basis to draw from and tailor for road infrastructure.

Whilst there are other asset owners with comparable assets, we also recognise the ease of uncontrolled public access to the company's assets and the impact that can have on the running of the network and delivering interventions.

Table 3 summarises key good practice learnings harnessed from various sectors. An expansion on these concepts and themes is provided in *Appendix C: Scope item 2 - Expanded review of WLC/WLV best practices*.

Table 3 Key External Good Practice Learnings

Learning Theme	Description of Best Practice
Determination of value	**Optimum Whole-Life Value for an organisation can only be achieved and measured when value is understood. Therefore, it is important for organisations to determine what value means in their context and then establish aligned criteria to inform decision-making.** Anglian Water uses the Six Capitals framework [1] to deliver value and build resilience in their investment planning. The Institute of Asset Management Subject Specific Guidance (IAM SSG) on lifecycle value realisation [2] recommends the application of the *Shamrock diagram* ***Error! Reference source not found.***methods to capture the different dimensions of assets value prior to assessments. The guidance on achieving WLV in infrastructure and buildings [3] requires WLC to be applied in combination with multi-criteria assessments and group decision-making processes, including value and risk management to deliver Whole-Life Value.
Parameters of analysis	**Following the exercise of value determination, organisations should define the input parameters for the WLC assessment. A WLC approach should analyse both tangible and intangible costs to provide a comprehensive evaluation of costs and benefits/ disbenefits before making decisions.** The below list the cost parameters considered in WLC assessments in the following sectors: • National Highways: OMR direct costs, QUADRO costs (safety, delays, emissions, road closures and vehicle operating costs). • Railway: Intervention and operational costs, safety and service risks, reputational and environmental impacts. • Construction industry: commercial cost, environmental costs, and performance assessments • Drainage: monetary cost and non-monetary costs (Environmental costs and benefits).

Learning Theme	Description of Best Practice
Data	**Quality of WLC assessment largely depends on the input data. Therefore, it is crucial to adopt improved data collection processes and create integrated data management systems with repositories of historic asset intervention data to input into WLC assessments.** Sustainable Drainage Systems (SuDS) categorises the data needed for WLC assessments into historic data relating to historic frequency and cost of interventions and predictive data relating to deterioration modelling. Historically data has not been systematically collected and analysed. [9] The water sector leverages data analytics and IoT devices, e.g. sensors on water assets for collection of asset performance data. This enables predictive maintenance planning. Integration of asset data from various sources, such as IoT sensors, asset management systems, and financial records, into a single system is essential for WLC application. It is therefore key to develop tools which help create a holistic view of the asset's lifecycle costs. [10] • The railway sector [4] has addressed data challenge through building libraries of through-life costs information. These are known as Asset lifecycle profiles (ALPs). • The water sector [7] has developed a Unit Cost Database (UCD) capturing historic costs from previous investment periods. • AtkinsRéalis developed the Unit Rate Calculator for HS2 to assess both CapEx and OpEx costs.
Uncertainty in Data	**WLC assessments should reflect uncertainty profiles associated with the examined investment options to inform decision-making. Therefore, it is crucial to address this by embedding features for uncertainty analysis in WLC tools.** Uncertainty in data can either relate to parameters (insufficient/ low quality of data), models (periods of analysis), or scenario (discount rates). This can be addressed though embedding sensitivity analysis, probabilistic modelling, and scenario analyses as features in the developed WLC tools. [11]

Learning Theme	Description of Best Practice
Feedback loops	**Feedback loops are essential to be embedded in OMR processes to enable continuous monitoring and evaluation of asset performance. The outcomes of collected information can then feed into WLC assessments. This particularly relevant to enable the adoption of TotEx models. TotEx models optimise investment spend through ensuring there is no bias towards CapEx or OpEx. The relationship between these two should therefore be established and feedback loops are a major enabler for this.** The whole-life appraisal tool by Scottish Future Trust [5] embeds Feedback loops in WLC processes. Established feedback loops are crucial in Whole-Life Cost (WLC) assessments as they allow for continuous monitoring and evaluation of asset performance. By regularly collecting and analysing data, organisations can identify areas for improvement, leading to better financial planning, resource allocation, and optimised asset performance. This is especially important for reactive maintenance, where frequent issues can be addressed with permanent solutions. Effective feedback loops also enhance stakeholder engagement and collaboration, resulting in more sustainable decision-making. [6] Feedback loops also appear as part of the TotEx framework developed by United Utilities [7] as part of their TotEx models which integrate CapEx and OpEx into a single framework providing a holistic view of costs. This model, part of The Water Services Regulation Authority (Ofwat's) regulatory framework, encourages cost-effective solutions without bias towards either OpEx or CapEx. [8]

Learning Theme	Description of Best Practice
Scalability	**A one-size-fits-all is not recommended for WLC applications. The application of WLC should be scalable for OMR based on a predefined set of criteria/thresholds (e.g., level of assessment (portfolio, programme, project level), value of schemes).** In the rail sector [4], Life-Cycle Costing (LCC) is applied with a decision hierarchy based on project complexity. The terms LCC and WLC are used interchangeably here as both assess the total cost incurred during a project's lifecycle. Initial decisions are made by reviewing asset policies or comparing precedents. If these do not apply, a qualitative or semi-quantitative LCC assessment is used to narrow options, followed by a full LCC for shortlisted options. The approach advises focusing on comparative assessments and requires formal LCC analysis for projects over a preset value.
Ownership	**Establishing ownership for WLC processes is essential for effective application and governance. Therefore, it is important that stakeholders and their roles in implementing and monitoring WLC processes are clearly identified within a governance framework. Using tools like RACI can help define ownership responsibilities.** A key pillar for achieving WLV is identification of stakeholders, their needs, and their relationship with the work subject to WLC activity. This enables the identification of ownership of WLC processes and roles within a governance framework. Network Rail [4] clearly outlines roles and responsibilities within Life-Cycle Cost assessments using a RACI (Responsible, Accountable, Consulted, and Informed) table. It also maps the process of LCC as part of the existing process guidance and stage gates required for any project.
Business Improvement management	**An effective business development endeavour will require the organisation to develop a road map with clearly defined set of initiatives, enablers, and timelines to successfully achieve the targeted improvement. The same applies for WLC processes embedment.** It is important to recognise that achieving change in ways of working is a gradual process which requires a structured approach over a period. An example is the Scottish Water Sustainable Investment Decision making framework (see Appendix B *Best Practice Examples from Other Sectors Regarding Change*). It was

Learning Theme	Description of Best Practice
	based on the four pillars: the Why, the What (target business architecture), the How (target operating model), and the business changes (transformation route map – with a set of initiatives at portfolio, system, and programme levels). A set of enablers were identified for achieving the initiatives, including asset data, cost data, use of analytics (data-driven), stakeholder engagement, and well-defined business architecture (roles and responsibilities and process flows). The Ministry of Defence developed a Decision Support Blueprint for submarines (see Appendix B *Best Practice Examples from Other Sectors Regarding Change* for more detail). To create tangible change, the blueprint was then translated to bottom-up actions and top-down investments. The bottom-up actions entail robust asset information requirements, consistent processes and procedures which enable scalable application of Decision support tools, stakeholder management, change planning, training and most importantly a cultural shift. From the top-down approach, the organisation needs to implement proper ownership and governance to embed a new decision support tool and needs to clearly determine organisational value as a basis for any change.

9 Scope Item 3 – Highlight National Highways WLC Best Practices and Share Across the Business

A review of exiting WLC approaches across the business identified several areas of good practice. WLC is being effectively applied to various schemes and portfolios to demonstrate and justify funding.

- Major Projects schemes have a well-established approach for conducting Economic analysis. This approach focuses on producing a Benefit Cost Ratio (BCR) for the changes the scheme will deliver over the current network, aligning closely with Treasury Green Book guidance.
- This guidance is established and maintained by the Customer, Strategy and Communication (CSC) Economics team, who also check and audit scheme appraisals. This approach ensures consistency and quality in the analysis.
- For the development of RIS3 Customer Strategy and Communication carried out portfolio WLC/WLV analysis to be able to demonstrate the Renewals case and provided justification for the funding.
- Renewals best practice in this space exists for Structures CD355, and this may also apply to Pavements Asset Management System (P-AMS) once fully rolled out and embedded into the business.
- Designated Funds/improvements follow a Safety Engineering and Standards process which has a scheme level assessment including WLC to justify allocation of funds.

10 Scope Item 4 – Assess WLC Approaches taken by National Highways against Industry Best Practice

National Highways has established Asset Strategies that clearly identify the need to carry out WLC analysis as part of investment planning. Approaches are embedded with in Standards and the Asset Class Handbooks, but their practical application differs across Regions. However, National Highways currently lacks a detailed delivery process for WLC analysis in Operations, and Renewal (OMR) investments, exceptions are structures renewal and Maintenance

As demonstrated by organisations like Scottish Water, there must be clear guidance throughout the process. This includes well-defined strategies, clear guidance, and a seamless flow of data into clearly defined investment processes to achieve the desired

business outcomes. Scottish Water recognised the need to transform their business to focus on delivering their strategies, this transformation is an ongoing process and takes time. Scottish Water has been developing for over 5 years and is maturing but still is on a defined improvement journey.

The following tables provide a 6-point scoring of the WLC approaches for each of the asset classes against the Licence requirements including, inputs into decision making, process, people and tools being in place and consistently applied. Table 4 describes the scoring criteria. ***Error! Reference source not found.***, *Table 6, and Table 7* examine the cases of renewals, operate and maintain, respectively. The findings are based on the information provided during the data collection phase of the task.

Table 4 6-point colour grading classification for National Highways' WLC evidence of existing Models

Score	Assessment
0	Not applicable
1	No evidence
2	Inconsistent local approach, low evidence provided
3	Approach applied with required improvement areas
4	Approach applied fully or with potential for minor improvements.
5	Approach fully applied with strategy, process, systems, training, management, and governance.

Table 5 provides the scoring for National Highways' WLC evidence of existing models for renewals investment decision making. Evidence shows that renewals appraisal is inconsistent by asset and Region and in some cases limited analysis is carried out. Structures asset investments are the only exception to this with CD355 ensuring a consistent approach across all Regions. For other asset classes, Regions broadly adopt a risk-based approach.

