DELIVERABLE REPORT

DELIVERABLE NO:	AM4INFRA D2.1
DISSEMINATION LEVEL:	PUBLIC
TITLE:	WHOLE LIFE COST AND RISK BASED MODELS FOR ROAD ASSET MANAGEMENT
DATE:	31/07/2017
VERSION:	FINAL 04/01/2018 10:21:00
AUTHOR(S):	ALAN DUNFORD (HE), NENG MBAH (HE), PETER SCOTT (HE), RAMESH SINHAL (HE)
REVIEWED BY:	(RWS)
APPROVED BY:	TECHNICAL COORDINATOR – RUUD SMIT (RWS)

GRANT AGREEMENT NUMBER:	713793
PROJECT TYPE:	H2020-MG-8.4B-2015-SMART GOVERNANCE, NETWORK RESILIENCE AND STREAMLINED DELIVERY OF INFRASTRUCTURE INNOVATION
PROJECT ACRONYM:	AM4INFRA
PROJECT TITLE:	COMMON FRAMEWORK FOR A EUROPEAN LIFE CYCLE BASED ASSET MANAGEMENT APPROACH FOR TRANSPORT INFRASTRUCTURE NETWORKS
PROJECT START DATE:	01/09/2016
PROJECT WEBSITE:	WWW.AM4INFRA.EU
TECHNICAL COORDINATION	RIJKSWATERSTAAT (NL) (WWW.RIJKSWATERSTAAT.NL)
PROJECT MANAGEMENT	UNIRESEARCH (NL) (WWW.UNIRESEARCH.NL)

H2020-MG-2015-713793— COMMON FRAMEWORK FOR A EUROPEAN LIFE CYCLE BASED ASSET MANAGEMENT APPROACH FOR TRANSPORT INFRASTRUCTURE NETWORKS

Acknowledgement:

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

1 - RWS – MINISTERIE VAN INFRASTRUCTUUR EN MILIEU - NL
2 - HE – HIGHWAYS ENGLAND COMPANY LTD - UK
3 - ANAS – ANAS SPA - IT
4 - FEHRL – FORUM DES LABORATOIRES NATIONAUX EUROPEENS DE RECHERCHE ROUTIERE - BE
5 - TII – NATIONAL ROADS AUTHORITY - IE
6 - UNR – UNIRESEARCH BV - NL
7 - CERTH – ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS- GR
8 - WI – WUPPERTAL INSTITUT FUR KLIMA, UMWELT, ENERGIE GMBH - DE

Disclaimer:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 713793. This document reflects the views of the author(s) and does not necessarily reflect the views or policy of the European Commission. Whilst efforts have been made to ensure the accuracy and completeness of this document, the AM4INFRA consortium shall not be liable for any errors or omissions, however caused.

Publishable Executive Summary

This report covers the completed Task 2.1 in the AM4INFRA project.
It considered the current practices and criteria for assessing network investment, improvement (major and minor), maintenance and operational needs for a 5-10 year horizon on road networks, and the application of a whole life cost and/or risk based approach.
It was recognised that, achieving a well-integrated, optimal performing transport infrastructure network in Europe is a key element in the White Paper on Transport's overall ambition for a single European Transport Area in 2050.
The AM4INFRA project was set up to respond to the challenge to provide the key stakeholders in the infrastructure governance with appropriate data, methods and tools in order to enable their decision making on cost-performance to be transparent, coherent and consistent across assets, across modes, and across borders.
The European Union and its governments have mandated that transport infrastructure authorities address these challenges. This requires two major development steps that build on current practices and approaches, to yield quick, practical, wins:
First, a further enhancement of current asset management practices is needed in order to enable effective and efficient decision making across all assets within individual transport modes.
The result from this first step, will serve as a consolidated basis for the second step: a strengthening of the asset management approach across modes and borders.
Therefore, this CSA aims to overcome the legacy of European transport networks under which they have been developed incrementally (and mostly fragmented) over time within the specific setting of mode and country, under various policies and service levels. Building on ongoing bottom-up actions, best practices and contemporary experiences of the National Infrastructure Agencies from four countries (The Netherlands, England, Italy, and Ireland), it will deliver the first ever common European asset management framework approach that enables consistent and coherent cross-asset, cross-modal and cross-border decision making in the context of the White Paper on Transport.
This will enable National Infrastructure Agencies (NIAs) to share a common vision and objectives, in a common language and a common information base.
Task 2.1 has been completed and this summary report should be read in conjunction with the first deliverables from Work Package 1, led by Rijkswaterstaat, and Work Package 3, led by ANAS.
The current practices and criteria for assessing network investment, improvement (major and minor), maintenance and operational needs for 5-10 year horizon were reviewed. The emphasis was on the application of a minimum whole life cost (or life cycle) and risk based approach.
These included:

- Investment strategies and contract policies
- Risk Management approaches and tools
- Whole life costs approaches and tools

There were some differences in the maintenance models adopted by different countries, and Highways England, and its predecessor Highways Agency went through many of these changes, and is still going through changes in order to find the best solution for this time. It is recognised that there is no best solution, but the responsibility is still, simply, to maintain the road networks for which NIAs are responsible.
Road Renewal may be divided into short term (0 to 5 years), medium term (5 to 10 years) and long- term (10 to 30, or even 50 years). This report covers the identification, management and governance of medium term renewal schemes, portfolios or programmes.
It is important to plan ahead, and to know future maintenance needs in order to establish forward programmes with a secure and established budget, while providing information about the risks and issues that might materialise over this period.

As a first step to proposing a framework for adopting whole life cost models and risk based approaches across Europe, this deliverable seeks to outline building blocks that should be in place, as part of a larger asset management system. Recognising variability in maturity and in current approaches across Europe, and a need to allow a degree of flexibility, the approach does not mandate or recommend detailed processes that should be followed.

