CEDR

Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

INFRACOMS

Innovative and Future-proof Road Asset Condition Monitoring Systems

Self-Assessment Methodology for NRAs

Deliverable D5.1

December 2023

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Innovative & Future-proof Road Asset Condition Monitoring Systems

Report D5.1

Self-Assessment Methodology for NRAs

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Abbreviations

Abbreviation	Definition
CEDR	Conference of European Directors of Roads
INFRACOMS	Innovative & Future-proof Road Asset Condition Monitoring Systems
ISO	International Standards Organization
NCHRP	National Cooperative Highway Research Program
NRA	National Road Authority
OECD	Organisation for Economic Co-operation and Development
PIARC	World Road Association
WP	Work Package

Executive Summary

INFRACOMS is a CEDR Transnational Road Research Programme Call 2022 project (June 2022 – May 2024), aiming to understand current and emerging remote asset condition monitoring and data collection techniques, to enable European National Road Authorities (NRAs) to strategically implement innovative technologies and approaches as standard practice. It has a specific focus on two primary asset types: road pavements and bridges.

Previous work packages in INFRACOMS have identified the priorities and needs of NRAs for the management of carriageway and bridge assets, in terms of their approaches to data collection and monitoring. INFRACOMS has already developed an appraisal methodology and toolkit for evaluating individual remote condition monitoring technologies for potential use in NRAs and has conducted several case studies describing actual implementations of those technologies. These appraisals and case studies have been included in an Appraisal Toolkit implemented under the project.

To date, then, INFRACOMS has been primarily concerned with the evaluation and implementation of individual technologies. This D5.1 *Self-Assessment Methodology* Report describes a self-assessment methodology and tool to assess the NRA's ability *as an organisation* to innovate. The report has been prepared under INFRACOMS Work Package 5 *Road Map and Action Plan*. It is accompanied by a self-assessment spreadsheet tool.

The self-assessment methodology and tool described here has been structured around the ISO 56000 international standard for Innovation Management. It also includes elements of an Open Innovation approach. The methodology is built around a questionnaire to be completed by NRAs to establish their current and future status, capability and ambitions with regard to innovation and technology.

The self-assessment methodology and tool are structured into four workstreams: strategy, planning, development, and implementation. Individual NRAs would review the questionnaire and tool, identify individuals or teams in the organisation to be involved in the self-assessment process, complete the questionnaire, evaluate the responses, and develop a roadmap to improve innovation in the organisation. Responsibility should also be assigned to driving the implementation of the roadmap forward, and for regular re-assessment of the organisation as part of a process of continuous improvement.

It is envisaged that the self-assessment methodology and tool will help NRAs understand at what level the organisation's current practice is compared to best practice. Whilst such a tool is primarily intended for self-assessment, it can also be used to compare the ability of CEDR NRAs to adopt new technologies and identify advanced authorities that can support the improvement of those that are less innovative. Hence the tool can also provide an indication of where any differences among NRAs lie.

This self-assessment methodology will be piloted in two NRAs under INFRACOMS Task 5.4.

Glossary

Table 1 summarises the terminology used throughout this document, and the INFRACOMS project.

Table 1. List of Terms and Meanings

Term	Meaning
Availability (Carriageways)	The ability of an item to perform a required function under given conditions at a given instant of time or during a given time interval, assuming that the required external resources are provided (1. This ability depends on the combined aspects of reliability, maintainability and maintenance supportability. 2. Required external resources, other than maintenance resources, do not affect the availability of the item) [EN 13306, PIARC, 2022)
Availability (Bridges)	The proportion of time a bridge is open for service. It does not include failure-related service outages but the ones due to planned maintenance interventions. Alternatively, availability can be measured as the additional travel time required due to an imposed traffic regime on the bridge.
Big data	A term that describes or relates to complex and large datasets where advanced analytics methods are employed to extract information or value from data.
Bridge	A civil engineering structure that affords a passage to pedestrians, animals, vehicles, waterways and services above obstacles or between two points at a height above the ground [COST 323]
BIM / Building Information Modelling	A process supported by various tools and technologies for creating and managing information on a construction project across the project lifecycle.
Carriageway	Part of the road or highway constructed for vehicular use (1. Reserved lanes, lay-bys and passing places are included. 2. The carriageway may include traffic lanes and the shoulder) (PIARC Road Dictionary, PIARC, 2022)
Common Data Environment	A platform that centralizes project data storage and access
Culture of Innovation	A "culture of innovation" refers to the shared values, beliefs, behaviours, and practices within an organisation that foster and encourage the generation and implementation of new ideas, processes, products, or services. It is a work environment where creativity, experimentation, and continuous improvement are not only encouraged but embedded in the organization's DNA. In a culture of innovation, employees feel empowered to contribute their ideas, take manageable risks, and explore unconventional solutions to challenges.
Economy	The financial management of an asset, particularly considering the focussed long-term costs of maintenance activities over the asset's service life.

Term	Meaning
Environment	The environmental impacts of an asset (bridge or carriageway), in particular in relation to minimizing any adverse influence that the asset has on the environment during the service life of a bridge or carriageway.
IoT / Internet of things	A system of interrelated computing devices, mechanical and digital machines, and objects, with the ability to connect, exchange and transfer data over a communication network without requiring human-to-human or human-to-computer interaction.
Life Cycle Cost Analysis	A process of evaluating the economic performance of an asset over its entire life. Sometimes known as total cost of ownership.
Key Condition Data	Data which is of key importance to understanding the condition of an asset and hence its likely availability, reliability etc.
Key Imperatives	Capabilities, properties or performance that are considered essential for an asset to meet its requirements and expectations.
Key Performance Indicator	A term that describes and/or measures the fitness for purpose of the physical asset.
Open Innovation	Open innovation is a collaborative approach to innovation that involves actively seeking and incorporating external ideas, technologies, and expertise into an organisation's internal innovation processes.
Performance Indicator	A term describing a particular technical characteristic of the condition of an asset.
Reliability (Bridge)	The probability that a bridge will be fit for purpose during its service life. It complements the probability of structural failure (safety), operational failure (serviceability) or any other failure mode.
Remote sensing/ monitoring	The practice of using sensors and software to monitor the condition, performance and behaviour of an asset, remotely rather than directly inspecting or observing the asset in person. Sensors may be attached to or embedded in the asset, but also included other sources such as satellites, aircraft, drones and other mobile sources (e.g. mobile devices, sensors built into vehicles).
Safety	The impacts of an asset (bridge or carriageway) on the health and safety of stakeholders/users. Structural failure is not included in this definition as it is contained within Reliability.
Socio-economic	The financial management of an asset, considering the maintenance/ management of the asset, and the costs related to society (e.g. costs of accidents, travel times, maintenance etc.
Technical Parameter	A parameter that describes a particular physical value/characteristic of an asset. This may be derived from various measurements, or collected by other forms of investigation
Technology Readiness Level	A method for estimating the maturity of technologies during the acquisition phase of a program. Originally developed by NASA in the 1970s for space exploration technologies.