Table 5 Scoring for Renewals Investment Decision Making

Asset Class	Renewals WLC evidence	Safety approach in current funding	Customer impact assessment (in MI*, MPI**, CPI***)
Structures	4	5	4
Pavements – Flexible	3	5	4
Pavements – Rigid	3	5	4
Drainage	2	5	4
VRS	2	5	4
Roadside Tech	2	5	4
Geotech	2	5	4
Significant Renewals	3	5	4

Notes
MI – Maintenance Integration*
*MPI** – Major Projects Integration*
*CPI*** – Capital Projects Integration*

Table 6 provides the scoring for National Highways' WLC evidence of existing models for operational investment decision making. A risk-based approach is adopted for the operate investment decisions to satisfy safety requirements. Limited evidence of regional WLC applications for this case is available.

Table 6 Scoring for Operate Investment Decision Making

Asset Class	Operate WLC evidence	Safety approach in current funding	Customer impact assessment (in MI, MPI, CPI)
Structures	3	5	0
Pavements – Flexible	2	5	0
Pavements – Rigid	2	5	0
Drainage	2	5	0
VRS	2	5	0
Roadside Tech	2	5	0
Geotech	2	5	0
Significant Renewals	0	5	0

Table 7 provides the scoring for National Highways' WLC evidence of existing models for Maintain investment decision making. The maintenance investment process is clearly defined and governed across assets. From available evidence the maintenance requirements plans achieves a lowest risk programme within budgets as a pragmatic adaptation of WLC principles.

Table 7 Scoring Maintain Investment Decision Making

Asset Class	Maintain WLC/VfM evidence	Safety approach in current funding	Customer impact assessment
Structures	4	5	4
Pavements – Flexible	0	5	4
Pavements – Rigid	0	5	4
Drainage	3	5	4
VRS	3	5	4
Roadside Tech	3	5	4
Geotech	0	5	4
Significant Renewals	0	5	4

11 Scope Item 5 – OMR Investments that do not have a WLC Approach

11.1 Renewal

The business was asked to provide evidence of how WLC is currently used in investment decisions for Operate, Maintenance and Renewals. Evidence was provided with several ad hoc historical examples of the application of PEAT/ SWEEP (Project Economic Appraisal Tool / Software for whole-life Economic Evaluation of Pavements) in various Regions and asset classes. However, this does not constitute a consistent, systematic, and evidenced approach.

- **Flexible pavement:** P-AMS, is being introduced currently but it has not been identified how this will become part of a quality management system and its intended purpose in investment decision making.
- **Rigid pavement:** there is no consistent WLC approach identified as part of investment decision making.

- **Structures:** CD355 has put Structures in advance of other assets. There are examples for all Regions; these include significant structures renewals.
- **Geotechnic:** There is no consistent WLC approach as part of investment decision making, the Regions are utilising PEAT inconsistently.
- **Drainage:** There is no consistent WLC approach as part of investment decision making.
- **Vehicle restraint systems (VRS):** There is no consistent WLC approach as part of investment decision making, Regions are utilising PEAT inconsistently.
- **Technology:** there is no consistent WLC approach as part of investment decision making.
- **Strategic renewal projects:** (A complex, large value renewal that could involve multiple assets). There is no clear approach to WLC.

Approximately 10% of Renewals are delivered as Minor Capital Interventions. This delivery route is applied to smaller, standardised-scope, low risk schemes. No evidence was provided of WLC being used for MCI investment decision making.

11.2 Operate

Asset defects are prioritised based on the risk to road users and asset condition in line with GM701 guidance. Decisions are made swiftly to ensure safety, reduce delays, and keep the network safe and serviceable.

Given that defects have varying intervention times, ranging from hours to weeks, it is essential to establish a cost-effective approach for reactive interventions. Due to the urgent nature of these interventions, there is often limited time to conduct WLC analysis in real time and so safety and customer are prioritised. However, this does not mean that WLC or WLV is entirely disregarded in the overall strategy.

There is an opportunity to analyse defect data to identify cause-effect patterns and develop standard approaches, such as decision trees. This ensures that the correct interventions are carried out at the right time, minimising costs, delays, and risk exposure for both workers and road users.

11.3 Maintain

Maintenance costs encompass planned cyclical maintenance activities such as planned emptying of gullies, re-tensioning, and inspection of safety fence, etc. The current approach requires Regions to produce a Maintenance Requirements Plan (MRP) that

covers all cyclical tasks. Each region uses a standard model to create these plans, which are then analysed by SES for compliance to standards and ensuring consistency.

The MRP maintains a record of all assets requiring cyclical maintenance and employs a model to determine the lowest risk approach within the available budget. Regions then update the output to consider customer issues, such as junctions and villages with limited access. This approach aims to minimise safety issues to road users and achieve best value within the budget constraints.

11.4 Relationship between Operate, Maintain and Renewals

There are interdependencies between these different OMR interventions and therefore cannot be properly analysed in isolation of each other when considering WLC/WLV. Whilst these interactions may be complex or difficult to ascertain, as an asset owner National Highways should look to take measures to analyse the cause-effect relationships and feedback loops, to gain insights and drive efficiencies to make conscious trade off decisions between all categories of spend and risk.

12 Scope Item 6 – OMR Investments that do have an established WLC Approach

Evidence was requested and provided by National Highways to their WLC approach to OMR investments. The evidence requested was for guidance, process, systems, training, governance, and ownership.

The evidence is available to demonstrate that Structures assets deploy a WLC approach that is consistent across the Regions. The Structures WLC approach is set out in CD355 and whilst robust, there are opportunities to further enhance the governance of delivery. CD355 takes an approach based on individual structural elements replacement for renewals. The review also evaluates delays during construction and produces data that will enable comparison over the given assessment period. The logic of the approach is driven by a standard, although there is no evidence that it is referenced by the quality management system (Way We Work (WWW)) which should align and provide direction for the delivery of all functions of the National Highways teams .CD355 works effectively but could be improved by aligning into the Quality management system training.

For Pavements, the P-AMS tool is planned to be introduced alongside user training. It is not yet clear how this tool will fit into the quality management system (WWW) to provide a comprehensive logic through delivery, feedback, and reporting.

National Highways provided evidence how it was inconsistently using Project Economic Appraisal Tool (PEAT) across assets and Regions, but this is not an established approach. PEAT is a simple WLC tool that can be applied to model investment scenarios across the asset base.

National Highways has a strong OMR delivery approach which encompasses financial, delivery and risk management with supporting guidance, reporting, governance, and assurance. Progress on Renewal scheme delivery is reported centrally and reviewed monthly using the Capital Delivery Management Tool (CDMT) which reviews in-year programme and future years.

13 Scope Item 7 – Barriers to WLC

Based on the interviews and evidence collated during this work the following factors need resolving to help improve the WLC/WLV approach for OMR, in accordance with the Licence requirement.

- Inconsistent interpretations of the Licence requirement amongst National Highways/ORR stakeholders were identified at the opening workshop and, and how it should be applied to OMR activities.
- Misconceptions that a WLC approach is of little use when budgets are constrained, just because the ideal option is not affordable. WLC/WLV data is useful in these circumstances to better articulate the implications of a constrained budget.
- The need for processes, tools, or information to evaluate consequences of having to select suboptimal interventions.
- The absence of clear guidance on the steps to be taken to deliver a WLC/WLV analysis for a scheme/programme/portfolio of works, in accordance with the National Highways quality management system requirements (Way We Work).
- Key Performance Indicators (KPI) metrics do not incentivise a WLC/WLV approach
- Data quality; the right data needs to be provided at the right intervals to input in deterioration/investment models appropriate to each asset class, that can
    - Establish the OMR relationships.
    - Determine the life and costs related to investments.
    - Assess the value of investment options.

In summary, National Highways requires a clear definition of roles and allocation of responsibilities for its WLC/WLV approach. Currently, there is fragmentation and differing perspectives. SES has a strong asset-specific focus, whereas Operations Directorate (OD) has a regional safety, customer, and performance/delay focus. There is a need for an

overarching framework, aligned to National Highways strategic objectives, that links investment decisions to performance consequences.

WLC is one of many investment perspectives in the business investment decisions process. National Highways needs to understand both WLC and WLV, and the interrelationship between them throughout the asset lifecycle. The associated societal benefit/risk consequences need to be monetised to balance investment decisions.

14 Scope Item 8 – Learning Lessons

No evidence was provided within the project time constraint to demonstrate that National Highways is systematically capturing and embedding lessons learned to improve its WLC approach.

See Recommendation #3 in Scope Item 9 section below.

15 Scope Item 9 – Recommendations for Improvement

15.1 Ownership

Findings: There is no single ownership of National Highways' end-to-end WLV planning and delivery approach. It appears O, M and R decisions are made based on the Design Manual for Roads and Bridges but at differing times of each other and the differing perspectives of CSC, SES, and OD do not always function cohesively. From the evidence received there is no clear statement of what National Highways is doing to satisfy Licence requirement 5.12, in respect of OMR.

Recommendation 1: National Highways should establish a framework, across the organisation, which establishes clear ownership of OMR WLC/WLV within the business, as follows:

- Produce a clear statement of what National Highways is doing to satisfy Licence requirement 5.12, in respect of OMR
- Define WLC/WLV terminology and the fundamental principles that apply to Licence requirement 5.12.
- Define and implement a RACI matrix to provide clarity on roles and responsibilities including, where appropriate, National Highways committees and meeting Terms of Reference.

15.2 Governance Capability

Findings: Currently, National Highways is not always able to provide evidence that whole-life decisions are undertaken systematically or consistently across the Regions. Furthermore, there is no decision-making criteria in place to ensure consistency in WLC/WLV for OMR approaches between the differing Regions. In summary:

- Renewals governance and assurance already exist for delivery through 3D/Capital Delivery Management Tool (CDMT), and WLC/WLV could be included alongside this once the guidance and process are established.
- Maintenance Requirement Planning (MRP) governance and assurance exist and could be amended to include WLC/WLV implications.
- Operational WLC/WLV governance and assurance would need to be established from first principles once the approach has been defined.
- Leading practice examples from comparable industries advocate a 'value framework' for end-to-end governance of planning and delivery.

