CEDR

Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

CEDR Contractor Report 2018-1

Call 2014: Asset Management and Maintenance

PREMiUM

ARISE

ISABELA

DRaT

BEST4ROAD

by

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September 2018

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The aim of the CEDR Transnational Road Research Programme is to promote cooperation between the various European road administrations in relation to road research activities. The topics covered by this Call were developed by TG Research to fulfil the common interests of the CEDR members.

The report was produced by AIT under contract to CEDR. The views expressed are those of the authors and not necessarily those of CEDR or any of the CEDR member countries.

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Executive summary

The aim of the Transnational Road Research Programme 2014 "**Asset Management and Maintenance**" was to gain better knowledge and guidance on how to manage and maintain all assets of a road network. The expected research built on the outcome of earlier calls, in particular on the ENR call 2010 – "Effective Asset Management meeting Future Challenges". The Programme was based on five objectives, with the concepts of:

Road Asset Management:

A) Road equipment asset management

B) Why and how to implement ISO 55000

C) Social benefits and costs

Road Maintenance

D) Use of standard ravelling tests to predict pavement durability

E) Recommendations for maintenance procurement by investigating current practices

Projects funded within this research programme had to focus on the sharing of national research, knowledge and experience at all levels, as an important prerequisite for achieving the goals of CEDR and its members. The results should accelerate the development of faster and more durable methods and techniques for road maintenance and management. It was particularly important that the results could be easily implemented through various demonstration projects in order to contextualise the benefits of the transnational collaboration.

Five projects were funded in the programme and were carried out during the period 2015-2017. Based on the previous experiences from CEDR, a Final Programme Conference was organised on 12-13th October 2017 to present the final results of the projects as well as to discuss highlights, implementation issues and open questions.

PREMiUM (Practical Road Equipment Measurement, Understanding and Management) aimed to the deliver improvements in the ability to manage road equipment specifically road markings, road signs, vehicle restraint systems and noise barriers. It accomplished its objectives by establishing the condition characteristics that should be included in an asset management strategy at network level (e.g. night-time visibility, wear, orientation, presence of damage, resistance to loads etc.), establishing existing and emerging measurement tools (e.g. LiDAR, visual inspection, in-situ techniques etc.), providing a list of parameters that could be used to assess condition and proposing a set of condition indicators (single, combined and asset indicators) for quantifying condition at network level. The results were demonstrated with a tool developed within the project that provides insight into the level of condition along a specific route. The output is an asset score between 0 and 5.

The clear and in-depth description of the measurement methods for various assets, including their availability, their potential and their maturity was seen as the most beneficial result of the project. The approach developed within PREMiUM should give NRAs the possibility to employ a more effective approach to managing equipment assets and will assist in establishing a budget and allocating it in an efficient manner.

ARISE (Application to Roads of ISO55000 using Exemplars) focused on producing guidance for national road administrations considering why and how to implement ISO55000. The project's aim was to facilitate open and practical dissemination of ISO55000 to a wide audience. The outcome was a guidance document entitled "Implementation Guide for an ISO 55001 Asset Management System", structured to lead asset owners and organizations at various stages of their maturity through the implementation process. The guidance is aimed at three roles within the NRAs: key policy makers and leaders, asset managers and asset operators. It goes through a systematic approach of the key activities towards identifying current asset management maturity, future demands and constraints on a road asset management system, before carrying out a gap analysis, planning for change, implementing change and achieving an improvement in asset management maturity.

Overall, the results of the project are seen as very helpful for the road authorities in the process of ISO certification, as it gives practical implementation guidance. The guidance document is available for download from the CEDR website (Implementation Guide for an ISO 55001 Asset Management System).

The main objective of the project ISABELA (Integration of social aspects and benefits into life-cycle asset management) was the definition of a holistic asset management framework for social key performance indicators (S-KPIs) and social benefit modelling in the form of social effects (monetary and non-monetary), social backlog and social risk. However, to perform a reliable and satisfactory socio-economic assessment of their maintenance policy, NRAs will probably have to gather more socio-economic information, i.e. parameters, coefficients adjusted to their context and to take a great care in collecting and storing their road data. For example, the availability of cost data, even if at estimate level, was considered highly awaited and appreciated by the NRAs. The pressure to justify maintenance measures has increased and the consideration of cost-benefit analysis is gaining importance.

Road authorities should take the results of ISABELA as input for contracts with private concessionaires to implement key performance indicators regarding environment and socio-economy for compensation, in addition to the established indicators.

The overall objective of DRaT (Development of the Ravelling Test) was to provide comprehensive advice and recommendations on how to refine prCEN/TS 12697-50 to be an acceptable standard. Three types of mixtures (PA, BBTM and SMA) were tested with four scuffing devices. No uniform correlation between the devices could be found nor could their results be culled or unified for a particular performance/loading in time that would convert to one common measure.

Nevertheless, the project has identified specific enhancements to the current draft of prCEN/TS 2697-50 to make a better and more unified document without rejecting any of the designs of the scuffing apparatus. It was concluded that the individual devices work for their intended purpose; when used for testing other mixture types, there is no best device, nor is there a universal device.

The main objective of the BEST4ROAD (Best Practice Guidelines for Procurement of Road Maintenance) project was the development of best practice guidelines and tools for the efficient procurement of road maintenance in a changing environment. Three typical scenarios were used to explain the risks associated with various procurement strategies, recommending measures to manage risks, presenting the competence profiles needed to implement the strategies and recommending the transition towards strategy implementation. The conclusion was that there is no best way to do it, as there is no definitive proof for an optimum method. The solution is to learn from others and to adapt the strategy to the politics, market, conditions of the individual road administration and country.

Based on the discussions and results of the Final Programme Conference, some overall observations and recommendations could be made:

- Having the right data and an optimum frequency of data collection is crucial for improving asset management and implementing any project results;
- A first step should be to analyse the real data and to define what is missing and what is already available. However, the frequency of data collection depends on the scope of the data and the type of asset;
- There is poor communication between experts and representatives of the political domain; political support is crucial in asset management. Limitations in communication exist also at NRA level, i.e. knowledge in-house.
- Outsourcing is not seen as an optimum solution by all NRAs, as the knowledge and expertise would be lost at road authority level; a solution would be to have a balance;
- All road authorities plan to implement the results of the five projects; however, more work is needed to achieve a successful implementation. Dissemination via local seminars could help spread the projects' results to a wider audience;
- The success of the CEDR 2014 Programme Asset Management and Maintenance was widely acknowledged. Lessons learned include that the quality of the work and of the project results are directly dependent on funding.

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1. Introduction

1.1 Background

In December 2014, the Conference of European Directors of Roads (CEDR) launched a call for proposals in the field of Asset Management and Maintenance. CEDR is an organisation which brings together the directors of 27 European road authorities. The aim of CEDR is to contribute to the development of road engineering as part of an integrated transport system under the social, economic and environmental aspects of sustainability and to promote co-operation between the National Road Administrations (NRAs). The website www.cedr.eu contains a full description of its structure and activities.

This Transnational Research Programme pools research funding from CEDR members to fund transnational research projects on topics of shared interest to European road authorities, and forms a continuation of previous programmes organised under the ERA-NET ROAD brand. “ERA-NET ROAD – Coordination and implementation of Road Research in Europe” was a Coordination and Support Action funded by the 7th Framework Programme of the European Commission which concluded in December 2011. The goal of ERA-NET ROAD (ENR) was to develop a platform for international cooperation and collaboration in research areas of common interest. This included the production of an “ENR-toolkit” for carrying out transnational research and trials of the various procedures developed through a series of projects and programmes funded directly by European Road Administrations. Full details of the research projects commissioned through this process, amongst others those of the 2010 Asset management Call, can also be viewed at the ENR website www.eranetroad.org.

The aim of the Asset Management and Maintenance Programme was to gain better knowledge and guidance on how to manage and maintain all assets of a road network. The expected research built on the outcome of earlier calls, in particular on the ENR call 2010 – “Effective Asset Management meeting Future Challenges”. The funding partners for this call are Belgium-Flanders, Finland, Germany, Ireland, Norway, the Netherlands, Sweden, United Kingdom and Austria.

The call had two sub-themes, with three respectively two research projects, mentioned in brackets, and which will be described in further detail in this report:

Road Asset Management:

- **F) Road equipment asset management (PREMiUM)**
- **G) Why and how to implement ISO 55000 (ARISE)**
- **H) Social benefits and costs (ISABELA)**

Road Maintenance

- **I) Use of standard ravelling tests to predict pavement durability (DRaT)**
- **J) Recommendations for maintenance procurement by investigating current practices (BEST4ROAD)**

The projects started in 2015 and ran for 24 months. Based on the previous experiences from CEDR, a Final Programme Conference was organised on 12-13th October 2017 to present the final results of the projects as well as to discuss highlights, implementation issues and open questions. Approximately 50 stakeholders participated (agenda in the Annex) including the Programme Executive Board (PEB). Two parallel sessions ensured fruitful discussions on the project results, their implementation, lessons learned and next steps.

This report presents brief summaries of the five projects, their objectives and results in Chapter 2. Chapter 3 presents the results of the conference in terms of highlights, implementation steps and open questions for each project.

2. Project descriptions

2.1 PREMiUM

Duration:	01.10.2015 – 30.09.2017
Budget:	EUR 346.440
Coordinator:	Alex Wright, Transport Research Laboratory (TRL), UK
Partners:	AIT Austrian Institute of Technology, Austria
	Belgian Road Research Centre (BRRC), Belgium
	PMS Consult, Austria
	Roughan & O'Donovan Innovative Solutions (ROD), Ireland
	The Swedish National Road and Transport Research Institute (VTI), Sweden
Website:	https://premiumcedr.com/

National road administrations draw upon knowledge of their assets to efficiently manage road networks. This knowledge includes data on asset inventory and asset condition, as well as information regarding the most appropriate maintenance approaches to take for the respective assets. Significant research and development has been performed for the assessment of pavement conditions at network level through the use of objective tools. However, this cannot be said for the assessment of road equipment. Previous ERA-NET research – HeRoad project – (Britton, 2014) has found that the management of equipment such as road signs, lighting, markings, restraint systems, noise barriers and Variable Message Sings (VMS) is often excluded from the integrated management process.

