Vision for Multimodal Traffic Management and Control

FREQUENTIS

Fintraffic

Version history

0.1	November 23, 2022	Janne Lautanala	Initial draft
0.2	June 27, 2023	Janne Lautanala	Small updates
0.3	June 29, 2023	Janne Lautanala	Added use cases
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Executive Summary

Global megatrends force traffic operators to accelerate development within traffic management and operations. Traffic emissions must be reduced so that we can reach the ambitious goals set out in the governments' programs. Urbanization and the ageing of the population also call for new traffic solutions.

We believe that in future, traffic needs to be controlled multimodally on the land, in the air and at sea. Traffic information needs to be provided to help companies to create new traffic and smart mobility solutions for people and goods.

Intelligent traffic control and management services, up-to-date real-time traffic information and the competence of the ecosystem involved improve the safety and smoothness of traffic and help reduce emissions.

The proposed approach is designed to support multimodal traffic management and control as well as aggregation, management and delivery of mobility, logistics and situational awareness data.

A key component for multimodality is to standardize to scale quickly and efficiently. Data standardization is an important component for success — one that should not be underestimated. We cannot hope to achieve goals that assume a 360-degree view of all stakeholders underpinned by the correct data without a common set of data definitions and structures across the involved stakeholders.

In this document, Fintraffic is showcased as an example of multimodal traffic management. Multimodal traffic management accelerates smart traffic and logistics, as well as creates new jobs, new services, and competitiveness.

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1 Purpose and background of this document

This document describes Fintraffic's and Frequentis' joint vision for multimodal traffic management and control for the year 2030. The document is intended both for internal and external use to stimulate discussion on the possibilities of digital transformation within traffic management and control and data economy in traffic in general.

1.1 Authors

The authors of this document include (in alphabetical order):

- Stefan Galler, Vice President Sales and Business Development, Frequentis USA
- Eduard Gringinger, Principal Data Scientist, Frequentis AG
- Janne Lautanala, Chief Ecosystem and Technology Officer, Fintraffic
- Raine Luntta, Head of Platforms and Architecture, Fintraffic Railway
- Tatu Mikkonen, CTO, Fintraffic Road
- Juho Pitkänen, Development Manager, Fintraffic VTS
- Harri Seppinen, Head of ICT, Fintraffic Road
- Jani Suomela, Head of Technology, Fintraffic ANS
- Christian Weiss, Director Strategic Programs ATM, Frequentis AG
- Dirk Withake, Director Business Unit EAD, Frequentis AG

2 Vision and goals for multimodal traffic management and control

2.1 Trends

Global megatrends force traffic operators to accelerate development within traffic management and operations. Traffic emissions must be reduced so that we can reach the ambitious goals set out in the governments' programs. Urbanization and the ageing of the population also call for new traffic solutions.

Some megatrends open up opportunities. Digitalization makes it possible to use intelligent traffic services that we cannot yet even imagine. At the same time, the way in which people move is changing: instead of owning means of transport, people are now more willing to buy mobility services. The sharing economy is empowered also from this change.

Intelligent traffic control is largely based on having a real-time overview of traffic. Data-based services offer the opportunity to combine different modes of transport into travel chains. They also allow for autonomous vehicles and novel modes of transport. We believe that we are only at the beginning of this development.

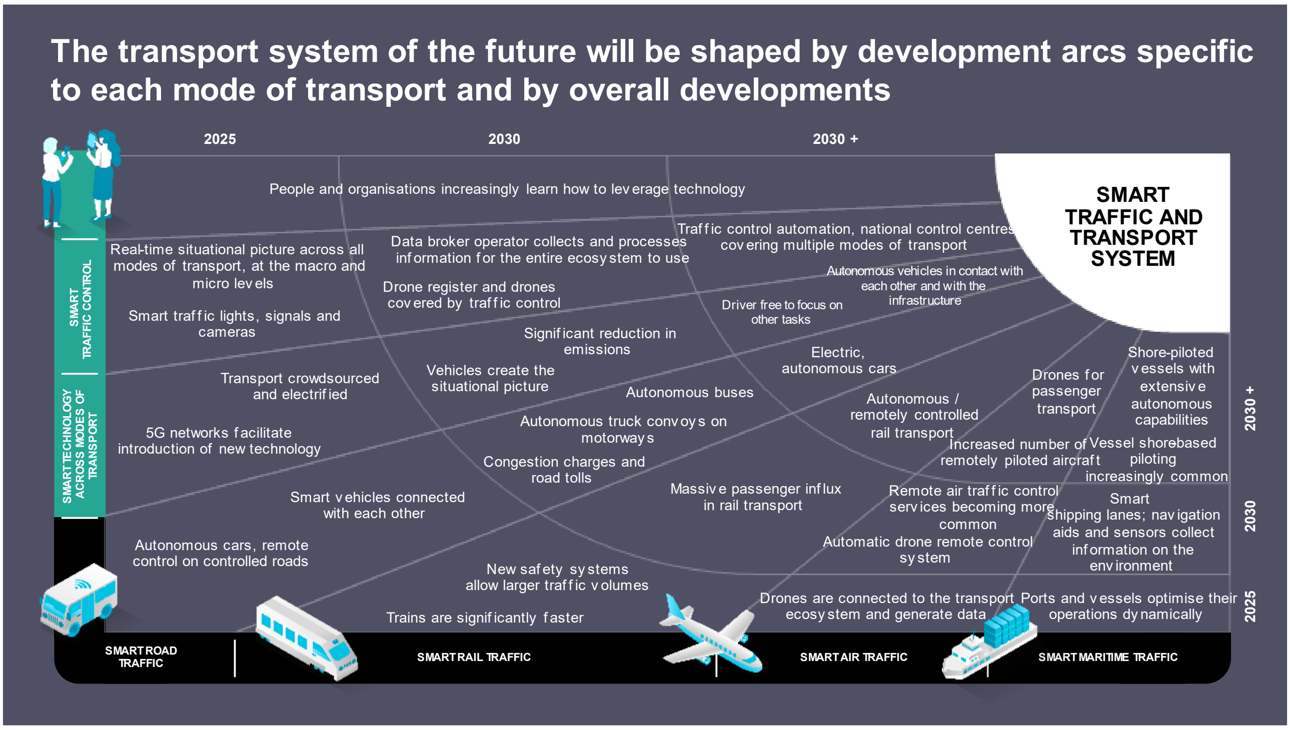


Figure 1. Transport system of the future will be shaped by several trends.

2.2 Vision for multimodal traffic management

We believe that in future, traffic needs to be controlled multimodally on the land, in the air and at sea. Traffic information needs to be provided to help companies to create new traffic and smart mobility solutions for people and goods.

Intelligent traffic control and management services, up-to-date real-time traffic information and the competence of the ecosystem involved improve the safety and smoothness of traffic and help reduce emissions.

KEY STATEMENTS:

Our key statements on how the traffic management will change in future:

1. **Multimodality will be a game-changer:** Traffic modes should not be treated as silos but rather handled jointly, looking it as an overall traffic system. Increased and smarter utilization of data results in increased productivity and efficiency as well as currently unimaginable new services. Traffic Management has been open for totally new types of modalities. New ways of transportation, such as, connecting cities via low-orbit flights will become a reality.

2. **Infrastructure and vehicles become more intelligent.** More intelligent infrastructure and vehicles are capable of deciding autonomously. Each vehicle will become an IoT device creating, consuming and analysing data to build a better model of the world.

3. **User Centricity: Utilization of Artificial Intelligence and automation will increase** and **improve user experience.** By incorporating AI into the design of multimodal traffic systems, we can create a more user-centric experience that prioritizes the needs and preferences of individual travellers. AI can analyse vast amounts of data in real-time to optimize traffic flow, reduce congestion, and improve safety.