Recommendation 2: National Highways should produce detailed and consistent WLC/WLV governance, guidance and tools to enhance business decision making capability for OMR activities. This should include:

- Developing capability and processes for OMR activities to understand how and when WLC/WLV is to be applied, including systems, skills, and training
- Establishing a consistent WLC/WLV cyclical maintenance approach, and analysis of its impacts on asset and network performance.
- Implementing a simple WLC/WLV approach for minor capital works or simple renewal activities, e.g. simple surfacing schemes. Programme wide assessments should be established and reflected in engineering standards for repeating activities in line with Treasury Green book guidance.
- Establishing a comprehensive WLC/WLV approach for significant renewals.
- Analyse occurrences of repeating intervention, by type or location, to identify opportunities for enhanced value by establishing a common repeatable approach that is regularly reviewed.
- Establish and roll out learning and development programme to ensure consistent application and collation of evidence.

As an interim WLC/WLV approach for Renewals, the Regions should initially re-utilise PEAT, provided that interim guidance is produced to guide teams in its application. Since there is already variable use of PEAT within the Regions, it could be rolled out quickly as a first step if it is believed to be effective. To further mature the WLC/WLV approach,

National Highways should build on the existing asset specific approaches (ref ***Error! Reference source not found.***) to develop a common suite of appraisal approaches. Subject to asset type and its respective characteristics, the WLC/WLV approach could be applied at scheme, portfolio, or programme levels.

WLC/WLV approaches must be proportionate to the complexity of the intervention and the benefit or assurance they provide. For example, a simple resurfacing scheme only requires a basic assessment.

In line with the researched best practice (scope item 2), the longer-term goal should be to finalise and embed the common value framework (currently in development) which determines what value means to NH in light of their strategic objectives. This then enables establishment of criteria to inform WLC decision-making, thereby providing overarching governance for planning and delivery. Any significant business changes resulting from the enhanced WLC/WLV approach should be aligned to the National Highway Business Improvement Programme that is going on in parallel. There is a need to assure and continuously improve the WLC/WLV governance capability. To enable this, lagging and leading measures need to be established at asset and system levels. Regular reviews (suggested annually) of all associated WLC/WLV processes and tools should be undertaken. This will take time but once in place, the feedback will drive improvements across the business.

15.3 Information

Findings: There is scope to improve the information flows that enable effective business decision making at company level and support the new corporate decision-making framework. For example, National Highways could have more informed funding discussions with Government if WLC/WLV was available to clearly demonstrate the most efficient decision making.

National Highways does not systematically evaluate WLC/WLV , this information would be of benefit to optimise investments and minimise risk and dis-benefit. Furthermore, It does not assess the potential reduction in asset life from having to selecting a sub-optimal treatment due to constrained funding. Such knowledge will enable more informed future MRP and RIS investment cases as the information could be articulated to government and policy makers to relay the decision implications on funding and risk.

Suitable lagging and leading key performance indicators or metrics should be developed to incentivise a WLC/WLV approach.

Recommendation 3: National Highways should capture and maintain improved data and analysis to drive more informed WLC/WLV funding discussions.

For Renewals, National Highways should establish a process to capture (in 3D/CDMT) the consequences of having to select sub-optimal treatments, at scheme level, due to constrained budgets. This should include having to apply interim treatments through minor capital interventions. Collating this information will enhance the case investments for future RIS periods and the risk to network performance. WLC/WLV information should be utilised to better demonstrate the benefits and risks of intervention options. This should encompass the consequences on asset life, risk from repeat intervention, carbon footprint or delay for road users. Once these information needs are identified, they should be built into the OMR WLC/WLV governance and reporting to ensure a constant supply of vital information.

For Maintenance, National Highways should embed processes to;

- Demonstrate that best value is being delivered within the constraints of the available budget.
- Establish feedback process to report MRP outputs versus plan.

For Operations, National Highways should analyse occurrences of repeating treatments, by type or location, to identify opportunities for enhanced value.

16 Scope Item 10 – Recommendations for reviewing WLC

It is a statutory requirement to ensure the Licence is complied with and National Highways must demonstrate this is the case. Review's currently do not take place of OMR WLC. Assessment information needs to be understood for asset investment, this can then be used and articulated internally and externally. Approaches need to be tailored according to the asset and investment types. A simple review framework could be developed to ensure an effective approach.

Operational investments cover reactive interventions, which have the shortest period from identification to works delivery. It is recommended that a portfolio approach be established. This approach should be reviewed initially when set up and then annually to ensure it delivers the right outcomes. The measure needs to be able to demonstrate an intelligent approach to the reacting asset needs, such as reducing the attendance rates of similar pavement defects at the same location over time. For example, there may be opportunity to analyse defect data to identify cause-effect patterns and develop standardised intervention approaches, such as decision trees. This will ensure that the

correct interventions are carried out at the right time, minimising costs, delays, and risk exposure for both workers and road users.

Maintenance investments already follow an established approach to reduce safety issues with a fixed budget, applied consistently across Regions. This approach is annual, with all Regions producing output and SES providing governance. The company should annually review delivery versus plan of the current year's regional MRP and the basis for future year MRP. Future years' reporting should include the associated risks and impact on asset life if the budget is limited, as well as a gap analysis to the ideal funding position. This way, delivery and risk would be reviewed, and the funding gap would be identified to better inform all relevant parties.

Renewal Investments cater for small, simple, combined assets, as well as complex technical and delivery projects. National Highways needs to establish an approach for each category.

For small and simple assets, a portfolio approach can be taken in line with the Treasury Green Book. While this may not account for the highest spend, it will cover a high percentage of overall deliverables through Minor Capital Interventions (MCI). Like maintenance, an annual review looking both backwards and forwards should be conducted to ensure the right interventions are happening for the right reasons and are economically viable. This review should also clearly capture the consequences of a limited budget.

For more complex projects, a PEAT or similar assessment is needed to provide a scheme-level WLC assessment. PEAT can also demonstrate efficiencies from combining works. If this information is captured in the 3D process, it would be included in CDMT and could be reported upon. Whilst time and expense would be required to amend 3D/CDMT to capture the data and create reports, it would become business as usual after the initial upgrade.

Overall OMR activities are interrelated and when National Highways have matured, they will be then able to better understand the relationships between OMR activities.

17 Conclusion

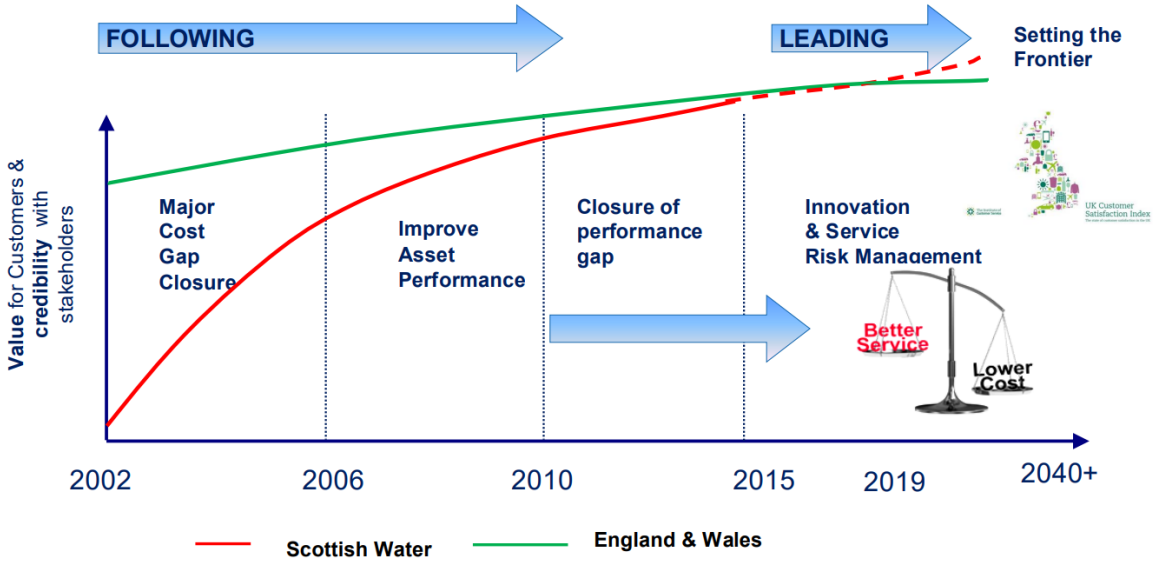
This review of National Highways current approach to Whole Life Cost/Value reveals several areas of good practice and for improvement. The findings indicate a lack of cohesive ownership and systematic decision-making across Operations, Maintenance, and Renewals (OMR), which hinders the organisation's ability to meet Licence requirement 5.12 effectively.

By implementing the recommendations in this report, National Highways can improve its governance capability and ensure consistent application of WLC/WLV principles. In turn, this will drive continuous improvement towards achieving better value and performance across the Strategic Road Network. Regular reviews will be essential to sustain these enhancements and align them with broader organisational business improvement initiatives.