The six building blocks outlined are:

- Appropriate governance and processes
  These could include a framework for making strategic decisions and carrying out work correctly when these decisions are translated into regional or route based programmes and projects. Governance, including responsibilities and accountability should also be defined.
- Agreed service levels for assets and intervention levels
  This is a fundamental of asset management and the ability to link asset condition to maintenance decisions is key to managing risk.
- Detailed knowledge of the assets
  This knowledge could include inventory, construction data, condition and performance data, risks and safety issues associated with assets, maintenance data, financial data and operational data, as described in the project Asset Data Dictionary (ADD, Deliverable D3.1).
- Deterministic and risk based probabilistic tools
  Short term (0 to 5 years) programmes are typically deterministic, based on knowledge and evidence; medium term programmes (5 to 10 years) should also incorporate probabilistic models, using service life expectancy, as well as evidence based deterministic decisions; long term programmes are likely to be based solely on probabilistic models.
- Whole life cost calculation
  Ensuring all potential costs throughout an asset's lifecycle are considered means decisions about initial investment, whether for prioritisation or solution selection, can be properly informed.
- Route based renewal and maintenance
  To encourage smooth flow on the TEN-T network, maintenance and renewal could be carried out for whole routes, or corridors. This will require cross-border communication and collaboration.

The building blocks highlight the essence of established best practice for managing risk within an asset management framework. It is hoped that the simple outline approach will encourage a basic level of investment and consistency across the TEN-T network with the aim of harmonising asset management across the different modes of transport in Europe.

The next task in WP2 will be to provide case examples of good practice for applying whole life cost and risk based approaches on strategic, tactical and operational levels.

Finally, WP2 will provide a framework for adopting whole life cost models and risk based approaches across Europe. The building blocks described here form the basis of the approach. They will be refined using results from case examples and the outcomes from WP1 (in particular the living laboratories), WP3 (the specification for an asset information management system), and especially from WP4 (stakeholder feedback).

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1 Purpose of the document

1.1 DOCUMENT STRUCTURE

This document is structured in the following way:

- Chapter 1: description of the brief for Task 2.1; any deviations in scope and time as stated in the Grant Agreement Annex 1 Part A
- Chapter 2: summary of the project deliverable Task 2.1; activities required in developing Task 2.1 to meet the tasks and overall project objectives;
- Chapter 3: background on the European transport network; summary of asset owners best practice approach to asset whole life cost and risk;
- Chapter 4: initial proposal for a Europe wide asset management strategy
- Chapter 5: summary, conclusion and next steps

1.2 DEVIATIONS FROM ORIGINAL DESCRIPTION IN THE GRANT AGREEMENT ANNEX 1 PART A

The objectives set out in the GA for task 2.1 are:

- To deliver a clear understanding of how whole life cost and risk based approaches, as tools, are adopted as part of the network and operational policy decision making based on stakeholders needs, with a clear understanding of the current position, the benefits and the future direction.

1.2.1 DESCRIPTION OF WORK RELATED TO DELIVERABLE IN GA ANNEX 1 – PART A

- Task 2.1 - Whole Life Cost and Risk Based models for Roads Asset Management - scope is to analyse current practices and criteria for assessing network investment, improvement (major and minor), maintenance and operational needs for 5-10 year horizon and the application of a whole life cost and/or risk based approach.

1.2.2 TIME DEVIATIONS FROM ORIGINAL PLANNING IN GA ANNEX 1 – PART A

No time deviations from the original GA; all work for Task 2.1 was delivered by end of month 6 of the project i.e. February,2017.

1.2.3 CONTENT DEVIATIONS FROM ORIGINAL PLANNING IN GA ANNEX 1 – PART A

No deviations in the content from the GA.

2 Introduction

This document forms part of the Coordination and Support Action (CSA) on a life cycle based asset management approach for transport infrastructure networks. The overall aim of this CSA is to launch a life cycle and risk based Asset Management framework approach enabling effective governance of transport infrastructure networks across Europe. The framework is needed to effectively maintain a sustainable transport infrastructure, helping to meet common economic goals and drive forward the well-being of society.
Work Package 1 (WP1), led by Ministerie Van Infrastructuur En Milieu (Rijkswaterstaat, RWS), and the Deliverable D1.1, covers the need for smart governance of transportation networks. It provides a resume of Asset Management (AM) requirements, which include levels of service, optimizing life cycle costs and strategic, tactical and operational AM objectives. The resilience of transportation networks are also discussed in the deliverable, including technical and organisational dimensions required to achieve smart governance.
Work Package 2 (WP2), led by Highways England (HE), looks at developing a whole life cost and risk based approach for road network management within Europe. This will be delivered by:

a. Analysing current practices and criteria for assessing network investment, improvement (major and minor), maintenance and operational needs for 5-10 year horizon and the application of a whole life cost and/or risk based approach.
b. Analysing case examples of good practices for deploying whole life cost and risk based tools for optimising network and scheme level programmes.
c. Developing good whole life cost and risk based practice guidance including a framework for meeting strategic, tactical and operational needs of the road administration bodies in EC countries.

The summary results from the analysis identified in part a. are contained within this document, which is Deliverable D2.1. They are here presented as an outline of best practice, to be implemented as part of an asset management framework that deals with risk and whole life cost. It is hoped that the analysis of best practice and comparison with current position will enable European National Infrastructure Agencies (NIAs) to appreciate the benefits and the future direction of whole life cost and risk based approach tools.
Risk, in the context of this work, is the risk to the National Infrastructure Agency, through increased costs and reputational damage, *and* risk to infrastructure users, through safety issues or poor levels of service.
A European wide policy for the Trans-European Transport Network (TEN-T) should be to provide an optimised budget based on network capacity and maintenance need over a 5-10 year period .i.e. a theoretical figure for the amount of money required to make the network work in an ideal fashion. The consequences of constraining this budget should be identified to inform politicians of the risks of not providing funding.
Work Package 3 (WP3), led by ANAS SPA (ANAS), deals with data and information management and Deliverable D3.1 presents concepts for an Asset Data Dictionary and the Asset Information Management Core System.

It should be noted that the analysis identified in part a. above was carried out seeking direct input from the AM4IFNRA project partners RWS, TII, HE and ANAS by means of a questionnaire found in Annex A. The completed questionnaires have not been included within this document however the content from the completed questionnaires form the core principles that have been developed in this deliverable D2.1. Additionally published literature and recent conference proceedings were also taken into account so as to ensure that all publicly available documentation, at the time this document was created, was reviewed.