4. **Planet-centricity: Safer, smoother, eco-friendlier multimodal traffic helps people to come together, making world a better place.**

5. **Abstraction level will increase: Mobility and logistics services need to be involved.** Traffic management cannot stay in traffic flow level only but needs to also support mobility and logistics services as well as crossing industries with heavy need for movement of goods or people (e.g., retail, construction, tourism…).

6. **Connected data and services will be key for the transformation:** In order to support the needs, more data needs to be utilized from internal and external sources. These sources can be e.g., sensors in vehicles, service providers, crowdsourced data from citizens etc.

7. **Multimodal traffic management and control needs new approach for technical architecture.**

Fintraffic's Vision for Traffic in 2030
Our vision for Traffic Vision for 2030 can be viewed online on Youtube:
https://www.youtube.com/watch?v=rG1Ecu81V9w (Traffic Vision 2030 | Fintraffic (EN))

2.3 Goals for the multimodal traffic management

By promoting the development of the traffic ecosystem and the introduction of intelligent traffic services, multimodal traffic management produces major benefits for the whole of society.

1. **Competitive advantage on the world market and for the population.** Ecosystem of enterprises, experts, government and citizens working towards a shared success and creating competitive advantage.
2. **Holistic optimization of traffic network.** Multimodal traffic management enables optimization of the whole traffic system – not just individual mode. Smooth transport of people and goods are an essential element of competitiveness.
3. **Cost-efficient mobility.** Intelligent traffic services increase competition, introduce new modes of transport on the markets and allow the choice of more affordable modes of transportation.
4. **Improved service quality.** Multimodal traffic services enables creation of services that the inviduals' needs better into account.
5. **Improved traffic safety.** Intelligent traffic solutions improve traffic safety by increasing automation and reducing the role of human involvement as well as enabling traffic control to focus on tasks that call for special attention. Intelligent traffic control helps emergency vehicles, for example, reach their destination more fluently.
6. **Reduced traffic emissions** Smooth travel chains increase the share of public transport by reducing travel times and helping with the planning of journeys.
7. **Introduction of exportable traffic services is boosted.** There is a growing global demand for intelligent traffic services, as the same megatrends influence development all over the world.

3 Traffic management and control ecosystem

3.1 The need for collaboration

Building the transport system of the future requires cooperation from the entire sector. There are multiple reasons why collaboration is needed:

- to increase the market for companies operating in the traffic sector
- to create new operating models for the traffic sector
- to boost operational efficiency by sharing and utilising information
- to save costs through co-creation
- to reduce the environmental damage caused by traffic emissions

Over the coming years, renewing traffic will, above all, be about making much better use of all kinds of traffic-related data. In order to create the strongest possible foundation for a sustainable transport system and enable the breakthrough of new traffic services and solutions, data must flow smoothly between routes, vehicles, different modes of transport, service providers and end users. It doesn't matter what we're talking about – travel chain services, autonomous vehicles, boosting the efficiency of logistics nodes, shortening warehousing times for goods, or the increasing volume of drone traffic. And at the same time, this will generate new business opportunities for parties.

3.2 How can we achieve the goals together?

There are several means to achieve the goals together, working as an ecosystem:

1. By inviting all stakeholders to participate equally in the joint and open development of a traffic data ecosystem.
2. By working towards common objectives and common action, by sharing knowledge, and by engaging in co-development to increase the value of the traffic and logistics market.
3. By making more data available – either with or without charge – in a mutually agreed format.
4. By making use of jointly developed rules and clear working practices.

5. By making it easier for different operators to work together with the aid of things such as common data models, jointly defined technical interfaces, and international standards.

6. By building cooperation networks that can market, sell, and supply interoperable solutions.

7. By respecting current legislation under all circumstances, and particularly about privacy protection, trade secrets, competition law, data protection and data security.

8. By leveraging multimodal traffic management operators' unifying role between all modes of transport in the creation of the data ecosystem, particularly in the creation of market references and key market-based services that are difficult to launch, and primarily as an enabler rather than a creator of services for end users.

9. By actively communicating agreed measures, progress, and achievements; and by facilitating interaction between operators at all stages of the process.

3.3 The benefits of traffic ecosystem

The traffic data sharing will generate diverse benefits for the ecosystem:

- **For society**, it will provide resource-wise transport system data that will enable us to reap the full benefits of data processing, and act as a building block for a sustainable and competitive society. The ecosystem will also spawn new innovations, companies, and jobs.

- **For the environment**, it will mean cleaner traffic thanks to greater utilisation of public and shared transport, which will be enabled by providing alternatives to private cars and individual deliveries.

- **For households**, it will mean better-informed travellers and data-based services that provide genuine alternatives for safe, sustainable, affordable, and smooth travel and logistics, in both rural and urban areas.

- **For organisations that use services**, it will provide attractive and competitive service packages with lower emissions and lower costs.

- **For companies that provide services**, easily accessible traffic data will accelerate the creation of new business, create new markets (including internationally), and facilitate cooperation and the formation of joint offerings in business networks.

- **For logistics operators**, it will provide cost-effective and integrated logistics chains enabled by data sharing.
- **For the public sector**, it will mean the opportunity to build higher quality and more efficient mobility and transport services that are more compatible with companies.
- **For R&D companies**, widely available open traffic data will provide an internationally significant advantage in setting up research activities that accelerate service development and in implementing development environments that involve several actors.
- **For the international community**, it will enable data-utilisation operating models and service packages tried and tested to be tailored to local needs or scaled up for wider market.

Case example: Traffic Data Ecosystem in Finland

Building the transport system of the future requires cooperation from the entire sector. More than 170 traffic organization in Finland are working together to accelerate utilization of data in traffic and logistics.

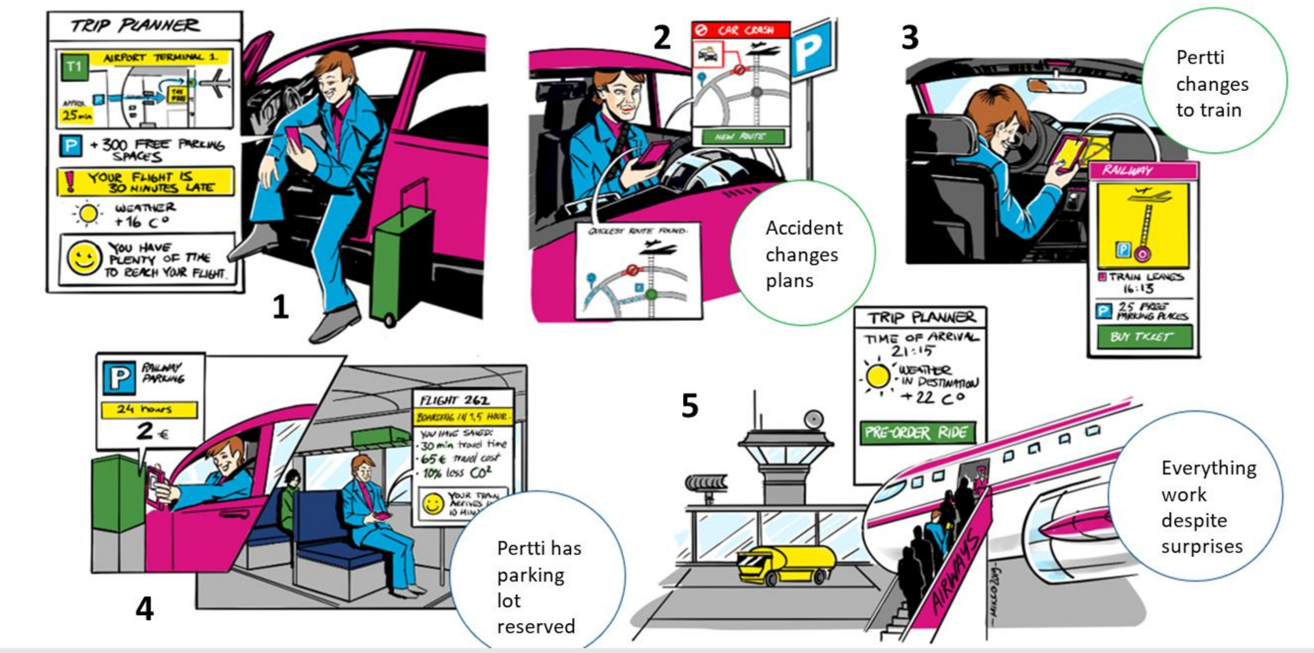
Over the coming years, renewing traffic will, above all, be about making much better use of all kinds of traffic-related data. In order to create the strongest possible foundation for a sustainable transport system in Finland and enable the breakthrough of new traffic services and solutions, data must flow smoothly between routes, vehicles, different modes of transport, service providers and end users. It doesn't matter what we're talking about – travel chain services, autonomous vehicles, boosting the efficiency of logistics nodes, shortening warehousing times for goods, or the increasing volume of drone traffic. For more information, please visit: https://www.fintraffic.fi/en/trafficecosystem