Appendix A Best Practice Examples from Other Sectors Regarding Change Management

Scottish Water – Maturing Asset Management through Leveraging Business Architecture

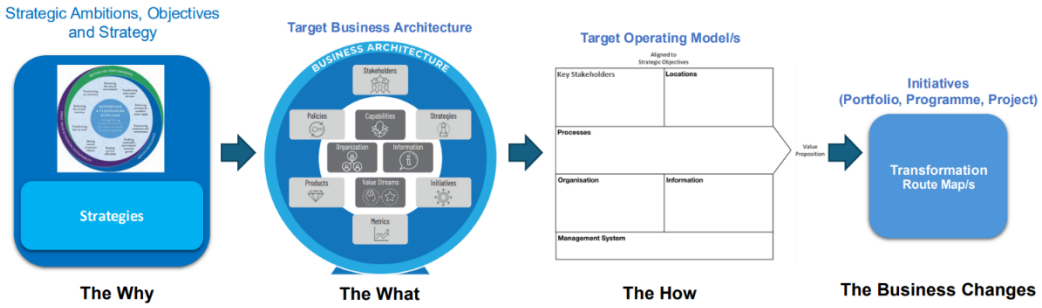
The Journey of improvement for our customers



Our Learning – maturing our approach

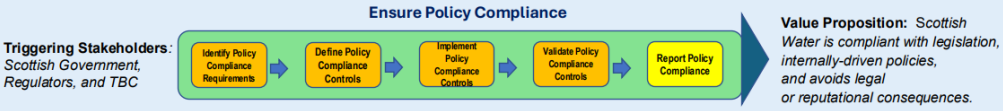
- How do we maximise Value from the changes we implement
- How do we prioritise to do the right things at the right time
- How do we align to deliver shared business objectives
- How do we continually measure our maturity and demonstrate effective change

Our Solution - The Transformation Framework



The 'Golden Thread'

Value Streams



"An **end-to-end collection of activities that create a result for a customer**, who may be the ultimate customer or an internal end-user of the value stream" * The value stream has a clear goal: to satisfy or to delight the customer**

Target Operating Model - 'TOM on a Page'

Key Stakeholders

Regulators:
1. WICS
2. SEPA

External Stakeholders:
1. Customers
2. Contractors
3. PFI Group
4. Horizons
5. Scottish Government
6. SW Board
7. Local Authorities

Internal Stakeholders:
1. Financial Control
2. Scientific Services
3. Zero Emissions
4. Business Excellence
5. Water Operations
6. GIS Operations
7. Development Services
8. Etc.

Collaborative Teams:
1. WW Service Strategy
2. Investment Approval Group
3. Executive Leadership Team
4. Management Approach Owners
5. Senior Leadership Team
6. Customer Research Coordination Group
7. Customer & Community Centricity
8. Investment Group

Locations & Assets

Location of all Assets Recorded

Key Assets:
1. WW Treatment Works
2. Sludge Treatment Centres
3. Sewage Pumping Stations & Rising Mains
4. Drainage Networks
6. Septic Tanks
7. SUDS / Blue-Green Infra
8. Combined Sewer Overflows
9. Monitor & Control Systems
10. Bioresource Centres
11. Tanker Fleet

Key:
Existing
Proposed
Proposed (needs further investigation)

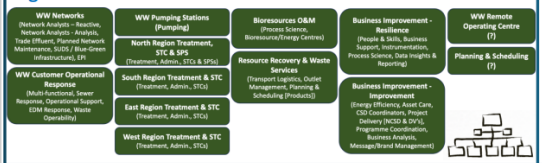
Processes

1. Operate WWTW
2. Maintain WWTW
3. Operate WWPS
4. Maintain WWPS
5. Operate WW Networks
6. Maintain WW Networks
7. Operate WW Drainage
8. Maintain WW Drainage
9. Operate Bioresources
10. Maintain Bioresources
11. Provide E&M Services for Bioresources
12. Manage Incidents
13. Manage Mains Incident Repairs
14. Manage Sewer Issues
15. Deliver Non-Complex Interventions
16. Operate STC's
17. Empty Septic Tanks
18. Manage PFI returns
19. Generate Revenue – Resource Recovery
20. Operate & Monitor Remotely (ROC)
21. Plan & Schedule Work
22. Provide Structured Training Programme
23. Monitor & Comply with Business Rules
24. Provide Admin Services
25. Manage Brand / Comms / External Risk
26. Manage Products
27. Provide Process Science Support
28. Provide Data Reporting & Insights
29. Deliver Business Change Projects
30. Monitor Environmental / Legislation Changes
31. Enable Delivery of Capital Projects
32. Deliver Asset Improv. Projects

Value Proposition

'Wastewater Operations steward the delivery of an efficient and sustainable wastewater operation and maintenance service for our customers, always striving to protect and enhance the environment. Our value proposition is based on our commitment to sustainability, innovation, openness, transparency and customer satisfaction. We believe that by providing high quality wastewater management services, we can help our customers, and regulators, achieve their goals and contribute to a cleaner and healthier environment.'

Organisation



Information

Key IT Applications:
1. Maximo
2. GIS
3. Enablon
4. AI Tool (Research support)
5. Intelligent Asset Base
6. Operational Management
7. Power BI
8. Dynamics 9. Salesforce

Key Information:
1. Business Rules Catalogue
2. System Analysis (SIDM)
3. System Plans (SIDM)
4. Asset Health, Criticality, Risk & Reliability Engineering
5. Asset Costs aligned with Finances
6. Asset Data (including location)
7. Management Approaches
8. Service Level Agreements
9. Schedules of Work
10. Data Improvement Plan
11. Self Service FAQ's & Reports
12. WW Ops Branding

Management System

- Objectives & Key Results Reporting
- KPI's Reporting
- Business Process Ownership
- Monitor Business Rules Compliance
- Business Process Change Control Governance
- Monitor Performance of Business Processes
- Monitoring of Contractors SLA's
- Agreed Process Decision Making Criteria
- Monthly Meetings With P&OD
- Monthly Business Manager's Meeting
- Annual Planning & Budgets
- Best Practice Utilisation
- Incident Reviews
- Risk Framework

Closing the Gap – Revisited

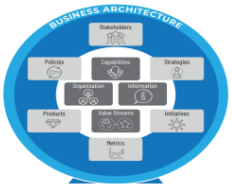
Maturity Assessment & Recommendations Provided

Programmes,Projects set up

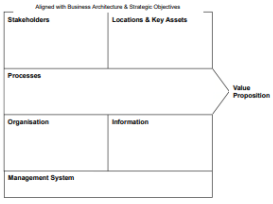
Strategic Ambitions, Objectives and Strategy

Strategies

Target Business Architecture



Target Operating Model/s



Transformation Route Map/s

Submarine Delivery Agency: Developing a Decision Support Blueprint

Why is a Decision Support Blueprint needed?

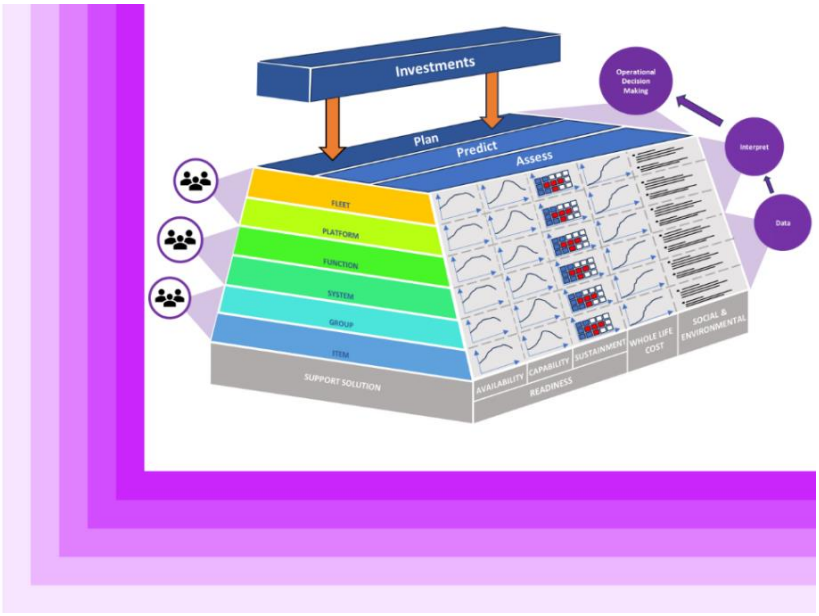
"The MoD remains stuck in a cycle of focusing on short-term financial pressures. It has sought to balance its annual budget by again deferring or descoping the development of capabilities, resulting in poor long-term value for money and the use of all its contingency funds in 2020-21 to help offset funding shortfalls. The MoD "must make tough choices to end the vicious circle of short-term financial management and delays in developing military capabilities."

Defence Equipment Plan 2020–2030 - Public Accounts Committee - House of Commons (parliament.uk)

DECISION SUPPORT BLUEPRINT

Decision Layers

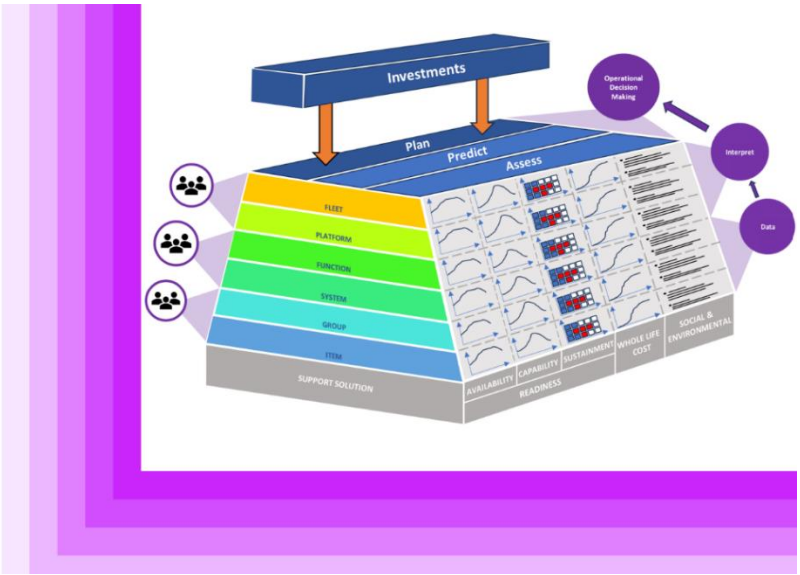
- **Group:** Represents grouping of items by common features for a number of purposes which offers useful insights not available as part of a hierarchy, e.g. common equipment used in different platforms, or purchasing economies of scale for the procurement of common or related items;
- **Item:** Range of insights which relate to individual equipment Items, their condition, disposition and even the capacity of support required to maintain their state. Readiness is used as an indicator at this level and informed by the combination of the availability of an asset, its capability and sustainment;
- **System:** An assembly of Items within a platform which act together. This decision layer provides an insight to systems specialists on the performance of the systems as a whole and the contribution, or limitations, of individual items;



DECISION SUPPORT BLUEPRINT

Decision Layers

- **Function:** Captures the performance of High-level functions provides by Platform Systems. Examples could include Propulsion, Navigation, Communication etc. Analysis at this level will provide insights to the capability of any given function;
- **Platform:** Represents the End Item, i.e. a Submarine,. Rolled up data from Items (including the End-Item), Systems and Functions provide a view of the capability and capacity of the platform to perform a particular role or mission;
- **Fleet:** Can be defined in a number of ways and could be a Task Force as a collection of disparate Platforms assembled to carry out a mission or task.