3 Background

3.1 THE TEN-T NETWORK

With a growing population, changes in technology, transportation and travel the need has arisen to consolidate existing transport modes and create new transport patterns across Europe. According to research carried out by the European Union Road Federation (ERF) in 2011, more than 70% of inland freight transport in European Union (EU) is carried for all or part of its journey on roads; with the other transport modes contributing almost 30% (Rail over 17%, Inland Waterway ~6%) (European Union Road Federation, 2011). This highlights the need to improve and ensure a similar level of service, design, construction and maintenance, are provided on all European road networks.

The total paved road network within the 28 European states currently stands at 5 million km of which 66,700 km are classified as motorway, more than 215,000 km of railway lines and 41,000 km of navigable inland waterways. Of this 136,706 km of road, 138,072 km of railway lines and 23,506 km of navigable inland waterways are part of the TEN-T network (European Commission, 2017).

The main purpose of the TEN-T is to transform the existing patchwork of European roads, railways, airports and canals into a unified transportation network.

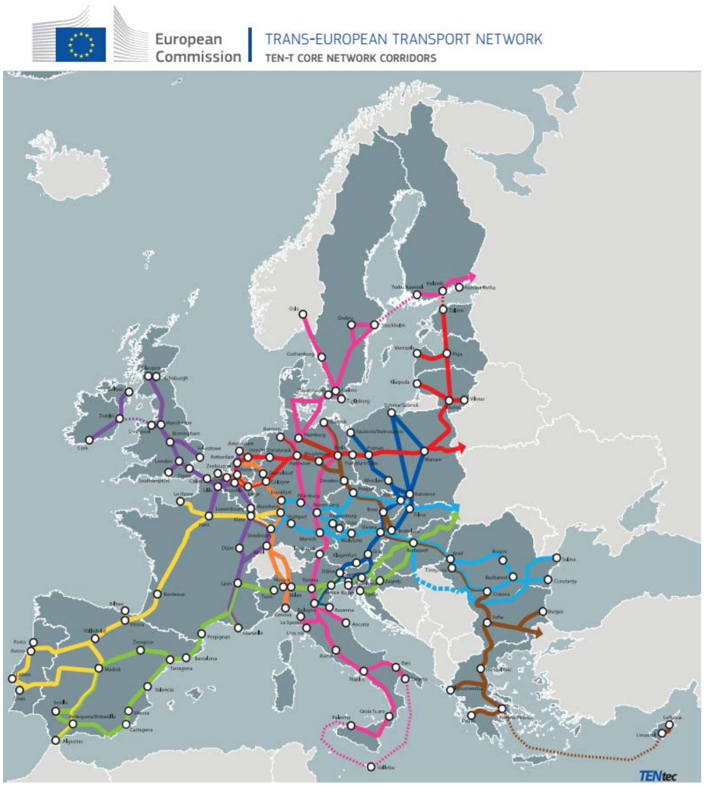

Figure 1 TEN-T core network corridors

3.2 REVIEW OF CURRENT PROCESSES ADOPTED BY SELECTED ROAD ADMINISTRATORS

A review of the current asset management strategies (whole life cost and risk based approaches) within AM4INFRA project NIAs (RWS, ANAS, TII) was undertaken. The various methods and processes used by Highways England, currently, in the past or planned for the future, were set out and circulated to prompt discussion along with a set of questions (see Appendix A).

The review sought to understand the processes adopted for operational maintenance; short, medium and long term asset renewal plans; and major and minor improvements on both national and regional level in the areas of:

- Investment strategies and contract policies
- Risk Management approaches and applications
- Whole life costs approaches and applications

The analysis found both similarities in the roles, processes and contractual policies used for asset management but differences in details of lifecycle asset management plans and the specific tools used for whole life cost and risk analysis. Whole life cost tools take into account, to a varying degree, economic, environmental and societal impacts.

The above analysis, coupled with literature findings on current European practices and the consensus of the AM4INFRA partners at the AM4INFRA General Assembly (26-27 January 2017), was used to develop a proposed interpretation of asset management in Europe, which is detailed in Chapter 4 of this report.

4 Building blocks for risk based asset management

ISO55000 provides a process framework for good practice for asset management, and defines an Asset Management System (referred to from here forward as Asset Management Process) as:
"A set of interrelated and interacting elements of an organisation, whose function is to establish the asset management policy and asset management objectives, and the processes, needed to achieve those objectives. And in this context, the elements of the asset management system should be viewed as a set of tools, including policies, plans, business processes and information systems, which are integrated to give assurance that the asset management activities will be delivered."
The paragraphs below are proposed as part of the asset management process, as could be applied to the TEN-T road network, focussing on the management of risk and consideration of whole life costs. The building blocks proposed could be developed into a minimum level of asset management to be applied across the network.
The contents of this document are therefore presented as a set of core principles for managing risk within an asset management framework. The intention of this document is to outline best practice rather than mandate a specific asset management procedure to be rigidly followed. Organisations will inevitably differ in their approach to asset management and it is more appropriate to provide an outline for best practice, rather than detailed processes and methods. It may be useful to measure the extent to which an asset operator is able to apply the core principles or to assess a 'maturity level' in line with ISO 55000. Documentation, such as the Institute of Asset Management's Self-Assessment Methodology – Guidance, is publicly available to aid National Infrastructure Agencies (NIAs) in assessing their "maturity level" and it is therefore not within the scope of this document to specify how this assessment should be undertaken.
Throughout, the MoSCoW method for prioritisation has been used (*Must* have, *Should* have, *Could* have, and *Won't* have but would like). For example: NIAs *Must* have procedures in place that deal with assets in a way that is analogous to at least some of these building blocks (see Figure 2); they *Should* have basic methods under every one of these building blocks; they *Could* have detailed processes for all of these building blocks and additional elements in place, forming a complete asset management system; but it is expected that they *Won't* have clear guidelines in place for dealing with cross-mode or cross-border interaction.

