Progress towards Federated Logistics through the Integration of TEN-T into A Global Trade Network

D3.1 LL1 Specifications and baseline measurements

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
3PL	Third Party Logistics
5G	Fifth Generation of Mobile Communication Systems
ACL	Access Control Lists
AEM1	Asia Mediterranean 1
AGV	Automated Guided Vehicle
AR	Augmented Reality
B/L	Bill of Lading
B2B	Business-to-Business
B2C	Business-to-Consumer
BC	Blockchain
CA	Certificate Authority
COARRI	Container discharge/loading report message
CODECO	Container gate-in/gate-out report message
DG	Dangerous Goods
DSS	Decision Support System
D2D	Door to Door
EDI	Electronic Data Interchange
EGTN	EU-Global Transport &Logistics Networks
ETA	Estimated Time of Arrival
EU	European Union
FIFO	First In First Out
GRAI	Global Returnable Asset Identifier

GPU	Graphics Processing Unit
GPS	Global Positioning System
HQ	High Quality
ICT	Information and Communication Technologies
KPI	Key Performance Indicator
LL	Living Lab
LL1	Living Lab 1
LMD	Local Mean Decomposition
LTE-M	Long Term Evolution
MSP	Membership Service Providers
NB-IoT	Narrowband - Internet of Things
NVOCC	Non Vessel Operating Common Carrier
PCS	Port Community System
PI	Physical Internet
POD	Proof of Delivery
SLA	Service Level Agreement
SSCC	Serial Shipping Container Code
T&L	Transport and Logistics
T/H	Temperature and Humidity
TEN-T	Trans-European Transport Network
TTW	Tank to Wheel
UC1	Use Case 1
UC2	Use Case 2
WTW	Well to Wheel

1 Executive Summary

This document provides a detailed description of LL1's specifications and the implementation plans for optimising door-to-door logistics in the connection between Asia and the Mediterranean corridor through the use of technologies such as blockchain, artificial intelligence (AI) or the Internet of Things (IoT), along with application of Physical Internet (PI) concepts. As part of this work, the deliverable includes an overview of the assessment plan for the infrastructure corridor analysis and the simulation-based designs under developed, and to be integrated as part of PLANET EGTN infrastructure.

Based on LL1's vision, the main objectives of this deliverable are: (i) to identify LL1 goals in technical and business domains; (ii) to define a set of technical requirements to be addressed by the technological solutions designed to be applied in LL1, (iii) to specify the test planning procedures and define the evaluation plan needed to test the different systems and applications developed in LL1, and (iv) to define Living Lab's organizational structure and implementation & assessment plan that would materialize the above objectives.

To test PLANET's solutions and concepts LL1 is segmented in two use cases: use case 1 is about containerized cargo optimization between China and Spanish hinterland, through the main Spanish ports; and use case 2 focus on warehouse operations optimization and last mile efficiency and sustainability. According to PLANET project objectives and challenges, the above mentioned Use Cases are employed to examine the role of new technologies on EU's strategic transport corridors and they can be summarized as follows: (i) Blockchain (BC) technology for paperless and real-time secure data sharing among port community actors; (ii) Artificial Intelligence (AI) combined with Physical Internet (PI) principles for better forecast and intelligent decision at logistics nodes for dynamically identified optimized routes; (iii) Internet of Things (IoT) for tracking data remotely and monitoring container position and cargo status; (iv) Machine Learning (ML) and Data Analytics for warehouse demand forecast and last mile collaboration; (v) Digital clones for warehouse .

Finally, to assess the impact of the innovations adopted as part of the Living Lab roadmap, the project has identified a set of Key Performance Indicators (KPIs) that will allow to quantify the benefits introduced by the different technological solutions. KPIs are defined and classified according to the technology innovations and compared against existing baseline measurements.

2 Introduction

PLANET LL1 evaluates how novel technologies and concepts such as blockchain, Artificial Intelligence, Internet of Things or Physical Internet can enhance the efficiency of the processes and operations performed along the door-to-door transport and logistics in the link between the Maritime Silk Road and EU internal corridors. To that end, LL1 is divided in two different use cases: (i) UC1 on the optimization of maritime and terrestrial transportation of containerized cargo between China and Spain, and (ii) UC2 on the automation of warehousing operations towards the creation of intelligent logistics nodes.

In this context, the main objective of this document is to provide a detailed description of LL1 specification and implementation plans for the different initiatives to be developed as part of LL use cases.

As part of LL1 specification, the deliverable will define the scope of work of UC1 and UC2, describing the different activities to be performed and examining the application of new technologies and secure and privacy-preserving mechanisms for reinforcing strategic transport and logistics supply chains between EU and China. Complementing this aspect, the document aims also at describing LL1 AS-IS situation regarding infrastructure corridors and the exchange of information flows in transport service contracting and maritime and terrestrial transportation planning.

D3.1 also aims at defining the LL1 goals in technical and organizational aspects such as envisioned physical and information flows, interoperability between different platforms, envisioned business models, logic and rules to be followed for intelligent decision-making algorithms, business drivers for digital clone applications and the impact assessment of adopted innovations. To complement these goals, baseline measurements and target values are defined in the shape of Key Performance Indicators to assess the impact of LL technical development.

After that, the document will define a set of technical requirements and KPIs for the different technologies and concepts exploited in UC1 and UC2 use cases, i.e., EGTN infrastructure, blockchain and IoT technologies, AI-based decision-making algorithms, digital clones. Complementarily, simulation-based designs for LL's EGTN will also be addressed.

According to the definition of requirements and LL goals, this document targets the definition of a test planning strategy based on the definition of test cases, where the role of actors and involved systems will be identified. After that, an execution plan will be defined for the set of test cases, specifying the expected test results and the evaluation plan.

Finally, D3.1 will also serve as reference document for defining the LL1 organisational structure, where roles and responsibilities will be identified for all partners involved. As part of this LL planning, implementation, innovation and assessment plans will also be drafted.

In the following chapters, the mapping of these objectives with the expected PLANET outputs is detailed together with the structure of the current document.

2.1 Mapping PLANET Outputs

The purpose of this chapter is to map PLANET's Grant Agreement commitments, both within the formal Deliverable and Task description, against the project's respective outputs and work performed.