Term	Meaning
Unmanned Aerial Vehicle	Commonly known as a drone, it is an aircraft (not exclusively) without any human pilot, crew, or passengers on board.

1. Introduction

1.1 The INFRACOMS project

The application of consistent, reliable information has been a key component of highway asset management for over 40 years. The information and the tools to help collect, interpret and apply data have continuously evolved during that time. Technologies with the potential to support asset management include remote sensing, intelligent infrastructure monitoring, crowdsourcing, data analytics and visualisation. In this report they are collectively referred to as 'Remote Monitoring Technologies'. However, National Road Authorities (NRAs) in Europe are not yet fully exploiting their potential in the highway environment to better understand highway assets and to improve reactive and proactive asset management decisions.

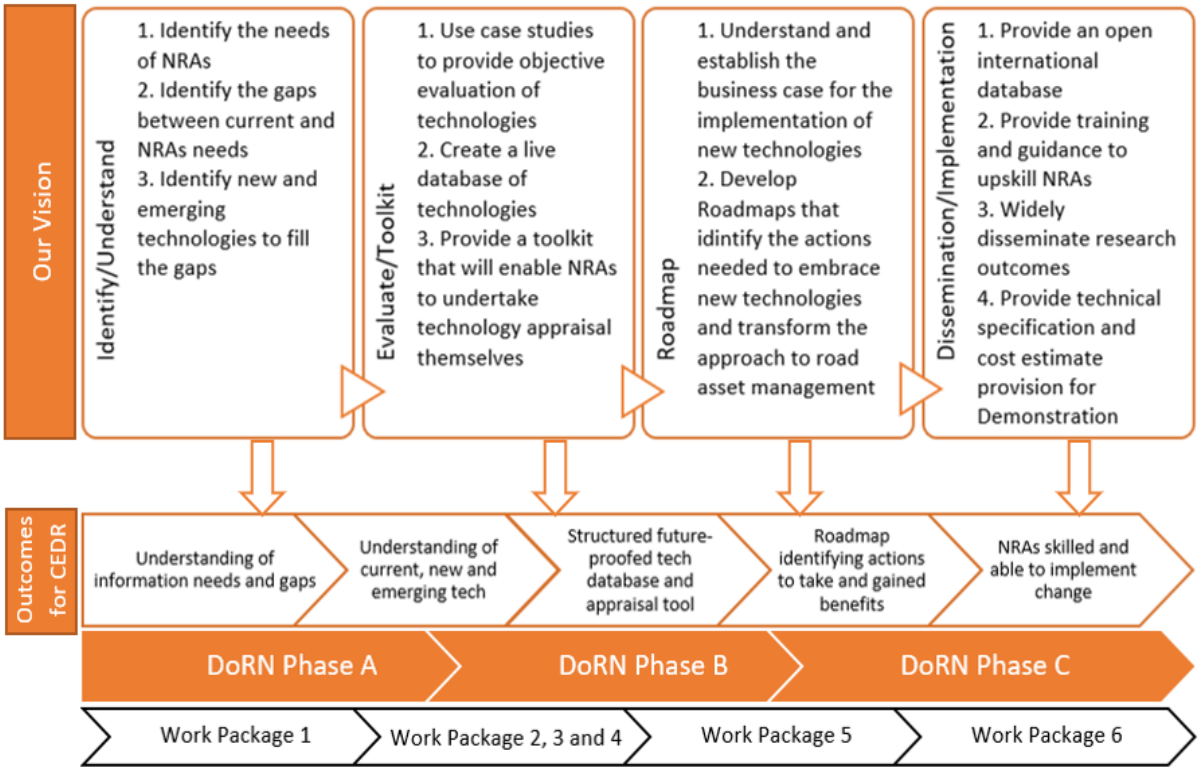

Figure 1. Vision and outcomes of INFRACOMS.

INFRACOMS aims to equip NRAs with the ability to better leverage the technological evolution in data and monitoring. Figure 1 summarises the approach being taken in this project. INFRACOMS is investigating the capabilities and benefits of new technologies for understanding the performance of highway assets. INFRACOMS is establishing a database of these technologies and a toolkit to appraise them, which aims to help NRAs assess the costs, benefits and limitations of applying the technologies in their own environments. INFRACOMS will also provide a roadmap to provide strategy and guidance for NRAs to improve their business processes for more effective assessment and implementation of new technologies.

1.2 Overview of INFRACOMS Work Packages

This report (D5.1 – Self-Assessment Methodology) has been prepared under Work Package 5 of the INFRACOMS project. Figure 2 shows the relationship of the INFRACOMS work packages, tasks and deliverables with respect to WP5.

