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REVISION HISTORY

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QUALITY CONTROL

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DISCLAIMER

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List of Acronyms

Abbreviation/acronym	Description
5G	Fifth-generation technology standard for broadband cellular networks
AET	Autonomous Electric Transport
AEV	Autonomous Electric Vehicle
AI	Artificial Intelligence
BAPLIE	Bay Plan Including Empties
CDP	Customer Data Platform
CEF	Connecting Europe Facility
CO2e	CO2 equivalent
COARRI	Container discharge/loading report message
CODECO	Container gate-in/gate-out message
COREOR	Container release order message
CPU	Certified Pickup
CUSCAR	Customs Cargo Message
DCSA	Digital Container Shipping Association
DTLF	Digital Transport and Logistics Forum
EAP	Electrification & Automation Planner
eCMR	Electronic consignment note following certain standards
EDI	Electronic Data Interchange
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
EFTI	Electronic Freight Transport Information
EGNOS	European Geostationary Navigation Overlay Service
ETA	Expected Time of Arrival
EU	European Union
FENIX	Future business models for the Efficient recovery of Natural and Industrial secondary resources in Extended supply chains contexts
GHG	Greenhouse gases
GLEC	Global Logistics Emission Council
H2020	Horizon 2020
ICE	Institute of Civil Engineers
IMO	International Maritime Organization
IoT	Internet-of-Things
ISO	International Organisation for Standardisation
LSP	Logistics Service Provider
MOS	Motorways of the Seas
MPA	Marine Protected Area
NLP	Natural Language Processing
NSR	New Silk Route
ODD	Operational Design Domain
PI	Physical Internet
PLANET	Progress towards Federated Logistics through the Integration of TENT-T into A Global Trade Network
PIONEERS	Portable Innovation Open Network for Efficiency and Emissions Reduction Solutions
PPE	Personal Protective Equipment
SAE	Society of Automotive Engineers
SME	Small and medium enterprise
STM	Sea Traffic Management
SYNGRO-NET	Synchro-modal Supply Chain Eco-Net
TEN-T	Trans-European Transport Network
TMS	Transport Management System
UNECE	United Nations Economic Commission for Europe

Executive Summary

This deliverable describes the ePIcenter Physical Internet Open Vision. It is the result of work done for task 1.4 of the project.

This is a public document explaining the overall ePIcenter vision on how the ePIcenter consortium expects an ePIGEN (Enhanced Physical Internet enabled Global-European Network) of the future to operate, and describes the contribution of the project in terms of the innovations we will be working on in the different demonstrators.

The vision presented in this document is based on the work that was done so far in work packages 1, 2, 3, and 4 of the project and the initial descriptions of the different demonstrators. It incorporates input from most partners. Therefore, the document contains many extracts from other previously published articles, which have been edited and collated, within ePIcenter,

The different innovations within ePIcenter are described at a high level, which includes:

- A **data sharing layer** to share data between supply chain stakeholders in a safe, secure and trusted environment.
- A **visibility** solution combining the data to provide insights into various aspects such as carbon footprint monitoring, cargo status, exception handling, freight cost monitoring, etc.
- **Synchromodal Logistics Algorithms** which will address a wide range of optimisation and planning problems.
- **Modular containers**, providing a possible solution for container imbalances for 20’ and 40’ containers.
- **Autonomous Electric Vehicles**, with the electric pod providing a green, driverless alternative to be used on the transport network.
- **Hyperloop**, similarly providing a fast, safe and green option for transport.
- A **Freight Network Configuration Comparator**, addressing the problem of understanding the impact of new technologies, new operating procedures, and new infrastructure on the freight flows.
- And finally, **Environmentally Friendly Ship Routing & Propulsion**, developing new ship routing and propulsion optimisation algorithms which reduce fuel usage (and therefore GHG emissions), while also reducing the impact of shipping on cetaceans. As well as routing algorithms that can be used in difficult ice scenario’s, such as the Arctic region, increasing safety and reducing the risk of environmental damage.

It is clear that the scope of the ePIcenter project is very broad, covering many different innovations. To give a view of what the future could look like, making use of these new technologies, we tell two stories showing our vision in practice. One focussing on transatlantic trade between Europe and Canada, while another looks at trade between China and Europe, and beyond.

Next, the scope is defined for the different innovations, describing what the plans are within the project. ePIcenter groups it’s practical use cases, applying the new technologies, into 3 demonstrators:

1. **ePI-Link**: considering a network spanning different continents. The demonstrator on the physical-, logistics- and data links in the network.
2. **ePI-Node**: aimed at understanding how new concepts in transportation solutions have an impact on the efficiency and throughput of major nodes in the supply chain. This demonstrator will include the AEV, Connectainer and Hyperloop components.
3. **Arctic**: focusing on how the new fuel minimisation and ice routing algorithms can cope with one of the most challenging regions: the Arctic.

The different innovations are expected to have beneficial impacts, environmental, societal and economic. As well as resulting in an increased understanding of potential uses and future innovation potential.

This document is strongly related to D1.10 ePIcenter Project Success Criteria, which provides confidential information about the ePIcenter innovations that are intended to be shared by the consortium only. Initially it was assumed that D1.8 and D1.10 would form a single deliverable, with public and confidential sections, but this was changed during the Grant Agreement process to split these sections into two separate documents.

1 Introduction

1.1 Objective of this deliverable

The objectives of deliverable 1.8 are:

- To explain the overall ePIcenter vision
- To give an overview of the work being done within the ePIcenter project, and how it will help towards that vision.

It will describe how the Node of the future ("ePI-Node") and the Link of the future ("ePI-Link") will operate and form the overall Enhanced Physical Internet-enabled Global-European Network ("ePIGEN").

The ePI-Link demonstrator will set contemplate freight operations spanning three continents (Europe, Asia, and North America) focussing on the physical, logistics and data links in the network. It aims at assessing the impact of major data visibility as well as on shifting cargo from ocean and air to long distance rail, and synchromodal logistics planning.

The "ePI-Node" demonstrator aims at understanding how new concepts in transportation solutions, in combination with new strategies to organize freight flows in major ports, have an impact on the efficiency and throughput of major nodes in the supply chain, and the knock-on effect on global freight transport.

The ePIGEN description will include:

- scope & main innovations
- high level approach
- expected benefits & impacts

Through storytelling of future scenarios, we will give examples of how the ePIcenter project sees the future, and how the different concepts and solutions come to getter to create more efficient, resilient and greener transport.

The position of European and International governmental organisations as well as industry and public interest stakeholders is represented.

The stakeholder-specific and overall functional, technical, security and design requirements to achieve the ePIcenter vision are explained, considering practical implementation constraints identified in T1.3 from a survey of user partners and industry associations. Input from stakeholder roundtable sessions with external stakeholders has also been very important. Requirements are driven by process models and collaborative business models that benefit all parties while protecting commercially sensitive information.

In preparation of this deliverable, as well as deliverables D1.10 and D4.1 (amongst others), templates were created which were used by the different case leaders of the demonstrators to describe the case they will be working on within the ePIcenter project. These completed "use case documents" were used as input and inspirations to describe the project vision, success criteria and KPI's. Additional input was gathered from other deliverables that have been completed so far in work packages 1, 2 and 3. On top of that, additional checks were done with various ePIcenter project partners on the content in this document that is relevant to them.

This document was originally envisaged to be integrated with the Deliverable D1.10 "ePIcenter Project Success Criteria" which is also due at month 24. However, during the preparation of the Grant Agreement, it was noted that this integrated document would have had public material (the overall vision of the project) and confidential material (e.g., details about the specific innovations and technical characteristics/designs), so it was split into two separate deliverables.

Therefore, this deliverable (D1.8) should be considered as complementary to D1.10. It is not intended to include detailed descriptions of the work undertaken in WP2 and WP3 but highlights the main innovations leading towards that vision. In summary:

- D1.8 “ePIGEN Physical Internet Open VISION”: a public document explaining the overall ePIcenter vision and the component innovations
- D1.10 “ePIcenter Project Success Criteria”: this document, which highlights further technical details about the innovations and aims for the project.
- D2.1-D2.5 and D3.1-D3.6: detailed description of the ePIcenter innovations.

1.2 Necessity of the project

The industry and economy have been reshaped these last two decades by advancing technologies (for example Artificial intelligence, Internet of Things, Blockchain, Autonomous vehicles), new business models and dramatic shift in customer behaviour. This so-called Industry 4.0 is creating a giant leap forward driven by digitalisation, data sharing and adopting new technologies to streamline operations and processes.

These changes have consequences for the logistics sector. Logistics companies have followed a conservative approach towards sharing information and adopting new technologies. They need to accelerate to keep up with the industry and close the gap. Here lies the main challenge as the supply chain is very interconnected, it cannot happen in isolation. You need buy in from all parties in the logistic chain to obtain optimal results. Therefore, advancement need to be at industry level, not just within the organisation. The logistic industry needs to focus towards the same goal of interoperability and building an ecosystem. The solutions we investigate in the ePIcenter project are driving this change.

The past couple of years of disruptions, global (trade) conflicts, natural disasters, resource shortages or other unpredictable events have shown that supply chains need to be agile and resilient.

The Covid crisis showed the critical role of supply chains to keep goods moving around the world, the need to ensure business continuity and improve the resilience of critical supply lanes – this created the base for one of the ePI-link cases. **Digitalisation** is important to obtain this. Not the technology but the capability to change fast, embrace increased collaboration to share information to obtain business continuity. Being on the outside (still paper based) is a strong disadvantage.

Another feature of global logistics is technology change. **Autonomous Electric Vehicles** and **Hyperloop** are just two examples, and these innovations are being considered in ePIcenter. The concept here is to develop an approach and simulation/optimisation toolset that enables a deeper understanding of the impact of these technologies on freight operations, and furthermore how best to deploy such technologies if and when they become commercially viable. ePIcenter focuses on AEVs and Hyperloop as examples, but the concept is broader: a toolset that can be used to model many different types of new technology and logistics processes.

Besides the innovativeness of technology and software, new logistic concepts will drive supply chain changes in the near future. As part of the ePIcenter project, we investigate **Synchromodality**, where there is no fixed routing or transport mode to move goods. Cargo is transported in the most optimal combination between cost, speed, and sustainability. Besides end-to-end visibility, information on the possible transport modes, a complex transport planning is mandatory to drive this, as the routing and transport mode can change during the transport. In the ePIcenter project we look at potentials in **new trade routes** like the new Silk Route between China and Europe and the Arctic North-East Route. Synchromodality is crucial for the roll out of the **Physical Internet**. This is the ultimate innovation target for the logistics sector. The EU designed a roadmap with different steps to achieve the Physical Internet. Several different aspects we investigate in the ePIcenter project will support this.

