LIVING LAB REPORTS

SUMMARY OF D1.4 AND D4.2

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1 Introduction

The PILL living labs were constructed to build and validate the key optimisation scenarios of a Physical internet and define the architecture necessaryfor these optimisations in a PI blueprint. These key optimisation scenario's were: Strategic optimisation, Planning optimisation and real-time rerouting. To build and validate these 3 optimisarion scenarios, PILL conducted 3 Living Labs, each with their own focus:

- **Living Lab 1 – PILL Simulation**
  Risk-free development and assessment of a PI data model and the impact of the PI routing optimisation in a logistics network that fully adopted the PI blueprint design principles for information sharing.
  Validation of the PI blueprint in identifying strategic optimisations, comparing a BAU with a network that incorporates the PI principles.

- **Living lab 2 – PILL POC 1**
  The first prototype of a decentralised PI connector and validation of the PI data model and routing optimisation from Living lab 1.
  Validation of real-world planning optimisations, using the Prototype.

- **Living lab 3 – PILL POC 2**
  The development and testing of a decentralised framework that enabled real-time collaboration, incorporating all components of Living lab 2 and expanding on the decentralised framework of the PI-connector.
  Validation of resilience through real-time rerouting, using the prototype.

The final PI blueprint architecture was refined through each of these 3 living labs to its final conclusion (see the deliverable "The PI Blueprint"), and lead to the definition of the following solution requirements that proved the PI design principles:

- **Open, decentralized network**: Behaviour & Governance rules for of a network for decentralized information sharing & interoperability.

- **Standardised data model & processes**: Data and process standards for logistics transport, expanding on the existing DCSA standard, rooted in the larger UN/CEFACT

- **Universal PI-client connector**: Software component that connects parties to the network & orchestrates interoperability between stakeholders.

- **Routing engine & simulation model**: Component responsible for the holistic calculation of the most optimum flow of goods, provider & mode agnostic.

These solution requirements were demo'ed in the living labs through the following building blocks:

- **PI network state + data model**
  2D map that provides visbility to the stakeholders about the network and all its nodes, transports & service providers. All stakeholders and their services are represented on the network, and have a full overview of the entire network state. Information sharing on the network state follows the defined PI data model.

- **Pi route planner and track & trace**
  First PI pplication, encorporating the Pi routing engine and track & trace component. The PI route planner uses information of the network state to calculate the best possible (re)routing options for a

shipment.

- **PI-connector & PI data space***
  Decentralised network with a universal PI-connector that connects to the network, ensures interoperability with peers, and manages third-party applications. The Data Space network covers the concerns of connectivity to the network, identification on the network, discovery of services on the network and data sharing between parties.

  **Livng Lab 3 concludede that to achieve full interoperability, the PI data space should be enrichted with an additional layer for Process Sharing (Process Space). The design principles of this Process Space have already been encorporated in the PI blueprint, however the final Living Lab demo is still limited to a PI Data Space. The development and validation of this Process Space will be the topic of a follow-up research.*

- **Simulation model**
  simulates container flows over the proposed physical internet, producing detailed measurements. The Simulation model is the basis used for future strategic optimisations, where stakeholders can simulate different routing options with alterations to thet network state (eg with an additional terminal or logistics service)

Decentralised network
Can we automatically identify and discover new nodes that join our network?

Interoperability
Can we create synchromodality by combining live location and ETA prediction with the route planner?

Data model
Does our PILL data model work with data space framework?

PI business value
What is the value of real-time rerouting on planning efficiency and resilience?

2 Living Lab 1 Report – Simulation Model DPworld flows comparison

The goal of the PILL simulation was to assess, on a risk-free environment, the basic building blocks of the proposed system:

- the data model enables the planning and tracking of freight containers in the hinterland
- verify that the routing engine (custom implementation of A* shortest path algorithm) enables the efficient planning of transport plans

We created a simulated environment where we simulate historical flows (business-as-usual) and theoretical flows using the PI business logic with the components above-mentioned. The risk-free experiments were conducted in the geographical region of Belgium, with flows from DP-World terminal at PoAB.

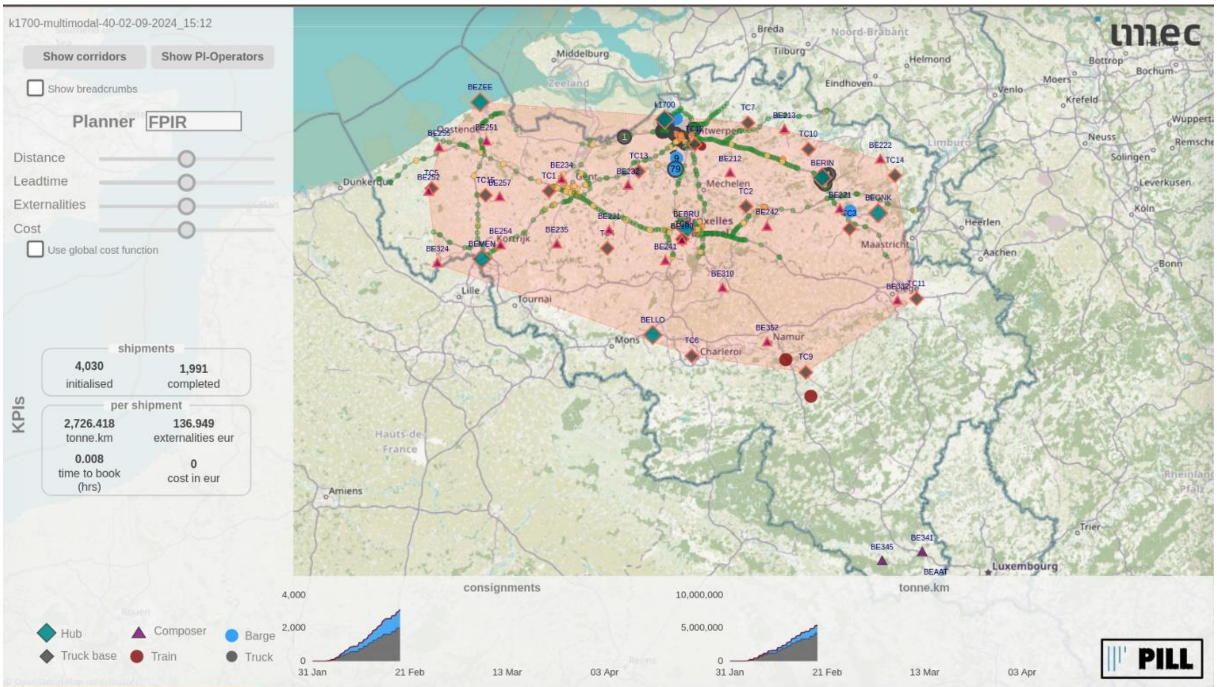

Figure 1: visual of the simulation model

2.1 Solution design

Data model

With insights from the ontology developed by the Federated Project (https://www.federatedplatforms.eu/) for secure, open and neutral data sharing infrastructure provision, we developed a data model that covers the following aspects:

- non-confidential network data, the network state
- and container transport planning data

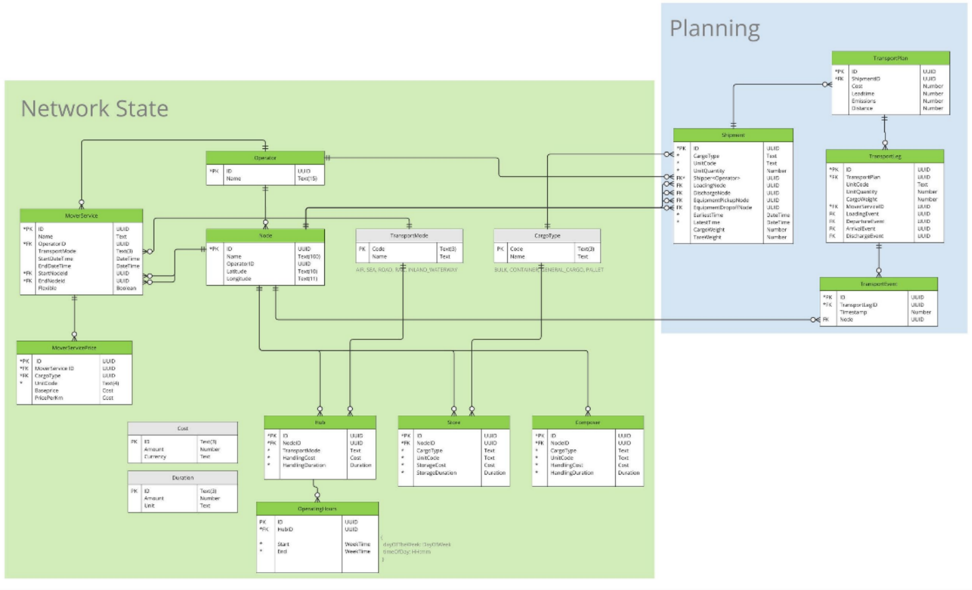

Figure 2: entity-relationship diagram of the PI data model

The former includes information about each logistics service provider network, like hubs, storage capabilities, scheduled connections and other transport offerings. The latter forms the necessary data to plan and track a multi-model container transport.

Routing engine

The routing engine is an implementation of A* (https://en.wikipedia.org/wiki/A*_search_algorithm) where not only multi-modal transport legs are considered, but also storage facilities. Given collection of network information for a specific period, the network state, and shipment details (i.e. pick-up and drop-off location, delivery time-window, container size and details…) the routing engine can generate transport plans.

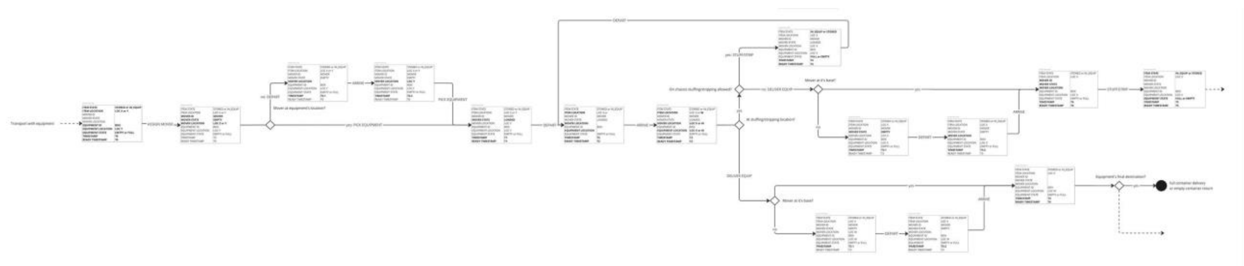

Figure 3: Planning graph presentation

To search for valid route, the proposed algorithm navigates a graph of states (fig 3), where it is tracked the container state, as well as the mover state. This allows for a comprehensive and strict search for valid transport plans.

Simulation

We developed a simulation model using the Anylogic software, for its GIS capabilities, following the agent-based framework (https://en.wikipedia.org/wiki/Agent-based_model). Simulations allow the study of dynamic systems, where interactions between agents are based on stochastic processes. It simulates a group of logistic service providers and expeditors, importing and exporting freight container over a period.

Agents

In this modelling paradigm, agents play the most important role, acting independently and reacting to environment changes. We propose the following agents: the operator that handles transport services, by managing the available capacity; the expeditor that requests and/or plans transports, by effectively communicating with operators to book consignments; and the mover, with a more passive role of transporting containers between locations.

Environment

Operators and expeditors rely on a fully connected graph to exchange information. The mover agent follows a GIS representation of the real physical infrastructure, represented on a separate graph for road, rail and inland waterways.

Process and scheduling

Operator agents are responsible for sharing information about their transport offerings (network state), as well as managing requests for bookings. A pre-determined number of shipments are scheduled to occur on a specific date, based on historical data. And movers fulfil the transportation of consignments based on the confirmed reservations made during the planning stage.

2.2 Validation goal PILL Simulation

Decentralised network

How can we simulate a network of fully autonomous logistics operators collaborating?

Interoperability

What “business rules” (behaviour) should PI participants follow to achieve synchromodality?

Data model

What are the minimal data sharing requirements in a synchromodal network that enables (1) planning routes, (2) tracking orders and (3) rerouting in case of disruptions

PI business value

What is the impact of a synchromodal PI-network that follows our business rules and data model?

2.3 User story mapping

User story	Description
Input data	**As a:** data scientist **I can**: edit and upload simulation setup files **So that**: configure any kind of simulation scenario
Output data	**As a:** data scientist **I can**: generate output files with detailed information **So that**: i can verify that the simulation is working as intended

Control user interface	**As a:** data scientist **I can**: easily control the simulation **So that**: I test different parameters manually
Simulation user interface	**As a:** data scientist **I can**: visualise the simulated environment **So that**: verify that it is working as intended
Generate transport plans	**As a:** expeditor agent **I can**: given a shipment details, I can generate routes **So that**: I able to plan container transports
Book transport plans	**As a:** expeditor agent **I can**: book transport legs with transport operators **So that**: book and receive a confirmation

2.4 DP-World flow experiment

This experiment was designed around the historical data of import/exported containers at the DP-World terminal at the PoAB, where for a period of 2 months we observed the following distribution of containers per transport mode

Figure 4: distribution of the import and export modes in the DP-world data model

For this experiment we want to understand how efficient, in terms of greenhouse gas emissions (GHG), is our proposed system compared to business-as-usual (BAU). In order to establish a baseline, we have taken all the container that arrived/departed the terminal via truck, assuming that the other modalities are already emissions friendlier, to form the number of containers to be simulated. This also includes container types and weights.