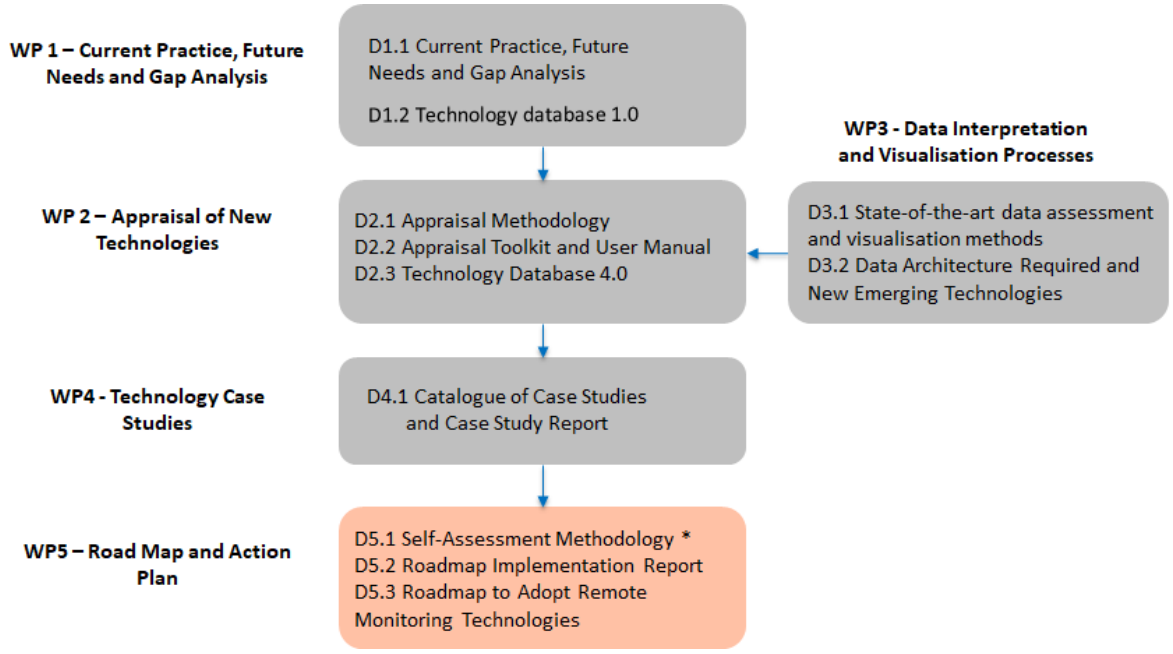

Figure 2. Relationship of WP 5 to other Work Packages, Tasks and Deliverables

WP1 report D1.1 on Current Practice, Future Needs and Gap Analysis identified the priorities and needs of NRAs for the management of carriageway and bridge assets in terms of their approach to data collection and monitoring. It identified gaps in data, challenges in collecting data, and challenges in application of data. It also identified technologies that can address those gaps and challenges. WP1 also produced D1.2 - Technology Database 1.0. This contained a list of remote condition monitoring technologies and mapped them against the current and future asset management needs / use cases identified in the consultation.

WP2 combined the outputs from WP1 with the outcomes of a review of appraisal methodologies and a workshop with NRAs to devise an overall methodology for appraising the technology using technology use cases. The outcomes of this work were presented in INFRACOMS deliverable D2.1. An Appraisal Toolkit and User Manual were also completed (D2.2), along with Technology Database 4.0 which includes appraisals of around 20 technology use cases (D2.3).

WP3 reviewed and evaluated the data assessment and visualization methods provided by the types of technologies contained within the Technology Database. It discussed the types of data that may be provided by a technology to describe the physical asset and produced a methodology for assessing the methods provided by the technology for data analysis and representation (D3.1). It also produced a methodology for assessing data architectures of NRAs and an appraisal scoring process to evaluate the potential of technologies to support practical decision-making (D3.2). These methodologies were incorporated into the overall appraisal methodology of WP2.

WP4 produced a set of real-world case studies for the most promising technologies identified using the methodology. It developed a semi-formal approach to undertaking detailed assessment of selected technologies, including costs and benefits associated with their implementation, and practical issues around implementation of the technologies encountered by individual NRAs. The case studies included mobile imaging, aerial satellite spectroscopy, a virtual bridge inspection platform, a wireless acoustic emission measurement system, and bridge weigh-In-motion technology.

WP5 will develop a Self-Assessment Methodology for NRAs (D5.1), a Roadmap Implementation Report (D5.2), and a Roadmap to Adopt Remote Monitoring Technologies (D5.3). This report represents Deliverable D5.1 and describes the work undertaken in Task 5.1 to produce a Self-Assessment Methodology for NRAs.

1.3 Scope of this Report (D5.1)

This report presents a self-assessment methodology and tool for NRAs to evaluate their capabilities regarding the introduction of new data collection technologies. It aims to help NRAs understand their current capability, identify areas for improvement, and to foster a culture of continuous innovation.

Figure 3 shows the tasks, milestones and deliverables from WP5, and the relationships between the tasks and deliverables. It highlights in orange Tasks 5.1 and 5.3 which are the focus of this report.

Task 5.1 has developed the self-assessment methodology. The core part of the methodology consists of a series of statements for NRAs that relate to the evaluation and implementation of emerging technologies for data collection. These statements should be interpreted and answered in a way that best describes the organisation's current practice. Task 5.3 has produced a self-assessment spreadsheet tool, based on the methodology described in this report. It is suggested that readers consider these two outputs together – i.e. this report D5.1 and the self-assessment spreadsheet tool.

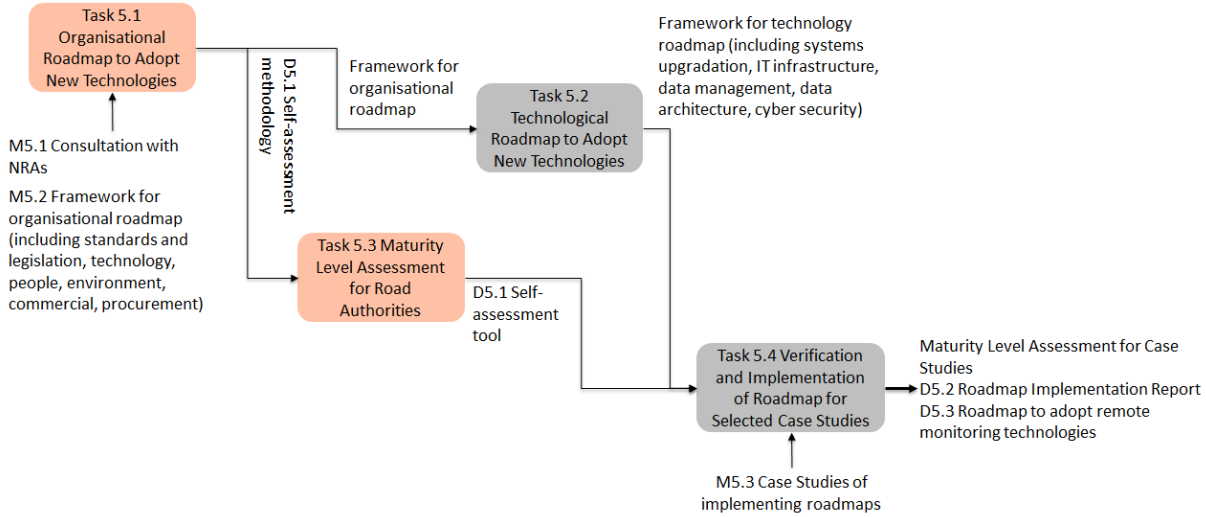

Figure 3. Scope of Deliverable 5.1

The self-assessment methodology and tool will be piloted under INFRACOMS Task 5.4 with selected NRAs. Task 5.4 will also produce a roadmap to assist NRAs to improve their innovation capabilities. Assessment of their maturity level will also help to benchmark against other NRAs. The intention is that the tool can be used by any NRA in future to conduct self-assessments and produce their own roadmaps. The roadmaps for NRAs will be structured around the framework for the organisational roadmap already developed under Task 5.1, and the framework for a technological roadmap being developed under Task 5.2.

