Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

INFRACOMS

Innovative and Future-proof Road Asset Condition Monitoring Systems

Demonstration case specifications and cost estimate report

Deliverable D6.2

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THE FUTURE OF TRANSPORT

Belgian Road Research Centre
Together for sustainable roads

DANISH TECHNOLOGICAL INSTITUTE

Project acronym: INFRACOMS

Innovative & Future-proof Road Asset Condition Monitoring Systems

Report D6.2

Final Version 1.1

Demonstration case specifications and cost estimate report

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Abbreviations

Abbreviation	Definition
AI	Artificial intelligence
CVI	COWI Virtual Inspection
CEDR	Conference of European Directors of Roads
INFRACOMS	Innovative & Future-proof Road Asset Condition Monitoring Systems
NPRA	Norwegian Public Roads Administration (NO)
NRA	National Road Authority
RGB	Red, Green, Blue (colour model)
UAV	Unmanned aerial vehicle
WP	Work Package

Executive Summary

INFRACOMS is a project under the CEDR Transnational Road Research Programme Call 2022 (June 2022 – May 2024) that aims to understand current and emerging techniques for remote asset condition monitoring and data collection to enable European National Road Authorities (NRAs) to strategically implement innovative technologies and approaches as standard practice. The project focuses specifically on two main types of assets: road pavements and bridges.

Previous INFRACOMS work packages 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. The project has developed an appraisal methodology and toolkit for the evaluation of individual remote pavement and bridge condition monitoring technologies for potential use in NRAs and has conducted several case studies describing the actual implementation of these technologies. These appraisals and case studies were included in an Appraisal Toolkit implemented as part of the project as an on-line tool.

This report presents Deliverable D6.2. The aim of this work has been to develop a technical specification and cost estimate for a possible future demonstration of a technology identified by INFRACOMS. The methodology for selecting a demonstration project involved identifying promising technologies from previous Work Packages, ensuring the availability and willingness of NRAs to participate and conducting structured interviews with technology providers and NRAs to gather necessary information.

It is proposed that the COWI Virtual Inspection (CVI) platform be demonstrated on the Stavåbrua bridge in Norway, managed by the Norwegian Public Roads Administration (NPRA). The CVI platform utilizes drone imagery and AI/computer vision technologies to automate the detection of defects in bridge structures, aiming to enhance the efficiency, safety, and quality of bridge inspections. The Stavåbrua bridge has been well investigated, it is therefore interesting to find out what this technology can contribute and compare it with findings from traditional inspections.

The demonstrator case has been designed using a structured framework for information acquisition developed by INFRACOMS. This has been applied to design a program for the demonstration that includes: preparatory assessments (reviewing regulations, policies, IT architecture, and organizational capacity), detailed planning (on-site planning with experts for optimal documentation of bridge elements), drone-based surveys (surveys to capture high-quality RGB and thermal images), data processing (creating a detailed 3D mesh model and utilizing AI for defect detection), virtual inspections (performing inspections using the CVI platform and documenting findings), and documentation and knowledge transfer (lessons learned and developing a plan for wider adoption).

The total estimated cost for the demonstration is €53,000, covering software licenses, data collection, data processing, training, and reporting. The cost breakdown includes €5,000 for the software license CVI, €28,000 for data collection, €11,000 for data processing and handling, €0 for training (provided by COWI), €7,000 for discipline lead, preparation, and communication, and €2,000 for bridge inspection and reporting.

This report hence provides a detailed plan and cost estimate that can serve as a robust foundation for NPRA to initiate a future demonstration project of CVI. However, the framework for designing a demonstrator could be applied to other technologies. The CVI demonstration would assist NPRA in understanding the wider potential of the technology and how it could contribute to modernizing bridge inspection processes. Disseminating the outcomes via the INFRACOMS toolkit could pave the

way for broader adoption of such innovative monitoring technologies across CEDR member organisations, contributing to improved infrastructure management practices throughout Europe.

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.

