TECHNICAL REPORT

Effective asset management meeting future challenges 2010-2013

CEDR

road ERA net

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https://sites.google.com/site/assetcall
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FOREWORD

Road Asset Management is a vital element in keeping the European society in motion. Proper and timely intervention strategies ensure mobility and development across borders.

In a time with many constraints, including the economic and environmental crisis, we must strive to save resources, both in terms of money and in terms of fossil fuels and materials. We face a double challenge: to provide cost-effective solutions to a complex and expensive infrastructure while at the same time servicing our primary clients, the road users, with safe and secure roads that are inter-modal, quiet, carbon neutral, flexible and forever open.

In a sense, the European Road Authorities are stewards of these values and responsible for living up to these expectations. The answer to the challenge is cooperation, and the Asset Management Programme has lived up to this by working together across Europe through the joint research collaborations ERA-NET ROAD and CEDR.

This is an important step forward for the European road research collaboration. And it is a success for the European Union, as well as for all the partners involved.

The next step forward is refining research results and getting them out on the roads to work for society. The AM programme has recognised this by initiating a series of case studies and by incorporating the social and technical benefits in a cross-asset exercise that hopefully will inspire the European NRAs to work closely together towards implementation.

The results of the case studies will be made available following the Asset Management symposium the 22nd – 23rd May 2013.

Bjarne Schmidt

Programme Executive Chairman

May 2013

The technical highlights of the Asset Management programme are presented in this report.

The social benefits of the programme are described in a social benefit report.

Both reports are available on the website:
https://sites.google.com/site/assetcall

Executive Summary

The term 'Asset Management' when applied to highways has, over the past 15 years or so, come to stand for recognised 'best practice' in the planning, management and operations concerned with the whole lifecycle of physical road infrastructure. By encompassing all different types of asset, and the whole life of each component from concept, through construction, maintenance, operation and disposal, this should be a truly 'holistic' approach. It should also provide a single 'line of sight' from strategic policy making through tactical planning to operational delivery. Yet across Europe, the understanding and implementation of Asset Management concepts, processes, models and best practice has been fragmented and there exists little in the way of common standards and best practice.

This was the backdrop for the Transnational Research Call in 2010, under ERANET Road II (ENR). At the inception of the programme, the following important statement was included in the press release;

> At present there is often a lack of customer focus and engineering standards solely drive the maintenance programme. The ERA-NET programme aims to support the change in culture of managing the road network such that there is a more balanced approach in using maintenance funds and a greater focus on customer needs.
>
> *ERANET Press Release October 18th 2010*

The seven projects awarded funding through the ERA-NET ROAD II call, 'Effective Asset Management meeting Future Challenges' (AM programme), addresses important aspects of managing the strategic road networks, through the following objectives:

- A to determine the requirements and expectations of stakeholders,
- B to improve understanding of asset performance
- C the development and use of Performance Indicators for managing the network
- D cross-asset optimisation

To address the necessary change in culture to achieve these objectives, it was recognised from the outset of the programme that communication and use of real-world case studies and examples would be vital. The work of the Technical Adviser (TA), the Communication Adviser (CA), and initiatives promoted by the Programme Executive Board including organising implementation case studies (the subject of a separate report) and a Final Symposium have all been focussed on achieving these goals.

In this report, the Technical Adviser addresses, from the perspective of key stakeholders (National Road Administrations (NRAs) – represented collectively by CEDR);

- The scope and effectiveness of the deliverables and outcomes of each project
- The extent to which the results are practical and ready for implementation
- Conclusions on the programme and recommendations to take forward

Overall, the Asset Management Programme has delivered a wide range of practical information, proof-of concept models, and best practice techniques that have been shown, in the majority of cases, to be capable of adoption and implementation by a Road Administration. The challenge of such implementation remains the institutional and political changes that are often necessary, and the cost of filling gaps in existing data and systems to support the new approaches.

The seven selected projects were:

Objective A: SABARIS + EXPECT

Timely intervention strategy for road maintenance + Involving stakeholders in the prioritising of road maintenance

Objective B: HEROAD

Hollistic view of road maintenance (provides a new view on effect)

Objective C: SBAKPI + EVITA

Finding best methods to assess the value of road maintenance + Thinking about the environment in road maintenance

Objective D: ASCAM + PROCROSS

Costs and benefits of road maintenance + Involving all aspects of the road in road maintenance

Contents

1 Technical Highlights of the Programme

While the four 'headline' objectives of the programme were straightforward, the technical breadth of the subjects to be covered was extensive. This ambitious programme was always going to need clarity of vision, reference back at all stages to 'real world' practice in stakeholder organisations, and a clear focus on implementation.

It was recognised that there was some synergy between projects, particularly those in the same objective grouping but overlap was to be avoided. At an early stage in the TA's work, an analysis of the scope and synergies of the seven projects was undertaken. This is illustrated in Figure [1].

When practitioners are considering which projects might address subjects in which they are interested, reference can be made to this table, and then more detail found in section 2 below.

Another way of viewing the technical scope of the seven projects is to consider their scope mapped onto the broader picture of the phases in an asset management system. This is depicted in Figure [2] below, from which it is seen that some projects focussed more on process and practice, and others on measurement and performance. Some focussed on inputs (stakeholder requirements) and others on outcomes (performance). Viewed in this way, we observe other links and inter-dependencies between the projects.

OBJECTIVE GROUPING/ PROJECT		TOPIC: Stakeholders	Benefits/Costs	Optimisation	Case Studies	Current Practice	Standards	Data/ Monitoring	Pavement Perf.	Structures Perf.	Road Furniture Perf.	Environment	Condition Data	P.I.'s	Tools/Models	Risk
Stakeholder Expectations	SABARIS	✓	✓	✓	✓										✓	
	EXPECT	✓				✓	✓									
Understanding Asset Performance	HEROAD							✓	✓	✓	✓	✓	✓			
Key Performance Indicators	SBAKPI	✓				✓		✓						✓	✓	
	EVITA	✓				✓						✓		✓		
Cross Asset Management	ASCAM	✓	✓	✓			✓	✓	✓	✓	✓		✓		✓	✓
	PROCROSS	✓		✓		✓										

Figure [1]