Table 1. Adherence to PLANET's GA Deliverable & Tasks Descriptions

PLANET GA Component Title	PLANET GA Component Outline	Respective Document Chapter(s)	Justification
DELIVERABLE			
D3.1 LL1 Specification and Baseline measurements	*This deliverable will provide in-depth analysis of the current situation, including identification of key needs and problems affecting global transport, definition of use cases, KPIs and the respective tests and produce the complete definition of the organization and planning for the LL.*	*Chapters 4-6, 8-9*	*Chapter 3 describes the two different use cases in LL1.* *Chapter 4 identifies the AS-IS situation for infrastructure corridor and information flows* *Chapter 5 and 6 identify the goals and requirements to meet for addressing use cases.* *Chapter 8 defines the planning of tests, expected results and evaluation procedures* *Chapter 9 describes the LL organization and planning*
D3.1 LL1 Specification and Baseline measurements	*The report will also address simulation-based designs for the LL's EGTN.*	Chapter 7	*Chapter 7 describes simulation-based designs.*
TASKS			
ST3.3.1 LL AS-IS analysis and detailed specification and plan	*ST3.3.1 LL AS-IS analysis and detailed specification and plan will provide an in-depth analysis of the current situation, including infrastructure analysis for the corridor as the basis for the identification of main needs and problems affecting global transport corridors, warehousing and last mile distribution, and the final selection of the specific problems that will be addressed in the LL.*	*Chapters 3 and 4*	*Chapters 3 and 4 describe LL use cases and activities to be carried out as well as the current situation of infrastructure corridors and information flows.*
	This subtask will provide a complete definition of organization and planning of the LL1, LL2 and LL3. More specifically, (i) th purpose of the test; (ii) the actors and systems involved; (iii) the link with the EGTN	*Chapters 5-6, 8-9*	*Chapter 5 details the business models and data sharing rules for decision making algorithms.*

	technological framework and infrastructure designed in WP2; (iv) the plan and calendar for the preparation and execution of the test, as well as for the analysis of results; (v) the business model, data sharing, rules for intelligent decision making and incentive system for the implementation of the solution or concept being tested; (vi) the related KPIs for evaluation; (vii) the expected results and (viii) specification of surveys from LL actors to ascertain impact KPIs as specified in chapter 3.1.		*Chapter 6 enumerates requirements and KPIs for addressing LL1 use cases.* *Chapter 8 describes test cases and actors and systems involved together with expected results and the evaluation planning* *Chapter 9 describes the LL organization and planning*
	Simulation based designs of each LL EGTN of a PI-inspired network including entry nodes (ports or inland terminals, warehouses, intermediate TEN-T Nodes and city-hubs) will be produced	*Chapter 7*	*Simulation-based designs of LL1 including the ports and warehouses will be developed in Chapter 7.*

2.2 Deliverable Overview and Report Structure

The rest of this report is structured in chapters as follows:

Chapter 3 describes LL1 scope of work, which has been specified for UC1 and UC2 by describing the corresponding activities.

Chapter 4 provides an analysis of LL1 AS-IS situation focusing on infrastructure corridor and information flows aspects. After that, LL1 goals are specified in

Chapter 5 for different technical and business segments.

Chapter 6 describes the technical requirements to be met by the different technologies and concepts for addressing the corresponding use case needs.

In Chapter 7, simulation-based designs are described focusing on the PI nodes considered in this LL.

After describing the goals and requirements, the required tests and demonstrations are planned in Chapter 8, where test cases, actors and involved systems are described. This chapter also describes the execution plan for these tests and the evaluation and validation methodology in each case.

Chapter 9 details the LL organization and planning focusing on the organizational structure and describing implementation, innovation and assessment plans.

Finally, conclusions and references are addressed in Chapter 10 and 11, respectively.

3 Living Lab 1 scope of work

LL1 aims at testing new solutions (IoT, AI, blockchain) and concepts (PI) to improve process, operations, and efficiency along D2D transport chains linking China with Spain.

Two use cases will be developed:

1. Use case 1 on improving container cargo operations between China and Spanish hinterland.
2. Use case 2 on optimizing warehouse operations and automation and last mile deliver efficiency and sustainability.

3.1 Living Lab 1 Use Case 1

The use case 1 will be developed by performing the following activities:

1. Intelligent decisions at transport and logistics hubs (operations and routing):
   i. Simulation and assessment of a real-time synchro modal planning approach aligned with PI principles where the port-terminal logistics hubs provide optimized dynamic routing of containers through the network considering capacity, level of service and cost of the multiple modes of transport available; the connection of the Spanish network with the European TEN-T will be assessed.
   ii. Application of intelligent algorithms (based on AI machine-learning) for the detailed assessment of the impact of route changes of large oceanic container ships on terminal operations, considering the necessary inland transport re-routing of shipments.
2. Extend the simulation performed in activity 1 to the last mile delivery, testing of a PI network, including entry nodes (ports) and adding warehouses (DHL) and city-hubs (CityLogin) using the EGTN Architecture designed in WP2. Specification of a PI network in Spain, by providing intelligence to the entry nodes to take decisions and linking them to the automated warehouse nodes that will then be connected with the city nodes. Activity 2 is a common activity between UC1 and UC2.
3. Develop the blockchain technology at Valencia Port's hinterland, managing multiple interactions and transactions during import procedure with a large number of different stakeholders, public and private, including port and maritime authorities, customs and other inspection bodies, transport companies, port terminals and rail terminals, freight forwarders, importers and exporters, etc. Explore the possible interoperability in between independent blockchain platforms: connectivity between Valencia port blockchain and DHL blockchain, and interoperability with BlockLab (LL2).
4. IoT deployment for end-to-end visibility over different operators and means of transport.

3.2 Living Lab 1 Use Case 2

The use case 2 will be developed by performing the following activities:

1. Intelligent decisions at transport and logistics hubs (operations, transport, and warehousing)
   i. Enhance predictive logistics planning by applying Data Analytics & Machine Learning through a prediction model for volume flow into warehouse (Demand Forecast)
   ii. Based on the Demand Forecast model apply Simulation for optimization possibilities in terms of resources and warehouse operations
2. Simulation of optimal routes to deliver goods coming from ports to warehouses and city-hubs to test the PI Network. Assessment of the impact of green vehicles replacement (DHL vs CityLogin), apply algorithm for last mile collaboration for urban uncertainty and use of Artificial Intelligence and Blockchain for Smart contracts.
3. IoT deployment for end-to-end visibility over different operators and means of transport

4 Living Lab AS-IS situation

In Use Case 1, the current situation of transport containerized cargo from China to Spain is analysed considering the different activities identified:

- In the activity 1 and 2 on Intelligent decisions at transport and logistics hubs (operations and routing) and PI, the focus will be on import operations from China ports to Madrid involving two maritime routes from China to Valencia served by AEM1 and AEM2 COSCO's oceanic service lines, then pre-defined inland movements to Madrid dry port by rail and to customer final destination by truck. Additional routes from China ports to Spain, served by AEM1, AEM2, AEU2 and AEU6 COSCO's service line with final delivery to end customer destination by truck, will be also considered. The analysis of these routes will support identification of possible optimisation through the implementation of the intelligent algorithm and PI concepts.
- At local level, Activity 3 on blockchain is involving inland transport of containers from / to Valencia port to / from Spanish hinterland, finding possibility to improve document exchange and reduce paper-based processes
- Activity 4 on testing of IoT devices will support the monitoring of container position and cargo status in real-time along inland routes from Valencia port to DHL warehouses.