The PREMiUM (Practical Road Equipment Measurement, Understanding and Management) project aimed to deliver improvements in the ability to manage road equipment, through the following objectives:

- Establish the condition characteristics a national road administration should include in their asset management strategy for these road equipment assets, in order to manage the potential risks related to the loss of these assets;
- Help road owners to understand and balance network level and project level management of these assets so that they can establish a practical monitoring regime that enables a better understanding of the conditions and associated risks;
- Identify the existing and emerging measurement tools that could be applied by road owners to better understand, monitor and manage these assets;
- Propose objective measures that could be applied to understand and quantify the performance of these assets, which are feasible for use at the network level;

- Enable road administrations to establish a maintenance regime that minimises the risks of performance deterioration and to focus maintenance expenditure on these assets in an efficient manner.

The project started with a literature review as part of the first two work packages (as seen in Figure 1), in which a review of standards and guidance documents was performed to identify current condition characteristics that are used to understand the performance and the condition of road equipment assets. A consultation was undertaken with NRAs/asset managers to collect information on the current practice in managing the condition of four asset types, i.e. road markings, road signs, vehicle restraint systems and environmental noise barriers.

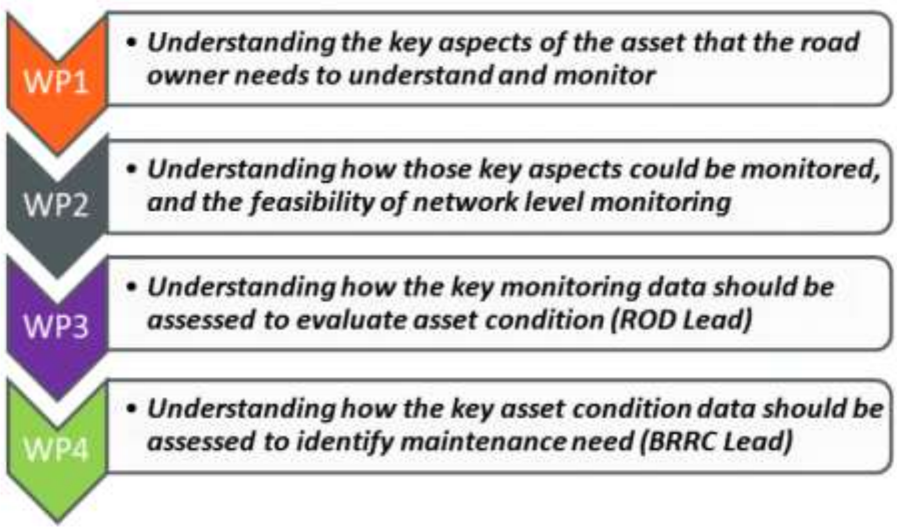


Figure 1 PREMiUM Work Packages (Source: Benbow and Wright, 2017)

A common requirement identified in the consultation of stakeholders was that to effectively manage road equipment assets, it is important to have information on the asset inventory. A robust and accurate inventory is an essential tool for providing engineers and decision makers with key information about the assets on their road network. However, PREMiUM found that even though this information is critical for understanding the performance of the asset, many current inventories are out-of-date and incomplete and the characteristics are not routinely measured. Therefore, the project proposed a set of key information requirements for establishing a robust network level inventory shown in Table 1.

Table 1 PREMiUM Inventory requirements for road equipment assets (Source: Benbow and Wright, 2017)

Road markings and studs	Road signs	Vehicle restraint systems	Noise barriers
Location reference Type of marking/stud Colour of marking/stud Date of installation Dates and details of maintenance Dates and details of last inspection	Location Reference Identification Code Date of Installation Maintenance Records Cleaning Interval Manufacturer Declared Performance Characteristics	Location reference Manufacturer declared design and performance characteristics Date of Construction Method of post installation Length of barrier Terminals on the safety barrier Hazards protected Speed limit of road Historical maintenance records Dates and references to inspections and inspection data Scheme/Contract references.	Location Reference Acoustic Type (Absorptive/Reflective) Acoustic Element Composition Post Type (if used) and Mounting Description, fitment Date of Installation Date/Details Previous Inspections Physical Condition Reports Geometric Properties Manufacturer Declared Initial Performance Characteristics Details of Complaints

After establishing a network inventory, a requirement was to identify the key condition characteristics that need to be well understood in order to manage these assets. By combining this outcome with a review of relevant standards as well as with input from technical experts in the design, management and assessment of these assets, the project was able to propose and rank in order of importance, the key characteristics that would ideally be measured to effectively understand and manage these assets, for each of the asset types considered (with a rank of 1 being the most important). Table 2 shows these characteristics.

Table 2 PREMiUM Key condition characteristics for assets (Source: Benbow and Wright, 2017)

Rank	Road markings and studs	Road signs	Vehicle restraint systems	Noise barriers
1	Night-time visibility (markings)	Damage/Loss	Presence of damage	Airborne sound insulation
2	Night-time visibility (studs)	Obstruction/ Obscuration	Presence of corrosion/rust	Sound absorption/ reflection
3	Day-time Visibility (markings)	Orientation	Ground bearing capacity	Vibration and Fatigue
4	Wear (markings)	Panel Alignment (signs using more than one panel)	Mounting height	Impact from Collision
5	Skid Resistance (markings)	Night-time Visibility	Fixing condition	Resistance to loads
6		Colour Fade		

WP2 further considered the methods available to measure these characteristics and to obtain inventory data. Several methods are currently being used including Historical Record Review, Traffic-speed Visual Survey and Slow Speed Visual Survey. Nevertheless, emerging methods such as LiDAR, video and others show much promise, especially for a network level assessment of the equipment condition. An examination showed different levels of maturity in the measurement methods available for network level assessment of the four assets, with road markings-specific methods having the highest maturity. Therefore, the project evaluated the available and emerging technologies and techniques, leading to a set of recommendations for each equipment type. Moreover, alternative potential measurements that could be implemented given suitable investment and development were also investigated. These are summarized in Table 3.

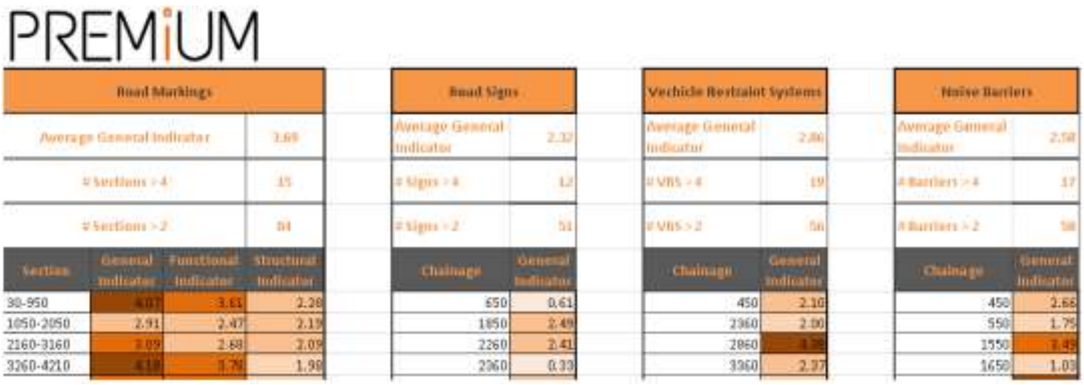
Table 3 PREMiUM Proposed measurement methods to monitor road equipment assets at a network level (Source: Benbow and Wright, 2017)

Road signs	Vehicle restraint systems	Noise barriers
Night-time Visibility: Existing mobile reflectometer or LiDAR but not widely tested	**Presence of damage:** Potential for visual inspection from video, but only for the front of barrier	**Sound reflection, Airborne Sound Insulation, Sound Diffraction:** Requires in-situ (smart technology)
Damage/Loss, Obstruction/ Obscuration, Panel Alignment: Potential for visual inspection from video, with automatic analysis feasible in the long term	**Presence of corrosion/rust:** Potential for visual inspection from Video, but only for the front of barrier	**Vibration & Fatigue:** No potential network level method identified
Orientation: Potential for visual inspection from video or LiDAR, with automatic analysis feasible in the long term	**Ground Bearing capacity:** Requires in-situ (smart technology) measurements	**Resistance to loads:** No potential network level method identified
Colour fade: Potential for Visual inspection from video	**Mounting height:** Potential for use of video or LiDAR surveys and automatic analysis	**Impact from collision:** No potential network level method identified
	Fixing condition: Requires in-situ (smart technology) measurements	

The cells highlighted in pale blue represent the methods that are considered practical for development or implementation in the next 5 years, subject to appropriate investment. Of these, the traffic-speed methods showing the most potential for near term application are those used for the assessment of signs using mobile-reflectometers, for which commercial systems are now available. For the other equipment/characteristics, there will be a need for significant further development if network level assessment is to be achieved. LIDAR, video and in-situ techniques show significant potential for the measurement of several characteristics. The use of LIDAR/video would exploit the same capability identified for use in inventory measurements, but would draw more value from the video data via the classification of condition. The challenge for this application is the development of assessment processes that deliver consistent quantitative information and that the video itself contains enough detail to observe deterioration. There is even less experience in the use of in-situ technologies. However, it was found that options are becoming available for small low-cost sensors that could be applied to e.g. measure vibration and movement in VRS or even to continuously monitor traffic noise and hence track changes in the ability of a barrier to attenuate this. For more details, the project has published a set of four deliverables on the key characteristics for condition measurements of each of the road assets (Deliverables D1a and D2a, D1b and D2b, D1c and D2c, D1d and D2d, Spielhofer et al, 2017).