4 Sample use cases for multimodal traffic management and control

To highlight the value of multimodality both for the end users as well as traffic management, we are describing 2 sample use cases that highlight the future approach and value for the stakeholders.

4.1 Sample use case 1 – “Pertti on his way to the airport”

Pertti is a busy consulting executive and is on his way to a business trip from his hometown in Kirkkonummi, Finland via Helsinki-Vantaa Airport in Helsinki Finland to Barcelona, Spain via a connecting flight through Frankfurt, Germany.



Step #	How it feels like	What is happening behind the scenes?	Data needed
1	Pertti is leaving for the airport. He gets full visibility to status of all along his trip to his destination in Barcelona.	Information is gathered from various sensors / traffic management systems and 3rd parties (air liners, weather info providers, parking companies etc.) to understand the trip parameters.	Pertti’s Flight data and schedules (including Estimated time of departures), Profile information, traffic management provider

	The app suggests taking a private car based on Pertti's preferences and weather. The app calculates estimation of trip total cost, CO2, time and evaluates risks involved.	Personalized AI predicts Pertti's preferences and suggests modalities and schedules. One app provides all information (3rd party supplier) which utilizes APIs provided by different parties.	situational awareness data, weather info, position data, situational awareness of the whole route.
2	Pertti receives push notification about a car crash on the route. The app provides info and impact on travel time. Pertti has the possibility to see in real time camera / video stream of the traffic jam that is happening and estimated time for traffic jam to be cleared. He also sees that if he stays in the car, he will be late for his flight.	Vehicles in the accident site provide information about a car crash and traffic jam caused by it. Traffic cameras provide real time info about the traffic jam. Traffic management system estimates impacts and delays caused by the accident. Information gathered from car sensors (C-ITS) / traffic management and 3rd parties (air liners, weather info, parking companies etc.) is analysed to understand the trip impact and overall situation.	C-ITS vehicle information, Flight data, Profile information.
3	Pertti receives suggestion to take a local train instead to avoid the traffic jam and gets suggestion for connected parking. He has the possibility to reserve and buy tickets for both the parking and train. Pertti sees the real time location and ETD of the train in the connected station.	The App AI evaluates other routes and suggests changing the train. Even though the train is late, as the real time geo-location of the train is available with ETA to each station, Pertti is suggested to take the train. There is real time info available of the occupancy of the parking lots in the train station. The app makes a reservation for the train and parking.	Train schedules, locations, ETAs to each station. Parking lot info, prices, availability.

4	Pertti enters the parking lot and pays for the parking via app. He sees impacts on the trip cost, schedule, CO2 and gets confirmation that he will reach the flight on time as the flight departure is also delayed by 60 mins. Because the Helsinki-Vantaa train station is at the airport, Pertti can easily walk from train station (inside the airport) to the airport.	The parking lot info is integrated to app as well as payments. Pertti's personal mobility calculators calculates trip cost, schedule, CO2.	Parking lot info, CO2 calculation
5	Pertti reaches the flight on time and sees the gate information and expected time needed to reach the gate including needed at the security check. He sees his ETA on the destination hotel at Barcelona and has a possibility to prebook Uber ride to his hotel in Barcelona. Despite the accident and surprises, Pertti's trip was smooth, and he felt that he is under control all the time.	Barcelona's Uber system is integrated with the app.	Uber availability information, weather information, flight information, security check queue information.

4.2 Sample use case 2 – “Logistics chain from port to front door“

Minna is an enthusiastic music shop owner in Kajaani, Finland. She has ordered a pack of new guitar pedals through her dealer in Germany to be sold in the biggest music festival in Finland. A delay at sea risks the just in time arrival for the music festival.

Image source: pixabay.com

Step #	How it feels like	What is happening behind the scenes?	Data needed
1	A packet is on its way to Finland in a vessel – the delivery is delayed by 24 hours. The recipient receives real time information of the location & ETA of the packet as well as environmental information (e.g., temperature, humidity) of the packet.	AI calculates real-time estimated time of arrival to port and informs of the situation to all stakeholders in the port. The plans for the stakeholders in the port change accordingly.	Vessel location, parcel location in container, and container location on vessel. Environment data from the parcel. Weather, wind, and sea locations. Docking locations availability, duck boat and pilot schedule, crane and crane staff schedules, harbour truck logistic provider schedule.
2	As a result, the connected road logistics is predicted to run into further delays due to traffic jam caused by local music festival.	The Digital Twin responsible for optimizing packet delivery route end-to-end simulates multiple available updated delivery options. The current route is expected to lead to further delays because the truck delivery might run into traffic.	Multi-modal delivery model Capabilities of different modes of transport/logistics Traffic, weather data and prediction

		A new route via train and final delivery truck, which route is less effected by the festival traffic is simulated to be fastest	Street maps Train track maps Distribution center location Distribution centre “turnaround time” Distribution centre connections (streets, tracks, airspace/air routes) Boundaries of allowed options with respect to time, cost, CO2.
3	Therefore, the logistics operators switch from street logistics to train that connects with a distribution centre with less expected traffic for the final delivery.	System provides updated proposal to ordering company for semi-automated approval. The system updates orders/contracts.	
4	Mi gets updated information of the ETA for the packet.	Systems are updated with the latest information/route. Information is pushed to Minna for information and higher-level coordinating entities.	
5	With the package arriving later, Minna is not in the home office anymore but will be in the office at the expected time of arrival. She uses the App to update the final delivery address.	The logistics provider is informed immediately. The delivery ordering entity is informed. New routes and options are simulated, and preferred route selected.	Delivery contract details