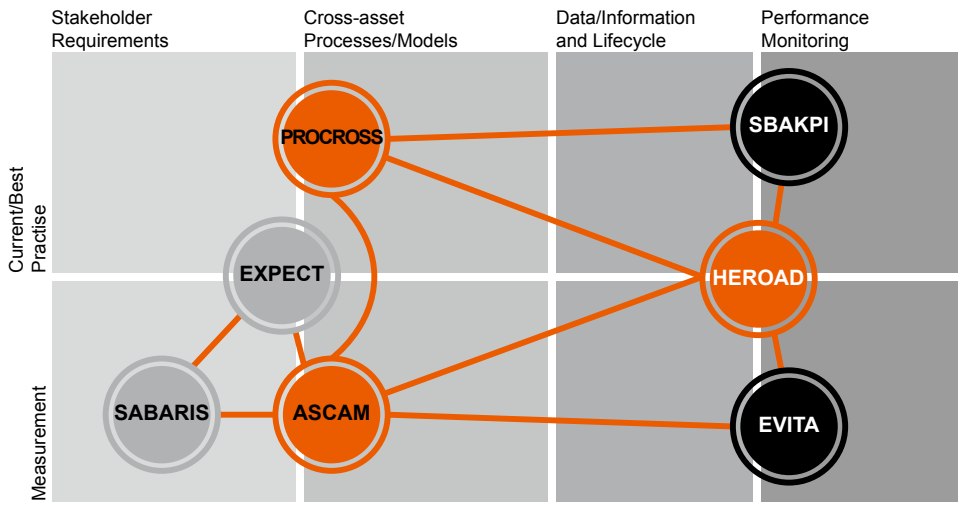

Figure [2]

One of the key messages that needs to be communicated to practitioners, is that an 'asset management system' is much more than just a suite of computer models and processes. Modelling and new tools are important, but integration into local systems is always the challenge. The ENR asset management programme has highlighted some of these opportunities, and demonstrated proof-of concept models, but work must be done (by NRAs) to embrace these models and incorporate them into their own 'systems'. This is why, in section 4 of this report, there are more recommendations related to NRA implementation of the results than to further research work.

A recurring and important theme emerging from the projects is the need to view the asset management process from both 'Top Down' (driven by policy and strategy) and 'Bottom Up' (the need for good quality, consistent data and processes to underpin decision making).

Another common theme is communication with stakeholders; by this, we are referring to stakeholders in the community who use or interact with the road asset infrastructure in some way. The research gives some excellent advice on how an NRA might go about engaging with its stakeholders, whether directly or indirectly affected, and also those which have a responsibility which impact upon the infrastructure. A clear understanding of this is essential for every road administration and its service delivery partners if it is going to reap the benefits of better asset management.

Finally, the theme of Key Performance Indicators is a practical highlight of the ENR asset management programme; not because this is the first time that this subject has been addressed (there are many previous projects and reports referenced in the project reports, such as SBAKPI and EVITA), but because a lot of effort has gone into testing and evaluating proposed indicators for their practical 'implementability'. It is hoped that these results may not only be of benefit to individual road administrations, but also more widely across Europe, through adoption by CEDR or the European Commission.

SABARIS - Stakeholder Benefits and Road Intervention Strategies
EXPECT - Stakeholder Expectations and Perceptions of the future Road Transport System
HEROAD - Holistic Evaluation of Road Assessment
SBAKPI - Strategic Benchmarking and Key Performance Indicators
EVITA - Environmental Indicators for the Total Road Infrastructure Asset
ASCAM - Asset Service Condition Assessment Methodology
PROCROSS - Development of procedures for cross-asset management optimisation

The projects are further explained in chapter 2

2 Project Commentaries

In this section of the Technical Report, each project is examined and comments made on the outcomes and deliverables. The comments start in each case with a summary table comparing the outcomes with the original objectives of the project, and is followed by a descriptive 'commentary'. Comments include the relevance and ease of implementation of the project results, and any shortcomings or further development required. Finally, these comments will be updated once the results of the case studies and trials are complete.

Technical liaison did take place, to a greater or lesser extent, between projects in the same objective groups, and also through individuals/organisations working on more than one project. Where this made a notable contribution to the outcome, a comment has been made in the relevant section.

2.1 Stakeholder Expectations; SABARIS

Stakeholder Benefits and Road Intervention Strategies

Project Coordinator;
University of Twente (Netherlands)

Project Partners;
ETHZ (Switzerland)
IFFSTAR (France)
Catholic University of Leuven (Belgium)
AT Osborne B.V. (Netherlands)

Commentary - SABARIS

The SABARIS project covered the whole issue of definition of stakeholders and the measurement of their 'satisfaction' with road maintenance in great detail. The approach was very much project-focussed, and so the models they used when putting these concepts into practice with their two case studies, were deterministic and quite detailed.

SABARIS focussed on how directly-affected stakeholders in a scheme can be engaged before, during and after the scheme takes place.
Two case studies were chosen reflecting different scenarios;

- The A20 urban ring road in Rotterdam, Netherlands
- The E17 inter-urban motorway between Ghent and Kortrijk in Belgium

These examples, cannot be said to represent the full range of permutations experienced in practice. It is the principles that were established in the project which are important, and which can potentially be applied by Road Administrations in a wide range of situations.

The demonstration optimisation tool used EXCEL to provide an accessible interface, and was used initially to show the relative impact of different maintenance scenarios on stakeholders.

PROJECT SABARIS	Objective	Outcome
	Classification of stakeholders in terms of road types and road benefits	An in-depth review of stakeholder definitions and classifications was undertaken
	Ranking of benefits for different categories of road types according to stakeholder valuation	The theories of Importance- Satisfaction (though not new) were described in detail by SABARIS and related to the highways context
	Stakeholder engagement strategies for different categories of road types	This was covered but not in great detail (see EXPECT project)
	A prototype optimisation tool for the evaluation of intervention strategies that simultaneously takes into consideration the different valuations of road benefits from multiple stakeholders	A software tool for performing a deterministic optimisation model was developed. This comprised inventory, modelling and graphical output components
	Guidelines for use and implementation of such an optimization tool, in general and for different road types, and for different road agencies	Chapter 2 in the End Report presents a step-by-step guide with a supporting diagram
	Case studies illustrating and comparing the implementation, usage and outcome of the optimisation tool	Two project-based case studies were undertaken, one a one-month Urban Arterial main road in the Netherlands and the other a substantial 6-month E-motorway project in Belgium

2.2 Stakeholder Expectations; EXPECT

Stakeholder Expectations and Perceptions of the future Road Transport System

Project Coordinator;
TRL (UK)

Project Partners;
TNO (Netherlands)
AIT (Austria)
VTI (Sweden)
BRRC (Belgium)

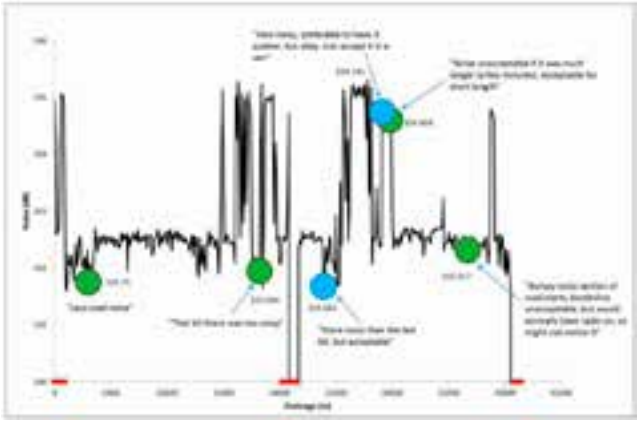

Figure [3] – Accompanied Journey Noise assessment (example) (source; EXPECT D4 Fig 5)

Commentary - EXPECT

The EXPECT project has delivered results complying with all of its original objectives. In particular, it has developed an innovative methodology ('accompanied journeys') for assessing stakeholder perceptions and requirements in association with focus groups, which has been tested in a real environment.