WP3 and WP4 sought to build on the outcomes of the previous WPs by demonstrating how a network equipment condition assessment regime could benefit the NRA, through the asset management process. Therefore, the work performed in WP3 and WP4 proposed how key characteristics could be used in the asset management context by providing a methodology to allow measured asset conditions to be assessed objectively. For each of the proposed characteristics, indicators to express the condition were developed. The indicator development was based on the assumption that the data required would be available to the road administration applying the indicator. Transfer functions for delivering indicators for the majority of the key characteristics were proposed. Moreover, the project also proposed how single indicators could be combined to obtain an overall indicator of functionality, i.e. an indicator that indicates whether the road equipment meets its purposes. Indicator weightings based on the level of importance of the various conditions characteristics expressed by potential users were established. At network level, the indicators could be applied by NRAs to report the condition of the network within an asset management regime. This could be on a road, route or network basis.

For the purposes of illustrating the concepts developed in the PREMiUM project, a demonstration tool based in Excel was developed. Filling in specific road equipment and network data, the tool provides insight in the level of condition along a specific route. Assets are grouped according to score, giving a number between 0 and 5, in line with the asset management systems used worldwide, with 0 meaning that the asset is in good condition. Figure 2 shows an overall performance of the route for each of the four road equipment assets. Such an objective approach to the management of equipment assets should enable an NRA to employ a more effective approach to managing equipment assets and will assist in establishing budgets and allocating them in an efficient manner.


PREMiUM

Road Markings			
Average General Indicator			3.69
# Sections > 4			15
# Sections > 2			84
Section	General Indicator	Functional Indicator	Structural Indicator
30-950	[illegible]	3.61	2.28
1050-2050	2.91	2.47	2.15
2160-3160	[illegible]	2.68	2.09
3260-4210	[illegible]	[illegible]	1.98

Road Signs	
Average General Indicator	2.32
# Signs > 4	12
# Signs > 2	51
Chainage	General Indicator
650	0.61
1850	2.49
2260	2.41
2360	0.33

Vechicle Restraint Systems	
Average General Indicator	2.86
# VRS > 4	19
# VRS > 2	56
Chainage	General Indicator
450	2.10
2360	2.00
2860	[illegible]
3360	2.37

Noise Barriers	
Average General Indicator	2.58
# Barriers > 4	17
# Barriers > 2	58
Chainage	General Indicator
450	2.68
550	1.75
1550	[illegible]
1650	1.03

Figure 2 PREMiUM Route performance of road equipment assets (Source: Benbow and Wright, 2017)

More details regarding the indicators for each road asset type considered in the project, final recommendations and the demonstration tool can be found in Deliverables D3 and D4 (O'Connor et al, 2017).

2.2 ARISE

Duration: 01.06.2015 – 31.08.2016

Budget: EUR 279,890

Coordinator: James Elliott, WSP Parsons Brinckerhoff, UK

Partners: Egis Road Operation, France

Hyperion Infrastructure Consultancy Ltd, UK

Road Administrations around Europe have been on an evolving journey towards a more systematic and holistic management of their assets in recent years. Standardisation of the approach to establishing an Asset Management System (AMS) – in its broadest sense – started with the publication of British PAS-55 standard in 2008. This has attained international standing through the development of a new ISO standard, built on the PAS-55 foundation. ARISE (Application to Roads of ISO55000 using Exemplars) focused on producing advice and guidance for road sector organisations considering why and how to implement ISO55000. The results were based on examples taken from case studies of organisations that were at various stages of their asset management system implementation and which had specific experience of IS055000 or its 'parent', PAS-55. The project culminated in a dedicated Open Workshop for road administration managers and personnel to learn 'Why and how to implement ISO55000', backed up by a comprehensive Guide to Implementation. The project's aim was to facilitate open and practical dissemination of ISO55000 to wide audience. The specific objectives of the project were:

- Learning from the experience of ISO55000 and its predecessor PAS55 from other organizations:
  - Across different infrastructure sectors (e.g. motorways, rail, power);
  - Across different countries;
  - At different stages along the "ISO" implementation journey.
- Analyse the evidence based gathered;
- Identify where possible, costs and benefits directly attributable;
- Write guidelines aimed at Road Authorities with practical advice on How and Why To Adopt the ISO55000 Approach.

The international standard for asset management comprises three complimentary documents ISO55000 – Overview, principles and terminology, ISO550001 – Management System Requirements and ISO55002 Management systems –Guidelines for the application of ISO 55001. Figure 3 provides an overview of the work package structure of ARISE.

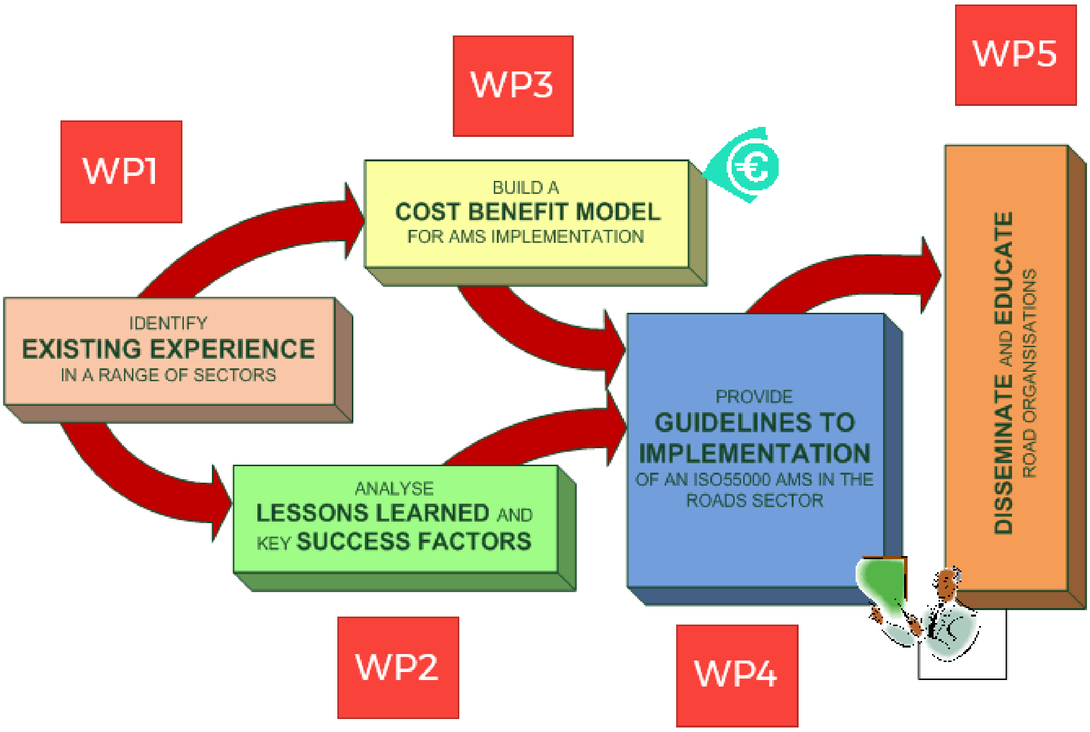


Figure 3 ARISE Work Packages

The project work started with the identification of candidate case studies from a range of sectors, the design of an information collection exercise as well as the actual collection of data. The case studies were shortlisted from a pool of 24 organisations across five sectors. Eight full and one partial case study from energy, aviation and road sectors were selected from UK, Finland, Ireland and Austria (Transport for London, Highways England, FINGRID, ASFINAG, etc.). The case studies were analysed by the seven ISO element headings:

- Context of the organization
- Leadership
- Asset management planning
- Support functions (such as competence and information)
- Asset management operations
- Evaluation of asset performance
- Continual improvement.

The lessons learned and key findings were highlighted together with relevant quotations within the case studies, in order to make the Guidance Document as practical as possible.

The next step was to identify the costs and benefits of implementing an asset management system – an ISO 55001 compliant system in particular. A template model for Cost Benefit Analysis (CBA) was designed to capture key learnings from case study organizations and to evaluate the effort of applying good asset management principles as well as the additional effort of implementing ISO55000. Evaluation of each of the elements in the context of ISO 55001 indicated that the “Support” element was the main heading under which costs could be incurred and/or benefits accrued in contributing activities under the remaining elements. Within the template, the Support element was sub-divided in:

- Resources – human and non-human including tools and equipment;
- Competence – skills, experience, training and training management;
- Awareness/Communications – including the awareness of asset policy and practices and of external and internal communication;
- Information – the identification and management of asset information needs and of asset systems (Such as inventory and deterioration modelling);
- Documentation – what is required and how it is controlled and managed.

A basic scoring system was developed based on the indicative values for costs incurred or benefits realised, in order to create a benchmark level of understanding and use the values as a comparison between sectors. Four organizations provided sufficient data for performing a cost benefits analysis. The results of the CBA showed a good correlation between sectors and clear value areas that additional investments will bring. The highest value was from investments in leadership of organizational asset competence and organizational asset documentation. However, there was limited value gained in improving asset benefits from high investment in asset operations.

The project was completed through WP4, producing the “Implementation Guide for an ISO 55001 Asset Management System”. The document is structured to lead asset owners and organizations at various stages of their maturity through the implementation process. It is intended for everyday use as a reference guide and supplements the “formal” language used in the ISO standard. The guidance is aimed at three roles within the NRAs: key policy makers and leaders, asset managers and asset operators. It goes through a systematic approach of the key activities towards identifying current asset management maturity, future demand and constraints on a road asset management system, before carrying out a gap analysis, planning for change, implementing change and achieving an improvement in asset management maturity. The specific three key areas required in ISO 55001 arising from these activity steps are:

- Engaging with stakeholders and understanding their needs and expectations;
- Developing a Strategic Asset Management Plan (SAMP) which aligns with an organization’s Asset Management Policy and its Asset Plans;
- Certification Audit – the final stage of implementing ISO55000.