Flows

Given the fact that, for DP-World, the origin and destination of handled containers is unknown, we used a data from FOD Economie that includes the quantity of freight container transport between NUTS3 regions in Belgium, given that DP-World's terminal is located in **BE236** (Arrondissement of Sint-Niklaas) we used the following geographical distributions for import and export:

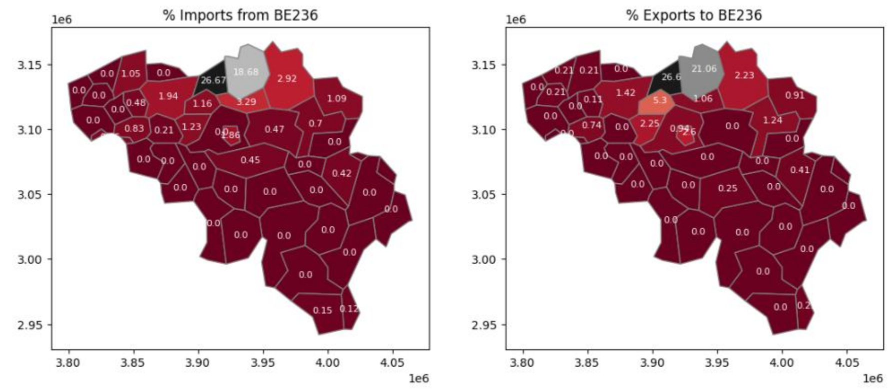

Figure 5: container flow distribution in the DP-world data model

Locations

Given the flows above, we assumed an expeditor for each NUTS3 region (Fig. 6) where a flow was present. Another important aspect is the truck operators' locations, which impact the travelled distance. For this we clustered the known road transport operators published by Kruispunt Bank der Ondernemingnen. The clustering resulted in the following locations:

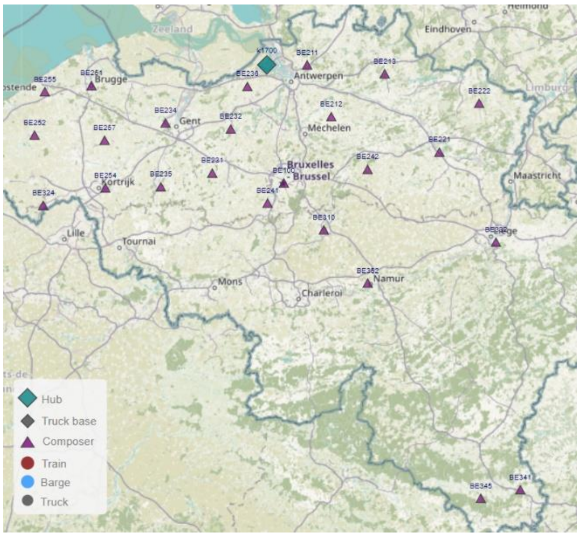

Figure 6: Expeditor locations in the DP-world simulation

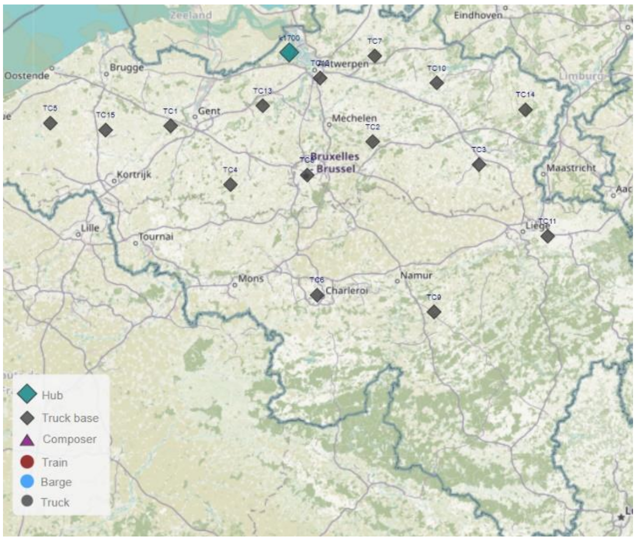

Figure 7: road transport operators in the DP-world simulation

Improvements

The data above, only with road transport available, forms our baseline scenario. The physical internet framework promises improved flows using multi-modal options. Hence, we propose other scenarios that include hubs with trains and barges connections to the port (Fig. 8).

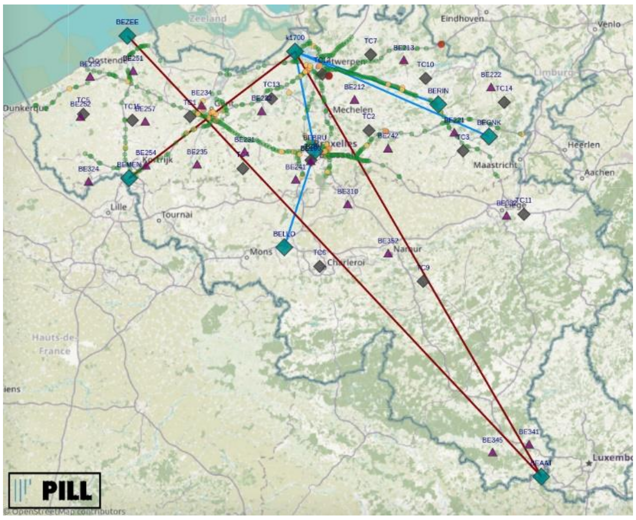

Figure 8: Multi-modal scenarios:

To model unused capacity of these new connections, we will simply sample them from a uniform distribution, where a percentage of the full capacity is free and published into the PI network:

- Inland waterway
  - total capacity for a 135 m barge: 350 TEU
  - uniform(0, 135 * percentage) TEU
- Rail
  - total capacity: 90 TEU
  - uniform(0, 90 * percentage) TEU

2.5 Results of the DP-World flow experiment

With this experiment, we compare the business-as-usual scenario with a set of multi-modal scenarios. The goal is to quantify the benefits of being part of PI for container flows that historically have been transported by truck, the highest emitting mode in our context.