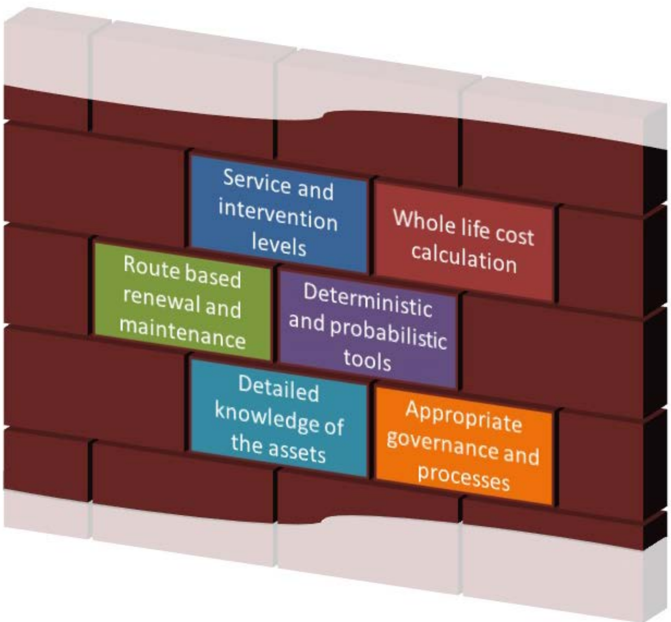

Figure 2 Building blocks to handle risk in an asset management framework

A successful lifecycle and risk-based model should be based on the following building blocks:

- Appropriate governance and processes
  These could include a framework for making strategic decisions and carrying out work correctly when these decisions are translated into regional or route based programmes and projects. Governance, including responsibilities and accountability should also be defined.
- Agreed service levels for assets and intervention levels
  This is a fundamental of asset management and the ability to link asset condition to maintenance decisions is key to managing risk.
- Detailed knowledge of the assets
  This knowledge could include inventory, construction data, condition and performance data, risks and safety issues associated with assets, maintenance data, financial data and operational data, as described in the project Asset Data Dictionary (ADD, Deliverable D3.1).
- Deterministic and risk based probabilistic tools
  Short term (0 to 5 years) programmes are typically deterministic, based on knowledge and evidence; medium term programmes (5 to 10 years) should also incorporate probabilistic models, using service life expectancy, as well as evidence based deterministic decisions; long term programmes are likely to be based solely on probabilistic models.
- Whole life cost calculation
  Ensuring all potential costs throughout an asset's lifecycle are considered means decisions about initial investment, whether for prioritisation or solution selection, can be properly informed.
- Route based renewal and maintenance
  To encourage smooth flow on the TEN-T network, maintenance and renewal could be carried out for whole routes, or corridors. This will require cross-border communication and collaboration.

The building blocks are interconnected so that the output from processes in one may be required as input for processes in another. In particular, detailed knowledge of assets is required for processes in every other building block. It is likely, therefore, that the processes, as part of an asset management process, are interconnected and iterative.

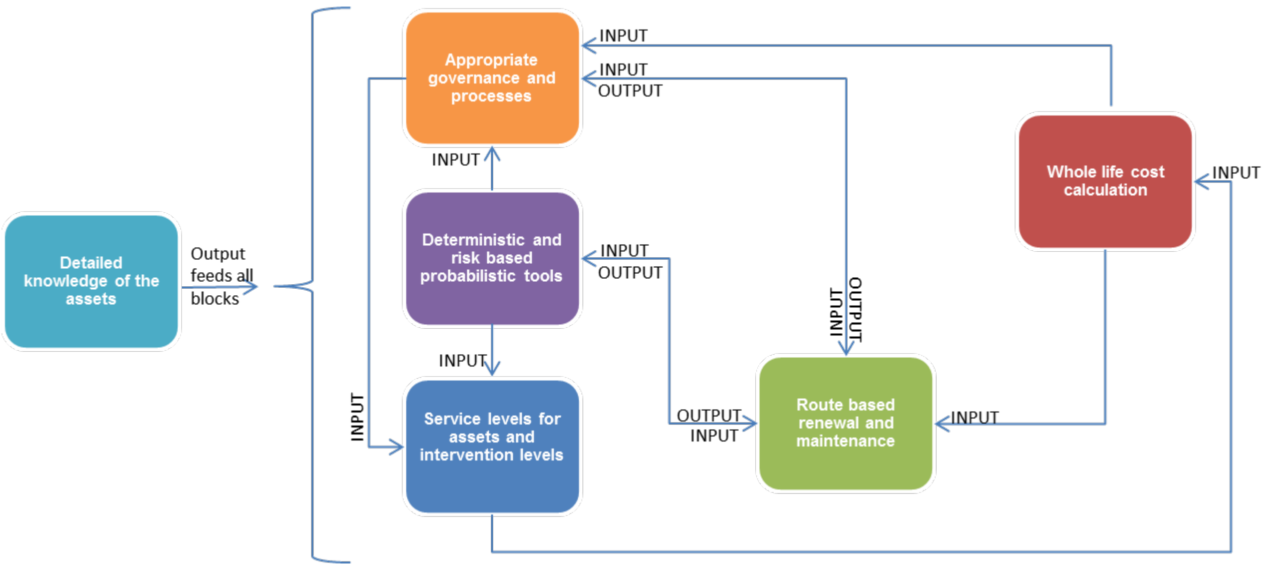

Figure 3 Interconnected nature of building blocks

The following sections describe the building blocks and outline some methods that could be put into place to achieve the intended goal for each.

4.1 APPROPRIATE GOVERNANCE AND PROCESSES

A control framework should be in place to set out how asset renewal across the network is managed and delivered through programmes of work. The purpose of the framework is to ensure that the asset is maintained so as to meet customers' needs in a cost efficient and timely manner, and ensure the long-term sustainability of the network for the future.

The whole framework formally places accountability and responsibility for the delivery of programmes on strategic and senior management. It sets out an approach to managing assets but gives middle management and asset management teams the flexibility to tailor its adoption to meet specific network needs.

Management of the whole framework should be undertaken by experienced and competent staff, working in close communication with all others involved.