The final considerations and recommendations of ARISE are (for more details on the ARISE project, please see Deliverable 4.1 (Britton et al, 2016)):

- The number of European organisations in the range of sectors examined that have made significant progress with ISO55001 certification was found to be very low, though the search for case studies undertaken in the project was not exhaustive. However, two organisations were reported upon that have achieved ISO 55001 certification status.
- Adequate cost benefit information was obtained for the planned high-level ranking analysis to be performed and this should provide useful pointers to other organisations when building a business case for ISO 55001 adoption.
- There is a considerable level of ignorance about ISO 55000 (and its constituent parts) in many motorway-related organisations, although asset management as a discipline and a system is being taken up by many.
- There is some confusion (irrespective of industry sector) about the difference between establishing a generic Asset Management System, and the added rigour that seeking ISO55001 certification provides. It is important to understand this before being able to build a business case for implementing ISO 55000; this constitutes an area where the Implementation Guidance is designed to assist NRAs embarking on this journey.
- As ISO 55000 is generic and applicable to all infrastructure sectors, there will be an ongoing need to share experiences in the motorway sector, as maturity grows in different countries and different types of organisations, i.e. governmental, concessions, operations and maintenance and contracting. This sharing could be facilitated by CEDR through conferences and workshops.
- As the implementation of a major international standard is complex and could take a considerable period of time to become embedded across Europe, it is recommended that an annual monitoring exercise is undertaken by CEDR.

2.3 ISABELA

Duration: 01.08.2015 – 31.05.2017 (15.09.2017)

Budget: EUR 387,362.81

Coordinator: Alfred Weninger-Vycudil, PMS-Consult GmbH, Austria

Partners: Slovenian National Building and Civil Engineering Institute (ZAG), Slovenia

Logiroad, France

CESTEL, Slovenia

University of Belgrade, Serbia

The Brauschweig Pavement Engineering Centre (ISBS TU Braunschweig), Germany

National Laboratory of Civil Engineering (LNEC), Portugal

The main objective of the ISABELA project (Integration of social aspects and benefits into life-cycle asset management) was the definition of a holistic asset management framework for social key performance indicators (S-KPIs) and social benefit modelling in the form of social effects (monetary and non-monetary), social backlog and social risk. ISABELA aimed to provide an essential enhancement for the life-cycle-assessment of maintenance strategies and enabled the incorporation of social aspects and benefits into classic asset management.

ISABELA aimed to identify clear and repeatable social key performance indicators (S-KPIs) in combination with existing technical parameters, described in previous projects such as COST 354 (Litzka et al, 2008), FORMAT (FORMAT, 2005), EVITA (EVITA, 2012), and SBAKPI (SBAKPI, 2012). The use of these new indicators in parallel with existing technical performance indicators helped underline the necessity of road infrastructure maintenance and was the basis for a holistic definition of a new maintenance benefit considering the following maintenance aspects:

- Availability and disturbance (e.g. travel time, vehicle operating costs);
- Road safety (e.g. fatal and severe accidents related to asset condition);
- Environment (e.g. noise, air pollution, natural resources);
- Socio-economy (e.g. asset value, wider social benefits).

To achieve its objectives, the project was divided into five work packages, as seen in Figure 4. The objective of WP1 was to collect information on social key performance indicators and their use in asset management systems. The review included a literature review, as well as interviews with experts from 12 road directorates (RDs) and two regions regarding their current practice and the use of S-KPIs, in order to check and complete stakeholders' expectations and requirements along with the inventory of available indicators, data, models and methods already available from existing groups/projects. It was revealed that most of identified S-KPIs are not used in a systematic way in the development of asset maintenance programs by road authorities. However, there is considerable interest to use selected indicators in the future, especially those for which data are available.

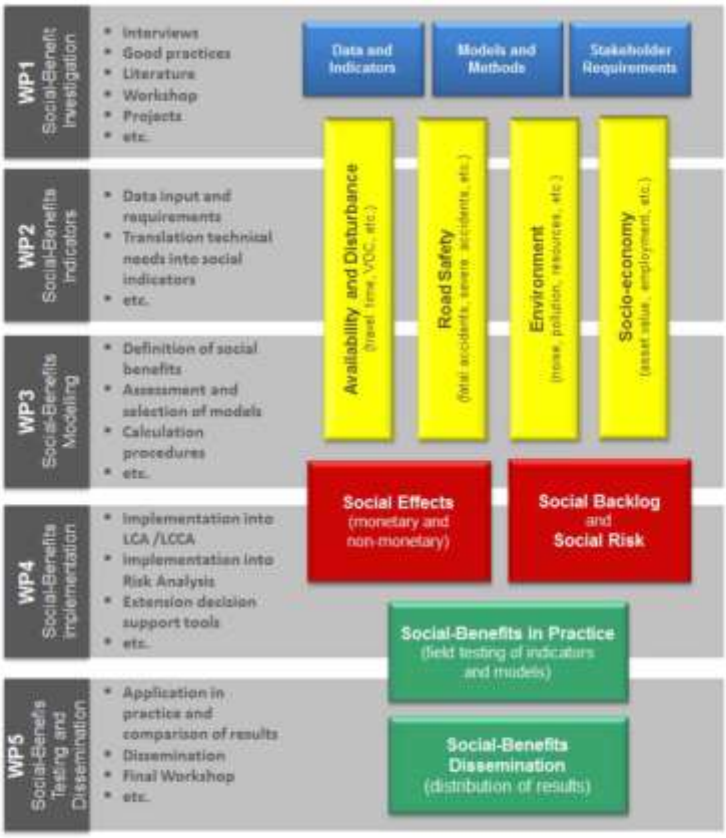


Figure 4 ISABELA Work Packages structure

In the area of road availability and disturbance in maintenance planning, the indicators used mostly include some form of condition rating for pavements and bridges, while other indicators related to accessibility, congestion, availability and travel time are used to a lesser extent.

All national road administrations use S-KPIs related to road safety, e.g. number of fatalities, injuries, or simply number of accidents. Based on these data, more complex indicators related to safety cost or frequency of occurrence of accidents may be calculated. In addition, many administrations use condition parameters in order to identify adequate maintenance treatments to achieve certain safety related levels of these parameters.

Noise stands out as the most important environmental parameter used by most NRAs due to the implementation of the European Noise Directive (EC, 2002). Other parameters, such as air quality, CO2-emissions, environmental costs, natural resources, soil and water quality do not affect planning at the moment, but are part of national legislation.

Among the parameters related to economy, cost efficiency and particularly benefit/cost ratios of maintenance programs appear to be used by most administrations in order to assess socio-economic impact of maintenance policy. For more details regarding WP1, please see Deliverable D1.1 (Kokot et al, 2016).

WP2 dealt with the assessment of the identified indicators, in two phases. After a preliminary assessment during which the indicators were organized and consolidated, an assessment based on identified stakeholders' needs and expectations, general specific applicability, level of applicability and use, spread of use, data requirements, availability and reliability. Other aspects such as if the indicators can be monetized, if it is possible to develop models for social benefit, social risk and social backlog were also taken into account. For these purposes, a template for indicator assessment was developed, which allowed an easy and systematic evaluation of the indicators. The assessment yielded a list of indicators as seen in Figure 5.

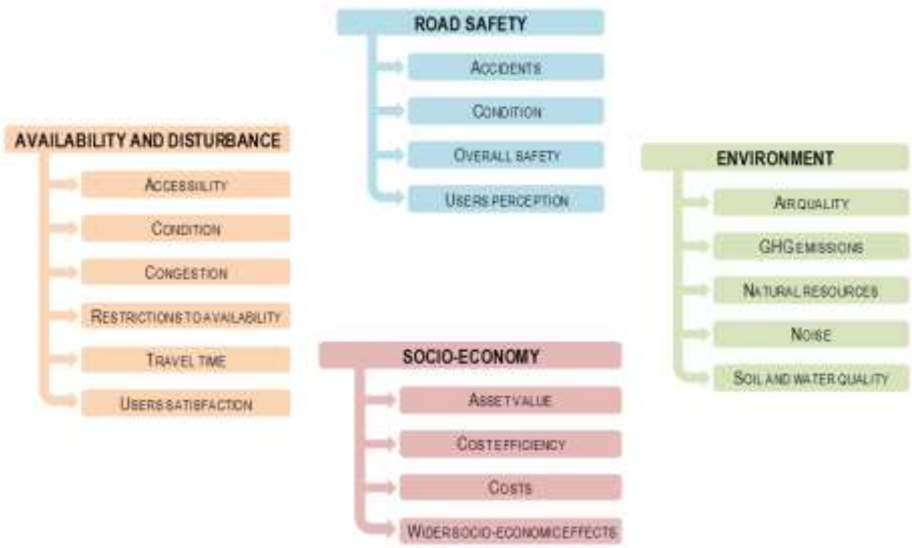


Figure 5 ISABELA List of indicators

The project also performed a comparison between the indicators identified in the project and a set of 21 indicators selected by the CEN Workshop Agreement. A high number of similarities between the indicators could be identified, although differences exist. However, while the primary purpose of the CEN indicators is to enable road sustainability assessment at the project level, the ISABELA indicators are used to include social aspects into the road network asset management. Further details can be found in Deliverable D2.1 (Mladenovic et al, 2016).

WP3 looked at the different options to model social benefits for the four main areas: safety, environment, availability and economy. Firstly, the basic terminology of social benefit, social risk and social backlog was discussed and reported in Deliverable D3.1

(ISABELA, 2016). In a second step, the definition of social benefits and the assessment and selection of adequate models with necessary calculation procedures was performed. Mathematical modelling was utilized to calculate the key parameters – social benefit, social backlog and social risk. The investigation showed that most of the social aspects could be covered by simplified approaches, taking into consideration existing models and available input data, as well as their correlation to the expected output and results. Most of the assessed models were based on simplified relationships between traffic, asset condition and physical or economic effects, which makes them suitable for an asset management software solution. Especially the social areas of availability and disturbance, safety and environment could be related to existing models and previous research projects. In the socio-economic area, the road specific models and related data were missing thus it was not possible to obtain similar quality. Nevertheless, the work includes clear and repeatable ideas which social aspects could be considered and how such an approach could look like. More details can be found in Deliverable D3.2 (Weninger-Vycudil et al, 2017).

