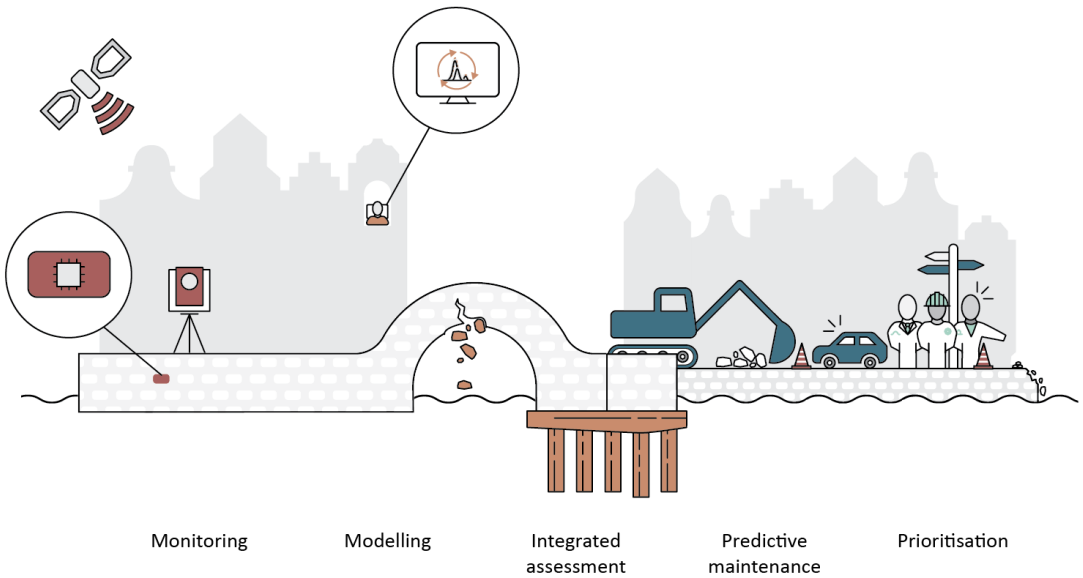
LiveQuay: Live Insight in Bridges and Quay Walls

Summary

Cities, public asset owners and citizens currently struggle to keep bridges and quay walls, often long passed their (technical) end of service life, in adequate condition and open for traffic. Asset owners urgently need reliable and transparent knowledge and tools to support decisions on maintenance prioritisation and potential lifetime extension. LiveQuay will provide an integrated assessment of the safety and performance of bridges and quay walls by designing a **decision support platform that will be interactive and based on values from stakeholders.** Within the platform, our unique system will indicate **more accurately and faster** than currently possible, whether the structure is still safe to operate or approaching failure.

LiveQuay addresses the challenge to **provide insights in what the most effective information is that supports decision making for asset owners** given the complexity of the different views and values the stakeholders have. For this, a co-creation approach is set up involving all stakeholders in the knowledge chain. Furthermore, most historic structures are built up from a variety of materials (masonry, timber, soil), and failure mechanisms for these material combinations are difficult to quantify, highly non-linear and changing over time. Therefore, LiveQuay **combines several sources of heterogeneous monitoring data with the complex physics behind the prediction of failure mechanisms and the remaining life span of bridges and quay walls**. The engine of the platform will be a continuously evolving, probabilistic physics-informed machine learning model, which will significantly increase our understanding of the behaviour of bridges and quay walls over time.

Both challenges combined, the LiveQuay platform will lead to a **more realistic estimate of the strengthening / renewal needs** and will increase the **transparency of decision making**. If existing structures can remain in function longer, **investments can be postponed** and the impact on cities and people can be reduced significantly.



Consortium partners

Main applicant			
Name, title(s)	*Organisation*	*Position*	*Expertise (in key words)*
Mandy Korff, dr. ir.	TU Delft/Deltares	Associate professor at TU Delft, strategic advisor at Deltares	Integration monitoring and modelling for quay walls, geotechnics

Co-applicants			
Name, title(s)	*Organisation*	*Position*	*Expertise (in key words)*
Andreas Hartmann, dr.	UTwente	Associate professor	Infrastructure asset management, life-cycle decision making, stakeholder management
Ramon Hanssen, prof.dr.ir.	TU Delft	Full professor	Geodetic measurements, satellite radar interferometry (InSAR), stereo photogrammetry, monitoring
Giorgia Giardina, dr.	TU Delft	Assistant professor	Integration monitoring – modelling for bridges, geotechnics and structures
Alice Cicirello, dr.	TU Delft	Associate professor	Integrated data and physics modelling, uncertainty quantification in SHM and design decision making
Martine van den Boomen, dr. ir. MBA	Rotterdam University of Applied Science (RUAS)	Lector asset management	Asset management, predictive maintenance, reliability engineering, life cycle costing, decision making under uncertainty
Timo Schweckendiek, dr. Ir.	Deltares	Specialist	Reliability in geotechnics and structures
Alessandro Antonini, dr. Ir.	TU Delft	Assistant professor	Hydraulic structures, field modal test, Structural Health Monitoring (SHM)

