Logiquay

Adaptive Multi-Actor Multi-Modal Closed-Loop Planning and Logistics for Renewal and Renovation of Urban Bridges and Quay Walls

Summary

Many bridges and quays in historic city centres, such as in Amsterdam, show signs of overdue maintenance and have reached the end of their technical or functional life. Renovation or renewal is required in the short term. This is a large and complex task, not only because of its size, but also because of intertwinement with the environment, trade-offs between socio-economic values, the desire to maintain original bridges and quay walls useful, and impacts on utilization and preservation of cultural heritage.

An effective, safe and sustainable approach requires both technical and process innovations that contribute to the efficient renewal of bridges and quay walls. Accelerating renovations is an urgent objective, while keeping the city safe, liveable and accessible at the same time. This is a complicated task, as it requires balancing many economic, social and environmental objectives, involves large numbers of stakeholders, and entails many complex interactions.

The Logiquay project aims at the joint development of scientific and applied knowledge development and application with the knowledge institutions, municipality and companies involved. The aim is accelerating innovation, increasing control, and improving sustainability through circular logistics solutions, such as closed-loop material cycles for reuse of secondary materials and reduction of transport movements and emissions. The research methodology is based on Digital Twin simulation for joint closed-loop logistics planning, materials flow analysis and multi-actor adaptive control of simultaneous projects.

Logistical prioritization, mitigation and decision-making dynamically assess interests of involved stakeholders. By closely integrating academic innovations and real-world pilot projects, the proposal aids in shaping a value framework to support multi-actor- and multi-criteria decision-making involving multiple stakeholders.

Consortium and cooperation partners

The project coordinator is Dr. ir. R. Vrijhoef, Senior researcher at the TU Delft (r.vrijhoef@tudelft.nl).

Objectives

The overall aim of the Logiquay project is accelerating innovation, increasing control, and improving sustainability through circular logistics solutions, such as closed-loop material cycles for reuse of secondary materials and reduction of transport movements and emissions.

The corresponding objectives of the Logiquay project are:

- Acceleration, innovation and cost reductions of quay and bridge renovations, adaptations and complete renewals.
- Bundling logistics flows for quay and bridge works, for maximum efficiency and capacity utilisation and mitigating environmental effects of construction projects in the urban context.
- Closed-loop logistics, innovative implementation methods for improved transport efficiency, less transport, efficient space use, less traffic pressure, less nuisance and emissions, and better safety and liveability.
- Circular material reuse and circular facility development for quay and bridge works, within the context of broad ambitions of the municipality to upscale the local circular economy in general for all sectors.
- Ensuring programmability and predictability of urban infrastructure works, in particular bridges and quay walls, and the effective decision-making and prioritization of works in the urban context.

- Ensuring accessibility, constructive safety, timely maintenance of bridges and quays, safeguarding the living environment, and preservation of the cultural heritage in the city.
- Contribution to the value framework and providing insight into trade-offs between values and interests of individual stakeholders vis-à-vis the general interests and requirements for society.

Work plan

Logiquay is divided into four work packages (WPs). The work package setup is deliberately comparable to that of the renovation project itself (1. planning, 2. engineering, 3. controlling, and 4. evaluating), emphasizing the ability to run adjacent to real-world projects. In this context, each WP provides input to the next, forming a closed loop in which evaluation insights are used to improve planning mechanisms.

The work packages are aligned with the research objectives. Planning (WP1) encompasses smart planning, connecting logistics flows, while considering the variety of parties and values involved in the project. This will be done by (i) designing a multi-agent Digital Twin simulation environment and (ii) creating a joint planning methodology that integrates multiple real-world projects.

Engineering (WP2) moves forward by assessing the balance and circular potential of materials and waste to maximize efficiencies. Therefore, WP2 will (i) develop applied material reusability assessment and balancing methods for bridge and quay wall works, (ii) develop a method to define optimised routing for circular flows and (iii) devise strategies for efficiently capturing, processing and re-using waste stemming from bridge- and quay wall works.