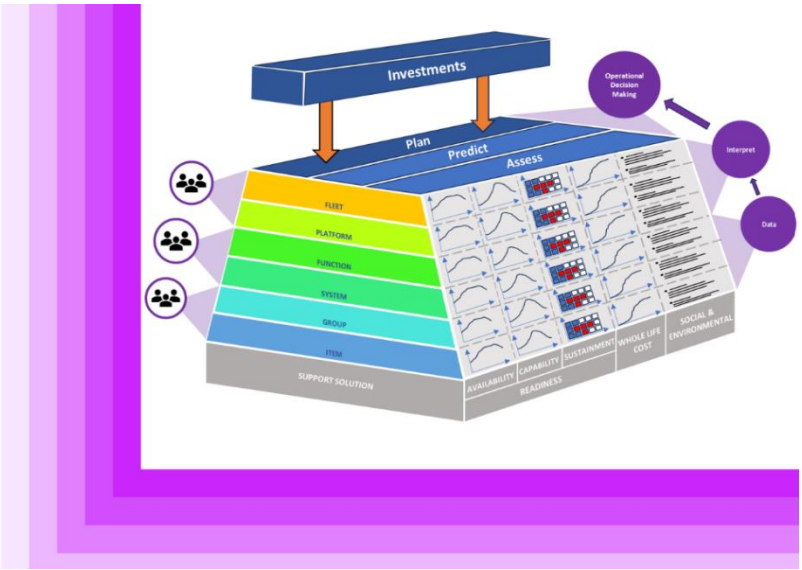


DECISION SUPPORT BLUEPRINT

Value Framework

- **Readiness:** a measure of how Available, Capable, Sustainable the equipment, platforms etc are to meet mission objectives now and into the future;
- **Whole Life Cost:** understanding the whole life cost is importance to understand the longer-term financial profile for RDEL CDEL planning;
- **Social & Environmental:** provide insight to the impact Navy is having on the UK & wider interests.

Based on rationalised 6 capitals framework

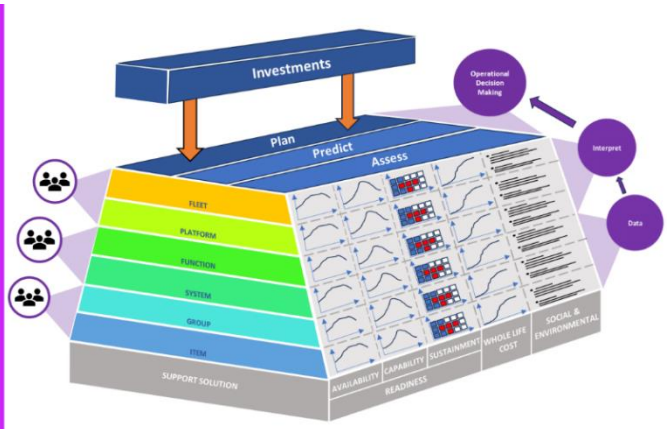


DECISION SUPPORT BLUEPRINT

Whole Life

- **Assess:** current position against a range of factors;
- **Predict:** how these factors will change over time and the potential impact to factors such as Readiness;
- **Plan:** investment choices of people, finance etc to move the dial on platform and fleet performance.

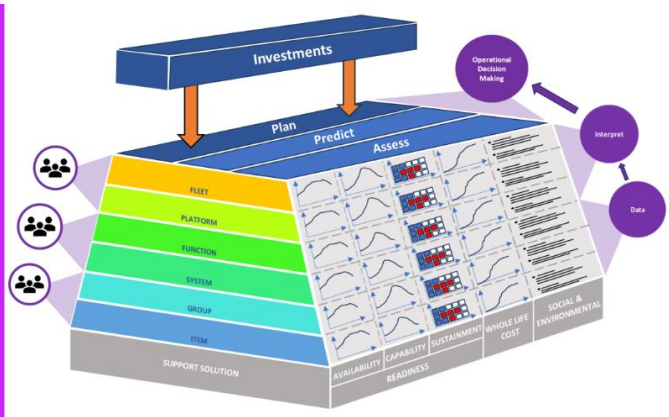
Asset Health & Risk… but in plain english



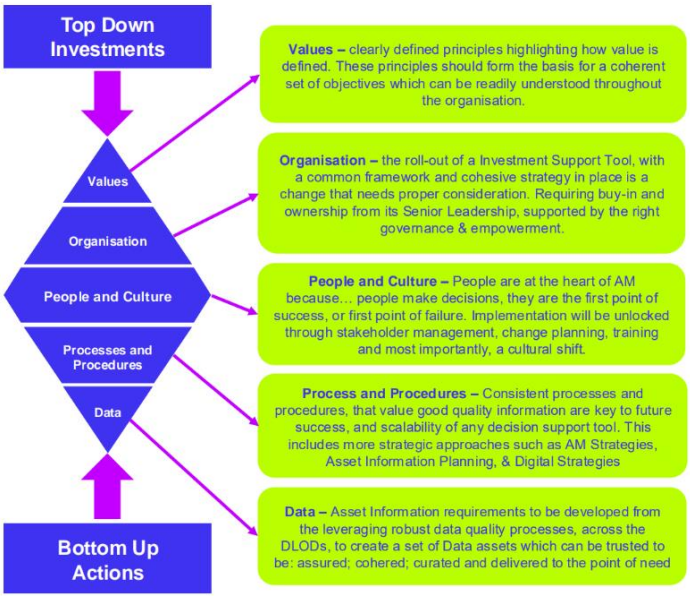
DECISION SUPPORT BLUEPRINT

Data? Tacit & Qualitative

ISO 19650 illustration of the interaction between information management & Asset Management



Unlocking the change?



How will we implement the Decision Support Blueprint?

Asset Management Objectives inspired by the Infrastructure & Projects Authority to:

Optimise value & **align thinking** through a common decision framework

Improve decision making based on **good quality data**

Empower people through tools that align the way the organisation & its supporting organisations **acts**

Appendix B List of Evidence

Category/ Team	Document title
SES	Asset Class Handbook - Whole-Life Cost
SES	Asset Class Handbook - Drainage
SES	Asset Class Handbook - Geotech
SES	Asset Class Handbook - Lighting
SES	Asset Class Handbook - Pavement
SES	Asset Class Handbook - Structures
SES	Asset Class Handbook - VRS
SES	GM 701- Asset delivery asset maintenance requirements – revision 1
SES	GS 801 – Asset delivery asset inspection requirements – Revision 1
SES	Lifecycle Planning Guidance Note – Version 0.1
SES	M5 Wynhol and Tickenham Cuttings Optioneering Report
SES	M5 SB J13-14 MP104/2 - MP104/5 3D Stage Gate 3 Report
SES	Structures Asset Management Planning Toolkit – part c: supporting information – version 2.01
SES	DSBP – Section A: Ancillaries Asset Renewals
SES	DSBP – Section A: Drainage Asset Renewals
SES	DSBP – Section A: Flexible Pavements Asset Renewals
SES	DSBP – Section A: Geotechnical Asset Renewals
SES	DSBP – Section A: Lighting Asset Renewals
SES	DSBP – Section A: Rigid Pavements Asset Renewals
SES	DSBP – Section A: Road Restraint Asset Renewals
SES	DSBP – Section A: Structures Asset Renewals
SES	DSBP – Section A: Roadside Tech Asset Renewals and National Programme
SES	DSBP – Section A: Renewals Investment Planning Overview and Methodology
SES	Technical Assurance and Asset-Specific Requirements for Pavements Renewals- Technical assurance for the 3D Process
SES	Whole-Life Cost Summary Road Investment Strategy - January 2022 - Rigid Pavements - Flexible Pavements - Road Restraints - Roadside Technology
SES	CM 231 Pavement surface repairs
MCI	2.1 MCI Communication Pack; updated Jan 2024
MCI	4. LIVE - MCI End User Guide v. Dec 2023
MCI	5. MCI Case Study - E; Fox Brook
MCI	5.1. MCI Case Study - SW; A30 Broad Lane
MCI	5.3. MCI Case Study - Mids; J15a

MCI	5.4. MCI Case Study - A11
MCI	5.5. MCI Case Study - A14
MCI	MCI_ Minor Capital Interventions Comms Pack
MCI	SED 03 03 Deliver Minor Capital Interventions
Training	National Highways Pavement Management System Appendix for Whole-Life Costing Project Reference: PRO 1335
Training	Slide pack: WLC training and how that applies to asset investment decision making – Feb 2025
Regional Audit AIP	A47/A11 THICKTHORN JUNCTION Structures Option Report- Volume 5 Addendum - Footbridges Reference: East HE551492-SKAG-SGN-000-RP-CB-50005_C01_A5 signed
Regional Audit AIP	Regional Delivery Partnership A46 Newark Bypass Structures Options Report Notts - Lincoln Railway Line West Midlands HE551478-SKAG-SBR-SECT1_B04N-RP-CB-00001_SES_Accepted_25102023
Regional Audit AIP	Midlands Renewals P84 Ray Hall CP Renewal Options Report
Regional Audit AIP	Midlands Renewals P84 Ray Hall CP Renewal Options Report - Appendix M - WLC
Regional Audit AIP	Midlands Renewals P87 Bromford CP Renewal Options Report Rev A SES Accepted 24042024 (1)
Regional Audit AIP	Midlands Renewals P87 Bromford CP Renewal Options Report Appendices Rev A (2)
Regional Audit AIP	NW 70108330-OAR-002 - M6 Thelwall Phase 2 Options Report - Issue 2
Regional Audit AIP	SE M3_Junction_9_-__M3_J9_Gyratory_Bridges_SOR_rev_C02_-_HE551511-VFK-SBR-E_RNBT_01-RP-CB-0001
Regional Audit AIP	SW GCCM5J10-ATK-SBR-J1_JN-RP-CB-000001 [0.2] N Bridge SOR
Regional Audit AIP	Y & NE Clint Lane OB SOR Rev P03 Signed TAA 27 April 2022
Regional Audit AIP	NW M6 THELWALL VIADUCT Appendix D: Joints WLCs
PD06 Ops	Building the MRP - PD06 process map
PD06 Ops	Building the MRP - PD06 supporting narrative
CSC	Slide pack: OMR case study: A14 Haughley to Toothill Concrete Road VfM analysis
CSC	Benefits Management Homepage
CSC	The Value for Money Framework
Rigid Pavements	Activity 3.0a + 4.0b - Asset Management