We consider the containers from arriving and departing from quay K1700 at the Port of Antwerp to the Belgian hinterland. Our baseline scenario (BAU) is compared to scenarios where intermediate hubs and more sustainable solutions we introduced with varying levels of published capacity:

- 20% free capacity
- 40% free capacity
- 60% free capacity
- ∞ free capacity

We ran a Monte Carlo experiment on all scenarios, measuring the average emissions per shipment. Where a shipment is considered the container's hinterland transport, for import and export. The experiment stopping criteria is defined by:

- confidence interval of **95%**
- error percent of **0.05%**

	scenario	scenario	scenario
1	baseline	469	**295.9**
2	multimodal 20	1089	**257.3**
3	multimodal 40	1157	**248.6**
4	multimodal 60	882	**246.0**
5	multimodal ∞	706	**242.6**

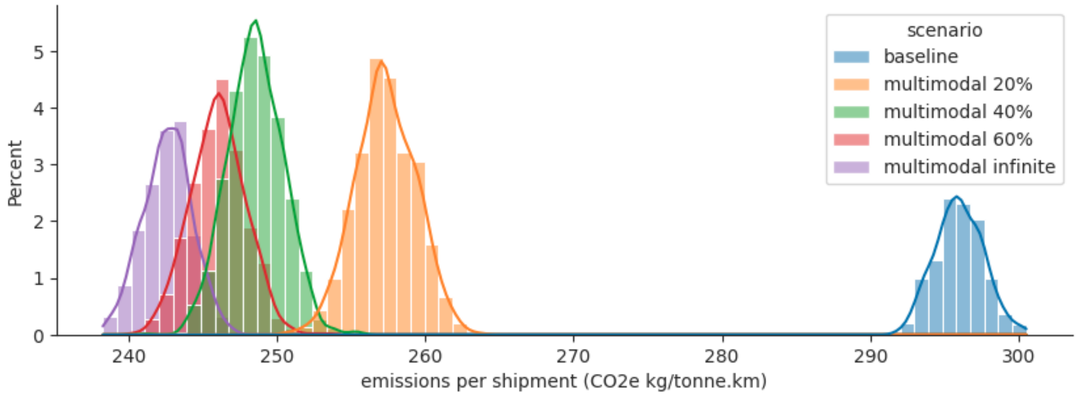

Figure 9: Histogram of Monte Carlo results

This solution proves that the developed data model and routing engine enable the creation a network of independent logistics actors, where planning and booking of containers can be achieved without exposing sensitive information. Whilst, the numerical experiment, given the proposed corridors, showed that with only 20% of capacity is made available, we can observe an average reduction in GHG emissions of 13.04%. And given the scenario's container flows, and infinite free capacity, we would peak at 18.01% reduction.

2.6 Outcome of the Simulation Model Living Lab

Given the experiment results above, we can it summarise as:

Decentralised network

How can we simulate a network of fully autonomous logistics operators collaborating?

Modelling each logistic operator as autonomous agents, with pre-defined rules and behaviours, we observed an efficient overall performance without a centralized entity overseeing the system. This is due to expeditors having a wider range of transport options, resulting in lower emissions routes.

Interoperability

What "business rules" (behaviour) should PI participants follow to achieve synchromodality?

The simulated environment showed that different logistics networks can be integrated, resulting in a more extensive and interoperable network. The use of a shared data model enables capabilities and transport data to be collected and used by different operators.

Data model

What are the minimal data sharing requirements in a synchromodal network that enables (1) planning routes, (2) tracking orders and (3) rerouting in case of disruptions

The identified data model elements provided the necessary data to be exchange between participants, in order to tackle the three phases of the problem, achieving a synchromodal logistics network.

PI business value

What is the impact of a synchromodal PI-network that follows our business rules and data model?

The use case where we compare historical flows on a business-as-usual setup to a physical internet setup, showed an improvement in emissions reduction by opting for multi-modal plan. This could only be achieved by the collaboration between expeditors and operators under a unified data-sharing system.

3 Living Lab 2 Report - PILL POC 1

The goal of the PILL POC 1 was to lay the groundwork of the principles of a Physical Internet defined in the PI blueprint and validate its impact in real-world planning optimisations.

The technical design principles of PILL POC 1 architecture were

- Trusted collaboration through fair data sharing on a decentralised network
- Stakeholder interoperability through common ontologies & data standards
- Increase stakeholder transparency through a shared network state visibility

For this, the PILL POC 1 consisted of the design and validation of a PI route planner as first application to validate standardised interoperability and a PI-client connector that created the decentralised network. These allowed logistics stakeholders to plan synchromodal (truck, train, barge) container routes, using a full network overview.

To achieve higher supply chain transparency, the POC also saw the realisation of the so-called "Network State", which is a 2D representation of all the nodes, hubs, transport services, routes, corridors and logistics players. By allowing everyone to have access to a real-time view of the network state, we increase transparency and improve planning options.

Figure 10: Overview of the platform with a mock Network State

3.1 Solution design

The PILL POC 1 consisted of two components:

PI route planner

The PI route planner was the first decentralised application, allowing collaboration on the PI network. The route planner was a locally stored application, that would share information with all other local versions, through the PI-client connector.

The PI route planner can be used by forwarders and transporters to calculate and book routes. the PI route planner gave an overview of the "Network State", a real-time overview of all possible nodes, capabilities and transport services. This Network State followed a data standard that came out of the PI blueprint research.

The route engine used to calculate the routes was itself designed and validated in the Simulation Model earlier in the project.

PI-client connector

The PI-client is the proof-of-concept of the PILL blueprint, serving as a universal connector that created a decentralised PI-network. This universal connector enabled collaboration and information sharing between stakeholders on a decentralised network, in a privacy-secured way. More information about the backend setup of PILL POC 1 can be found in the demo of D3.2

By connecting the route planner with the Pi-client, the PILL POC 1 was the first test of decentralised collaboration on a PI network.

