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The Role of Democratic Platforms in Transport System Innovation

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Abstract

Digitalisation and technology are enablers for innovating the transport ecosystem. However, due to the collaborative nature of transport, such innovation processes cannot ignore the human and organisational aspects. The business practice cannot be detached from the technologies to be used. In this article we explore how so-called *democratic platforms* (the data sharing technologies and collaboration arenas for reflection and co-creation), may be used to redesign current transport practices and as means for eliciting requirements on future digital interfaces. We argue that a democratic platform is a necessary intermediary step in transport system innovation by reducing time to implementation, saving costs, allowing actors to co-create for societal change, develop well-anchored solutions that become reliable and efficient when implemented in operational environments, and achieving a sustainable change within the transport ecosystem.

Keywords:

ITS, Federated network of platforms, collaborative decision making, requirements elicitation, platform interoperability, living labs, demonstration platforms, situational awareness

1. Motivation

The multi-modal transport system is conducted within a self-organised ecosystem with autonomous actors that are both dependent on each other and adapt to each other (Watson et al., 2021). Today we experience that there are a multitude of sub-optimisations that create an unnecessary carbon footprint, increased costs, and dissatisfied clients (Lind et al., 2022). Efforts to improve this situation are underway in multi-modal inter-operable transport services, guided by such things as the European ITS directive (EU, 2010) and maritime informatics[1]. As the global multi-modal transport sector is not suited to an overarching governance body, the key becomes to let involved actors share a common situational awareness built upon pieces of information that come from the many different parties. Having said that, as informed by the guiding concept of collaborative decision making, there is a need to assure that the different actors can collaboratively align with each other (Lind et al., 2020). The transport ecosystem also requires that trust is developed among the collaborating actors engaged in the transport ecosystem, where the performance of the transport ecosystem is dependent upon inter-operability and democratic

[1] www.maritimeinformatics.org

governance (figure 1).

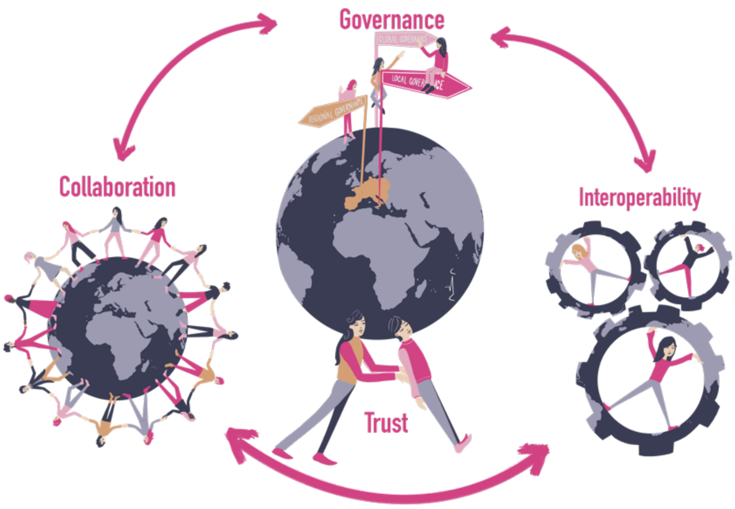

Figure 1: The inseparable trinity of governance, collaboration, and interoperability driven by trust among participants and to different incentives in the transport ecosystem (FEDeRATED, 2022) (Illustration: Sandra Haraldson)

Digitalisation enables connectivity between the actors involved in the transport ecosystem as well as providing access to an ever-increasing number of new data sources relying on the Internet of Things (IoT). This also provides opportunities for the actors to exchange data between each other in patterns of digital collaboration, informing each other about plans, progress, and disruptions along the multi-modal transport chain. The actors most often collaborate using data-sharing platforms, such as in the cases of airports or port community systems. These platforms need to be allowed to exchange information that brings the local actor communities together and ultimately provides the clients of the transport ecosystem with up-to-date information on the progress of their consignments (Lind & Renz, 2020). Contemporary efforts are now being made, as well as substantial investments in developing support (standards, semantics, etc.) to support these developments; for example, those within the Digital Transport and Logistics Forum (DTLF) community in which the principles for a federated network of platforms have been defined and validated.