Another part of achieving the Physical Internet is the integration of standards. Maritime containers are the best example of a standardised worldwide transport mode. Their presence supported the exponential grow of volume in maritime transport. Although the standards are not optimal, every shipping line has their own set of containers and exchange amongst the different lines is not usual, mainly due to commercial and brand issues. In addition, two different sizes of containers are mainly used that are not interoperable. Both factors are causing imbalance in the logistics process with a negative impact on the economy and environment. Re-use of the container is a lot of times not possible, therefore many empty containers are being “re-positioned”. **Connectainer**, a new technology in the ePIcenter project, is addressing this by using modular containers that can be adjusted to the needs of the client, adapted to their type of merchandise.

Stronger government regulations for sustainability have created a need for **environment-friendly solutions** in supply chains. Infrastructure, assets of transport nodes and networks are facing their limits in spatial (e.g., capacity), societal (e.g., liveability) and environmental (e.g., emissions) terms, yet in regard of a more efficient use of space, infrastructure, and assets (human recourses, equipment…). Opportunities like digitalisation, data sharing, Synchromodality and new technologies investigated in the ePIcenter project will support the efficient use of existing resources and greener alternatives. For example, innovative **AI-based fuel minimisation algorithms**, combined with **ship routing algorithms** are considered which not only reduce costs and energy usage, but also attempt to avoid marine animals such as whales. The concept here is how to develop win-win algorithms and strategies which benefit all stakeholders, including even non-human “stakeholders”.

The ePIcenter project has a strong link with EU initiatives and regulations. Deliverable D1.1 and D1.9 describe the Single Maritime Window, the eFTI regulation, the DTLF initiative, but also the strong focus with Connecting Europe Facility (CEF) and the Motorways of the Seas (MoS). The project will focus on digitalisation (and the role of seaports as pivotal nodes in this network), and on the development of a sustainable, seamless and smart European Maritime Space through the improved adoption of digital tools throughout the industry. For example through the digitalisation of trade lanes, interoperable data sharing, and Sea Traffic Management (STM).

2 The ePIcenter Vision

ePIcenter has the ambition to become the most relevant cloud-based toolset for user-friendly extensible Artificial Intelligence-based (AI) logistics software. Enabling all players in global trade and international authorities, to co-operate with ports, logistics companies and shippers and to react in an agile way to volatile political and market changes and to major climate shifts impacting traditional freight routes.

The project wants to achieve solutions which reduce environmental impact while also reducing costs in the supply chain.

ePIcenter thus addresses MG-2-9-2019 of H2020 Mobility for Growth "InCo Flagship on Integrated multimodal, low emission freight transport systems and logistics", particularly in what refers to new logistics concepts, new disruptive technologies, new trade routes (including arctic routes and new Silk routes) and multimodal transfer zones. ePIcenter will speed up the path to a Physical Internet and will benefit peripheral regions and landlocked developing countries.

- The ever-increasing expectation of 21st century consumers for cheaper and more readily available goods puts enormous pressure on infrastructure, logistics providers and on the Earth itself.
- New trade routes such as the New Silk Road are changing the pattern of freight movements, so Europe requires a strong logistics network to cope with the demand of these new routes and trade flows.
- Disruptive technologies (e.g., Hyperloop, autonomous/robotic systems, innovative modularization, blockchain, digitalisation, single windows, EGNOS, Copernicus) are exciting if properly used and integrated.
- Environmental and political macro effects create imbalance, uncertainty & nervousness in the supply chain.
- Sustainability and quality of life issues have never been more prominent: environmental impact, congestion, health, social equality, and work-life balance must all be considered in future strategies.

ePIcenter will accelerate progress towards an Enhanced Physical Internet enabled Global-European Network. i.e., efficient integration of the infrastructure or "hard" TEN-T network with global networks, and seamless integration in the "soft" layer: secure international information flows and digitalisation, combined with ethical algorithms for environmentally friendly logistics and seamless freight movements.

The objective is to demonstrate that ePIcenter drives deeper understanding and increased exploitation of emerging paradigms and technologies, creating a European logistics answer by improving coordination of freight flows through seamless connectivity. This will accelerate progress to an Enhanced Physical Internet enabled Global European Network, optimising transport nodes & links to global networks and including disadvantaged regions in the international supply chain.

Global events of the past two or three years have emphasised the importance of flexibility and responsiveness, while climate change and pollution continue to be an important challenge.

The flow of goods and commodities within Europe (on the TEN-T network) and entering and leaving Europe via shipping and rail corridors such as the new Silk Road routes, has been subject to rapid and unpredictable change. Concurrent problems such as congestion in ports, container imbalance and personnel shortages have added to the challenges faced by logistics companies and shippers.

In this example, we illustrate how ePIcenter's vision for the ePIGEN would help mitigate and react efficiently to these drastic changes and important challenges, while at the same time reducing environmental impact.

Flexibility and broad scope are a key aspect of ePIcenter. To illustrate the concept, we consider different types of goods:

- High-tech, high value goods such as electronics, for which there are of course major flows between Europe and Southeast Asia for example, and for which the new Silk Road routes are of great relevance.

- Speciality chemicals and biofuels, which are moved in bulk ships and ISO tanks, and for which there are complex operational and safety rules.
- Beverages supply chain such as beers, wines, and spirits, for which there are major production facilities in Europe and large import/export operations.
- Transport of temperature-sensitive goods transported by refrigerated containers.

At the planning stage, the emphasis is on developing green, robust synchromodal strategies. The manufacturer may for example be shipping goods to and from multiple destinations in Southeast Asia and Europe. Possibly, they have opened a new production facility or product range, or maybe they wish to strategically optimise their supply chain.

The rail connections along the New Silk Road are of interest due to their speed but may not be appropriate for all product types. Ocean routes of course are used extensively. In some cases, the product type may determine the mode, but for many cases, there is a choice. Furthermore, there are potentially many different entry/exit points in Europe for ocean and rail movements, and within Europe the plethora of connections and services available on the TEN-T network makes it very hard to select the best option. With an eye on the future, the potential use of Hyperloop for certain types of freight (e.g., high tech), and possibly other new modes, adds to the available options in the network.

Of course, nearly all modes and routes have experienced disruption in recent years, due to events like the terrible war in Ukraine and Covid, as well as perhaps smaller (but still very significant) events such as the recent blockage of the Suez Canal.

Therefore, a synchromodal strategy may offer a good option: optimised choice of a mix of modes based on expected volumes and lead times, assuming a degree of flexibility to dynamically re-route, which de-risks the overall operation.

The ePIcenter algorithms optimise the planned flow of freight through the TEN-T network, integrated with the choice of international ocean and rail routes and corresponding European entry/exit points. A key aspect of the vision for ePIGEN is this capability to model large, complex flows, giving the planner a more sophisticated and nuanced perspective that encompasses environmental impact and sustainability, as well as lead times and costs.

At the operational level the ePIGEN operates with a high degree of physical and informational automation. Taking as an example a major inland logistics hub in Europe with sends and receives goods to/from Southeast Asia:

- The **ePIGEN** will include diverse ePI-Links, offering many possible paths to bring the freight to the inland terminal:
  - Ocean container vessel to a major port, followed by autonomous e-barge movements to the terminal (see e.g., the PIONEERS project);
  - Ocean container vessel to a major transhipment hub, followed by feeder/coastal services to regional ports, followed by last-mile e-truck or rail connections.
  - Rail freight via the New Silk Road, with Autonomous Electric Vehicles shuttling containers over the last-mile connection to/from the hub.
  - Bulk shipping to a major port, followed by ISO tank intermodal movements via barge, truck and rail to final destination.
  - Many other combinations of ocean, inland waterway, rail, Hyperloop, and truck are envisaged.
- **Visibility** of inbound movements and status updates are made available to relevant stakeholders (terminal, depot, shipper, transport operators, authorities) via automated secure data sharing platforms, with information enhanced by visibility tools and AI-based solutions. Automated logistics planning systems receive continuous updates, while dashboards and exception monitoring tools keep planners and managers informed.
- **Synchromodal algorithms** automatically react to variations in the ePIGEN, for example, dynamically switching between modes/services depending on the updated ETAs and urgency of the freight.
- **Autonomous Electric Vehicles** move the inbound (modular) containers to the correct warehouse or unloading point in the ePI-Node.

- It is expected that the ePI-Node of the future will be supported by robotic handling technologies that are being developed in complementary research and innovation actions to unload and load freight.
- **Hyperloop** may be used as transport for larger ePI-Nodes and industrial areas as a low energy/low emission/low noise/high speed solution.
- **Connectainer Modular Containers** are used to optimise reverse logistics at the ePI-Node. If the inbound freight was high-tech goods, it may well in be 40' containers. Exports of heavier products such as beverages should use 20' containers: the inbound 40' Connectainers are split into 20' containers and taken to the local warehouse (by AEVs) to be loaded and brought back to the freight terminal.
- **Visibility technology** and **synchromodal algorithms** are again used to optimise the export movement, this time from the logistics hub in Europe to the final destination in Asia. Barge/ocean/barge combinations may be scheduled, or for higher priority freight rail/rail connections may be used e.g., via the New Silk Road routes.
- The path of the freight movement is continuously reoptimized in response to changes in the ePIGEN. User-friendly interactions via a **chat-bot** type interface allow changes and exceptions to be managed, prompting the user to select the best overall solution that considers environmental and sustainability factors as well as cost and speed.

The best way of showing how the ePIcenter innovations will affect the future supply chain is by telling a story about two logistic flows (Trans-Atlantic trade and trade from China to Europe and onward). These flows are operational today with their own challenges, bottlenecks, and disruptions. The story will address how the flow can be improved using the ePIcenter technologies, but also including technologies developed in other projects.

2.1 Vision in practice: Trans-Atlantic Trade

Pharmaceutical products are produced on the site of a German pharmaceuticals company. From the production site, they are transported to the logistics area using **Autonomous Electronic Vehicles (AEV's)** (Figure 1). As the goods are temperature sensitive, they are loaded into three reefer containers and prepared for transport. IoT sensors on the containers will be used to monitor the goods throughout the journey. According to the plan, the containers are then loaded unto three electric trucks to transport them to the terminal in the Port of Antwerp.

