FMaaS: A User-Centric Freight Transport Platform Solution for Transport Operators

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***Abstract*—To create a secure shared data space between multiple parties is a challenge. The International Data Space (IDS) created guidelines and principles that allow companies to set up such a framework. This report presents an architectural framework for implementing FMaaS from the perspective of Transport Operators using these IDS principles. It includes a business process viewpoint which provides a roadmap of the delivery management cycle. The report includes a technology and application usage viewpoint that highlights the Transport Management System (TMS) and Fleet Management System (FMS). A SWOT analysis identifies strengths, weaknesses, opportunities, and threats associated with the implementation of FMaaS, in addition to a risk analysis addressing challenges that could present themselves during the implementation process such as cybersecurity and stakeholder resistance to change. An implementation and migration viewpoint lays down the plan to actually transition from the baseline architecture to the FMaaS platform. Architecture governance principles such as establishing an architecture review board are recommended to ensure alignment with organizational goals. Lastly, the report suggests a validation framework for continuously evaluating the implemented architecture, making the FMaaS solution solid and efficient.**

I. Introduction

Transport operators and Logistics operators face complex challenges in managing orders, optimizing routes, and maintaining system efficiency. This project aims to design a solution centered around Freight Mobility as a Service (FMaaS) using the TOGAF framework. The goal is to create a unified digital platform that improves efficiency, capacity utilization, and sustainability while enhancing user experience.

To guide this, we employed the Motivational Requirements Canvas (MRC), which helped identify key stakeholders and align their goals with project objectives, ensuring a well-structured, collaborative approach to achieving desired outcomes.

The goal of this report is to plan a transformation for transport operators implementing an International Data Space through FMaaS.

A. Scenario Description (as Transport/Logistic Operator

The process starts when a shipper places an Order Request. This kicks off the Order Management process, where the order is first Registered to log it into the system. After the order is logged, it is carefully evaluated to make sure all details are correct, and the order can be fulfilled. Once the order is checked and accepted, it moves to the Valuation step. Here, the cost and resources needed to carry out the delivery are calculated. This helps to set the right price for the delivery service. After figuring out the costs, the Payment step happens, where the money for the service is processed. At the same time, the best way to send the package is decided in the Evaluate Transport Modes step. This decision is based on what's being sent, where it needs to go, and how quickly it needs to get there. The choices might include using trucks or other methods like freight. Once the method of transport is picked, the Transport Management phase starts. This begins with Route Planning, here the best path for the delivery is planned out considering distance, traffic, and other rules. After the route is planned, the Execution step happens where the actual delivery of the package takes place. During the delivery, the package is Tracked to make sure it's moving as expected, and everyone involved knows where it is at all times. Alongside these steps, there's an Internal Fleet Management process that ensures everything needed for the delivery is ready. This includes making sure the vehicles are available (Availability Check), assigning the right drivers (Driver Assignment), and making sure vehicles can handle the job (Asset Capacity). There's also a Maintenance step to keep all vehicles in good working order, which helps avoid delays and breakdowns.

B. International Data Space

The International Data Space (IDS) Association developed by the Fraunhofer Institute aims to create a secure environment for data sharing while increasing data value. IDS provides a virtual data space founded on existing standards, technologies,

and governance models to ensure secure, standardized data exchange and connectivity. Comprising initiatives focused on research, standardization, and product development. IDS provides a virtual data space, or reference architecture, for secure, sovereign data exchange through decentralized databases. This architecture includes data connectors, stored in the IDS connector repository, enabling data access exclusively for trusted parties and applications. IDS aims to facilitate business value creation by ensuring controlled, on-demand data availability, interoperability among partners, and secure data governance.

The use case requires a secure, federated data-sharing platform. This platform should ensure data sovereignty and trust among all stakeholders. IDS provides this solution as other existing solutions don't offer the trust, flexibility or real-time capabilities needed for multi-stakeholder collaboration.

II. Methodology

In this project, the TOGAF framework [13] is used to develop an enterprise architecture that maps out the context of the project and the implementation plan regarding FMaaS. During the research, other methodologies like

The usage of TOGAF yields a systematic process for identifying and analysing problems and opportunities faced by transport operators and other stakeholders, in addition to getting a clear and well-structured overview of the project context. Figure III-C below shows the TOGAF framework.

TOGAF is an architecture method that is iteratively applied across the project phases, notably the four iteration cycles:

1) Architecture Context
2) Architecture Delivery
3) Transition Planning
4) Architecture Governance

During each of these phases, ArchiMate models are made to visualize the information gathered. During the architecture context phase, a motivational viewpoint is drawn to get an overview of the relevant stakeholders, project scope, and business goals. During the architecture delivery phase, business process viewpoint, application usage viewpoint, and technology usage viewpoints are drawn to get an overview of the business's architecture regarding processes, applications, and technology. During the transition planning phase, a SWOT analysis and migration viewpoint are drawn to identify opportunities and risks that are relevant for implementing FMaaS, based on the information gathered from the previous phase, and create a plan for the actual migration of the business architecture. Lastly, during the architecture governance phase, ongoing oversight and management activities are established to ensure that the architecture remains aligned with the set project goals and adheres to established standards.