As in all IT-driven projects, there is a need for requirements to be stipulated that guide the development / procurement of IT-solutions for operational use. The above-mentioned efforts to establish connectivity between different platforms drives two parallel change processes:

- the change of the collaborative practice that the actors are engaged in
- the development of new digital interfaces for the exchange of data with other stakeholders

As all changes are building upon experiences derived from the current practices that people are engaged in, there is a need to allow people to reflect on how things should work in the future before deciding on the final requirements to be used in an operational solution. As is claimed in design research (Hevner et al., 2004), when artifacts are brought to human practices and actors are engaged in using those artifacts, patterns of behaviour can be revealed and arenas for reflection can be established. In this article we are looking into how so-called democratic platforms are being used to redesign current transport practices by LivingLab, as collaborative arenas, and data sharing technologies. Democratic platforms are characterised as being data agnostic, actor-neutral, multi actor driven and ecosystems focused. Such platforms adopt agreed principles of co-creation of practices and technologies, multi-actor collaboration, trust and voluntariness.

2. LivingLabs as collaboration arenas in democratic platforms

Innovating the transport domain requires that involved actors meet and join forces to seek each other's contribution to an overall common object of interest (figure 2). Such an approach ensures ecosystem innovation by focusing on the value creation process in which involved actors are value contributors. Related to transport operations, such common objects of interest might concern such things as a port call pursued at a (sea)port, a passenger's journey through multiple transport nodes, or the processes pursued at a railway yard and stations. The objective for the actors participating in a LivingLab as an arena for reflection and co-creation, are to achieve better overall collective performance and thereby improve their individual efficiency, reputation and profitability by contributing to ecosystem improvement and societal change.

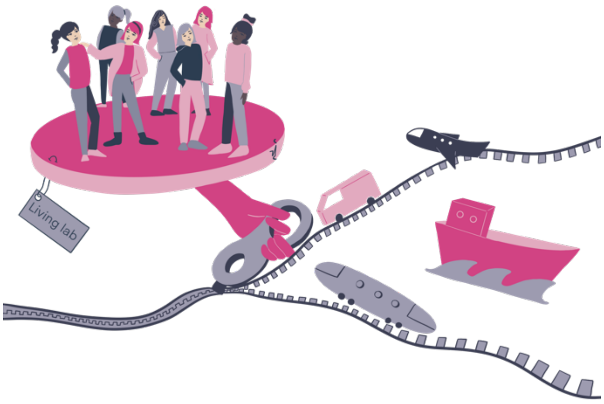

Figure 2: Innovating the transport ecosystem enabling seamless transports and logistics (Lind et al., 2021) (illustration: Sandra Haraldson)

Following the LivingLab methodology (Pallot, 2009; Haraldson et al., 2015), the key actors involved in the common object of interest are engaged in a collaboration arena. The actors co-create a common understanding on how the actors currently collaborate, define objectives for the common object of interest, identify information sharing needs to realise desired effects, understand actors' incentives to data sharing and conceptualise collaboration principles. A LivingLab approach is preferred as it shortens the time between idea and implementation and paves the way, through stakeholder buy-in, for a successful implementation.

Getting the key actors involved is important to establish relationships of trust and identify incentives for the participating actors to share information. The LivingLab approach is aimed at encouraging the different stakeholders involved in the common object of interest to participate in the use, refinement and evaluation of more efficient procedures and collaboration, principally through improved data sharing. The purpose of the LivingLab approach is to integrate and engage the participating actors in the development process as prospective users and co-creators of transport ecosystem innovations. It allows them to explore, test and evaluate digital collaboration through the approach and principles of the guiding concept, utilising data sharing technologies (figure 3).

Figure 3: Demonstration arena exploring different innovations (Lind et al., 2021) (Illustration: Sandra Haraldson)

One collaborative, data-sharing approach that has been successfully validated and adopted in multiple settings, is collaborative decision making (CDM) at various transport nodes, such as at airports (A-CDM), within ports (PortCDM), within stations and Yards (StationCDM and YardCDM), and at inland terminals (RRTCDM). Below are three examples in which transport ecosystem innovation informed by a democratic platform (data sharing technologies and collaboration arenas) has been pursued.

