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Leveraging the Potentials of Data Sharing

Insights from a Transportation Testbed

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CONTENTS

FIGURES

TABLES

Seamlessly sharing data across organizational boundaries is one of the most pressing challenges facing businesses today. For digital twins to deliver actionable insights and meaningful value, they rely on data that is often outside of an organization's domain and control. Effective data sharing is the key to unlocking near real-time insights, improving decision-making, and increasing operational efficiency. However, achieving this level of collaboration often requires organizations to overcome complex technical and organizational barriers. Addressing these barriers is critical to driving innovation and maintaining competitiveness in a rapidly evolving landscape.

Digital twins, virtual replicas of physical systems, increasingly rely on robust data-sharing mechanisms to fulfill their promise of enhancing operations, providing predictive insights, and fostering collaboration across industries. By integrating data from diverse stakeholders, digital twins can offer a comprehensive understanding of complex systems. However, in practice, many organizations face challenges in meeting the requirements for integrating data sources from various stakeholders. Without reliable frameworks for data sharing, the potential of digital twins remains underutilized.

This article provides insights from a transportation testbed initiated by Düsseldorf Airport and the Ferdinand Steinbeis Institute (FSTI). This project serves as a real-world example of how organizations can overcome the challenges of data sharing and unlock the potential of digital twins to enhance public transportation services. The testbed demonstrates how data sharing and digital twin technologies can come together to establish a solid foundation for digital service creation in heterogeneous ecosystems.

1 INTRODUCTION

Consider the following scenario: You arrive at your business meeting just minutes after stepping off the plane. The autonomous rail system, seamlessly connected to the airport, has transported you efficiently and without delay. There are no lines, no traffic jams - just a coordinated, frictionless travel experience. Achieving this vision, however, requires overcoming a critical challenge: the airport, as the central organization in this ecosystem, lacks access to the comprehensive data and insights needed to optimize service delivery.

This vision of seamless, connected mobility is exactly what Düsseldorf Airport in Germany is working to achieve. In partnership with the Ferdinand Steinbeis Institute, the airport launched a pilot project to improve digital collaboration between transportation providers. At the heart of this effort is the exploration of how sovereign data sharing can empower digital twins to drive cooperative service creation.

Düsseldorf Airport is committed to providing a seamless and hassle-free experience for all passengers, from the moment they arrive to the moment they depart. This includes facilitating the flexible transfer between local and long-distance transportation services and different carriers. The airport serves as a transportation hub, connecting a comprehensive transportation network that includes national and international air connections, light rail and bus services, local and long-distance trains, and a private transportation infrastructure. It should be noted, however, that these efforts are not the sole responsibility of the airport. A number of other organizations and companies are part of and contribute to the transportation ecosystem.

To fully realize this potential, organizations must participate in the data economy, sharing data and collaborating to develop data-driven services based on shared data [1]. This process is known as data sharing, which can be defined as "*[...] the domain-independent process of giving third parties access to the data sets of others. These third parties can be other companies (usually not direct competitors), individuals, or public institutions. The shared data is often used to develop new applications and services.[...]*" [2]. Unlike the straightforward approach of integrating different data sources, data sharing addresses critical issues such as data ownership, sovereignty, and collaboration in areas where established APIs or traditional integration methods are either unavailable or inefficient [3]. By creating frameworks that allow participants to retain control over their data while facilitating standardized and secure exchanges, data sharing enables solutions in contexts where integration alone cannot. This approach fosters innovation, expands the scope of applications, and makes it possible to create cooperative services across organizational boundaries [4]. In doing so, data sharing opens opportunities to exchange information in domains where a data-based cooperation was previously impractical or non-existent, while ensuring that stakeholders can maintain their proprietary interests and trust [5].

This article examines how Düsseldorf Airport and other organizations are using data sharing to improve digital twin-based applications and services, thereby enhancing the travel experience at Düsseldorf Airport. It looks further into the critical issue of fostering trust and transparency between stakeholders in heterogeneous ecosystems. It argues that enabling solutions based on data sharing requires addressing a multifaceted problem that demands a systematic approach. The method presented here represents a first step toward overcoming these challenges, offering valuable insights into creating data based cooperations that drive innovation and digital service creation.