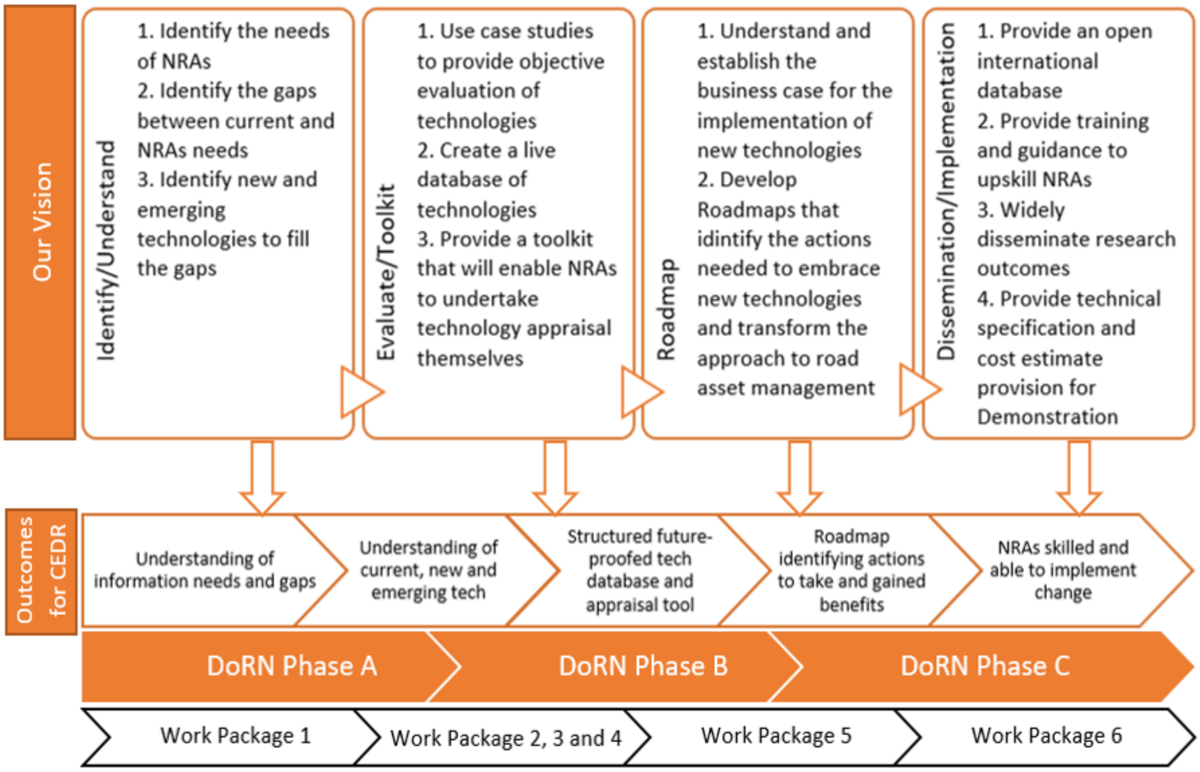


Figure 1. Vision and outcomes of INFRACOMS.

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 (D6.2 – Demonstration case specifications and cost estimate Report) has been prepared under Work Package 6 of the INFRACOMS project. Figure 2 shows the relationship of the INFRACOMS work packages, tasks and deliverables with respect to WP6 D6.2.

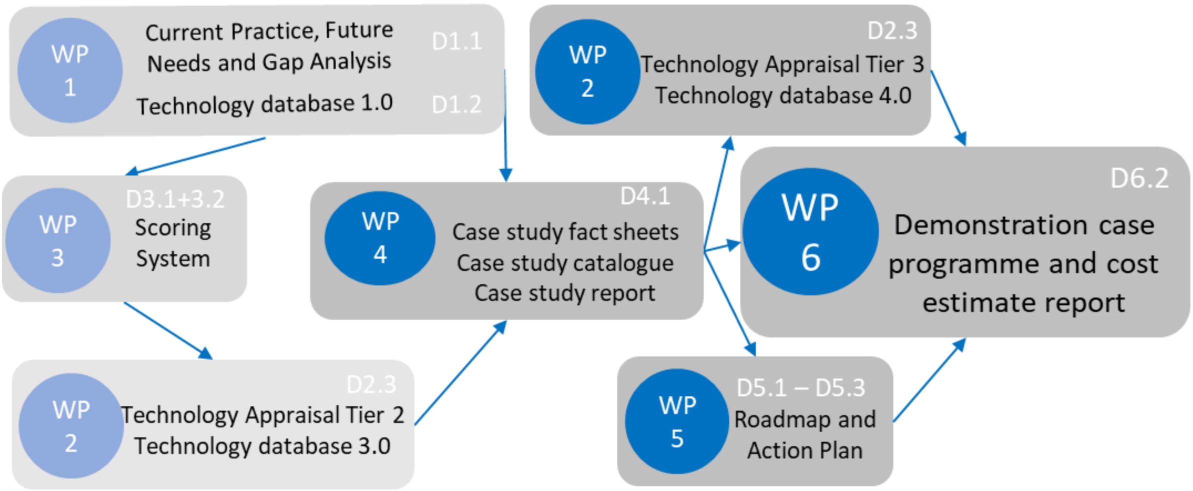


Figure 2. Relationship of WP 6 to other Work Packages, Tasks and Deliverables.