2.1 Example 1: A LivingLab for Port Collaborative Decision Making

PortCDM (Lind et al., 2018) was inspired by the aviation sector, in which considerable gains have been achieved in European air transport, such as shorter flight times, a reduced environmental footprint, and enhanced reliability in determining arrival and departure times. PortCDM supports the port call optimisation process by promoting; the extension of planning horizons, the sharing of the timing of future events for the coordination of the port call process, the combination of multiple sources of data for enhanced predictability, machine-2-machine connectivity for instant sharing of data from the source based on agreed message formats and interfaces for digital collaboration, shared situational awareness by sharing data on the progress of a port call among internal and external involved actors and acknowledgement of discrepancies in the port call process.

During the STM validation project,[2] a testbed engaging 13 different LivingLabs, in different European ports, was established to validate the concept of PortCDM and to seek opportunities for port call actors to become further aligned. In each of these LivingLabs a *metromap* (figure 4), capturing the common object of interest, was used for the actors to identify the key points of coordination, and come to agreement on which data was needed to be shared between the participants.

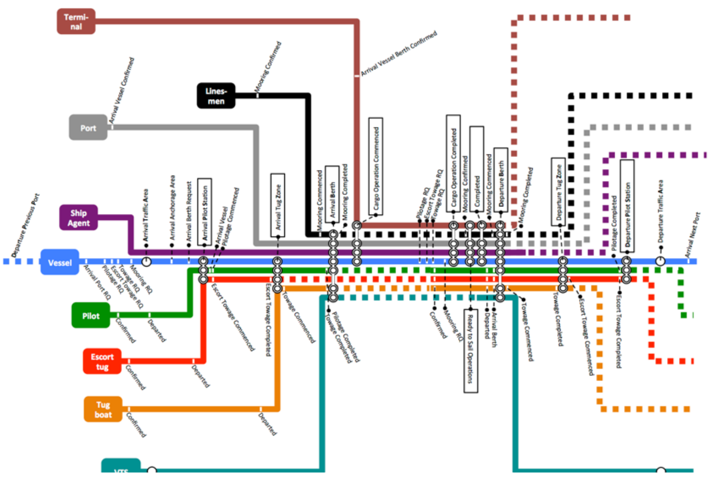

Figure 4: PortCDM metromap (Lind et al., 2016)

The different coordination points depicted in the metromap, based on the specific circumstances of the port under study, was then used to establish processes of digital collaboration as part of a PortCDM data sharing environment. This environment incorporated a demonstration platform with possibilities for participants to provide and subscribe to data as well as user interfaces allowing the engaged cluster of actors to experience and elicit requirements for common situational awareness for improving the port ecosystem. This digital infrastructure was populated with real time data from real port calls, providing the engaged cluster of actors with access to interfaces depicting a common situational awareness, leading to the identification of new practices only made possible through digital collaboration.

2.2 Example 2: A LivingLab for Station Collaborative Decision Making

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[2] www.STMvalidation.eu

StationCDM - Station Collaborative Decision Making, is a concept for digital collaboration that aims to contribute to the optimisation of stations and yards as transport nodes, as parts of the larger transport system. Such a transport node can also cooperate with other nodes, which enables multi-modal coordination and synchronisation. Coordinated execution of railway yards, stations and other transport nodes with rail capabilities in the transport system is important for contributing to the UN Agenda 2030 sustainability goals and for the strategy of moving freight transport from road to sea and rail.

The StationCDM concept is based on a common situational awareness being shared among the involved actors as a basis for better planning capabilities and as an improved decision-making basis for enhanced coordination of resources and infrastructure as well as increased information transparency. Improved situational awareness contributes towards the need to optimise the use of existing infrastructure because of ever-increasing freight volumes, which also requires a higher coordination ability among actors in the rail transport system but also to other nodes, regardless of the mode of transport.

In an ongoing Swedish project, coordinated by RISE and financed by the Swedish Transport Administration, the StationCDM Concept is demonstrated, adopting a LivingLab approach and using the data sharing platform Deplide (see section 3.3) for demonstration purposes. The project evaluates the concept by using data components to build a common situational awareness among involved actors, based on shared data, for increasing predictability and punctuality in rail transport. Based on the defined common object of interest, relevant processes and events have been captured in a metromap (figure 5), which highlights the key coordination points. Relevant information is then retrieved from actors' systems and other data sources and shared through a data sharing platform by involved actors, according to defined collaboration principles, as time stamps (estimates and actual times). The overall goal is to enhance the predictability of departure and arrival times from/to the stations and yards to enhance punctuality in the rail transport system. The outcome of the project is to elicit requirements and formulate advice for future implementation of digital collaboration identified in the StationCDM concept.