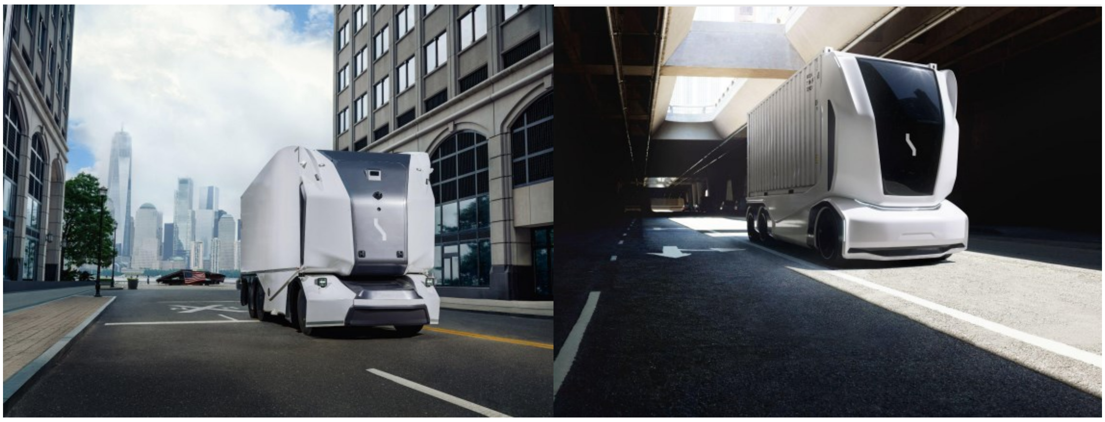

Figure 1. The. Einride AEV Pods (source: Einride)

The destination of the goods lies in Canada. Considering the intended arrival time of the goods, the **Synchromodal Logistics Algorithm** determined the most optimal route (Figure 2). This route, which keeps ecological impact and cost to a minimum, is to use an electric truck to transfer to a barge terminal, by barge to the Port of Antwerp, maritime transport to the Port of Montreal, transport by rail through Canada and using a truck for the last mile.

Figure 2. Green SLA plan for transport (source: MJC²)

Through data sharing between the different stakeholders, visibility is maintained on the location and status of the cargo throughout the journey, which will allow action to be taken if there are any deviations from the plan.

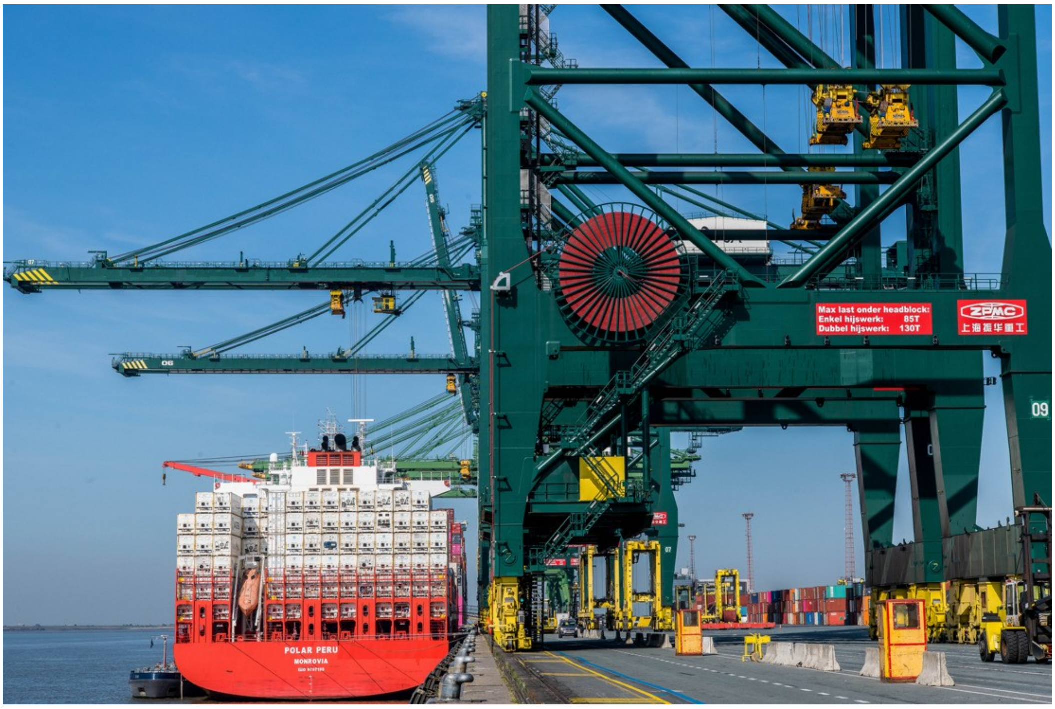

Figure 3. Vessel being loaded at terminal (source: Port of Antwerp)

While the containers are waiting to board the vessel and start the maritime journey, Canadian Authorities indicate that certain cargo is considered critical to them, as there is an epidemic outbreak in the country. When it becomes available, the export manifest is scanned by Belgian authorities using an AI solution, looking for these **critical goods**, and identifies that the pharmaceutical products in the containers are goods that Canada is looking for to fight the epidemic. Canadian authorities are notified of this and receive the container numbers. Extra attention is also paid to terminal events at this point, to ensure that the container is, in fact, loaded onto the vessel (Figure 3).

Meanwhile, another AI solution determines the **optimal propulsion** for the vessel throughout the voyage. Amongst other things, it takes the following factors into account: weather, eco-sensitive or Marine Protected Areas (MPA's) where the vessel needs to slow down, vessel characteristics and the expected arrival time at the Port of Montreal. All this in order to determine the optimal propulsion throughout the voyage, minimizing fuel consumption and thus CO2 output, while arriving at the optimal scheduled time at the port.

Near the end of the journey, the sensors on the container return some temperature fluctuations in one of the containers. An **AI-chatbot** notifies an operator of this. It is decided that the cargo could be lost if the container malfunctions on the onward train journey. With the help of the chatbot, it is decided that the best course of action is to send the container to a depot to take care of the problem and use a truck for the onward journey instead of a train, as this will greatly reduce the chance of the goods being lost.

When arriving at the Port of Montreal, the early availability of data, combined with a dynamically updated synchromodal transport plan, and autonomous handling and shunting systems, means that the dwell-time of the containers containing critical cargo is kept to a minimum and ensuring that the containers that are still continuing by train can continue their journey.

With these measures, using several of the ePIcenter solutions and solutions developed by other funded projects, both by the EU and other countries, it could be assured that the cargo could be transported efficiently while minimizing CO2, as well as helping assure the safety of valuable cargo over the course of the journey.

2.2 Vision in practice: Asia-Europe Trade

A shipment of electronics goods is going from China to Spain. It is loaded onto a **modular 40-foot container**. The **synchromodal logistics algorithm** suggests some possible routes. High urgency freight is routed via the China-Europe rail connections, and onwards through the TEN-T network, making best use of the available capacity. For less urgent items a maritime transport to the Port of Algeciras is chosen as the preferred option

. . For the first mile, an electric truck will take the container to a rail terminal, after which it will travel to the port by train, where it is loaded onto the vessel. From the port of Algeciras, transport by rail is also chosen to transport it out of the port area, after which a **hyperloop** transport will take it to its final destination.

Like before, AI calculates the optimal propulsion for the route for the ship, and data is being shared to achieve E2E visibility between the different stakeholders involved on the transport and appropriate actions can be taken if there are any deviations from the plan.

An unexpected congestion occurs along the route, which causes the vessel to be delayed, and the delay cannot be made up for by adjusting the propulsion plan. The Port of Algeciras and the operators of the onward journey from the port are notified of this, so their planning and schedules can take it into account as well. The synchromodal algorithms automatically update the onwards journey accordingly.

Upon its arrival at port, albeit delayed, , the container continues its onward journey according to the adjusted plan, being transported out of the port area by train. Containers are then emptied, and the cargo continues its journey on pallets by a **Hyperloop** connection, and AEVs complete the journey where appropriate

The empty containers are transported back to a local depot (i.e. minimal repositioning) . As the demand for 20-foot containers in the area is greater than the demand for 40-foot containers, in the depot the **modular container** (Figure 4) is converted into its 20-foot configuration, making two of those available. The unique container identification number is adjusted to reflect the new configuration. The containers might then be re-used full in that configuration for a transport of cargo to an African port, and thence to another location, and so on, using the flexibility to swap between 20’ <-> 40’ to avoid having to be repositioned empty.

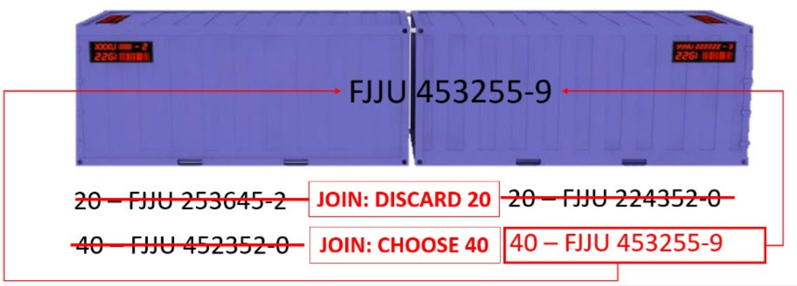

Figure 4. Connectainer- Modular containers (source: ESES)

3 Scope of ePIcenter and the main innovations

To help achieve the vision, ePIcenter is developing many different types of innovation and technology, ranging from new governance models for secure data exchange across borders, to innovative transport technology, to sophisticated algorithms, models, and data processing techniques.

A common theme when designing these innovations is that, while they should of course take a major step beyond current state of the art and should offer significant enhancements to European and global logistics operations, they should integrate and be compatible with existing technologies, infrastructure, systems, and standards as much as possible. This is expected to smooth the path to deployment of these solutions and accelerate the resulting positive impacts.

For example, the solutions are compliant with existing standards such as EDI311 (vessel manifest data); UN/EDIFACT messages such as CUSCAR, COARRI, COREOR and CODECO; X12; the MIF/MID map data standard which is used by industry and open data sources; ISO 1406X standards, IMO FAL Forms and e-Freight, while from a security perspective the proposed solutions are compliant with ISO27001 and this standard would be used to provide assurance about information security to stakeholders.

Furthermore, the consortium is following initiatives such as the Digital Transport and Logistics Forum Expert Group, FENIX, PLANET and PIONEERS, and is building on the successes of previous projects such as eFreight, EUROSKY and SYNCHRO-NET. This helps ensure that ePIcenter achieves the twin goals of providing powerful solutions and innovations, which are useful in their own right but are also compatible and complementary to other innovations and initiatives, as well as with existing state-of-the-art and legacy platforms.