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 / gaps 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, on the basis of technology use cases. The outcomes of this work were presented in INFRACOMS deliverable D2.1. An Appraisal Toolkit and User Manual were also implemented as a wiki solution using the Confluence platform (D2.2). The Appraisal Toolkit incorporates the Technology Database 4.0, which includes appraisals of around 20 technologies in the context of specific use cases for those technologies (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 asset and its condition 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 the 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 reported on a set of real-world case studies for the most promising technologies identified using the appraisal 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 developed a methodology and toolkit for NRAs to guide them in the stages of work required to integrate new technologies into their asset management processes. This includes an organisational self-assessment tool to help NRAs understand their strengths and weaknesses around various aspects of best-practice in innovation. Using the results of their self-assessment, NRAs should be able to develop an organisational roadmap to help them improve in appropriate areas. A further aim of WP5 was to develop a framework for a technology implementation plan (or “roadmap”, which was the term used in the INFRACOMS proposal). This should help NRAs identify the key technological components that would need to be included when developing a plan of action for introducing or implementing a specific technology that has already been appraised under the INFRACOMS appraisal methodology.

1.3 Scope of this Report (D6.2)

Deliverable 6.2 develops a technical specification and cost estimate for a potential follow-up demonstration project to demonstrate the practical application of an INFRACOMS technology for a selected use case. The demonstration project itself is not part of this project, but the estimate is prepared should an NRA wish to take it up at some time in the future. It should be noted that the NRA may need to go through a public tendering process to implement such a project and there is no expectation that the participating NRA undertakes to use the technology proposed. Accordingly, D6.2 provides information and advice on the work that would be required to demonstrate the selected technology in a real-life project application.

This Deliverable 6.2 (Demonstration case specifications and cost estimate report) is related to the other work packages as shown in Figure 2 and described below.

WP2 – Appraisal of new technologies. The technologies considered for the demonstration case are selected from the list of appraised technologies contained in Technology database 4.0, produced in WP2.

WP4 – Technology case studies. The case studies compiled in WP4 provided practical examples and information to support the planning of the demonstration case.

WP5 – Road map and action plan. WP5 identified the 2-3 most promising technologies from the appraised list as potential technologies demonstration. The roadmaps and implementation guidance from WP5 have fed into the planning of the demonstration case.

In summary, Deliverable 6.2 has taken the outputs from WP2, WP4 and WP5 related to the most promising appraised technologies, case studies, roadmaps and implementation guidance, and used those to develop a technical specification and cost estimate for a possible follow-up demonstration project.

2. Selection of the demonstration case

The selection of demonstration cases was based on three key factors:

- The list of most promising technologies identified in Work Package 5 (WP5).
- The interest of the NRA to investigate what is required and the possibilities of testing/using this technology.
- The interest of Technology Provider to contribute and describe a possible demonstrator case.

The COWI virtual inspection platform[1] satisfied all of the necessary conditions for a demonstration case. The NPRA also accepted the selection of this technology and provided a specific use case and bridge location for the demonstrator project. The Stavåbrua bridge has been extensively investigated in the past. It is therefore interesting to find out what this technology can contribute to the current information available on the bridge and compare it with findings from traditional inspections. This technology was therefore selected for preparation as a demonstrator project.

The following section presents the proposed activities for the demonstration case and a cost estimate. These activities are based on a framework for demonstration cases that INFRACOMS has designed to facilitate the acquisition of information, through structured interviews with technology providers and National Road Authorities (NRAs). The developed framework is provided in Appendix A. Although D6.2 presents a single demonstration case, this framework could be applied in future when considering the demonstration of other technologies.

3. Demonstration case – Virtual Inspection platform on Stavåbrua managed by NPRA

The proposed demonstration will pilot the virtual inspection platform for automated detection of defects on bridges, leveraging drone/UAV imagery and AI/computer vision technologies. The solution will be applied to the Stavåbrua, which is a reinforced concrete arch bridge built in 1942.

The virtual inspection platform is designed to improve the efficiency, safety, and quality of periodic bridge inspections currently conducted by NPRA using traditional manual methods.

The following provides technical specifications and cost estimates to enable an NRA to initiate the project at some time in the future. It is noted that the cost estimate and implementation plan are contingent upon the existing state of the relevant technologies and the specific asset's characteristics. For instance, in the case of the virtual inspection platform, the method employed for acquiring image data is reliant on the bridge's structural details and their compatibility with drone flight operations. Furthermore, there is an ongoing progression towards enhanced camera technology, drones with improved manoeuvrability and obstacle avoidance capabilities for capturing high-quality imagery with substantial overlap for photogrammetric applications, and advanced AI algorithms for defect detection. These advancements could potentially impact the cost and implementation strategies, including the utilization of photogrammetry techniques for virtual inspections. As such, the provided estimates and plans should be considered within the context of the current technological landscape and asset-specific factors, subject to potential revisions as

[1] Report D4.1: Report and catalogues of Case Studies for INFRACOMS.

innovations emerge. It should also be noted that the estimated cost is higher compared to the consecutive bridge inspection scans since the first scan is considerably more expensive than those to follow.