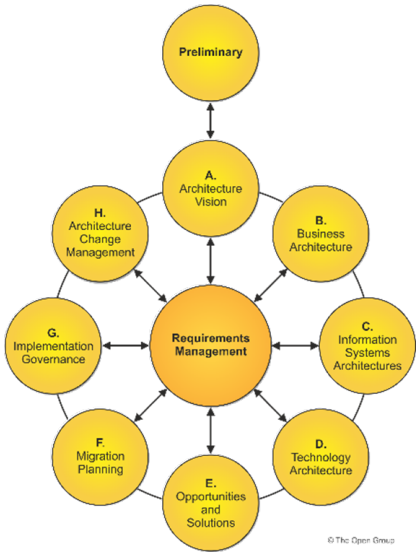

Fig. 1. TOGAF framework

III. Application of TOGAF for an FMaaS Solution

A. Architecture Context

In developing an FMaaS solution, the TOGAF framework provides a structured approach to define and align the architecture with business objectives. By applying TOGAF's iterative methodology, we systematically explore key areas like stakeholder needs, business processes, technology alignment, and migration strategies.

1) Stakeholder Analysis: To see our stakeholders and their roles in the FMaaS infrastructure see tables below:

TABLE I
Primary Enterprise Contacts

Organization	Role	IDS Roles
Transport Operator	Route planning, execution	Data Provider, Data Consumer, Data User, Connector User, Service User
Logistics Provider	Consolidation, coordination	Data Provider, Data Customer, Service Provider

TABLE II
Secondary Enterprise Contacts

Organization	Role	IDS Roles
FMaaS Platform Providers	Platform orchestration	Broker, Connector Provider, Service Provider
Customs Authority	Customs clearance integration	Data Consumer, Data Providers, Identity Verification, Data Verifier
Shipper Company	Freight demand generation (Shipper)	Data Creator, Data Provider, Data Consumer, Connector User

TABLE III
TERTIARY ENTERPRISE CONTACTS

Organization	Role	IDS Roles
Technology Providers	Provide software solutions, data sharing platforms, or infrastructure	Connector Provider, Service Provider, App Provider
Government Agencies	Ensure compliance with transportation laws, customs, and environmental regulations	Data Consumer, Data Verifier
Insurance Providers	Manage risks by providing insurance services	Data Consumer, Data Provider

In the context of implementing FMaaS, stakeholders hold distinct roles [5] within the International Data Space (IDS), which ensures secure and efficient data exchange:

Transport Operator: They are at the core of route planning and delivery execution. As Data Providers and Consumers, they share and receive critical operational data like route plans and delivery statuses. They also serve as Connector Users to interface with other stakeholders and Service Users to leverage FMaaS services effectively.

Logistics Provider: Focused on coordination and consolidation of freight, Logistics Providers act as Data Providers by sharing cargo and routing information. As Data Customers and Service Providers, they utilize data-driven insights and provide essential logistical services to clients and partners.

FMaaS Platform Providers: Orchestrate the platform's infrastructure and operations. As Brokers, they facilitate interactions among stakeholders, and as Connector Providers, they enable secure data integration and interoperability. Their role as Service Providers involves delivering key platform functionalities and services.

Customs Authority: Their main responsibility is ensuring compliance during cross-border transport. Acting as Data Consumers and Providers, they validate shipment data. As Identity Verification and Data Verifiers, they authenticate user identities and verify the integrity of transmitted information, ensuring adherence to regulations.

Shipper Company: Generates freight demand and drives the order process. Acting as Data Creators, they initiate the flow of information by creating shipping requests. As Data Providers and Consumers, they interact with transport operators and other stakeholders to ensure efficient service execution.

Technology Providers: These stakeholders are responsible for providing the necessary digital infrastructure and solutions. As Connector Providers, they enable seamless connectivity. Additionally, as Service and App Providers, they maintain and support essential applications and systems that power the FMaaS platform.

Government Agencies: They ensure compliance with various regulations, including transport laws and environmental policies. They act as Data Consumers to access relevant information and as Data Verifiers to ensure compliance with established standards.

Insurance Providers: They play a vital role in managing risks. As Data Consumers, they gather information regarding shipments and associated risks. Acting as Data Providers, they offer insurance solutions tailored to the transport context.

2) Motivational Viewpoint: In the motivational model from Figure 2, it was clear that all stakeholders within this sector share similar drivers. They all want to be as cost-efficient as possible, want increased capacity utilization, be as sustainable as possible, have a well-designed user experience, be flexible and have synchronized systems. To ensure this, assessments were created and linked to certain goals and outcomes and eventually ended up at some key principles that must be considered when developing and changing the system. These principles are quite broad and need to be dug into even further. Some of the most notable ones are interoperability, transparency and inter-connectivity. All parties use different systems as of right now and to have a well-working system together, these will need to get synchronized. This will not be an easy task, and it will be hard to convince all parties. But this is a must if this shift were to be wished for.

The model in Figure 2 shows a simplified version of a more complex motivational viewpoint which can be found in Appendix I. The complex model gives us the opportunity to find certain links that we would not have thought of otherwise and deeper insight and options for the other models in which we aim to find the correct steps to improve.

3) Business Goals: From the Motivational viewpoint, different goals have been derived. These should be central in this project to ensure content stakeholders.

