CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME

Call 2021

Remote Condition Monitoring of Physical Road Assets

CEDR Transnational Road Research Programme

funded by

(countries to be confirmed)

Description of Research Needs (DoRN)

DRAFT

Draft DoRNs have no details of the potential budget or the funding countries, but they have all the necessary technical details.

Publishing DoRNs does not constitute a commitment by CEDR or any of its members to launch the corresponding research call.

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1 General Introduction

This Description of Research Needs (DoRN) relates to a Call for Proposals entitled **CEDR Transnational Road Research Programme Call 2021** launched by the Danish Road Directorate on behalf of the Conference of European Directors of Roads (CEDR). CEDR is an organisation which brings together the directors of 29 European road authorities. CEDR provides a platform for cooperation and promotion of improvements to the road system and its infrastructure, as an integral part of a sustainable transport system in Europe. The website ***www.cedr.eu*** contains a full description of its structure and activities.

CEDR recognises the importance of research in the development of sustainable transport and has established Working Groups (WGs) aimed at the analysis of relevant and specific topics of interest from an NRA perspective. Through CEDR Working Groups, CEDR members work together to identify needs for research collaboration and manage research activities.

The Governing Board of CEDR (CEDR GB) has given a mandate to relevant WGs to identify opportunities for transnational road research programmes on an annual basis. CEDR GB also requested that:

- WGs only propose suitable research topics and identifies good research proposals;
- WGs present research proposals, when appropriate, to CEDR GB for decision; CEDR GB will decide what programmes are taken forward;
- All call procedures shall be open and transparent and organisation from all European countries shall be invited to participate, with no advantages given to preferred suppliers or groups of suppliers; and
- The costs of developing and managing the transnational calls shall be supported only by those CEDR members and their partners taking part in the programme.

2 Introduction to Call 2021

The CEDR Transnational Research Road Programme is supported by CEDR to fulfil the common interests of the National Road Authority (NRA) members of CEDR. The participating NRAs in this Call are (to be determined). As in previous collaborative research programmes, the participating members will establish a Programme Executive Board (PEB) made up of experts in the topics to be covered: the PEB will act as a steering committee for the programme. The research budget will be jointly provided by the participating NRAs: the participating NRAs will also nominate the individual member of the PEB. The PEB will designate one of its members to act as PEB chair.

CEDR GB has, appointed a Programme Manager (ProgMan) to take over the administration of this Call for Proposals. For this Call, the ProgMan will be the Danish Road Directorate, Denmark. The responsibilities of the ProgMan include preparation of the Call for Proposals, financial management of the programme and setting up and managing the contracts with the research providers. These responsibilities will be conducted by the ProgMan in its country under its law and regulations. The terms under which the ProgMan and PEB will operate will be set out in a Collaboration Agreement, signed by senior representatives of each participating NRA.

Applications are invited from suitable qualified contractors in response to this Call for Proposals. There are no geographic restrictions on contractors, however project consortia must be led by a legal entity established in a European country. Individuals and organisations involved in the development or approval of the Call specification are prohibited from any involvement in proposals. Applications should 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. This will accelerate the development of faster and durable methods and techniques for road maintenance and management. It is particularly important that the results be easily implementable by road authorities across Europe, and applicants are encouraged to include case studies and demonstration projects in submissions so as to contextualise the research and illustrate the benefits of transnational collaboration.

Applications will be evaluated by the PEB in relation to:

- Extent to which the proposal meets the requirement of the DoRN
- Track record of consortium members
- Management of project
- Value for money.

Details of these evaluation criteria and how they will be interpreted and applied by the PEB are presented in the Guide for Applicants (GfA) which accompanies this Call for Proposals.

3 Aim of the Call

The aim of this Programme is to undertake research into current best practice on the remote monitoring and inspection of physical road assets and provide advice on implementing new techniques as business practice.

The primary focus of the research will be on road pavements and bridges. However, it will consider if the new approaches can also be applied to tunnels, drainage and geotechnical assets.

The outputs of the research will improve European road operators knowledge and understanding of remote asset condition monitoring and data collection to make lifecycle asset management decisions.

Furthermore, they will enable European road operators to strategically implement innovative technologies and approaches to remote asset condition monitoring and inspection, focusing on the greatest need and delivering the maximum value.

Dissemination leading to implementation is an essential part of the call.

This will result in improved and efficient asset management and maintenance activities which extend the life of assets and avoids asset failures. This will help deliver a safer, more free-flowing, more reliable and more sustainable European road network.