There are a range of operational models in place across the TEN-T network. There should be Division of responsibility for elements of the framework, with roles such as **Asset Owner, Asset Manager and Service Provider** each carrying varying levels of risk and decision making. Further details on best practice governance of networks can be found in Deliverable D1.1, which discusses framework architecture.

EU wide variation is not necessarily detrimental to the implementation of a common governance and process framework. Ideally, responsibility for needs identification and programme management should sit with asset management teams within the NIA, with service providers and contractors being used to carry out project management and undertake construction works.

The framework should incorporate the following core principles:

- The Programme Lifecycle: the programmes of all renewal and improvement works follow a standard lifecycle, divided into phases, or stages (see Figure 4) with decision points (see Figure 5).
- Processes: these are specified to ensure that the framework is implemented in a consistent and timely manner across all programmes and schemes and that everyone involved in implementing the framework can plan ahead with a clear understanding of who is required to do what and when.
- Framework Deliverables: the framework focuses on what needs to be delivered within each stage of the lifecycle. Physical work to the network produced through the implementation of schemes is called output, while all other deliverables required at any stage of the cycle are called products. For example as-constructed record drawings are products of the framework.
- Governance: the framework should mandate controls including regular reporting, exceptional reporting, product sign-off and clearly defined roles and responsibilities.

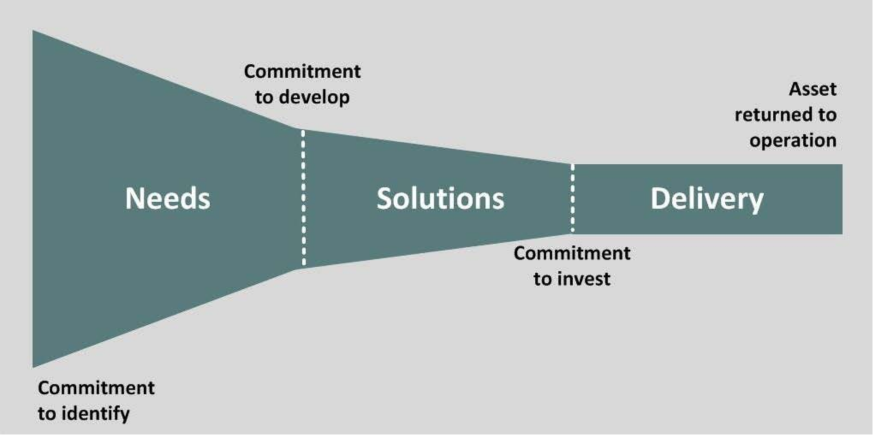

Figure 4 Forward Programme lifecycle: Renewal schemes covering a period from 0 to 10 years, from the identification of potential candidate schemes, to construction

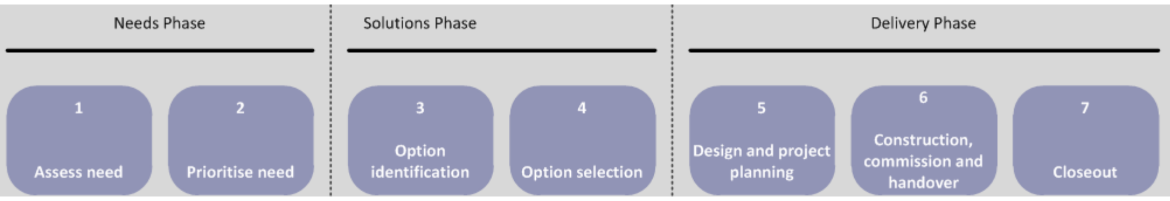

Figure 5 Decisions made at each stage of a renewal scheme

Input to the needs phase of this example should be driven by deterministic and probabilistic modelling, using detailed asset knowledge.

4.2 AGREED SERVICE AND INTERVENTION LEVELS, WITH TOLERANCES

In order to assess network need, appropriate levels of asset performance should be identified and agreed. These levels, or indicators, may be split into two facets: service levels, which relate to the experience a user might have on a given section of network, and intervention levels, which relate to the condition of an asset or group of assets compared with its expected service life. The same asset condition information can be used for comparison against the two sets of levels, but they both need to be assessed and understood at outset. Appropriate service levels might be established through road user surveys, and intervention levels are likely to be asset dependent and related to design specifications. Levels of tolerance, associated with the certainty or accuracy of asset condition, can be set to accommodate different levels of risk exposure.

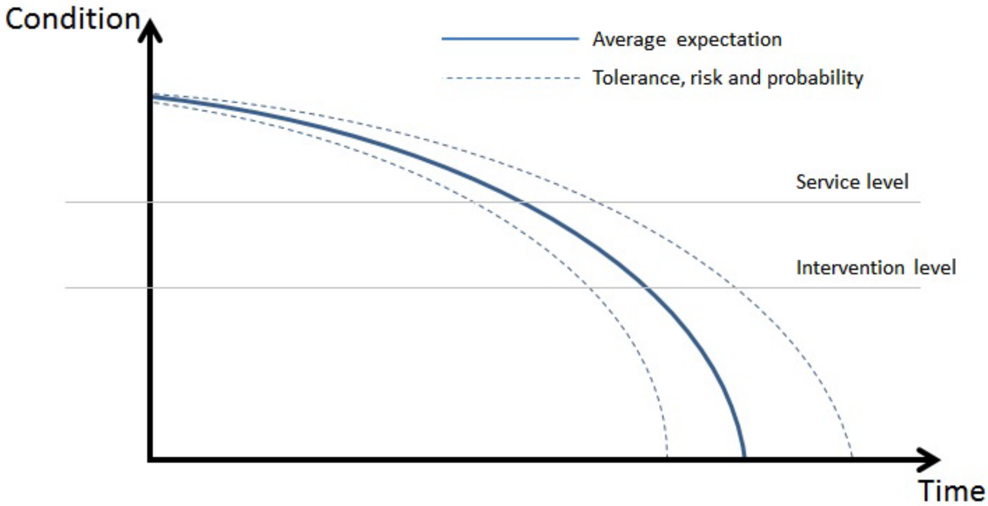

Figure 6 Condition (or performance) vs remaining service life

For example, if the number of potholes present is an indication of pavement condition, then an appropriate a rate of one pothole per kilometre might be sufficient as a service level for customer satisfaction but a rate of ten potholes per kilometre suggests that a pavement is nearing the end of its service life and could therefore be used as an intervention level.