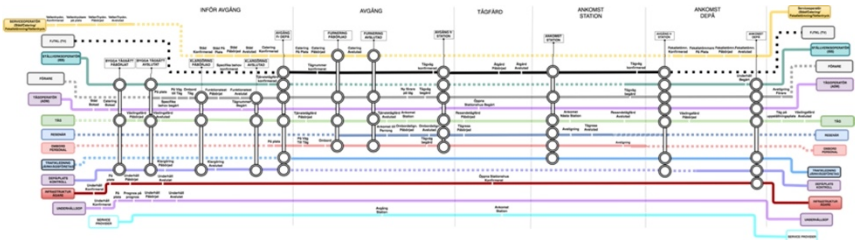

Figure 5: StationCDM metromap (Haraldson, 2019)

The data was delivered using diverse front-end interfaces (see figure 6 for an example) in diverse use cases that are supporting the enhancement of coordination within railway transport.

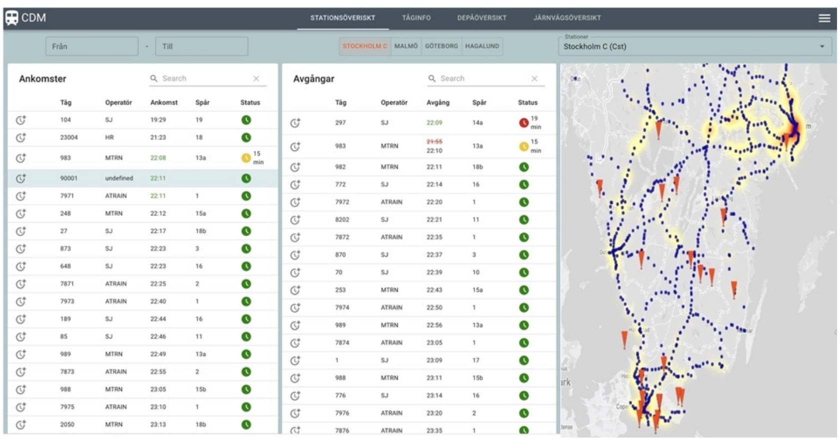

Figure 6: Front-end interface for StationCDM

2.3 Example 3: RFID in rail providing supply chain visibility based on the FEDeRATED principles

FEDeRATED[3] is a both-feet-on-the-ground EU funded CEF (Connecting Europe Facility) data sharing project. The aim is to demonstrate how a federated network of platforms as proposed by the EU DTLF can actually work. The goal is seamless data flow management in logistics and smart mobility services in multimodal transport. The project is running from 2019-2023, has 15 partners located in 6 EU Member States and connects many stakeholders through 23 cross-bordering LivingLabs.

One of the 23 LivingLabs concerns the use of Radio-frequency identification (RFID) for locating goods in transit. This LivingLab aims at consolidating and scaling up the current RFID solution in Sweden for multi-modal transport (including rail) to a European level. The LivingLab is run by the Swedish Transport Administration with a focus on reducing administrative time and work in terminals, harbours, shunting yards, etc. The data collected from RFID readers installed throughout the railway network in Europe are fed into a data sharing environment (see section 3.3) as data streams and visualised in different front-ends for real-time track and trace of trains and railway vehicles (see figure 7 for an example).

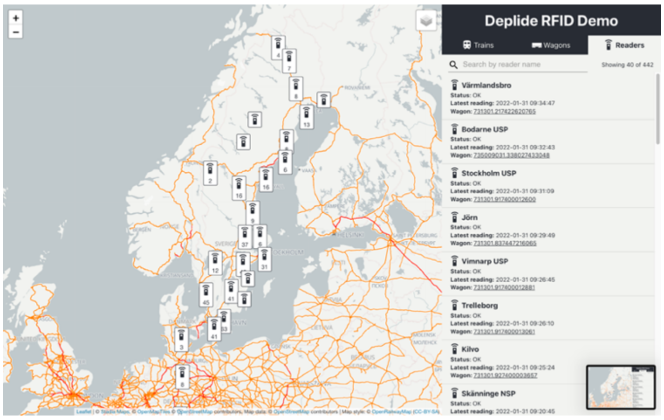

Figure 7: Front-end example of RFID reader positions

The democratic properties of the data sharing environment – especially in the sense that the environment is actor-neutral and non-commercial – has proven to be crucial when trying to get access to RFID data owned by different transport actors from different countries. Experiences from the LivingLab and the exploration of different front-ends directly support procurement requirements generation.

