

Steel Infrastructure as Socio-Technical Systems

By

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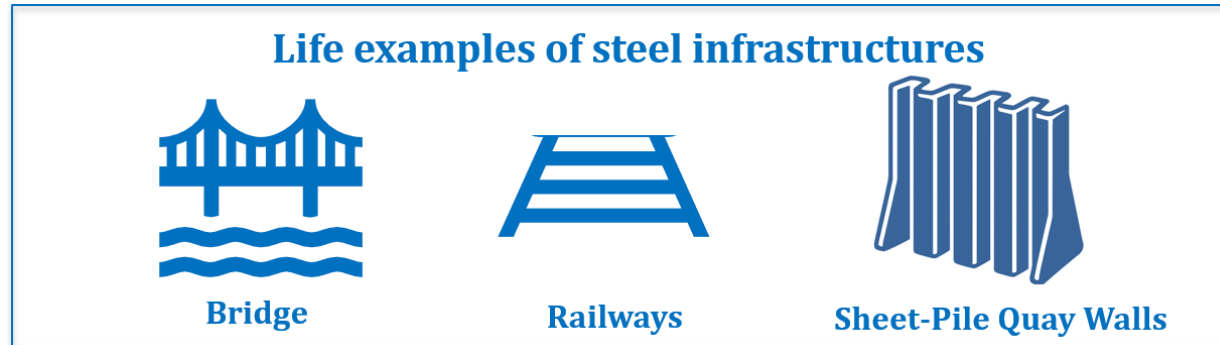
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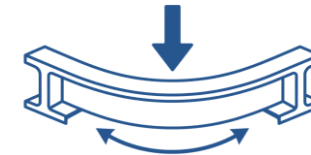
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Introduction and streamlining

- ❑ **Steel-based infrastructure** has been widely used and has supported major urban infrastructure systems.



- ❑ This is because steel is **a flexible and stable material** with high strength.



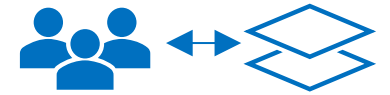
- ❑ They are not just physical/technical systems, because they play a key role in our society



They are *socio-technical* and long-lasting built assets used by the public!

Introduction and streamlining

- ❑ **Socio-technical system:** A system in which *social* and *technical* components, people and infrastructure, depend on one another (Trist and Bamforth, 1951).



- ❑ Adopting this multidimensional view enables us to understand the complex and interdependent challenges facing steel infrastructures

Conflicting (socio-technical) challenges facing sustainability/resilience in steel infrastructure