Following the work in WP3, WP4 aimed to integrate social aspects and benefits into life cycle asset management processes under various requirements, especially the availability of input data for modelling. It focused on two main tasks – developing a framework to compare different maintenance policies by applying Life Cycle Assessment (LCA), Life Cycle Cost Analysis (LCCA) and Risk Analysis (RA) and preparing a demonstration of the methodology developed in the project. The result of the first step translated into adapting the procedures of LCA, LCCA and RA to the specificities of road asset management. Considering the advantages and disadvantages of each method, ISABELA considered the incorporation of LCA and eventually LCCA approaches. More details can be found in Deliverable 4.1 (Lepert, 2017).

For the demonstration, two road administrations (Flemish Road Administration and Austrian Motorway operator ASFINAG) provided the respective input information for the practical testing of the project models. Therefore, two use cases in Belgium (E40, 253,1 km) and Austria (A4, 65.8 km) respectively were selected for practical application. In agreement with the two NRAs, the use cases focused on the following areas: 1) Additional costs due to disturbances induced by maintenance works; 2) Savings in accident costs and additional accident costs due to maintenance projects; 3) Savings produced by noise reduction after maintenance projects. Two asset management systems (AMS) were selected for the implementation of the project methodology: L^{2}R (France) and dTIMS (Canada). More details can be found in Deliverable 4.2 (Lepert and Weninger-Vycudil, 2017).

The most important findings resulting from the demonstration exercise are:

- Socio-economic impacts assessment can certainly be performed with ISABELA methodology and models in most existing AMS, provided they fulfil some requirements derived from the study.
- However, to perform a reliable and satisfactory socio-economic assessment of their maintenance policy, NRAs will probably have to gather more socio-economic information, i.e. parameters, coefficients adjusted to their context and to take a great care in collecting and storing their road data.

- The results of a socio-economic analysis can be used on different levels, depending on the level of application (for single assets or for maintenance projects) and should be integrated into the decision process.
- In general, the assessment of socio-economic impacts can become a complex problem and finally a complex solution. A simplified approach is recommended, which enables to use existing data, existing models, reduces the effort of implementation into an existing (or new) AMS but also helps the user to understand the calculation process and the results.

Finally, WP5 provides solutions and recommendations for the implementation process of the ISABELA solution. More details can be found in Deliverable 5.1 (Weninger-Vycudil et al, 2017).

2.4 DRaT

Duration:	01.09.2015 – 31.08.2017
Budget:	EUR 531,956
Coordinator:	Matthew Wayman, Transport Research Laboratory (TRL), UK
Partners:	The Netherlands Organization for Applied Scientific Research (TNO), The Netherlands
	Belgian Road Research Centre (BRRC), Belgium
	BAM Infra Asfalt bv, the Netherlands
	Heijmans Integrale Projecten, the Netherlands,
	The French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR), France
	Darmstadt Technical University (TUDA), Germany
	Institute of Highway Engineering (ISAC), Germany

The overall objective of DRaT (Development of the Ravelling Test) was to provide comprehensive advice and recommendations on how to refine prCEN/TS 12697-50 to be an acceptable standard.

Recently, several simulative laboratory tests have been developed that claim to give an indication of ravelling, a common mode of early failure for many types of asphalt pavement. These tests use scuffing machines that repeatedly apply a scuffing action to slab or core samples to replicate in-service loading. The test methods for four such scuffing machines have been written-up as a draft technical specification by CEN as prCEN/TS 12697-50: Resistance to scuffing. However, these methods need to be culled or combined so that there is only one test method for this one property before the technical specification can be converted into a test standard. There is a need for a direct scuffing test to assess the resistance to ravelling of asphalt mixtures, but this method needs to be a single measure that is validated against site performance and has good precision. To this end, DRaT looked at the test methods and the results produced by the four scuffing machines in order to identify:

- The extent to which sample preparation needs to be standardised, such as compaction level, evenness, storage conditions and age when tested;
- The most effective method of measurement in terms of extent of differentiation, validity as a measure of ravelling and practicality;
- Whether the results from one or more scuffing machines can be validated from experience on site;
- Whether the results from different scuffing machines can be converted to a common measure;
- Estimates of the precision of the results with each scuffing machine or if the results can be converted to a common measure;
- Whether the results from either pair of similar machines are comparable and their results are reproducible
- A procedure to identify if other scuffing machines can be used for the standard test.

Five work packages were defined in the project to achieve the aimed results, as seen in Figure 6. The project started with a review of the available literature to identify the parameters that can influence the propensity for mixtures to ravel.

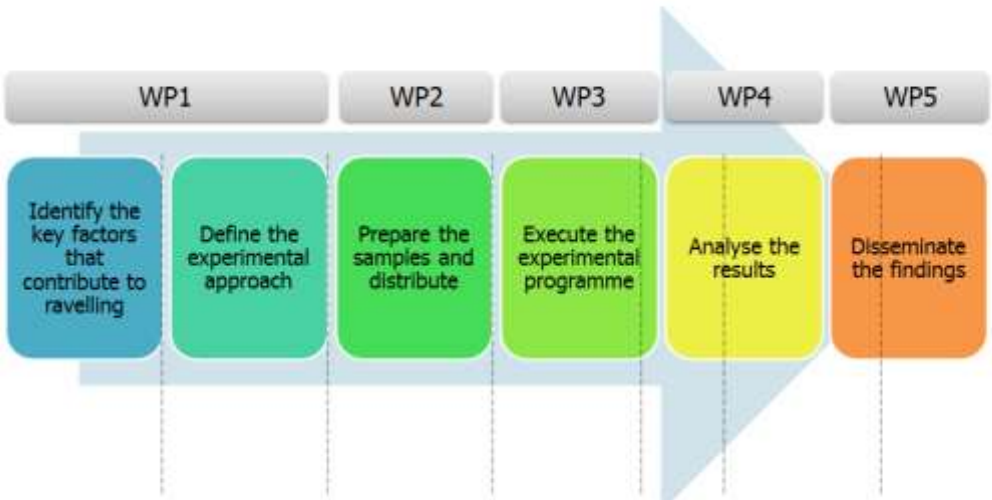


Figure 6 DRaT Work Packages

Whilst there is an acceptance of the ravelling failure mechanism and its importance, it was found that there is limited research into the subject. Nevertheless, the investigation revealed a large number of factors that affect the potential for ravelling. These factors include:

- Materials (e.g. aggregates should be clean when mixed into asphalt);
- Mix design (e.g. the binder content should be as high as practicable without causing other problems such as rutting or bleeding in order to minimize the potential for ravelling);
- Construction (e.g. asphalt that is not sufficiently hot when compacted is liable to ravel due to poor or bad compaction);
- In-situ (e.g. ravelling damage tends to be more severe during cold weather, particular in freezing conditions).

The basic strategy to minimize ravelling is to produce and lay a material that will overcome these various causes for ravelling, to apply the best possible construction practices and to use only highly resistant mixtures in zones which are subjected to very high shear stresses. For more details on the causes of the ravelling, please see Deliverable D2 (Nicholls et al, 2015).

In addition, a review of available data on the performance of various asphalt mixtures with respect to ravelling on site was performed. Three locations were investigated, in the Netherlands, Belgium and UK. The Dutch studies showed for example that the use of polymer-modified bitumen does not reduce the tendency to ravel. The Belgian trial showed that twin-layer porous asphalt is more susceptible to ravelling than more dense asphalts. Finally, the UK survey showed, among others, that higher binder contents tend to reduce ravelling. For more details, please see Deliverable D3 (Nicholls, 2016).

Based on the work in WP1, the second work package dealt with the preparation of the asphalt samples to be tested in the project. Specifically, the component materials for the mix design were chosen, the test specimens were manufactured and distributed to the relevant testing laboratories. The mixtures chosen by the consortium were:

- One porous asphalt (PA) mixture according to EN 13108-7
- One asphalt for very thin layers (BBTM) mixture according to EN 13108-2
- One stone mastic asphalt (SMA) mixture according to EN 13108-5.

Table 4 DRaT Mixes and mix variations

Mix type	Binder	Aggregate grading	1 - Reference	2 – lower compaction temperature	3 – lower binder content
PA	B70/100	0/16 mm	Compaction at 150°C 5.2 % binder	Compaction at 110°C	4.2 % binder
BBTM	B50/70	0/6 mm	Compaction at 160°C 5.6 % binder; 12-19 % air voids	Compaction at 110°C	4.6 % binder
SMA	PMB with 3 % SBS polymer	0/11 mm	Compaction at 160°C 6.8 % binder; 3 % voids; fibres	Compaction at 110°C	5.5 % binder

For each mixture, a reference and a maximum of two variations of characteristics was chosen, as seen in Table 4. The variations included degree of compaction, temperature, amount of bitumen, air voids and others. A total of 15 slabs per mix were developed in a laboratory in the Netherlands and checked in terms of flatness, density, texture and visual inspection. Lastly, they were transported to the participating laboratories with the scuffing machines in the test programme. For more details, please see Deliverable 4 (Jacobs, 2016).

The testing preparation, procedure and undertaking as well as the collection of test results occurred in WP3. Detailed instructions were provided to all the laboratories on the testing preparation requirements, conditions (temperature, load, number of cycles, measuring intervals, etc.) and the procedure for measuring scuffing as well as other related parameters such as surface temperature. Four scuffing devices (Aachener Ravelling Tester – ARTe; Darmstadt Scuffing Device – DSD; Rotating Surface Abrasion Test – RSAT; TriboRoute device – TRD) were used by six partners to execute the tests. All test data and results were reported in a report template (Excel) developed within the project. Some observations could be made based on the processing of the results (please see more details in Deliverable D7 (De Visscher, 2017):

- The reported data on density and thickness of the specimens reflected the high quality and repeatability of the slab manufacturing and compaction.
- The rate of material loss (slope of the curves) behaved differently, depending on the test device. The DSD showed an increasing rate, especially for the PA and BBTM mixtures, while RSAT showed a decreasing rate. For the other devices, the rate was more or less constant.
- The plots showed no correlations between mass loss and either density or texture. This was not surprising, as the variations in density and MTD (Mean Texture Depth) within each series of samples of the same mix were very small. The conclusion was that the repeatability of the sample manufacturing for the test program was very

good and that the mass loss measurements were not biased by differences in density and texture variations

- Visual inspection of the pictures taken from the test specimens before and after the tests did not reveal anything particular, although it is very difficult to evaluate the damage from a picture. An exact protocol for taking pictures before and after the test (same resolution, lighting, distance, angle, etc.) may improve the comparability of pictures.