In Use Case 2 the current situation is analysed: transport containerized from Valencia Port arrives at DHL warehouse, container is unloaded, and then deliver pallet/parcels to final destination with standard truck/van.

Different situations to be explored:

- The activity 1 is focused on the arrival of the container to DHL warehouse involving not only warehouse operations but also transport from warehouse to final destination in order to improve operations. Analysis will take into consideration transport and human resources optimization combined with AGVs. (AS-IS situation is not including Demand Forecast/ Simulations).
- The activity 2 is more focus on the complete PI Network in Spain and how material flow could be improved at each node and their interconnection (AS-IS situation is not including PI principles, green vehicle replacement algorithm for last mile collaboration and use of Blockchain/smart contracts).
- Activity 3 will analyse the tracking and tracing system and how it can be improved though IoT devices (AS-IS situation is not including sensors for tracking and tracing).

4.1 Infrastructure Corridor Analysis

Following the activities identified and described in Section 3.1, the infrastructure corridors will be analysed per each use case.

UC1

The port-logistic sector and its associated transport corridors are key economic drivers for keeping the leadership and competitiveness of the European Union in the present circumstances of a world pandemic. Moreover, the importance of European ports as strategic logistic hubs that connect global supply chains and enable international and intra-European trade is undoubtedly decisive for boosting the EU economic and trade activity while maintaining environmental sustainability of the passenger and freight transport sector.

For decades, ports and maritime transport have increased their capacities and infrastructures to respond to the growing traffic volumes and cargo flows. However, this continuous growth has been taking place with a parallel structural fragmentation of the ecosystem of agents that operate along global supply and maritime-port logistic chains. This fact leads to the current inefficiencies and bottlenecks at operational level of ports, port terminals and, in general, the maritime and land transport corridors: unnecessary waiting times on the berth and land interfaces of ports, increased energy consumption and generation of greenhouse gas and pollutant emissions are some examples of the inefficiencies mentioned [1].

Activities 1 and 2

In order to mitigate the abovementioned inefficiencies, the first scenario has the aim to enhance transport planning by applying Artificial Intelligence and Machine Learning, identifying real-time optimal routing considering synchro-modality, therefore supporting daily decision-making and improving Transport Service Level. The identification of optimal routes will consider minimization of carbon footprint, costs and time impact.

The AI will be also used to assess the impact that changes out of planned schedules in maritime routes may have on inland transport of shipments. This impact would depend on identifying the parameters that most affect particular corridors and their availability in the shape of data, which would be used by AI models to output the required forecasted information. For example, it could happen that due to unplanned events (weather conditions, traffic congestion, etc.), containers may not be discharged on time at Valenciaport terminals. Under these circumstances, new alternatives for assigning alternative port call in other ports should be studied and decided with short notice. The intelligent algorithms will then support line planners during daily decision-making procedures to identify alternatives of discharging container at a new port and re-route inland transport of shipments. It will be developed to analyse and evaluate different alternatives estimating effects and costs for the shipping company.

Matters to be addressed:

- Complexity of line planner decision making and lack of support tools: currently there are no line planning software tools (only bay planning software) used to carry out such tasks, hence all decisions made by a shipping company's line planner are carried out manually with the information provided from a number of different actors involved in the supply chain (local agents, company's headquarters and ship captain). Before achieving fast, efficient and cost-effective solutions, a necessary provision of validated information is needed, that consequently relate to time-consuming efforts, which could be streamlined.
- Information dependency: A line planner depends on the information provided by several different parties (local agent, port and terminal information; ship captain information and ETA simulations; company headquarters' information; etc.) to be able to provide solutions. Last minute information updates can force last minute decision changes.

The second scenario addresses the implementation of PI principles in order to simulate a real-time synchro modal approach, and to identify the optimized route of containers through the inland network corridors considering capacity, level of service and cost of transport modes available.

In the current situation, real time information is not used for optimized routing. Once full cargo release is generated, the customer sends the request of transport (including the route plan) to COSSP to organize it. In the case where inland transport is managed by rail, the customer first requires information on date and time of container arrival at the rail terminal. Only in few cases and when the last mile delivery is managed by COSSP, the customer also provides details on possible dates he wants to receive container at destination. The transport department then gets in contact with the rail operator to ask for slot availability for next days. Once received, COSSP provides information to the customer who then sends the final request to receive the container at final destination and COSSP arranges the transport orders. It is important to underline that requests are managed according to a FIFO logic without considering customer instruction on delivery date and time.

Activity 3

COSCO is a global operator coordinating complex supply chains through multimodal corridors along the Maritime Silk Road. This requires multiple interactions and transactions along complicated supply chains, with a large number of different stakeholders, public and private, exchanging data and using their local systems: port and maritime authorities, customs and other inspection bodies, transport companies, port and rail terminals, freight forwarders, importers and exporters, banks, etc. The processes and the way to perform these interactions and transactions depend on the country, the port, the terminal, or the specific stakeholder involved. In many cases, these transactions are already electronic but not optimized because same information has to be sent several times to different actors in the same Port area, the electronic document exchange (such as the EDI) still has a lot of troubles including complicated standards and delay of data transfer. In some other cases, they are still paper based. Digitalise and optimise these transactions using blockchain will improve interactions, reducing documentary time and costs. All actors will be identified in the blockchain with different permissions to access information in real time, reducing respite or documentation loss.

Activity 4

The aim of this activity is to be able to get tracking data remotely in real time of the containers in order to monitor container and cargo which will help to improve operations. Furthermore, this gives the opportunity of having a logging of historical events of the shipment during the whole trip and this will be valuable in case of future disputes.

Foreseen connection with the blockchain platform developed in the activity #3. Data and events are registered in the blockchain and can be available to actors interested.

The actual scenario is that no sensors are installed in containers to collect relevant data. The only information available of the container is in the terminals regarding the charge or discharge but not in real time, and its location during the ocean trip “through” vessel position.