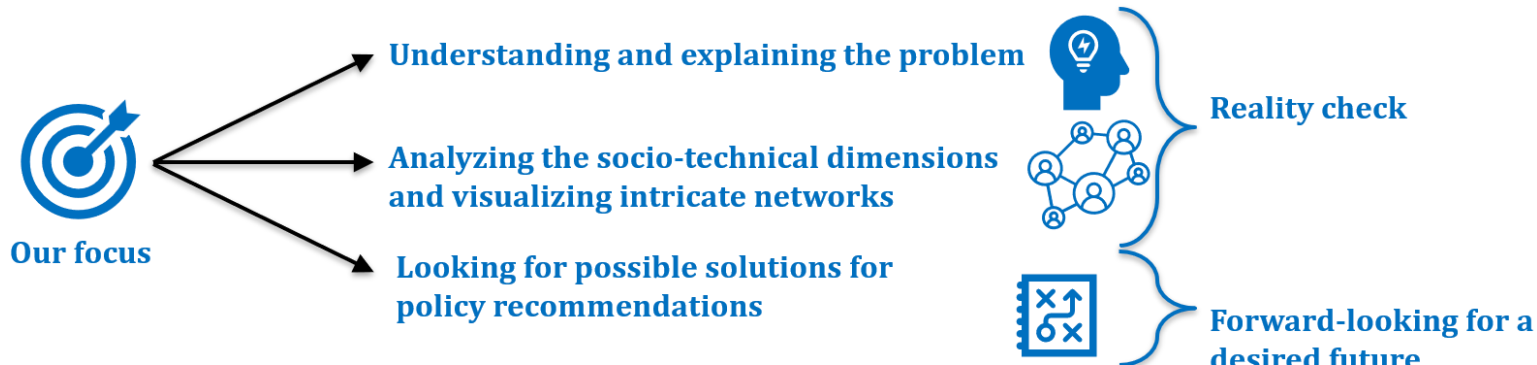
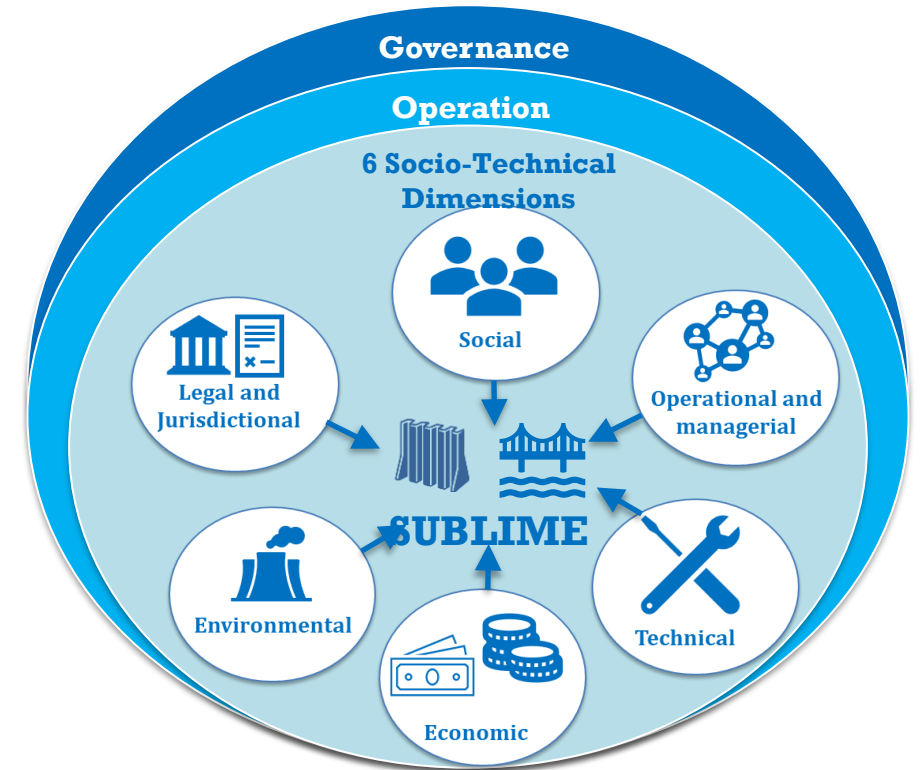


Sources:

Trist, E. L., & Bamforth, K. W. (1951). Some Social and Psychological Consequences of the Longwall Method of Coal-Getting: An Examination of the Psychological Situation and Defences of a Work Group in Relation to the Social Structure and Technological Content of the Work System: An Examination of the Psychological Situation and Defences of a Work Group in Relation to the Social Structure and Technological Content of the Work System. *Human Relations*, 4(1), 3-38.

The SUBLIME project and its socio-technical framework

Dimension	Brief description
Technical	Physical and technological characteristics associated with the infrastructure assets and their components
Economic	Financial considerations related to the infrastructure assets
Environmental	Ecological aspects associated with the infrastructure assets and their environmental impacts
Legal and jurisdictional	All authority- and legislation-related aspects affecting the regulation and governance of the infrastructure assets
Social	Societal needs and impacts on the infrastructure assets
Operational and managerial	Processes related to aspects associated with the management models of the infrastructure assets, including the stakeholders involved in the planning, operation, and maintenance of infrastructure assets



The use of our framework as an exploratory tool

Multiple sources of evidence are iteratively used in two use cases.