Rigid Pavements	pp - Deliver 3D Stage 0 - Scheme Identification
Rigid Pavements	pp - Deliver 3D Stage 1 - Options Assessment
Rigid Pavements	sharepage - Deliver 3D Stage 0 - Scheme Identification
Rigid Pavements	sharepage - Deliver 3D Stage 1 - Options Assessment
Sig Renewals	1. Identification - Significant Renewals Guidance
Sig Renewals	2. Assessment - Significant Renewals Guidance
Sig Renewals	3. Transfer - Significant Renewals Guidance
Sig Renewals	4. Governance - Significant Renewals Guidance
Sig Renewals	5. Finance and Budget - Significant Renewals Guidance
Sig Renewals	6. Contract - Significant Renewals Guidance
Sig Renewals	7. Performance Management and Reporting - Significant Renewals Guidance
Sig Renewals	8. Assurance - Significant Renewals Guidance
Sig Renewals	8. Assurance - Significant Renewals PCF Matrix Review
Sig Renewals	Significant Renewal Delivery - sharepoint page
Pavement examples of WLC	16708_210513_164109_E1Report_Ph1 Goodstone
Pavement examples of WLC	16708_210513_164109_SubmissionReport_Ph1 Goodstone
Pavement examples of WLC	E1 Report M27 Rbt
Pavement examples of WLC	PEAT WLC Analysis A30 Meldon
Pavement examples of WLC	PEAT WLC Analysis A30 Shallowater
Pavement examples of WLC	PEAT WLC Analysis Assumptions A30 Meldon
Pavement examples of WLC	PEAT WLC Analysis Assumptions A30 Shallowater
Pavement examples of WLC	SWEEP Report M27 Rbt

Pavement examples of WLC	SWEEP_E1Report Newcott
Pavement examples of WLC	SWEEP Submission Report Newcott
Regional WLC – East and NYE	Spreadsheet: Area 12 marker post defects
Regional WLC – East and NYE	Email comms: FW Service Delivery - Network Defects Worst areas
Regional WLC – East and NYE	Spreadsheet: ILM_25_26 GG104 Risk Assessments_270924
Regional WLC – East and NYE	Spreadsheet: Pavement defects M1 SB jct 38 to 37
Regional WLC – East and NYE	Email: Re Weekly Review Report
Regional WLC – East and NYE	Email: RE RRP0939 A47 EB J17 ThomasCook-J19 rsf RRP0745 A11 SB Attleborough-FenSt rsf for review
Regional WLC – East and NYE	Email: RE FOR ACTION Whole-Life Cost workshop - next steps
Regional WLC – East and NYE	Spreadsheet: RRP0745 SES Meeting Minute 14_05_24
Regional WLC - SE	Spreadsheet: SE WLC by Asset class

Appendix C Scope Item 2 - Expanded review of WLC Best Practice

Appendix C.1 Parameters of analysis

A Whole-Life Cost (WLC) approach should analyse both tangible and intangible costs to evaluate total costs and benefits before making decisions. This is particularly relevant when attempting to achieve optimum Whole-Life value. WLV extends beyond financial aspects to include social and environmental factors, as emphasised by the Treasury's Green Book [9]. The methodology must be adaptable to incorporate these external factors and consideration of all stakeholders. Multi-Criteria assessments and group decision-making processes, including Value and Risk Management, are useful tools for WLV assessments. [3]

Anglian Water [1] provides an example of delivering value which is focused on building resilience in their investment planning through linking their sustainability efforts with financing. They use the Six Capital metrics (natural, social, financial, manufactured, people and intellectual) to consider the broadest value when making investment decisions.

These metrics have been incorporated into their value framework, which attributes a notional financial value to elements such as biodiversity and amenity value, risk and opportunity and value tools and process. They are also aligned with their benefits realisation management, to assess options and measure outcomes. They have introduced a set of KPIs to align the Sustainable Finance Programme with their long-term delivery strategy.

The dimensions of analysis will depend on how each organisation determines value which will follow their organisational objectives. The Dimensions of WLC analysis in the different sectors are summarised in *Table 8* below.

Table 8 Dimensions of Analysis

Sector	Dimensions of analysis
National Highways (Tangible Costs)	OMR direct costs
National Highways (Intangible Costs)	Impact analysis (QUADRO tool considers – safety, delays, vehicle operating costs, Green House Gases (GHG) emissions, road closures)

Sector	Dimensions of analysis
Railway (Network Rail) – Tangible Costs [4]	Intervention and operational Costs
Railways (Network Rail) – Intangible Costs [4]	Intangible Costs (Safety and service risk, environmental and reputational impact)
Built environment – Tangible Costs [5]	Whole-life commercial cost
Built Environment - Intangible costs [5]	Whole-life performance assessment (Functionality, complexity, adaptability, accessibility, quality of service, design quality)
Built Environment - Intangible costs [5]	Whole-life environmental assessment (BREEAM rating, energy performance certificate, energy use per M2, carbon per annum, carbon per whole-life, embodied carbon)
Drainage - Tangible Costs [9]	monetary costs
Drainage - Intangible costs [9]	Non-monetary costs (Environmental costs and benefits)

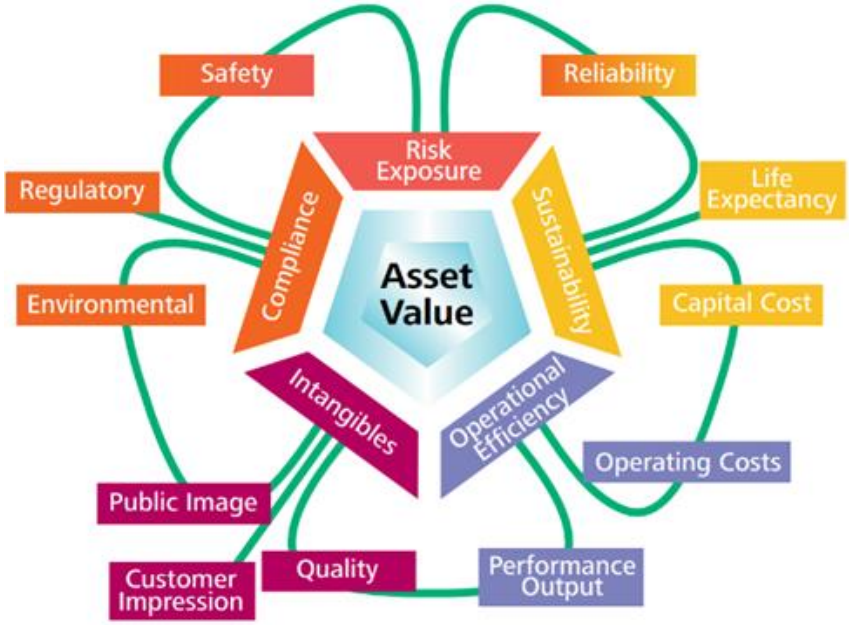
Prior to implementing WLC, the exercise of determining what value means for the organisation is needed. This will enable a clear identification of the factors to be inputted into WLC and their quantification to then achieve 'best-value' solutions.

The IAM SSG on Lifecycle value realisation [2] recommends five methods (inner group in *Figure 2*

Error! Reference source not found. to comprehensively capture the different dimensions of asset value (outer group in *Figure 2***Error! Reference source not found.**.

Risk, sustainability and intangibles are more difficult to quantify. In such instances qualitative or indirect methods are advised. In both the railway and built environment guidance reviewed, qualitative assessment of intangible impacts is adopted, particularly around performance-related factors.

Figure 2 Shamrock Diagram of competing influences on asset value (IAM SSG: Lifecycle Value Realisation [2])



Appendix C.2 Processes and tools

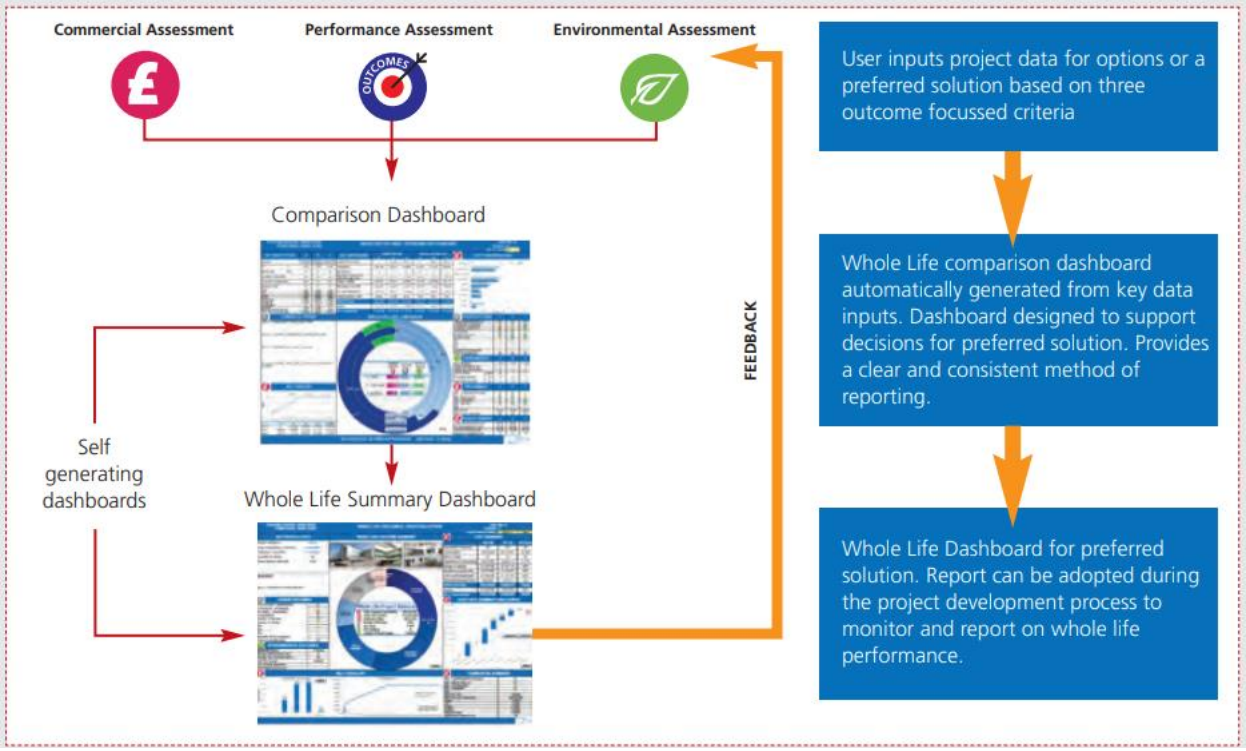
To optimise Whole-Life Cost (WLC) for any project, it is crucial to start at the earliest stage when the business case is being examined. [5] This requires well-embedded processes and tools that allow for continuous refinement of the WLC assessment throughout the project lifecycle. By doing so, options that align closely with user needs and accurately estimate costs and benefits can be generated, leading to the best value for money option that meets performance requirements at a lower WLC. The following sections will outline good practices from various sectors that can be adopted.