Stakeholders were representative of different categories of road user; car drivers, cyclists, motorcyclists, HGV drivers, bus drivers, disabled people and pedestrians. The weightings in the multi-criteria model developed to score each criterion for each type of stakeholder is illustrated on page 10;

PROJECT EXPECT	Objective	Outcome
	To develop methodologies to help National Road Administrations to determine the requirements of different categories of stakeholders and develop effective strategies that address stakeholder expectations	'Accompanied Journeys' methodology successfully developed, trialled and documented. When used in conjunction with Focus Groups (also trialled in the project) the method worked well
	Establishment of who the "stakeholders" are and their interactions with the different road assets	This was covered by EXPECT in report D4
	An understanding of stakeholder's perceptions and requirements of the different road assets and the overall network	The trial focus groups tested the methodology in this context and comprehensive recommendations are made in D2.4.1 (Addendum). Multi-Criteria Analysis (MCA) was employed to evaluate the data, and a spreadsheet tool has been developed for the specific purpose
	Establishment of stakeholder priorities and levels of tolerance (e.g. for unacceptable condition)	This has been demonstrated to be successful using the methodologies above, and 'tolerance' has been extended to relative importance/weighting (see EXPECT reports D4 and D2.4.1)
	Translation of the factors into measurable parameters (e.g. engineering standards) for the identification of maintenance needs	In order for stakeholders to be productively engaged in the whole process, it was necessary to carry out this 'translation' using example parameters used for the trials
	Development of methodologies to integrate these factors within the overall asset management process to enable a customer focussed efficient road network	This objective was quite loosely defined, but can said generally to have been met by the project within the methodologies described above

CRITERIA			Importance by stakeholder (low/medium/high: 1/2/3)						
			Road Users						
			Car drivers	Cyclists	Motorcyclists	HGV drivers	Bus drivers	Disabled people	Pedestrians
Category	**Criteria**	**SCORE**	17	15	13	19	13	13	2
Ride comfort	**Smooth ride**	2.2	3	3	3	2	3	1	1
	Low angle of inclination	1.7	1	3	1	2	1	3	3
	Large arch in curves	2.0	3	1	2	3	3	1	1
	Water free road	1.5	3	1	3	1	1	1	3
Road safety	**Low number of accidents**	2.2	2	3	3	2	2	3	3
	Low severity of accidents	2.1	2	3	3	2	1	3	3
Level of service	**Reliable travel time**	2.1	3	1	3	3	3	1	1
	High speed	2.0	3	1	3	3	2	1	1
Environment	**Green surroundings**	2.2	2	3	3	1	3	3	3
	Low noise level	1.5	1	3	1	1	1	3	3
	Low visual disturbance of construction	1.8	2	3	2	1	1	3	3

Figure [4] – Multi-criteria scoring by stakeholder groups (source; EXPECT D3)

Lessons learned have either already been incorporated, or have been well documented for the benefit of any organisation such an NRA, which may wish to adopt and utilise the methodology.

The project also developed some tools to work alongside the methodology. These took the form of the multi-criteria analysis model, and a mobile device app (for data gathering on the journeys). The latter has not been fully developed or documented as part of the project, having been offered to the project at one of its trial sites in Sweden. The tool can be made more widely available, but requires some further development.

SABARIS focussed the tools that might be employed to measure network-wide levels of service and outcomes from a road user perspective.

2.3 Understanding Asset Performance; HEROAD

Holistic Evaluation of Road Assessment

Project Coordinator;
VTI (Sweden)

Project Partners;
ZAG (Slovenia)
AIT (Austria)
TRL (UK)
FEHRL (European Association)
BRRC (Belgium)

Commentary – HEROAD

HEROAD was a project which took the broadest overview, and arguably looked at some of the most demanding aims and objectives of the Programme. Although the definition of an 'holistic approach' can vary widely, it generally is taken as evaluating a combination of different asset types, across the whole life cycle of each asset, and using common measures of 'benefit' to monitor performance of the whole road asset. To meet its objectives, HEROAD carried out extensive desk study and research of common and 'best' practice, and identified new challenges and technologies that might be brought to bear when considering an holistic approach. The project had a strong emphasis on data collection, and reported on issues concerning data quality - a key factor in successful implementation of asset management and one which is often overlooked. HEROAD also cross-referenced work that was undertaken in other ERANET projects in the Asset Management Programme, in particular those addressing stakeholder requirements and also cross-asset management tools. The HEROAD reports D5 and D6 represent comprehensive summaries of current practice as well as aspirations for administrations moving towards a new holistic approach; these reports are a good starting point for anyone new to this subject.

PROJECT HEROAD	Objective	Outcome
	To review current practice (and identify Best Practice) in data collection, condition assessment and reporting regimes, organised by asset component; Pavement, Structures, Road Furniture and Environment	Reports on current practice were produced as follows; D1.1 Pavement assessment performance D 2.1 Structures assessment performance D 3.1 Equipment assessment performance
	To organise findings as an 'holistic' assessment process; technical parameters ► condition ► valuation ► prognoses ► estimation of level of functionality ► asset valuation	Section 10 in D5 makes reference
	Use real world case studies to identify where 'best practice' has brought significant benefits to an authority	Selected case studies were presented in deliverables D1.1, D2.1 and D3.1
	Terminology; provide comprehensive glossary of terms and a discussion about its use across the complete range of road asset management activities	See Appendix B in D6 Final Summary Report
	Describe how 'common evaluation tools' could be developed through the identification and development of comparable assessment parameters	A summary discussion is presented in section 10 in report D5 and is also referenced in report D6
	Recommendations on QA procedures to control data quality	Reports D1.2 and D6 refer to this question in relation to pavement assets
	Summary of 'new challenges' (e.g.; low volume roads, inclusion of road furniture management, climate change, traffic configuration, new materials, LCC and the focus on road users expectations)	Section 8 in D5 and report D6 both refer to these aspects
	Recommendations on how to make good use of new technologies within an individual management system, or in backlog assessments and ultimately in cross-asset management systems	This is addressed in report D5
	Guidance to authorities on the benefits of adopting/ implementing the 'best practice' techniques/processes	This is addressed in report D5

2.4 Key Performance Indicators; SBAKPI

Strategic Benchmarking and Key Performance Indicators

Project Coordinator;
TRL (UK)

Project Partners;
DTU (Denmark)

Commentary - SBAKPI

The technical ideas for strategic KPI's presented by SBAKPI are well researched and have been subject to a degree of testing/benchmarking. Feedback from the NRA's on the final ten KPI's, 5 of which were 'universal' and five 'regional (focussed)' has been summarised in the table below. This indicates, broadly, whether the proposed KPI is ready to be adopted (from both the point of view of business relevance and data availability).