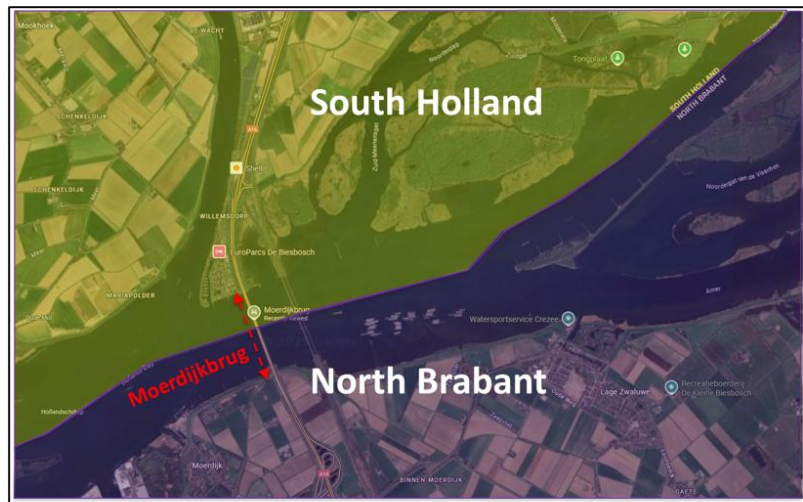
In-depth interviews



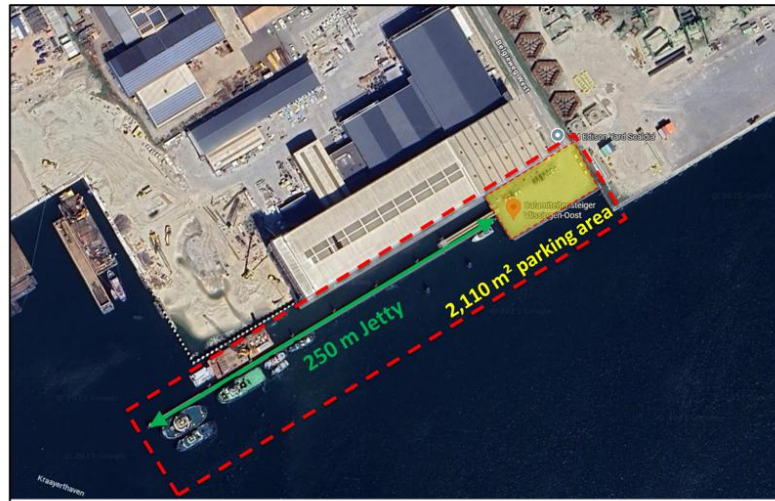
Data modelling and visualization
(AIS & NDW data to analyse the use pattern)



Archival and desktop research



Moerdijkbrug (RWS), NL



VK0805 sheet-pile quay wall (NSP), Vlissingen, NL

RETHINKING STEEL INFRASTRUCTURE AS SOCIO-TECHNICAL SYSTEMS OF MULTIDIMENSIONAL AND INTERDEPENDENT ASPECTS: THE CASE OF A BRIDGE AND A SHEET-PILE QUAY WALL IN THE NETHERLANDS

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Although steel infrastructures play a key role in supporting societal services, their sustainability and reliability remain overlooked due to their socio-technical complexities. This ongoing study, which is part of the SUBLIME project, aims to analyse the socio-technical dimensions associated with sustainable and reliable steel infrastructures. A case study approach has been used on two cases: a bridge and a sheet pile. Mixed-research methods have been iteratively used, namely document review, data modelling, and in-depth interviews. The results show context-specific similarities and differences in the socio-technical dimensions. Both cases share the same technical condition in terms of their reliability and longevity. Economically, both asset cases play a key role in supporting the freight sector. However, they differ in the environmental, legal, social, and operational dimensions. The paper bridges a theory-practice gap between the call for rethinking urban infrastructure assets as socio-technical systems, in a broader perspective, and practices of managing steel infrastructure projects. Particularly, the observations of this study can set the stage for putting forward policy recommendations and decision-making models for sustainable and reliable steel infrastructures.

Keywords: asset management; governance; infrastructure; networks; sustainability

INTRODUCTION

As cities and urban areas have been argued to be networks of socio-technical systems of interacting processes and components, their infrastructures constitute essential interrelated and interdependent systems that contribute to their evolution by virtue of connecting the physical landscape with human activities (Graham, 2000). Infrastructures are the lifeline of cities (Yan *et al.*, 2024), supporting mobility, services, and the economy (Neuman, 2020). Although they play a key role in providing societies with public assets that support a wide range of services, they can