The main innovation areas of ePIcenter are:

- **Trusted Data Sharing Layer** (supported by Governance Models), flexibly supporting interaction modes such as a Hub-and-Spoke, Federated Network and Point-to-Point. In ePIcenter this approach is implemented by NxtPort's innovative 'smart data sharing' platform, although the architecture and corresponding governance approach is consistent with other platforms also, and open standards, open data, open source and open innovation are key architecture principles.
- **Visibility Solution Layer**, providing end-to-end transparency in the logistics process, not by using expensive tracking devices, nor by utilizing a single data source that is prone to errors, but instead consolidating multiple data-sources in a powerful data analytics engine to provide early, accurate and complete data.
- **Synchromodal Logistics Optimisation**, providing powerful new algorithms which can optimise multimodal movements through an ever-increasingly complex network of modes (including future tech such as Hyperloop, AEVs and modular containers), taking advantage of the increased availability of data such as that provided via the Trusted Data Sharing and Visibility Solution layers.
- **Freight Network Impact Configurator**, which provides new tools, methodologies, models, and algorithms to enable deeper understanding the impact of new technologies, new operating procedures and new infrastructure on the freight flows. Examples in ePIcenter will focus on Hyperloop, AEVs and possibly Connectainer also, but the toolset is intended to offer capabilities in other areas as well.
- **Connectainer (Modular Containers)**, a highly innovative technology for shipping containers which addresses the significant and well-documented problem of container imbalance globally. The technology allows a 40' container to be split into 2x20' containers and incorporates an innovative electronic ink display. In other respects, Connectainer is designed to meet existing standards for conventional shipping containers, ensuring interoperability with existing handling equipment and regulations.
- **Autonomous Electric Vehicles ("Pods")**, i.e., an all-electric autonomous Pod, providing Transport as a Service as part of a fleet of vehicles that are coordinated by an intelligent Freight Mobility Platform. The removal of the driver and the driver's cab motivates the safe development of higher levels of autonomy and improves the unit economics of electrification.
- **Hyperloop**, focusing on taking a further step towards possible applications of Hyperloop as a green, low energy and fast transport mode for freight. In ePIcenter lab simulations and analysis will be undertaken

to further understand the potential benefits of Hyperloop, and to develop possible business case scenarios for its use.

- **Environmentally Friendly Ship Routing & Propulsion Algorithms**, which optimise shipping activity in terms of fuel consumption and impact on marine mammals (specifically cetaceans in Arctic waters in ePIcenter although a similar approach may be applicable to many other cases). New algorithms are being developed which optimise the route of a ship through Arctic seas, while fuel minimisation algorithms will attempt to optimise propulsion and energy usage.

These innovative modules will be validated by some of the largest most demanding ports, logistics operators and shippers in the World, and project results will be augmented and enhanced by the presence of leading organisations from North America, South America, and China in the consortium, providing advances in environmental and geo-economic understanding.

As mentioned above, this document Deliverable D1.8 is intended to the ePIcenter vision and how the planned innovations work towards that vision. More details about these innovations will be provided in other Deliverables within the project.

In the following section, the different ePIcenter innovations are highlighted and how they will contribute to the ePIcenter vision

3.1 Trusted Data Sharing Layer

ePIcenter's Technology Agnostic Integration Architecture & Standards Used (please see Deliverable D2.1) are defined based on key principles such as: open standards, open data, open source and open innovation; loose coupling should be followed when integrating solutions; security is a key priority; adherence to the (legal) requirements of data protection (I.e., Privacy/GDPR); data governance which includes ownership, monitoring, high data quality, dedicated mastering, continuous (metadata) improvement, documentation & sharing of documentation around the data, avoidance of data redundancy.

Within the ePIcenter demonstrators, the NxtPort data sharing platform is the preferred platform for sharing data between stakeholders. NxtPort is an innovative 'smart data sharing' platform that contributes to digitize logistics, maritime and industrial processes. Data is crucial to roll out smart logistic processes. The one who has access to the right data at the right time can use this knowledge to improve their operations and reduce waste.

The NxtPort solution makes use of data sharing 'communities' that can provide different features. Through a community platform, different stakeholders can connect and exchange data with each other. A community has a community manager who can decide which assets become available within the community marketplace.

The backbone is designed for scalability by leveraging cloud infrastructure, and a micro services architecture (Figure 5).

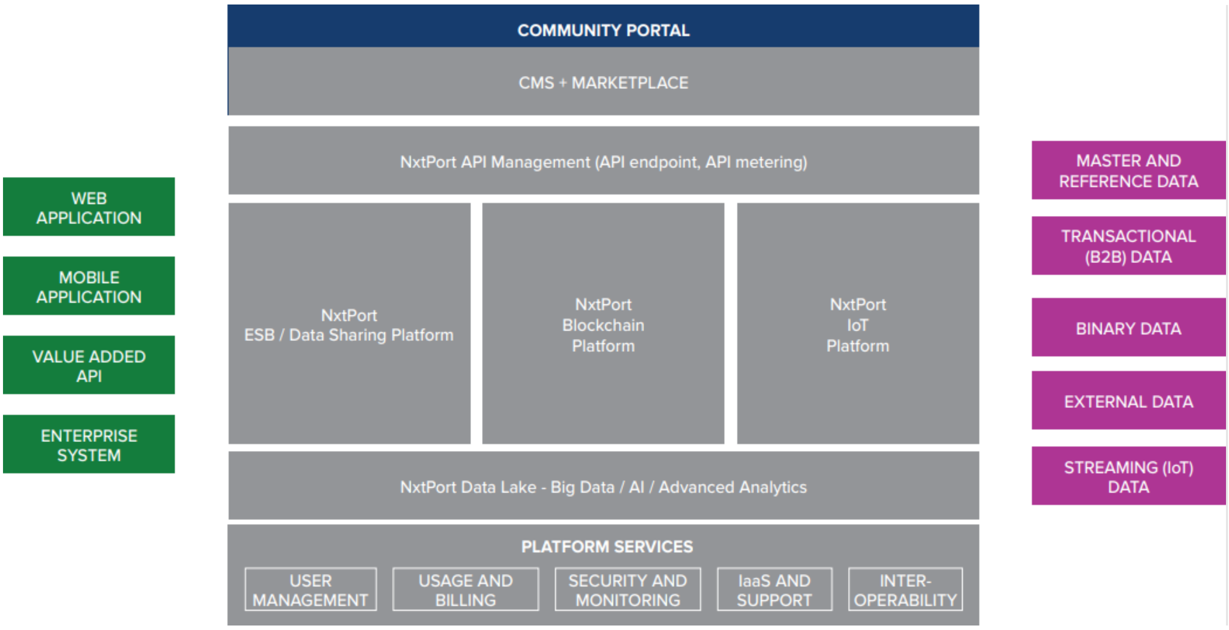

Figure 5. NxtPort Architecture (source: NxtPort)

A major advancement is to facilitate a move from unsecured e-mail (or other point-to-point sharing) towards a secured ledger technology that is also accessible by other stakeholders, would make the exchanges more timely, accurate and secure, as well as allowing other stakeholders to improve service levels by accessing the information.

With respect to timeliness, this allows information to be available to the receiving port much earlier than at present. For example, vessel manifest data is currently only delivered 24 hours prior to berthing – this could be much improved with the ePIcenter approach.

Furthermore, the potential for such data exchange between international ports such as Antwerp and Montreal (which is the intended use case to be considered in WP4) would be a major advancement. For example, Port of Montreal has invested in a sophisticated AI-based solution, which accelerates the handling of critical medical cargo in the port – this could be further enhanced via this new information exchange mechanism. A similar approach could be relevant for urgent transport of humanitarian aid cargo (e.g., relating to the ongoing Ukraine situation or the emergency in Lebanon), as well as for lower (but still high) priority freight such as reefer cargo.

Current practice often involves exchange of strategic and sensitive information via email format (as attachment), with little or no encryption. This is inherently insecure, and due to this low security level and lack of safeguards, critical information otherwise present and necessary in the file is withdrawn. The application of a Controlled Ledger approach enabling digital trust within files are exchanged will maintain and protect the integrity of contents and accelerate transfer.

From a governance perspective, the proposed approach also enables a clear definition of 'hand over'-moments of the responsibility and reading rights of the data.

3.2 Visibility

Data users can make use of visualisation-, optimisation-, simulation- and other solutions to that are used in their processes. These tools may need data both from the data user directly, as well as needing to be able to access data that is shared by data providers.

With reference to the ePIcenter architecture defined in Deliverable D2.1 the Visibility Solution is provided by the Logit-One Visibility Module, which provides end-to-end transparency in the logistics process, not by using expensive tracking devices, nor by utilizing a single data source that is prone to errors, but by consolidating multiple data-sources in a data analytics engine (Figure 6).

Figure 6. Logit One data sources (source: Logit One)

The above-mentioned operational data allows us to deliver additional value in areas like supply chain event management, demurrage & detention monitoring, carbon footprint calculation, business intelligence etc. This presents information to users on two levels:

- Information on individual shipments to support operational decision making (*example*: CO2 footprint);
- Information on periods and collections of shipments to support tactical decision-making (*example*: performance benchmarking).

Examples of requirements addressed by the Visibility Solution include:

- **Carbon footprint monitoring**: Comparing greenhouse gas emissions (GHG) across different modes of transport can be like comparing apples to oranges. That is why the Global Logistics Emissions Council (GLEC) developed the GLEC Framework. The only globally recognized methodology for harmonized calculation and reporting of the logistics GHG footprint across the multi-modal supply chain, designed to inform business decisions and steer efforts to reduce emissions. It is in alignment with the Greenhouse Gas Protocol, the UN-led Global Green Freight Action Plan, and CDP reporting.
- **Exception handling and managed notifications**: Exception management is an effective mechanism in supply chain management. With supply chain visibility, customers can easily know the location of the cargo movement and get full access to information on every factor of the supply chain process, improving process efficiencies. This notification part creates the basis for managing by exception, because there are notifications for all events when they occur or are about to occur. In this way, one can improve planning by taking the right business decisions and mitigate risks across the entire supply chain.
- **Freight cost monitoring**: Several freight costs can only be determined during execution, as it depends on cost factors that are not known beforehand. One of the most obvious examples is demurrage &

detention: The costs charged by an ocean carrier because of a full container staying on a terminal too long (demurrage), and the costs charged by an ocean carrier as a result of the empty container taking too long to return to the ocean carrier (detention).

- **Connectivity**: From user to visibility, for receiving a shipment tracking request, or from visibility module to user, for reporting shipment status. Relevant information includes shipment identification, itinerary, milestones along the itinerary, timestamps for these milestones (planned, expected, actual), carbon footprint, and overall shipment state.

3.3 Synchromodal Logistics

In Task T3.1 a range of synchromodal scheduling, modelling and simulation tools and algorithms are being developed which will address a wide range of optimisation and planning problems/questions. The applications are aimed at industry users (e.g., for operational, tactical, and strategic planning) as well as at researchers and policy makers.

