INFRACOMS Appraisal Toolkit for NRAs to Assess Emerging Technologies in Bridge and Pavement Management

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Abstract. National Road Authorities (NRAs) draw on a wide range of technologies and tools to support robust decisions on asset maintenance. However, in recent years there has been significant progress in the development of sensing technologies for data collection and advanced techniques for data processing. These technologies present an opportunity to improve asset management decisions, but also present a challenge for NRAs, as they seek to realise the benefits. This contribution presents the appraisal methodology for emerging technologies proposed by the INFRACOMS project commissioned by the Conference of European Directors of Roads (CEDR). The methodology provides objective appraisals since technologies are scrutinised against proposed subsequent criteria. Cost factors, potential benefit categories and limitations are identified. Technologies are ranked by key imperatives and scored. Technologies with a good score are evaluated more thoroughly, which may need specialist input and discussions with the technology supplier. It results in a technical score, a benefit/cost assessment and identified steps in a roadmap toward implementation. The NRAs can share their individual appraisals in a database. The second part of the project develops an action plan to guide NRAs in adapting and implementing promising emerging technologies and training sessions on the use of the developed appraisal toolkit.

Keywords: Monitoring Data · Digitalisation · Sustainability · Asset Maintenance Management · Asset Condition Data · New Technologies

1   Context at European NRAs and the INFRACOMS Project

The application of consistent, reliable information is a key component of highway asset management. The information and the tools to help interpret and apply data have continuously evolved. However, NRAs are not yet fully exploiting their potential in the highway environment. By bringing these components of sensing and measurement together, NRAs could better understand highway assets and improve both reactive and proactive asset management decisions.

The project "Innovative & Future-proof Road Asset Condition Monitoring Systems" (INFRACOMS) is a CEDR Transnational Road Research Programme Call 2021 project (July 2022 – June 2024), see also at web pages: [1, 2]. It aims to empower NRAs to effectively leverage technological advancements in data/monitoring.

The first action in the project consisted in identifying the information needs, gaps, and priorities of NRAs in terms of their approach to data collection and monitoring, and a list of current and emerging measurement technologies. This was reported in [3].

Commonly used appraisal methodologies that can be used to evaluate the effectiveness, suitability, and potential impact of new technologies for an organisation include Technology Readiness Levels (TRLs), Cost Benefit Analysis (CBA), Life Cycle Cost Analysis (LCCA), Risk Assessment, and Multi-Criteria Decision Analysis (MCDA). Elements of these commonly used methodologies are included in the INFRACOMS appraisal methodology.

The INFRACOMS appraisal methodology described here is designed around the technology use case, that is, a particular application of a technology by an NRA. It also includes processes for NRAs to define their strategic and technical priorities so that the appraisal process can be tailored to addressing their individual requirements, as identified in the first action of the project. Some technologies may have more than one technology use case within an NRA. Each technology use case should be subject to a separate appraisal, as their costs and benefits, risks and limitations will be different. The methodology was designed and fine-tuned by applying it to several examples of emerging technologies. INFRACOMS will ultimately deliver a Technology Database and a Technology Appraisal Toolkit to CEDR. The database will comprise appraisals and will be the subject of a future publication.

2   Core Processes of the INFRACOMS Appraisal Methodology

The proposed INFRACOMS appraisal methodology is presented in Fig. 1. The processes shown in orange boxes represent the core components of an INFRACOMS appraisal. The blue boxes are filtering and prioritisation processes, representing the ways in which the methodology can be tailored to individual NRAs.

An INFRACOMS appraisal has three (3) core processes, with increasing levels of detail and complexity: a Pre-Evaluation, an Evaluation, and a Case Study. These core processes apply at the level of where the technology can be applied: a specific "use case". Although the appraisal focusses on a specific technology use case, the Pre-Evaluation and Evaluation stages are still considered generic, and would be useful to any NRA considering applying that technology in a broadly similar use case. Case Studies are
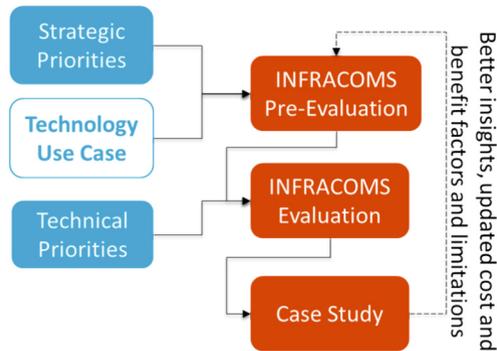
Fig. 1. The Technology Use Case oriented INFRACOMS appraisal methodology.

normally conducted with an individual NRA and more focused, and with use of CBA, LCCA and Risk Assessment criteria for that specific NRA. Shared completed Case Studies will provide valuable insights for other NRAs interested in evaluating that (or similar) technology.

Both the pre-evaluation and evaluation processes also consider the strategic and technical priorities of the NRA. Strategic Priorities must be established by the NRA with respect to the key imperatives that the NRA wishes to address using emerging technology. Four key imperatives were established in the first action of the project [3, 4]: safety, environment, socio-economic, and availability. Technical Priorities must be established by the NRA to define its technical priorities with respect to the capabilities for use and integration of technology. Four key components that that were identified [3, 4] for use in a technical evaluation are: the need for associated data analysis, ease of data visualisation, potential for improvement in decision-making, and ease of data integration. The ranking between these priorities may differ for different NRAs. A technology may be less relevant for an NRA when it does not address any of the priorities.