The results of the round robin were statistically analysed to identify the similarities and differences between the designs of the scuffing apparatus as well as to look at correlations and precision of the results. The analyses were used to determine the variation of similar samples under near-homogeneous conditions (repeatability) of the test for the different asphalt types. Statistical techniques were employed to find potential outliers. In addition, scaling factors were calculated to convert the outcome of one device to the outcome of another device, and it was checked whether these scaling factors and the damage evolution in time per device depend on the asphalt mixture. Using the data collected for the different asphalt materials, with variation in standard ("good") and low-temperature-compaction/low-bitumen designed mixtures ("bad"), the power to detect significant differences between the test results of the scuffing devices was established. The following conclusions were drawn:

- The scuffing devices or methods cannot be used interchangeably because the devices' discrimination power for standard and poor-quality materials of the same type are not comparable.
- No single device was capable to detect all the designed differences between the standard and poor-quality materials according to the current test methods. However, per asphalt type (PA, BBTM and SMA), specific devices appeared capable in detecting the designed differences.
- The test methods have relative large geometric standard deviations (often more than 30%), but the number of slabs tested (four) provided enough potential to discriminate between poor-quality and standard materials for a large set of the tested devices.
- No uniform correlation between the devices could be found nor could their results be culled or unified for a particular performance/loading in time that would convert to one common measure.

Nevertheless, the project consortium has identified specific enhancements to the current draft of prCEN/TS 2697-50 to make a better and more unified document without rejecting any of the designs of the scuffing apparatus. For more details on the statistical analyses, as well as a version of the standard with the proposed improvements recommended, please see Deliverables D8 and D9 (Schoen et al, 2017; Nicholls et al, 2017).

2.5 BEST4ROAD

Duration: 01.06.2015 – 31.05.2017

Budget: EUR 317.324

Coordinator: Andreas Hartmann, University of Twente, The Netherlands

Partners: Deltares, the NEtherlands
University of Bath, UK
Durth Roos Consulting GmbH, Germany
Ramboll, Finland

The main objective of the BEST4ROAD project was the development of best practice guidelines and tools for the efficient procurement of road maintenance in a changing world. Based on a comprehensive and integrative framework for maintenance procurement, the project brought together the extensive yet scattered procurement knowledge and experiences of 11 National Road Authorities including the US and Australia. It determined the lessons learnt by the NRAs and based on that, developed a number of hands-on tools and step-by-step guidance for procuring road maintenance, while taking current and future challenges of NRAs into account.

Six work packages were defined, as seen in Figure 7 to deliver the following results:

- A cross-country comparison of current maintenance procurement practices at NRAs with lessons learnt and an easy to follow methodological framework to update these comparisons periodically;
- A set of maintenance procurement strategies NRAs can follow including their effects on maintenance efficiency;
- An evaluation tool for assessing the effects of procurement strategies on maintenance efficiency;
- An insightful game – Road Roles 2.0 – that will give NRAs an insight in the strategic behaviour of contractors and the effects on network condition as a result of policy changes at the NRA;
- A quick scan method for risks related to maintenance procurement strategies and measures to manage them;
- Competence profiles that are required at NRAs to follow different maintenance procurement strategies;
- A step-by-step guideline for changing maintenance procurement strategies at NRAs;
- Case examples demonstrating the implementation of maintenance procurement strategies at NRAs;

- Best practice guidelines that recommend maintenance procurement strategies, competence profiles and transition processes depending on current and future social, organisational, political and environmental drivers.

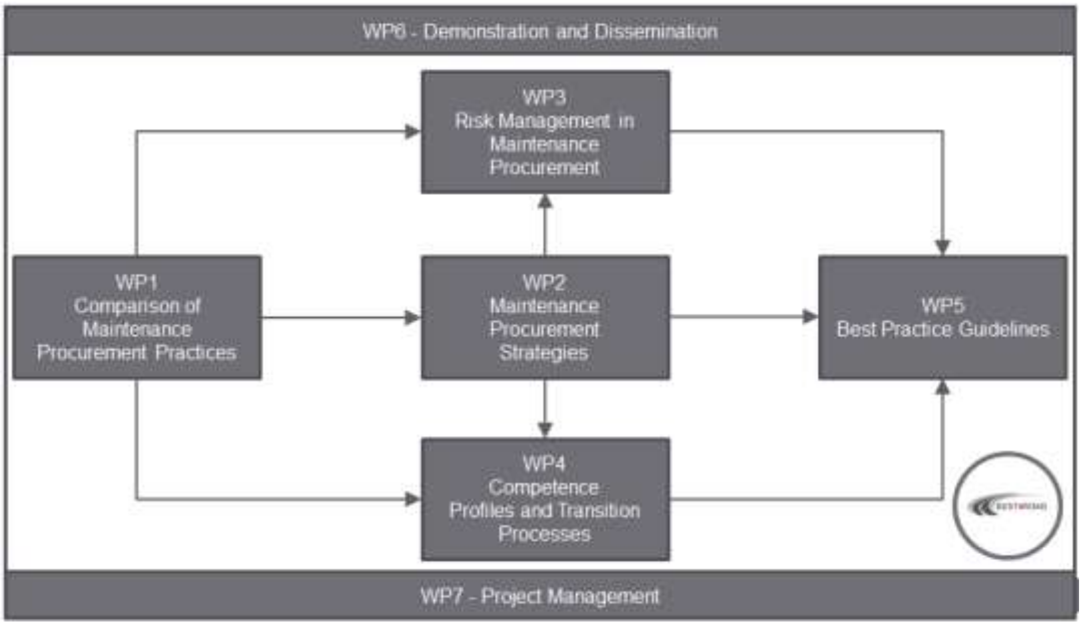


Figure 7 BEST4ROAD Work Packages

The first work package dealt with an evaluation and comparison of maintenance procurement practices of nine NRAs (through 48 interviews), to identify commonalities and differences in terms of driving factors for maintenance procurement practices, effects of maintenance procurement practices on road quality and maintenance costs, and risks experienced with current maintenance procurement practices and how they are managed. In order to study and compare maintenance procurement across different countries, a comprehensive framework was developed, describing how maintenance activities are procured, what are the drivers for these practices and more. The framework consisted of four components – (maintenance procurement) context, practice, outcomes and competences (for more details, please see Deliverable D1.1 (Hartmann et al, 2016)). The main findings of this evaluation were:

- All road authorities outsource road maintenance, but the level of outsourcing differs. Moreover, they follow different trajectories of outsourcing and integrating road maintenance. The differences can be partly explained by climate zones, infrastructure peculiarities and organisational policies;
- There are three main procurement groups. The first group is characterized by a low level of outsourcing and integration and includes Belgium and Germany. The second group shows a medium/high level of outsourcing and integration. The Netherlands, Norway and the US belong to this group. In the third group are NRAs with a high level of outsourcing and integration. These are Australia, the UK, Sweden and Finland;

- Discrete and framework contracts are used by all NRAs. Authorities have reverted to these contracts more often in recent years, since they allow more flexibility and control of the maintenance work than integrated contracts;
- The experiences with integrated contracts are mixed across road authorities. Integrated contracts can be cost-effective, but require from both NRA and contractor – the development of other competences and skills to work under these contracts;
- Procurement of road maintenance requires contractual, relational and technical competences from NRAs and contractors. All NRAs underpin the importance of technical competences for being an informed client and competent partner for the market;
- Important lessons learned by NRAs are that contracts need to have the right incentives for the contractor, the complexity of contracts needs to be reduced, contracts should have more flexibility, risks need to be appropriately allocated, relationship building between NRAs and contractors is a key success factor and outsourcing decisions should always include an assessment of the consequences for knowledge development and retention. For more details, please see Deliverables D1.2 and D1.3 (Aijö et al, 2017; Hartmann and Aijö, 2017).

The project continued in WP2 with the identification of similar practices in the different countries and the development of maintenance procurement strategies that NRAs could follow. Five such strategies were identified, from “Buy nothing”, i.e. all regular maintenance and rehabilitation tasks are performed by NRA staff, to “Buy all”, i.e. all maintenance and rehabilitation tasks are outsourced and performed by a single contractor. Considering context and consequences, three strategies reflected current procurement practice. For more details, please see Deliverable D2.4 (Hess and Hartmann, 2017).

Work package four identified the appropriate competences which are needed to develop and implement various procurement strategies by the NRAs, in order to achieve good value for money. Based on the analyses of interviews and workshops as well as reports, policy briefings and other datasets, three levels of competences were identified:

- Contractual competences (e.g. monitoring and surveillance skills, procurement and commercial knowledge, contract coordination skills, quality management skills etc.);
- Relational competences (e.g. communication skills, stakeholder management skills, understanding of roles and responsibilities, human resource management skills etc.);
- Technical competences (e.g. understanding of asset condition data, understanding of duration and costs of maintenance activities, understanding of technical peculiarities of local networks etc.).

In addition, transition processes that road administrations should follow when changing their procurement strategies were described. For more details, please see Deliverable D4.4 (Roehrich et al, 2017).

Building upon the work in WP2 and WP4, the work in WP3 developed a quick scan method for assessing risks associated with the procurement of maintenance works while taking into account the situation of the NRAs and their corporate procurement framework. The risk scan method comprises of four steps:

- Context analysis
- Procurement risk assessment
- Procurement risk mitigation
- Monitoring and evaluation.

A risk check list related to outsourced and in-house activities, performance specifications, payment mechanism, tender evaluation and others was established. Using the quick scan method, a road authority is able to identify an appropriate procurement strategy given these risks as input. More details in Deliverable D3.2 (Bles, 2017).