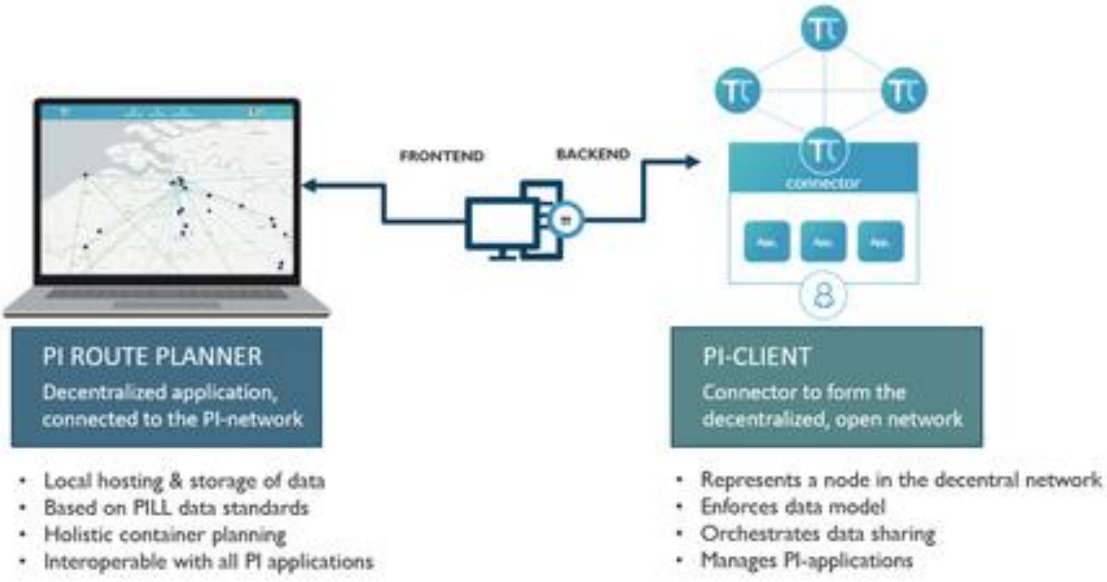

Figure 11: Overview of the 2 key components of the PILL POC 1 Solution

3.2 Validation goal PILL POC 1:

Decentralised network
Can we create and run a software on a decentralized network?

Interoperability
Can we use data on a decentralized network to calculate & plan transport?

Data model
Can we create a data standard for container planning?

PI business value
What is the value of increased transparency of the Network state on planning efficiency and resilience?

3.3 User story mapping

Stakeholders

The PILL POC 1 identified 4 key user roles, although all capabilities were available for all user roles.

Stakeholder type	Context	Goal in PILL POC
Network user	Group name for all users of the PI network	Have access to the latest network state
Planner	Owner or responsible of the containers (often the expeditor or shipper)	Find and book a transport route through the PI network
Node operator	operator of any node (terminal, transport, infrastructure…)	share their capacity, schedules, capabilities to the network state
Transport operator / transporter	specific node operator that operates the different types of transport: truck, barge, train	confirm/deny capacity for specific transport requests from expeditors

User stories

for the scope of the PILL POC 1, the route planner consisted of the following 6 key user stories.

User story	Description
View network state	**As a:** Network operator **I can**: view a real-time overview of the network state **So that**: I can have a transparent view of the current logistics situation and possible transport options
Manage network state information	**As a:** Network operator **I can**: Add and manage my own nodes, capabilities and transport services to the network state **So that**: I can be discovered by other logistics players
Calculate routes	**As a:** Planner **I can**: calculate all the possible routes for my booking, using the route engine and the available information on the network state **So that**: I have a fuller overview of all the possible options out there, regardless of my own personal network.
Book routes - request capacity	**As a:** Planner **I can**: Send out capacity requests for my list of calculated routes. Once a request has been refused, the planning tool will send out a request for the next route in the list,

	until a route has been found with capacity. **So that**: I know which of the routes has availability with the transport operators
Accept/refuse capacity requests	**As a:** Transport operator **I can**: anonymously view and manage upcoming booking request from planners **So that**: I can share my capacity in a privacy-secure way (without sharing my identity)

3.4 Living Lab intervention Scenario

Living lab participants.

A first group of 30+ Participants were involved in a first mock testing of the platform. Once the platform was validated, a shortlist of 10 participants were chosen to join in a live Living Lab.

The 10 participants were chosen to include all stakeholder types relevant to the platform(as discussed in chapter 3): forwarders, shippers, truck transporters, barge transporters, train transporters, Terminal Operators. By offering all possible modes of transport, true multimodal routes could be calculated by the platform.

The 10 participants of the Living Lab were:

Planners (forwarders)

- Essers
- Emmbassy Freight

Terminal operators

- DPWorld
- Liege Container Terminal

Transport operators – barge

- BCTN

Transport operators – train

- Lineas

Transport operators – truck

- ICS transport
- Handico trucking
- Vintra
- Gommeren

Setup

To test the efficacy of the route planning and network state in generating more and more effective route options, the PILL POC 1 Living Lab focussed on one specific coridor. Based on the list of participants the **corridor of the Port of Antwerp and Genk, via the Albert Canal**, was chosen for the PILL POC 1 Living Lab.

For each participant, **a separate copy of the route planner was hosted on the imec servers.** Each participant had their own personal account and login for their platforms.

A few weeks before the test, all participants inputted their Network information on the route planner, to **create a complete and decentrally shared "Network State**" of their corridor. The data that was required of participants were:

- their node locations & roles**.**
- The capabilities of their nodes (hub, gateway, store, depot, composer), such as schedules and handling time/ costs
- Transport services such as transport modes, schedules and transport costs

Living Lab test

In April 2023, the 10 stakeholders participated in a 2-week operational test. In this period, the participating planners would use the platform to plan routes for all their container orders on the corridor.

Once ideal routes were found, the planners would send out a capacity request to the included transport operators.

The transport operators could accept / refuse capacity. If a route was refused, the route planner would automatically send out a capacity request for the next route in the list, until a route was found with capacity.

Over the 2 week period 6 booking requests were sent out, of which 2 had capacity.

Figure 12: Overview of the Living Lab participants and the network state of the Corridor

3.5 Outcome of PILL POC 1

When reviewing our validation goals, we can conclude the PILL POC 1 as follows:

Decentralised network

Can we create and run a software on a decentralized network?

It is possible to connect data bases with each other through a PI-client and share information between local platforms without a central orchestrator.

Interoperability

Can we use data on a decentralized network to calculate & plan transport?

Automated data sharing on a decentralized network is possible and can be applied in (routing) apps.

Data model

Can we create a data standard for container planning?

The PILL data model is a good starting point and sufficiently elaborated to allow route planning. However the current data model will be too restrictive for edge cases. Additionally, cost flexibility should still be improved.

PI business value

What is the value of increased transparency of the Network state on planning efficiency and resilience?

The concept of a Network State is a drastic improvement to transparency over the network. However, the platform is limited to information sharing and yet lacks collaboration on process-level. This is a crucial next step for interoperability.

3.6 Next steps – PILL POC 2

With the PI-client, PILL has demonstrated the feasibility of interoperability on a decentralised network. To scale the Physical Internet to a commercial application, the PI-client must evolve into a plug-and-play solution adept at addressing all potential concerns about joining in and collaborating on a decentralised network. However, the current technology of creating a decentral, interoperable network still faces several scalability challenges, such as discoverability, identification and agreements.

These challenges align closely to the concerns being researched in the domain of "Data Spaces", an emerging technology ecosystem centered on data sharing through decentralised networks. The similarities between data spaces and PI present an opportunity to combine both technologies and leverage the benefits of both Data Spaces and the Physical Internet.