These goals have been connected to the implementation and migration viewpoints to motivate different actions that facilitate these. The main goals are:

1) Optimize Freight Transportation
2) Improve Capacity Utilization
3) Reduce CO2 Emissions
4) Ensure Synchronization
5) Enhance Customer Experience

B. Architecture Delivery

Business Process Viewpoint: This business process viewpoint provides a detailed roadmap of the delivery management cycle, starting from the initial Order Request through to the execution of delivery. The process starts when a shipper places an Order Request. This kicks off the Order Management process, where the order is first Registered to log into the system. After the order is logged, it is carefully evaluated to make sure all details are correct, and the order can be fulfilled. Once the order is checked and accepted, it moves to the Valuation step. Here, the cost and resources needed to carry out the delivery are calculated. This helps to set the right price for the delivery service. After figuring out the costs, the Payment step happens, where the money for the service is processed. At the same time, the best way to send the package is decided in the Evaluate Transport Modes step. This decision

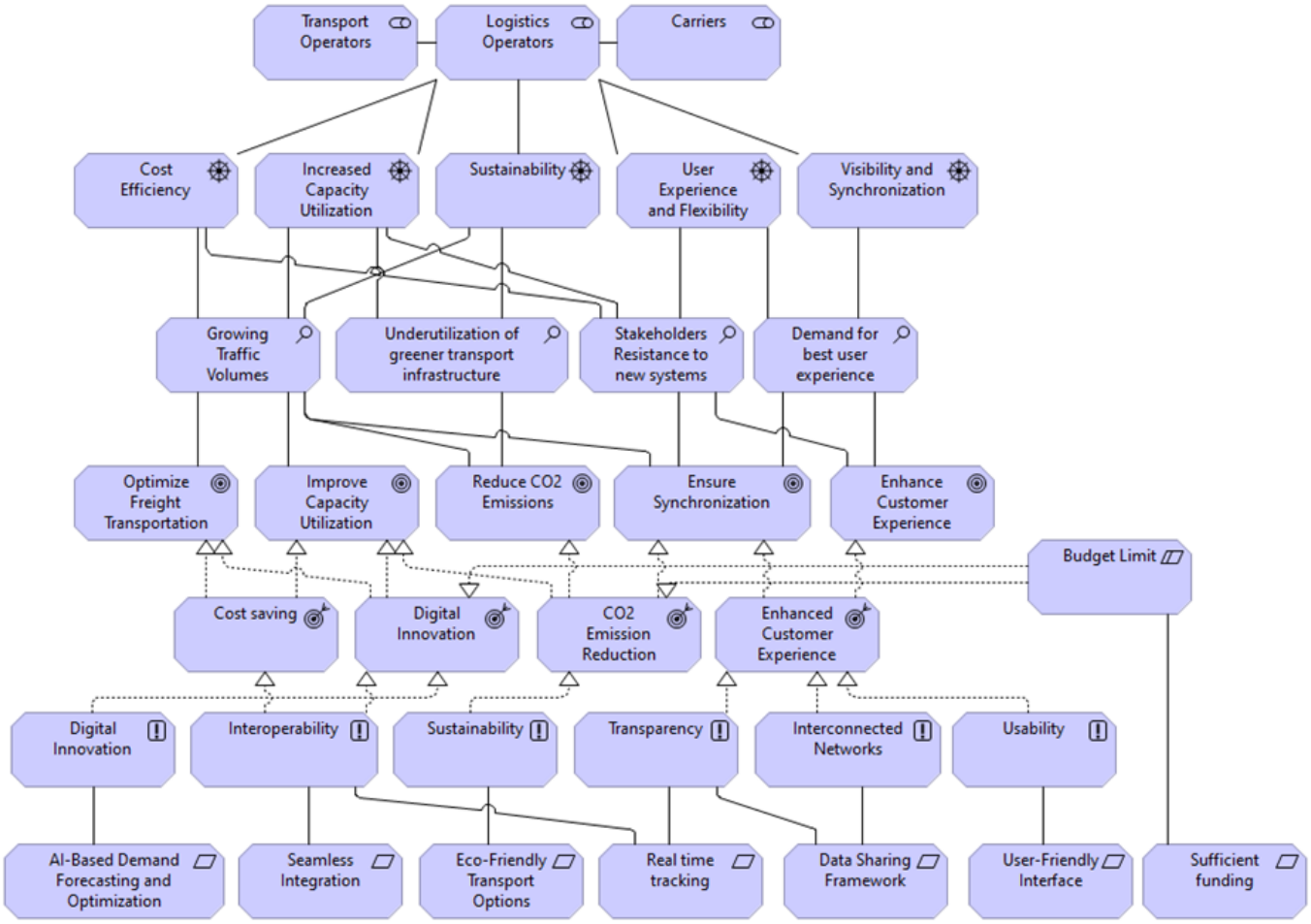

Fig. 2. Motivational Viewpoint

is based on what's being sent, where it needs to go, and how quickly it needs to get there. The choices might include using trucks or other methods like freight. Once the method of transport is picked, the Transport Management phase starts. This begins with Route Planning, where the best path for the delivery is planned out considering distance, traffic, and other rules. After the route is planned, the Execution step happens where the actual delivery of the package takes place. During the delivery, the package is Tracked to make sure it's moving as expected, and everyone involved knows where it is at all times. Alongside these steps, there's an Internal Fleet Management process that ensures everything needed for the delivery is ready. This includes making sure the vehicles are available (Availability Check), assigning the right drivers (Driver Assignment), and making sure vehicles can handle the job (Asset Capacity). There's also a Maintenance step to keep all vehicles in good working order, which helps avoid delays and breakdowns.