2. Development of the Self-Assessment Methodology

2.1 Introduction

The first part of the INFRACOMS project (WP1) identified the needs, priorities, and challenges of NRAs in monitoring the condition of highway assets. INFRACOMS developed an appraisal methodology and toolkit to evaluate technologies and create a technology database of promising technologies (WP2, WP3) including selected case studies (WP4).

Thus to date, INFRACOMS has been primarily concerned with the evaluation and implementation of technologies for data collection. However, any framework to improve the uptake of new technologies must address organisational and cultural aspects beyond the purely technical considerations. Therefore, WP5 has developed a self-assessment methodology to assess the NRA's ability to innovate as an organisation. This organisational self-assessment tool can be used to develop a roadmap for improving innovation in the organisation. Together with an approach to appraisal and evaluation of new and emerging technologies, INFRACOMS thus provide methods and tools to produce roadmaps that help NRAs identify, develop and implement innovative new technologies. See Figure 4.

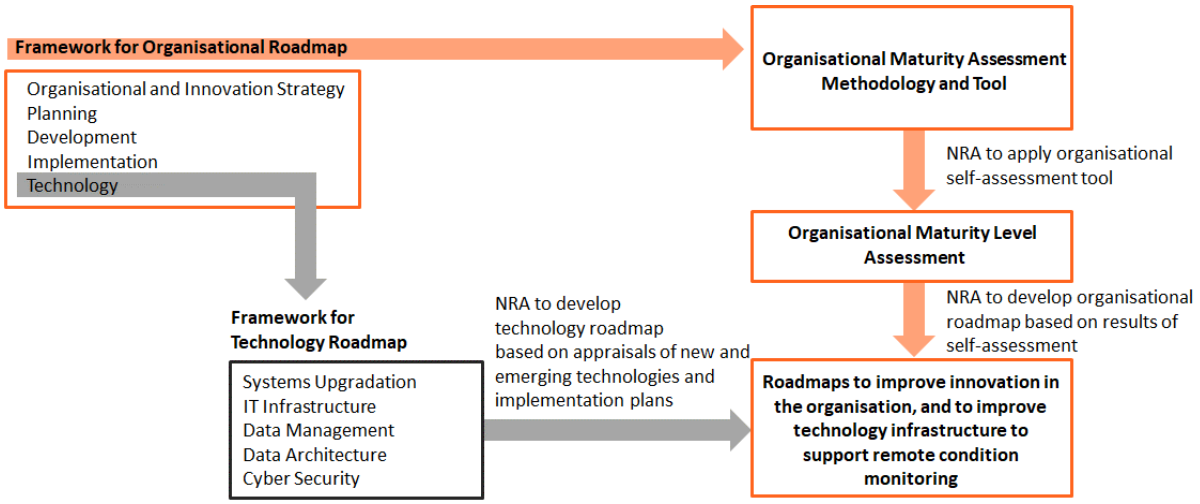

Figure 4. Production of organisational and technology roadmaps using INFRACOMS methodologies and tools

2.2 Framework for Organisational Roadmap

The framework for an organisational roadmap for INFRACOMS 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. In summary, ISO 56000 is a series of international standards that provide guidelines for managing innovation. It includes a set of principles, processes, and tools to support organizations in developing and implementing effective innovation management systems. It consists of several parts:

1. **ISO 56002:2021 - Innovation Management System – Guidance.** This standard provides general guidance on establishing, implementing, maintaining, and continually improving an innovation management system.
2. **ISO/TR 56004:2021 - Innovation Management Assessment.** Provides guidance on how to assess an organisation's innovation management system and identify areas for improvement.

3. **ISO 56005:2021 - Innovation management - Tools and methods for innovation partnership**. Provides guidance on how to develop and manage innovation partnerships between organisations.
4. **ISO 56006:2021 - Innovation management - Strategic intelligence management.** Provides guidance on how to manage strategic intelligence for innovation purposes.
5. **ISO 56007:2021 - Innovation management - Idea management.** Provides guidance on how to manage idea generation and selection processes to support innovation.

Figure 5 depicts a core innovation process in an organisation, with five (orange) processes to Identify Opportunities, Create Concepts, Validate Concepts, Develop Solutions, and Deploy Solutions. The inputs to these core processes are the Opportunities and Intent (coming in from the left), and the outputs are the Innovation Value (coming out on the right), emphasising that innovations should be deployable and should add value to the organisation. The grey 'funnel' in the background indicates that potential opportunities are gradually whittled down to actual solutions through the evaluation process, which will weed out some innovations as non-viable.

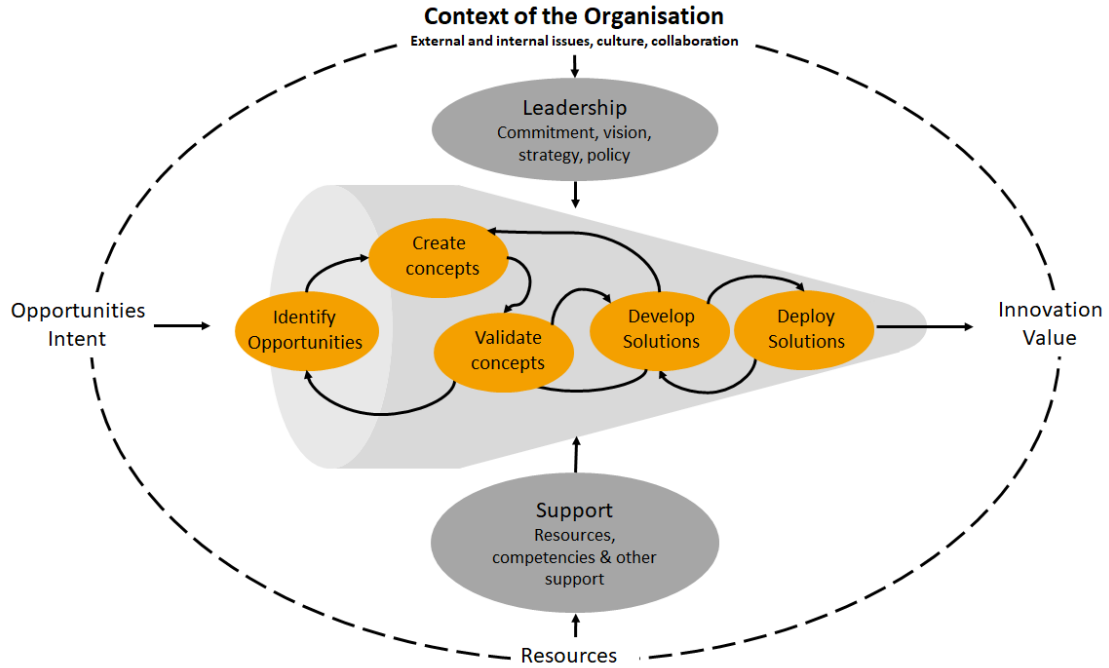

Figure 5. Innovation Process in an Organisation (adapted from ISO 56002:2021)

The Context of the Organisation at the top of Figure 5 represents the organisational culture and the national innovation ecosystem within which the organisation exists. The national ecosystem may provide national resources including funding, training and services. The Leadership box reflects the leadership's commitment to innovation, which helps drive the vision, strategy and policy towards innovation. The Support box at the bottom of the diagram shows support activities, which may include human resources, procurement, training and dissemination.