3 Pre-evaluation

The pre-evaluation process is a high-level analysis of the anticipated benefits, limitations and costs, and an assessment of the readiness level of the technology for a particular use case, based on readily available information about the technology such as supplier's (promotional) material. It also scores the technology for the particular use case against the key imperatives of the NRA. Pre-evaluation should be accomplished quite quickly). It would require general knowledge of technologies and their applications, and an understanding of the potential applications by the NRA.

3.1 Pre-evaluation Appraisal

An overview of the technology is made which includes descriptive text of the overall system from collection to delivery, supported with diagrams, a description of the underlying technologies, and the potential use case in a roads agency. A high-level assessment

is to be made of anticipated cost factors, benefits and limitations for the technology when applied in the proposed technology use case.

3.2 Pre-evaluation Readiness Level

Pre-evaluation includes an assessment of the readiness level of the technology for the proposed technology case from the supplier's perspective, using the generic TRL scale adopted by the European Commission and introduced in EU funded projects in 2020 as the point of reference for determining the development or maturity of a research and its readiness for market uptake and potential investment.

3.3 Pre-evaluation Score

The pre-evaluation also provides a scoring of the technology use case against the key imperatives of the NRA. This is a simple ranking to identify which of the strategic priorities is addressed by the technology (rank of 1 for main priority, to 4 for lowest priority addressed by the technology).

4 Evaluation

The evaluation process is a more detailed breakdown of the benefits, limitations, and cost factors of the technology within the proposed use case, including a more in-depth technical evaluation and an assessment of the steps needed that would be required to implement it in an NRA. It provides an assessment of the readiness level of the technology from the NRA's perspective. Evaluation will certainly take longer to accomplish than the pre-evaluation. It would require input from a specialist or expert in the field, and discussion with the supplier of the technology, to gain a full understanding of the technology and its potential application for a NRA.

4.1 Appraisal of the Technology

The evaluation builds on the expectation that the proposed technology use case is associated with an existing decision-making process in the NRA, and this new technology is being evaluated as a potential replacement for (or improvement to) the technology or data that supports this decision-making process.

The INFRACOMS methodology provides a canvas for the appraisal. It must describe where/how the technology could contribute to improved operation of the network. It must describe the new data collection method and any opportunities for enhancement of the existing process. It must provide a more detailed analysis of the cost factors, benefit categories and limitations of the technology use case than in the pre-evaluation step.

4.2 Scoring of the Technology

In addition to the in-depth evaluation of the technology use case, INFRACOMS includes a simple scoring mechanism to allow comparison of technologies. Four components are given a score from 1 (poor) to 5 (excellent): data analysis associated to the technology, data visualisation, its potential for practical decision-making, and ease of data integration. Before scoring, a description of the technology must be made according to a predefined format. The scoring is guided by predefined matrices with standard questions, where the answers to the questions should be available in the description of the technology. This process is detailed and illustrated on examples in [5], available on the website of the INFRACOMS project ([2]).

A radar diagram where each 'spoke' represents the technical score for a component provides a concise interpretation of the strengths and weaknesses of the technology in each of the technical evaluation areas.

4.3 Roadmap

Evaluation also includes an assessment of the steps needed that would be required to implement the technology (for the identified technology use case) in an NRA. These can include significant amount of detail depending on the technology being evaluated, the maturity level of the technology, and the technology use case.

4.4 Summary Evaluation: INFRACOMS Readiness Levels

Finally, a summary evaluation is made of the readiness level of the technology from an NRA perspective (as opposed to the supplier perspective in the pre-evaluation) for the proposed technology use case. The INFRACOMS Readiness Level have been based on the Readiness Levels defined by Transport Infrastructure Ireland (TII) [6]. The INFRACOMS Readiness Levels (see Table 1) emphasize the use and deployment for an infrastructure authority and for the use case under consideration.

Table 1. INFRACOMS Readiness Levels for a particular use and deployment of a technology.

IRL	Description
9	Proven Solution Deployment
8	System Level Production Verification
7	Pre-Production Controlled demonstration
6	System Based Representative Testing
5	Isolated Representative Testing
4	Laboratory Testing
3	Research and Validation
2	Applied Research
1	Concept Exploration / Fundamental Research

5 Case Study

A Case Study involves a comprehensive analysis of a fully implemented technology within a specific NRA context. The specific inputs required for the study will vary depending on the technology and use case under assessment, potentially taking several weeks to gather all necessary information. It encompasses details about the employed technology, project structure, implementation location, and the NRA's experiences regarding benefits, challenges, and costs. Collaboration and discussions between the technology provider and the NRA are crucial to obtaining the information and gaining insights in the full implementation of the technology. The INFRACOMS pre-evaluation and evaluation stages already identify cost factors for inclusion in CBA and LCCA. The case study findings, such as additional cost factors or benefit categories, will be used to update the pre-evaluation and evaluation stages.

6 Conclusion

In conclusion, the INFRACOMS project commissioned by CEDR aims to equip NRAs with the capability to leverage emerging technologies in data monitoring. The project has developed an appraisal methodology that includes pre-evaluation, evaluation, and case study processes. These processes allow NRAs to assess the effectiveness, suitability, and potential impact of new technologies based on their specific needs. By utilizing the INFRACOMS methodology, NRAs can make informed decisions on adopting emerging technologies, leading to improved asset management and better decision-making processes. The project will provide a Technology Database and Appraisal Toolkit to guide NRAs in implementing promising technologies and offer training sessions for their use.

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