The expected research will build on the outcomes of earlier CEDR calls in relation to remote condition monitoring:

ERA-NET Road: Effective Asset Management Meeting Future Challenges (2010)

Call 2014: Asset Management and Maintenance

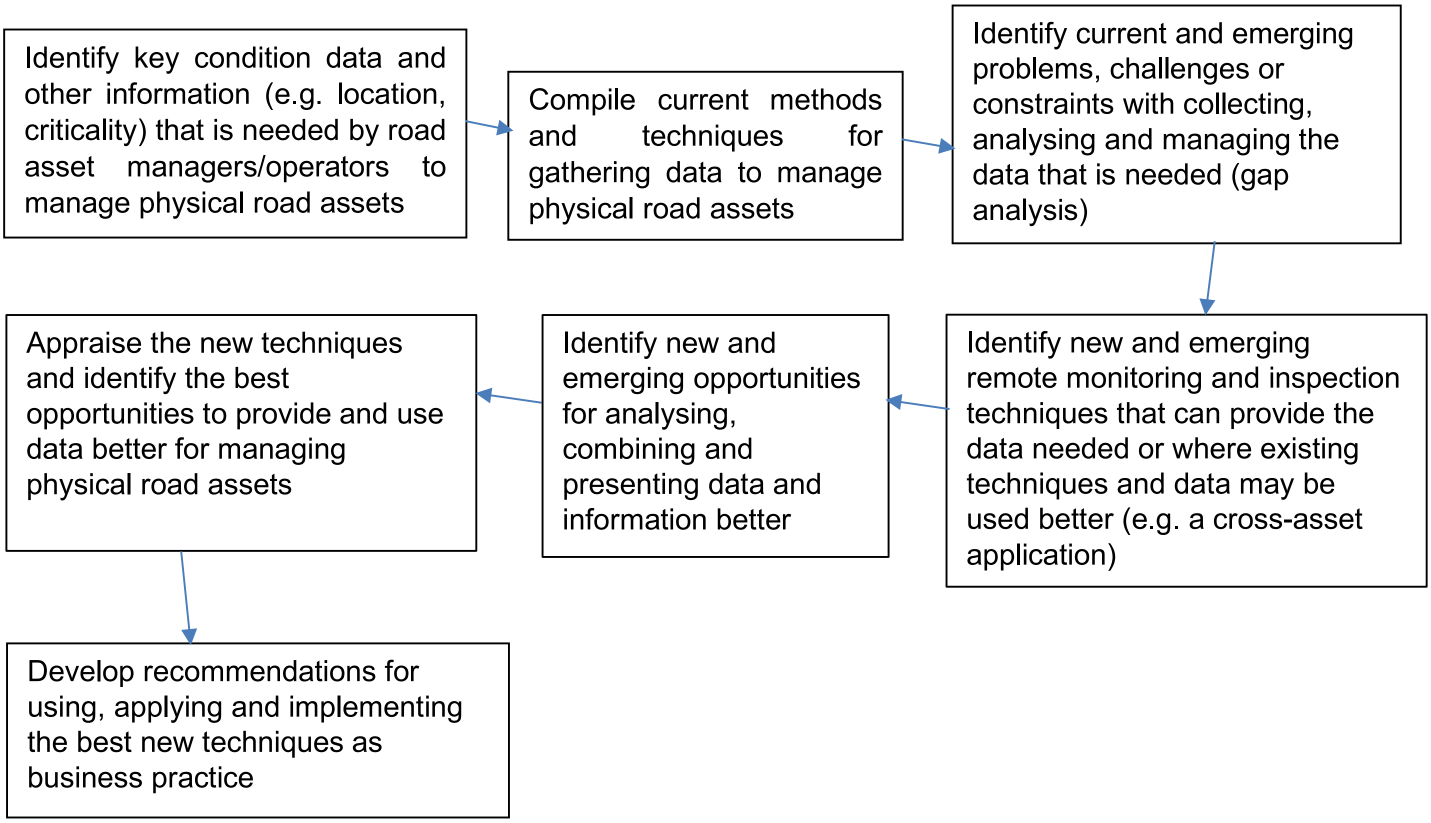
Call 2015: Asset Information Using BIM

Call 2018: Building Information Modelling

Call 2020: Impact of CAD on Safe Smart Roads

The research should also build on available best practices and research sponsored, financed or published by e.g. EU, PIARC, US-FHWA, TRB.

The research will follow these steps:



The Programme has the following phases:

a. Information needs and current practice

b. Key issues and new approaches

c. Recommendations for implementation and dissemination

In undertaking the research, the research providers will engage with relevant stakeholders including members of CEDR, road authorities, city authorities, industry partners and other infrastructure owners and operators both within the transport sector and in other industries and use their publicly available data, knowledge and experience. The data and information collected and used during the course of the research will be kept available for dissemination after the research has been concluded.

The research will also take into account European geographic differences in physical road assets and how they are managed and operated so that the outputs are applicable to all European regions and road operators.

4 Reasons for this Transnational Road Research Programme

Lack of timely information on road asset condition and performance can result in infrastructure deterioration and even lead to disruptive and catastrophic failure of road infrastructure assets.