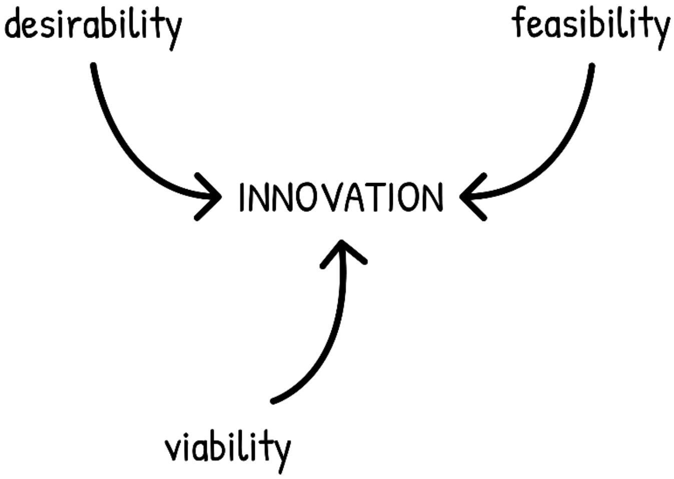
		Time, cost, and CO2 updates of preferred route are provided to delivery ordering entity for semi-automated approval, depending on contract Minna may need to confirm for increased cost.	
6	When the packet arrives by train at the local distribution centre, the packet is unloaded and moved to final mile delivery drone (to accompany the flexible change of delivery address).	Systems calculates the best flight plan and files it.	Airspace Airspace usage/flow information Drone capabilities and flight performance.
7	The delivery drone is rerouted due to ad-hoc airspace closure around the festival area.	Digital twin receives air closure NOTAM, new routes are calculates/simulated, and preferred route requested. Stakeholders' information systems are updated in real time about ongoing activities, but only final decisions are pushed as active notification. Capability of drone to still execute on new route is calculated. Preferred route is requested from ATC. Upon approval, all stakeholders are informed of their status.	Airspace information Drone energy, remaining energy. Flight profile energy requirements Weather, wind, … Flight plan Overall flow data
8	Minna receives information about final mile delivery through drone and the real time location of the drone. Minna finally receives the packet and is happy to start planning for the selling of the new gear in the music festival.	Package marked as delivered.	

5 Designing big things with planet-centric design

Our purpose is to be the catalyst that makes the world work better. We will achieve this by bringing our planet to the centre of our multimodal services' design work.

Traditionally, the blueprint of an innovative product or a service consists of three features:

- Desirability: Is the product or service wanted?
- Feasibility: Is the product or service possible to make?
- Viability: Is the product or service financially viable?



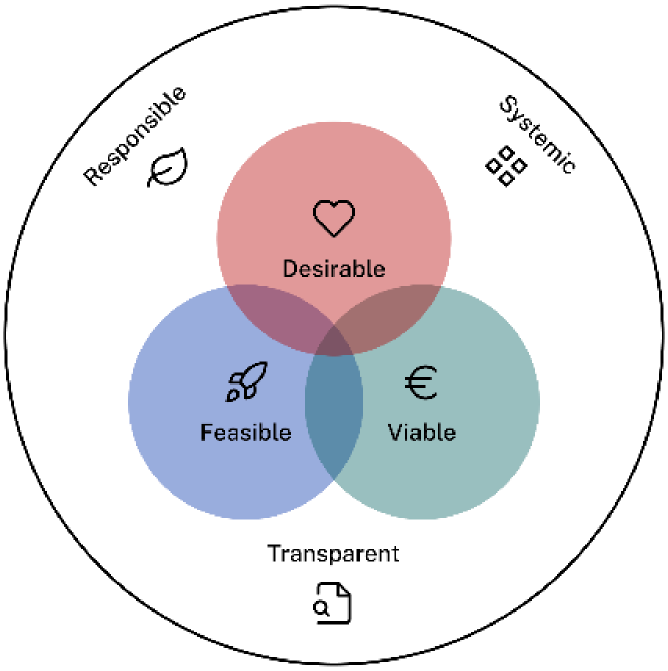
Traditional blueprint of an innovative product (Tim Brown, 1995)

Using this blueprint, the social and environmental sustainability of a product or a service is usually considered only by proxy, for example with questions such as "Does making it more socially or environmentally sustainable make it more profitable?" It all boils down to making the product or service more successful with little to no thought given to the social or environmental impact it has. Products and services designed like this can often have a planet negative impact.

Vincit's Planet-centric Design suggests adding three additional features to the core of an innovative product or service, which help to transform it into something with a planet positive impact. These three features are:

- Responsibility: Is producing the product or service responsible socially and environmentally? Can we stand behind what we put out in the world?
- Systematicity: Is the whole ecosystem and context considered when making the product or service? Can we see and embrace the complex effects it has beyond the immediate? Does the product or service work to elevate and improve the system?

- Transparency: Can we open up our processes and systems to share knowledge, ideas, and solutions to others to accelerate a more sustainable change? How can we be as transparent as possible while making the product or service?



Planet-centric Design diagram (planetcentricdesign.com)

Bringing planet and sustainability to the centre of the design process makes it more visible and allows us to think about new innovative and sustainable ways to achieve a planet positive impact with our products and services.

Planet-centric and sustainable design approach is not a new idea. Victor Papanek's book "Design for the Real World" from 1971 includes many of these topics and ideas. But while it is not a new idea, it has seen a large surge of adoption in the past few years and has proven to be a viable way for businesses to design new products and services.

Adopting planet-centric design is not an easy task. We've put together an easily understandable and followable list of principles for us to follow in designing a more sustainable tomorrow.

5.1 Principles of planet-centric design

Design Principles are a set of considerations that form the basis of any excellent product or service. They work as high-level guidelines to help execute our multimodal traffic control vision.

Our planet-centric design principles for Multimodal Traffic Management are:

1. The world can be redesigned
2. Design systemic change
3. From short- to long-term impact
4. Measure the impact and consequences
5. Design transparently, with others

5.1.1 The world can be redesigned

Our human-built world is mostly a product of design. It works how it works because it was designed to work this way. And because it was designed to work this way, it can be redesigned to work in another way – for the benefit of the planet and the life on it.

To change the world, we must first accept our ability and responsibility to change it. To create innovative, socially, and environmentally sustainable services and products, we need disruptive, revolutionary, and radical design.

Complex systems, such as ecosystems, are often emergent systems that have evolved over time. We can’t always control them or understand why they work like they do, but we can dance with them. We can iterate our services and products by experimenting with these complex systems while adapting to them and shaping them.

5.1.2 Design systemic change

Lifecycle of a product or a service is often represented linearly, but it's actually circular and systemic. We need to take a step back and consider our designs in their larger, more complex ecosystems and contexts. Because whether we do it or not, the consequences of our designs happen.

“*You can design a chair without considering the landfill, but whether you include it in your process or not, the circle completes itself.*” - Jeff Humble

Design products and services with planet positive impact that fit into their larger ecosystems by developing or changing the whole ecosystem for the better.

“Always design a thing by considering it in its next larger context – a chair in a room, a room in a house, a house in an environment, an environment in a city plan.”
- Eliel Saarinen

5.1.3 From short- to long-term impact

Designing products and services is by nature a forecasting practice. We try to design in a way that the products and services would fit into the world when they are ready.

Designing for problems like climate change or societal problems like multimodal public transport and traffic management have much longer timelines and there won't be release dates for all-in-one systemic solutions. Transitions are slow and can happen over multiple generations, or at least over many years. People also often change during these slow rollouts and transitions, so it is crucial to manage the transition to achieve the desired impact.

Designing for long-term impact is a never-ending marathon with multiple timelines and horizons. For example, using three horizons framework to represent Fintraffic's business development gives us an idea of all the transitions we have ahead of ourselves and gives us a tool to manage them. Working on all three horizons need to happen concurrently, not one after the other.

- Our first horizon consists of our current core products and services, such as different traffic management services and open data platform.
- The third horizon consist of services and products related to our multimodal traffic management vision.
- Lastly, our second horizon we should have transitional, emergent, and innovative services and products that lead us from the first horizon to the third.

5.1.4 Measure the impact and consequences

Designing products and services with long-term impact will often also have unintended consequences, even if we try to account for everything beforehand by designing systemic change. It is important to measure the impact of our designs, whether intended or unintended.

