



INFRACOMS TOOLBOX FOR NRAS TO LEVERAGE TECHNOLOGICAL EVOLUTIONS FOR BRIDGE AND PAVEMENT MONITORING AND MAINTENANCE

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Abstract

National Road Authorities (NRA) draw on a wide range of technologies and tools to support decisions on asset maintenance. Recently, there has been significant progress in developing sensing technologies for data collection and advanced techniques for data processing. While these technologies present an opportunity to improve asset management decisions, they also challenge NRAs as they seek to realise the benefits. The INFRACOMS project, commissioned by Conference of European Directors of Roads (CEDR), aims to understand current and emerging remote asset condition monitoring and data collection techniques to enable European NRAs to implement such technologies and approaches as standard practice. The project focuses on carriageways and bridges. INFRACOMS has developed an openly accessible Technology Database that identifies and provides an appraisal of the technical capability of current and emerging remote monitoring technologies showing potential to fill a previously identified gap in the bridge or carriageways management processes. A flexible, sustainable, and future-proofed appraisal toolkit is developed, enabling NRAs to continue to appraise emerging technologies and add them to the database. INFRACOMS has also considered the wider requirements that must be met to implement new technologies as business as usual. A self-assessment toolkit has been developed that enables NRAs to establish the general environment for adopting innovation within their organisations. A technology implementation framework has been produced that assists in the development of roadmaps to adapt and implement specific gap-filling technologies. With these tools the NRAs should be better equipped to take on the challenge of innovation and realise the benefits of new technologies.

Keywords: monitoring data, digitalisation, sustainability, asset maintenance management, asset condition data, new technologies

1 Introduction

The emergence of new technologies presents an opportunity to improve asset management processes within NRAs. However, they also present a challenge for NRAs, as they seek to realise the benefits. The project “Innovative & Future-proof Road Asset Condition Monitoring Systems” (INFRACOMS) aims to help NRAs more effectively leverage technological advancements in asset data / condition monitoring. INFRACOMS is delivering an openly accessible Technology Database that identifies, and provides an appraisal process for, the technical capability of current and emerging remote monitoring technologies. This is being provided as a flexible, sustainable, and future-proofed toolkit which will enable NRAs to appraise emerging technologies and add them to the database. INFRACOMS is also supporting the development of action plans to guide NRAs in adapting and implementing these technologies [1, 2].

INFRACOMS’ first action was to identify the information needs, gaps, and priorities of NRAs in terms of their approach to data collection and monitoring, and to establish a list of current and emerging measurement technologies. This is discussed in Section 2 and reported in [3] and in project Deliverable D1.1 [4].

The second part of the project has developed an action plan to guide NRAs in adapting and implementing promising emerging technologies and developed training sessions on the use of the appraisal toolkit, as discussed in Section 3. The interested reader is referred to INFRACOMS’ contributions to ERPUG 2023 [5], TRA2024 [6], and IABMAS2024 [7], and to project Deliverable D2.1 [8].

INFRACOMS has also developed guidance to assist NRAs in developing their own organisational roadmaps that would support greater implementation of promising / emerging technologies. The INFRACOMS guide NRAs is discussed in Section 4. The originality of this paper resides in the presentation of the whole solution developed in the project. However, whilst the following sections summarise the overall outcomes of INFRACOMS, we provide greatest detail on latter stages of the project – the development of organisational roadmaps.

2 Needs, gaps, emerging technologies

Through a desk study and stakeholder consultation process with NRAs, INFRACOMS has identified the needs, priorities, and challenges of NRAs in monitoring highway assets, in terms of the NRAs’ approach to data collection and monitoring, and the key data required for performance indicators and the maintenance and operation of these assets. The gaps in asset management data (i.e. the gap between the current solutions available to provide data, and the wide range of required performance assessments and technical parameters) were grouped into themes associated with the type of challenge that the data gap presents – these being “data collection”, “data analysis”, and “data management”. To fill the gaps there is a need for the introduction of new data collection technologies, new data analysis methods (which may combine data from different sources) and better support/management of the data (e.g. via integration of data into asset management systems), or combinations of these themes.