Ideally, performance indicators should be set so that asset managers can review the effect of maintenance or renewal within a short timeframe. Expected future behaviour must be considered with a degree of tolerance: the further ahead one predicts behaviour, the greater the range of potential inaccuracy. The extent to which that range of potential inaccuracy is tolerated depends on the performance level being measured.

These performance levels are intrinsically linked to the deterministic and probabilistic models because the same assumptions about asset deterioration will be used to predict future performance. It is important that levels of service and intervention are agreed. The condition of a network that is seen as acceptable will make a significant impact on the budget required to maintain or improve that condition within an accepted tolerance of risk. The acceptable range of the performance levels set, can also, ideally, include a safety buffer zone. If the tolerance is set too high, the financial estimates may be compromised. Too low, and the service levels may be compromised.

4.3 DETAILED KNOWLEDGE OF ASSETS

Ideally, all asset information should be stored in an integrated database using common location referencing. A specification for information and data management is part of Deliverable D3.1; including a structure for the dictionary with asset categories (carriageway, structure, drainage, lighting, furniture, equipment), each with a set of asset types. An aspirational goal may be to incorporate universally agreed language and asset descriptions as part of accreditation to Building Information Modelling (BIM).
To prioritise need and mitigate the risk of failure, routine condition surveys should be undertaken for all assets. The frequency and scope of these surveys will vary depending on asset life expectancy and deterioration behaviour. To further mitigate risk, the scope of condition surveys could also incorporate an assessment of asset criticality. Assets, or asset types, that are considered to be critical, could be monitored more thoroughly and more frequently.
The amount of information required for decision making is dependent on asset type and on lifecycle stage. For example, Table 1 suggests minimum levels of detail required for four asset types, both for identification of need to mitigate the risk of failure, and for the development of treatment options. Deliverable D3.1 The complexity of the asset drives the need for the volume and frequency of data required and the stage in the renewal lifecycle drives the need for the detail required.

Table 1 Example minimum levels of information required for key road-based assets

Asset type	Information required for need identification	Information required for treatment development
Pavement	Annual network wide surveys of skid resistance and surface condition (e.g. laser based surveys of rutting, longitudinal profile, and texture).	Detailed visual inspection, construction detail (verified by coring), strength testing (e.g. deflectograph; falling weight deflectometer).
Bridge	Cyclic inspections to ascertain condition of all components, both visible and hidden, estimated and evidenced.	Detailed investigations, including and forensic analysis if required.
Earthworks	Network inspections over a five to six yearly cycle. Monitoring of all sites exhibiting signs of movement, and or local failure.	Full monitoring and investigation with analyses to determine optimum design solutions.
Culvert	Drainage records and details of localised flooding events, cyclic visual and cctv surveys.	Investigate blockages or collapsed drains. Analyse drainage catchment area with different theoretical and actual storm profiles to determine constraints on drainage capacity. Consider future developments, expansion of asset and consequence of climate change.

It is important to get the asset data requirements correct at outset because, as with any asset management framework, data is the key to success. All other building blocks described below make use of the data collected and stored; incorrect or incomplete data is likely to result in increased risk.

4.4 DETERMINISTIC AND PROBABILISTIC TOOLS

In the short term (0-5 years), maintenance and renewal will be determined on the basis of evidence, condition and asset performance. Assets that are currently at an imminent risk of failure (at or below intervention level) or assets that are unacceptable to the road user (at or below performance level) can be re-prioritised and re-programmed, to be placed in the appropriate year of treatment.

In the medium term (5-10 years), it will be necessary to predict the performance need of assets based on expected deterioration, or on expected changes in service requirement. For some asset types, current condition alone may be sufficient information to programme maintenance or renewal five years in advance and so a combination of deterministic and probabilistic modelling will be required.

In the long term (10-30 years), probabilistic modelling will be required for most assets. If average design and service lives are known from experience then average renewal costs can be estimated. Some assets will inevitably fail earlier and some later but the average cost of maintaining the whole network will remain relatively stable, albeit within the range of calculation error and tolerance. Schemes identified in the long-term will gradually filter, in time, into the medium or short term programmes as they are monitored, surveyed, investigated and inspected.

The identification of need, including an assessment of criticality, should be carried out along routes or corridors (Section 4.6), and should incorporate maintenance or renewal need across multiple asset types and, possibly multiple transport modes. The risks and consequences of failure at a given network location should be determined based on the sum of risks for all assets at that location.

There are several examples of methods for incorporating or amalgamating asset deterioration curves into assessment of risk and criticality. One such example is the X-ARA – Cross-Asset-Risk-Assessment project, which sought to develop a comprehensive risk assessment framework including a set of guidelines and a practical software tool for the network level assessment of asset risks and impacts. A tool like this could be incorporated to fulfil the requirements of this building block.

Alternatively, the requirement to have a process under this building block could be fulfilled by using simple deterioration models on an asset by asset basis. As long as asset data, and in particular, asset condition is well surveyed and well updated, it should be possible to determine which assets will be in need of maintenance or renewal in the medium or long term. The advantage of more sophisticated tools is that multiple factors and multiple assets can be considered at once so that an overall risk (as opposed to the risk of failure at an individual asset) can be managed.

Output from deterministic and probabilistic models will be used by asset managers to determine network need and will be integral to the processes described in the previous building block.

4.5 WHOLE LIFE COST CALCULATION

There should be a commitment to calculating whole life cost at tactical levels, and there could be a commitment to considering both direct costs and indirect costs at operational levels, when investment decisions are made. Direct costs are those costs associated with construction and ongoing asset maintenance activities such as labour, plant and materials, including traffic management. Direct costs are already commonly considered for investment decision. Indirect costs are those costs associated with society, such as user delay, accident costs, fuel consumption, and the environment such as carbon, noise or air quality. Indirect costs are less commonly considered and their inclusion may depend on local political or corporate priorities. Inclusion of environmental costs, at least, should certainly be encouraged.