3.1 Infrastructure asset

It is proposed that the system be demonstrated on the Stavåbrua road bridge on the E6 in Rennebu municipality in Trøndelag, three kilometers south of Berkåk. The bridge crosses the river Stavåa ‑ a tributary to Orkla ‑ over a 70 m high gorge and is 104 meters long. The Stavåbrua was built in concrete by Norwegian workers during the German occupation of Norway in 1942. As the asset is located in Norway, NPRA would be the appropriate NRA to lead this demonstration.

The Stavå bridge is a reinforced concrete beam arch bridge with three side spans. The main span is 53 meters, and each of the side spans is 8 meters. The arch is fixed at both supports. The arch is made up of two arches connected by cross-members. The cross-section of the arch is largest by the supports and becomes gradually smaller towards the crown. The bridge deck is a continuous double T-beam, which is supported on roller supports at both the abutments. The bridge deck is connected directly to the top point of the arch. The rest of the bridge beam is supported on columns connected to the arch. In the transverse direction, the web of the T-beam rests on one column each. There is a cross member between the two webs at each point where the bridge beam is connected to columns. All the columns are pinned at both ends. See Figure 3 for location and Figure 4 for a technical drawing of the bridge.

Figure 3: Location of Stavåbrua.

Bridge crossing the river of Stavå:

Bridge Type: Concrete beam arch bridge

Construction Period: 1942

Length: 104 meters

Width: ~7 meters

Vertical Clearance: ~18 meters

Main span: 53 meters

Traffic lanes: 2 (vehicles)

***Note:** Since March 2022 the bridge has been temorarily closed*

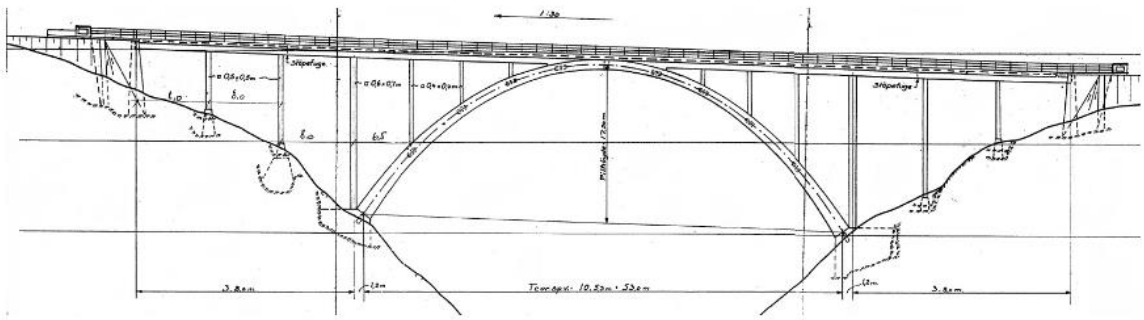


Figure 4: Technical drawing of Stavåbrua.

3.2 Possible scope of the demonstrator project

3.2.1 Aim

The primary goal of this project is to adopt new technology to enhance security, improve inspection quality, increase data accessibility, and streamline bridge management processes. This estimate will enable NPRA to conduct a pilot study, subject to budget and procurement rules. This includes assessing the organizational requirements, integration with existing and future asset management systems, and alignment with the Norwegian Public Road Administration's (NPRA) business model. Additionally, NPRA aim to explore the costs and long-term sustainability of the technology, as well as data ownership and sharing concerns.

3.2.2 Objectives

- Conduct a thorough inspection of part of one bridge, with focus on the lower arches, all four sides, and the facade of the road deck. If only part of the bridge is being focused on, then an explanation should be given as to why the other parts could not be focused on. Are there limitations and challenges for data capture or 3d modelling of the other parts?
- Assess the data collection process using drones and photogrammetry for creating 3D models of the Stavå bridge.
- Evaluate the defect detection and annotation capabilities of the platform, including AI-assisted analysis and automated defect identification.
- Assess the cost-effectiveness and potential benefits, disadvantages/limitations of the virtual inspection platform compared to traditional bridge inspection methods.
- Identify any regulatory, operational, or organizational challenges and requirements for adopting the technology within NPRA’s existing workflows and processes. For example can challenges arise which may compromise ability for NPRA to realise long term benefits of the technology when NPRA may need to change supplier due to procurement rules.

3.2.3 Expected outcomes

- Obtain comprehensive information about the condition of bridges, enabling cost-effective maintenance planning and prolonging the operational lifespan of these critical assets.
- Gain a comprehensive understanding of the Virtual Inspection platforms capabilities, limitations, and suitability for the NPRA’s specific needs and requirements.
- Obtain insights into the potential costs associated with implementing the virtual inspection platform, including initial investment, training, and ongoing operational costs.
- Understand the requirements and considerations for successful implementation and integration of the platform within the NPRA’s existing asset management systems and processes.
- Receive guidance on selecting suitable bridges for virtual inspection based on factors such as size, complexity, accessibility, and criticality.
- Identify opportunities for process optimization and streamlining of bridge inspection activities through the adoption of the virtual inspection platform.
- Obtain AI-proposed maintenance activities based on identified defects and/or use the data as a basis for training an AI to suggest maintenance activities.
- Knowledge on how the NRA should address the need for physical inspection/testing where this is required.