For instance, in the case where some incidences happen to container (e.g. not optimal good condition due to changes in the temperature and humidity in the container during transport, or container gets damaged by dumping). In these cases, nowadays, the control of when and where this event has occurred is not available, generating conflicts between customer and other actors.

So, the data stored can be useful to improve operations and control. In the cases described, COSSP can use data stored by the sensor to verify the container status during and after the “trip/transport”. Other type of data, like crossed countries or seal status, can be useful for customs control.

UC2

Activity 1

Scenario 1 main objective is to enhance predictive logistics planning by applying Analytics and Machine Learning. Data is claimed to have taken the place of oil as the world’s most valuable commodity, and logistics players operate in a particular data-rich environment, handling millions of pieces of information about customer orders, shipping movements, and the location and conditions of assets.

Historical data from DHL (inflow warehouse material) will support the development and refinement of a prediction model for volume flow into the warehouse. Based on the outputs from the Demand Forecast model, we will be able to simulate warehouse operations to optimize resources (transport and human).

The past several years in the logistics industry have featured more transformational change than in perhaps the previous century, and the full effects of this are just beginning. The maturation of globalization, the exponential rise of e-commerce, the constant threat of technology disruption, and, most recently, the coronavirus pandemic have fundamentally shifted the entry costs of doing business in the 21st century. From collaborative robotics to big data analytics, artificial intelligence, and the Internet of Things, logistics professionals have had to make sense of wave after wave of disruptive technology, driving higher levels of digital maturity. For this reasons, Activity 1 will address following matters:

- Predictive logistics remains the most important AI application for industry professionals, given the abundance of supply chain data, as well as better machine-learning algorithms from which to draw predictive insights. From capacity planning and forecasting to network optimization, the predictive capabilities of AI are helping logistics operators make precise decisions to proactively streamline operations. For instance, with double-digit e-commerce growth increasing last-mile diversity and complexity, this final segment of delivery is still the most expensive link of supply chains. The challenges of balancing delivery time windows, fuel consumption, travel distance, traffic patterns, load capacity, and ad hoc pickups while simultaneously communicating accurate arrival times and updates to customers make the last mile difficult and costly for operators. Instead of waiting for the material arrival to the warehouse, AI will go beyond same-day or same-hour, by supplying a volume prediction to optimize use of human resources (to assess number of persons needed for next day in the warehouse) and transport needs (possibility to know how many vehicles well be needed and to plan in advance deliveries with a better time-frame).

- Simulation is becoming increasingly important tools for supply chain management. The ability to run global supply chains at peak efficiency is more challenging as worldwide complexity grows. Warehouse operators and supply chain managers can make better decisions with granular visibility of processes like order management, and inventory levels and resource utilization become transparent in live dashboards. By uncovering patterns and anomalies in advance, operators can do things like allocate the optimal number of staff to certain tasks within a warehouse, group similar orders into the most efficient pick routes, and determine the optimal number of staff and assets between a group of warehouses. Simulation models take optimization one step further by allowing logistics planners to test the impact of various levers that could be costly to execute on the ground. From exploring the consolidation of distribution centers to testing new delivery routes, simulations help answer service, cost, and risk questions in different scenarios.
- Warehouse digital clones are an ideal place for this technology to take hold in logistics. A virtual 3D model of the facility can be paired with inventory and operational data including the size, quantity, location, and demand characteristics of every item. In addition, digital clones can support the design and layout of new facilities, allowing companies to optimize space utilization and simulate the movement of products, personnel, and equipment. In the framework of the project we will take advantage of the Digital Clone develop by DHL ("Mercury", under pilot phase), to extract relevant information for simulation and data analysis purpose.

<u>Activity 2</u>

The second activity will support the implementation of PI Network principles based on the simulation of optimal routes to deliver goods coming from ports to warehouses and city-hubs. We will consider the different nodes as intelligent nerve nodes to reduce uncertainty (apply Algorithm for last mile collaboration), to automated tasks (use of AI and Blockchain for Smart Contracts) and to assess the impact of green vehicles fleet replacement in the last leg of the network (last mile). Activity 2 is a common activity between UC1 and UC2, integrating both use cases for the adoption of the PI Network principles. In UC2, we will demonstrate the link between the port facilities (UC1) together with the DHL warehouse (UC2).

<u>Activity 3</u>

The third activity is based on the deployment of IoT devices for the container tracking. Connected containers can provide real-time visibility of global cargo flows, enabling customers, facility operators, and carriers to obtain critical information of the supply chain and the goods held inside. Utilizing sensors and next-generation wireless networks, connected shipping containers can act as point measurements of when, where, and possibly why disruptions and delays occur, all the while empowering handlers with opportunities to proactively intervene and minimize impacts along the supply chain. Furthermore, outputs from IoT-connected containers can be integrated with operational data which, when combined with artificial intelligence and Blockchain, can transform ordinary warehouse into smart one. Optimized facilities, vehicle traffic, and efficiently orchestrated container movements will substantially increase logistics productivity and service quality.

This activity will address the following key opportunities:

- Increases the visibility, traceability, reliability, and security of logistics operations to enable a more proactive orchestration of tasks within the warehouse
- Real-time connectivity to improve service quality, optimize asset utilization, and shorten response times for operations support

Improved operational efficiency via automatically triggered actions from IoT data.

4.2 UC1 Information Flows

In Use Case 1, information flows related to maritime and terrestrial transport are used as the baseline for exploiting AI decision making algorithms in order to assess and optimize the impact of re-routing container ships and inland transport shipments. Additionally, the exchange of this information will also be assessed for the development of BC platforms. In the following subsections, information flows related to both domains are described:

4.2.1 Maritime transport planning

The process of maritime transport planning is controlled by COSCO HQ. The planning office in HQ receives the loading forecast from each port, that includes:

- Quantities to be loaded detailed:
    - Per cargo agent.
    - Per POD.
    - Per container type.
    - Per weight range.

- Details of special containers to be loaded:
    - Reefer cargoes.
    - DG cargoes.
    - Other special cargoes (under deck, alcohol, etc…)

With all this information and taking also into consideration the quantities to be discharged in the port, the planner sets up the loading plan and sends it to the Terminal.

Upon arrival, the terminal provides the provisional stowage plan to the chief officer of the vessel who checks stability, stack weight, dg cargo segregation, etc… and makes the changes needed.

Once the stowage plan is verified and approved by planner and chief officer, loading operations can start.