2 TRANSPORTATION TESTBED

This paper examines a transportation testbed focusing on the SkyTrain, a driverless passenger suspension railway system at Düsseldorf Airport. The system connects the airport terminals, parking facilities, and a nearby long-distance train station. The route is utilized by a considerable number of passengers and employees daily for travel to and from the airport. As the railway system is driverless, the system operators rely extensively on data. This makes the SkyTrain an ideal asset for a testbed approach. The FSTI collaborated with Düsseldorf Airport to identify potential partners who could provide support by sharing pertinent data and contributing specialized expertise. Contact was made with the relevant organizations, and a testbed setting was arranged. Table 2-1 provides an overview of the testbed setting.

The Airport oversees the operation, while a major traffic engineering company handles the maintenance and technical operations of the physical train system in close proximity to the airport. The SkyTrain offers the most efficient connection between the airport terminals and a nearby long-distance train station, operated by a transport company and independent from the airport. The airport is responsible for operating the various train platforms where passengers enter and exit the SkyTrain. To gain insight into passenger volumes at the platforms, the airport collaborates closely with an analytics provider that specializes in passenger flow analysis. Additionally, while the SkyTrain represents the final leg of travel to the airport, travelers should have access to accurate timetable data in their preferred planning apps. To this end, the transport association responsible for managing and procuring timetable data for all public transportation in the region was identified as a key stakeholder.

Participating Organizations (PO)		Goal of the Testbed
PO1	Düsseldorf Airport	Create a collaboration platform for the driverless passenger suspension railway system, which makes relevant data along the cross-organizational passenger transport process available to participating organizations.
PO2	Traffic Engineering Company	
PO3	Transport Company	
PO4	Transport Association	
PO5	Analytics Company	
PO6	FSTI	

Table 2-1: Overview of the Transportation Testbed.

The testbed can be roughly divided into three phases: 1) Identification of the partner network, 2) Creating a concept for cooperation, 3) Further specify and implement the cooperative services. Each phase presents unique challenges and activities, outlined in Figure 2-1.

This article focuses on activities in Phase Two, highlighted in blue. The resulting artefact marks a significant milestone in the transition from Phase Two into Phase Three, which will be further elaborated in the discussion below.

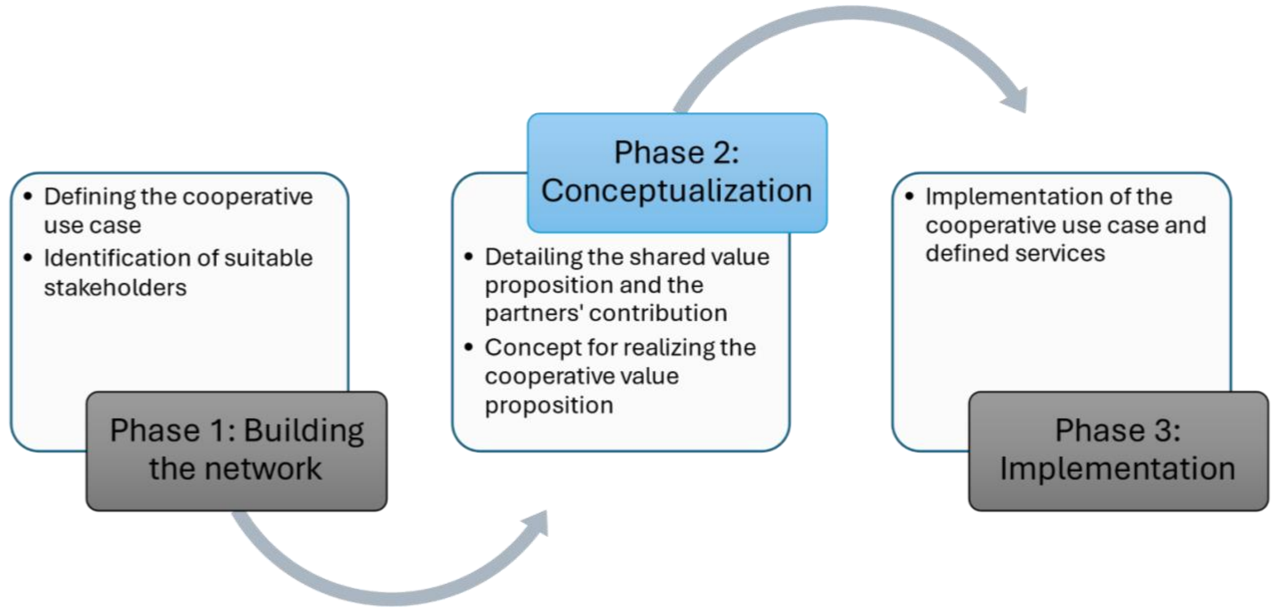

Figure 2-1: Phases of the Transportation Testbed.