The proposed development and research can be summarised as follows:

Synchromodal Logistics Planning Algorithms and Software

This development will result in operational and strategic planning tools and algorithms that allow shippers, freight forwarders and logistics operators to plan container movements through a multimodal global logistics network. This will be integrated with an experimental chatbot layer to create a prototype "FreightBot" to assess the potential for applying AI chatbot-based technology to complex logistics planning problems.

Multimodal Transfer Zone Optimisation Toolsets

The Multimodal Transfer Zone Optimisation development will focus on applications of these algorithms to the integrated hinterland/terminal operation i.e., optimisation of freight movements in and out of a terminal/port from/to its associated hinterland. This will be enhanced by new models to address modular containers and take a step towards a Physical Internet-type approach in which algorithms are used to automatically allocate freight to transport connections/capacity, while considering some aspects of modularisation.

Optimisation Models for Design of Physical Internet Networks

This work will focus on the research question "*How could Network Design decisions be optimised in the PI context?"* The core of this research is the study of optimization models to design Physical Internet Networks. The research is focused on three types of decisions, namely: a) Locating PI-Hubs, b) Allocating non-Pi-Hub nodes to PI-Hubs, c) Defining the best routes to traverse the network. Linear topologies are considered initially, with a view to applications to fluvial transport and potentially hyperloop in the future.

Innovative tools & models for decision-making in development of international multimodal transport corridors

To ensure an efficient intermodal transport process in the TEN-T corridors and their connections with third countries, there is a need for compatibility of the existing infrastructures, coordination between infrastructure managers and operators and the technological integration of maritime and land terminal information management systems. This innovative model's concepts have the potential to ensure sustainability, flexibility, and cost reduction in the freight transportation sector.

Cargo Flow Modelling

The Cargo Flow modelling tools aim to present the benefits of choosing short sea shipping for cargo transport. The simulator calculates all transport-related and external costs such as accidents, noise, pollutants, climate, infrastructure degradation and congestion. The system for calculating alternative routes takes into account such parameters as: the length of the route; transport time (only taking into account permitted speeds); transport costs (i.e. fuel costs, personnel costs, handling costs), the mass of the load, environmental costs (calculated based on a defined pollutant emission factor). This simulation will be applied to new shipping routes connecting to the Arctic.

3.4 Connectainer (Modular Containers)

Transport by container has become an important part of global transportation and continues to grow. However, because of trade imbalances, the repositioning of empty containers is gaining importance. In 2020, 24% of worldwide container movement consisted of empty containers. 20 percent of those empty units moved are standard 20 foot and 40-foot containers. This inefficiency is known as “container imbalance”.

Modular containers have the potential to provide part of the solution to container imbalance. For a large percentage of trade flows equipment imbalance is based on container size. For instance, when the main container size imported is 20-foot, but 40-foot containers are mainly used for export. For this type of equipment imbalance, modular containers could be used instead of moving empty containers.

Connectainer is a 20’ modular container, capable of joining with any another Connectainer (they do not need to be paired, every Connectainer can be connected with any other Connectainer) to become a fully functional 40' HC (See Figure 7**Error! Reference source not found.**).

Figure 7. Connectainers in 20’ configuration (Source: ESES)

To meet the requirement of unique identification, Connectainer uses electronic ink displays that allow the container number to always be unique and unrepeated (see Figure 8). This unique, non-repeating number is important because of the current configuration of port and customs declarations. This will allow the use of the modular container in international trade without having to change the current administrative and regulatory tasks. Each Connectainer has an internal electronic circuit which will, upon connection, compare the serial numbers that each unit has pre-assigned for 40' feet mode and will show the lower of both. This allows having a unique and unequivocal registration, both for authorities and shipping companies.

Figure 8. Connectainer Unique Identification, 40' (Source: ESES)

Modular containers give the flexibility to adjust to the needs of the client, adapting to their type of merchandise, this means that the containers that previously needed to be repositioned empty now are not. This fact will allow shipping companies to have a lower number of containers traveling empty, so their need to have that greater stock to compensate for the lack of efficiency disappears, that is to say; shipowners can reduce their overall stock. Fewer containers but with a more efficient use that will cover the same demand.

The shipowners are the ones who suffer the most from the empty equipment problem. They are the ones who must provide their customers with the equipment they need for their merchandise, which forces them to move empty equipment from one part of the world to another to get it. The maritime routes with a great imbalance due to the difference between the type of equipment that arrives at its ports and the one that is really needed for its exports, or vice versa, are the optimal ones for the use of modular containers. The shipowners are perfectly aware of the routes in which their imbalance is important, given that their effort, both economic and logistical, is enormous.

3.5 Autonomous Electric Vehicles ("Pods")

Einride's solution is the first electric and autonomous truck, the Pod, providing Transport as a Service as part of a fleet of vehicles that are coordinated by an AI powered software, Einride SAGA (Figure 9), that optimizes the transport network. The solution addresses the main challenges now facing the transport industry:

1. electrification provides a path to decarbonizing freight transport,
2. removal of the driver and the driver's cab motivates the safe development of higher levels of autonomy and improves the unit economics of electrification, and
3. its integration with the SAGA platform that optimizes capacity utilization, flexibility, and energy consumption.

The Pod is the first autonomous, all-electric freight vehicle to operate on a public road in the world, and a ground-breaking design that will change the future of freight. It operates autonomously at SAE level 4, can be controlled remotely via 4G or 5G connection, and is truly cabless, with no space for a driver on board. The cabless design allows for lower weight, better aerodynamics, and with remote oversight, negates the need for a safety driver to be on board. The pod is capable of operating at over 80 km/h.

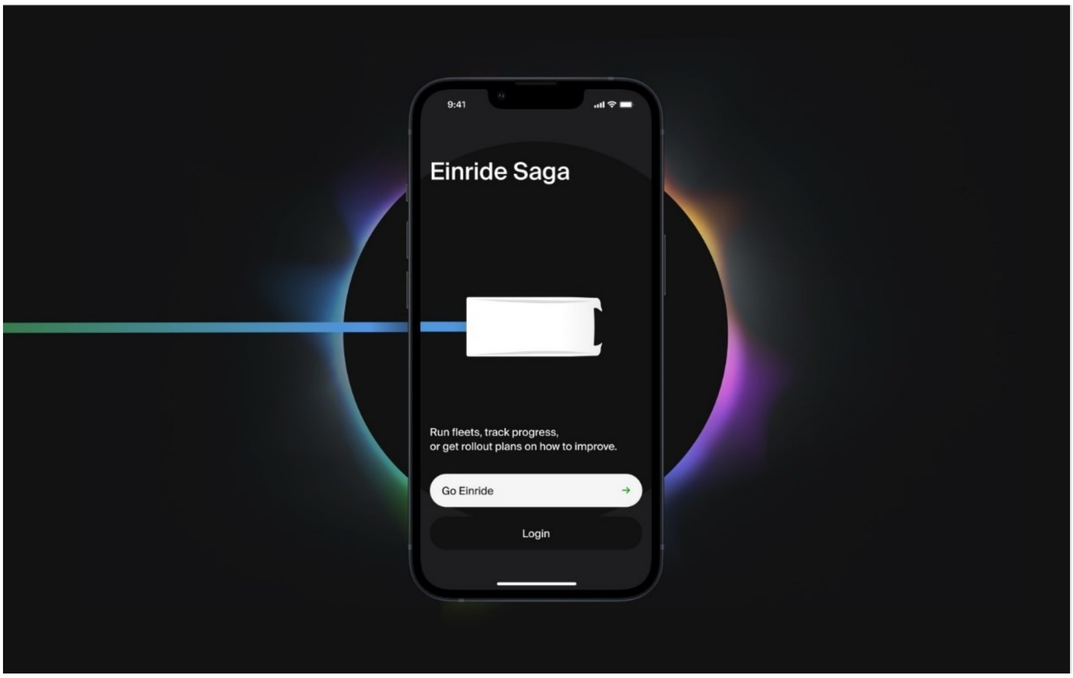

Figure 9. Einride software SAGA (Source: Einride)

In the ePIcenter project, both the Einride Pod and the Einride's software SAGA will be implemented and demonstrated.

Einride's work will support and increase the pace of an introduction of automated and electrified transport in Europe by providing better knowledge on what transport applications a commercial deployment of AET is feasible for now, and during the coming years. Thereby it is expected to contribute to a more efficient and sustainable multimodal freight transport system and logistics by increasing visibility and collaboration, by making the supply chains or logistic processes more transparent through cyber secure data exchange and sharing.

Einride has already developed functionality for strategic analysis of AET as part of its software, SAGA The current functionality is primarily for automated analysis of electrification feasibility. Within ePIcenter, Einride will do work mainly on the automation aspects of AET to improve the functionalities of Saga. The work performed within ePIcenter will support the development of the following specific features:

- Improved modelling and representation of vehicle utilization and transport capacity.
- Development of cost models for automated transport specific features such as automated loading/unloading of trucks and remote operations.
- Automated AET network scoping (what parts of a transport network various versions of pod can operate).
- Exploratory modelling analysis functionality for automated scenarios- and what-if analysis of AET feasibility in future scenarios representing different paths for technological development and external factors (e.g., fuel and energy prices).

However, in addition to the AET levels, which primarily separates AET by their ODDs, there are other related variables which are highly important to consider for a large-scale deployment of road freight operations without a driver in the truck. Two of the topics that are in focus for Einride's work in WP3 which are also relevant for WP4 are:

- **Managing non-driving activities in nodes without a driver**
  How will non-driving activities that truck drivers typically perform, or assist with today be managed when trucks are driverless? The specific requirements vary significantly between different transport applications, but such activities may include loading and unloading of the truck, load securing, vehicle

inspection, document handling, access management and more. For electric trucks, another important aspect is charging. Depending on the transport application, the available and most cost-efficient solutions may differ. In some cases, staff at the origin and/or destination site may be able to perform these tasks while in other cases, technology for automated loading/unloading and charging is a better option.

- **The need and role for remote operations**
  To what extent should the AET pods utilize remote operations? Remote operations could be used for various purposes such as to enhance the ODD for AET to reach more destinations or access other parts of the road network, or to perform complex manoeuvring or overseeing operations in nodes and terminals. A key variable for the cost efficiency of remote supported AET is how many operators are required to operate a fleet of a given number of vehicles. It is preferable to have as few operators per vehicle as possible (conditional on that strict safety requirements and service levels are met). On the other hand, remote operations will enable AET for transport applications which would otherwise not be feasible. However, predicting the number of required operators for an AET fleet for a given network is a complex matter which does not only depend on the type of routes operated and the ODD of the vehicle, but also on aspects such as the operating schedules of vehicles (e.g. how concentrated in time are vehicles at locations where there is a high probability that remote operations are required), the need for remote operations in nodes (e.g. terminal areas) and dynamic variability in the operating conditions such as weather, traffic, etc.