In the rail sector [4], Life-Cycle Costing (LCC) is applied during feasibility and option selection phases, with a decision hierarchy based on project complexity. Initial decisions are made by reviewing asset policies or comparing precedents. If these do not apply, a qualitative or semi-quantitative LCC assessment is used to narrow options, followed by a full LCC for shortlisted options. The approach advises focusing on comparative assessments and requires formal LCC analysis for projects over £3m.

The whole-life appraisal tool by Scottish Future Trust [5] consists of an online Excel workbook that offers a consistent method of reporting whole-life outcomes for a project.

The key output of the tool is a whole-life Dashboard which summaries and compares whole-life outcomes for different options or for a preferred solution. The tool is shown in Figure 3 Figure 3 Whole-Life Tool Process – Built Environment . A key element of WLC is feedback loops. Established feedback loops are crucial in WLC assessments as they allow for continuous monitoring and evaluation of asset performance. By regularly collecting and analysing data, organisations can identify areas for improvement, leading to better financial planning, resource allocation, and optimised asset performance. This is especially important for reactive maintenance, where frequent issues can be addressed with permanent solutions. Effective feedback loops also enhance stakeholder engagement and collaboration, resulting in more sustainable decision-making. [6]

Figure 3 Whole-Life Tool Process – Built Environment [5]

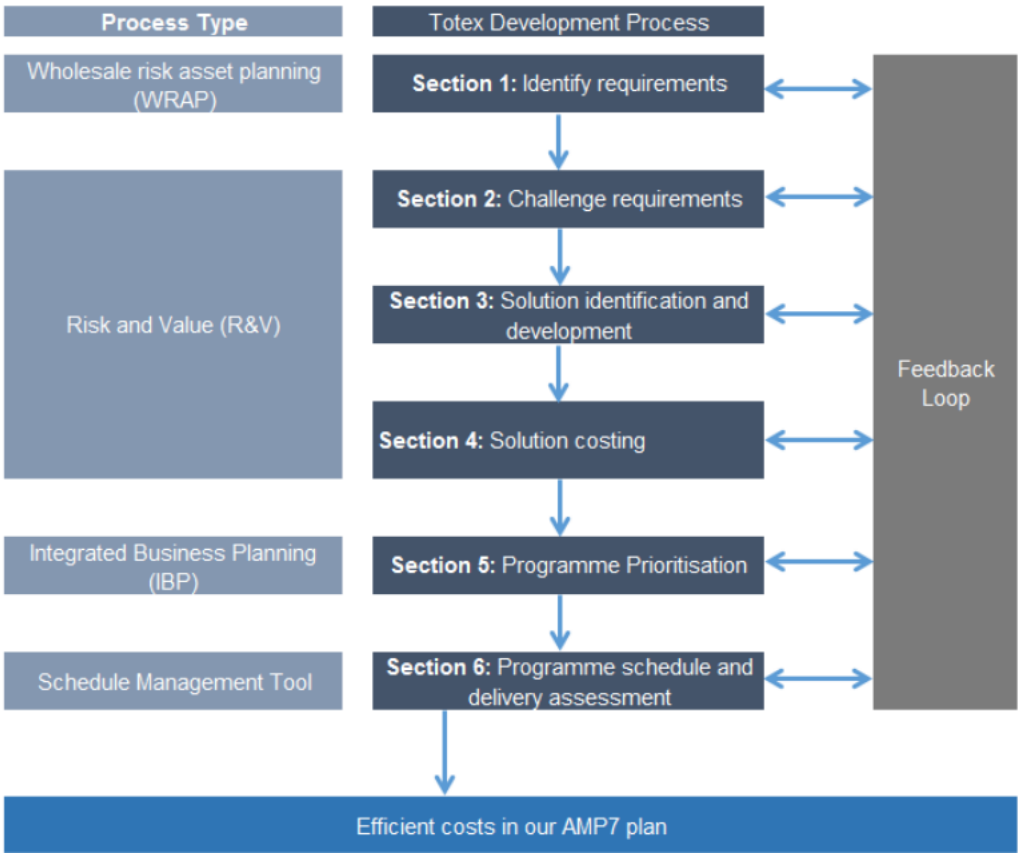


The water sector uses TotEx models to integrate CapEx and OpEx into a single framework, providing a holistic view of costs. This model, part of Ofwat's regulatory framework, encourages cost-effective solutions without bias towards either OpEx or CapEx. [7]

During the PR19 review, Anglian Water proposed a TotEx plan with significant investments to improve service and environmental outcomes. Key features of the plan include econometric modelling for base TotEx, and the need for high-quality input data supported by Ofwat. United Utilities developed a process focusing on delivering outcomes at the

lowest WLC, featuring risk and value considerations and feedback loops throughout the project lifecycle, guided by HM Treasury's green book. [7] The developed approach is shown in *Figure 4*.

Figure 4 United Utilities – Approach for development of TotEx plans [7]



Appendix C.3 Data

Substantial amounts of high-quality data, that is complete, accurate and up to date, is required for reliable WLC assessments. The Drainage sector [9] categorises operational, maintenance and renewal data used in WLC assessments into two main types:

1) Historic data on the magnitude and frequency of costs of asset interventions, impact on performance, and impacts on environment.
2) Predictive data on maintenance/ replacement needs and costs. This requires an understanding of the assets condition profile and reliable deterioration modelling for predictive maintenance planning.

A major challenge with WLC is that data is not always available to the required quality. This stems from past practice where data has not been systematically collected and analysed. Accurate and comprehensive data collection is essential for effective WLC. Data analytics and IoT devices are major aids in data collection for WLC. They provide real-time data collection which allows monitoring of asset condition which in turn helps planning of maintenance activities. The water sector is already leveraging predictive maintenance enabling tools as part of WLC such as sensors installed on the water infrastructure.

Integration of collected data is key to be able to use it in WLC applications. Integrating data from various sources, such as IoT sensors, asset management systems, and financial records, helps create a holistic view of the asset's lifecycle costs. This integration supports better analysis and decision-making.

The railway sector [4] has addressed this challenge through building libraries of through-life costs information. These are known as Asset lifecycle profiles (ALPs). Similarly, the water sector [7] has developed a Unit Cost Database (UCD) capturing historic costs from previous investment periods. Example ALP dashboard is shown in *Figure 5*.

Figure 5 Example - ALP Dashboard [4]

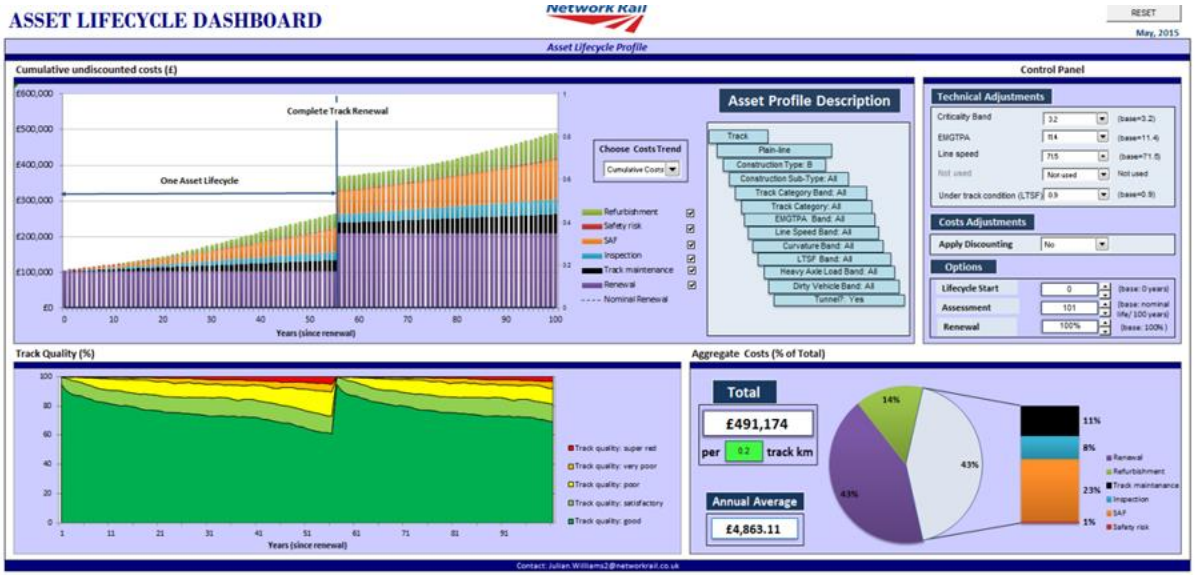


Figure 13 – Interactive dashboard for a plain line track ALP

AtkinsRéalis developed the Unit Rate Calculator (URC) for HS2 to assess both CapEx and OpEx costs over 120 years. The tool calculates initial construction costs and future Operations and Maintenance (O and M) costs, helping asset owners plan maintenance schedules and costs. OpEx activities are built from first principles, while CapEx activities use unit rates from the Structures Investment Toolkit (SIT) and Structures Asset Management Planning Toolkit (SAMPT). SAMPT, initially developed for national Highways, focuses on CapEx and was adapted to create SIT.