3.3 Deliverables stated by supplier

- Provision of a virtual 3D model of the Stavåbrua bridge (available in the CVI platform for 5 years).
- All collected RGB and thermographic images as well as the virtual 3D model of the bridge can be delivered in standard formats.
- Inspection report documenting the current bridge state, defects found and recommendation for a maintenance strategy.

3.4 Stakeholders and roles

The successful implementation of CVI requires the involvement and coordination of various stakeholders, each playing a crucial role in ensuring a seamless and effective deployment:

- NPRA's asset management team, including bridge inspectors and decision makers.
- COWI representatives to:
  - Issue licenses to and maintain the CVI platform.
  - Collect data in collaboration with drone service provider.
  - Process and handle data.
  - Train NPRA operators in use of the inspection platform.
  - Conduct report with pictures and recommendations for maintenance strategy.
- Drone service provider to assist with detailed flight plan and data collection.
- Relevant regulatory authorities for necessary permits and compliance.

3.5 Program for demonstrator project

This section provides a step-by-step plan for the demonstration project.

- Step *1. Preparatory assessments* and Step *6. Document findings, knowledge transfer, plan for scaling up and wider adoption* are based on the *Framework for an Implementation Plan* proposed in *INFRACOMS REPORT 5.2-5.3*.
- Steps *2-5* are technology-specific and are explained in greater detail in *INFRACOMS REPORT D4.1 Case study report* and in *Appendix B – ATR CVI Stavåbrua*.

3.5.1 Preparatory assessments

Prior to commencing a project, a range of questions must be considered as follows:

- ➢ Review existing regulations
  - Investigate whether there are any legal or regulatory barriers related to the technology (e.g. drone use). Does it require any permits or approvals?
  - Would it be necessary to propose new regulation and how long would that take?
  - Does procurement comply with existing regulations?
- ➢ Review policies / Standards
  - Review existing organisational policies to confirm that CVI will be compliant with overarching policies and develop or update as necessary.
  - Review the standards or procedures in the organisation that may need to be updated with respect to the use of CVI for decision-making, especially if it is replacing an existing established process.
- ➢ Ensure compatibility with the IT architecture of the "receiving" organisation
  - Review the compatibility of the existing systems to accept the new technology, how would they interact, are the data compatible etc.

- What are the data storage requirements? If very high, what resources will be required? Does the NRA require the results only, or do they need the raw data as well?
- When/how often does the software need to be updated? How will these be planned and accommodated across the lifecycle of the technology and the systems into which the data is to be loaded?
- Are there any potential cyber-security concerns/risks over the new technology? What actions will be needed across the lifecycle to manage these?
- Which safety procedures need to be implemented prior to using this technology?

➢ Review organisational capacity
- Investigate the requirement for buildup of capacity within the organisation.

➢ Health, safety, and environment
- Develop health, safety, and environmental impact assessments with mitigation strategies.

3.5.2 Planning

The virtual inspection should be carried out in close collaboration between domain experts within drone-based data collection, data processing, concrete and bridge inspection.

Detailed planning for the bridge access/inspection should be conducted on site in connection with execution of the drone-based survey.

The bridge will be documented with RGB and thermographic images. There should be special focus on documentation of the arches, the cross beams that connect the two arches and the edge beam, since there may be significant damage to these bridge elements, but which may be physically smaller to identify. On the vertical bridge piles and on the underside of the road deck, significant damage will be bigger and thus easier to locate.

3.5.3 Drone based survey

The survey would be carried out using drones. All accessible concrete surfaces on bridge elements shall be documented (imaged) with RGB and thermal images, with photogrammetric overlap between the images.

The survey will be carried out as soon as possible after the bridge is declared ready for inspection, taking into account the following weather guidelines:

- Calm wind conditions with a maximum of 10 m/s.
- Good light conditions and visibility.
- The concrete of the bridge must be dry during execution of the survey.
- The best quality of the thermographic images is achieved in periods where the temperature is changing.

3.5.4 Data processing

The captured drone imagery will be processed by photogrammetry to create a highly detailed 3D mesh model i.e. a virtual photorealistic digital representation of the bridge, that allows for visiting any part of the bridge from a PC or mobile device. The virtual model contains potential defects identified by an AI algorithm, which can later be assessed by a trained specialist.