Cooperation and supporting partners

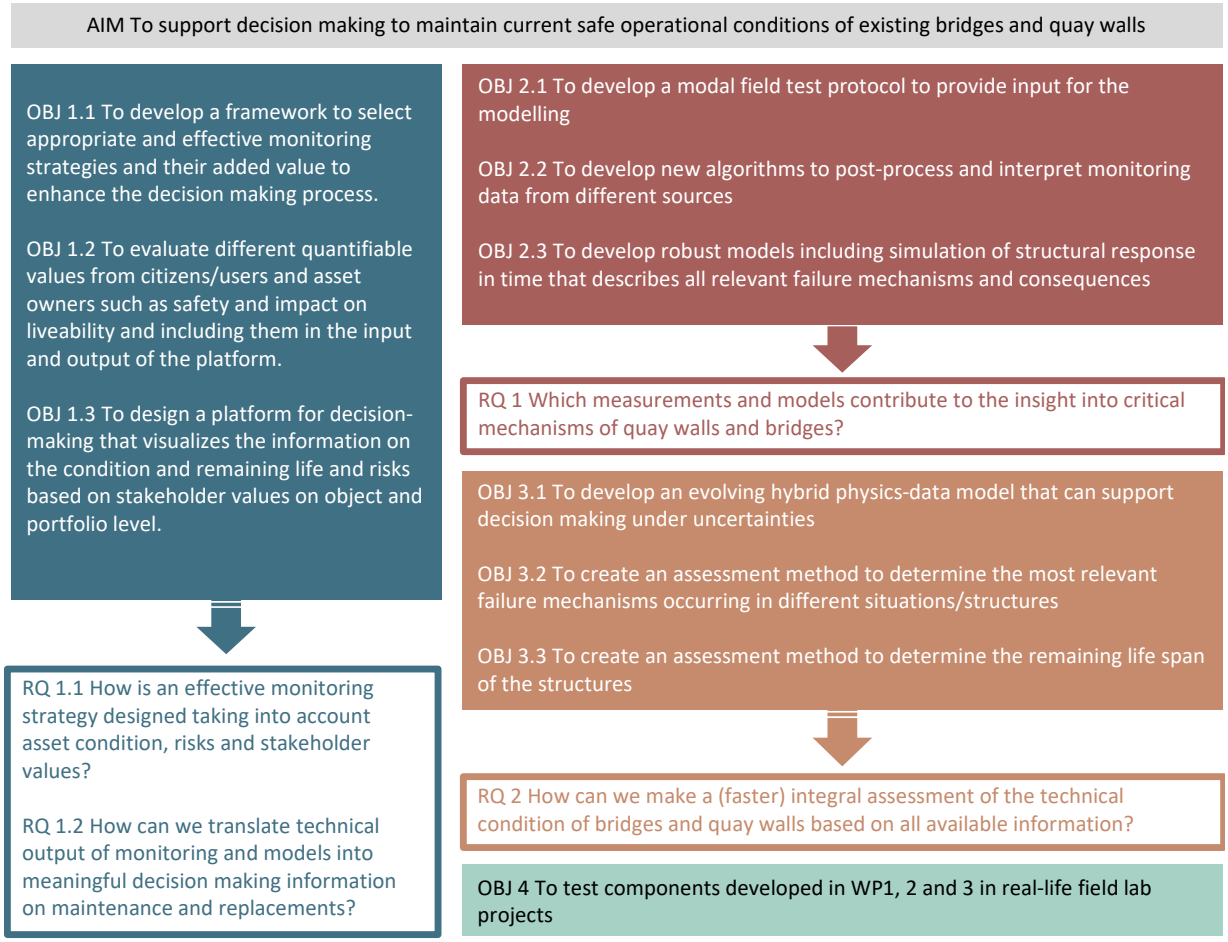
Applicants:

Supporting partners:

Cooperating partners:

Objectives and research questions

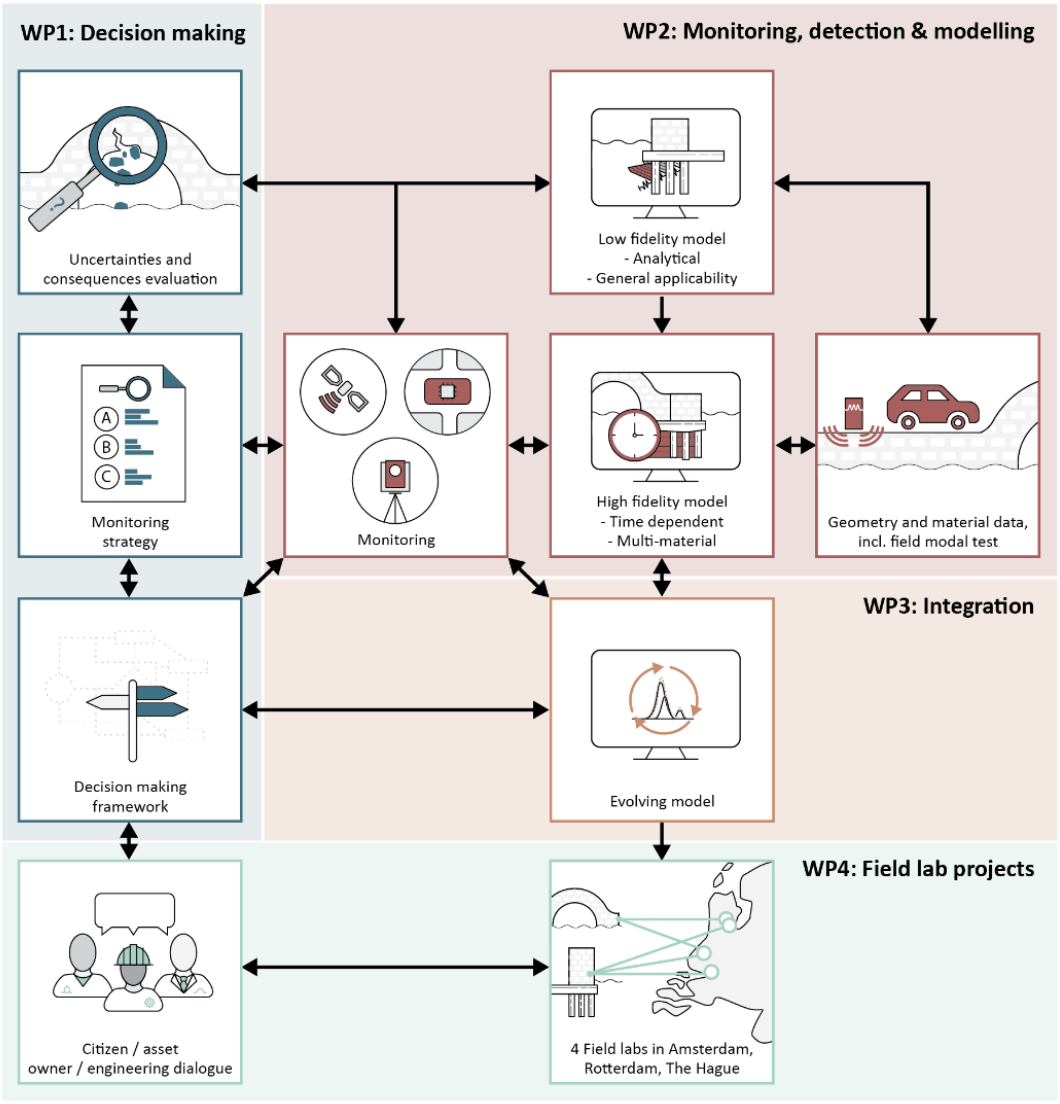
The overall aim of the project is to improve decision making to maintain the current safe operational conditions of existing infrastructure, by assessing the remaining useful life span and the potential need for measures on quay walls and bridges in urban environments.



Research questions and objectives of LiveQuay

Work plan

The LiveQuay project is built up in four distinct, but interrelated work packages, shown in Figure 4. **WP1** forms the interaction with the stakeholders in the field of decision making, **WP2** and **WP3** are the technological developments in monitoring and modelling and **WP4** is the fast-track implementation and feedback loop with the field lab projects.



Work packages, activities and relations

LiveQuay will support 3 postdoc positions (at U Twente, RUAS and TUD) and 2 PhD positions (both at TU Delft).

Output planned

The output of LiveQuay will be the design of the platform, including the underlying elements that it is built of and the application of those in four field lab projects:

- WP1 will deliver visualisation of the **uncertainties and risks**, combined into an overview of the **consequences** of failure for both bridges and quay walls. It will further deliver a **monitoring strategy** implemented in a guideline, which will help to judge the added value of different information sources (mainly monitoring techniques and modelling methods). The workshops on citizen/asset owner/engineering will lead to an **evaluation of the values of the stakeholders**. WP1 also integrates all results of the project in the design of the **platform for decision making**.
- WP2 delivers both the **low-fidelity** as well as the **high-fidelity models** for understanding all failure modes of quay walls and bridges over time. It will also deliver **the modal field test protocol** for rapidly

checking the input of the models. WP2 also delivers **new procedures and algorithms to post-process monitoring data** so that it can be included in the evolving model of WP3.

- WP3 delivers a **novel strategy for developing an evolving, probabilistic physics-informed machine learning model** that can support decision making under uncertainties. In particular, novel statistical model updating approaches will be developed for use of heterogeneous prior information; accounting for the model error, as well as spatial and temporal correlations in the measurements. Also, an **efficient computational strategy** for evaluating the resulting posterior with innovative advanced Monte Carlo-based sampling strategies will be explored.
- WP4 creates as output **four field lab projects (2 in Amsterdam, 1 in The Hague, 1 in Rotterdam)** in the portfolios of the asset owner partners where early results are tested for their merits. Successful field lab projects show a reduction of uncertainties in the assessment of its specific object (quay wall or bridge).