The next phase of the PILL project will therefore focus on setting up a third living lab, aimed at integrating the PI-client into the data space architecture. This merger of concerns and solutions from data spaces into the PI blueprint is expected to lead to the creation of a logistics PI data space that solves several scalability challenges currently hindering the PI-client.

4 Living Lab 3 Report - PILL POC 2

The goal of the PILL POC 2 was to expand on the POC 1 design principles and increase the Technology Readiness Level (TRL) of the POC 1 route planner closer towards real-time logistics collaboration on PI network. By integrating real-time logistics collaboration, the Living Lab aimed to validate the impact of the prototype on resilience through real-time rerouting.

Where the PILL POC 1 architecture laid the groundworks of the principles of the PI blueprint -namely (1) trusted collaboration on a decentralised network, (2) increased interoperability and (3) supply chain transparency through a shared network state- the PILL POC 2 architecture built further on these groundworks, increasing the technological framework for a decentralised network and the capabilities of the route planner towards synchromodal logistics.

4.1 Project Synergies: PILL + SYTADEL

Besides PILL, imec is also involved in another VLAIO project aimed towards Synchromodality, called SYTADEL. Where the purpose of PILL is to start from the 2040 vision of the Physical Internet to create a blueprint for a full-fledged PI network, the purpose of the SYTADEL project was to improve the logistics processes of today by establishing synchromodal operations. To achieve this, the SYTADEL solution used data spaces -a new technology that had not yet matured at the start of PILL- to create a decentralised network, to improve vessel tracking and ETA predictions.

The PILL POC 2 consisted of an integration of these SYTADEL components into the existing PILL POC 1 solution to create a stronger joint solution (1+1=3). This integration had several advantages for the PILL POC:

1. **It strengthened the PI network by integrating PI-client in a data space network**
   In PILL POC 1 we used a dedicated PI-client connector to create a decentralised network. However, this PI-client was still a first proof-of-concept and faces several scalability challenges, such as discoverability, identification and agreements. To mitigate these challenges, the PILL POC 2 aimed to integrate the PI-client inside a logistics “Data Space”, an emerging technology ecosystem centered on data sharing through decentralised networks. By integrating the PI-client in data spaces, the resulting decentralised network is based on an already validated and established scalable framework, which covers many of the shortcomings identified in PILL POC 1.

2. **It achieved synchromodality of the route planner by integrating Track & Trace**
   The route planner of PILL POC 1 was a tool for forwarders to explore potential route options for their transport, through data on the network state, and validate capacity of these routes through a booking request. However, this capability is still limited to the planning phase, reducing the experienced viability of the tool by the participants. By connecting a real-life track & trace to the route planner, the planner could automatically calculate alternative routes, once a delay was flagged. This would bring the solution one step closer to real synchromodality.

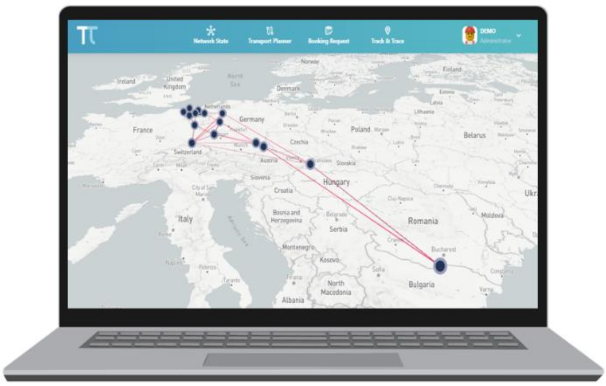

Figure 13: integration of the T&T in the PI route planner

4.2 Solution design

The initial solution design of PILL POC 1 consisted of (1) a route planner to calculate alternative routes and have a view of the logistics "Network State", and (2) a PI-client connector which enables communication of the route planners on a decentralised network. The PILL POC 2 solution extended on the existing architecture of the PILL POC 1 by adding two additional components from the SYTADEL project: A data space connector and a PI track & trace platform

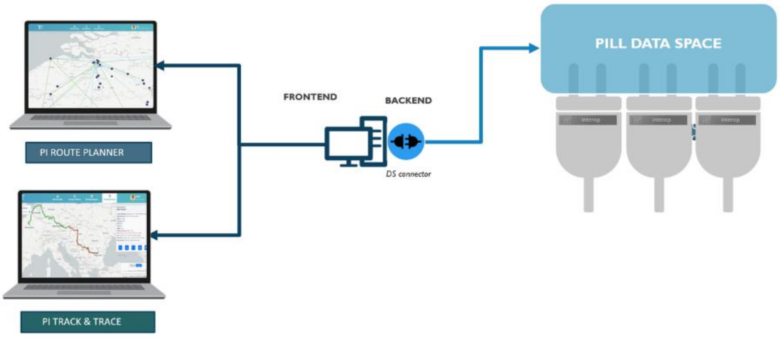

Figure 14: Overview of the PILL POC 2 Solution components

PI data space connector

the PILL POC 1 used the framework of Interplanetary File Systems (IPFS) to create a decentralised network. The SYTADEL network was built on the architecture of data spaces, using the Eclipse Data Space Connector (EDC). The data space connector works by uncoupling the individual concerns of collaborating on a decentralised network into separated components. Where the PI-client achieved in establishing connectivity, the discoverability and identification of nodes / peers across different networks was a challenge for the technology of the Interplanetary File System. The uncoupling of concerns of the data space solved the issues of identifying and discovering other nodes on the network. By integrating the current PI-client solution of the PILL POC 1 behind the EDC connector of SYTADEL, we resolved the limitations of the IPFS network for identification and discoverability of other nodes. In this situation, the PI-client would still trigger and define the required communications between the individual route planners to calculate routes or share information on the network state, but establishing the decentralised network and transferring the communication would be performed by the EDC connector.

You can read a more detailed elaboration on this topic in the technical demo of POC 1 and 2.