This causes economic damage and also increases safety risks to travellers on the European strategic road network. If deterioration is not observed, the life of valuable infrastructure assets are shortened or it results in inefficient maintenance and repairs which adds to traffic disruption and increases the safety risk for both road workers and road users.
European road operators are faced with managing and maintaining ageing infrastructure assets which are vital to the wellbeing of economies, societies and individuals. Collecting information about the condition and performance of these assets is a significant challenge. Such information is critical when making decisions on how to deliver maintenance activities with reduced costs, reduced impacts on road traffic and reduced environmental impacts.

One of the largest groups of assets constituted by the road infrastructure are road pavements and bridges. These structures are subjected to different kinds of actions (load and environment related) that affect the physical integrity and consequently the performances. Relative deterioration rates are dependent on conditions such as weather, traffic volume, quality of the design, construction and materials, and age of the asset. The agencies responsible for the transport infrastructure must maintain, operate, improve, replace and preserve these assets. To accomplish this obligation, they have implemented different measurement strategies and methods capable of assessing the condition and optimizing maintenance. Anyhow, existing methods still have some limitations since they are not always i) able to provide all needed data, ii) able to access all locations and iii) economically effective. In some cases, the measurement method is used with a sampling rate lower than the rate of change in physical properties and a different application of the method might become too expensive. Some data cannot be exploited to their potential because it is not properly integrated with additional information. In addition, information and communication technology architectures may not be structured to easily accommodate new data sources and the data itself may not be validated or cleansed sufficiently to provide robust information.

The technological development is now offering a new scenario where some of these limitations can be overcome by the implementation of alternative solutions capable of providing additional information and flexible usage. In fact, the application of the Internet of Things (IoT) is believed to transform asset management towards an integrated system where conventional and innovative data sources and new uses of data become complementary.

These new solutions should help lower operating and capital costs by facilitating proactive servicing and repair of assets, while allowing the more efficient use of resources and also reducing traffic disruption.

Therefore, the research needs to explore technological solutions and data analysis approaches to:

- enable real-time remote monitoring;
- improve detection and prediction of structural failures;
- improve accessibility of information on transient physical properties.

5 Research Objectives

5.1 Phase A: Information needs and current practice

Description of Problem/Description of Research Need

Information needs

Ageing infrastructures becomes an increasing worldwide problem. Infrastructure tends to have a long life. During this period, the use will change. Road infrastructure has to deal with increasing traffic intensity, and heavier vehicles. At the same time, the structural capacity decreases due to ageing. For this reason, failure probabilities increase. Asset managers need to deal with this problem. They need an insight in the actual safety of their structures, and need a prediction on how the safety will develop. This structural evaluation and remaining life prediction can be very costly, and generally speaking are insufficiently reliable.

Data is needed to understand current and future performance of assets, to predict their life expectancy and schedule maintenance interventions to increase serviceable life. Improved understanding of asset performance can also lead to more efficient design which uses less resources.
Also, real time monitoring is becoming increasingly important to detect any distress in sub-standard structures and allows prompt intervention.

Road infrastructure comprises different asset types which require different datasets and data analysis to provide the information that road operators and asset managers need to make effective and timely decisions.

In order to effectively manage its road pavement and bridge assets, an organisation needs to gather a variety of (key performance) data. Depending on the nature of the decision that needs to be made (more general and/or on the long term and/or strategic vs. more specific and/or on the short term and/or on a project level) and depending on the specificity of each (group of) asset(s), the kind of provided information/data that needs to be provided to decision-makers should be:

- more or less accurate;
- more or less integral;
- more or less granular;
- more or less frequently updated;
- more or less quickly available and/or easy accessible.

Apart from that, regarding this subject, the provided data should always show consistency which is often not the case when provided from different sources. This important condition becomes even more pertinent when decisions need to be made over more than one (kind of) asset or when a multi/cross-asset approach is to be achieved.
The data also needs to be compatible with the data conventions, such as Object Type Libraries, used by the asset owners.

The research will identify the key information needed by road operators and asset managers to effectively manage road pavement and bridge assets and the data that is required to provide this information.

Current practice

The first step of the condition assessment and monitoring consists in setting up the inventory for road bridges and pavements. The inventory contains the identification data for each asset type, as well as the boundary conditions, geometrical and structural features. More specifically, it includes the following information: position and location data, physical and geometric description, the historical data record when available, registration and results of inspections, assessment of structural and non-structural elements using a type of damage index and finally an action programme that is generally related to regular maintenance or, in some cases, an urgent programme action. This information is collected during the first inspection and then updated each time another inspection is carried out. Inspections are the source of the real-world data that is input into the management system. It must be highlighted that the quality of the inventory is determinant of the collection of accurate data.