The consultation with NRAs established the types of new and emerging monitoring technologies already implemented by NRAs, and a consultation with Technology providers identified further available remote monitoring technologies and the future trends. These were combined to support a “gap analysis”, which identified the gaps between the current survey regimes/strategy and the current and future data needs of NRAs. Emerging technologies offer the potential to enhance monitoring capabilities. INFRACOMS has categorised these emerging technologies into four broad groups: Remote Sensing technology; Internet of Things (IoT); Crowd sourcing and Advanced data processing (including visualization systems/software).

This led to the development of a Technology Database which provides a list of technologies for remote condition monitoring, mapped against current and future asset management needs, including use cases that were identified in the consultation.

3 Appraisal toolkit of technologies

An appraisal methodology and toolkit for evaluating remote condition monitoring technologies was developed in the second stage the project. To support this, several case studies were identified that describe actual implementations of these technologies.

The appraisal methodology considers the data that these technologies provide and how they could be integrated into NRAs' asset management systems. Cost factors, potential benefit categories and limitations are also identified. Technologies are ranked by the key asset information imperatives they support and are scored. The appraisal methodology has two phases. Following initial scoring, technologies with a good score are evaluated more thoroughly, which may require specialist input – for example discussions with the technology supplier to better understand the capability. This results in a technical score, a benefit/cost assessment and the steps that may be required in a roadmap toward implementation of that technology. INFRACOMS recognises that the capability rating of technologies may be affected by the intended application. Therefore, NRAs are encouraged to undertake assessments with reference to the specific context of the proposed application. As a result, it is possible that technologies could have more than one assessment in the database, supported by application specific case studies. A Business Case layer has been added to the appraisal process to encompass the implementation process, benefits, challenges, and costs faced by the adopting NRA in their case study. For delivery, INFRACOMS has implemented the Technology Database within an online Appraisal Toolkit implemented in the Confluence system [5], in which appraisals and case studies can be included. This allows NRAs to share their individual appraisals, ensuring greatest value is achieved across NRAs. For the purposes of demonstration, INFRACOMS selected five case studies from the initial Technology Database for full appraisal with the INFRACOMS methodology.

4 Organisational aspects in the implementation of emerging technologies

It is noted that the above appraisal process is primarily concerned with the evaluation and implementation of individual technologies for data collection and data interpretation, and how the data provided could match the needs, priorities, and challenges of NRAs when monitoring the condition of bridges and carriageways. However, any process that aims to improve the uptake of new technologies must also address organisational, business, and cultural aspects, in addition to technical considerations.

The INFRACOMS approach to developing organisational frameworks for technology is based on the principles of the ISO 56000 series of standards for innovation management. This is concerned with organisational and innovation strategies, including the culture of innovation. It is also concerned with the planning, development, and implementation of innovation, and includes a set of principles, processes, and tools to support organizations in developing and implementing effective innovation management systems [9], and other innovation literature and self-assessment tools [10-13]. Whilst the INFRACOMS evaluation methodologies discussed above effectively encapsulate the first three of the core innovation processes in ISO56000 ('Identify Opportunities', 'Create Concepts' and 'Validate Concepts'), the organisation components of INFRACOMS - a self-assessment methodology and framework for implementation - address further aspects of innovation management relating to development and deployment of solutions, strategy, culture, leadership, and support.

The INFRACOMS framework is summarised in Figure 1. The project has developed a self-assessment methodology to help NRAs understand their current ability to innovate as an organisation. Then, having established the current situation, the further actions required to implement particular technologies within their organisation can be identified and planned via a technology roadmap.