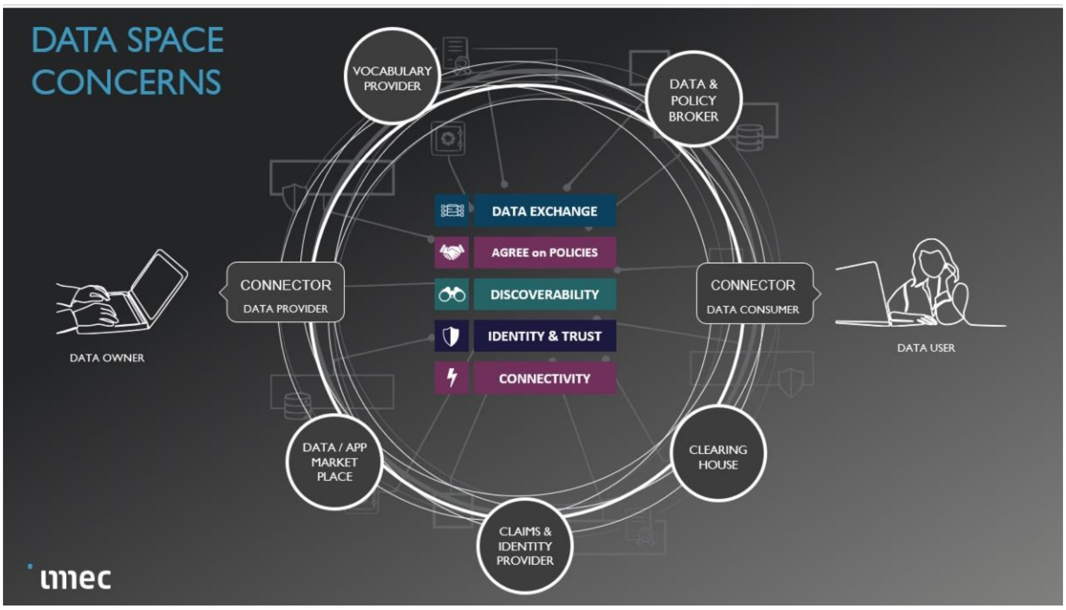

Figure 15 Overview of the data space concerns, covered by separate components

PI Track & Trace

The SYTADEL Track & Trace platform was limited to tracking vessels over a data space using AIS data, and visualise the vessel location on a map. By linking the track & trace solution of the SYTADEL project to the route planner of PILL, the track & trace gained access to the network state of the route planner and the route planner gained access to the real-time ETA of the track & trace. Now, once the track & trace predicted a delay, it could automatically trigger the route planner to calculate alternative routes, using the network state, and inform the planner of alternatives. Instead of getting an alert that your vessel is delayed, the planner would immediately have alternative rerouting options to choose from. This would bring the solution one step closer to real synchromodality.

4.3 Validation goal PILL POC 2

Decentralised network
Can we automatically identify and discover new nodes that join our network?

Interoperability
Can we create synchromodality by combining live location and ETA prediction with the route planner?

Data model
Does our PILL data model work with data space framework?

PI business value
What is the value of real-time rerouting on planning efficiency and resilience?

4.4 User story mapping

Stakeholders

Besides the existing stakeholders of PILL POC 1, the PILL POC 2 identified 2 new stakeholders

Stakeholder type	Context	Goal in PILL POC
New stakeholders POC 2		
Skipper	The actual transporter of the vessel. Since Skippers often live on their barges, location of a barge can be sensitive information.	Grant permission to access to vessel location
AIS data provider	Data providers for the live location of the vessels	Connect to the data space and share vessel locations
Existing stakeholders POC 1		
Network user	Group name for all users of the PI network	Have access to the latest network state
Planner	Owner or responsible of the containers (often the expeditor or shipper)	Find and book a transport route through the PI network
Node operator	operator of any node (terminal, transport, infrastructure...)	share their capacity, schedules, capabilities to the network state
Transport operator / transporter	specific node operator that operates the different types of transport: truck, barge, train	confirm/deny capacity for specific transport requests from expeditors

User stories

The user stories of POC 1 were enriched with the additional user stories that the track & trace included:

User story	Description
User stories POC 2	
Offer cargo location	**As a:** Skipper **I can:** Assign specific permissions of my vessel's location **So that I:** have more control who sees my vessel location
Track my assigned cargo locations	**As a:** network operator **I can:** view the route details of the cargos that are assigned to me, such as origin, destination, route. **So that I:** have a higher transparency of the route and situation of my transport.
View cargo route details	**As a:** planner **I can:** view the details of my cargo's route, such as origin, destination, route. **So that I:** have a higher transparency of the route and situation of my transport.
Calculate & alert ETA	**As a:** planner **I can:** View a real-time updated ETA of my cargo locations and get an alert once a delay is identified **So that I:** immediately know when my cargo is delayed
reroute delayed vessel	**As a:** planner **I can:** use the route planner and network state to calculate alternative routes for a delayed vessel **So that I:** immediately can reroute my vessel to avoid a delay
user stories POC 1	
View network state	**As a:** Network operator **I can**: view a real-time overview of the network state **So that**: I can have a transparent view of the current logistics situation and possible transport options
Manage network state information	**As a:** Network operator **I can**: Add and manage my own nodes, capabilities and transport services to the network state **So that**: I can be discovered by other logistics players
Calculate routes	**As a:** Planner **I can**: calculate all the possible routes for my booking, using the route engine and the available information on the network state **So that**: I have a fuller overview of all the possible options out there, regardless of my own personal network.
Book routes - request capacity	**As a:** Planner **I can**: Send out capacity requests for my list of calculated routes. Once a request has been refused, the planning tool will send out a request for the next route in the list, until a route has been found with capacity. **So that**: I know which of the routes has availability with the transport operators

Accept/refuse capacity requests	**As a:** Transport operator **I can**: anonymously view and manage upcoming booking request from planners **So that**: I can share my capacity in a privacy-secure way (without sharing my identity)

4.5 Living Lab intervention Scenario

Living lab participants

The First SYTADEL Living Lab recruited a forwarder that operated mostly through waterway logistics, its waterway transport operators and the transporters/skippers. The SYTADEL Living Lab set up a data sharing agreement between the skipper and the forwarders to view the vessel location, and between the transport operator and the forwarder to view the route information of the vessel, such as origin, destination and route taken. The PILL POC 2 living lab reused the data of the SYTADEL Living Lab to onboard these stakeholders as well.

These participants were as follows:

planner:

- Arcelor Mittal

Transport operator:

- Lalemant
- Preymesster
- Eurobulk

AIS data provider:

- Euris

Skippers (boat names):

- Vaiana
- Cecilia
- Isabell
- Sinn
- Zelpha
- Destino
- Hellfried

To calculate alternative transport routes, a list of transport operators needed to be onboarded to create a suitable network state. Onboarding the actual transport partners of Arcelor Mittal turned out challenging. Instead, the information of the 30+ transport operators from the PILL POC 1 mockup test were reused to create a fictional network state for alternative route calculations. Although this would not offer the same business value as real transport services, the conceptual value and technical feasibility could still be demonstrated.