PROJECT SBAKPI	Objective	Outcome
	Wide European based consultation programme engaging with NRAs, and other key Stakeholders	20 European countries/regions were invited for consultation/trials but only 4 responded, including one from outside the EU. While some interesting information was received, the project acknowledged this shortcoming in 'lessons learned'. A useful resumé of European legislation and its impact as a 'driver' to measure KPI's was presented as part of the desk study
	Development of a Benchmarking Framework (and tool) for developing, reviewing and reporting on Environmental and Social KPIs	A 'Framework' of possible PI's was drawn up for the consultation. A formatted example sheet (rather than a spreadsheet tool) was developed to reflect significant variations in knowledge and data available in the NRAs
	Identification of existing good KPI practice throughout Europe/Rest of World	Good practice from a limited range of European countries was represented. The rest of the world was not well represented, although partners were aware of experience in the USA and New Zealand in particular
	Development of an initial set of KPIs identifying ; ● Existing useable KPI ● Core (Universal KPIs) which can be applied to all the Strategic Road Networks ● Regionally significant (KPIs) which may reflect geographic, constructional, management or developmental differences in the European regions	KPI's in eleven different topic areas were identified, consulted upon and recommendations made
	Trial use of the Benchmark Framework and KPIs over a 6 month period	The project suffered from a very poor response to the trial; of 28 organisations invited, 18 initially expressed interest but only 6 actually took part; Belgium (Flanders), Denmark, France, Ireland, Scotland and Sweden. There was no representation from southern Europe, nor from more recent accession countries
	Feedback and dissemination of results to NRA and Key Stakeholders	Final deliverables have been made available and a paper is being presented at the final symposium. There was no software tool delivered as part of the project
	Further refining of the Framework and KPIs and publication of a final report and the tool	

KPI	KPI Description	From trial - able to be adopted?	Recommendations
Noise	Noise complaints reported to the NRA. Number of dwellings exposed to excessive noise/NRA road networked mapped.	**Not at this stage**	Concentrate on the noise exposure KPI element. A forum should be identified to explore this opportunity linked to EU law when it arises.
Air Quality	Level 1 Number of AQZAs/km of NRA road network. Level 2 Length of road network within AQZA/km of NRA road network.	**Not at this stage**	Discussion needs to be held at appropriate forum to determine level of NRA interaction with EU law.
Water Quality	Level 1. Proportion of NRA road with managed drainage. Level 2. Number of Managed Drainage Outfalls. Level 3. Outfalls with water quality treatment.	**Yes, with some development**	Implement as a first step the level 1 indicator.
Waste/ Natural Resources	Level 1: Tons of waste sent to landfill / km (maintenance). Level2: Tons of waste sent to landfill / km (new road). Level 3: Tons of waste sent to landfill / km (total).	**Not at this stage**	The KPI should be expanded to include consumption of natural materials as well as waste data availability to be established.
Climate Change	Carbon dioxide (CO_2) emitted by NRA and contractors per year/ km NRA road network.	**Yes, with some development**	Define the boundaries for construction related calculations. Joint NRA work on this desirable.
Biodiversity	Number of wildlife crossings on the network / 1000km NRA road network.	**Yes, with some development**	Implement the indicator with an alternative normalisation factor and consider developing a more informative KPI if this can be agreed.
Stakeholder satisfaction	Number of complaints to NRA / km NRA road network. Number of responses from NRA / km NRA road network.	**Not at this stage**	Determine whether a common satisfaction survey format report could be implemented across NRAs and the score reported as a benchmark.
Safety	Annual reduction in number of people killed or seriously injured (KSI) in road traffic accidents, as a 3-year rolling average.	**Yes, with some development**	Draw on work outside this project which is identifying a common metric for safety.
Development	Population / km new road constructed Population / km new lanes constructed Population/ km ITS/ICT constructed	**Yes, with some development**	Identify an appropriate forum to agree on what constitutes development.
Travel	The length of road affected by schemes to reduce congestion and improve journey time reliability per 1000km of the NRA road network per year.	**Not at this stage**	A discussion is required between NRAs to identify a more specific KPI for journey time reliability.

Figure [5] – Summary of recommended KPI's and feedback from NRA Trials

The overriding issue arising from this project, and which is clearly described in the project Final Report section 7 'Lessons Learned', concerns involvement and active 'buy-in' from the key stakeholders, namely NRAs. It was apparent that questions requiring cross-department, or supply-chain involvement were particularly difficult for an NRA to respond to.

The benchmarking tool was simplified into a form. This simple form allows NRAs the choice of providing basic data or caters for the provision of greater detail and calculations if this is feasible, and thus provides flexibility for the user.

The findings provide a useful starting point for considering national or pan-European environmental and social KPIs at the strategic level. In common with EVITA, the SBAKPI KPIs would form a useful input to any future consideration by CEDR of performance monitoring across Europe on the TEN-T network.

2.5 Key Performance Indicators; EVITA

Environmental Indicators for the Total Road Infrastructure Asset

Project Coordinator;
IFFSTAR, formerly LCPC (France)

Project Partners;
ZAG (Slovenia)
PMS-Consult (Austria)
University of Belgrade (Serbia)
TRL (UK)
Portuguese Laboratory of Civil Engineering (Portugal)
DCC Consulting & Engineering Ltd. (Slovenia)

Commentary - EVITA

In its first phase, the EVITA project reviewed 'performance' from a Stakeholder perspective, which in common with the parallel project SBAKPI, answered the following questions;

- Which stakeholders are strongly expressing this type of expectation?
- How do they express them?
- Which kind of answer are they expecting?

It is worth remarking at this point that the distinction between EVITA and SBAKPI, is that EVITA was tasked with investigating detailed, technical KPI's and was restricted to environmental factors, while SBAKPI was tasked with developing strategic, network-level PIs across a wider range of factors (see section 3.7 below).

Stakeholders were classified into four groups, as illustrated below;

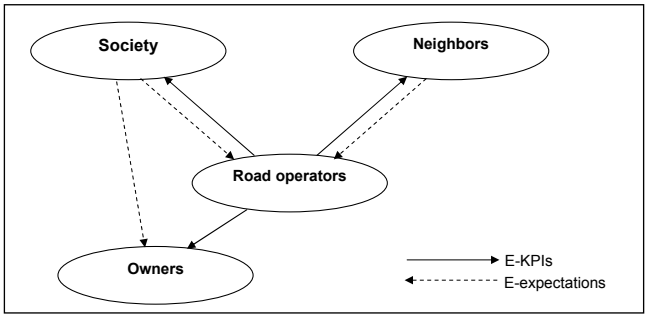

Figure [6] – Relationship between stakeholders: E-expectations and E-KPIs (source; EVITA D2.1 Fig 6)

The EVITA stakeholder analysis resulted in some interesting observations on relative priorities, as illustrated below.