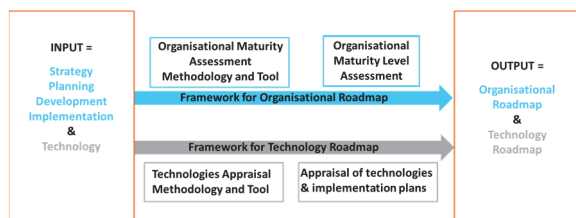


Figure 1 Production of organisational and technology roadmaps using INFRACOMS methodologies and tools

4.1 NRA self-assessment

The self-assessment methodology for NRAs (Figure 2) establishes the general situation of the organisation in terms of its ability and aspiration to implement new technologies. It establishes the general environment in which any specific technology implementation will exist. The Self-Assessment Methodology is built around a questionnaire that is completed by NRAs to establish their current and future status, capability, and ambitions regarding innovation and technology.



Figure 2 INFRACOMS self-assessment methodology

The assessment considers standards and legislation, technology, people, environment, commercial factors, and procurement. The questionnaire is designed as a series of statements. While some of the statements have been selected to assess capability around innovation in general, many are tailored specifically towards INFRACOMS, and the remote condition monitoring technologies considered by the project. The NRA should decide who should be involved in the maturity assessment in terms of work units and employee roles but should include a variety of perspectives and interpretations of new technology adoption efforts. INFRACOMS worked with two NRAs (NPRA, Norway and National Highways, England) to understand their experience undertaking organisational self-assessment to refine the content of the questionnaire (see project Deliverables D5.1 [14] and D5.2-D5.3 [15] for details). The self-assessment tool has been provided as an MS Excel workbook, which produces a table and a radar chart summarising and visualising the maturity level of the organisation (Figure 3).

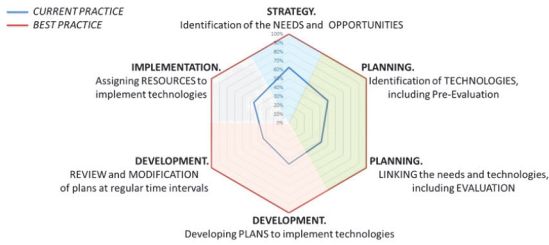


Figure 3 INFRACOMS self-assessment methodology

In the light of the self-assessment NRAs may wish to explore the strengths and weaknesses that have been uncovered, identify areas where they can improve, review any available case studies and literature to see how other organisations manage innovation, and evaluate the efforts needed to take steps to improve in the different areas highlighted by the questionnaire. From this, the NRAs could produce a roadmap to improve innovation, with a set of actions, timelines, and resources, and appoint an individual or team to implement those actions.

It is recommended that NRAs review the results of the self-assessment regularly (by re-conducting the assessment), and track improvements by comparing the new results to the baseline assessment. Self-assessments should be conducted by a NRA on a regular basis, perhaps once every 5 years or so in parallel with the development of the NRA’s strategic plan and innovation strategy. For organisations that are in the early stages of implementing an innovation process, more frequent assessment or review may be conducted. In any case, the self-assessment would be part of a process of continuous improvement in the NRA.

4.2 Roadmap for technology implementation

Whilst there will be a general level of maturity within the organisation in relation to the adoption new technologies, there will also be specific organisational aspects that influence the ability (and barriers) to implementing a specific technology for a specific use case. To assist NRAs in identifying these barriers, INFRACOMS has developed a framework for technology implementation.