Because the impact and consequences of our designs is not always apparent or even measurable for many years, it is important to keep gathering data about them. Once we understand the impact and consequences, it is a lot easier to develop the product or service.

5.1.5 Design transparently, with others

The bigger the design challenge, the smaller the egos must be.

Designing complex things is not a solo mission, but a joint effort between many people and organizations working in multiple timelines (three horizons approach). It can include codesigning with a wide variety of stakeholders, such as citizens, government officials, competitors, clients, and company management.

When possible, open up processes and systems for peer review and critique, share knowledge and ideas to drive and improve the sustainability and competitiveness of the whole ecosystem.

Fintraffic's strategic drivers

- **Aiming for the safest, smoothest, most efficient, and reliable traffic management in the world.** We honestly believe in aiming high – not less than providing the best traffic management service in the world.
- **Automation takes care of routines:** Our time is freed up for decision-making and communication when traffic management tools implement human-made decisions reliably and safely.
- **Proactive grip of the future:** With the help of traffic forecasts and up-to-date information, we anticipate conflicts in cooperation with other traffic and transport operators
- **Farewell to the patchwork of systems:** Based on the needs of our users, customers, and stakeholders, we offer services, data, and tools with smooth and seamless user experience where information does not have to be pieced together from several diverse sources.
- **From working alone to self-directed teamwork:** The support of the team and the work community help with processing information and data, solving problem situations and equalizing the load between people in changing situations.
- **The disruption of work must also happen between the ears:** The change of new and better ways of working, both in operational work and in development, is above all a change in the way of thinking

6 Data

6.1 Role of data & analytics in multimodal traffic

Data plays a crucial role in multimodal traffic management. Here are some key roles that data plays in this context:

- Traffic Monitoring: Data is used to monitor and gather real-time information about traffic conditions. This includes collecting data from sensors, cameras, GPS devices, and other sources to track the movement of vehicles and pedestrians. This data helps transportation agencies and operators understand current traffic patterns and identify congestion or other issues.

- Traffic Prediction: Historical and real-time data can be analysed to predict future traffic patterns and congestion. Machine learning algorithms can be employed to forecast traffic conditions, enabling proactive traffic management strategies.

- Route Optimization: Data-driven algorithms can help commuters and transportation services find the most efficient routes based on real-time traffic conditions. This can reduce travel times, fuel consumption, and overall congestion.

- Public Transportation Management: Data is used to optimize the scheduling and routing of public transportation services, such as buses and trains. Real-time passenger data can help adjust service frequency and routes to meet demand.

- Incident Management: Data helps detect and respond to traffic incidents such as accidents, road closures, and breakdowns more efficiently. Timely incident management can reduce the impact on traffic flow and improve safety.

- Infrastructure Planning: Data analysis helps transportation planners make informed decisions about infrastructure improvements, such as road expansions, adding bike lanes, or enhancing pedestrian walkways. This ensures that transportation systems are designed to accommodate various modes of travel.

- Multimodal Integration: Data integration from various transportation modes (e.g., buses, trains, rideshares) enables seamless transfers between modes and improves the overall efficiency and convenience of multimodal travel.

- Demand Management: Data can inform demand management strategies, such as congestion pricing, parking management, and encouraging the use of alternative modes of transportation. This helps distribute traffic load more evenly.

- Environmental Impact Assessment: Data can be used to assess the environmental impact of transportation systems and make decisions that promote sustainability, such as encouraging cycling, walking, and the use of electric vehicles.

- Public Information: Data is used to provide real-time traffic updates to the public through mobile apps, websites, and electronic signage, allowing commuters to make informed decisions about their travel routes and modes.

Data is the foundation of effective multimodal traffic management. It enables stakeholders to monitor, analyse, and optimize traffic flow, enhance safety, and improve the overall efficiency and sustainability of transportation systems. This data-driven approach is essential for addressing the complex challenges of urban transportation in the modern world.

6.2 Let the data flow!

A key component for multimodality is to standardize to scale quickly and efficiently. Data standardization is an important component for success — one that should not be underestimated. Traffic Management organizations cannot hope to achieve goals that assume a 360-degree view of all stakeholders underpinned by the correct data without a common set of data definitions and structures across the involved stakeholders.

Fintraffic’s approach is to open data by default - we want to stream that data in real time to everyone who needs and has access to it. There needs to be, however, be a clear separation between safety-critical data and non-safety-critical data, and capability to handle both without mixing them up.

7 Digital twin

7.1 Definition of digital twin

A digital twin is a virtual representation that serves as the real-time digital counterpart of a physical object or process.

The digital twin concept consists of three distinct parts: the physical product, the digital/virtual product, and connections between the two products. The connections between the physical product and the digital/virtual product is data that flows from the physical product to the digital/virtual product and information that is available from the digital/virtual product to the physical environment.

Characteristics of Digital twin technology include:

- Connectivity
- Homogenization of data
- Reprogrammable and smart
- Digital Traces
- Modularity

Digital twins develop in stages. Below is a picture describing potential maturity levels.

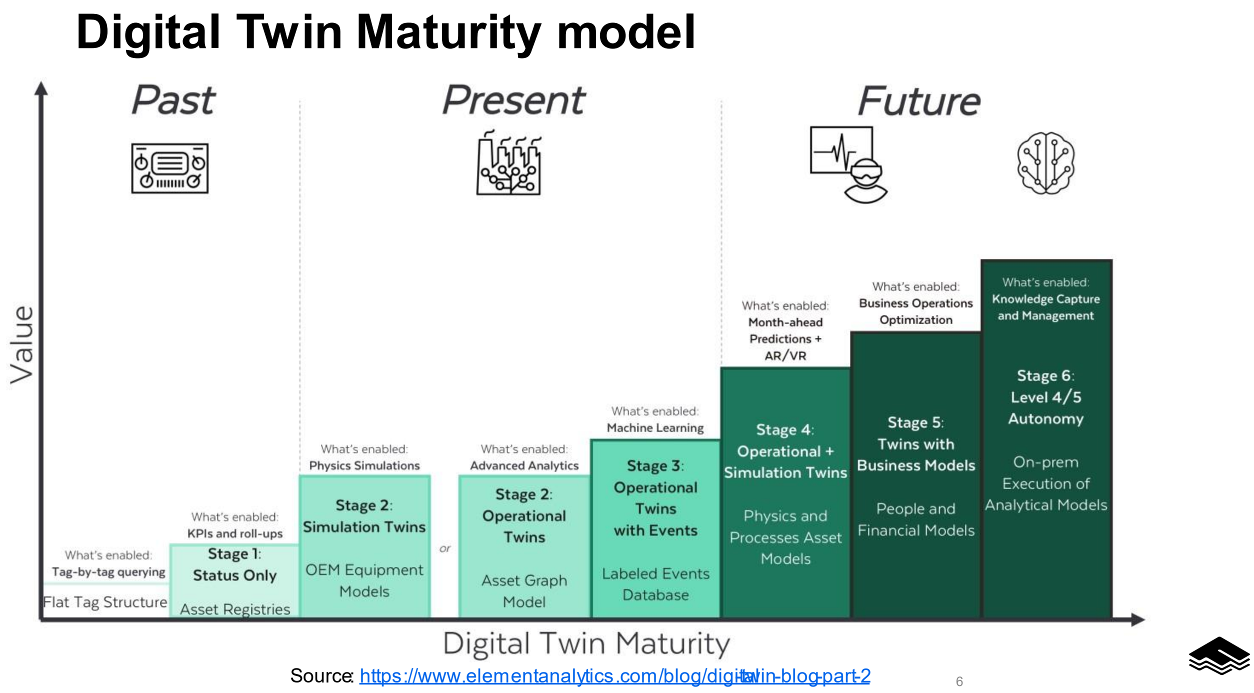


Figure 2. Digital twin maturity model (source: https://www.elementanalytics.com/blog/digital-twin-blog-part-2)

7.1.1 Digital twin development approach

Together with other players (e.g., Väylä), Fintraffic is building a shared digital twin related to traffic management & control, mobility, and logistics. The digital twin provides information on past, present, and future. The build will be a gradual process with the ultimate goal of a multimodal traffic system model.