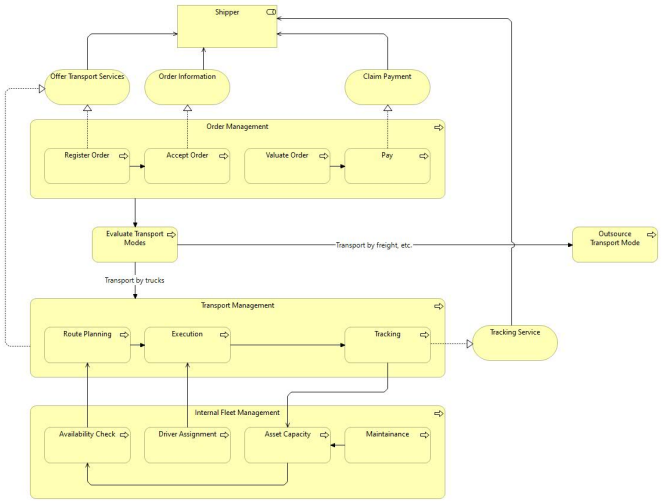

Fig. 3. Business Process Viewpoint

Technology and Application Usage Viewpoint: Starting with route planning, which is a key step for trucks transporting goods. The Transport Management System (TMS) is crucial here. It uses tools like the Routing and Scheduling Service to figure out the most efficient and cost-effective routes by taking into account things like traffic conditions and distances. The

Fleet Management System (FMS) also plays a big role by keeping track of all the vehicles, making sure the right trucks are available and ready when needed. These systems talk to each other through APIs, which are ways for different software programs to communicate and share data seamlessly. When it comes to the delivery phase, the TMS remains a central component, managing operations to make sure goods reach their destinations on time. International shipments add a layer of complexity because of customs requirements. The Customs Clearance Service handles this by ensuring compliance with the laws and regulations of the countries involved, helping to avoid delays and legal issues. Keeping an eye on shipments while they're on the move is super important for maintaining oversight and giving transparency to everyone involved. This is achieved through the Track and Trace System, which provides real-time updates on where the goods are and their status. The Tracking Data Sharing Service supports this by enabling tracking info to be shared with customers and other relevant parties. There's also a mobile app that makes it easy for users to access tracking information conveniently, kind of like tracking your food delivery on your phone. In the technology layer, each application system is supported by its technological infrastructure, usually consisting of separate servers and relevant APIs. This modular setup ensures that applications can run efficiently and be maintained or updated independently, which contributes to the overall robustness and scalability of the system.

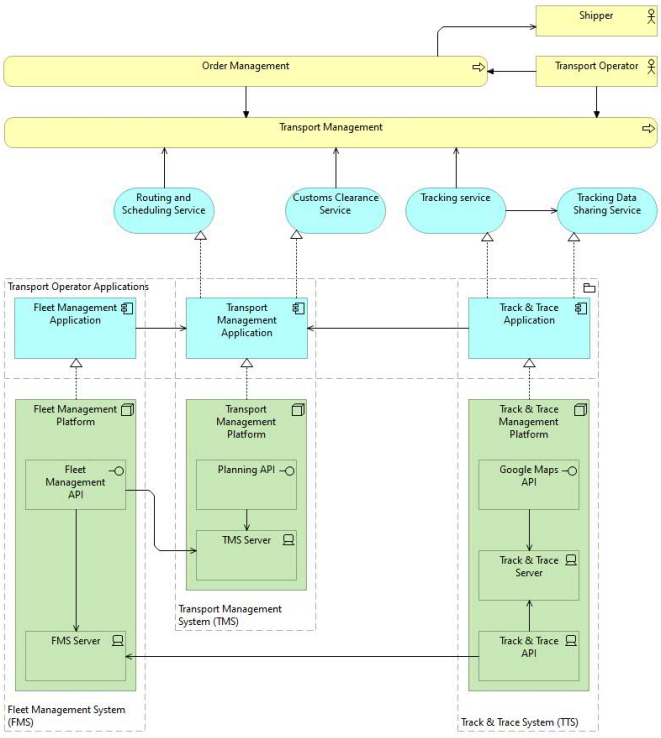

Fig. 4. Technology and Application Usage Viewpoint

C. Transition Planning

SWOT Analysis: A SWOT analysis of the current baseline architecture provides an evaluation of the strengths, weaknesses, opportunities, and threats associated with the existing systems and processes. This analysis helps identify areas where the baseline architecture can be optimized or adjusted to enable a more efficient, scalable, and future-proof FMaaS solution.

TABLE IV
BASELINE SWOT ANALYSIS

Strengths	**Weaknesses**
- Established Networks - Operational Experience - Asset Ownership	- Fragmented Systems - Lack of Real-Time Data - Resistance to Change
Opportunities	**Threats**
- Digital Transformation - Sustainability Trends - Market Expansion	- Regulatory Changes - Data Security Risks

To elaborate on the strengths, weaknesses, opportunities and threats in the table, they are explained in more detail below. Firstly, the strengths of the current baseline architecture are discussed:

- *Established Networks:* There already are many strong existing networks between different parties. Their relationships and needs are known, facilitating smooth operations and reliable service.
- *Operational Experience:* The networks have been established for a while, and most stakeholders possess extensive experience and expertise in their respective fields, leading to high efficiency in communication and handling.
- *Asset Ownership:* Many assets, such as ships in their fleet and the corresponding infrastructure, are already in place and owned by different parties, granting them control over operations.

Secondly, the weaknesses are explained:

- *Fragmented Systems:* With many different stakeholders using their own systems, often with varying levels of complexity, it is difficult to integrate them, leading to inefficiencies.
- *Lack of Real-Time Data:* Many existing systems do not provide or process real-time data, which would need to be created or implemented from scratch. This absence of real-time data results in unoptimized operations.
- *Resistance to Change:* Many parties are already satisfied with their systems due to years of experience, leading to skepticism and resistance to adopting new digital solutions.

Third, the opportunities are presented in detail below:

- *Digital Transformation:* A digital transformation could introduce several features that would enhance functional efficiency. The addition of real-time tracking and the synchronization of different services would improve overall functionality.
- *Sustainability Trends:* Adopting greener practices by investing in sustainability is essential. It allows compliance with environmental regulations and improves the organization's reputation.
- *Market Expansion:* Developing and implementing a new digital system may open up new markets and enhance existing services, creating opportunities for growth and innovation.