As a last step, the project developed best practice guidelines with recommendations of maintenance procurement strategies for typical scenarios, explaining the risks associated with each strategy, recommending measures to manage risks, presenting the competence profiles needed to implement the strategies and recommending the transition towards strategy implementation. The three scenarios were based on the procurement practices of the nine NRAs involved in the project:

- Scenario 1: Outsourcing and integration
- Scenario 2: Extreme weather and unique structures
- Scenario 3: Urban area and technology development

For each scenario, recommendations were provided for adapting the current procurement strategy and were related to contract incentives, complexity and flexibility, risk transfer, relationship building and competence development and retention.

However, it is important to note that each NRA has its own organisational history, structure and working culture. Whether and how procurement strategies should be changed depends on a number of organisational factors such as the available technical and managerial knowledge and skills, the existence of careful asset inventories, sound history and trend data on asset conditions and maintenance cost. Please see Deliverables D5.5 for more details (Hartmann, 2017).

In addition, the last technical work package included the development of a game Road Roles 2.0 that gives NRAs insights into the strategic behaviour of contractors and the effects on maintenance efficiency as a result of procurement changes at NRAs. The game is based on Road Roles 1.0 (Altamirano and de Jong, 2009). Road roles 2.0 provides knowledge on:

- The consequences of giving greater freedom to contractors and holding them responsible for the condition of a complete road network;

- The medium and long-term effects of innovative contracting practices and the impact of different incentive schemes on promoting cooperative or defecting contractors' behaviour;
- The impact of knowledge and competences on the ability of the agency to keep in control and ensure a long-term optimal performance of the road network in the most cost-effective way possible. (for more details, please see Deliverable D5.4, Altamirano, 2017)

3. Outcomes of the Final Programme Conference

At the conclusion of the Programme, a two-day conference was organised to present the results and overall conclusions of the five projects. The conference was held on 12th-13th October 2017 in Vienna, Austria. Two parallel group discussions on the five projects were carried out, with focus on three main issues:

- Highlights: What project outcomes are considered the most important?
- Implementation: How can the project outputs be implemented in NRA activities? What are the benefits and obstacles for implementation?
- Open questions: What questions remain to be solved?

3.1 PREMiUM

3.1.1 Highlights and remarks

The following remarks arose from the discussions on the PREMiUM project:

- Standards review and questionnaire responses were used to identify the key characteristics of each asset that are important to condition monitoring;
- Asset owners cannot design or implement a vigorous and effective asset management strategy if no knowledge of the most basic features and records of the assets are available. Many inventories are out of date and incomplete;
- The project team identified current traffic speed methods for some key characteristics but these need further testing and "standardisation";
- The standard review identified that in some cases there is no clear set of existing thresholds for condition monitoring;
- Three types of indicators were proposed – single performance indicators, combined indicators and asset (global) indicators:
    - Single performance indicators are calculated using measurements for individual characteristics e.g. retro-reflectivity of road markings for night-time visibility;
    - Combined indicators are calculated using two or more of the single indicators and are classified in functional, structural and durability indicators;
    - An overall indicator can be a combination of the functional, structural and durability indicators, giving an overall assessment of the condition for the equipment asset.
- Single and combined condition indicators can be used to determine likely maintenance needs;

- The results of the project could be used to set the right focus. Results clearly indicated what methods are currently practical and what is still in development. Current limitations of methods were also clearly shown.

3.1.2 Implementation steps

The successful implementation of the PREMiUM results and tool depends on multiple factors, as seen in the following observations:

- Implementation requires establishment of a monitoring condition regime
- Road administrations are able to use the results in order to understand the implications for management of equipment assets:
    - E.g. to combine inventory, maintenance need and costs, to calculate the level of budget needed to keep equipment assets in good condition;
    - E.g. to determine whether maintenance regimes are effective i.e. change in condition;
- The clear and in-depth description – with regards to the measurement methods - of what is currently possible and how mature these methods really are, was seen as the most beneficial result of the project;
- PREMIUM will be used as a reference for the implementation of monitoring regimes for the asset categories considered within the project.

3.1.3 Open questions

The following open issues remain:

- PREMiUM identified traffic speed methods that could provide inventory and condition data at traffic speed, but these methods are not widely implemented. Therefore, it is recommended that work is undertaken to assist the development and implementation of traffic speed systems, as this could rapidly allow the introduction of routine surveys on road networks;
- With increased focus on work and worker safety, the trend is to avoid manual work on roads. In this context, the implementation of traffic speed survey methods is a prerequisite for network wide monitoring regimes;
- With regard to the standardisation of inventory and condition survey methods for the asset categories investigated in PREMIUM, there is still a lot of work to be done;
- Thresholds and rating schemes currently in use in different road authorities would benefit from alignment.

3.2 ARISE

3.2.1 Highlights and remarks

The discussion on ARISE focused on the applicability of the guidance document developed in the project. Some of the key remarks include:

- The guidance document can help the NRAs to understand “why and how to implement ISO 55000”, according their needs;
- ISO 55000 identified the need to link organisational goals to asset activities;
- The guidance document is based on case studies, which have been drawn from a pool of 24 organisations across five sectors. The project team was able to successfully analyse 8 full and 1 partial case study from the energy, aviation and roads sectors;
- In addition, a bespoke cost/benefit ranking model was created and used successfully to analyse the data provided by four of the case study organisations;
- The guidance document is structured to lead asset owners and organisations at various stages of their maturity through the implementation process;
- The support document is intended for everyday use as a reference guide and supplements the ‘formal’ language used in the ISO standard;
- During the project work, it became evident that the project came at the right time, as in many interviewed organisations, the ISO 55000 became a topic of greater interest recently. Feedback from the organisations involved was that they were really in need of a guidance and practical support.

3.2.2 Implementation steps

Regarding implementation, the guidance document provides a solid and comprehensive basis:

- The guidance document is downloadable from the CEDR website (Implementation Guide for an ISO 55001 Asset Management System);
- The guidance is signposted for three common role types within road owner/operator organisations: (1) Key Policy Makers and Leaders, (2) Asset Managers and (3) Asset Operators;
- The guide goes through a systematic approach of the key activities towards identifying current asset management maturity, future demands and constraints on a road asset management system, before carrying out a gap analysis, planning and implementing change and an improvement in asset management maturity;
- The specific three key areas required in ISO 55001 are:
    - Engaging with stakeholders and understanding their needs and expectations;

  - Developing a SAMP (Strategic Asset Management Plan) which aligns with an organisation's Asset Management Policy (upwards) and its Asset Plans (downwards);
  - Certification Audit – the final stage of implementing ISO55000.
- Leaders need to understand that asset management does not focus on the asset itself only, but on the value that the asset can provide to the organization. Staff have to be aware that every member of the organisation is contributing to asset management – not only the asset managers themselves, but also HR (human resources), accounting, etc.
- Key factors for leaders to consider before implementation include governance structure, change management accountabilities, change risk process, staff awareness training, synergies with other ISO Quality Systems and benefits realisation phasing;
- Overall, the results of the project are seen as very helpful in the process of ISO certification as it gives practical implementation guidance.

3.2.3 Open questions

The following open questions remain:

- Will there be an update of the guidance documents produced in ARISE when new versions of the ISO 55000/ISO 55001 standards are published? How can it be avoided that the guidance document becomes outdated?
- Will there be an update of other standards related to the ISO 55000/ISO 55001?

3.3 ISABELA

3.3.1 Highlights and remarks

The main observations of the discussion related to the ISABELA project were:

- A collection of indicators through literature and interviews was performed, resulting in more than 100 indicators;
- It was not expected to find so much information and related projects available on this topic;
- The project is a starting point in answering what is the impact of doing asset management on the economy and what is behind social-economy in this context;
- Stakeholder requirements and expectations were grouped into four areas related to the following maintenance aspects:
  - Availability and disturbance;
  - Road safety;

   - Environment;
   - Socio-economy.
- ISABELA is a network level approach for the assessment of committed or recommended maintenance programs, considering maintenance project specifications and the potential effects of maintenance treatments on social benefits;
- The following network level S-KPIs were defined during the project:
   - Social benefit
   - Social backlog
   - Social risk
- It was found that input parameters are available for European countries;
- The model developed within the project is not too complex and can be applied in practice.

3.3.2 Implementation steps

The following implementation findings were identified:

- Socio-economic impact assessment can certainly be performed with ISABELA models and methodology in most existing AMS;
- To perform a reliable and satisfactory assessment of their maintenance policy, road authorities will have to gather more socio-economic information;
- The results of the project can be used on different levels (for single assets or for maintenance projects) and should be integrated into the decision process of NRAs;
- The implementation of the results is best suited for NRAs; nevertheless, the results could be used to formulate the KPIs that a contractor would have to fulfil. The practice has been tried in the UK, i.e. socio-economic KPIs are included in contracts and their fulfilment is considered for payment;
- In general, the assessment of maintenance programmes can become a complex issue. A simplified approach is recommended – to use existing data, existing models and help the user to understand the calculation process and the results risk;
- The availability of cost data, even if they are still estimates, was considered highly awaited and appreciated by the NRAs. The pressure to justify maintenance measures has increased and the consideration of cost-benefit analysis is gaining importance;
- Road authorities would take the results of ISABELA as input for contracts with private concessionaires to implement key performance indicators regarding environment and socio-economy for compensation, in addition to the established indicators.

3.3.3 Open questions

The following open questions remain:

- The full implementation of social aspects in the context of the assessment of maintenance investment programs is strongly dependent on the structure of the organization and how strategic targets and requirements will be used in the decision process;
- ISABELA did not review the possibilities of a full integration into the asset management processes on both levels – strategic and technical, and how the results can be used in making decisions. Especially, the comparison with social effects from non-infrastructure areas could show the full potential of the project results;
- Furthermore, ISABELA focused on four social areas only and did not give an outlook into additional areas. ISABELA should be seen as a starting point, where the different road administrations need to improve and extend the findings into a holistic social solution, which addresses the most important social questions to be answered.