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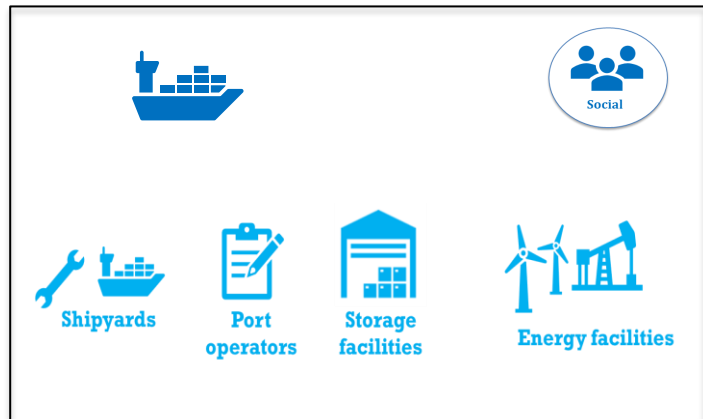
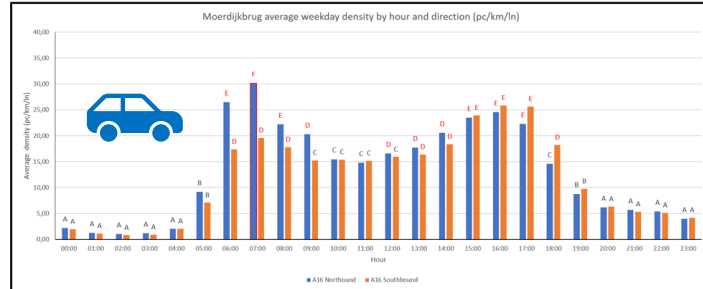
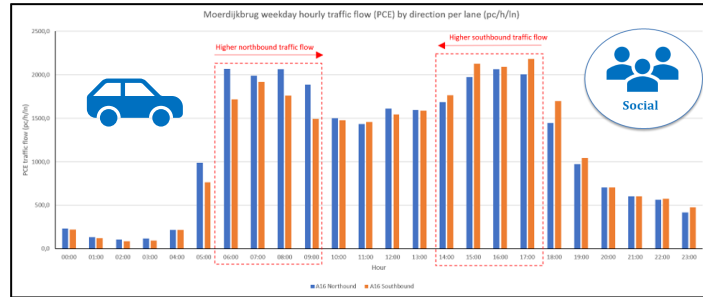
Hamida, M B, van den Berghe, K and Kattavenaki, K (2026) Rethinking Steel Infrastructure as Socio-Technical Systems of Multidimensional and Interdependent Aspects: The Case of a Bridge and a Sheet-pile Quay Wall in the Netherlands In: Chow, V and Neilson, C J (Eds) Proceedings of the 42nd Annual ARCOM Conference, 7-9 September 2026, Loughborough University, UK, Association of Researchers in Construction Management, 388-397.