Finally, the threats associated with the current architecture are the following:

- *Regulatory Changes:* Regulations are constantly evolving, and adjusting to them can be difficult, particularly if they are not aligned with current systems and practices.
- *Data Security Risks:* Implementing data sharing and synchronization across different systems may introduce security risks. The transmission of data across systems, if not handled carefully, could create vulnerabilities.

Risk Analysis: A risk analysis [8] is performed considering the FMaaS adoption and the introduction of the International Data Space. The identified risks helps modelling the target architectures.

TABLE V
RISK ANALYSIS

RISK	RISK SEVERITY	RISK LIKELIHOOD	RISK LEVEL
Regulatory Changes	TOLERABLE	POSSIBLE	MEDIUM
Cybersecurity threats	INTOLERABLE	PROBABLE	EXTREME
Resistance to change	TOLERABLE	POSSIBLE	MEDIUM
Technological integration with partners	INTOLERABLE	PROBABLE	EXTREME
Data migration failures	UNDESIRABLE	POSSIBLE	MEDIUM
System failure	INTOLERABLE	POSSIBLE	HIGH
Increased competition from new logistic companies	ACCEPTABLE	POSSIBLE	LOW
Inability to transition fast enough	INTOLERABLE	POSSIBLE	HIGH

- *Regulatory Changes Networks:* Regulations around data privacy, environmental sustainability, and international shipping constantly change. There is always a possibility of new compliance requirements. This risk can be mitigated by closely monitoring regulatory trends and collaborating with legal experts to ensure all compliance requirements are met.
- *Cybersecurity threats:* The large amount of shared data through the International Data Space (IDS) and the FMaaS platform can be attractive targets for cybercriminals. To mitigate this risk, investments in cybersecurity measures can be done and cybersecurity tests should be conducted to ensure security is on the right level.
- *Resistance to change:* Where there is transition there is always the risk of resistance to change from employees, who are used to doing this "the old way". A mitigation strategy could entail providing employees with training and clearly communicate the benefits of FMaaS, such as the improved efficiency. [6]
- *Technological integration with partners:* The need to integrate systems with partners that may use other software systems leads to risks such as incompatible systems or failure to integrate due to complexity. This risk should be avoided by standardizing integration, using open APIs and offering technical support to partners. In case data standardization is an issue for partners, implementing a component that converts the data into the right format would be a good solution to avoid this risk too.
- *Data migration failures:* Due to the sheer amount of data needed to be migrated, there are risks of system downtime during the migration process, data loss, or corruption. The risk can be mitigated by implementing backup processes before migrating data or migrate the data in phases. [9]
- *System failures:* FMaaS's dependency on interconnected systems and the digital complexity this brings increases the risk of system failures. Mitigation can be done by implementing cloud-based systems and ensure real-time monitoring. [14]
- *Increased competition from new transport companies threats:* The shift to FMaaS/International Data Space (IDS) may attract new tech-driven startups that are already familiar with digital platforms, potentially bringing fierce competition. However, to tackle this risk it is important to differentiate from competitors by emphasizing strengths, and continuously innovate.
- *Inability to transition fast enough:* If not given enough priority, there is a risk of not being able to adapt enough to FMaaS, possibly resulting in lost customers and business opportunities. This risk should be avoided by giving full priority to the FMaaS transition, adopt a structured transition plan. Increase urgency among staff. Good leadership is needed to guide the transformation and reduce the associated risk of failure. [2]

Implementation and Migration Viewpoint: The goal of the Implementation and Migration Architecture Viewpoint is to define how the Target Architecture will be implemented and transitioned from the Baseline Architecture. It provides a roadmap for managing the migration, aligning projects with business goals, and ensuring smooth integration across all architectural layers.

In our case the target architecture includes a Freight Mobility as a Service (FMaaS) solution. FMaaS refers

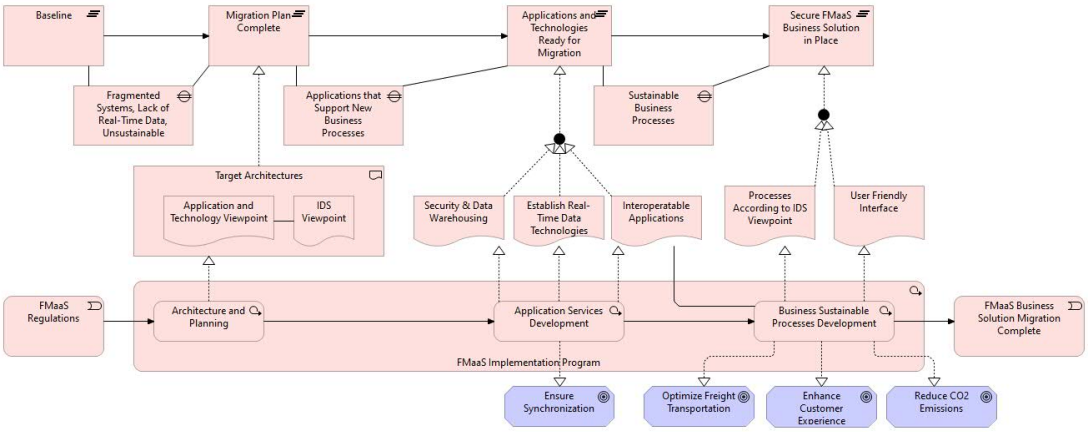

Fig. 5. Migration Viewpoint

to a digital platform that optimizes and manages freight transportation by integrating multiple services, such as booking, tracking, and payments, into a unified, user-centric system. Transitioning from a baseline architecture to a secure FMaaS business solution involves: Baseline Architecture: Assessing the existing logistics and transportation infrastructure, including legacy systems, manual processes, and security protocols. Target Architecture: Developing a secure, cloud-based FMaaS platform that incorporates data integration, automation, enhanced cybersecurity measures, and real-time visibility. The first deliverable for this migration will be designing to-be (target) architectures which should have an interoperable design. Based on these architectures, further deliverables can be designed. The Implementation and Migration viewpoint can be found in Figure 5.