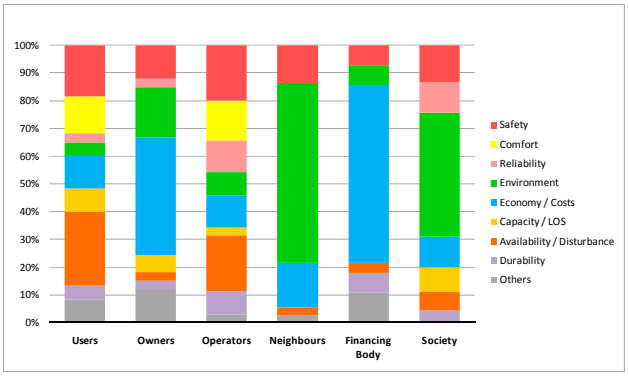

Figure [7] – Stakeholders Expectations Distribution (source; EVITA D2.1 Fig 3)

PROJECT SBAKPI	Objective	Outcome
	Key Objective/Research Hypothesis; To develop and integrate new and existing key performance indicators in the asset management process	The project developed and tested 9 e-KPI's, in 4 key domains. Trials were undertaken using real data, and NRAs consulted to check data availability and practicality of each e-KPI
	To take into account the expectations of all stakeholders	A wide review was undertaken (see report D 2.1)
	Applicable to managing all road infrastructure components	In principle this was covered by EVITA, but in practice environmental factors impact on the whole road infrastructure rather than selected components. EVITA did address the application of the e-KPIs to lifecycle phases; Construction/ Maintenance/ Operation (see report D4.1)
	Easily understandable Environmental technical KPIs	Consultation was held with specific organisations and also at workshops to test the understandability and ease of application of each proposed e-KPI
	Identifying existing best practice in the implementation of KPIs	An extensive assessment and evaluation of current practice was undertaken (see report D 2.2)

The project then went on to consider a wide range of Performance Indicators developed or proposed in other projects and contexts, from which a short-list of preferred KPI's emerged as well as 'gaps' which presented opportunities for developed of new e-KPI's as part of the project.

The project selected four domains for the development of its new e-KPIs;

- noise
- air pollution (including emissions of CO_2 from vehicles)
- water pollution
- natural resources (including lifecycle CO_2 emissions arising from construction and
- maintenance activities)

While all environmental considerations and impacts may be said to be location-specific, it can be seen that this is more true for some of the selected topic areas than others. Noise is very locations specific, and very much focussed on the viewpoint of people exposed from a particular viewpoint or location in relation to a road.

Both noise and air pollution are directly related to traffic, while water pollution is a more risk-based indicator. The impact of construction and maintenance activities on natural resources is more a global indicator than location-specific.

An NRA considering the adoption of one or more of these proposed indicators, needs to bear in mind their nature being either location-specific or global. This is important, since publication of a global-type indicator will generally impact upon a whole organisation, its supply chain and its operating units. Publishing location-specific indicators will generally have an impact on very specific mitigating actions at that location only.

A good feature of the EVITA approach is that a common 'scale' to describe performance has been adopted for each different e-KPI, and this makes results easier to compare and make sense of. This dimensionless index is on a scale from 0 (very good) to 5 (very poor) as illustrated below.

The EVITA project has provided an excellent 'Practical Guide for the use of E-KPIs in pavement management practice. 'Application Sheets' have been prepared for each of the 9 e-KPI's (including additional sheets where options exist for calculating the indicator) and these should be easy for and NRA to pick up and use if it is interested in applying an indicator. The application sheets provide a definition of the indicator, its application, input data requirements, calculation method, outputs and use. They also describe options for a particular indicator, that may be adopted depending on the level of data available within a particular NRA. When viewed alongside worked examples, which are also provided, these represent a very practical way for an NRA to make use of the proposed e-KPIs.

Figure [8] – Performance Index Scale
(source; EVITA D4.1 Table 3)

2.6 Cross Asset Management; ASCAM

Asset Service Condition Assessment Methodology

Project Coordinator;
TNO (Netherlands)

Project Partners;
ZAG (Slovenia)
AIT (Austria)
VTI (Sweden)
IGH (Croatia)
BRRC (Belgium)

Commentary - ASCAM

ASCAM focuses on End User Service Levels (EUSLs), but necessarily, the project had to select examples only. Those chosen, (safety, traffic delay/network availability, risk, cost and noise) would seem to be reasonably representative of typical types of EUSL, but are only examples. Environmental factors, demonstrated as important on other ERANET projects, were not considered in ASCAM, although the potential to add these was discussed. Further testing would be needed to substantiate the statement that these additional factors could be successfully added to the model.

Evaluation of risk is included, and as this is an important factor in all aspects of asset management, it is good to see ASCAM addressing this. In the ASCAM context, risk is defined as 'the possibility that a certain unplanned measure has to be taken, causing extra hindrance and unreliable traffic time'. One could add, that risk goes beyond that to any negative impact on EUSL's. The use of Monte Carlo simulation to model unpredictable risks is justifiable, however it must be recognised that this is only one way to model risk/variability. Other projects in the AM programme have not taken risk on board to the same extent as ASCAM, and the whole subject of risk is one which needs to be revisited in future research programmes.

PROJECT ASCAM	**Objective**	**Outcome**
	Key Objective/Research Hypothesis; Can we show that a framework, to connect existing asset management practices into a holistic, integrated cross asset and pro-active approach, is feasible and of (practical) added value for NRA's?	The feasibility of such a 'framework' (which may also be called a 'model') has been demonstrated using selected example End User Service Levels (EUSLs). The demonstration worked best with sub-networks, although it is stated that in principle it could also be applied to an entire network/ aggregation of sub-networks
	Connect (technical) measures to end-user service levels	The EUSL's selected were; ● Safety ● Traffic delay/network ● availability ● Risk ● Cost ● Noise
	Add value by connecting inspection and monitoring information to the necessary measures	The importance of condition monitoring and inspection is stressed in the reports, and is also linked to the issue of risk and uncertainty
	Compare maintenance strategies (measures and costs) in terms of end-user service level	Three scenarios (strategies) were run using the Demonstrator, and results compared
	Add relevant topics like "grand societal challenges" (mobility, climate change) to the end-user service levels	Risk was modelled with some degree of success, however climate change and similar macro effects on society were not able to be tested
	The demonstrator to show the added value and prove the feasibility of the concept	Demonstrator software built and functioning as proof-of-concept. Populated mainly by conjectural data; Follow-on case study to run using 'real' NRA data. Conclusion; works best with sub-networks

Three types of asset class were considered in the ASCAM model; Pavements, Structures and Road Equipment. These, being the most extensive types of asset within the highway, are a good starting point, but it must be recognised that a truly comprehensive (holistic) model would need to take into account other asset types.

The most tangible output from the ASCAM project is the demonstrator software. Although based on simple spreadsheet technology, the model is relatively complex and capable of user-configuration in the hands of an expert.

ASCAM helpfully describes the process (within and NRA) of developing an EUSL-driven asset management system, and the main steps necessary. It sets the model and demonstrator in this context, making it clear that further steps would be necessary in an NRA to fully implement such an approach.