3. Data sharing technologies in democratic platforms

Digitalisation is an enabler for innovating the transport ecosystem. However, digital interaction in multi-modal transport requires infrastructure support, such as the coordination of information in interoperable systems. Currently, operational data sharing systems exist for more-or-less limited purposes, often around transport nodes of different types. Operational system vendors offer the means of integrating to other operational systems, but this is a slow process that does not easily support new ecosystem actors and the exploration of new business models or use cases. Furthermore, the operational systems are typically not suited towards adding different types of sensors required for digitalising the operations around multi-modal transport nodes. The introduction of data feeds emerging from connected (physical) devices through sensors is expected to grow exponentially (EU, 2020) and may be a source to enhance the quality of the data managed by different system environments and thereby also the quality of the

[3] www.federatedplatforms.eu

data being shared across environments (Lind & Renz, 2020).

3.1 The need for demonstration platforms supporting ecosystem innovation

As the examples in the previous section have shown, there is a need for different types of data sharing technologies, as part of the democratic platform, to support ecosystem innovation in multi-modal transport. Operational systems need to be complemented with demonstration platforms tailored to collect information from different data sources and to test new solutions in a fast and flexible way (figure 9). Besides data from operational systems like Port Management Systems (PMS), Port Community Systems (PCS) and Terminal Operating Systems (TOS), there is a multitude of different sensors providing data for digitalising key parts of operations, such as RFID readers, cameras with image processing algorithms, GPS, IoT sensors for temperature, humidity (such as the ones installed in Smart Containers (Becha et al., 2020)), etc., sourced from different physical entities and owned by different actors. Based on data from different sources, prototype solutions can be built for different use cases, like the automation of recurring events at a transport node, end-to-end supply chain visibility, etc. Learnings from the prototype solutions can then be used for maturing the requirements for developing operational applications supporting the use cases in later phases (Lind et al., 2021).

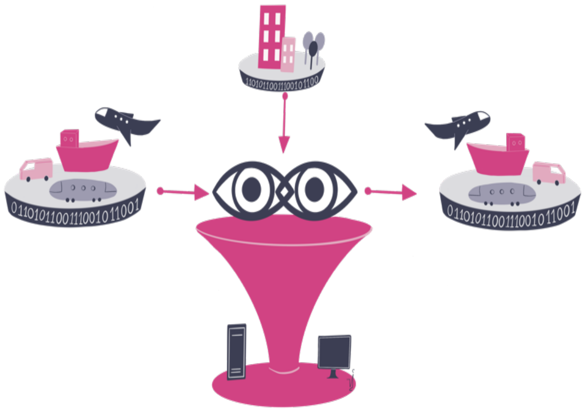

Figure 8: A demonstration platform facilitating digital interaction in multi-modal transport (Lind et al., 2021) (Illustration: Sandra Haraldson)

Besides facilitating the test and demonstration of data sources and use cases in a neutral setting, business models and other incentives for sharing data are crucial in digital interaction and can be explored in this type of demonstration platform (figure 8). Common ecosystem needs and capabilities can be identified, such as new standards, processes, etc. Security threats can be explored and system mechanisms taking care of identified threats can be verified. Finally, learnings and experiences from test and demonstration activities to elicit requirements for forthcoming implementations are valuable input when sourcing operational platform solutions.

Data sharing technologies in the form of demonstration platforms as described in this sub-section are tailored to support collaboration arenas such as LivingLabs described in section 2. Together – data sharing technologies in the form of demonstration platforms and collaboration arenas in the form of LivingLabs –constitute the central building blocks in a democratic platform supporting ecosystem innovation.