ARCOM Conference 2026,
Loughborough University, UK

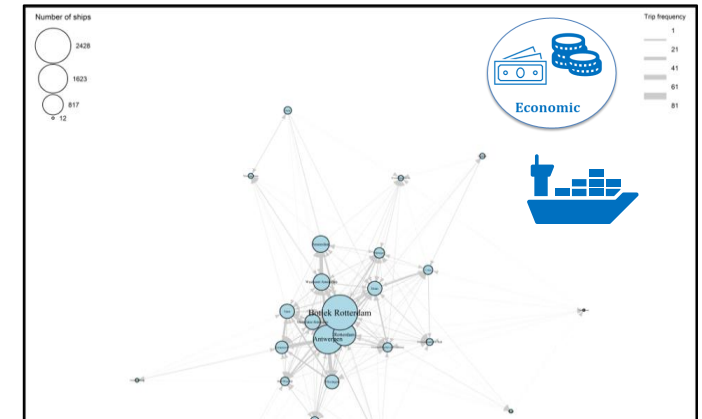
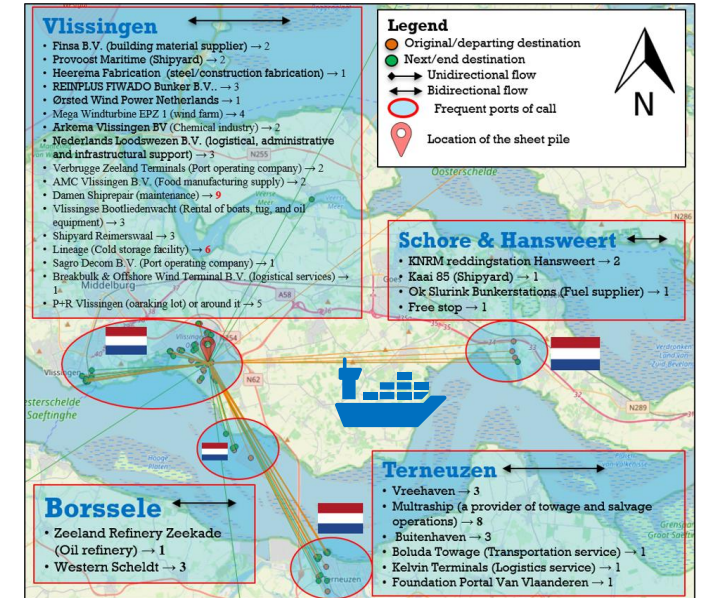
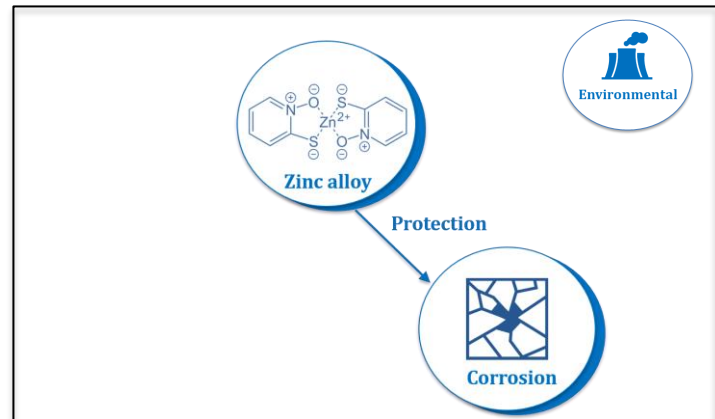
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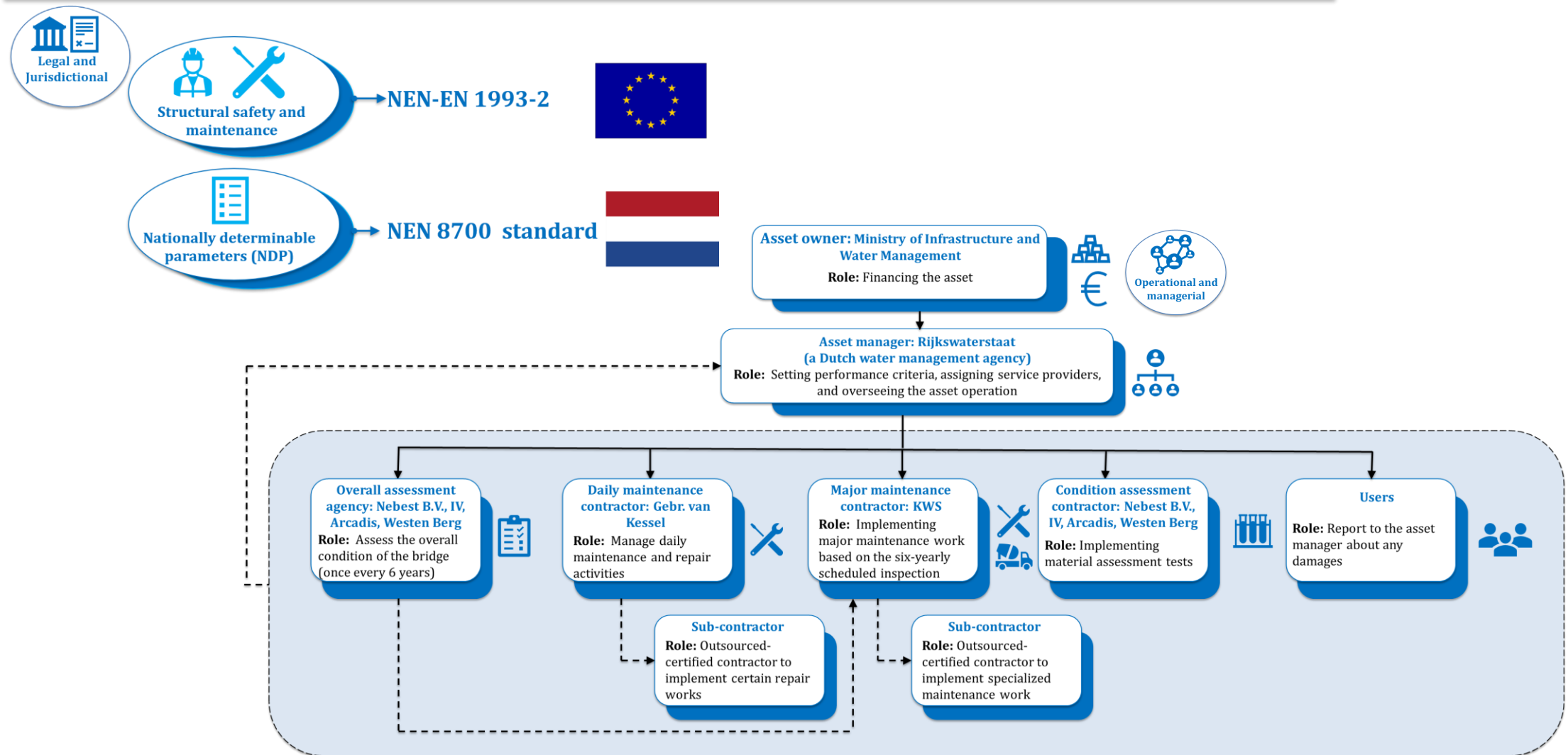
The use of our framework as an exploratory tool