Setup

The PILL POC 2 setup followed the SYTADEL setup, which tracked the orders of Arcelor Mittal that were going from their All-Weather Terminal in Zelzate (East-Flanders) towards their client in Giurgiu, Romania via barge transport. Arcelor Mittal had an agreement with this client to continuously supply a minimum stock of cargo (steel coils) to their Warehouses. Due to the weight of steel coils, barge transport is the most cost-effective mode of transport. However, the corridor Belgium - Romania through the canals Ghent, Duisburg and Regensburg was prone to unexpected delays due to lock planning misalignments and repairs, or general droughts. Additionally, miscommunication between Arcelor Mittal and the transport provider resulted in a late notification of the delays.

The scope of the initial SYTADEL POC was to track and visualise all barge transport, carrying Arcelor Mittal coils on this corridor, on the track & trace platform.

This living lab required the folllowing setup

- An initial data sharing agreement between the skippers and Arcelor Mittal.
- Integration of the Euris AIS-database on the data space
- Onboarding of Arcelor Mittal and the transport operators on the T&T platform
- The vessels that you could track, depended on the access rights of the data sharing agreements

The Living Lab followed the barges for 6-12 month (depending on the ship), regularly identifying delays in that time. Once a delay was identified, the platform sent an automatic message to Arcelor Mittal, highlighting the delay. However, this platform was limited to simply tracking vessels and calculating ETA. Although it increased transparency, it did not yet improve the synchromodal logistics.

Figure 16: the initial SYTADEL tracking platform with limited capabilities

The PILL POC 2 living lab extended on this setup. It added more capabilities to the platform, making it more useful for Arcelor Mittal to keep track on the status of their vessels. Additionally, PILL POC 2 created a network state of alternative transports on the corridor Zelzate - Giugiu by adding data of 30 fictional transport operators. The PILL POC 2 platform tracked the vessel just as before, but now once a delay was measured, the route planner would be triggered to calculated alternative route options, using the transport operators on the network state. Arcelor Mittal now received a message with a notification of the delay, and a list of alternative route options with the option to send out a booking request.

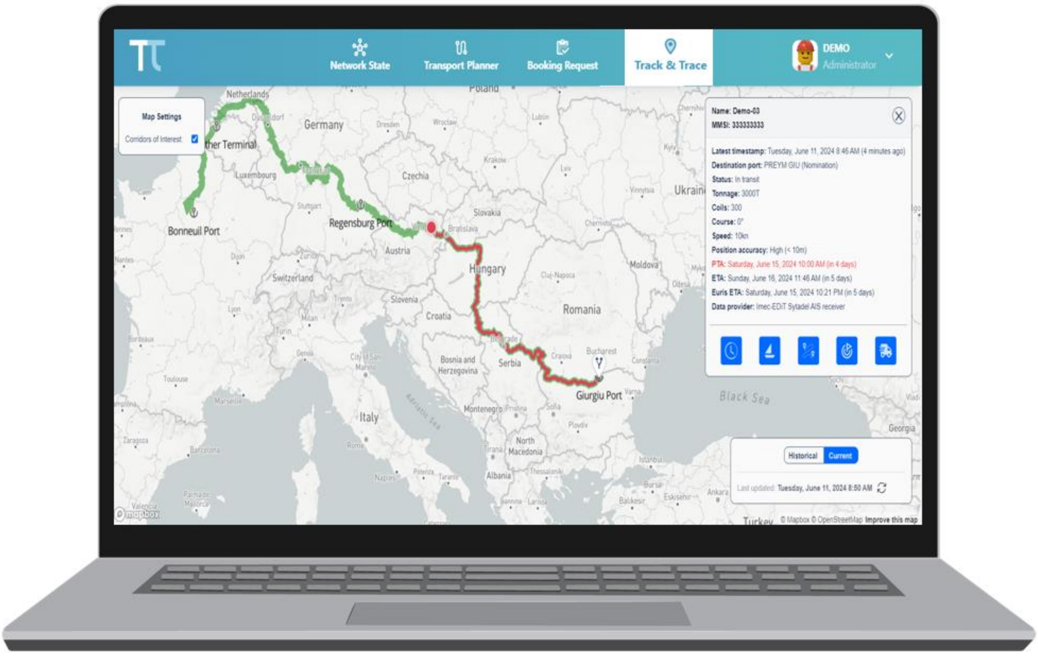

Figure 17: the track & trace platform with expanded capabilities integrated in PILL and

This Living Lab ran for 2 months. However, since the information was fictional, the messages were forwarded to an imec email address. No delays were identified over the 2 months, but the Living Lab was demonstrated with several simulated delays that triggered rerouting. The results were presented to Arcelor Mittal after the test.

4.6 Outcome of PILL POC 2

Overall The outcome of the PILL POC 2 were a success and seen as a significant contribution to the PILL POC 1. Further limitations and next steps were identified for each of the validation challenges and will be further detailed in the next chapter Next Steps.

Decentralised network

Can we automatically identify and discover new nodes that join our network?

The combination of the PI-client and data space framework strenghtened the decentralised network and allowed for automatic identification and discoverability of new peers on the network. This resulted in a demonstrated framework for a decentralised network that allows for connectivity, identification and discoverability of new peers.

However automated collaboration beyond information sharing still requires further investigation (see next steps).

Interoperability

Can we create synchromodality by combining live location and ETA prediction with the route planner?

The current solution allows for real-time replanning of vessel cargo, which was considered a big leap forward. However for true synchromodality, the actual rebooking of the cargo should also be automated. This requires further investigation (see next steps).

Data model

Does our PILL data model work with data space framework?

We sucesfully integrated the PILL POC 1 data model in the data space framework, allowing for decentralised information sharing of cargo location and network state.

However the data space framework is limited to simply data sharing. Sharing more interactive information -

such as specific events or processes (e.g. a booking request)- need additions to the data space framework which require further investigation (see next steps).

PI business value

What is the value of real-time rerouting on planning efficiency and resilience?

The value was experienced as a significant leap forward from the current way of working and the PILL POC 1. However for true synchromodality, the solution should also integrate more interactive information sharing - such as specific events or processes (e.g. a booking request). This requires further investigation (see next steps).

5 Next steps - follow-up projects

The solutions of the PILL living labs, ended in a demonstration and validation of the PI blueprint principles and a route planner as first PI application, with real-time replanning capabilities that reduced the gap towards true synchromodality. However, the capabilities of this PI route planner are limited to tracking the location of cargo and calculating alternative routes. Booking and planning of the routes still requires manual interventing. If this gap could be bridged, we can speak of true synchromodality.

However, the current technological framework is limited to information sharing. To achieve this synchromodality, we need real-time interoperability not only on information sharing, but on events and statusses: process sharing.

Integration of this process sharing in the current framework of PILL will be the next step for this consortium. For a more detailed view on this valorisation plan, we refer to deliverable 5.3.