The ISABELA project aims to identify clear and repeatable social key performance indicators with categories such as availability and disturbance, road safety, environment, and socio-economy. By monetising these indicators and incorporating them into asset management, they may be used in calculations for whole life cost.

Where possible, tools should be used that automatically calculate at costs over an appropriate defined period (e.g. in the UK, The Treasury uses 60 years for most assets) using existing condition data, agreed performance levels and models for asset deterioration. These tools should focus on direct costs, but should allow inclusion of indirect costs if information is available.

The calculation of whole life cost should be carried out so that:

- Treatment solutions can be selected based on knowledge of ongoing commitment
- Investment decisions can be made based on the perceived value for money of carrying out works over the long term.

In both cases, decisions should be guided by the calculation of costs and not necessarily driven by a need to minimise whole life cost. For example, a treatment solution should not be selected based solely on its having the lowest whole life cost, if doing so means that other essential works cannot be carried out within existing financial constraints. Similarly, value for money must be considered alongside whole life cost: a scheme with a high whole life cost that results in an improved service level may be a better investment than an equivalent scheme with a low whole life cost that only maintains the service level. Further, in addition to the consideration of service levels in the context of value for money, overall strategic goals should be borne in mind.

As in previous building blocks, calculation of whole life cost could be achieved simply, by listing and then summing the expected major maintenance and operational costs (direct costs) over the expected life time of an asset. In this case, the main risk to be managed is that associated with cost to the National Infrastructure Agency. That risk may be better handled by using more sophisticated modelling tools that consider myriad costs (direct and indirect) alongside predicted deterioration and funding scenarios.

4.6 ROUTE BASED RENEWAL AND MAINTENANCE

This building block is complementary to the governance and processes of portfolio, programme and project management described above. Renewal programmes should be developed based on the whole route and all the assets along each route, and how they fit together within a route or corridor. This is important so that a customer (road user and anyone else affected by the road) experiences the same level of service for an end to end journey. All major renewal works should be justified well in advance, and planned and constructed to provide a minimum whole life cost solution, with minimum disruption across all the assets for the route, or corridor. In addition to geographical division, routes may be divided into natural sections based on age, condition, criticality and future needs.

The diagram below shows activities that might be undertaken for different sections of a typical route. It illustrates the need to consider the impact of renewal at one section on the remainder of the route.

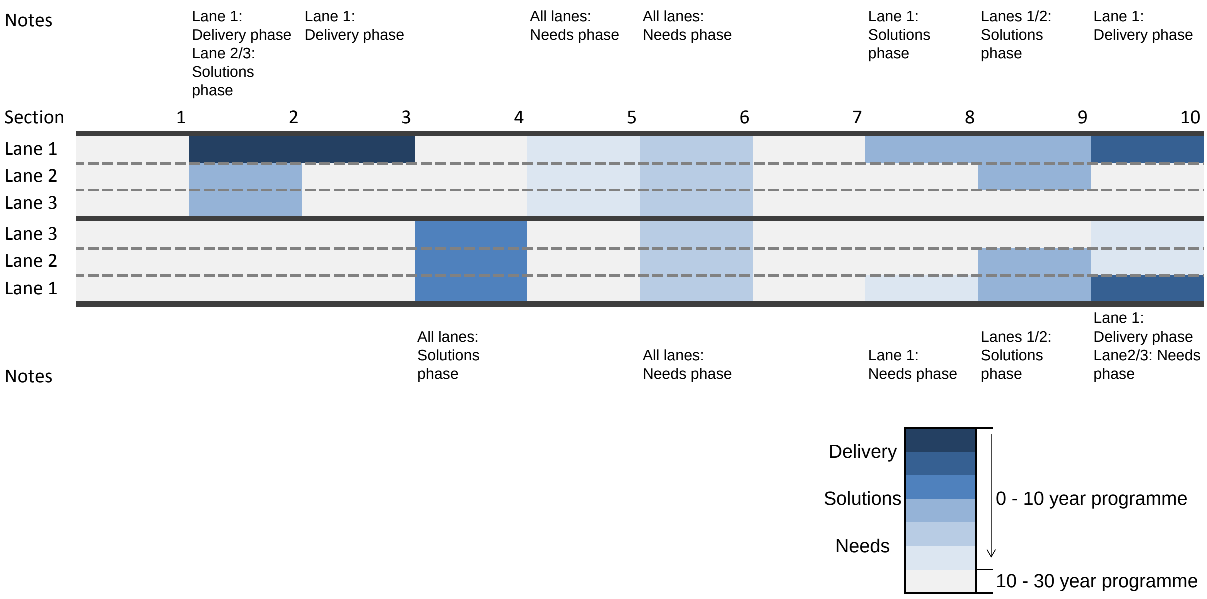

Figure 7 Generic 30 year route maintenance plan

This concept will be of particular importance where a route, or corridor, crosses other transportation routes or international borders. Furthermore, route based strategies should not necessarily be restricted to one form of transport; where a route incorporates a change of modality, NIAs should manage assets holistically.

5 Discussion and concluding remarks

The building blocks above highlight the essence of established best practice for managing risk within an asset management framework. Intentionally, little detail has been offered in this document for the processes and methods that might be employed under the heading of each building block. NIAs can either use or adapt their current practices or, in the case of NIAs with emerging asset management maturity, simple methods that work at outset can be developed to work in a local context. It is hoped that the simple outline approach will encourage a basic level of investment and consistency across the TEN-T network. This will also allow a degree of flexibility, and a range of maturity levels, with the aim of harmonising asset management across the different modes of transport in Europe.

Where processes have been detailed further, those details have been offered with road networks in mind. It is anticipated that the building blocks are applicable to all modes of transport, even if the methods and processes encompassed under the headings are dependent on the transport mode.

The next task in WP2 will be to provide case examples of good practice for applying whole life cost and risk based approaches on strategic, tactical and operational levels. It is intended that these case examples will demonstrate that risk is adequately managed if the building blocks described here are used in practice. It will also be possible to describe in more detail the processes that have been followed, under each building block, in order to achieve a successful outcome.