Figure [9] – Demonstrator summary output showing 3 scenarios (source; ASCAM R1 Fig 3.7)

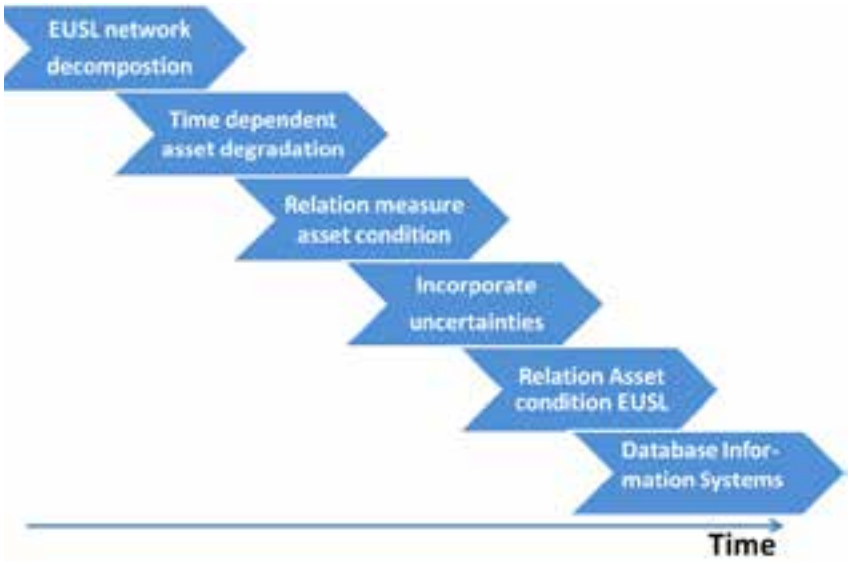

Figure [10] – Probable prioritisation of development of the main components of the ASCAM Framework (source; ASCAM D7 Fig 2)

2.7 Cross Asset Management; PROCROSS

Development of procedures for cross-asset management optimisation

Project Coordinator;
AIT (Austria)

Project Partners;
SEP (Germany)
ZAG (Slovenia)
Trinity College Dublin (Ireland)

Commentary – PROCROSS

PROCROSS addressed the key challenge of how to optimise all maintenance activities across different sub-assets, to deliver the expectations and requirements of all stakeholders. The way the project went about this was by taking a logical sequence of;

Review current practice → Assess requirements → Model strategic solutions → Propose practical implementation potential

PROCROSS organised an independent Technical Advisory Board (TAB) which it involved in consultations and technical assurance activities at three key point during the project. This was a very useful and successful approach to employ, and would be a useful model for other future projects, especially as it kept the stakeholders (in particular NRAs) close to the heart of the project.

PROCROSS has presented a considerable amount of material in the form of process flow diagrams, describing aspects of the cross-asset management process within a typical NRA organisation. For example, showing the top-to-bottom concept;

PROJECT PROCROSS	Objective	Outcome
	An holistic approach for the cross asset optimisation of maintenance activities on the total road infrastructure	A proof-of-concept model for cross asset optimisation was developed and presented using 'typical' (though not 'actual') data
	A survey of the State-of-the-Art to find out good practice in cross asset management optimisation	Survey and comparisons were made between 5 different organisations in 4 different countries
	Benchmark of cross asset management optimisation procedures	Analysis reflected top-down and bottom-up approaches
	Improve efficiency of asset management of the total road infrastructure	This is a high-level objective and very difficult to measure success against
	Assess maintenance activities from different stakeholders' expectations and requirements	The same 6 stakeholder categories/ groupings as used in EVITA were adopted in PROCROSS, and these in turn originated from PIARC
	Support of the decision makers to underline the necessity of maintenance activities from a holistic point of view	This was reflected in the Top-Down approaches described
	Provide a basis for the implementation of cross asset management optimisation procedures in the form of the Final report "The Procedures for Cross Asset Management Optimisation"	Final Report (D4) addresses this

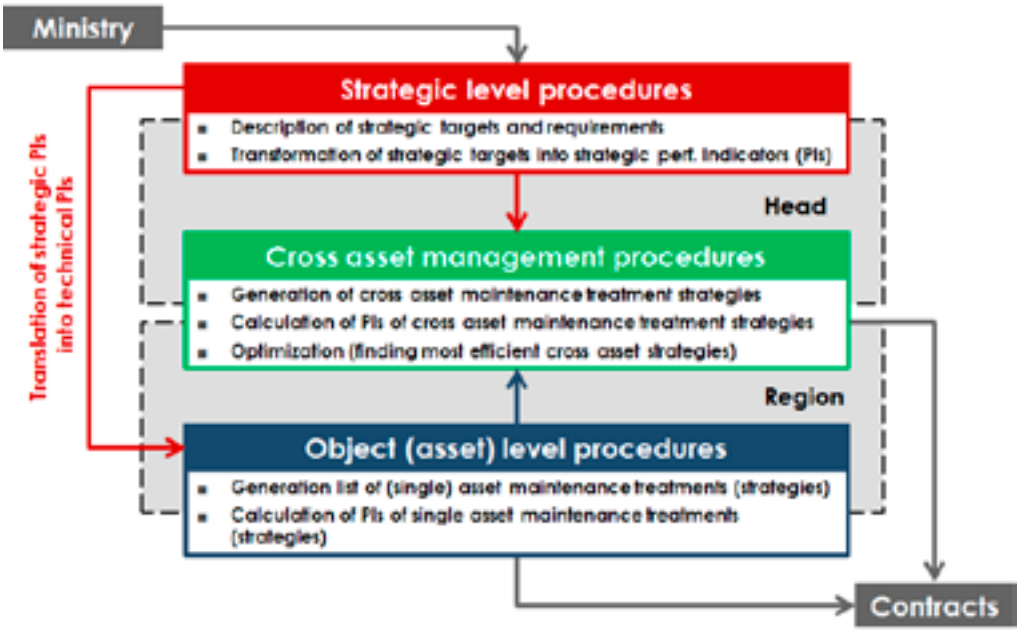

Figure [11] – Cross-asset management procedures within the asset management approach (source; PROCROSS D4 Figure 28)

At a more detailed technical level, the proof-of-concept model developed by the project team made use of some existing software tools and brought together data related to example sub-assets such as pavements, bridges, tunnels and noise barriers. A cost-benefit model was applied as the optimisation tool, in an iterative process, under a range of budget constraints. While simple in its construction and content, this model did provide a useful illustration of an approach to cross-asset optimisation, as illustrated in a typical output below;

In terms of the readiness of the PROCROSS model for potential implementation by an NRA, it must be appreciated that it is only a proof-of-concept model. It would be up to an individual NRA to evaluate how the model could be incorporated into its own Asset Management Systems, not least considering the data and local parameters that would be needed to make it work in a given technical, institutional and political environment.