3 Methodology

The FSTI is a research institute focused on the study of cross-organizational value-adding processes and data sharing in multi-actor settings. In a testbed, the FSTI's role is to spearhead the process, identify potential participants, oversee the moderation of the testbed, and conduct a scientific evaluation of the results.

To subject the testbed to scientific evaluation, we based our activities on Action Design Research (ADR), a research approach often employed when working with businesses and organizations in a real-world environment. In ADR, the research process culminates in the creation of an artifact, which is then developed and evaluated in cycles. In addition to monitoring the process, researchers are actively involved in the design of the resulting product. This ensures that the final product meets scientific standards and provides tangible benefits for practitioners [6].

The testbed commenced in March 2022 and concluded in August 2023. During this period, a series of workshops were conducted with the participating organizations, along with bilateral interviews between researchers from the FSTI and the practitioners. The researchers prepared and moderated the workshops and documented them using photo protocols. At least two researchers were present at each workshop to ensure comprehensive documentation. At least one scientific representative was present during the interviews, which were documented through discussion protocols. This resulted in a detailed and comprehensive empirical basis for a qualitative analysis in line with Mayring's approach [7].[1]

4 FINDINGS

As previously stated, the testbed underwent multiple phases. This article presents the results of the second phase, during which the POs developed a concept for cooperative service creation. This concept is the result of several workshops and interviews, with the findings consolidated into a single document. It comprises several layers, with the content of each layer informed by the analysis of interviews and workshops. While the specific instance of the transportation testbed is presented in this chapter, a more generalized framework is subsequently discussed and presented as the scientific artefact.

4.1 STARTING WITH THE WHY – DEFINING THE BENEFITS

Trust and transparency are considered to be key success factors for data based cooperative service generation. This includes transparency of the motivations of the POs to commit to the effort. It is therefore prudent to begin by exploring the potential benefits. The objective of the initial phase is to ascertain the advantages for the POs. The key inquiry guiding first steps is: "*How do the POs benefit from the realization of the cooperative use case?*"

Cooperative projects are typically defined by overarching value propositions, which are often so complex that a single company cannot fully implement them on its own. Consequently, the various companies contribute to the overarching value proposition [8]. Upon closer examination, the participating companies are asked the following question: "*How do POs benefit from fulfilling your contribution to the overarching value proposition?*"

Engaging intensively with the benefits in the early stages of a project has several advantages. By addressing the value proposition, we can establish the motivations for participating in the cooperative project at an early stage. This allows the participating partners to justify the expenses incurred during the project in relation to the expected benefits. In the event that sufficient motivation for a partner cannot be identified despite an initial, intensive examination of the potential benefits, or if the benefits are not seen to be in a justifiable relationship to the costs incurred, potential partners may withdraw at an early stage of the project for good reason.

In this phase, the FSTI engaged in discussions with the other POs to ascertain their contributions to the overarching value proposition and their motivation for making these contributions. The

[1] Parts of the methodology chapter will also be published in an upcoming paper in the 2025 proceedings of the Hawaii International Conference on System Sciences which focusses on the importance of trust and transparency in data driven cooperative service generation by the same authors.

content of these discussions was documented and summarized. They make up the blocks in the utility layer shown in Figure 4-1.