Finally, WP2 will provide a framework for adopting whole life cost models and risk based approaches across Europe. The building blocks described here form the basis of the approach. They will be refined using results from case examples and the outcomes from WP1 (in particular the living laboratories), WP3 (the specification for an asset information management system), and especially from WP4 (stakeholder feedback). It is expected that recommendations will be made for implementation of a common framework, or minimum specification, which can be used across Europe with a high degree of consistency.

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Appendix A – Questions to aid review

Dear AM4INFRA Colleagues,

Please provide Highways England with your input for Work Package 2.1, based on the requirements laid out in the Grant Agreement or, otherwise, by answering some of the questions below.

Sample questions for discussion by the AM4INFRA consortia:

1. Contract – Service Provider Model on the TEN-T network

1.1 Is the contract model you use the same as: Asset Owner, Asset Manager and Service Provider? Where does the Asset Steward role fit in?

1.2 If your model is different, which Operational contract model does your Agency use?

1.3 Discussion 1: Contractual policies #1

Are your Agency's contractual policies similar to any of the models used by Highways England?

1.4 Discussion 2: Contractual policies #2

Which would be your preferred Contractual model that would provide an optimal life cycle analysis for operational, strategic and tactical plans? (Or should we build a range of options that will allow each country to have different operating models?)

2. Lifecycle Asset Management Plan(s) (L-AMP)

2.1 How do your L-AMPs' budgets and renewal programmes differ for the following:

i. Operational (routine) maintenance?

ii. Short-term (renewal) 0 to 5 years?

iii. Medium term (renewal (or partial replacement)) 5 to 10?

iv. Strategic Long term (renewal or replacement) 10 to 30 years?

v. Improvements (major and minor projects)?

2.2 What tools do you use for carrying out whole life cost, and/or risk-based analyses?

2.3 Are your Lifecycle Asset Management Plans led by your Service Provider or by the Asset Manager?

2.4 Who finally decides on the operational, tactical (short and medium term), and strategic, and improvement needs, for your part of the TEN-T network?

2.5 Who prioritises the needs against budgets, and estimates the projected consequences on the road network if there is a short-fall in the projected available budget against needs? And what tools or models are used in carrying out these exercises in changing circumstances?

3. Lifecycle Analysis (LCA) Models and Staff Competency

3.1 Do you use models that make sense of all the data you hold, so that you are confident in bidding for the optimal LCA - M & R budgets (maintenance and renewal)?

3.2 Do you have models that you use for prioritising your cross-asset renewal programmes within constrained budgets?

3.3 Do some of your analyses and models encompass failure probability distributions that take account of the age, construction, and the present and projected condition of the asset components?

3.4 Discussion 3: Computer LCA models Linked with Staff Competency

For any complex models to be properly utilised, they either need to provide simple output information, or otherwise be interpreted and understood by capable staff.

Do you agree? Or will computers possibly be able to provide the optimised results to people of at all levels of asset management, risk management, and financial management? Who provides the checks that the results are correct?

We have choices to make with any proposed LCA models, with what data goes in, and what information comes out.

Complex LCA outputs require competent staff to apply the results.

Simple LCA outputs probably require even more knowledgeable experienced and competent staff.

3.5 Alternative Discussion 4: Use of data intelligence, and Competency of staff

LCA Models obviously need to be used by good staff. There are good models around, but they need to be informed by good data, and used by competent and experienced staff.

What levels of staff competency will our new models require from the participating countries? Should we possibly be recommending that there should be LCA information and financial manager posts, at different levels of management?

Highways England has been told that it needs better data and better modelling. Are you in the same position, or could you provide some advice?

3.6 LCA are already made at the short-term project level, but Highways England's L-AMP (local), R-AMP (regional) and S-AMP (Strategic) models will stretch to the strategic long-term in the future. How do you manage this range at present?

4. Data, Known and Unknown, Complete or incomplete, Lost or Missing

Professional Civil and Highway Engineers, who are Asset Managers, are problem solvers. And to solve problems they need data or other information that allows them to make important decisions. If they have little available data, they still have to make the best decisions they can. So, do you know what you know, and, are you aware of what you don't know?

4.1 Do you focus on the key data and information that speaks to you? What is the data that helps you to make the best, optimal, decisions?

4.2 We could always do with more data, but we still have to make full and informed use of what data we have. Do you manage and make full use of all the available intelligence available to you on your assets, both objective and subjective?

4.3 Where are your main data gaps, and how do you work around them, to provide the best 'guess' or estimates on the strategic budgetary needs?

4.4 What different data sets should feed into our models as a minimum, and as an ideal? How often should this data be reviewed and updated?

4.5 Do you support BIM, and if so, should our model be developed with BIM? This might exclude countries that do not follow BIM principles.

5. Risk, Certainties and Uncertainties

5.1 Risk is about uncertainties and probabilities. How effective is your Risk Management at the strategic level and scheme level?

5.2 What risk information do you refer to on some of your assets, and what information are you unsighted on? How do you model and prioritise your programmes between the two different extremes, and across different assets: through condition projection and probability analysis?

5.3 Is individual scheme prioritisation made through risk assessments and information and knowledge based on different levels of network criticality?

5.4 Do your maintenance policies contain a consequence based framework, together with risk assessment, which include the economic impact and benefits analysis?

5.5 Are the Highways England risk models satisfactory, or how might they be improved?

6. Budgets and Funded Programmes

6.1 Are you managing your assets over the short-term with constrained budgets, or the long-term with sustainable budgets?

6.2 When, or at what stage are your budget assessments made and approved at:

1. National level?
2. Regional level?
3. Route level?
4. Scheme level?

6.3 Do you have Decision Gateways or steps in developing, refining and updating and approving Forward Programmes?

6.3 What or who are your main drivers (or obstacles) in LCA funded Asset Management?

- Performance indicators
- Minimum whole life cost
- Knowledge of assets and up to date data
- Asset management systems
- Senior management
- Middle management
- Asset management teams
- Commercial demands
- Training
- Succession planning