Ships passing under the Moerdijkbrug		
Cargo		108
Tanker		41
Other Type		31
Wing in ground (WIG)		11
Pleasure Craft		11
Dredging or underwater ops		4
Tug		3
Law Enforcement		2
Passenger		2
Military ops		1
Port Tender		1
Not available (default)		9
Total		224



The use of our framework as an exploratory tool



The use of our framework as a development tool

The Workshop – Rethinking Steel Infrastructure as Socio-Technical Systems

The afternoon was devoted to an interactive workshop led by **Dr. Mohammad B. Hamida** (TU Delft), based on his research on governance and actor-network theory. His approach views steel infrastructures not merely as technical assets, but as **socio-technical systems** shaped by multiple interdependent dimensions – technical, environmental, economic, legal, managerial, and social.



The workshop unfolded in three phases:

- 1. Problem Definition** – participants identified challenges hindering the sustainable and reliable operation of steel infrastructures. Technical issues such as corrosion and fatigue were raised, but also uncertainties in inspection methods, budget constraints, and the growing impact of climate change (e.g. heat waves affecting movable bridges).
- 2. Practice Exploration** – through group discussions and collaborative use of digital tools, participants mapped key stakeholders in governance and operation, from asset owners and contractors to regulators, shipping companies, and end-users. The exercise highlighted the complexity of overlapping roles and responsibilities, as well as gaps in data and long-term planning.
- 3. Solution Identification** – participants proposed strategies ranging from technical innovations (non-destructive testing, load reduction measures, improved refurbishment practices) to policy and managerial interventions (better inventory systems, clearer contracts, adaptive regulations, subsidies for circular practices). Environmental strategies such as modal shifts in transport and promotion of cycling were also discussed.

The workshop provided a valuable space for dialogue between researchers and practitioners. As one participant noted, **“Research and practice come together here, giving us new perspectives.”**

Conclusions and Outlook

The WP3 progress meeting and workshop demonstrated the strength of combining **quantitative material flow and LCA analysis, practical design and reuse strategies, and socio-institutional perspectives**. Together, these approaches shed light on the multiple pathways toward more sustainable and reliable steel infrastructures in the Netherlands and beyond.

Looking ahead, the insights from this meeting will feed into upcoming WP3 deliverables, including scenario-based LCA studies, governance recommendations, and integration with technical findings from WP1 and WP2. The discussions also reinforced the importance of **close interaction between academia, industry, and government stakeholders**, ensuring that research outcomes remain relevant and actionable.

SUBLIME workshop at TU Delft builds on earlier insights

By Viktoria Savran / September 10, 2026



On 1 April 2026, TU Delft hosted a follow-up workshop on *Sustainable and Reliable Steel Infrastructures*, continuing the work started during the first SUBLIME workshop held in September 2025 at Leiden University. The workshop focused on the challenges, solutions and stakeholders associated with the sustainable and reliable operation and governance of steel infrastructures.

In that the previous workshop, the participants identified **34 challenges, 33 potential solutions and 16 key stakeholder groups** related to the sustainable and reliable operation of steel infrastructures. However, these elements remained largely unconnected. The objective of this second workshop was therefore to move from exploration to structure and bring things together by linking challenges, solutions and stakeholders into a coherent framework for future policy recommendations.

Working in groups, the participants used structured templates (see photo) to map concrete relationships between challenges—such as fatigue, corrosion, high maintenance costs, material scarcity, and environmental impacts—and corresponding solutions. These included, for example, improved monitoring strategies, the use of non-toxic coatings, promotion of circular materials, and adjustments in maintenance and asset management approaches.



A key step forward in this workshop was the explicit connection to stakeholders and their roles, also the solutions to their corresponding challenge. Participants linked solutions not only to technical challenges, but also to actors such as asset owners, contractors, policymakers, material suppliers, monitoring companies and researchers. This made clear that many solutions are not limited by technical feasibility, but by governance, coordination and economic conditions.