Note that the outer circle of Figure 5 represents a cycle of continuous improvement. This can be envisaged as a Plan / Do / Check / Act (PDCA model). The PDCA model is a systematic framework for continuous improvement and quality management.

ISO 56000 represents a generic standard for managing all aspects of innovation in any organisation, whether large or small, and public sector or private sector. The INFRACOMS pre-evaluation and evaluation methodologies developed in WP2 effectively encapsulate the first three of the core

innovation processes in Figure 5, namely 'Identify Opportunities', 'Create Concepts' and 'Validate Concepts'. The INFRACOMS self-assessment methodology addresses these and other aspects of innovation management relating to development and deployment of solutions, strategy, culture, leadership and support.

2.3 Framework for Technology Roadmap

The framework for a Technology Roadmap is being developed in WP5.2, and consolidates the work completed in INFRACOMS WP3 around integration of new technologies into data architectures. A Technological Roadmap for an NRA will consider systems upgrade, IT infrastructure, data management, data architecture, and cybersecurity.

An NRA should therefore use the Organisational Self-Assessment Methodology and tool as described in this D5.1 report to produce an Organisational Roadmap; and the Appraisal Methodology and tool as described in the earlier D2.1 report to produce a Technology Roadmap.

Task 5.4 will work with two case study organisations to apply these methodologies and tools to help produce outline roadmaps for organisational and technological improvements. These will be reported upon under Deliverable D5.2 Roadmap Implementation Report.

3. INFRACOMS Self-Assessment Methodology

3.1 Introduction

The INFRACOMS Self-Assessment Methodology has been developed based on the organisational framework described in Chapter 2. Figure 6 show the Self-Assessment methodology. It covers the key elements of the ISO 56000 process for innovation management, although for simplicity INFRACOMS groups them differently. Hence, the self-assessment methodology is organised into four workstreams:

- **Strategy:** covering the ISO components Organisational Context, Opportunities and Intent, Leadership, Identify Opportunities, and Create Concepts
- **Planning:** Covering the ISO component Validate Concepts
- **Development:** Covering the ISO component Develop Solutions
- **Implementation:** Covering the ISO components Deploy solutions, Support and Resources, and Innovation Value.

Figure 7 shows, through colour coding, how these key components of the ISO 56000 process are represented in the INFRACOMS methodology (i.e., how the coloured boxes in Figure 6 relate to the processes in Figure 7).