3.5.5 Virtual inspection

The virtual model will be accessed in a project folder in "CVI platform" – a web-based platform, which can be accessed by all relevant stakeholders. COWI will provide training to NPRA in use of the virtual platform. Based on the virtual model a complete inspection of the bridge will be carried out by a trained specialist supported by a trained AI algorithm. Identified defects will be registered on the virtual model and included in a full report. The report will also contain a maintenance strategy for the identified defects.

3.5.6 Documentation, knowledge transfer and scaling plan

Findings, lessons learned and best practice from the demonstration project will be documented and a plan for potential wider adoption and scaling of the technology across NPRA's bridge network proposed.

3.6 Risk register

This is a list of potential risks:

- Change in regulations for drone flight.
- Regulatory and legal risks (drone permits, data privacy).
- Technical risks (data quality, AI performance).
- Operational risks (weather, access restrictions).
- Organizational risks (change management, staff training).
- Reputational risk (damaged reputation of the organisation).

3.7 Cost estimate for demonstrator project

A table with breakdown of cost factors and suppliers involved:

Factor	***Supplier***	***Budget price***
Software license CVI	*COWI*	*5.000 Euro (estimated)*
Data collection	*COWI/drone partner*	*28.000 Euro*
Data processing and handling.	*COWI*	*11.000 Euro*
Training	*COWI*	*0 Euro*
Discipline lead, preparation, communication etc.	*COWI*	*7.000 Euro*
Bridge inspection including detailed report with pictures and recommendations for maintenance strategy	*COWI*	*2.000 Euro*
		Total 53.000 Euro

A detailed description of what is included in the price is provided in Appendix B.

4. Conclusions

This Deliverable, D6.2, has developed a comprehensive plan and cost estimate for a proposed demonstration project for a promising technology identified in the INFRACOMS technology database – specifically the COWI Virtual Inspection (CVI) Platform. The primary aim of this report was to show the structure and content of a potential demonstrator project and provide detailed technical specifications and financial projections for such a future demonstration project using a specific technology.

The demonstrator case has been designed using a structured framework for information acquisition developed by the project.

The program for the demonstrator project includes several key phases:

- **Preparatory Assessments:** Reviewing regulations, policies, IT architecture compatibility, and organizational capacity.
- **Detailed Planning:** Conducting on-site planning with domain experts for optimal documentation of bridge elements.
- **Drone-Based Surveys:** Executing surveys to capture high-quality RGB and thermal images.
- **Data Processing:** Creating a detailed 3D mesh model and utilizing AI for defect detection.
- **Virtual Inspections:** Performing comprehensive inspections using the CVI platform and documenting findings.
- **Documentation and Knowledge Transfer:** Recording lessons learned and developing a plan for wider adoption.

The total estimated cost for the demonstration project is €53,000, covering software licenses, data collection, data processing including a maintenance plan for the bridge defects identified, training, and reporting. It should be underlined that the first scan required to initially build the 3D model is the most expensive one – consecutive bridge scan would have a reduced price.

The CVI Platform is an example of technology that was appraised in the INFRACOMS project, which was identified to have high potential in the use case of bridge condition assessment and management. This report, D6.2, has provided a detailed plan and cost estimate that can serve as a robust foundation for NPRA to initiate a future demonstration project. However, the framework for designing a demonstrator could be applied to other technologies.

The CVI demonstration would assist NPRA in understanding the wider potential of the technology and how it could contribute to modernizing bridge inspection processes. However, disseminating the outcomes via the INFRACOMS toolkit could pave the way for broader adoption of such innovative monitoring technologies across CEDR member organisations, contributing to improved infrastructure management practices throughout Europe.

Appendix A. Framework for demonstrator projects

1. Headline demonstrator case

Short intro mentioning the technology involved, NRA and the asset on which it is planned to be used. The selected technology and confirmed NRA are inputs from WP5. The selected technology is planned to be deployed on a specific asset proposed by the NRA.

1.1 Infrastructure asset

A similar description as for the case studies to understand the complexity of what the technology is planned to be applied on. This information is obtained from the interested NRA or TP.

1.2 Scope of the demonstrator project

1.2.1 Aim

One sentence summarizing the aim.

1.2.2 Objectives

3-5 bullet points with objectives.

1.2.3 Expected outcomes

3-5 bullet points with expected outcomes.

1.3 Deliverables stated by supplier

1.4 Stakeholders and roles

A list of relevant stakeholders for implementing the technology and the reason for them being included. This list is created by the consortium potentially requiring input from the technology provider.

1.5 Program for demonstrator project

A step-by-step plan for the demonstration project.

1.6 Risk register

List foreseen risks.