Currently, the above topics are rather unexplored both when it comes to how to conceptualize these for strategic, economic modelling and when it comes to real world testing and operations for providing reliable data on the performance and costs for alternative solutions. In other words, these are two areas which have high importance for modelling the feasibility for, and economics of AET operations which is the purpose of Einride's work with developing the EAP in WP3 for which there is a strong need for empirical insights from test, and real-world operations.

Einride's ambition with the AET use case in WP4 is to test concepts related to connectivity, loading/unloading, parking, integration with other modes of transport of Einride's electric and autonomous truck, the Pod. The test will be through demonstrations realised both in a restricted area, the AstaZero's test track in Boras, and to the premises of one of Einride's key customers, confirming the adoption of new technologies from end users & industries for achieving the targets of lower costs, better safety and zero emission.

3.6 Hyperloop

Hyperloop is a new mode of transport and a solution to many of today's pressing challenges. A lot of high value objectives are gained when using Hyperloop as a system to connect major freight-, but also transport hubs in general. Some of the objectives of Hyperloop include high reliability, increased speed, very high energy efficiency and the possibility of transporting goods without polluting the environment in an ecological, but also an economically feasible new mode of transport.

A better understanding of Hyperloop as part of a multimodal freight network can help with finding optimal first routes for this new mode of transport, especially as Hyperloop would establish connections between large logistics centres and hubs with high throughput. Therefore, Hyperloop will be modelled in simulations with parameters that are gained from two lab demonstrators derived from the specific use case (Figure 10).

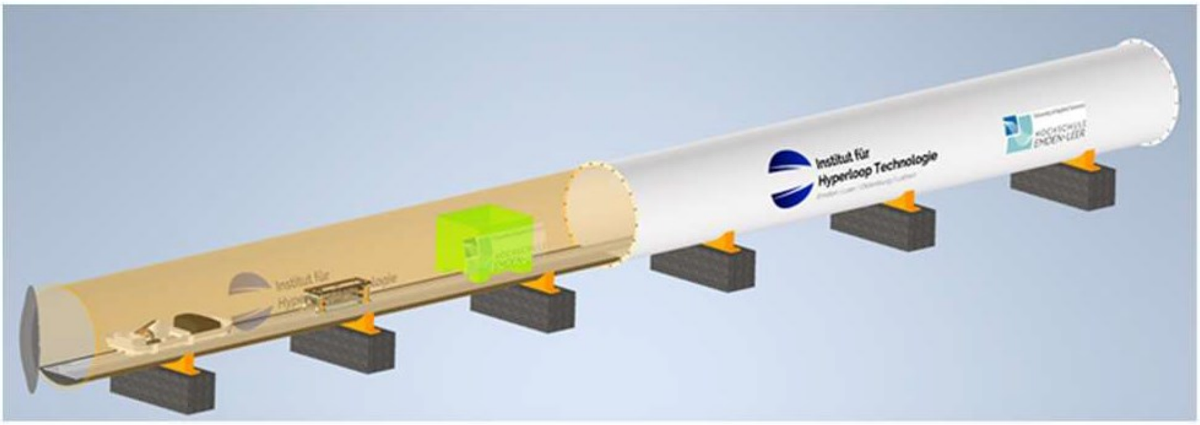

Figure 10. Hyperloop concept (Source: HSEL)

The lab demonstrator work in ePIcenter will focus on:

- **Cargo Handling**
  A scaled down lab demonstrator will be conceptualised to specifically look at loading and unloading and suggest a procedure for Hyperloop cargo applications. The procedure is based on scalability, the weight of the box, the volume of the container and other logistical as well as technical considerations. Finally, scalability will be investigated to derive parameters for logistics simulations.
- **Freight in Transit**
  Specific parameters will be observed and estimated to model freight volume and frequency for this new mode of transport. Subsequently, suggestions will be drawn for handling of the goods for vacuum and low pressured environment and the acceleration profiles. Connecting cargo handling and freight in transit in a model, will result in a capacity for throughput, speed, number of available pods, available airlocks, loading and unloading technologies, handling of goods regarding vacuum conditions and other parameters for Hyperloop cargo applications. Simulations will be able to input parameters like distance, volume, batch size, frequency, and scalability of the demonstrators.

3.7 Freight Network Configuration Impact Comparator

The Freight Network Configuration Impact Comparator addresses the problem of understanding the impact of new technologies, new operating procedures, and new infrastructure on the freight flows.

This is a wide-ranging question, and ePIcenter does not set out to address all aspects and technologies, as this would be a vast undertaking. Instead, the ePIcenter concept is to initiate a "living" toolset of software, algorithms, methodologies, and simulator equipment/techniques that supports interoperability and allows end users to undertake different types of analysis.

An early version of the framework for Freight Network Configuration Impact Comparator has already been defined, as illustrated in Figure 11. below.

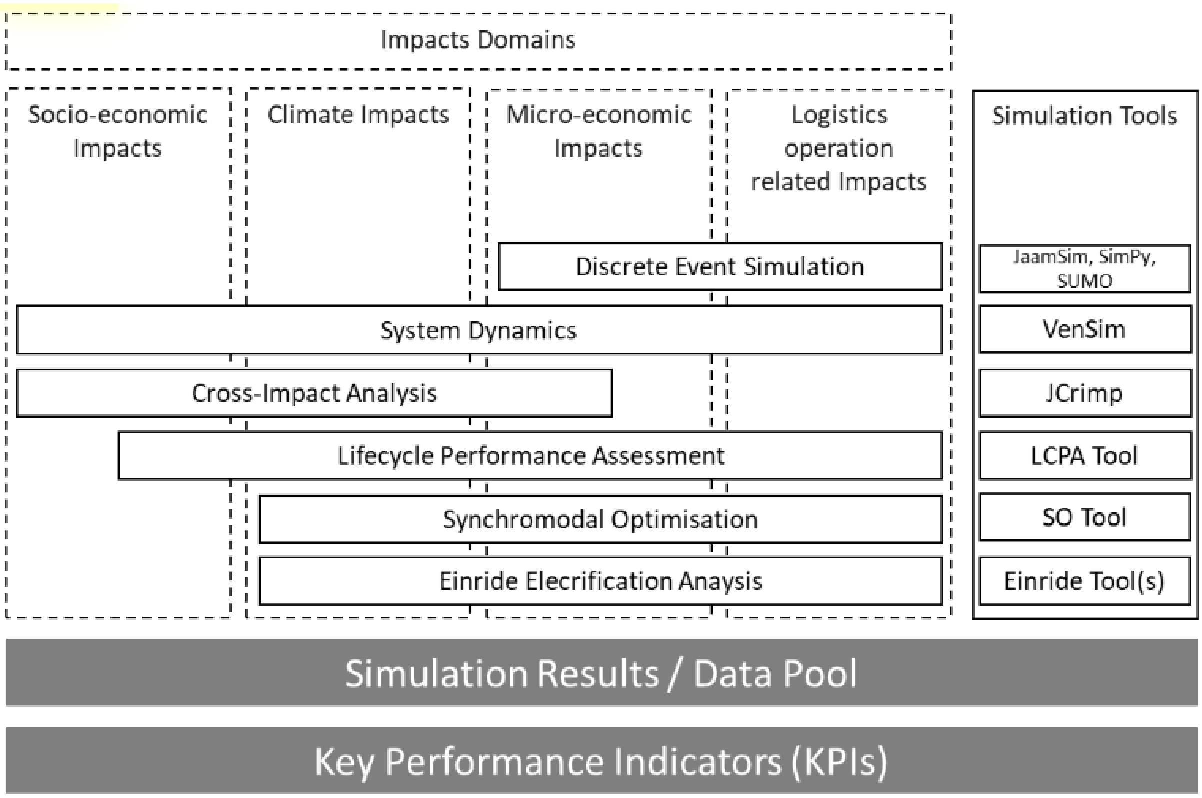

Figure 11. The Framework for the Freight Network Configuration Impact Comparator (source: MJC²)

This framework consists of several parts. The main part is a division of the potential impacts into impact domains:

- **Socio-economic Impacts**: Socioeconomics is the part of social science that studies how economic activity affects and is shaped by social processes8. In general, it analyses how modern societies progress, stagnate, or regress because of their local, regional or the global economy. Societies are divided into three groups: social, cultural, and economic. It also refers to the ways that social and economic factors influence the economy.
- **Climate related Impacts**: Socio-economic system at the regional level have a significant impact on the environment through deforestation, pollution, natural disasters, and energy production and use. Through tele coupled systems, these interactions can lead to global impact such as the climate change coupled with the global warming.
- **Micro-economic Impacts**: This domain relates to the behaviour of individuals and firms in making decisions regarding the allocation of scarce resources and the interactions among these individuals and firms. One goal of micro-economics is to analyse the market mechanisms that establish relative prices among goods and services and allocate limited resources among alternative uses. Therefore, this domain includes all income and cost related factors of the involved stakeholders.
- **Logistics Operations related Impacts**: Within this domain, all aspects related to the operation of transport networks are subsumed. Examples are freight throughput, load capacities of vessels, imponderability in transport, or packing and warehouse related issues.

In the frame of ePIcenter project, Einride will develop a proof-of-concept version of a strategic freight transport market model tool as part of the Electrification & Automation Planner (EAP) of the Einride SAGA. This will be a high level strategic model that forecasts the demand for autonomous and electrified transport (AET) for a given market depending on costs and characteristics of AET operations, the available AET infrastructure, costs and characteristics of other transport options, and the characteristics of the market under study. This enables identification of market potential of AET in mid- to long term for a wide range of scenarios. The EAP should be considered as an internal strategic decision-making tool for provision of info on technology, product, and market issues as well as implications of AET across various future scenarios and for different markets.

While there is a growing number of demonstrators and initial commercial projects with driverless trucks, the focus has been on automated driving while less attention has been given to how autonomous (and electrified) trucks can be operated in an efficient and safe way when also considering transportation and logistics activities upstream and downstream of driving currently performed by the driver. If these activities cannot be handled in a cost-effective way, it will limit the potential market for AET to applications where the driver is only performing the driving task. Likely, the efforts to automate terminal operations of AET will also have positive effects for using AET in multimodal transport chains as it may reduce transfer costs, which today is one of the key barriers for multimodality. This may also benefit the potential for combining AET with novel transport solutions such as the hyperloop case that is demonstrated in ePIcenter.