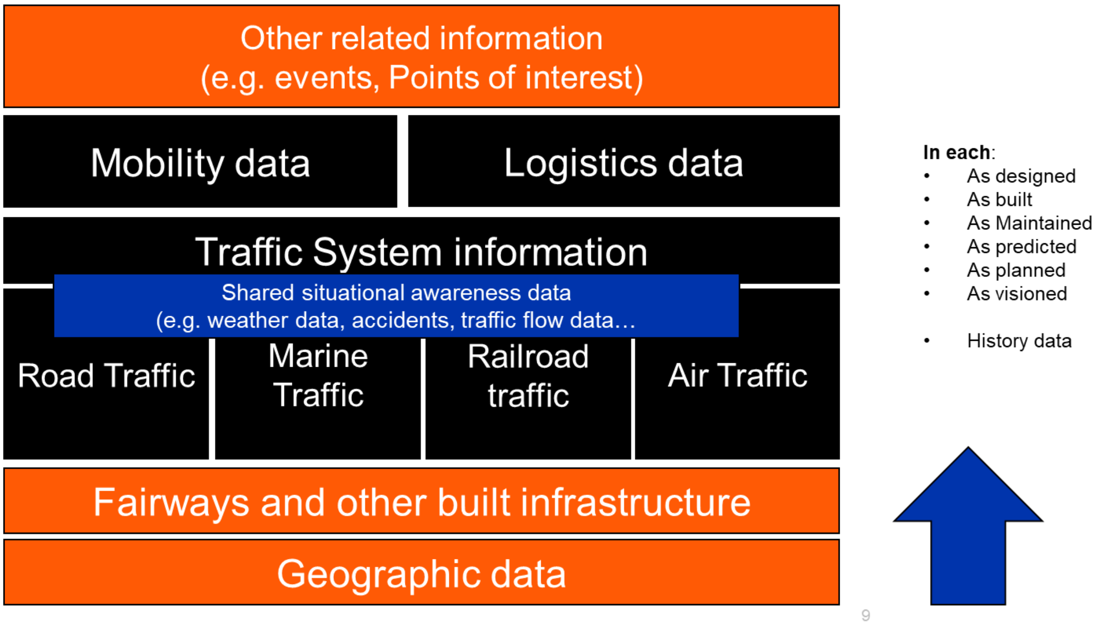


Figure 3. Potential Digital Twin stack.

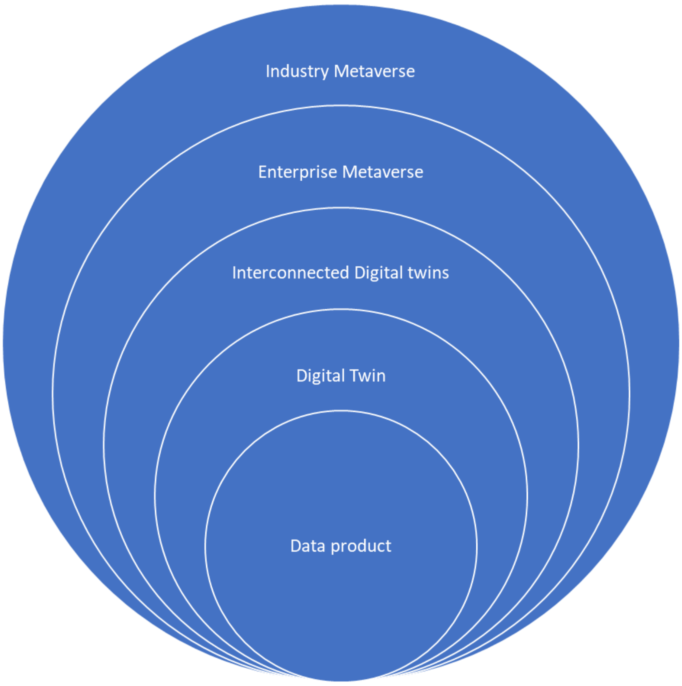
7.1.2 How to build the first digital twin?

Aligning stakeholders on a clear vision of digital twins is a crucial first step. A blueprint should define the types of twins the organization will pursue, the order for building them to maximize value and reusability, the way their capabilities will evolve, and their ownership and governance structures. Without all this, organization build disparate single-use twins with limited engagement by the business and no way to attribute value from use cases back to the twin. The answers to eight key questions can help leaders create this blueprint:
What is the overall vision for digital twins?

- Which digital twins give the greatest leverage and opportunities for reuse?
- What is the total value at stake?
- What are the highest-value, most feasible use cases we should deliver first, and what is the process to attribute value to digital twins?
- What data layers and attributes do we need to collect?
- How will we source and model the data?
- What models will be built on top of the data? What is the end-state architecture?
- How will the project team work together with business users to deliver the digital twin and use cases it supports?

With the blueprint in place, the basic digital twin is to be built. The build phase begins with assembling the core data product. To do so, data teams engineer structured and unstructured data to ensure their quality and usability. This in turn enables the development of visualizations and allows data science professionals to build out one or two initial use cases that generate additional data and insights—and create an early digital twin.

Once the digital twin's initial use cases are up and running, it is time to expand its capabilities by adding more data layers and analytics to support new use cases. At this stage, the twins are advanced from simply representing assets, people, or processes to providing simulations and prescriptions using AI and advanced modelling techniques[1].Organizations can begin the journey by starting with just one digital twin that has a data product at its core, evolving it over time to provide increasingly powerful predictive capabilities. They can then move on to interconnecting multiple digital twins to unlock even more use cases and, finally, layer on the additional technologies required to transform this network of digital twins into the enterprise level or industry level metaverse.



[1] https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/digital-twins-the-foundation-of-the-enterprise-metaverse

8 Processes

Moving from single-modal (focusing on a single mode of transportation, such as cars) to multimodal traffic management (considering multiple modes of transportation, such as cars, buses, bicycles, pedestrians, etc.) introduces a more complex and integrated approach to urban mobility. This shift requires adjustments in various aspects of traffic management processes. Here's how the traffic management processes change when transitioning to multimodal management:

- **Data Integration and Analysis:** Multimodal traffic management involves collecting and integrating data from various sources, including sensors on roads, public transportation systems, pedestrian movement, and more. Advanced data analytics and machine learning techniques can be used to process and interpret this diverse data to gain insights into traffic patterns, congestion, and usage of different modes.
- **Infrastructure Planning and Design:** Urban infrastructure needs to be designed and optimized to accommodate multiple modes of transportation. This might involve creating dedicated lanes or paths for cyclists, pedestrians, and buses, as well as considering the placement of bike-sharing stations, pedestrian crossings, and public transportation stops.
- **Signal Coordination and Timing:** Traffic signal timing and coordination become more complex in a multimodal environment. Systems should be designed to prioritize and optimize the flow of different types of traffic, minimizing wait times and congestion for all modes.
- **Dynamic Routing and Navigation:** Multimodal systems require navigation tools that can suggest routes considering various transportation modes. GPS and navigation apps can provide real-time information about transit options, traffic conditions, and alternative routes for different modes.
- **Public Transportation Integration:** Efficient multimodal traffic management involves seamless integration of public transportation services (buses, trains, trams, etc.) with other modes. This includes designing transfer points that minimize waiting times, providing accurate real-time information, and coordinating schedules to reduce intermodal transfer difficulties.
- **User Information and Engagement:** For successful multimodal management, users need accurate and accessible information about various transportation options. Mobile apps and digital platforms can provide users with real-time updates, trip planning, and even options for booking and paying for different modes of transport.
- **Policy and Regulation Changes:** Transitioning to multimodal traffic management often requires changes in regulations and policies. These changes can involve implementing policies to promote non-motorized modes (cycling, walking), creating incentives for using public transportation, and introducing measures to discourage single-occupancy vehicles.