Within this phase the research will focus on compilation of current methods and techniques for gathering data to manage pavements and bridges. As described further in Phase B, this allows for an appraisal of those methods in regard to the needs of the asset owner for a modern and efficient management. It is expected to:

- present the state of the art for the condition assessment techniques, targeting structural and functional performance, for road pavements and bridges

- present how findings from assessment techniques are encapsulated in a kind of "key performance and damage index" which indicates the state of health of each structure and its components (if any) and how this information is linked with a strategy for further actions (urgent of future intervention, developing of concepts for optimal maintenance).

Expected Outputs

The research focus as described above would have to result in:

- Identify and collate by asset type, the key condition data and other information (e.g. location, criticality) that is needed by road asset managers/operators to manage road pavement and bridge assets
- Overview of existing methods for condition asset monitoring, with emphasis on the remote technologies.
- Overview of available applications and methods (*focusing on IoT based technology*) to identify critical infrastructure assets, their failure modes and set real-time alerts that can be applicable for an entire group of assets with similar basic characteristics.
- Present existing key performance indicators used to establish the condition of a given asset and the relative remaining lifetime.

5.2 Phase B: Key issues and new approaches

Description of Problem/Description of Research Need

Problems with collecting data (gap analysis)

Traditional inspection and survey methods can be problematic when they require important traffic restrictions. Traditional methods may also be inefficient for locations hard to survey with difficult access, for instance viaducts with high piles with foundations on steep slopes or within rivers, lakes or seas or deep pavement layers. There are also problems with collecting data due to the limitations of the technology employed and weather constraints.

As these methods are very specific and labour intensive to perform they are highly dependent on the availability of dedicated, skilled personnel. For this reason, they have a direct impact on personnel budget and/or outsourcing costs which are in most cases under a constant review and/or stress of optimization and cost savings. Complementary these methods are regularly bringing its executors into hazardous situations which is a situation that needs to be avoided.

The data that is obtained using these methods is highly subjected to the risk of human error and may contain inconsistencies and voids as a result of different individual interpretations, methods and/or conventions. In many situations the data that is manually collected needs to be typed over when not directly registered within a dedicated inspection application. These human interventions, again, come with an extra effort and a supplementary risk of error, voids and/or inconsistencies. The process of data collection with these methods therefore should also regularly be audited.

Because of the above limitations these methods are merely fit to provide data with rather limited frequency updates where a certain delay does not pose a problem. For situations when real time information is requested, probably other methods make better fit to that need.

In order to cope with the given issues, alternative sources of data and other methods of collecting data are preferable and should be used to complement the data that is collected using more traditional methods.

But, inherently, as a result of all these different data sources, that provide data in such a wide variety of consistency, integrality, granularity, accuracy, update frequency, availability,... , for an organisation it has become extremely challenging to figure out how to optimize its efforts/costs to gather data in such a way that it is suitable for use afterwards and that it benefits optimal and effective decision making. In order to gather data, a considerable part of an organisations budget and effort risks to be spent inadequate and even go to waste. Consequently, there is a risk that decisions are ineffective or wrong because they are based on flawed assumptions. These decisions, in turn, are leading to less overall performance such as non-effective or even unnecessary investments, poor operationality and missed opportunities. This leads us to the following step: how to use the collected data in the right way.

Using the output from Phase A, the research will include an analysis of the current and emerging problems, challenges and constraints with collecting the data that is essential to effectively manage road pavement and bridge assets.

Problems with using data (gap analysis)

Strategies to maintain pavement and bridges are supported by data or information collected using standard surveys or inspections. Pavement and bridge assets require continuous investments to guarantee safe driving conditions and preserve the physical integrity. To succeed with this goal, road administrators use data and inspections which are not always complying with the needs. When considering skid resistance of pavements for example, special focus is given to the initial properties while the changes in friction given by different deterioration processes or weather conditions are not always monitored by the administrator. When referring to the assessment of the structural integrity, a conservative approach is often used. In fact, a structural evaluation underestimates the remaining lifetime and possible available reserves due to uncertainties in the model (like material properties, load distributions and climate effects) but on the other hand may also neglect some actual risks related to flaws in design and execution or undetected deteriorations and defects. When referring to bridges, the following scenarios are often experienced: i) structures are being strengthened or replaced for a problem that exists only on paper or ii) structures may be regarded safe even though they are not in reality.

There is a need for data driven technologies that assess risks for the users and remaining life more accurately in a timely fashion.

Data driven technologies should be used to update and improve a-priori models that assess and predict the absolute and changing condition that affects the capacity of the asset. Data may come from any source, for instance internal or external sensors, scanning devices, statistics, etc.

Cost effective

The ambition of this research is to review and identify current and emerging practice in the use of cost effective, self-updating data driven models, such as AI (Artificial Intelligence) technologies to reduce uncertainties in existing models and to detect anomalies (unexpected deviations from the model). These models should be as simple as possible, but as precise as needed, with a potential to be used for large scale infrastructure-stock evaluations.