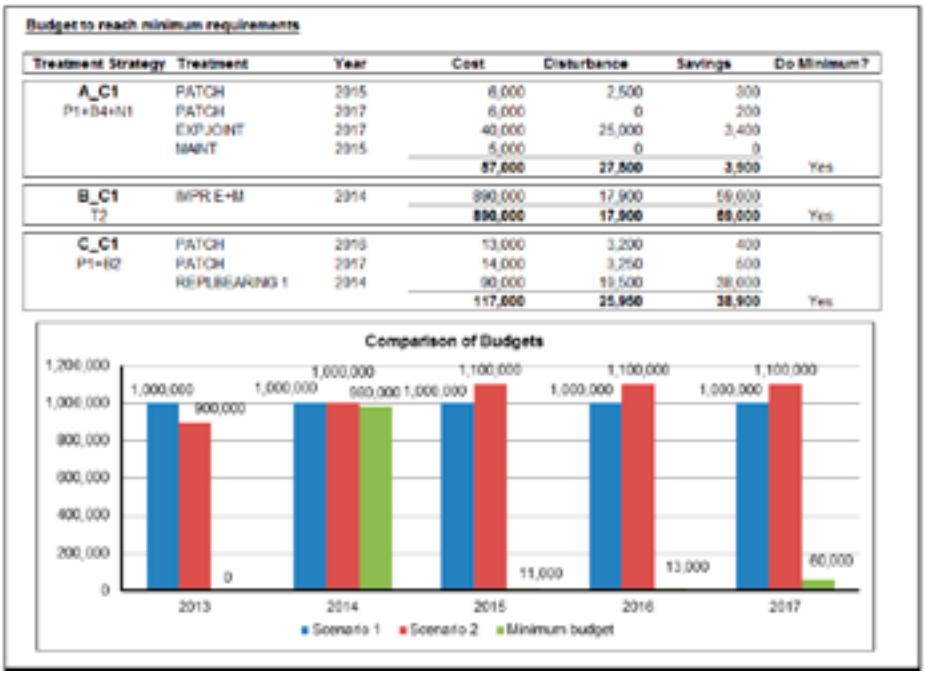

Figure [12] – Example solution which fulfils the minimum requirements (source; PROCROSS D4 Figure 20)

3 Benefits of the Programme to NRA stakeholders

The benefits to the key stakeholders in the NRAs were reported back to the Programme Executive Board, having been considered in relation to the original programme groupings of the projects under the four Objectives (themes), as follows;

- Stakeholder Expectations
- Understanding Asset Performance
- Key Performance Indicators
- Cross Asset Management

Some cross-project exchanges took place through individuals being involved in more than one project, for example between ASCAM and PROCROSS. ASCAM also commented upon its relationship with SABARIS and EXPECT.

Engagement with the key stakeholders, namely the NRA's, was taken very seriously by the projects. PROCROSS went to the lengths of establishing its own Technical Advisory Board (TAB) which provided active input at workshops, and was consulted when technically reviewing deliverables. Other projects obtained knowledge, data and comments from NRA's which had connections with research partners (see Figure 13).

The PEB introduced technical sessions and also an early SWOT analysis in parallel with its regular meetings, which encouraged a sharing of progress between projects. This sharing and discussion was particularly useful when accompanied by facilitated group work sessions.
Typically, stakeholders in an NRA are likely to have different potential to gain benefit from each of the objective themes in the ENR programme as illustrated in the matrix in Figure 14;

	NRA stakeholder grouping			
	Senior Management	Planning	Design & Construction	Operations & Maintenance
Stakeholder Expectations	High	High	Medium	High
Understanding Asset Performance	Medium	High	Low	High
Key Performance Indicators	High	Low	Medium	High
Cross Asset Management	Medium	High	Low	High

Figure [14]

Project	Links with/inputs by National Road Administrations
ASCAM	**Through partners** (Austria, Belgium, Croatia, Netherlands, Slovenia, Sweden)
EVITA	Workshops attended by representatives from several countries
EXPECT	**Consultations** (Austria, Belgium, Denmark, England, Finland, France, Germany, Ireland, Lithuania, Norway, Scotland, Slovenia, Sweden, Netherlands)
HEROAD	**Desk study** (Austria, Belgium (Flanders), Denmark, Finland, France, Germany, Ireland, Lithuania, Netherlands, Norway, Slovenia, Sweden, UK)
PRO-CROSS	**TAB representatives** (Austria, Belgium (Flanders), Denmark, Finland, Germany, Ireland, Netherlands, Norway, Slovenia, Sweden, Switzerland, United Kingdom)
SABARIS	Netherlands, Belgium
SBAKPI	United Kingdom, Germany, Israel, Belgium

Figure [13]

While the European Commission has an interest in promoting efficiencies and sharing of best practice across member countries, asset management is such a diverse subject, and so dependant upon local factors, that it is hard to see benefits from considering top-down standardisation of asset management systems. On the other hand, incentives to member countries to adopt best practice, such as by publishing Key Performance Indicator data, seems to be a beneficial and positive option.

Of particular importance to NRA stakeholders, case studies were undertaken by six projects following their final concluding reports. Six national road administrations offered to be directly involved in one or more of these case studies;
Rijkswaterstaat(NL), Danish Road Directorate, Finnish Transport Agency, Highways Agency (UK), The Slovene Roads Agency (DRSC) and Motorway Company in the Republic of Slovenia (DARS) (both SLO), Trafikverket (SE)

The aim of the Case Studies was to establish an understanding of what would be involved in the typical implementation of the results of each research project by a Road Administration. The results of the case studies are reported separately.

4 Conclusions and Recommendations

4.1 Communication and Stakeholder involvement

4.1.1 The AM programme demonstrated both the importance of understanding what the legitimate drivers are for asset management, and also some innovative ways of capturing this information in a practical and transparent way. Projects EXPECT and SABARIS focussed directly on measuring and evaluating stakeholder requirements, while other projects showed the mechanism by which these requirements can be used 'top-down' to drive asset management priorities.

4.1.2 One of the biggest challenges of Cross-Asset management is establishing a way of setting stakeholder priorities in a way that can be applied to physical assets which vary widely in their character, operation and performance. This challenge remains only partly addressed in this Programme.

4.1.3 Active involvement of NRA stakeholders is crucial to all applied research of this nature.

4.1.4 Language and understanding; clearly, language will always present a challenge when trying to communicate complex technical concepts. It is recommended that a common Data Dictionary for Asset Management is established, and translated into a limited number of key languages by expert technical translators.

4.2 Asset Performance

4.2.1 The HEROAD project addressed one of the biggest challenges facing road asset management, not just in Europe, but across the world. It is not surprising therefore, that a single 'holistic' methodology that addresses all asset types, over the full lifecycle, measured on a common performance basis, and analysed in a common system has yet to be found. However, many new condition evaluation techniques, life cycle costing models, and systems have been identified and, by driving asset performance from the top down (stakeholder requirements), it should be possible in the near future for NRA's to introduce a more holistic approach to the management of all their assets.

4.2.2 Good, consistent data, suitably specified and quality assured, is a vital underpinning component to any asset management system, and any NRA considering improving its asset performance regime must ensure that a robust data QA process is in place before any new system is adopted.