- **Emergency Management:** Multimodal systems also need to consider emergency response and management for various modes of transportation. This includes having plans in place for accidents involving pedestrians, cyclists, buses, and other transportation modes.
- **Sustainability and Environmental Considerations:** Multimodal management can be more environmentally sustainable by reducing the overall carbon footprint of transportation. Prioritizing low-emission modes and providing infrastructure for electric vehicles and charging stations can be part of this effort.
- **Stakeholder Collaboration:** Multimodal management often requires collaboration among various stakeholders, including government agencies, public transportation operators, private transportation providers, and urban planners.

In essence, transitioning from single-modal to multimodal traffic management is a holistic approach that involves technological advancements, policy changes, infrastructure upgrades, and a shift in the way urban mobility is perceived and managed. It aims to create a more efficient, sustainable, and user-friendly transportation system that caters to the diverse needs of a modern city's population.

9 Architecture

9.1 Architecture Design Principles

The proposed architecture is built to support multimodal traffic management and control as well as aggregation, management and delivery of mobility, logistics and situational awareness data.

The proposed key principles include:

- The architecture will be **based on open, standard technologies and interfaces**
- The architecture needs to **scalable** to meet increased data volumes and needs.
- The architecture shall **support all modes of traffic** and also mobility and logistics services.
- **Modular and built for change:** If possible, the architecture is based on microservices to support inevitable changes.
- **Driving collaboration and multimodality with modern technology architecture.** The solution should support collaboration beyond organization boundaries and traffic modalities by nature.
- **Ensuring, enabling, and empowering cross-organization success with microservices.** The solution should be built for change and reuse, thus microservice approach is preferred.

10 Physical environment

The physical work environment should support efficient work in collaborative mode. This chapter illustrates some of our thoughts on how the physical environment in traffic control centres should evolve over time.

Figure 4. Control centre workspaces. *The workspaces of the control centre are bright and comfortable. Everyone has their own safe place to adjust to the work task before moving to the control room. (Source: Fintraffic Railway's Traffic Control Center vision for 2030)*

Figure 5. Change in shift. The team of the new shift opens a connection with the person of the team leaving the shift and the members of the fresh team move to the control room. The teams briefly exchange affiliations, and the terminals are activated for the new team. The workstations adapt to predefined personal ergonomic work positions (Source: Fintraffic Railway's Traffic Control Center vision for 2030)

Figure 6. Control room. The atmosphere in the control room is harmonious and supports concentration on work. With the large transfer walls in the space, it is possible to divide the space into areas of different sizes and thus calm the space into smaller parts in different situations and for different configurations. In addition to dividing the space, transfer walls aim to reduce the transmission of sound in the space, but in addition to space solutions,

work tools and operating methods should take into account how extra noise can be controlled. The open space and raised technical floor allow flexibility for rearranging workstations, wireless should be prioritized whenever possible. Team and conference rooms and telephone booths are in the immediate vicinity of the control room and thus easily accessible in various situations and meeting needs. Support activities are located in a nearby multifunctional space that is supported by freer movement, and the control room itself is dedicated to work that requires concentration. Other work, hanging out and visits are handled in nearby multipurpose facilities, and only certain people have access to the control room. Visits by outsiders (e.g., maintenance) are not organized in the control room or meetings. The control centre must have its own quiet space open to the control room, this aims to improve communication and working together with other traffic management.

(Source: Fintraffic Railway's Traffic Control Center vision for 2030)

11 Business case and business models

There are several business models that can be applied to a multi-modal platform involving data and respective services based on AI and automation.

Data as a product: This model involves monetizing access to data. For example, any data that is specifically generated or derived within the platform could be monetized for businesses or other stakeholders (e.g., punctuality data could be valuable for airlines or train operators).

Data as a service: This model involves providing data-driven services to businesses or organizations. For example, AI-powered predictive data that is derived by the system could be sold to traffic-related businesses that want to improve their decision-making or service quality.

Information as a service (AI-enabled): This model involves using AI to create new products or services. For example, data from the system could be provided to enable traffic-related businesses to provide AI-powered chatbots for providing better customer service 24/7.

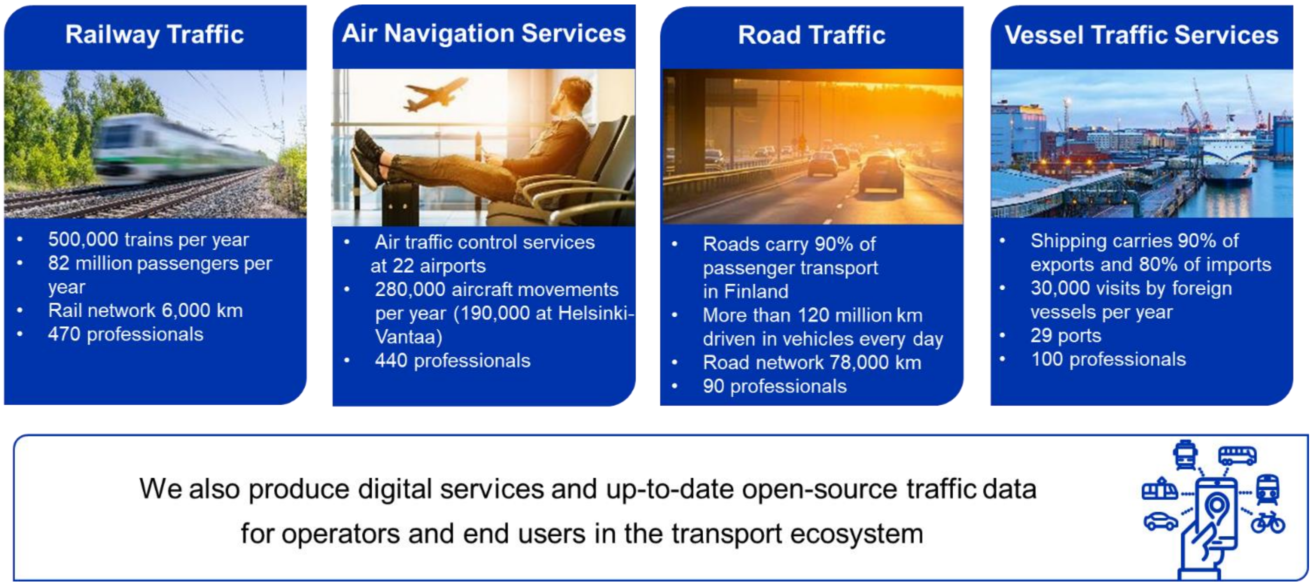
Platform as a product: This model involves creating platforms that allow businesses to share and collaborate on data. As the generation of a platform and digital twin is a target of the vision for multi-modal traffic management and control, the technology itself could be marketed and offered to other stakeholders targeting to implement similar systems.

Platform as a service: Extending on the model above, the platform can also be operated as a service for other businesses or government agencies.