Contribution to data driven Asset Management

This project should also contribute to demonstrate a more data driven approach to Asset Management. It should demonstrate how distributed data can be combined in an automated manner to support Asset Management.

Representation

Part of data driven Asset Management is the representation layer. This project should contribute to the development of digital twins / predictive twins for infrastructure. In a digital twin / predictive twin for infrastructure, data and models feed data to a 3D representation in a user-friendly manner.

For existing infrastructure, simple representations like 3D GIS models, wire-frame models, and scanning models are often used for simplified representation, since the production of full scale BIM-models is much too expensive. For this reason, representation of data and model outcomes in a digital twin or predictive twin should not rely primarily on the use of detailed BIM-models.

Integration of data / data architecture

Introducing new data sources (whether from sensors, crowd-sources, or models), and combination thereof with existing data sources, can create implementation issues that need to be dealt with. There are new interfaces with existing systems and integration issues with existing datasets. New data may be complementary or contradictory to existing data, so data validation becomes more important, especially because the amount of available data increases significantly. Simply assessing the new data by expert judgement becomes increasingly difficult and time consuming. Therefore, proper data validation and integration is needed, and consequently a data infrastructure and a revised architecture of the database system where standard data and new sources are integrated.

Examples

Typical variables for pavements are:

- Load bearing capacity
- Material properties
- Layer thicknesses
- transient physical properties
- Friction
- Cracks, potholes and other surface defects
- Transversal and longitudinal unevenness (Rutting and International Roughness Index)

Typical variables for bridges are:

- Load history and load distribution;
- Strength and other material properties;
- Stress distribution
- Displacements
- Deformations or cracks;
- Hidden loss of strength and reduction of redundancy

Using the output from Phase A, the research will include an analysis of the current and emerging problems, challenges and constraints with integrating, managing and using data that is needed to effectively manage road pavement and bridge assets.

New remote asset monitoring and inspection approaches

As mentioned above, the existing and commercialized methods for condition assessment and monitoring present several limitations. Other methods, which are currently in testing phase or used for scientific purposes can be more promising. Such methods should allow for remote condition assessment and monitoring of the road asset. They should guarantee a standard quality for repeated operations and reliable results.

Concerning inspections and surveys, the question of reliability should be resolved by using machine learning and algorithms that handle out with the problematic of lighting and shadow changes.

In such a way, human error is minimized and the expert's knowledge is not lost but rather maintained by being integrated in the machine learning procedure. In certain cases, as when detecting cracks patterns, crack openings, vertical and horizontal deformation, it should be possible to proceed to an appraisal of the deterioration both of the functionality and of the structural performance related to the aforementioned findings. Such a method is the digital image correlation that enables to provide performance indicators under continuous observation.

New technologies should be sought for remote condition and structural monitoring that obtain and effectively use the data essential for managing road assets.

The principal difficulty with adding new monitoring systems is that they can produce a vast quantity of data. Therefore, there is a need to manage this additional data effectively. For instance, bridge operators cannot make the best use of this data unless there is a very clear definition of both the trigger levels for the data and interventions for how to proceed if these levels are exceeded. This means that the structural engineer needs to identify what the most likely deterioration mechanisms are for the particular instrumented object.

Instruments such as strain gauges, accelerometers, fibre-optic sensors and displacement transducers are common in structural-health monitoring. These types of sensor can however possess drawbacks such as the need for external power, cabling and antenna for data collection and transmission, high data-acquisition channel counts and the limitation of only measuring at discrete points or along a line, so it is necessary to have an idea of where to expect damage and where not so instrumentation is installed on (a) representative location(s). These sensors can be used effectively to continuously monitor for abnormalities that indicate damage, but the type and severity of the damage can still be difficult to identify from discrete point measurements.

There is therefore a need to target what new data is obtained in order to add essential data where it is missing and avoid collecting unnecessary data so that the effort is proportionate to the risk being managed.

Other remote technologies can constitute interesting alternatives. The aforementioned method of digital image correlation can be useful not only for the condition assessment but also for remote structural monitoring. It represents a photogrammetry technique that is used to make accurate measurements of surface deformation. The digitized images (e.g. of a bridge deck) are compared in order to match facets from one image with another by using an image correlation algorithm. The image analysis involves capturing a reference image of a bridge component surface in its un-deformed state. As the load is applied (e.g. a truck load), additional images are collected. Another remote technology for structural monitoring consists the video camera based motion magnification. With the availability of inexpensive yet high quality data from digital cameras structural movements and vibrations can be captured, while fundamental frequencies can be calculated by using algorithms that are developed for this purpose.