Out of the Migration viewpoint a Target Application/Technology usage viewpoint and a Target Dataspace viewpoint are designed.

In Figure 6 there are multiple changes to enable a sufficient IDS connection. Firstly, we enhance our own systems by using VESDI [1]. VESDI helps to track and monitor data for areas like low-emission zones, making it easier to plan transports and improve the sustainability of logistics. This VESDI is connected to our Fleet Management Application and will help in fuel efficiency and route planning.

There also is a new component called the ”IDS Connector”. If functions as a connector to the FMaaS system. We use this connector with the OTM API [7]. Which is short for Open Trip Model, the OTM API aims to standardize data communication and make it easier for shippers, carriers, software vendors, and other entities to share transport information. The OTM is used to share data with the IDS connector to other parties and to the Shared Cloud database. Old data does not have to be in the new dataspace. Although if necessary we can use the data app store to provide a transformation tool to put the data in new format. To realize a good connection with the shipper that puts in an order request we designed a dataspace viewpoint 7.

At the core of the transport operator’s system, we see the primary functions of transport management and order management. These systems are responsible for receiving and processing transport orders and managing the logistics operations. Data exchange between transport operators and shippers is facilitated through secure connections using the International Data Spaces (IDS) framework. On both sides—transport operators and shippers—there are IDS connectors, which ensure that data is transmitted securely and efficiently. Shippers can send transport requests, receive data updates, and request transport services through their IDS connector, maintaining a secure channel for interaction with the transport operator.A central component in the architecture is the OTM API (Open Trip Model API), which connects the transport operator’s systems with standardized, real-time data exchange capabilities. This integration supports critical backend applications like fleet management, transport management, and tracking services. The transport operator’s systems communicate with these applications via REST/SOAP protocols, allowing for efficient order handling, vehicle management, and real-time tracking. Another notable element in this architecture is the connection to CBS through the Vehicle Emission Shipment Data Interface (VESDI). This linkage facilitates the aggregation and reporting of transport and emissions data, which is essential for regulatory compliance and for generating insights into vehicle usage and environmental impact. The data collected through VESDI enables more informed planning and policy-making. The diagram also features a shared cloud database server, which acts as a centralized repository for shared information accessible to all stakeholders. This cloud server is crucial for storing and retrieving data like transport orders, tracking information, and emissions records. Alongside the shared cloud server, there is a broker service provider that manages the data exchange between different connectors [4]. This service ensures secure and regulated interactions between parties, enhancing the overall efficiency and integrity of the system. The architecture includes a Data Apps Store, which plays a key role in transforming and aggregating incoming data