1.7 Cost estimate for demonstrator project

A table with breakdown of cost factors and suppliers involved:

Cost	*Factor*	*Supplier*
Total		

Appendix B. ATR CVI Stavåbrua

ATR sheet (Activity, Time and Resources)

COWI	**Project name** INFRACOM – COWI Virtual Inspection of Stavåbrua bridge			**Project number** Click here to enter text.	
Activity number	**Version** 1.0	**Date** 31.05.2024	**Prepared** CLBH	**Checked** MSSI	**Approved** MSSI

Activity name
Demonstrator case: COWI Virtual Inspection Platform for Stavåbrua Bridge Maintenance.

Objective of the activity
This demonstration project considers the implementation of COWI virtual inspection platform for the maintenance of the Stavåbrua managed by the Norwegian public roads administration (NPRA).

About COWI Virtual Inspection
COWI Virtual Inspection (CVI) is COWI's own developed concept that supports a digital method for inspection of large structures such as bridges. A CVI supported inspection is typically carried out according to the same principles as a principal inspection but carried out in the office.

The CVI inspection concept includes a complete documentation and AI supported damage detection of all surfaces of a structure. The documentation consists of RGB images typically collected with a drone, often in combination with other types of data such as thermographic images. Based on the collected images, a photorealistic 3D model of the structure is created. The virtual model is a complete documentation of the structure at the time of the survey.

The 3D model and the collected images are accessed via the web-based CVI platform, which is an inspection platform where you can easily and efficiently navigate around in the photorealistic 3D model of the structure.

The inspection itself is carried out directly in the 3D model, supported by capability to inspect specific details in the individual images. In the CVI platform, the individual damages can be registered, measured, classified, described, and summarized in an inspection report. The actual location of the damage can be seen directly on the 3D model.

About Stavåbrua bridge:
Bridge crossing the river of Stavå:

Bridge Type: Concrete beam arch bridge

Construction Period: 1942

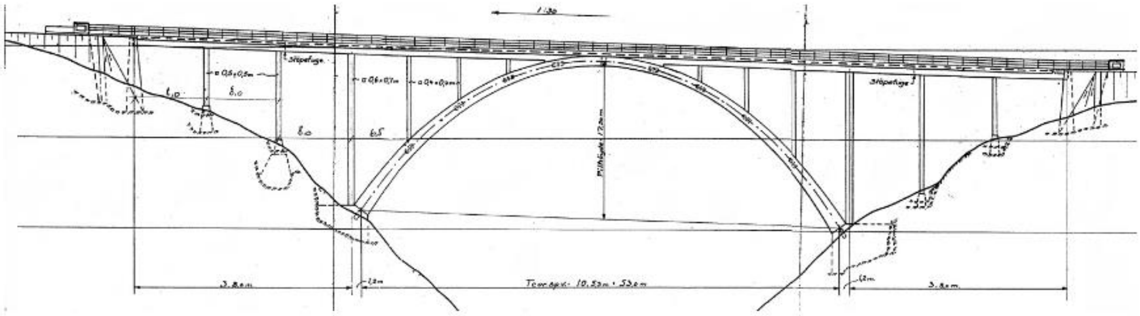
Length: 104 meters

Width: ~7 meters

Vertical Clearance: ~18 meters

Main span: 53 meters

Traffic lanes: 2 (vehicles)



Scope of services for the activity (quantified)

The price listed below includes production and access to a virtual model of Stavåbrua in Norway in the CVI platform and it also incl. a diagnostic of the bridge current condition and suggestion for a maintenance plan for the possible found defects.

The virtual inspection is carried out in close collaboration between domain experts within drone-based data collection, data processing, concrete and bridge inspection.

The bridge is documented with RGB and thermographic images. Special focus will be on documentation of the arches, the cross beams that connect the two arches and the edge beam. Since there may be smaller but significant damage to these bridge elements. On the vertical bridge piles and on the underside of the road deck, significant damage will be bigger and thus easier to locate.

Planning

Planning is carried out for the drone-based survey, where it is planned how the bridge elements can be documented in the best possible way.

The temporary bridge may be a challenge in relation to documenting various parts of the bridge from the most optimal angels. The detailed planning will therefore be carried out at the bridge, in connection with the execution of the drone-based survey.

Drone based documentation of the bridge

The survey is carried out using drones. All accessible concrete surfaces on bridge elements are documented with RGB and thermal images with photogrammetric overlap between the images.