New technologies for remote monitoring should also include methods that collect data from mobile sources such as sensors embodied in vehicles, crowd sourced data from mobile devices and road user feedback, which may give us information about displacements, accelerations, temperature and other.

The research will consider approaches and techniques used by road operators and other infrastructure owners and operators both within the transport sector and in other industries.

The research will identify new and emerging remote monitoring and inspection techniques that can better provide the data needed by asset managers or where existing techniques and data may be used better (e.g. a cross-asset approach).

It will also identify new and emerging opportunities for analysing, combining and presenting data and information better.

The primary focus of the research will be on road pavements and bridges. However, it will consider if the new approaches can also be applied to tunnels, drainage and geotechnical assets.

Appraisal of new approaches and identification of best opportunities

As discussed in Phase A, condition data and other information (e.g. location, criticality) is needed by road asset managers and road operators to effectively manage physical road assets. Data is needed to understand the current and future performance of assets, to predict their life expectancy and schedule maintenance interventions to increase serviceable life.

Improved understanding of asset performance can also lead to more efficient design which uses less resources.

However, it is becoming increasingly difficult to safely access assets to undertake inspections and gather data. And more frequent extreme weather events and increasing traffic loads are creating more asset defects and failures.

Road infrastructure is large, complex, and includes a wide variety of assets of varying size, age and complexity which exist in differing environments. Each asset presents unique maintenance challenges and access issues, and has critical dependencies with other asset types. Road assets are also continuously growing, being improved, renewed and maintained.

The internet of things (IoT), new technologies and innovations are providing the opportunities to better understand, in real-time, the condition and performance of road assets without the need for human inspections. However, road infrastructure comprises different asset types which require different datasets, sensors, monitoring technologies and data analysis.

Many examples of innovative technologies are already in place but in many cases, the use of technology is opportunistic and solution driven.

The right sensors need to be used that are durable, reliable and cost-effective. Factors such as ease of installation and retro-fitting, power consumption, communication requirements, data storage capabilities and longevity need to be considered.

Management of assets not only depends on collecting data but also on effectively turning this data into information and presenting it in a way that enables the right decisions to be made. The pre-existing condition of assets needs to be understood together with the trigger levels for intervention.
Use of machine learning, artificial intelligence, augmented and virtual reality is increasing. Data quality can be improved by more robust assurance and audit. Interfaces with inventory and condition data can be improved. Data retention and analysis can now be done in ‘the cloud’ (accessing servers and computer services on-demand and via the internet). Machine learning and statistical analysis can be applied to data to more effectively deduce trends and predict outcomes

There is therefore a need to take a more strategic view of the use of remote monitoring technology, and associated data analysis and management techniques. There needs to be focus on areas of greater need and adopting solutions that maximise benefit and value.

The research will undertake an appraisal of the new and emerging remote monitoring and inspection and data analysis techniques identified above in order to compare them and identify the priority applications. This will include comparison of possible techniques to identify which ones provide the most value for least cost in terms of providing sufficient data proportionate to the need, are easily deployable and have a wide application.

It will take into account, assess and build on the results of relevant, recent and ongoing research, innovation and best practice in this field at the national, European and wider levels (but without repeating work that has already been done).

It will also take into account European geographic differences in physical road assets and how they are managed and operated so that the outputs are applicable to all regions and road operators.

The research should achieve the outcomes of improving European road operators' knowledge and understanding of new and emerging remote condition monitoring and inspection of road pavement and bridge assets by undertaking the following:

- It will consider and use the data, knowledge and experience of relevant stakeholders including road authorities, city authorities, industry partners and other transport infrastructure owners and operators such as rail as well as other relevant sectors such as utilities and oil and gas.
- Include an analysis of gaps in current data provision and use in direct relation to different kinds of assets and at the same time related to the needs of the kind of decision that needs to be made about (a group of (interreacting)) assets
- Identify and review new and emerging approaches, techniques and technology that can be applied to remote monitoring and inspection of physical road assets
- Investigate and identify the capabilities, constraints, costs, benefits and performance of new and emerging sensing, detection and monitoring technologies for each asset type and different locations
- Investigate and identify the capabilities, constraints, costs, benefits and performance of new and emerging data analysis technologies and approaches for each asset type and different locations
- Appraise these new techniques and approaches and identify the best opportunities to provide and use data better for the management of physical road assets.

The research should achieve the outcomes of improving European road operators' knowledge and understanding of data driven safety evaluation and prediction as a part of data driven Asset Management:

- Investigating methodologies for data driven updating of structural models;
- Investigating the needed level of detail for these sort of evaluations in order to facilitate large scale usage;
- Investigation and design of data driven model updating for structural safety assessment and prediction;
- Investigation and design of data acquisition structure;
- Investigation and design of representation layer.