It should a target of a traffic management & control provider to make data available to its stakeholders with as little barriers as possible. To enable the development, creation and maintenance of the data platform and respective digital twin, the business models above should however be deeper explored.

12 Multimodal Traffic Management in Action – Case Fintraffic

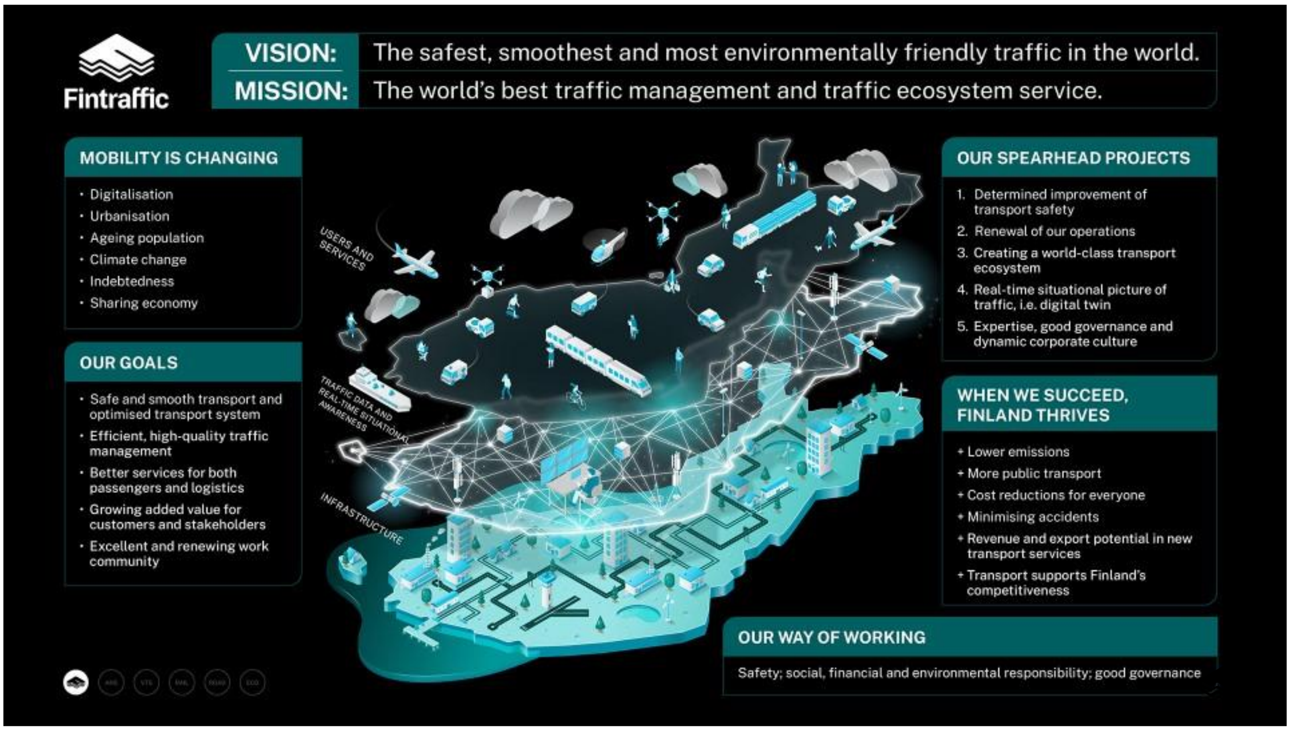
The purpose of Fintraffic is to ensure safe, smooth, and environmentally friendly mobility in Finland – by road, rail, air, and water. We ensure that pilots are cleared to land, that drivers are informed of disruptions on the road ahead, that rail passengers know that their train will arrive on platform three and that the captain of an oil tanker will know to avoid an impending collision. We are proud of our role in making Finland work by controlling traffic on land, at sea and in the air.



Our most important asset is real-time data. We know the status of the traffic system at any given time and are aware of what is happening in traffic. We want to ensure that all this data is efficiently leveraged and that all operators in the sector can have real-time access to the situational awareness that we produce.

However, we have more ambitious goals than that: we want to be able to anticipate what will happen in traffic and what will be the consequences of any particular incident occurring. By operating smartly, we can prevent accidents, reduce travel times, and streamline transfers from one mode of traffic to another. Similarly, we can accelerate the emergence of new door-to-door passenger services, reduce traffic emissions, and save taxpayer money. In the world we envision, the same rails can carry more trains, unmanned aircraft can fly safely, traffic lights are able to prevent congestion from forming, and trucks and ships can automatically regulate their speed to the most economical setting. Passenger rides can be automatically pooled in cities and in rural areas, and cargo from an inland factory to an overseas client can be carried affordably and efficiently. Trips and logistics chains involving multiple modes of traffic are provided with seamless transitions.

All this is quite possible but requires two things to make it happen. Firstly, Finland must build a new digital layer over the existing physical transport infrastructure to provide a real-time situational awareness of the entire transport system and the services therein. Secondly, Finland needs digital traffic regulations that govern how each individual operator can share data and build services that are 100% compatible with everything else. With this, we can create a Finnish network of traffic operators making the most effective use of data, a network unique in the world. This network will be a traffic ecosystem where everyone shares the same goals and common interests are everyone's interests. We want to be the coordinator in making this happen.



We have a unique opportunity. With this, Finland would be the only country in the world to bring all modes of traffic under one umbrella. This would give us an exceptional advantage that we could then leverage. We now have the opportunity to make Finland a showcase of smart traffic and logistics, besides creating new jobs, new services, and competitiveness. To make this come true, we need the input of every Fintraffic professional at all hours of the day, for the benefit of all of Finland.

Appendixes

About Fintraffic

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For more information, please visit https://www.fintraffic.fi/en/fintraffic

About Frequentis

The Austrian company Frequentis, headquartered in Vienna, is a global supplier of communication and information systems for control centres with safety-critical tasks. Such 'control centre solutions' are developed and marketed by Frequentis in the business sectors Air Traffic Management (civil and military air traffic control, air defence) and Public Safety & Transport (police, fire brigade, ambulance services, coastguards, port authorities, railways).

Frequentis develops and optimises systems for customers in safety-critical areas of the global mega-markets for transport and safety infrastructure – wherever efficient and flexible high-performance solutions are required. Increasing mobility, digitalisation, and rising safety and security requirements are driving long-term growth. Modern technologies are used to optimise control centres for traffic and public safety.

As a global player, Frequentis operates a worldwide network of branches, subsidiaries, and local representatives in more than 50 countries. Products and solutions from Frequentis can be found in over 45,000 operator working positions and in approximately 150 countries. Founded in 1947, Frequentis considers itself to be the global market leader in voice communication systems for air traffic control with a market share of around 30%. In addition, the Frequentis Group's AIM (aeronautical information management) and AMHS (aeronautical message handling) systems, as well as GSM-R dispatcher working positions for Public Transport are industry leading solutions.

More than 75% of employees have an educational and industry experience in science, technology, engineering and mathematics (STEM) competencies, which are essential to the further growth of the company.

Innovation is very important to Frequentis. The company is proud to be an innovation leader providing sustainable innovations and solutions to extend the market it addresses. The basis for this is interdisciplinary collaboration, which leverages the domain-specific know-how of the segments and the specialist expertise of the central support and governance functions. These activities are managed by the New Business Development department. The present focus is on the ongoing development of the digital (remote) tower technology, drone management, and the use of the 5G/LTE mobile communication standard in safety-critical applications. In addition to digital (remote) towers, which have already been used for a number of years, the realisation of this strategy includes the rollout in Norway of the first national drone management system and the investment in Nemergent, a Spanish software company operating in the field of mission-critical services.

For more information, please visit https://www.frequentis.com/