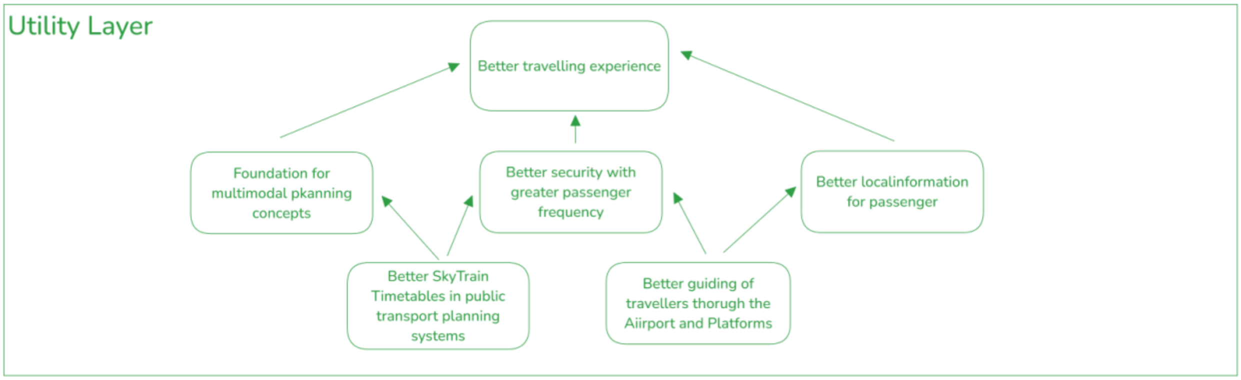

Figure 4-1: Utility Layer.

4.2 SHAPING THE 'HOW' – ASSESSING THE INFORMATION REQUIREMENTS

Once all POs are aware of the overarching value proposition and their respective contribution, the analysis can be deepened in line with the project's progress. First, the services that will be provided to deliver the intended benefit are defined. A service can be defined as a response to the following questions: "*What information is needed at what point to achieve the intended benefit?*" The next step is to identify the recipient(s) of the intended service.

There is no *right* configuration for this level. This step is intended to sketch out services in a greenfield approach. It is important not to restrict creativity and to put considerations of technical feasibility or existing solutions to the side. These circumstances will be considered at a later stage. A service bundles functionality to realize a benefit (or make a contribution to its realization). Figure 4-2 shows the service layer. For the sake of simplicity, only one service is shown, though there were multiple discussed in at this stage.

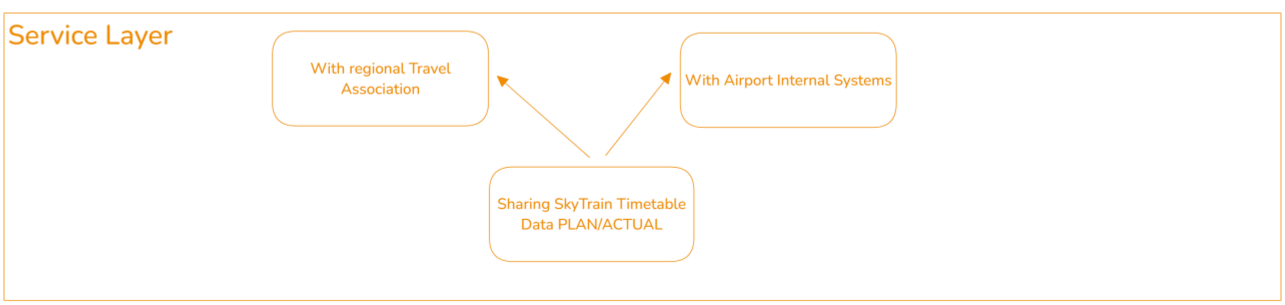

Figure 4-2: Service Layer.

Services are based on information, often based on current status information of real-world assets – also known as digital twins.[2] Subsequently, the main concern of the digital twin layer is to

[2] See the digital twin definition of the Digital Twin Consortium: *https://www.digitaltwinconsortium.org/initiatives/the-definition-of-a-digital-twin/*

define the requirements of the digital twins to enable and satisfy the aforementioned services. Each service serves as the starting point for an assessment of the information requirements. Central for the case at hand were the digital twin of the SkyTrain as well as digital twins of the platforms, each defined by a series of parameters needed to satisfy the information requirements of the services described in the layer above. Figure 4-3 shows a simplified version of the digital twin layer.