4.2.2 Land transport planning

The land transport planning process consists in the following steps:

1. The Transport department makes a tender to receive offers for a set of land transport services to be performed during a period.
2. The Transport department selects a set of transport service providers (both rail and truck) and defines with them the land transport services, routes, conditions, and rates.
3. The Equipment Control department generally provides to the Transport department the list of restitution depots or terminals for empty container pick-up or delivery instructions.
4. The Import or Export department receives the transport notifications including instructions from clients and sends this information to the Transport department.

5. The Transport department searches for the better transport option by considering the service rate agreement previously negotiated with the client.
6. The Transport department generates the transport order message through the Valencia Port Community System (ValenciaportPCS). These messages are received by the road carrier, the stevedoring company (terminal) and/or the empty container depot. Due to the closing time procedure, established at the Port of Valencia, there is a deadline for issuing this message.
7. The transport department receives confirmation from the transport provider.
8. The transport department follows the main transport events, informs the client - if needed or requested - and reacts in case of transport incidences happen by re-planning and/or re-routing the initial schedule.

4.3 UC2 Information Flows

To understand the information flow, we need first to understand the operation selected for the UC2. This UC has been stablished with data from one of our customers purposed to adapt the existing operation to the LL, feed the prediction model and improve the operational processes currently in place.

About DHL's customer:

- All kind of products for Pet Shop Chain Stores and pet's owners
- 65 shops in Spain
- Online channel: 2.500 orders/day (before Covid), 4.200 orders/day (after Covid)
- Retail channel: 4.000 pallets/months delivered in Shops
- More than 19.000 product references
- In the online channel the standard delivery commitment is 24/48 hours
- In the retail channel the standard delivery is twice a week

About DHL's warehouse:

- DHL Warehouse located in Seseña Nuevo, Toledo (South Madrid)
- A single "Omni-channel" platform with 15.000 m2 (at room temperature)
- Currently in the daily basis we have 70 workers and 8 robots
    - Merchandise reception: 8 people
    - Loading: 2 people
    - Picking: 46 people
    - Forklift Operators: 10 people
    - Loading belt: 4 people
    - 8 robots for picking assistance
- AGV's are operated 24/7, 365 days/year
- The robots assist the picker in the picking task, indicating the correct parcel to be picked up (quantity, location in the warehouse, exact place in the shelving, checking weight, reference, etc)
- Picking operator are continuously assisted by the robots to increase the picking process and to reduce errors
- Transport department have a visibility of volume coming to the warehouse with 24 hrs in advance. Therefore, they can plan the exact number of vehicles to be used next day, but not in a longer term.

The complete transport process as IT-IS is described in figure below:

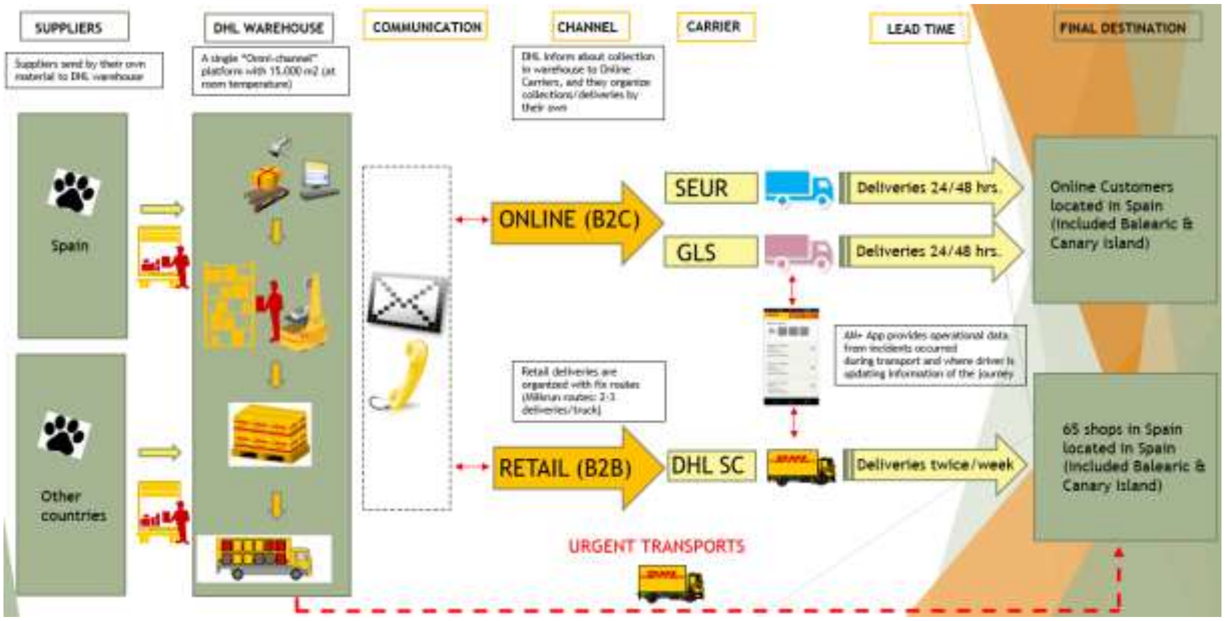

Figure 1. DHL Transport process

In order to integrate COSCO SHIPPING LINE and CityLogin in the scenario and to test the different technologies in the LL, we have modified the existing DHL operations in two aspects:

1. Material arrives from Valencia Port to DHL warehouse (instead from Pet Shop customer)
2. For the last mile delivery, material is distributed in Citylogin's green vehicles for the B2C (instead existing carries with standard vehicles)

In figure below, we can see the transport process selected for the UC2 (changes highlighted in blue):