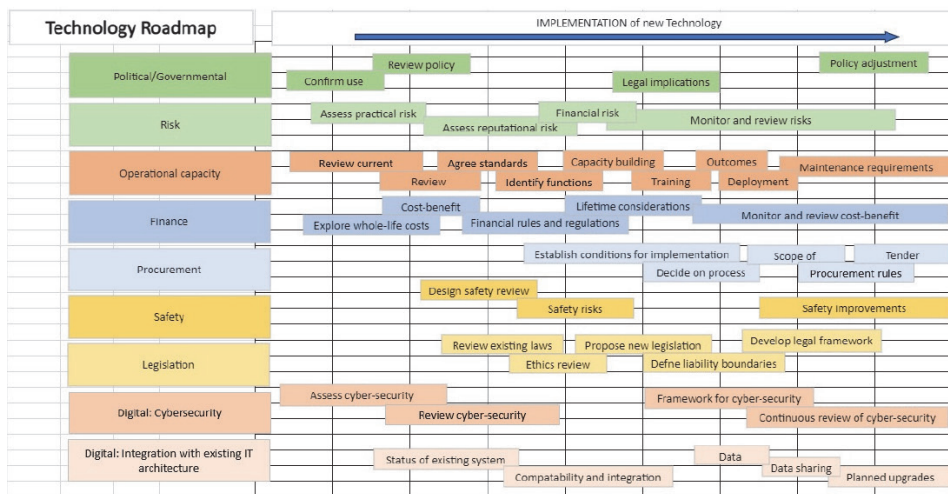


Figure 4 INFRACOMS technology roadmap

The starting point for this framework is the establishment of the use case for the chosen technology, to establish a clear set of objectives and goals that are to be addressed, including the boundary conditions for this use case (what is expected to be achieved and what is not expected to be achieved). The framework then presents a series of themes that need to be considered when developing an implementation roadmap in the light of this use case. This includes risk assessment and cost-benefit analysis, addressing procurement, safety, and legislative issues, and determining and addressing the IT infrastructure, data management, data architecture, and cybersecurity requirements (Figure 4). The approach proposed by INFRACOMS has drawn on the experience of TII, Transport Ireland [16]. In the final stages of the project, INFRACOMS is collaborating with experts from two NRAs to apply the framework to develop roadmaps for two relevant and promising technologies identified by the appraisal toolkit and presented in the Technology Database. The results of this exercise will be published in Deliverable D5.4 on the webpage of the project [2].

5 Examples and case studies

Initially, the INFRACOMS consortium identified 64 technologies. Of these, 24 had an estimated TRL of at least 7 and were appraised by consortium members from the perspective of an NRA [5, 7]. For bridges, the Bridge Management System (BMS) of Wallonia (Belgium) was used, and for pavements, the data architecture of the road asset management system iROAD-S™ of TRL Software formed the subject. These technologies were categorised under the four broad categories described in Section 2. For each, a description of the technology was written, and they were then appraised and scored following the method developed in the project (cf. Section 3). With the approval of CEDR, the consortium selected and produced case study reports for five appraised technologies, including: the “EyeVi platform” digitalising defects on Oslo’s urban road network; “aerial satellite spectroscopy” investigating shrink/swell ground movements across the M25 highway network in UK; the “COWI virtual inspection platform” applied to condition assessment on the Faroe bridges in Denmark; the “UniQ wireless acoustic emission tool” applied to bridge monitoring; and “Bridge Weigh-In-Motion” for the assessment of the structural safety of a multi-span bridge. Consortium members interviewed asset managers, and technology and service providers involved in those cases, using the INFRACOMS template structure of case study reports to transcribe their answers. Appraisals and case study reports were uploaded to the “confluence” environment and shared with CEDR. The Norwegian Public Roads Administration (NPRA) and National Highways in UK (NH) agreed to review the self-assessment tool as part of a self-assessment exercise. Their feedback led to some minor changes to the tool (cf. Section 4).

6 Conclusion

The INFRACOMS project has identified the priorities and needs of NRAs for the management of carriageway and bridge assets, and the gaps in their ability to meet these needs using current technologies. However, there is potential to fill these gaps using new/emerging technologies that could contribute to improve asset management within NRAs. A Technology Database was therefore created in the form of an Appraisal Toolkit. The Toolkit includes a methodology to assess the suitability of technologies to fill the gaps. As it is to be provided on-line, the toolkit offers the potential to enable NRAs to share their experience via the database.

INFRACOMS has also considered the wider requirements that must be met to implement new technologies as business as usual. The self-assessment toolkit enables NRAs to establish the general environment for adopting innovation within their organisations, and the technology implementation framework assists in the development of roadmaps to adapt and implement specific gap-filling technologies. With these tools the NRAs should be better equipped to take on the challenge of innovation and realise the benefits of new technologies.

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