Expected Outputs

The research will result in the following expected outputs:

- An overview of gaps in data provision and an overview of how to meet these gaps
- An overview of gaps in data management and analysis and an overview of how to meet these gaps
- An overview of new and emerging sensing, detection and monitoring technologies and data analysis technologies and approaches
- An analysis of which apparently non-relating data (sets) could be used in a complementary way to generate new useful information or fill out other gaps in above mentioned data needs

- Appraisal and ranking methodology that considers performance information, such as data quality, reliability, frequency and latency, considers ease of installation and replacement, considers whole life costs and benefits and the added value achieved by the new techniques in comparison with currently used condition monitoring approaches
- Assessment of existing and new data integration, validation and representation techniques combining the added data sources with the existing data, into a comprehensive asset management decision support system
- Assessing data architecture and ICT requirements consequences as a result of introducing the new data sources
- Description of existing and new standards useful for integrating remote monitoring data into the process of physical road management
- Ranking of new and emerging sensing, detection and monitoring technologies and data analysis technologies and approaches which can be used as input to Phase C.

5.3 Phase C: Recommendations for implementation and dissemination

Description of Problem/Description of Research Need

As discussed in Part 3, the aim of this Programme is to undertake research into current best practice on the remote monitoring and inspection of physical road assets and provide advice on implementing new techniques as business practice so that European road operators can strategically implement innovative technologies and approaches to remote asset condition monitoring and inspection, focusing on the greatest need and delivering the maximum value.

Therefore, presenting and disseminating the results and outputs of this research in order to facilitate implementation is an essential part of the programme.

The research will focus on ways of increasing knowledge of and use of new and emerging approaches to remote monitoring and inspection of physical road assets by national road authorities and their supply chains.

The primary focus of the research will be on road pavements and bridges. However, it will consider if the new approaches can also be applied to tunnels, drainage and geotechnical assets.

As part of the dissemination and implementation plan, the research will deliver technical and financial requirements for demonstrator or showcase projects for the most promising new and emerging remote monitoring approaches and technologies which, subject to the agreement of any 3rd parties involved, could be delivered as part of the implementation of the results of the research.

It should be noted that no discussions with NRAs who may host such demonstrator or showcase projects can take place prior to the submission of bids as this will invalidate any submission. However, discussions may take place with interested NRAs once the research is awarded. Therefore, bids should include indicative costs and technical requirements for such projects. It should be noted that the indicative costs do not form part of the payment schedule of the submission but are to be used to inform a subsequent showcase or demonstrator project.

It will consider and use the knowledge and experience of relevant stakeholders including road authorities, city authorities, industry partners and other infrastructure owners and operators both within the transport sector and in other industries.

It will also take into account European geographic differences in physical road assets and how they are managed and operated so that the outputs are applicable to all regions and road operators.

In developing the outputs of the research, preference should be given to the use of open source software which provides visibility of the coding. If applicable software is not open source, then demonstration versions of software should be provided, where available, to enable NRAs to understand their use.

In undertaking the research, any costs associated with the use of software should be included in the payment schedule of the submission.

If it is useful for software to be made available to enable NRAs to implement the outputs of the research, then the licensing and any other costs for doing so, for a period of 1 year after the completion of the research, should be presented as an additional option in the financial submission.

Taking into account the outputs from Phases A and B, the research will include consideration of the needs of road operators and asset managers, the knowledge gaps that currently exist, new and emerging techniques within the transportation and other sectors, appraisal of these techniques and strategies for their implementation.

The research should achieve the outcomes of:

- Gathering and collating knowledge and best practice on new and emerging remote road asset monitoring and inspection approaches and techniques

- Effectively sharing and embedding knowledge and best practice in road operators and supply chains to increase the deployment and management of new and emerging remote road asset monitoring and inspection approaches and techniques.

Expected Outputs

The research will result in the following expected outputs:

- Key deployment strategies and business cases tailored to different European situations

- Technical best practice guidelines, with case studies and reference to appropriate design standards and specifications, containing a priority strategy for organisations to organise data gathering activities in a cost-effective way to improve business performance

- Advice on draft standards/conventions/protocols that need to be developed

- Recommendations on the expertise and training needed to implement these measures

- A dissemination and implementation plan drawing upon the outputs of Phases A and B including requirements and indicative costs for showcase projects/demonstrators.

6 Overview of current and previous activities

A general overview of current and existing relevant research projects undertaken across Europe and other sources of information are outlined in Appendix A. These resources and subsequent reports will provide the starting point for proposals submitted in response to this Call and proposals will be evaluated on this basis. **Applicants must not duplicate existing results or ongoing projects and should inform the tenderer of any similar proposals currently under submission for funding by other publicly funded calls.** Proposals should be based on the outcomes and state-of-the-art identified in these projects listed below. Failure to take account of available research conclusions or notify the evaluators of similar proposals submitted to other funding schemes will disqualify proposals from this call or lead to termination of an awarded contract.