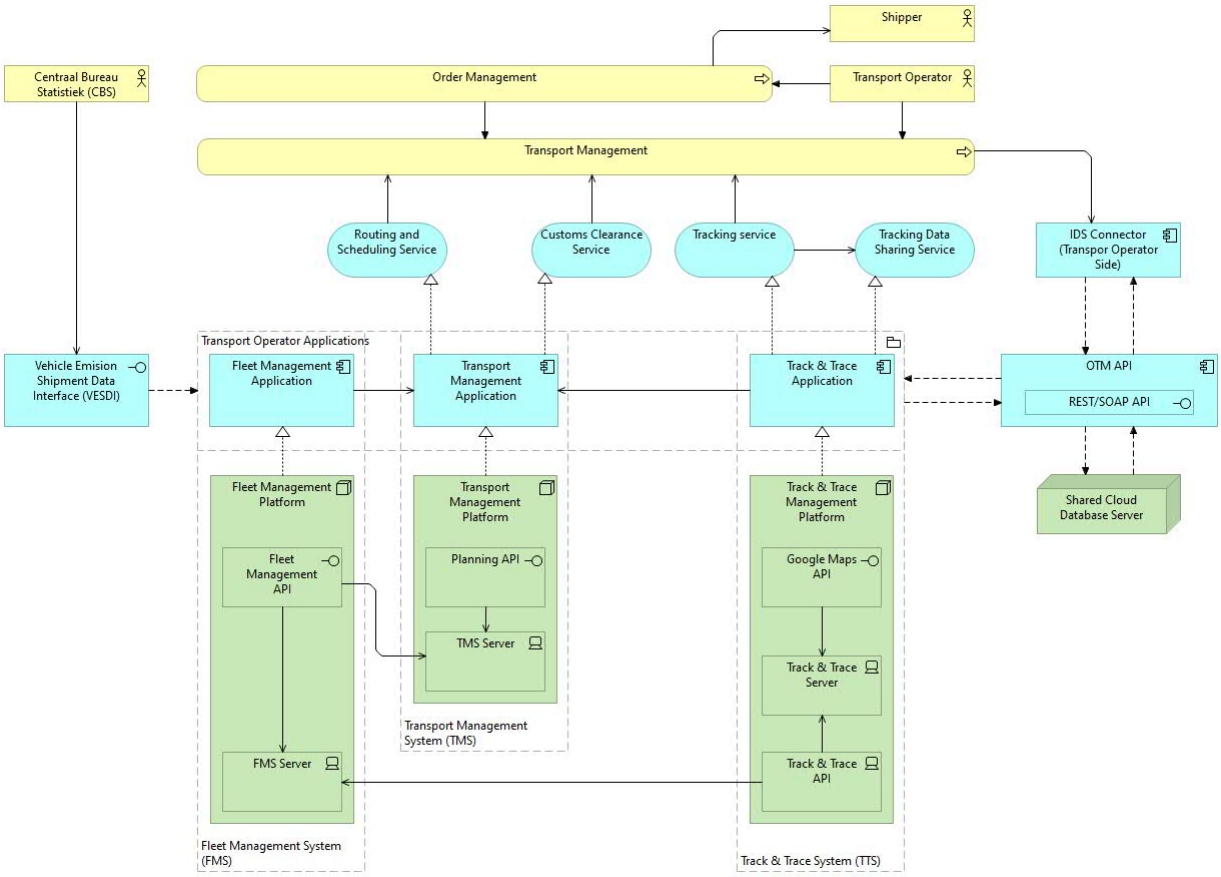

Fig. 6. Target Application/Technology viewpoint

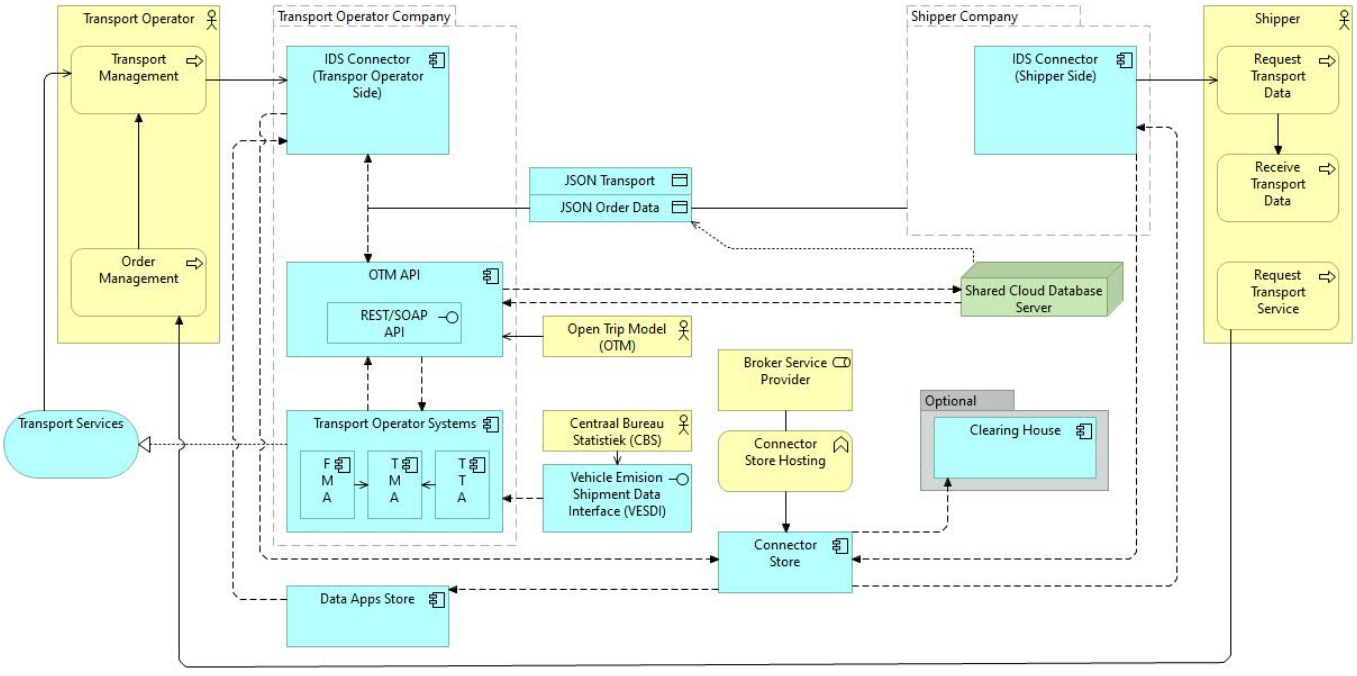

Fig. 7. Dataspace Viewpoint

into the correct formats required by the transport operator's systems. This capability is essential for maintaining data integrity and ensuring that all systems can access information in a consistent and usable form. Additionally, the IDS clearing house [3] functions as a type of smart contract or security layer for the broker. It serves to verify that all data retrieved and transmitted is valid and compliant with agreed standards and regulations. By acting as a mediator, the clearing house provides an additional layer of security and trust, ensuring that both the data providers and recipients can rely on the accuracy and authenticity of the shared information. A third party will run the clearing house to avoid conflict and gain trust.

D. Architecture Governance

Implementation Governance in TOGAF ensures that architecture is implemented according to the established design, standards, and principles. It acts as a control mechanism to maintain alignment between the architecture vision and the FMaaS solution being deployed.

Architecture Review Board (ARB): To provide oversight and strategic direction for the FMaaS architecture, an Architecture Review Board (ARB) is established [10]. The ARB acts as the central authority for all architectural matters, ensuring that the architecture remains consistent, efficient, and aligned with organizational goals.

Design Principles: One of the key design principles [12] in the FMaaS project is the Data Sharing Principle, which promotes secure, standardized, and efficient data sharing among stakeholders to enhance collaboration and operational efficiency. For governance we need to make sure stakeholders are on the same page with our models like the OTM and the IDS connectors.

E. Validation

This paragraph will describe a plan for validation of the results for transport operators wishing to use this study's FMaaS solution. In general, it is best practice to have some sort of architecture compliance review process [11] in place to regularly and thoroughly review the implemented architecture, this paragraph will highlight the most important parts to include.