3.2 Properties of demonstration platforms and their use

Besides facilitating the test and demonstration of data sources and use cases in a neutral setting, business models and other incentives for sharing data are crucial in digital interaction and can be explored in context in a demonstration platform (figure 9). Important properties of such a demonstration platform are (at least):

- Flexible collection and transformation of data from different data sources such as different sensors and operational platforms providing data for digitalising key parts of operations.
- Flexible access to collected data from different front-ends and applications exploring prototype solutions for important use cases addressing the needs of the participating actors.
- Efficient coordination, search, and manipulation of data flows captured in real-time from different data sources - so-called event streaming.
- Durable storage of collected data for later retrieval.
- Flexible connection to analytics and visualisation frameworks in real-time as well as retrospectively.
- A focus on short turn-around time for changes in the platform and development of connectors to integrate with existing systems.

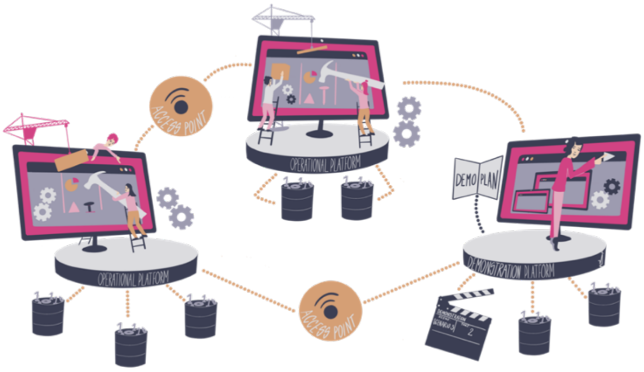

Figure 9: Emerging IT-infrastructural solutions for a Federated Network of Platforms (FEDeRATED, 2022) (Illustration: Sandra Haraldson)

3.3 Deplide as example of a demonstration platform

One example of a demonstration platform supporting ecosystem innovation in multi-modal transport chains is Deplide, being developed by RISE and used within different concept validation and requirement elicitation projects. Deplide is based on solid experience from similar platforms in several large-scale projects within the maritime sector adapted to more generic multi-modal transport needs. It has been developed primarily to support data sharing around a transport node, where main events along the supply chain occur. It integrates technology and solutions that are available as open-source and will itself be published as open-source.

Different types of data providers can be connected to Deplide, including temperature sensors, RFID readers, Port Management Systems, Terminal Operating Systems, etc. In a similar way, different types of data consumers can be connected, including front-end applications and services. These connection capabilities make Deplide ideal as a democratic platform for collecting different types of data, aggregating, and analysing streaming data. Front-end applications and services can be built on top of the platform to explore different use cases around multi-modal transport.

The data that needs to be shared are typically concentrated around events during the transport process; it could be a ship arriving at a port, an airplane arriving at an airport, or cargo that is transhipped at a logistic centre. A flow of events with associated data makes up a so-called event stream. Deplide is developed to manage event streams using Apache Kafka[4], an open-source distributed event streaming platform used by thousands of companies for high-performance data pipelines, streaming analytics, data

[4] https://kafka.apache.org

integration, and mission-critical applications. The use of Kafka and the layered structure of Deplide provides the important properties for a demonstration platform that was described in section 3.2.

4. Concluding remarks

Nowadays, transport ecosystem innovation can be significantly enabled by technologies. However, due to the collaborative nature of transport, such innovation processes cannot exclude the human and organisational aspects. The business practice cannot be detached from the technologies to be used. In this article, we have highlighted the use of generic and guiding concepts, such as concepts for collaborative decision making and concepts for a federated network of platforms, as a foundation to direct attention to the relevant themes within the specific practice and possible technological use. Those concepts both guide what to put at focus when bringing people together to reflect on current business practices and develop and evaluate new practices as well as being a foundation for eliciting requirements for emerging interoperable system environments.

In this article we have described some experiences gained from adopting a democratic platform to:

1) gather people from different organisations within the ecosystem;
2) pursue focused discussions on the collaborations and associated data sharing technologies needed to innovate the part of the transport ecosystem in focus (= the common object of interest); and
3) gather experiences from digital solutions, information sharing platforms and user interfaces, as becoming a support for establishing up-to-date common situational awareness.

We argue that democratic platforms are the foundations for transport ecosystem innovation by reducing time to implementation, saving costs, allowing actors to co-create for societal change, develop well-anchored solutions that become reliable and efficient when implemented in operational environments, and by that, achieve a sustainable change within the transport ecosystem.

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