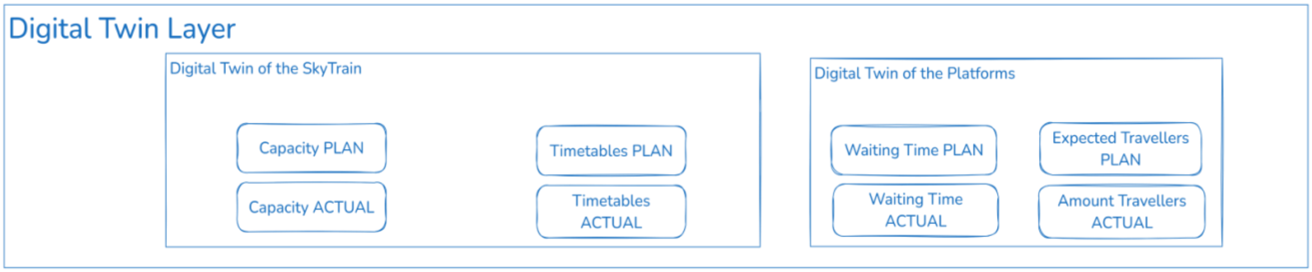

Figure 4-3: Digital Twin Layer.

But digital twins rely on data, often coming from different data sources and assets. To emphasize this distinction the method separates the digital twin and the data layer. Blocks defined in the digital twin layer are to be understood as “consumption ready” pieces of information, intended to be consumed by one or more services. Blocks on the data layer represent specific data points or data sets usually coming from various data sources, that need to be transformed and combined with other data points to eventually serve their purpose. See an extract of the testbeds data layer in Figure 4-4.

Figure 4-4: Data Layer.

The final step in assessing the required information is to identify the relevant data sources and assets. The primary objective when identifying relevant assets is to ascertain which sources are capable of providing the necessary data. At this juncture, it becomes evident that data sharing is a necessity, given that the disparate data sources are owned by different POs. The subsequent task is to devise suitable arrangements and conditions for the exchange of data to feed the defined digital twins and realize the intended services. Figure 4-5 shows an excerpt of assets with relevance to the example use case.

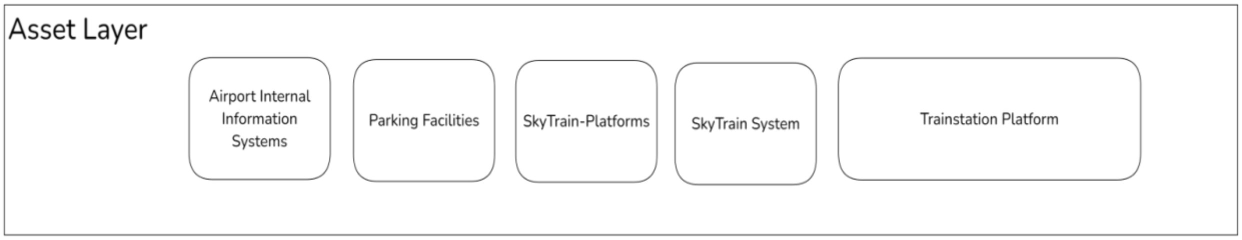

Figure 4-5: Asset Layer.

4.3 Bringing Everything Together

Insights gathered from interviews and workshops during Phase Two of the testbed culminated in a single visualization of a conceptual solution for the intended cooperative services. This visualization integrates all layers into a cohesive image, directly linking the expected benefits of the POs with the required information and relevant assets. It offers a simplified yet comprehensive overview of the intended efforts, serving as a foundation for planning and specifying subsequent activities in the testbed.

While the resulting diagram is read from top to bottom, the data flows within the image originate at the bottom and move upward. As data flows upward, it becomes progressively contextualized and aligned with the specific needs of stakeholders, enabling data-driven services that deliver tailored benefits across the ecosystem. Figure 4-6 illustrates the integration of all layers into this comprehensive visualization.

Stakeholders provided positive feedback on the methodical approach, emphasizing its role in fostering trust and enhancing collaboration. The testbed setting brought stakeholders together in a format unfamiliar to them, establishing new communication channels and facilitating dialogue that had not existed before. The structured methodology aligned expectations, enabling participants to better understand their respective contributions and uncover synergies, such as optimizing passenger flow data. Additionally, the transparent process reassured participants about data sovereignty and security, laying a foundation for stronger cooperation and data-sharing agreements.