7 Additional information

The aim of this Transnational Road Research Programme is to provide applied research services for the benefit of national road administrations in Europe. The Call is open to any contractor but lead entities must be established in Europe. Applications using the templates provided must be submitted by the applicant.

The expected duration of this programme is 36 months. The target dates within this programme are as outlined in the Guide for Applicants.

The duration for individual projects can be up to 24 months within the programme timescale and commensurate with the tasks envisaged.

The programme language is English: only proposals submitted exclusively in English are acceptable.

The research budget provided by the participating national road authorities for this research programme is (to be determined).

Please refer to the Guide for Applicants (GfA) for full details of how to submit proposals in response to this Call. Submissions using the templates provided must be made electronically using the (system to be specified by Programme Manager). Submissions received after the deadline cannot be considered.

Appendix A: Existing projects and resources

Europe wide

CEDR

ERA-NET Road: Effective Asset Management Meeting Future Challenges (2010)

https://www.cedr.eu/call-2010-effective-asset-management-meeting-future-challenges

Call 2014: Asset Management and Maintenance

https://www.cedr.eu/peb-research-call-2014-asset-management-and-maintenance

Call 2015: Asset Information Using BIM

https://www.cedr.eu/peb-research-call-2015-asset-information-using-bim

Call 2018: Building Information Modelling

https://www.cedr.eu/peb-research-call-2018-bim

Call 2020: Impact of CAD on Safe Smart Roads

https://www.cedr.eu/peb-call-2020-impact-of-cad-on-safe-smart-roads

European Union

Research and innovation in bridge maintenance, inspection and monitoring, science for policy report, Joint Research Centre (JRC), European Commission, ISBN 978-92-76-03379-0
https://publications.jrc.ec.europa.eu/repository/handle/JRC115319

AEROBI, AErial RObotic System for In-Depth Bridge Inspection by Contact, https://www.aerobi.eu/

MITICA, Monitoring Transport Infrastructures with Connected and Automated Vehicles

https://www.researchgate.net/project/MITICA-MonItoring-Transport-Infrastructures-with-Connected-and-Automated-Vehicles

PANOPTIS, Development of a Decision Support System for increasing the Resilience of Transportation Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools

http://www.panoptis.eu/

FEHRL

TRIMM, Tomorrow's Road Infrastructure Monitoring and Management

http://trimm.fehrl.org/

BD-Pave, Big Data for smart pavement management

https://www.bdpave.eu/

World wide

PIARC

Innovative approaches to asset management. PIARC Technical report 2019R19EN, ISBN 978-2-84060-541-6

https://www.piarc.org/en/order-library/31221-en-Innovative%20Approaches%20to%20Asset%20Management

Inspections and damage assessment techniques – Case Studies, PIARC Technical report 2018CS01EN, ISBN

https://www.piarc.org/en/order-library/29480-en-Inspections%20and%20Damage%20Assessment%20Techniques%20-%20Case%20Studies

State of the art in monitoring road condition and road / vehicle interaction, PIARC Technical report 2019R14EN, ISBN 978-84060-530-0

https://www.piarc.org/en/order-library/30891-en-State%20of%20the%20Art%20in%20Monitoring%20Road%20Condition%20and%20Road%20/%20Vehicle%20Interaction

The Use of Unmanned Aerial Systems for Road Infrastructure, PIARC Technical report 2018SP03

https://www.piarc.org/en/order-library/29470-en-The%20Use%20of%20Unmanned%20Aerial%20Systems%20for%20Road%20Infrastructure

USA, MIT Senseable City Lab 2, Good Vibrations

Good Vibrations

National programmes

Swiss Federal Roads Office, Structural Identification for Condition Assessment of Swiss Bridges, Juin 2015,

https://www.mobilityplatform.ch/fr/research-data-shop/product/666

Highways England Geotechnical Monitoring Selector, useful links: https://he-monitoring-selector.ilg.arup.com/links

Highways England, WP 1-086(PPRO 4/45/12) - Application of Remote Survey Data for Geotechnical Asset Condition & Performance, Phase 1 report:

https://s3.eu-west-2.amazonaws.com/assets.highwaysengland.co.uk/specialist-information/knowledge-compendium/2016-17/Application+of+Remote+Survey+Data+for+Geotechnical+Asset+Condition+and+peformance.pdf

Highways England, WP 1-086(PPRO 4/45/12) - Application of Remote Survey Data for Geotechnical Asset Condition & Performance, Phase 2 report:

https://s3.eu-west-2.amazonaws.com/assets.highwaysengland.co.uk/specialist-information/knowledge-compendium/2016-17/Application+of+remote+survey+data+for+geotechnical+asset+condition+and+performance++2+Report+v4.0_with+appendices.pdf

Danish Road Directorate, LiRA, Live Road Assessment

https://lira-project.dk/