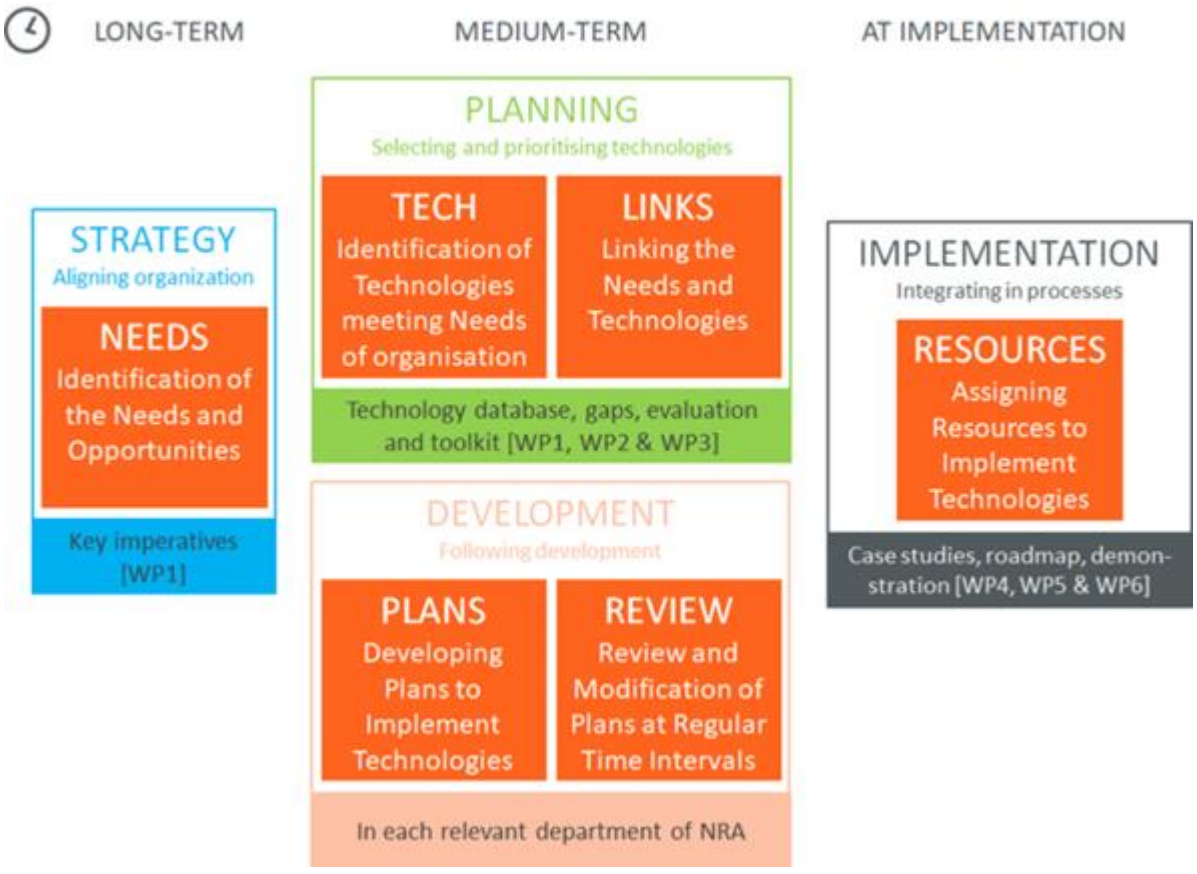

Figure 6. INFRACOMS self-assessment methodology

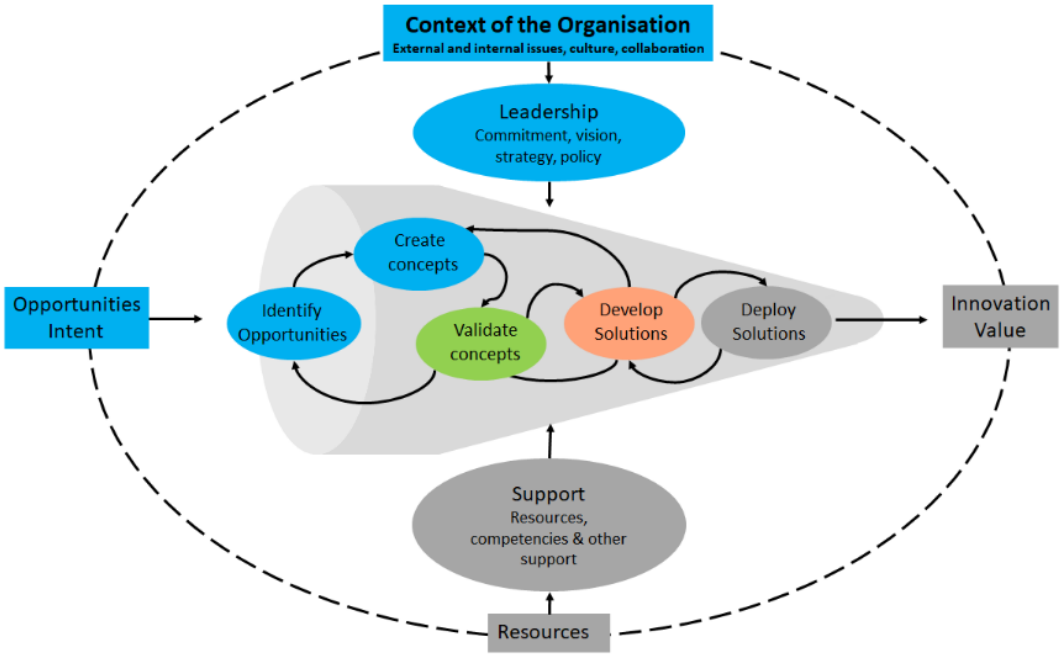

Figure 7. How the INFRACOMS Self-Assessment Methodology relates to ISO 56000

The methodology also includes elements of the Open Innovation approach. Open Innovation is a collaborative approach to innovation that involves actively seeking and incorporating external ideas, technologies, and expertise into an organisation's internal innovation processes (Chesborough, 2003). Open Innovation is in contrast to closed innovation where firms develop and promote their innovations using only internally generated resources. This has come about as a result of the need to be more efficient and creative. Research indicates that institutions that allow their operations to be permeable (either/both internally and externally) become stronger and more accessible to the wider society (Dalander & Gann, 2010).

3.2 The Self-Assessment Methodology and its Application by NRAs

The Self-Assessment Methodology is built around a questionnaire to be completed by NRAs to establish their current and future status, capability and ambitions with regard to innovation and technology. The questionnaire is shown in Table 2, and is completed using a self-assessment tool as described in section 4.

Most of the statements in the questionnaire are generic around innovation and innovation management. The statements could equally be applied to any innovation, i.e. they are not specific to remote condition monitoring which is the focus of INFRACOMS. For purposes of INFRACOMS, the self-assessment should be conducted from the point of view of remote condition monitoring technologies, and should be reviewed and answered by personnel involved in asset management and condition monitoring. Task 5.4 will pilot this questionnaire, and will develop additional guidance notes around the completion of the questionnaire from an INFRACOMS perspective.

To use or apply the Self-Assessment Methodology, NRAs would:

A. Review and evaluate the elements of the Self-Assessment Methodology and its dimensions (i.e. groups of statements to assess the maturity of an organisation in identifying, evaluating and implementing technologies). The NRA should decide who should be involved in the maturity assessment in terms of work units and employee roles. It should encourage employee input to allow for a variety of perspectives and interpretations of new technology adoption efforts.
B. Review the statements in the Self-Assessment Tool. NRAs may consider modifying certain statements or adding others as necessary.
C. Score each dimension/group of statements and calculate an overall score if necessary. When completing the questionnaire using the Self-Assessment tool, the tool automatically assigns scores to the maturity levels based on the selected answer. The scores for the current maturity levels are summarised for each group of statements.
D. Organise meetings to review the results of the Self-Assessment. NRAs should explore the strengths and weaknesses that are 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 further steps to improve in the different areas highlighted by the questionnaire.
E. Produce a roadmap to improve innovation, with a set of actions, timelines and resources, and appoint an individual or team with responsibility to implement those actions.

It is recommended that NRAs review the results regularly (by re-conducting the Self-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.

The following sections further discuss the basis and structure of the questionnaire.

Table 2. Self-Assessment Questionnaire

No	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Strategy						
1.	Asset management is clearly highlighted as a key area for innovation in the organisation's strategic plan.11					
2.	The organisation has a clear commitment to fostering a culture of innovation.					
3.	Responsibilities for innovation within the organisation are clear.					
4.	The organisation has a clear commitment to working with its supply chain and with wider industry to innovate to address emerging needs.					
5.	The organisation is open to considering innovative ways of funding technology implementations.					
6.	The organisation's human resource management policies and procedures actively encourage a culture of innovation (e.g. through a mix of measures including staff recruitment, staff evaluation, staff retention, incentives, training programmes, mentoring, and change management).					
Planning (Identification including Pre-Evaluation)						
7.	The organisation has a horizon scanning or foresighting process in place to identify technologies that may be of benefit to the organisation in the longer term.					
8.	The organisation has clear, comprehensive policies and procedures that gather, identify and conduct preliminary evaluation of innovation ideas from staff throughout the organisation.					
9.	The organisation encourages the supply chain to propose innovative solutions to address condition monitoring needs.					
10.	The organisation encourages startup companies to address condition monitoring needs in innovative ways.					