The survey is carried out as soon as possible after the bridge is declared ready for inspection, taking into account the following weather guidelines:

- Calm wind conditions with a maximum of 10 m/s
- Good light conditions and visibility
- The concrete of the bridge must be dry during execution of the survey
- The best quality of the thermographic images is achieved in periods where the temperature is changing

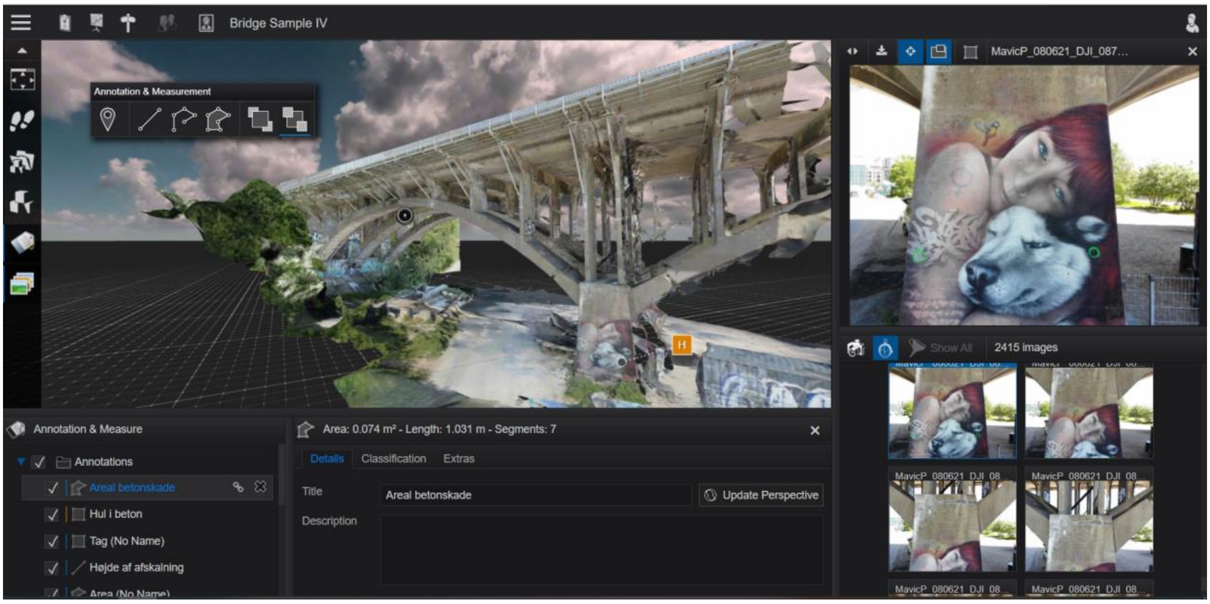
It is a complicated task to do the drone-based survey of the bridge and it requires an experienced drone pilot. To reduce the risk of insufficient coverage and thus repeated measurements of the bridge, it is recommended that the data collection be carried out in collaboration with COWI's drone partner with experience from documenting several large and complicated bridges.

If virtual inspection of several bridges is to be commenced, then COWI can assist in locating and training a local drone partner.

Virtual model

Based on the collected RGB images, a 3D virtual model of the bridge is being processed. A virtual model is a photorealistic digital representation of the real bridge that allows you to visit any part of the bridge from a PC, laptop or a mobile device.

COWI Virtual Inspection platform



The virtual model, colour and thermographic images of the bridge are accessed in a project in COWI's inspection platform (CVI platform). It is a web-based platform that can be shared between and accessed by relevant stakeholders.

The price for the CVI platform, as indicated in the resource table below, includes creation of the project, 5 years' license and 5 years' hosting of the collected data.

If the project is to be continued after the 5-year license period, an annual license and hosting expense must be expected for.

Bridge state evaluation

Based on the virtual model a complete inspection of the bridge is carried out by a trained specialist. Identified defects are registered on the virtual model and also included in a full report. The report also contains a maintenance strategy for the identified defects.

Training

After completion members of the INFRACOM community get access to the virtual model of Stavåbrua bridge in the CVI platform. This is followed up by a 2-3 hour online training session. The training session is held by both a data and platform expert and an expert in the inspection of concrete bridges. If there is a lot of interest, the training session is repeated.

The training seminar(s) is part of COWI's contribution to the project and is not charged.

Basis/assumptions for execution of the activity

COWI/drone partner staff is granted access to the bridge and permission to operate a drone near the bridge.

The client's services in relation to this activity

Access to the bridge and permission to operate a drone near the bridge incl. the temporary bridge.

Safety instructions, if needed.

Start-up and deadline

To be discussed.

Responsible for activity

Budget price	*Factor*	*Supplier*
5.000 Euro(estimated)	*Software license CVI*	*COWI*
28.000 Euro	*Data collection*	*COWI/drone partner*

11.000 Euro	*Data processing and handling.*	*COWI*
0 Euro	*Training*	*COWI*
7.000 Euro	*Discipline lead, preparation, communication etc.*	*COWI*
2.000 Euro	*Bridge inspection including detailed report with pictures and recommendations for maintenance strategy*	*COWI*
Total 53.000 Euro		

Result/deliverables
Access to a virtual model of the Stavåbrua bridge in the CVI platform in the period mentioned above.

All collected RGB and thermographic images as well as the virtual 3D model of the bridge can be delivered in standard formats.

Inspection report documentation the current bridge state, found defects and recommendation for a maintenance strategy