3.8 Environmentally Friendly Ship Routing & Propulsion Algorithms

ePIcenter aims to develop new ship routing and propulsion optimisation algorithms which reduce fuel usage (and therefore GHG emissions), while also reducing the impact of shipping on cetaceans. Apart from these innovative algorithms and methodologies, the ambition is to also obtain a better understanding of Arctic shipping and Potentially Sensitive Sea Areas with respect to cetaceans.

Development of ice navigation simulation software

This part of the work will focus on whale & ice-avoidance navigation algorithms

- Integration of ice-, wildlife-, and ship navigation data in GIS (Geographic Information System)–format
- Implementation & testing of ice resistance, ship speed calculation and fuel consumption algorithms with selected transit case(s)
- Simulation of ship transit through Arctic waters

Sensitive Areas and Measures for Wildlife Friendly Shipping

This work will focus on:

- Identification of Potentially Sensitive Sea Areas and collation of environment data.
- Review of Emerging Technology and Equipment.
- Potential collaboration with WWF Arctic.
- Spatial Analysis of Marine Protected Area within Arctic Shipping Routes.

AI Driven Ship Propulsion & Environmental Benefits

This part of the work will:

- Develop AI fuel minimization algorithm to dynamically optimize ship propulsion system.
- Simulate the scenarios of different voyage strategies on ship energy efficiency while considering the effects on marine wildlife (see Figure 12 – showing vessel parameter readings).

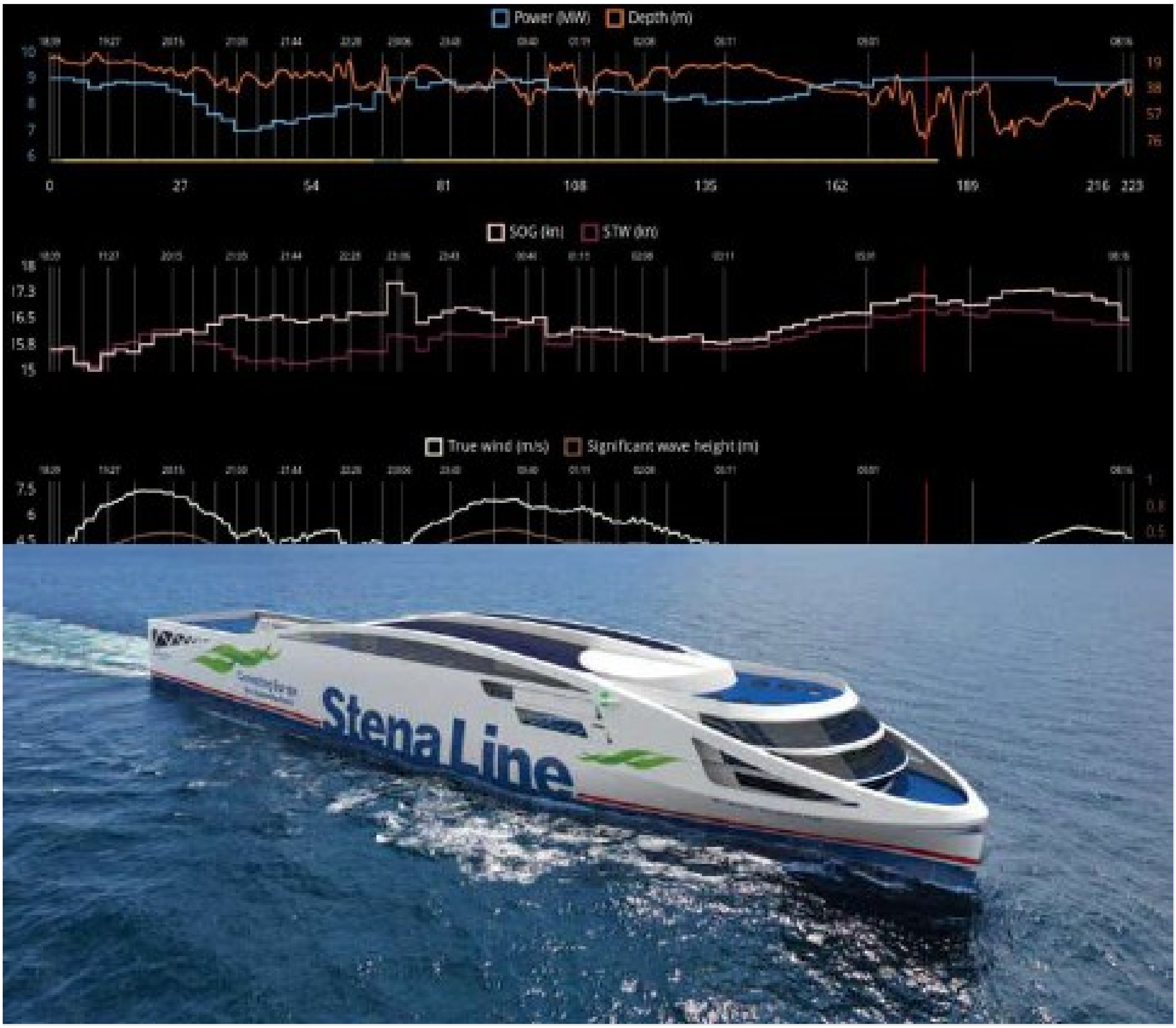

Figure 12. AI Driven Ship Propulsion & Environmental Benefits (Source: Stena Line)

4 High Level Approach

ePIcenter will test, validate and assess its innovations in three major demonstration scenarios. ePIcenter involves 36 partners (Figure 13), including fourteen industry partners who can assess first-hand how these innovations will impact on future operations

Figure 13. ePIcenter Partners (Source: ePIcenter project)

The three different demonstrators are handled in different work packages (Figure 14).

The "**ePI-Link**" demonstrator will consider a network, spanning three continents (Europe, Asia, and North America). Nine major stakeholders will interact in this trial implementation, focusing on the physical, logistics and data links in the network: three major nodes (Port of Antwerp, Port of Montreal & Duisport), four main logistics operators (DHL, Beijing Trans Eurasia International Logistics, Den Hartogh, and PKP Cargo), and two global manufacturers/shippers (Panasonic, AB InBev).

The "**ePI-Node**" demonstrator aims at understanding how new concepts in transportation solutions, in combination with new strategies to organize freight flows in major ports, have an impact on the efficiency and throughput of major nodes in the supply chain, and the knock-on effect on global freight. This demonstrator will include the AEV, Connectainer and Hyperloop components.

"The **Arctic Demonstrator** will focus on how the new fuel minimisation and ice routing algorithms can cope with one of the most challenging regions. Furthermore in terms of their potential benefit to the supply chain in terms of reduced transit times (and corresponding reductions in fuel usage and GHG emissions), but also in the context of possible impact on the local Arctic environment.

Within each demonstrator, one or more use cases were defined. These are based on input from end-users and stakeholder requirements, but also input from tasks 1.1, 1.2 and 1.3. The use cases vary from operational optimisation to more strategic tools. The cases have the goal of testing the ePIcenter innovations in real-world scenarios and involve industry partners.

Each case within the demonstrators has a team with members from the different involved ePIcenter partners. The team works on the practical implementation of the case scope. Again, as mentioned before, this document is intended to the ePIcenter vision and how the planned innovations work towards that vision. More details about these innovations will be provided in other Deliverables within the project.

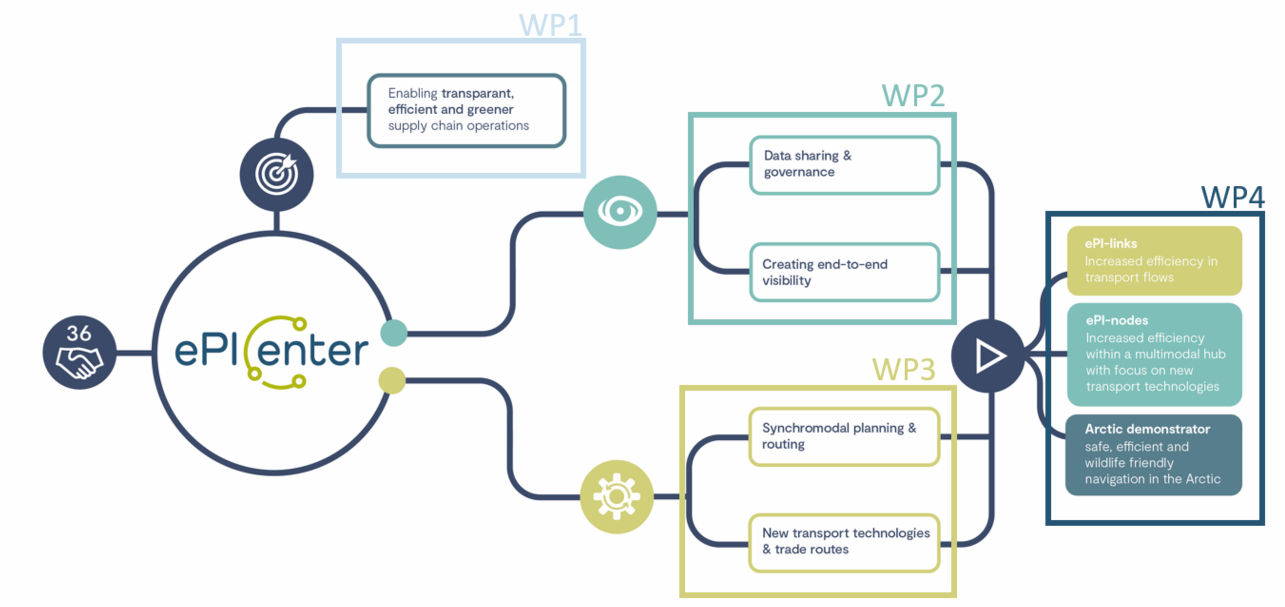

Figure 14. ePIcenter WP-Demonstrator overview(source: ePIcenter project)

5 Expected Benefits

The foreseen benefits of the ePIcenter project are numerous. As main benefits, we can highlight the following:

There is the **Improved integration of the European transport network** with the global network benefiting from the emergence of new trade routes and harmonised platforms in support of the sustainable development of new logistics routes and their link with national/regional markets. In the proposed Enhanced Physical Internet enabled Global-European Network, integration of the European transport network with the global network will be achieved via the seamless (but secure and controlled) information flow across borders. The market is currently very cautious about adopting data visibility initiatives due to perceived trust and commercial difficulties. ePIcenter will remove this barrier creating a harmonised neutral platform that exploits the increased reliability of cyber-secure data sharing models to massively speed up processes at ports and other major nodes which **link TEN-T to the Global Network**. This in turn will lead to major efficiency improvements which reduce congestion and increase modal shift to greener transport options.