C.3.1 Uncertainty

Data uncertainty is another critical aspect in WLC. Types of uncertainties can be categorised under one of the following [12]:

- Parameter-related uncertainty: stemming from ropey input data such as historic unit costs, and asset condition measures.
- Model-related uncertainty: arising from any assumptions such as period of analysis.
- Scenario-related uncertainty: related to future conditions such as changes in regulation, discount rates and environmental scenarios.

Addressing uncertainty should be embedded in WLC tools through the use of:

- Sensitivity analysis: to observe the impact of changes input parameters on the WLC outcomes. This is through building features in WLC tools which allow easy manipulation of model-related uncertainties.
- Probabilistic modelling: using statistical methods to account for variability and uncertainty in data. This is particularly relevant to uncertain unit costs. The proposed approach to handle this is through Monte Carlo Simulations as a tool to build uncertainty envelopes around the different options considered in decision-making. [11]
- Scenario analysis: evaluating different scenarios to understand their impact on WLC.

Incorporating risk management strategies into WLC helps mitigate the impact of uncertainty. This includes identifying potential risks, assessing their likelihood and impact, and developing contingency plan. Proposed approaches techniques handle uncertainty and risk management include qualitative methods like risk registers, Strengths, Weaknesses, Opportunities and Strengths (SWOT) analysis. Quantitative approaches include AI and Monte Carlo simulations. [13]

By setting up effective tools to manage data and embedding features to address uncertainty, WLC can provide more reliable and robust cost estimates, supporting better decision-making for infrastructure investments.

Appendix C.4 Ownership

A key pillar for achieving WLV is identification of stakeholders, their needs, and their relationship with the project. The range of stakeholders will be different for different types of projects and can include clients, developers, owners, funders, occupiers, managers, contractors, designers, the supply chain, users, neighbours, and the public [3]. It is important to understand the stakeholder degrees of influence towards achieving WLV throughout the different stage of a project lifecycle [3]. This will enable the clear identification of ownership of WLC within a centralised stakeholder team, which is crucial for effective application of WLC. Network Rail [4] clearly outlines roles and responsibilities within LCC assessments using a RACI (Responsible, Accountable, Consulted, and Informed) table. The overview of the responsibilities against LCC activities is shown *in Figure 6* . The LCC Manual describes the responsibility of each role within the Lifecycle assessment. It also maps the process of LCC as part of the existing process guidance and stage gates required for any project.

Figure 6 RACI Governance from LifeCycle Cost Manual - Network Rail

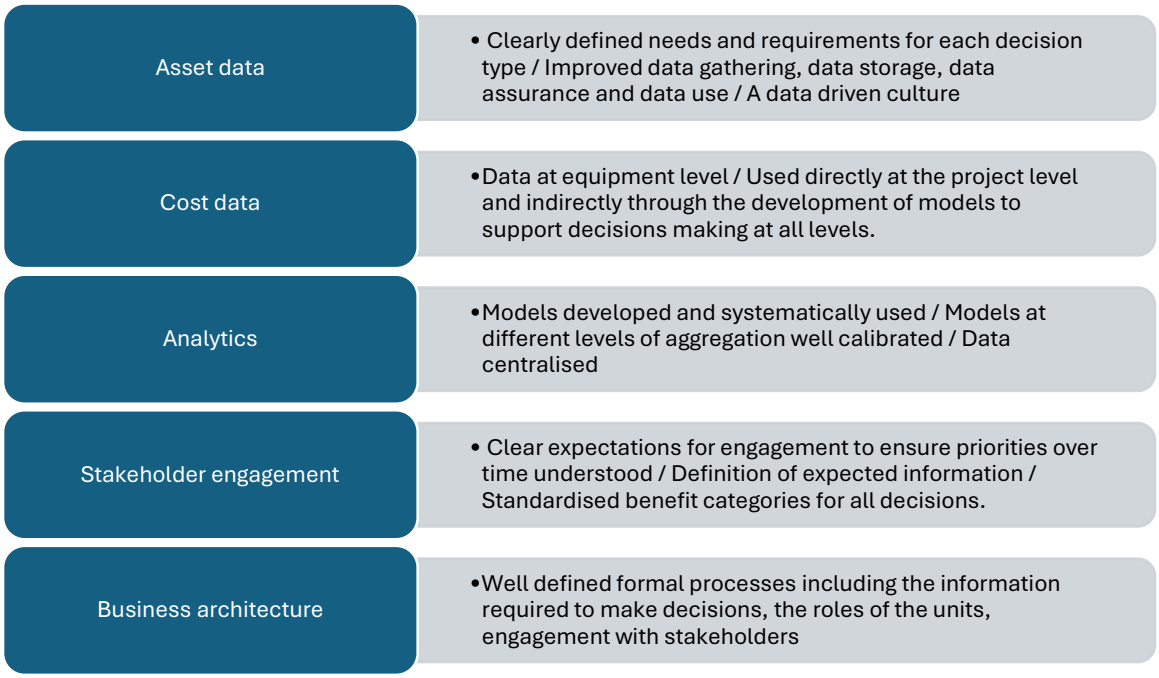
LCC key activities	Sponsor	Project Manager	Programme Cost Planning Manager	Cost Planning Manager	WLC Team	Risk and Value team	RAM	DPE
LCC remit[4]	R	C	I	I	I	N/A	N/A	N/A
LCC specification and tools including asset information	A	R	C	C	C	N/A	N/A	N/A
Allocation of LCC resource	I	A	R	C	I	N/A	N/A	N/A
LCC assessment	C	A	C	R	C	I	C	C
Gathering of information about safety and sustainability for LCC report	C	R	I	A	C	N/A	C	C
Drafting of LCC report	C	C	A	R	C	I	C	C
Methodology, tools and life cycle data	N/A	C	C	A	R	N/A	N/A	N/A

Appendix C.5 Change management and closing the gap

A useful model for change management is the one used by Scottish Water in their Asset management maturity journey. The main objective of the transformation project was to achieve sustainable investment decision making transformation (SIDM). The transformation framework was based on the four pillars: the Why, the What (target business architecture), the How (target operating model), and the business changes (transformation route map – initiatives at portfolio, system, and programme levels). The

target operating model identifies the key stakeholders, locations and key assets, processes, information and key IT applications, and the management system. Each of these elements identifies what exists and what is proposed. This transformation requires development of asset management capabilities with a set of enablers including asset data, cost data, analytics, stakeholder engagement and a well-defined business architecture with roles and responsibilities. These are shown in Figure 7. One of the main outlined challenges with this investment appraisals initiative is the speed of change. It is crucial to achieve the right balance between business-as-usual performance and transformational change of project-level decision making over time. This will also need to be a main consideration with embedding WLC appraisals in current practice at National Highways. The slides from this transformation programme are provided in *Appendix A Best Practice Examples from Other Sectors Regarding Change*

Figure 7 Asset Management Capability enablers



References

[1] Anglian Water, “Sustainable Finance Framework,” [Online]. Available: https://www.awg.com/siteassets/reports/sustainability-finance-framework-2024.pdf.

[2] Institute of Asset Management, “Subject Specific Guidelines - Life Cycle Value Realisation,” [Online]. Available: https://portal.theiam.org/shop/products/20660.

[3] Building Research Establishment, “Achieving Whole Life Value in Infrastructure and Buildings,” [Online]. Available: https://bregroup.com/store/bookshop/achieving-whole-life-value-in-infrastructure-and-buildings-download.

[4] Network Rail, “Life Cycle Cost Manual,” 2017. [Online]. Available: https://safety.networkrail.co.uk/wp-content/uploads/2023/02/Life-Cycle-Cost-Manual.pdf.

[5] Scottish Futures Trust, “Whole Life Appraisal Tool for the Built Environment,” 2016. [Online]. Available: https://www.scottishfuturestrust.org.uk/storage/uploads/Whole_Life_Appraisal_Tool_For_Construction.pdf.

[6] Institute for Change Leadership and Business Transformation, “Building a Continuous Feedback Loop for Real-Time change Adaptation: Best Practices and Tools,” [Online]. Available: Building a Continuous Feedback Loop for Real-Time Change Adaptation: Best Practices and Tools – ICLBT – Institute for Change Leadership and Business Transformation .

[7] United Utilities, “Our Approach to TotEx: Chapter 7: Supplementary Document,” [Online]. Available: https://www.unitedutilities.com/globalassets/z_corporate-site/pr19/supplementary/s6001_totex_our_approach.pdf#:~:text=This%20document%20outlines%20our%20overall%20approach%20to%20building,for%20customers%20at%20the%20lowest%20whole%20life%20cost..

[8] The Water Services Regulation Authority, “Final Determination models,” [Online]. Available: https://www.ofwat.gov.uk/regulated-companies/price-review/2024-price-review/final-determinations-models/.

[9] HR Wallingford, “Whole-life Costing for Sustainable Drainage,” 2004. [Online]. Available: https://eprints.hrwallingford.com/534/1/SR627-Whole-life-costing-sustainable-drainage.pdf.

[10] Ground Control, Smart Water Management: How Massive IoT is transforming the Water Sector, https://www.groundcontrol.com/blog/smart-water-management-how-massive-iot-is-transforming-the-water-sector/.

[11] Environment Agency, “Long term costing tool - Summary of Evidence on cost estimation,” 2015. [Online]. Available: https://assets.publishing.service.gov.uk/media/6034f187d3bf7f2656472e5a/Summary_of_evidence_on_cost_estimation__1_.pdf.

[12] The International Journal of Life Cycle Assessment, “Uncertainty in life cycle costing for long-range infrastructure. Part I: Leveling the playing field to address uncertainties,” 2016. [Online]. Available: https://link.springer.com/article/10.1007/s11367-016-1154-1.

[13] A. Boussabaine, “Whole Life-cycle Costing: Risk and Risk Responses,” 2004. [Online]. Available: https://books.google.co.uk/books?id=1aJehlxozw4C&pg=PA56&source=gbs_toc_r&cad=2#v=onepage&q&f=false.

[14] Anglian Water, “TotEx Cost Assessment at PR19,” 2015. [Online]. Available: https://www.anglianwater.co.uk/siteassets/household/about-us/totex-cost-assessment-2015.pdf.