No	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Planning (Linkages including Evaluation)						
11.	The organisation has a systematic process to record innovative ideas, assess them against needs, and record any assessments and decisions made.					
12.	The organisation's innovation projects are directly aligned with its key imperatives.					
13.	The organisation has clear policies and procedures such as Technology Readiness Levels to evaluate and prioritise implementation of new technologies.					
14.	The organisation has a clear approach to risk management to identify, assess and mitigate against potential risks during innovation.					
Development (Plans)						
15.	The organisation has an innovation portfolio which includes a mix of short, medium and long-term innovations to address the key imperatives.					
16.	The organisation encourages and collaborates on implementation plans internally throughout the organisation and with supply chain partners and other external stakeholders.					
17.	The organisation has clear and comprehensive procedures for cost-benefit analysis for planning and prioritisation of innovative technologies.					
18.	The procedure for cost-benefit analysis accounts for technology life cycle costs (from acquisition to end-of-life).					
Development (Review)						
19.	The organisation defines clear objectives and goals for innovation projects and manages those projects in a systematic way using principles of project management.					
20.	The organisation measures the benefits of innovation projects in a systematic manner.					
21.	The organisation carefully manages costs and resources around innovation projects so that issues are identified at an early stage.					
22.	The organisation regularly reviews implementation plans and if required, manages objectives and goals, detection of new technologies, appraisal measures and cost-related issues.					

No	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Implementation						
23.	The organisation has a systematic process to record "lessons learned" on innovation projects.					
24.	The organisation actively applies learnings and experiences from implemented technologies to develop competencies and capabilities within the organisation.					
25.	The organisation communicates the benefits and lessons learned from innovations to internal and to external stakeholders.					
26.	The organisation is able to deploy or scale up innovations through changes to business processes and/or invest in proven innovations.					
27.	The organisation employs change management principles to help plan for and scale up successful innovations into 'business as usual'.					

3.3 Questionnaire Statements

The questionnaire is designed as a series of statements. These statements are based around concepts from ISO 56000, the principles of Open Innovation (Chesborough, 2003), and other innovation literature and self-assessment tools (Daim et al., 2008; NCHRP, 2018; PIARC, 2019; OECD, 2020). While some of the statements around innovation strategy may be considered to apply to innovation generally, many of the statements in the later sections are tailored specifically towards INFRACOMS and remote condition monitoring technologies.

For each statement, the respondent can either “strongly agree”, “agree”, “disagree”, or “strongly disagree”. “Strongly agree” would indicate that the organisation’s policies and procedures regarding innovation are effective, while “strongly disagree” would indicate that those policies or procedures are not effective. The responses to each statement would prompt the NRA to conduct further investigation into what may be the issue (whether it is a real issue, or perception), to research what they could do to improve innovation, and put together an appropriate plan of action (or roadmap) depending on their circumstance and appetite.

A final option, “don’t know”, has been included to allow for cases where the user genuinely does not have an opinion on the statement. This “don’t know” option may be because the respondent is new to the organisation, or has not been closely enough involved with innovation in the organisation to have an opinion.

It may also be instructive to the NRA to understand if staff in different parts of the organisation answer differently on the same statement. A difference of opinion could, for example, indicate an issue of communication of innovation policies within the organisation, or perhaps indicate that some staff feel that they are not consulted in the overall innovation process. This will also be addressed in guidance notes for the completion of the questionnaire in the case studies.

3.4 Structure of the Questionnaire

Statements are grouped around the above mentioned four streams: Strategy, Planning, Development and Implementation.

Strategy

Organisational strategies are long-term plans that encompass the vision and mission of organisations. They define the raison d’être of organisations and their long-term goals, as well as how and when they are to be achieved, within a specified timeframe. Strategies also allocate resources to support decisions and activities in the various organisational units.

If organisations are keen to promote support the culture of innovation, their strategy would be a good place to explain and communicate this along with their vision, position, other goals and values. The questions therefore target activities that support the culture of innovation and the implementation of new technologies within an organisational strategy and organisational policies in support of asset management.

Planning ((Identification including Pre-Evaluation; Linkages / Evaluation)
Identifying technologies that meet an organisation's needs refers to processes that support the actual identification and subsequent evaluation of innovative technologies. Statements in this group are therefore asked about the general approach to data collection (e.g. by in-house staff or commissioning a service), the processes of identifying technologies and their capabilities.

In terms of planning processes, an INFRACOMS evaluation has three levels that provide successive levels of detail and complexity. These can be helpful in evaluating technologies that meet the needs of an NRA, especially if no processes have been developed for evaluating technologies:

- *Pre-Evaluation* provides a high-level analysis of the anticipated costs factors, benefits and limitations, and an assessment of the readiness level of the technology for a particular use case from the supplier's perspective. It also provides a scoring of the technology use case against the key imperatives.
- *Evaluation* provides a more detailed breakdown of the cost factors, benefit categories and limitations of the technology use case, a 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 an NRA perspective.
- *Case Study* is an in-depth analysis of a particular application of the technology for a given NRA. The length of inputs required will depend very much on the individual technology and use case being assessed.

The last set of questions aims to assess the ability to align technologies with the organisation's strategic needs (e.g., for data collection), from processes to identify gaps to identifying technologies and prioritising them as portfolios. An innovation portfolio is a tool used by organisations to manage and track their innovation projects and initiatives. It is a structured collection of different innovation efforts, ranging from sustaining, incremental, disruptive and radical improvements. A portfolio will typically include a mix of short-term and long-term projects as well as different types of innovation (such as product or process innovations).

Development (Plans; Review)
Technology acquisition plans are developed to illustrate the steps that would be required to implement the technology use case in an organisation. They are created to understand why a particular technology or technologies are needed, when they are needed, what improvements they will bring and what organisational goals they are intended to achieve. Statements in this group are based on the key components of such plans.

It is advisable to revise plans regularly and often enough to reflect changes in the work environment, incorporate new opportunities and support changes in an organisation's core objectives.

Implementation
Implementation concerns practices and methods related to the innovation culture within an organisation and the implementation of innovations. Statements of this group relate to many aspects including scaling up of technologies, human resources, employee competences, management of a portfolio of innovations, etc. It is likely that several employees with different professional profiles will be involved in developing elements of the roadmap framework, which will then also benefit from their different views.

4. INFRACOMS Self-Assessment Tool

The INFRACOMS Self-Assessment tool accompanying this report has been developed as a MS Excel workbook. It follows the principles of the INFRACOMS self-assessment methodology as described in Chapter 3. The workbook includes five tabs as described below.

4.1 How To

The NRA should decide which organisational units, staff, suppliers and/or external stakeholders that it wants to complete the questionnaire. The How To tab provides an introduction to the Self-Assessment tool and the structure of the questionnaire, to guide these stakeholders.

4.2 Statements

The Statements tab is the main tab. The Statements tab contains the series of statements/questions as discussed above, which the respondent(s) should answer.

In the tool a drop-down menu is provided next to each statement containing a selection of maturity levels. The respondent can select a level of agreement with a corresponding statement. Once an option is selected, the cell on the right displays the current state of the practice (maturity level) as a simple percentage of best practice.

The results of the self-assessment are displayed next to each statement. The tool calculates a cumulative score for each element of the assessment as a percentage of best practise. Cumulative results are summarised in the "SUMMARY_Table" tab.