Some examples that are investigated

- **Earlier and more accurate information** about freight as it approaches the port or international rail terminal allows forward planning of activities in the port/terminal and ongoing legs (e.g. by barge and rail on the TEN-T network) to reduce dwell time on the container terminal. The new integrated **synchromodal and multimodal transfer zone optimisers** will maximise throughput in the terminal and maximise the use of rail and barge connections, resulting in an increased modal shift.
- During the project ePIcenter will **research the impact of emerging trade routes** and their impact on the European network. This will include application of the new ePIcenter AI-based optimisers in the Demonstrator activity, as well as to other strategic or policy-level scenarios. The immediate emphasis will be on how best to integrate these new routes and corresponding flows into the European network. Currently there are issues with congestion, interruptions and complex routings resulting in increased CO2 emissions and costs. Waiting times at already crowded European “Hubs”, shortage of truck drivers or intermodal connections create inefficiencies. While the train only needs 8-10 days on the much longer distance from China to EU border, the lead times within Europe can easily go up to 8-10 days also. The main causes of this additional transit time are lack of transparency & efficiency in the information and planning process, which leads to bottlenecks on the network entry/exit points and thereby to underutilization of existing capacities.
- The ePIcenter toolset will be available to governmental users, researchers, and industry practitioners after the end of the project, via the ePIcenter Community. This toolset will be available to support these practitioners in the **development of new sustainable routes**, understanding their impact (economic and environmental), and how they can best link with national/regional markets, both in Europe and its trading partners. The consequences of new shipping routes in the Arctic are only just beginning to be understood. ePIcenter will make specific advancements in this area, but the toolset will be used for future research in what is likely to be a very active and challenging field of research. Related to the new Silk Road case, the terrible events which have occurred in Ukraine in recent weeks will almost certainly have an impact on the possibility of undertaking some of the originally planned work, especially for the use cases which focus on the New Silk Road rail routes which traverse Russia and Belarus, and Arctic shipping routes via the NSR. Furthermore, many of the researchers working on ePIcenter live in neighbouring countries and are understandably affected and concerned by these events, as indeed is the whole of Europe. At this stage, it is not clear what the future holds with respect to the New Silk Road/Arctic routes, so the original plans for any related activity have been removed from this document and replaced by placeholder comments. If it is not possible to focus on the New Silk Road as originally planned alternative demonstration cases will be considered which still test the validity of the ePIcenter solutions, but for different routes/operations. The focus will be on providing a Living Toolset of analysis modules and methodologies, it will be possible to dynamically update and refine models and strategies in response to unforeseen events.
- A wide range of **emerging technologies and innovative logistics concepts that are studied, tested, and demonstrated** including: Artificial Intelligence, Hyperloop, Blockchain, Autonomous Vehicles, Synchromodality and Innovative Modularisation, all of which have the potential to play an important role in the Physical Internet of the future. These innovations in turn exploit technologies such as 5G,

EGNOS, Big Data, Galileo and satellite data captured by the Copernicus Earth Observation programme. This work will (via trials, demonstrations, and detailed analysis in WP4) massively increase the understanding of the impact of these technologies on freight flows. However, ePIcenter will go beyond this, by creating a toolset of Artificial Intelligence optimisers/simulators, supported by methodology and guidelines, which can be applied to other new technologies as they emerge. This Freight Network Configuration Impact Comparator Toolset will greatly speed up future work by automating many of the calculations that are currently undertaken by hand. We estimate that this will reduce design work (e.g., for a full or proof-of-concept implementation of a new technology in an operation) by several months. Furthermore, the ability to quickly run multiple scenarios with accurate results will make it easier to convince end users and venture capitalists to invest in promising solutions. This will significantly boost innovation activity in Europe in the transport and freight sectors.

- For policymakers the ePIcenter toolset will **assist in making quantified recommendations/decisions for future investment** (e.g., for the CEF programme). Initial scenarios and answers will result from the demonstrators. This will help facilitate the development of disadvantaged regions and their inclusion into the international trading system and foster a better understanding of links between technological development, trade, and geopolitics.
- The **open data standards and protocols**, supported by a cloud-based deployment strategy, will minimise the barriers to adoption, especially for SMEs with limited development and infrastructure budgets, and enable rapid deployment of the ePIcenter solutions. A dedicated task has analysed how ePIcenter can be applied by organisations in developing countries and disadvantaged regions, This will encourage uptake and therefore drive the strategic aims of ePIcenter that benefit Europe as well (increased global integration/visibility and reduced GHG emissions) and will increase participation of these regions in the Enhanced Physical Internet enabled Global-European Network, through better (cost-effective) data integration. The ePIcenter simulation tools will show governmental organisations how multimodal operations can be established that move towards more sustainable approaches, avoiding large infrastructure investment. European authorities will also be able to use the ePIcenter toolset to understand how better links can be established between these new economies and the European network, while transport service providers will be able to model the economic benefits of new services. New technologies such as Hyperloop are expected to be environmentally neutral and can be powered by renewable sources such as solar energy, which opens up new possibilities for connecting landlocked developing countries to major trade routes.

5.1 Achieving the ePIcenter Impacts

This section summarises the analysis of how each of the main innovation areas covered in chapter 3 facilitate the ongoing exploitation and impact of ePIcenter beyond the end of the project, and how they help achieve the dissemination goals and adoption/exploitation prospects which have been specified in the WP5 work ("Exploitation, Communication & Dissemination").

ePIcenter has a diverse set of ambitions and goals:

- **Environmental Impacts**, such as reduction of GHG emissions in logistics operations and the impact of shipping on wildlife, while also aiming for other benefits such as noise reduction and reduced requirement for infrastructure that displaces natural resources.
- **Societal Benefits**, such as congestion reduction, better quality of life, increased flexibility, and resilience in supply chains (e.g., in response to pandemics or major polecat problems/changes).
- **Economic Benefits**, primarily cost reductions through efficiency improvements, but also increased service level and reduced dependency on fossil fuels.
- **Increased Understanding** of the impact of new technologies, paradigms, and new trade routes on the flow of freight in the TEN-T (and global) networks. In ePIcenter Hyperloop, AEVs, modular containers, AI, synchromodal algorithms, data sharing technologies and the Physical Internet are studied.
- **Innovation Potential**, which results from the new knowledge, tools, algorithms, and methodologies developed in ePIcenter, which can be applied to other scenarios, technologies and questions.

The following table cross-checks each innovation area against these aims, to ensure that each one contributes to at least one goal.

	Environmental Impacts	Societal Benefits	Economic Benefits	Increased Understanding	Innovation Potential
Trusted Data Sharing	✓	✓	✓		
Visibility Solution Layer	✓	✓	✓		
Synchromodal Logistics Optimisation	✓	✓	✓	✓	
Freight Network Impact Configurator	✓	✓	✓	✓	✓
Connectainer (Modular Containers	✓	✓	✓		✓
Autonomous Electric Vehicles ("Pods	✓	✓	✓	✓	
Hyperloop	✓	✓	✓	✓	✓
Environmentally Friendly Ship Routing & Propulsion Algorithms	✓		✓	✓	✓

Table 1. Achieving the ePIcenter impacts

To move towards achieving these impacts it is important that the proposed innovations make a significant advancement which (a) makes the result attractive and increases its exploitation and/or dissemination potential; and (b) brings the capability or technology significantly closer to realisation in a commercial or practical application.

6 Conclusion

The work undertaken in WP1 has resulted in a clear definition of the planned innovations and progress beyond the current state-of-the-art in all the areas and topics contemplated by ePIcenter. The project vision for future logistics networks and main innovations, along with their impact and how we will approach these, are summarised in this report, which is expanded upon in the private deliverable D1.10 that provides material about the technical ambitions and project success criteria.

The input used for this document is the work done in WP1 (and corresponding deliverables), as well as the findings from the Communications activity (T5.2), TEN-T Research (T5.3) and European and International Cooperation including Disadvantaged Regions (T5.5). Furthermore, the chronological overlap between WP1 and WPs 2/3 has allowed for iterative refinement of the technical ambitions and success criteria, facilitating exchange between the industry stakeholders and technology/research partners.

The resulting specifications for innovations have been cross-checked against the overall aims and desired impacts of the project, to ensure that all work makes progress to at least one of these ambitions, and that there is a technical advancement towards realisation of the impact.

The foreseen benefits of the project are numerous. As a main benefit we noted the Improved integration of the European transport network with the global network that will lead to major efficiency and sustainability improvements. Examples investigated were:

- Forward planning with earlier and more accurate information to drive synchromodal and multimodal transfer zone optimisation.
- Research on the potential of emerging trade routes and their impact on the European network.
- A toolset to support the development of new sustainable routes.
- A wide range of emerging technologies and innovative logistics concepts that are studied, tested and demonstrated.
- A toolset to assist policymakers in making quantified recommendations and decisions for future investment.

Clear societal and environmental impacts are expected, such as:

- Increased use of greener modes and reduction in emissions.
- Congestion reduction and effective increase in port/terminal capacity.
- Cost reductions in the supply chain.
- Increased understanding of cetacean movements and the possibility to lessen the impact of shipping.
- Deeper understanding of technologies such as hyperloop, AEVs and modular containers.
- Progress towards ambitious future logistics paradigms such as synchromodality and the Physical Internet.

Furthermore, these innovations are aligned with great exploitation potential and have provided input to the draft Exploitation Plan produced as part of Task T5.4 activity.

References

This paper was written based on information that was gathered in previous deliverables. As a reference we will list these deliverables :

- WP1: ePIGEN Vision, Opportunities & Requirements
  - D1.1: Initial Review of EU/global Initiatives, Policies & Standards
  - D1.2: TEN-T & Global Networks Initial Review of Challenges
  - D1.3: Arctic & New Trade Routes Challenges
  - D1.4: Initial Stakeholder Requirements Analysis
  - D1.5: TEN-T & Global Networks Review of Opportunities
  - D1.6: Arctic & New Trade Routes Opportunities
  - D1.7: Final Review of EU/Global Initiatives, Policies & Standards impacting ePIcenter
  - D1.9: Results of Technology Scan & Relevance to ePIcenter
  - D1.10: ePicenter Project Success Criteria
- WP2: Global Visibility Technologies & Governance
  - D2.1: Early Architecture Prototype
  - D2.2: Initial ePIGEN International Cooperation & Governance Model
- WP3: Artificial Intelligence & ePIGEN Optimisation
  - D3.1: Early Lab Network Simulator Prototype
  - D3.2: ePIGEN Synchromodal & Transfer Zone Optimization toolsets
  - D3.3: Arctic Navigation & AI Fuel Minimization Algorithms
- WP4: Demonstrators, Showcase & Lessons Learned
  - D4.1: ePIGEN Demonstrator Plans, KPIs & Success Criteria