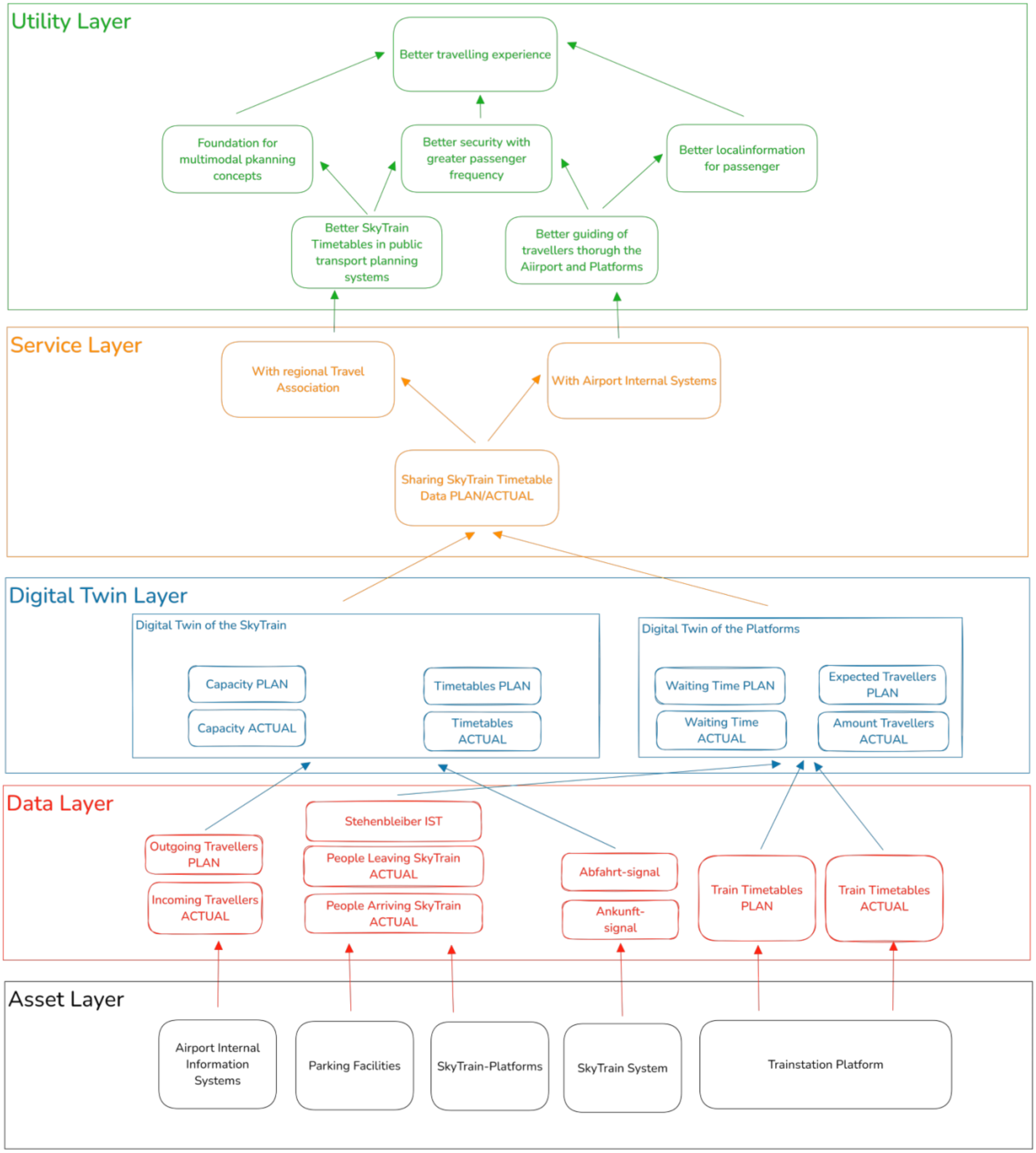

Figure 4-6: Conceptual solution for a cooperative use case in the Transportation Testbed.

5 Conclusion and Discussion

This report focuses on a single case study; however, the activities and resulting method are designed to support broader applicability for implementing testbed scenarios across various domains. The proposed method serves as a critical steppingstone to securing stakeholder commitment before significant resources are allocated to specifying and implementing cooperative services. By clearly defining the expected benefits and outlining the necessary data flows, the method empowers decision-makers to grasp the strategic value of digital services that depend on cross-organizational collaboration and information exchange.

The primary audience for this method includes C-suite executives and strategic planners responsible for setting budgets and determining project priorities. Rather than focusing on technical specifications, the method emphasizes the overarching motivations, contributions, and benefits for each participant. This high-level perspective fosters trust among stakeholders by transparently linking their contributions to the shared objectives of the testbed. Trust, in turn, is essential for enabling successful data-sharing initiatives in multi-organizational settings.