4.3 Summary Table

The table with summarised results is used to visualise the maturity level of the organisation in a simple table. See Figure 8.

STREAM	GROUP	CURRENT PRACTICE	BEST PRACTICE
Strategy	STRATEGY. Identification of the NEEDS and OPPORTUNITIES	71%	100%
Planning	PLANNING. Identification of TECHNOLOGIES, including Pre-Evaluation	75%	100%
Planning	PLANNING. LINKING the needs and technologies, including EVALUATION	63%	100%
Development	DEVELOPMENT. Developing PLANS to implement technologies	69%	100%
Development	DEVELOPMENT. REVIEW and MODIFICATION of plans at regular time intervals	50%	100%
Implementation	IMPLEMENTATION. Assigning RESOURCES to implement technologies	55%	100%

Figure 8. Summary table showing the results of an NRA's self-assessment

4.4 Summary Chart

The table with summarised results is used to visualise the maturity level of the organisation in a radar chart. See Figure 9.

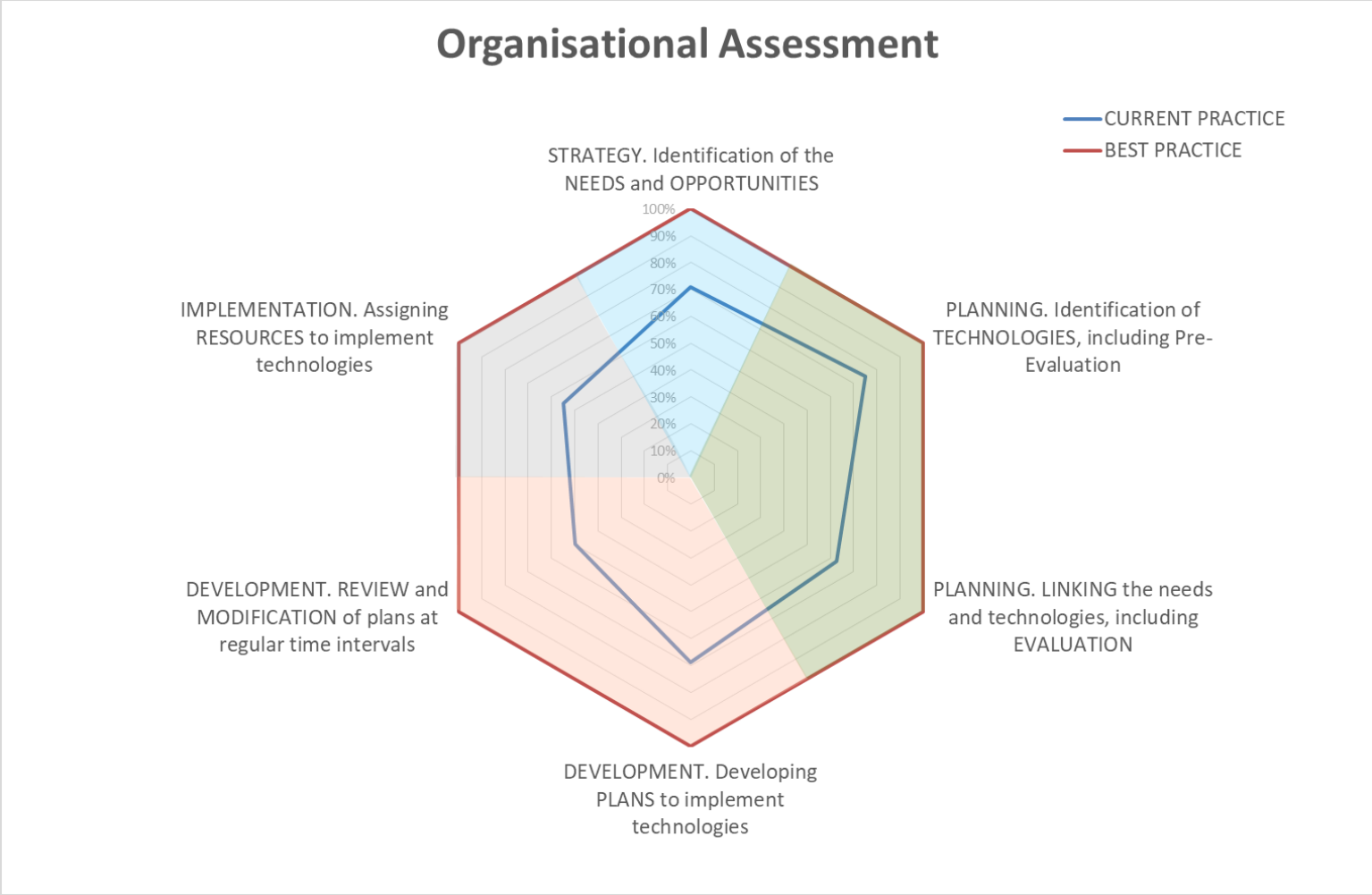

Figure 9. Radar Diagram of Organisational Assessment

5. Conclusion

Task 5.1 of INFRACOMS Work Package 5 (WP 5) has developed a step-by-step approach for NRAs to assess their ability to adopt new technologies, whether it is part of their innovation management activities or a stand-alone process. This self-assessment methodology consists of a series of steps that can help an NRA to identify their goals, strengths and weaknesses, and which can be used to support the development of roadmaps to improve the identification and adoption of new technologies.

Any framework aimed at improving innovation in an organisation must address organisational and cultural aspects in addition to innovation and technology. The methodology therefore aims to support the development of a framework for an organisational roadmap by completing a questionnaire to assess the capabilities (maturity levels) of an organisation, and its different work units, for identifying and implementing new technologies.

To accompany this report Task 5.3 of WP5 has produced a self-assessment spreadsheet tool based on the methodology. This is a practical tool that NRAs can use to assess their maturity, or to set their maturity targets. Whilst such a tool is primarily intended for self-assessment, it can also be used to compare the ability of CEDR NRAs to adopt new technologies, and identify advanced authorities that can support the improvement of those that are less innovative. Hence the tool can also provide an indication of where any differences among NRAs lie.

It is envisaged that the WP5 self-assessment methodology and tool will help NRAs understand at what level the organisation's current practice is compared to best practice. To meet their particular goals the self-assessment questions should be interpreted and answered in a way that best describes the organisation's current practices. It is also recommended that the NRA organise meetings to review the results of the assessment, explore the organisation's strengths and weaknesses, and develop a roadmap or action plan to improve innovation. Finally, it is recommended that NRAs conduct periodic assessments of its innovation policies and practice, as part of a cycle of continuous improvement.

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