4.3 Performance Indicators

4.3.1 Any NRA considering using strategic, environmental and social KPIs for regular performance monitoring are able to easily assess the feasibility of doing so using the application guidance in the EVITA and SBAKPI project deliverables. The most likely challenge to overcome is the type and availability of data needed in each case, which, if not already easily available, may need to be collected, with an associated cost implication.

4.3.2 SBAKPI KPIs and EVITA e-KPIs would form a useful input to any future consideration by CEDR of performance monitoring across Europe on the TEN-T network.

4.4 Cross-Asset Management Tools and Models

4.4.1 The software tools developed in the ENR Programme (notably, for ASCAM, PROCROSS and SABARIS) are all described as 'proof of concept'. Providing an NRA that wishes to consider using these models or approaches accepts this, and the implication that the models are not in a position that would permit them to be simply 'bolted into' an existing asset management system, they may form a very useful template which could be developed further within a PMS, BMS or other asset management systems.

4.5 Other Recommendations

4.5.1 Standardisation; a new ISO standard for Asset Management (ISO 55000) is currently under development and is due to be published in 2014. Based on the UK (BSI) 'Publicly Available Specification' (PAS) 55, which has been in use since 2004, this standard provides a comprehensive quality standard for all aspects of asset management. However, it is not sector-specific and each industry must consider how the standard applies to its own methods and best practice. It is recommended that CEDR carries out a feasibility study into the 'mapping' of PAS 55/ISO 55000 onto European Road Administrations' requirements, with a view to possible adoption of the standard as best practice across Europe.

List of deliverables

Webpage: https://sites.google.com/site/assetcall/document-base

Names of deliverables		Where to find them
ASCAM		
Partners: TNO, IGH, AIT, VTI, BRRC, ZAG		
D1	Framework concepts, variables, relationships, assumptions and limitations	*Webpage*
D2	Inventory Pavement Management practices	*Webpage*
D3	Inventory Bridge Management Practices	*Webpage*
D4	Inventory Road Equipment Management practices	*Webpage*
D5a	Software	*Ask project*
D5b	ASCAM Demonstrator User Guide	*Webpage*
D6	Framework presentation (Powerpoint)	*Webpage*
D7	ASCAM End Report	*Webpage*
EVITA		
Partners: IFSTTAR, PMS-Consult, TRL, ZAG, UoB-FCE, LNEC, DDC		
D1.1	Consortium Agreement (written during the phase of negotiation)	*For internal use*
D1.2	Project quality assurance plan decision making procedure; methods for controlling progress; scientific quality assurance system; role of the Scientific Auditor	*For internal use*
D1.3	1st semestrial progress report	*For internal use*
D1.4	2nd semestrial progress report	*For internal use*
D1.5	3rd semestrial progress report	*For internal use*
D1.6	Project final activity report project progress; difficulties encountered and decisions made to overcome these obstacles; summarise of the main findings of all Work Packages	*For internal use*
D2.1	Report on: stakeholders categories and sub-categories; list of expectations; list of necessary KPIs; presentation of existing KPIs	*Webpage*
D2.2	Report on assessment and evaluation of existing KPIs	*Webpage*
D3.1	Report on recommended E-KPIs	*Webpage*
D4.1	Report on Procedure for implementation of KPI	*Webpage*
D4.2	Practical Guideline for the use of KPI in pavement management practice	*Webpage*
D5.1	Web site	*http://e-kpi.fehrl.org/?m=64*
D5.2	Final Workshop Presentations on a CDrom	*Ask project after symposium*
EXPECT		
Partners: TRL, AIT, BRRC, TNO, VTI		
D1	Inception Report	*For internal use*
D1.2	State of the Art Report in asset management including case studies	*For internal use*
D1.3	Monthly progress report	*For internal use*
D2.4.1	Report on consultation meetings	*Webpage*
D3	Report describing tools to evaluate and prioritise different stakeholder requirements	*Webpage*
D4	Report describing the methodologies to align stakeholder expectations with engineering standards	*Webpage*
D4.2	6 monthly progress report	*For internal use*
D5	Final version of the webpage including documents produced for wider diffusion available at the end of the project	*http://eranet-expect.brrc.be/*
D5.2	Final report	*Webpage*

HEROAD
Partners: VTI, TRL, BRRC, FERHL, ZAG, AIT

D1.1	Report on pavement performance: Recommendations on optimised assessment of pavement condition, in particular making best use of new data collection methods (including traffic-speed techniques)	*Webpage*
D1.2	How the quality of pavement condition data is controlled in the EU, and recommendations for QA procedures	*Webpage*
D2.1	Report on structures performance: Recommendations on optimised structural assessment and their implementations in an efficient bridge (asset) management	*Webpage*
D3.1	Report on road furniture performance	*Webpage*
D4.1	Report on environmental components: Strategies for the effective integration of environmental parameters into asset management systems	*Webpage*
D5	Report on overall asset performance	*Webpage*
D6	Final summary report	*Webpage*

PROCROSS
Partners: AIT, TCD, SEP, ZAG

D1	Good practice in Cross Asset Management Optimisation	*Webpage*
D2	Effective monitoring of road infrastructure assets	*Webpage*
D3	Tentative Document - The Procedures for Cross Asset Management Optimisation	*Webpage*
D4	Final report "The Procedures for Cross Asset Management Optimisation	*Webpage*

SABARIS
Partners: UT, ETHZ, IFSTTAR, KUL, ATO

D1	Project Website	*www.utwente.nl/ctw/prime/researchprojects/finished/projectSABARIS/*
D2	List of road stakeholders	*In final report*
D3	List of road benefits	*In final report*
D4	List of engagement strategies	*In final report*
D5	Benefit hierarchy	*In final report*
D6	Values of benefit types	*In final report*
D7	WP1 report	*For internal use*
D8	Project progress report	*For internal use*
D9	Optimisation model	*In final report*
D10	Optimisation tool	*In final report*
D11	WP2 report	*For internal use*
D12	Case study findings	*In final report*
D13	Results of the sensitivity analysis	*In final report*
D14	Guideline for use and implementation of such an optimisation tool in road agencies	*In final report*
D15	WP3 report	*For internal use*
D16	Final project report	*Webpage*

SBAKPI
Partners: TRL, DTU

D1	Project Team Agreement (written during the phase of negotiation)	*Internal use*
D2	1st Steering Group Meeting	*Internal*
D3	2nd Steering Group Meeting	*Internal*
D4	1st Consultation Meeting	*Internal*
D5	2nd Consultation Meeting	*Internal*
D6	Draft Benchmarking Framework	*For internal use*
D7	Trial of Benchmarking Framework with up to 5 NRA	*For internal use*
D8	Revised Benchmarking Framework	*For internal use*
D9	Project Report and Dissemination of Benchmarking Tool	*Webpage*

Technical report

ERANET ROAD II SRO4 Effective asset management meeting future challenges 2010 – 2013