Architecture Review Coordinator: For the transport operators we advice to employ a architecture review coordinator, who's job it is to align the stakeholders' needs of the architecture and and sign-off on proposed models and systems. This ensures that the other stakeholders get the right information from the logistics operator and vice versa.

Scheduled Architecture Review Meeting: It is also good practice to have regular scheduled architecture review meetings where the architecture review coordinator and lead architect meet up to review the architecture to discover potential improvement opportunities or bottlenecks in the implemented architecture.

Discussion & Recommendations

To support a migration of this scale, establishing a well-resourced IT department is essential. The IT department must be capable of executing each stage of the migration efficiently, minimizing downtime and ensuring data integrity throughout the process. Beyond the initial setup, this team will also be responsible for maintaining, monitoring, and optimizing the new system to ensure long-term reliability and performance. Investing in training and advanced tools will further equip the IT department to adapt to evolving needs, manage upgrades, and respond proactively to any issues, ultimately enabling a seamless transformation and sustaining operational continuity.

To enhance impartiality and build stakeholder confidence, a third-party organization should operate the clearing house. This independent entity will manage data collection, processing, and distribution, ensuring that no single stakeholder has undue influence over sensitive information. Additionally, an independent clearing house can implement standardized protocols and compliance checks, enhancing accountability and reinforcing trust among participants. This separation of responsibilities mitigates conflicts of interest and promotes a collaborative environment where data is handled objectively.

Conclusion

This report explored the development of a Freight Mobility as a Service (FMaaS) solution designed specifically for transport operators, integrating International Data Space (IDS) principles to enable secure, sovereign data sharing. By utilizing the TOGAF framework, we took a structured approach to address the complexities and requirements of modern freight transportation systems. The analysis began by identifying the key stakeholders involved, such as transport operators, shippers, logistics providers, and regulatory bodies. Understanding their roles and needs allowed us to align the design of the FMaaS platform with the expectations and requirements of all participants within this ecosystem. We established clear objectives for the FMaaS solution, including improving the efficiency of freight transport, maximizing capacity utilization, reducing CO2 emissions, synchronizing systems, and enhancing the overall customer experience. These goals served as guiding principles throughout the development of the business process architecture, from order management to final delivery and tracking.

To enhance interoperability and data sharing, we incorporated IDS into the existing landscape, levaraging standards such as the Open Trip Model (OTM) API and the Vehicle Emission Shipment Data Interface (VESDI). A detailed SWOT analysis was conducted to identify the strengths, weaknesses, opportunities, and threats associated with the existing architecture. This analysis informed the development of a migration plan to transition towards a target architecture, which includes secure data exchange protocols, enhanced communication channels, and effective governance mechanisms. We also addressed potential risks, such as cybersecurity threats and stakeholder resistance, by outlining appropriate mitigation strategies. To maintain alignment between the FMaaS solution and strategic goals, we recommended the establishment of an Architecture Review Board (ARB) to provide oversight and ensure compliance

with set standards and objectives. Regular reviews were emphasized as part of the governance framework. In summary, applying the TOGAF framework enabled the creation of a well-structured and user-centric FMaaS platform. The proposed IDS-based architecture not only aims to optimize operational efficiency and sustainability but also supports transport operators in adapting to future industry challenges and opportunities.

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APPENDIX I

Data Category	Data Properties	Data Sources	Relevant Standards	Data Quality Requirements	Data Privacy Requirements	Data Owner
Master Data	Structured, static data, includes company info, fleet details, routes, and drivers	Fleet Management Systems (FMS), Transport Management Systems (TMS)	ISO 8000 (Master Data Quality)	High accuracy, completeness, and consistency	Must follow GDPR for personal info	Shippers, carriers
Traffic Data	Real-time, dynamic data including traffic conditions, accidents, and delays	Traffic monitoring systems, APIs	DATEX II	Real-time accuracy and timely updates	No personal data; minimal privacy concerns	Public sources
Localization Data	Real-time vehicle positions, GPS coordinates	Fleet Management Systems (Telematics Systems)	ISO 17572 (GNSS)	High precision, minimal latency	Pseudonymization required for driver data	Carriers
Routing Data	Optimized routes, alternate routes based on traffic and weather	Fleet management systems (FMS)	ISO 14825 (Geographic Data Formats)	High accuracy and reliability in real-time	No personal data concerns	Carriers, TMS
Weather Data	Real-time weather conditions impacting transport	Weather service APIs	ISO 19156 (Observations Data)	Timeliness and precision for weather updates	No personal data involved	External weather providers
Customs Data	Information on duties, taxes, and cross-border regulations	Customs authorities, Fleet Management Systems	WCO Data Model	Complete, compliant with international trade regulations	Data protection for trade secrets	Customs authorities, shippers
Tracking Data	Status updates, location, and estimated time of arrival (ETA)	Transport management Systems (Telematics systems)	GS1 XML	Real-time data integrity and accuracy for tracking shipments	Must comply with data sharing regulations	Carriers, logistics operators
Inventory Data	Stock levels, shipment contents, product SKUs, and inventory levels	Warehouse Management Systems (WMS)	ISO 19998 (Inventory Data)	Accuracy, traceability, and up-to-date information	Data privacy for sensitive inventory information	Shippers
Scheduling Data	Planned delivery times, vehicle availability, fleet schedules	FMS, TMS	ISO 19115 (Metadata)	Up-to-date and conflict-free scheduling	Pseudonymization for driver info	Carriers, logistics operators

Fig. 8. Technical description of data