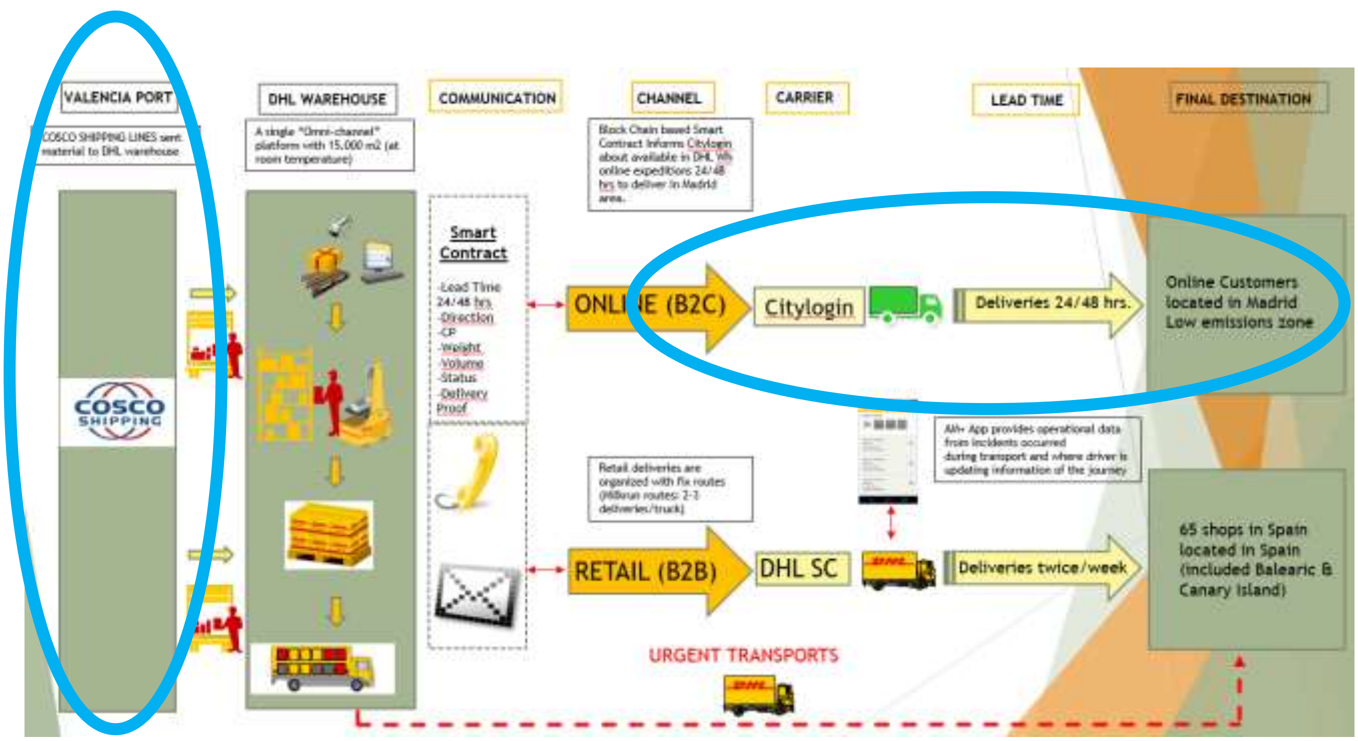

Figure 2. DHL Transport process adapted to LL1

4.3.1 Land transport planning (Port to warehouse)

Material is transported from the Port of Valencia to DHL warehouse. In this transport leg, we are not considering negotiation, transport rates, etc. as material comes directly from the customer. There is already a contract in place with transport conditions, rates, cut off times for reception, deliveries, etc. together with a SLA.

The land transport planning process consists in the following steps:

- Customer sends Advance Shipping Notice to DHL to inform about material to be deliver in DHL warehouse (24 hours before):
    - Container type (dimensions)
    - Container weight
    - Total number of containers
    - Customer Reference Number
    - Estimated time of departure from Port
    - Estimate time of arrival to DHL warehouse
- DHL agrees time window with customer for container unloading
- Customer sends vehicle to warehouse

4.3.2 Warehouse planning

Material arrives to DHL warehouse:

- Receiving: Receiving is the first warehouse process and one of the most crucial. To perform the receiving process properly, the warehouse should be able to verify that it has received the right product, in the right quantity, in the right condition, and at the right time. Failing to do so will have consequent impacts on all subsequent operations. Receiving also involves the transfer of responsibility for the goods to the warehouse. This places accountability on the warehouse for maintaining the condition of the goods until they are shipped. Properly receiving cargo will allow you to filter out damaged goods and avoid liability for them.
- Put-Away: Put-away is the second warehouse process and is the movement of goods from the receiving dock to the most optimal warehouse storage location. Failing to place goods in their most ideal location can impair the productivity of warehouse operation.
- Storage: Storage is the warehouse process in which goods are placed into their most appropriate storage space. When done properly, the storage process fully maximizes the available space in your warehouse and increases labour efficiency.
- Picking: Picking is the warehouse process that collects products in a warehouse to fulfil customer orders. Streamlining of this process should also focus on achieving higher accuracy, as errors can have a direct impact on your customer satisfaction and in costs.
- Packing: Packing is the warehouse process that consolidates picked items in a sales order and prepares them for shipment to the customer. One of the primary tasks of packing is to ensure that damages are minimized from the time items leave the warehouse. Additionally, packaging must be light enough so as not to increase the weight of the goods and minimal enough to control packaging costs.
- Shipping: Shipping is the final warehouse process and the start of the journey of goods from the warehouse to the customer. Shipping is considered successful only if the right order is sorted and loaded, is dispatched to the right customer, travels through the right transit mode, and is delivered safely and on time. In this specific scenario we deliver to:
    - B2C: delivery commitment is 24/48 hours
    - B2B: delivery is twice a week

4.3.3 Last mile delivery Planning

As explained before, DHL has two specific deliveries:

B2B Channel:

- 65 shops in Spain
- Retail channel: 4.000 pallets/months delivered in Shops

In addition, the B2C channel, in which we are going to focus for the UC2 demonstration´s purpose (online channel: 2.500 orders/day (before Covid), 4.200 orders/day (after Covid))

The last mile delivery planning process consists in the following steps:

- DHL planners organize routing for next day: numbers of vehicles, routes, stops, collection and returns, etc.
- Once material is prepared in the shipping area of the warehouse, material is collected by a standard truck/van (depending on transport needs)
- Material is delivered to final customer.

The complete AS-IS situation for the information flow in UC2 is shown in figure below:

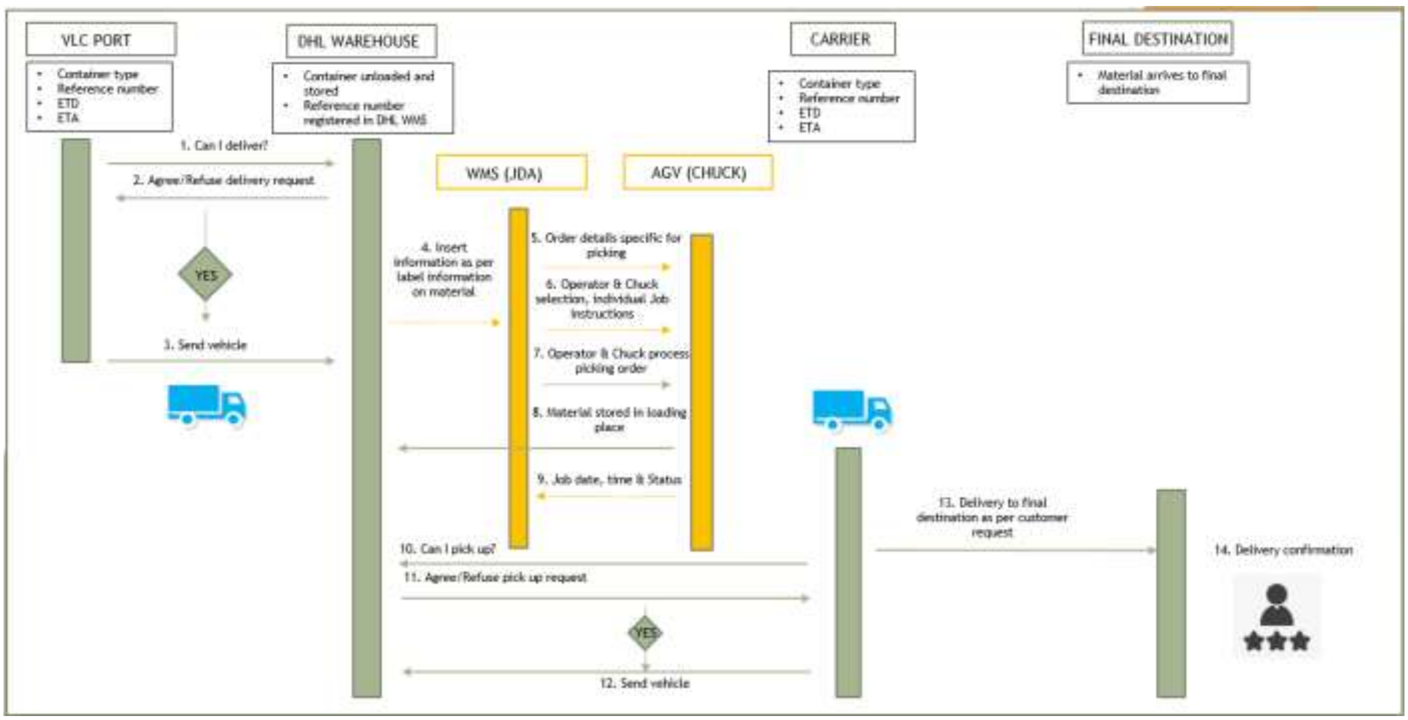

Figure 3. Information flow in UC2 (AS-IS situation)

5 Living Lab Goals

5.1 Envisioned physical flows

Physical Internet concepts will be implemented to demonstrate the possibility to build flexible and resilient door-to-door-services, where logistics assets do not follow pre-defined transport routes, but these are dynamically calculated and identified at each logistics node, which has the intelligence to identified the optimal routing, considering historical and real-time data.

The PI Network framework will include main logistics nodes in Spain, which are entry nodes (Valencia, Barcelona and Algeciras ports), inland nodes, such as Madrid dry port, warehouses (DHL warehouses located in Madrid area) and city-hubs (City login hubs), to evaluate new possible optimal routes to deliver goods to destination. This scenario will also demonstrate interrelation between the use case 1 and use case 2. More specifically, the use case 1 will draw the current situation to transport containers from China to Spain and give input to the use case 2 to demonstrate connection between terminal hubs and automated warehouses nodes that will been then connected with city nodes.

The first step of this activity is the identification of PI Nodes and Corridors to be considered in the simulation. These are inputs from activity #1.

In the use case 1 main PI Nodes are the following:

Table 2. UC1 PI nodes

Nodes	Type	Identification
Entry node	Port	Valencia, Barcelona and Algeciras
Terminal hubs	Dry port	Madrid, Zaragoza
Final Destination	Warehouse	Customer warehouses located in Madrid area

The PI corridors of the use case 1 are the following:

Table 3. UC1 PI corridors

Corridor	Type	Identification
Maritime corridor	Oceanic routes	Routes from China (Shanghai) to Spain (Valencia), served by COSCO's service
Inland corridor	Rail routes	Routes from Valencia port to Madrid and Zaragoza dry ports
Inland corridor	Truck routes	Routes from Madrid dry port to customer warehouse final destination

The Simulation model will be then used to simulate new possible scenarios that allow linking terminal hubs with automated warehouse and then demonstrate connectivity between automated warehouses and city hubs.

In the use case 2 main PI Nodes are the following:

Table 4. UC2 PI nodes

Nodes	Type	Identification
Entry node	Route	Madrid area
Warehouse	Depot	Madrid area
Final destination	Madrid City	Customer house/office located in Madrid area

The PI corridors of the use case 2 are the following:

Table 5. UC2 PI corridors

Corridor	Type	Identification
Inland corridor	Truck routes	Routes from Valencia port to Madrid area warehouse
Inland corridor	Truck/van routes in Madrid City	Last mile delivery routes from warehouse to customer house/office final destination

To develop this scenario, following assumptions are considered:

- As COSSP and DHL cannot identify a common customer, hypothetical customers will be identified, this will also ensure involvement of CityLogin.
- COSSP can manage and control cargo at container level, no different units are managed, this means that its role in the simulation is reduced to provide data until containers arrive at Madrid dry port.
- Containers arriving at DHL warehouses are managed to create pallets and then parcel units are sent to CityLogin.

5.2 Envisioned information flows, addressing interoperability requirements.

5.2.1 Blockchain

In the activity #3 the aim is to develop a blockchain solution in Spain for paperless transactions & transport event registration between the port and logistics community, then foreseen possible connection with existing blockchains, s.a. DHL blockchain and BlockLab in LL2.

The focus will be on the transport documents and the container as the main two assets that involve multiple information exchanges and transfers between different stakeholders along the transport chain with the aim to foster digital integration and secure monitoring transactions among actors in a win-win strategy.

5.2.1.1 Scenario #1. Port Container Management

This scenario is focused on providing an interoperable business network for integrated data sharing from seaport (terminal) to hinterland, thus enabling better and faster interconnectivity when selecting a hinterland transport mode. This will be achieved by creating an on-chain distributed ledger solution for container data sharing between globally interconnected supply chains, seaports container participants and the hinterland. The general components and participants of this network are presented in Figure 4.