3.4 DRaT

3.4.1 Highlights and remarks

The discussions regarding the DRaT project revolved around the definition of ravelling and the usability of the test devices:

- The project ensured a good cooperation of experts and laboratories in this topic;
- There was no surprise that the results were different, as the devices were different (e.g. different slopes, different wheel size, different construction, different purposes); nevertheless, the surprise was that there was no correlation found;
- The individual devices work for their intended purpose; when used for testing other mixture types, there is no best device, nor is there a universal device;
- Ravelling has become of interest in recent years when discussing durability. A potential application is that bad mixtures could be eliminated through ravelling tests executed with the devices used in the project;
- A lowlight was that no usable data was found for the validation of results; however, the scope was not to find the best machine, but rather to observe any correlation between them;
- It was considered that the samples were too “ideal” and that the mixes used in real life on the road are not that good;
- The test conditions are very important and different for the different mixes (e.g. in identical conditions, testing SMA would produce ravelling, while testing PA would produce none);

- The definition of what constitutes ravelling is very important. The project presented material loss, not only ravelling loss;
- Predicting lifetime involves a device that considers other factors. Aggregates means fatigue and this cannot be measured with only a wheel pass;
- Based on the results of the project, a new additional device could be recommended. However, what would be the added benefit? Any new devices would have to conform to most of the parameters;
- Nevertheless, for NRAs the most important point is to know when there is a need for resurfacing, irrespective of any ravelling or fretting that may have occurred on the road.

3.4.2 Implementation steps

Implementing the project results would benefit from a guidance annex:

- The project displayed different devices for different pavements – for answering different questions;
- There is some level of guidance on choosing the right method; however, this could be developed in more depth;
- A guidance for choosing between the devices, as an informative Annex to the specification would be welcomed;
- Although the scope of the project was to give an indication of the best device, the added benefit of the results is the possibility to give input to the prCEN/TS 12697-50, to be used in CEN TC 227/WG1/TG2.

3.4.3 Open questions

Open questions remain regarding taking the results of the project and bringing them to standardization:

- A standard for ravelling related tests would be great;
- How to go towards standardization? A follow-up step could be to go to CEN representatives and present the project results.

3.5 BEST4ROAD

3.5.1 Highlights and remarks

The discussion surrounding the results of the project included the following remarks:

- The project highlighted that every road authority uses some sort of practice for maintenance; even so, more interest was indicated by NRAs from the West of Europe, along with the US and Australia;
- The results of this project are very strategy- and politics-related; therefore, they should be reviewed by an expert with a higher-level position within the NRA; is the head of the road authority best suited?
- However, the insights and results gathered from the NRAs were obtained from the employees working at technical level;
- There is a need for technical knowledge – whether at the NRA level or at the contractor level. For example, in the UK – the trend is to place the expertise at the NRA level. In Australia, all the expertise was in-house in the 90s, while the trend is changing now;
- There is no best way to do it, as there is no definitive proof for an optimum method; the solution is to learn from others and to adapt the strategy to the politics, market, conditions of the individual road administration and country.

3.5.2 Implementation steps

The following observations were made regarding the implementation of the project results:

- The project provides a good overview of the possibilities that are available for maintenance procurement strategy;
- Drawbacks, advantages, consequences of applying different strategies are easily readable;
- From a maintenance point of view, specifically on a technical level, there is always the discussion of cost-benefit – when choosing your procurement strategy;
- There should be a very high correlation between procurement strategy and maintenance strategy – as road authorities could lose or save money;
- As different types of contracts stimulate innovation at different levels, a potential solution would be to have a stipulation in the contract – to bring innovation, therefore promoting innovation friendly procurement;
- A team with people with technical skills will bring innovation, while a team with procurement experts will hinder innovation.

3.5.3 Open questions

The following open questions remain:

- Who makes the decision regarding integrated contracts within the national road administrations?
- What are the improvements of having the expertise at NRA level (and not at contractor level)?
- How can we increase the cooperation between contractors?

4. Summary and final recommendations

Five projects were funded in the programme and were carried out during the period 2015-2017. Based on the previous experiences from CEDR, a Final Programme Conference was organised on 12-13th October 2017 to present the final results of the projects as well as to discuss highlights, implementation issues and open questions.

PREMiUM (Practical Road Equipment Measurement, Understanding and Management) aimed to the deliver improvements in the ability to manage road equipment specifically road markings, road signs, vehicle restraint systems and noise barriers. It accomplished its objectives by establishing the condition characteristics that should be included in an asset management strategy at network level (e.g. night-time visibility, wear, orientation, presence of damage, resistance to loads etc.), establishing existing and emerging measurement tools (e.g. LiDAR, visual inspection, in-situ techniques etc.), providing a list of parameters that could be used to assess condition and proposing a set of condition indicators (single, combined and asset indicators) for quantifying condition at network level. The results were demonstrated with a tool developed within the project that provides insight into the level of condition along a specific route. The output is an asset score between 0 and 5.

The clear and in-depth description of the measurement methods for various assets, including their availability, their potential and their maturity was seen as the most beneficial result of the project. The approach developed within PREMiUM should give NRAs the possibility to employ a more effective approach to managing equipment assets and will assist in establishing a budget and allocating it in an efficient manner.

ARISE (Application to Roads of ISO55000 using Exemplars) focused on producing guidance for national road administrations considering why and how to implement ISO55000. The project's aim was to facilitate open and practical dissemination of ISO55000 to a wide audience. The outcome was a guidance document entitled "Implementation Guide for an ISO 55001 Asset Management System", structured to lead asset owners and organizations at various stages of their maturity through the implementation process. The guidance is aimed at three roles within the NRAs: key policy makers and leaders, asset managers and asset operators. It goes through a systematic approach of the key activities towards identifying current asset management maturity, future demands and constraints on a road asset management system, before carrying out a gap analysis, planning for change, implementing change and achieving an improvement in asset management maturity.

Overall, the results of the project are seen as very helpful for the road authorities in the process of ISO certification, as it gives practical implementation guidance. The guidance document is available for download from the CEDR website (Implementation Guide for an ISO 55001 Asset Management System).

The main objective of the project ISABELA (Integration of social aspects and benefits into life-cycle asset management) was the definition of a holistic asset management framework for social key performance indicators (S-KPIs) and social benefit modelling in the form of social effects (monetary and non-monetary), social backlog and social risk. However, to perform a reliable and satisfactory socio-economic assessment of their maintenance policy, NRAs will probably have to gather more socio-economic information, i.e. parameters, coefficients adjusted to their context and to take a great care in collecting and storing their road data. For example, the availability of cost data, even if at estimate level, was considered highly awaited and appreciated by the NRAs. The pressure to justify maintenance measures has increased and the consideration of cost-benefit analysis is gaining importance.

Road authorities should take the results of ISABELA as input for contracts with private concessionaires to implement key performance indicators regarding environment and socio-economy for compensation, in addition to the established indicators.

The overall objective of DRaT (Development of the Ravelling Test) was to provide comprehensive advice and recommendations on how to refine prCEN/TS 12697-50 to be an acceptable standard. Three types of mixtures (PA, BBTM and SMA) were tested with four scuffing devices. No uniform correlation between the devices could be found nor could their results be culled or unified for a particular performance/loading in time that would convert to one common measure.

Nevertheless, the project has identified specific enhancements to the current draft of prCEN/TS 2697-50 to make a better and more unified document without rejecting any of the designs of the scuffing apparatus. It was concluded that the individual devices work for their intended purpose; when used for testing other mixture types, there is no best device, nor is there a universal device.

The main objective of the BEST4ROAD (Best Practice Guidelines for Procurement of Road Maintenance) project was the development of best practice guidelines and tools for the efficient procurement of road maintenance in a changing environment. Three typical scenarios were used to explain the risks associated with various procurement strategies, recommending measures to manage risks, presenting the competence profiles needed to implement the strategies and recommending the transition towards strategy implementation. The conclusion was that there is no best way to do it, as there is no definitive proof for an optimum method. The solution is to learn from others and to adapt the strategy to the politics, market, conditions of the individual road administration and country.

Based on the discussions and results of the Final Programme Conference, some overall observations and recommendations could be made:

- Having the right data and an optimum frequency of data collection is crucial for improving asset management and implementing any project results;
- A first step should be to analyse the real data and to define what is missing and what is already available. However, the frequency of data collection depends on the scope of the data and the type of asset;
- There is poor communication between experts and representatives of the political domain; political support is crucial in asset management. Limitations in communication exist also at NRA level, i.e. knowledge in-house.
- Outsourcing is not seen as an optimum solution by all NRAs, as the knowledge and expertise would be lost at road authority level; a solution would be to have a balance;
- All road authorities plan to implement the results of the five projects; however, more work is needed to achieve a successful implementation. Dissemination via local seminars could help spread the projects' results to a wider audience;
- The success of the CEDR 2014 Programme Asset Management and Maintenance was widely acknowledged. Lessons learned include that the quality of the work and of the project results are directly dependent on funding.

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6. Annex Call 2014 Asset Management & Maintenance - Final Conference

from October 12th to October 13th 2017

at Regus Vienna, Nineteen Workspace, Mooslackengasse 17, 1190 Vienna, Austria

Programme Day 1 – October 12th 2017

12:00 Registration & Business Lunch

13:00 Welcome and Introduction (bmvit/CEDR, FFG)

13:30 Project Presentations: **Asset management**
- ARISE
- PREMiUM
- ISABELA

15:45 Coffee Break

16:15 Project Presentations: **Maintenance**
- DRaT
- BEST4ROADS

17:30 End of Day 1

19:00 Working Dinner tbd (invitation by FFG)

Programme Day 2 – October 13th 2017

09:00 Coffee & Demonstration of results
the projects demonstrate their tools or guidelines

10:00 Group Discussion in 2 parallel sessions

a) Asset Management

b) Maintenance

To discuss:
- *Highlights*
- *Implementation*
- *Open questions*

11:30 Plenary & Summary

12:00 Business Lunch

13:00 End of Conference

Ref: CEDR Contractor Report 2018-1 (September 2018)

Call 2014: Asset Management

PREMiUM

ARISE

ISABELA

DRaT

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