The discussions also highlighted important tensions and also the interdependencies among the different dimensions. For example, while high-performance materials or long-life solutions may be beneficial from a lifecycle perspective, they can be difficult to justify within current budgeting and procurement frameworks. Similarly, better monitoring could extend asset lifetimes, but requires upfront investment and organizational alignment.



Group 1



Challenge	Solution(s)	Stakeholders	Role

Group 2



Challenge	Solution(s)	Stakeholders	Role

The use of our framework as a development tool



The outcomes of the two workshops have been reported, They have set the stage for a policy framework by bringing together solutions to challenges facing the provision of sustainable and reliable steel infrastructure, considering the active players.



Rethinking Steel Infrastructures as Socio-Technical Systems of Multidimensional Considerations and Interdependent Actors

Problem definition, Practice Exploration, and Identification of Possible Solutions

Workshop report

Research team
Mohammad B. Hamida, Karel Van den Bergh, Ellen van Bueren, and Katerina Kattavenaki (TU Delft)

October 2025

Towards a Socio-Technical Policy Framework for Sustainable and Reliable Steel Infrastructures

Bringing together challenges, solutions, and stakeholders

Workshop report

Research team
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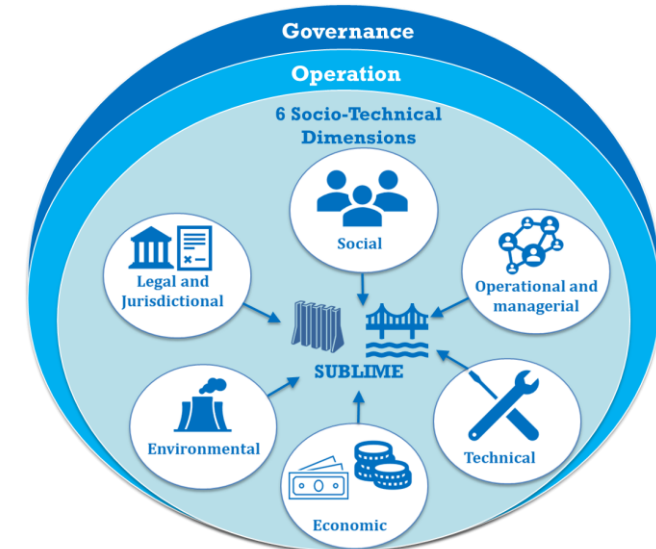
April 2026

Identification of Possible Solutions: Potential Strategies and Interventions for a Sustainable and Reliable Operation of Steel Infrastructures

Table 4: Challenges, solutions, and stakeholders associated with the managerial and operational dimension

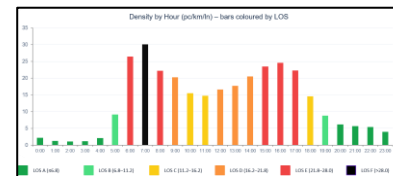
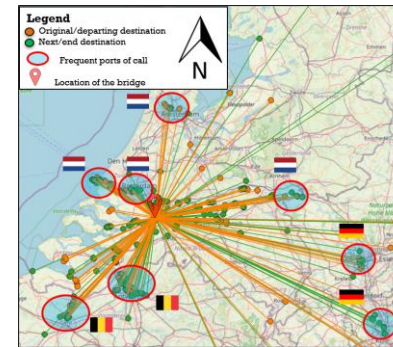
Challenge	Solution(s)	Stakeholders	Stakeholders' role	Challenge rank
Lack of technical staff and experts	- Knowledge sharing - Reorganized education	- Engineering/design firms - Maintenance contractor	- Connect and inform education - Enable communication	1
Lack of overview	Classification of steel infrastructures as national assets	- ProRail - Rijkswaterstaat	- Standardize asset management - Involve the employee	1
Organizational misalignment	- Provision of requirements for circular materials - Long-term planning and budgeting	Asset owners (e.g., North Sea Port and provinces)	Manage internal conflicts of interests	2
Multiplicity of considerations	Adoption of the aspects that are included in the RAMSHIP framework Asset RAM = Reliability, Availability, and Maintainability; HEEP = Health, Environment, Economic and Policy	Asset owners (e.g., North Sea Port and provinces)	- Build an other (e.g., second) options to avoid clashes - Communicate with users' external partners	2
Inadequate budgeting	- Public financing for renewables - Budget for a longer time (not for 4-5 years)	- Asset owners - Ministry of Infrastructure and Water Management	- Prioritization - Budget reallocation - Securing funding	1
Impracticability of solutions	Prescription of solutions in the contract	- Suppliers - Engineering/design firms	- Facilitate the understanding of the importance and meaning of different data - Make realistic designs, avoid choosing exotic materials, and standardize design	3
Standardized design	Easing parts exchange (e.g., stock)	- Rijkswaterstaat - ProRail - Provinces - Engineering/design firms	- Facilitate the understanding of the importance and meaning of different data - Make realistic designs, avoid choosing exotic materials, and standardize design	3