Controlling (WP3) addresses the need to monitor and intervene during execution, entailing factors such as adaptive control and traffic flow monitoring. Therefore, WP3 aims to develop methods that deal with real-time variations and disturbances that materialize during the execution of renovations. The overall objective is to develop a tool prototype (rooted in preference function modelling) that supports operational decision-making during the execution of a project.

Finally, evaluating (WP4) reflects on the project after completion, considering the impact on the value framework and the quality of collaboration.

Logiquay will support 2 PhD candidates and a Postdoc at TU Delft and 1 PhD candidate at the University of Twente.

Planned Output

Logiquay generates several direct and immediate insights. The outputs include:

1. Multi-agent simulation of multiple logistics flows
2. Multi-modal urban construction logistics
3. Construction and demolition waste material balancing
4. Assessing and increasing reusability of secondary materials
5. Optimised flexible logistics and project control
6. Value-based multi-criteria decisions
7. Structural safety for various planning scenarios

The various Work Packages exhibit distinct connections with the diverse outputs, resulting in different outcomes and impacts. This is illustrated in the figure below.

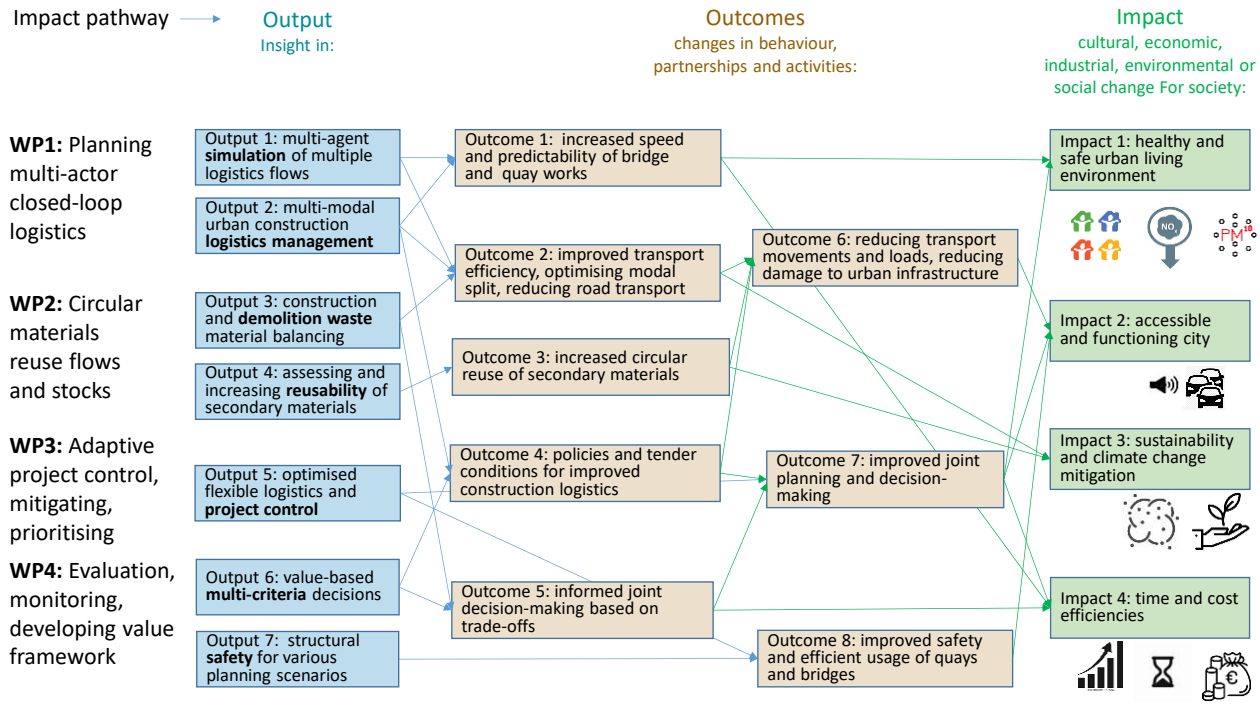

Figure 1 Output, Outcomes and Impact of Logiquay