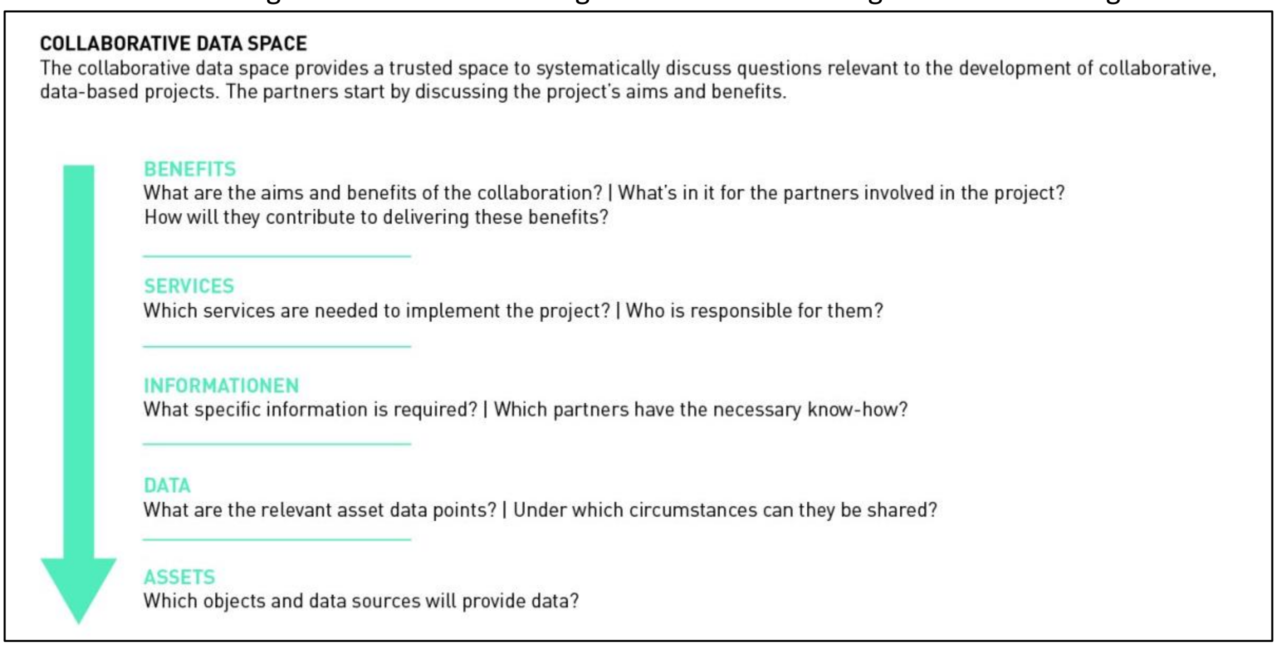

Figure 5-1: Method for enabling cooperative data sources.

A key contribution of this method is its ability to address the "data sharing problem"—the challenges of exchanging data across organizational boundaries while maintaining sovereignty and security. By tackling these issues early in the process, the method lays the groundwork for developing standardized interfaces and agreements for cross-organizational data exchange.

These foundational elements can then be refined through subsequent technical and operational efforts, ensuring that the final implementation is both practical and aligned with stakeholders' goals. Beyond the planning and initial discussions, the method serves as a visual and conceptual tool for integrating diverse perspectives. It enables stakeholders to collaboratively define the expected benefits, required information, and relevant assets. This structured approach reduces ambiguity, aligns the interests of all parties, and fosters a shared vision for the testbed's success.

Looking ahead, the research team at the FSTI aims to refine this approach into a systematic methodology for fostering collaboration in testbed environments. Future work will focus on extending the method's applicability to other domains, incorporating insights from additional case studies, and enhancing its capacity to address both technical and organizational complexities.

Ultimately, this methodology represents a crucial step toward realizing the full potential of digital twins through collaborative data sharing. By providing a clear roadmap for building trust and fostering cooperation, it lays the foundation for creating innovative, data-driven services—such as real-time passenger flow optimization or predictive maintenance for transportation networks—that benefit entire ecosystems.

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- Return to the beginning of this article
- Return to the Table of Contents