Note: 1 = high importance, 3 = low importance



Conclusion and looking forward

- ❑ Our socio-technical analytical framework has contributed to understanding reality and formulating the basis for policy recommendations.
- ❑ Looking ahead, a policy framework for sustainable and reliable steel infrastructure will be developed based on our twofold work.
- ❑ A decision-making model might be developed to assist decision-makers and asset managers in assessing the priority of their steel assets based on their socio-technical performance.

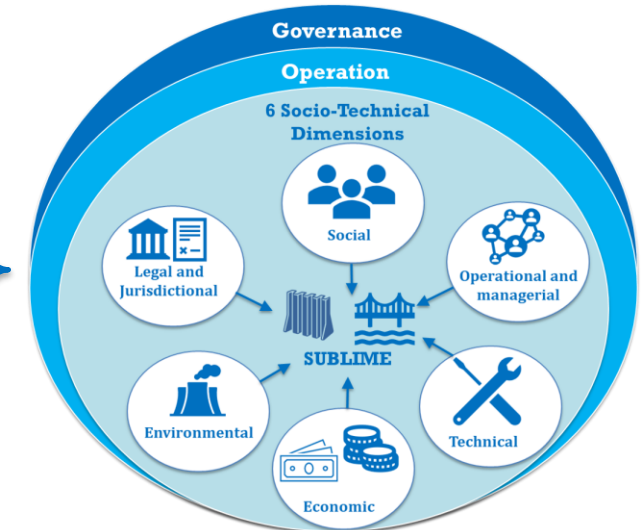


Identification of Possible Solutions: Potential Strategies and Interventions for a Sustainable and Reliable Operation of Steel Infrastructures

Table 4: Challenges, solutions, and stakeholders associated with the managerial and operational dimension

Challenge	Solution(s)	Stakeholders	Stakeholders' role	Challenge rank
Lack of technical staff and experts	• Knowledge sharing • Management education	1. Engineering/design firms 2. Maintenance contractor	• Connect and inform education • Enable communication	1
Lack of very own infrastructure as national assets	• Classification of steel infrastructure as national assets	1. Private 2. Rijkswaterstaat	• Standardize asset management • Involve the employees	1
Organizational misalignment	• Provision of requirements for circular materials • Long-term planning and budgeting	Asset owners (e.g., North Sea Port and provinces)	• Manage internal conflicts of interests	2
Multiplicity of considerations	Adoption of the aspects that are included in the RANDEEP framework: RANDEEP = Reliability, Availability, Maintainability, REEF = Resilience, Environment, and Financial	Asset owners (e.g., North Sea Port and provinces)	• Build on other (e.g., second) options to avoid clashes • Communicate with users/external partners	2
Inadequate budget	• Public financing for infrastructure • Budget for a longer time (not for 4-5 years)	1. Asset owners 2. Ministry of Infrastructure and Water Management	• Prioritization • Budget reallocation • Securing funding	1
Irreversibility of solution in the contract	Prescription of solution in the contract	1. Suppliers 2. Engineering/design firms	• Facilitate the understanding of the importance and meaning of different data • Make realistic designs, avoid housing exotic materials, and standardize design	3
Standardized design	Enabling parts exchange (e.g., MOW)	1. Rijkswaterstaat 2. Private 3. Provinces 4. Engineering/design firms	• Facilitate the understanding of the importance and meaning of different data • Make realistic designs, avoid housing exotic materials, and standardize design	3

Notes: 1 = high importance, 3 = low importance



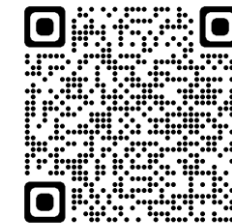
Thank you



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