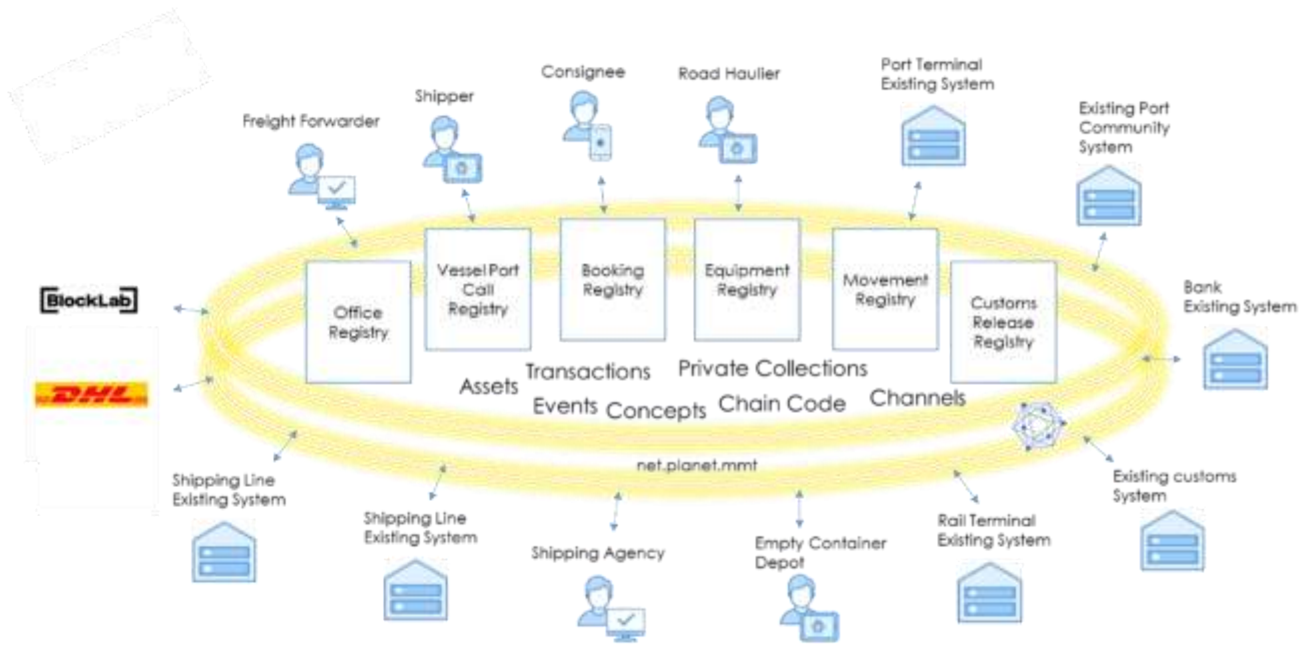

Figure 4. Port container management scenario

The port container management scenario will allow to identify and characterise the business network participants, the processes followed, the transactions, the documents and data sharing requirements, the transfer of responsibilities, the authorisations, and payments to check which take place in container logistics operations as well as the main associated bottlenecks.

5.2.1.1.1 Description of the container port logistics operations

The processes associated with container port logistics can be grouped into the following operations:

- Arrival of the ship
- Arrival of cargo
- Booking
- Container unloading
- Cargo and container release
- Container movements after discharge
- Container movements before loading
- Container loading
- Departure of vessel
- Payments

The details of the port logistics operations and the related transactions as well as the proposed data models for enumeration, participants, assets and transactions will be detailed as follows.

The following actors have been identified and considered for the business network model, as well as the roles (roles) that they can adopt in container port logistics:

- Shipping company (Carrier)

It is the company that transports cargo in containers using container ships. Confirms bookings and submits bills of lading. A shipping company, in addition to exercising the role of ocean carrier, can also act as owner of the ship.

- Shipping Agency

It is the company that represents the shipping company at a port. The same company can represent the shipping company in several ports and for this it can have several offices. A shipping agency can exercise different roles in the container's port logistics: agent of the sea carrier, agent of the owner of the ship, declarant in front of the port authority and customs, consignor, consignee, depositor, depositary, ordering party, land carrier, carrier railway, creditor and debtor.

- Trader

They are the companies that own the cargo and for which the containerized goods are transported. A merchant can exercise different roles in the container's port logistics, in addition to that of the cargo owner: declarant before customs, dispatcher, consignee, importer, exporter, depositor, depositary, ordering party, land carrier, rail carrier, creditor and debtor.

- Forwarder

In this group are circumscribed the companies (freight forwarders, shippers, logistics operators, 3PL, NVOCC, etc.) that deal with the administrative and logistical procedures necessary for the transport of goods, especially in ports. A freight forwarder can perform different roles in the container's port logistics: merchant representative, declarant to customs, dispatcher, recipient, maritime carrier (NVOCC case), depositor, depositary, ordering party, land carrier, rail carrier, creditor and debtor.

- Custom agent

It is the company in which its activity is limited only to being the representative of the merchant and the declarant before customs. The customs agent will act as the merchant's representative, the customs declarant and the creditor.

- Terminal

It is the company that stores the container, acting as its custodian. A terminal can be either a port terminal or an inland terminal. A terminal can play different roles in container port logistics: depositary, container handling and creditor.

- Empty depot

It is the company that exclusively stores empty containers, acting as a depository thereof. An empty warehouse will perform the role of depositary, container handling and creditor.

- Port Community System Operator (PCS)

It is the company that operates the port community system. The PCS has a special role of data aggregator and will be able to record transactions generated by other participants.

- Port Authority

It is the body responsible for managing the port. The port authority exercises the role of regulator of the port infrastructure, receiving the declarations required to exercise its function, mainly from maritime agents and terminals.

- Customs

Customs is the office in charge of controlling foreign trade operations, in order to register and control the international traffic of goods that are imported or exported and collect the records established by law. The main role played by customs in container port logistics is customs control, which includes fiscal control (import and export tariffs or duties and taxes), security (fraud and fight against smuggling), public health and statistics.

- Border inspection services

The border inspection services are the other agencies of the administration in charge of the sanitary and commercial control of the merchandise, and there may be different organisms for these functions (for example, external health, animal health, plant health, control of commercial policy, control of commercial quality, control of industrial products, protected species, ...). The main role played by inspection services in container port logistics is product control and inspections.

- Road carrier

It is the company in charge of road transportation of the container by truck. A land carrier can play different roles in container port logistics: road carrier, depositor, depositary, ordering party, creditor and debtor.

- Rail carrier

It is the company in charge of the rail transport of the container by train. A rail carrier can play different roles in container port logistics: rail carrier, road carrier, depositor, depositary, ordering party, creditor and debtor.

- Bank

It is the financial company in charge of the transfer of funds between a creditor and a debtor. A bank will act as a fund transferor.

The role of each actor will be reflected taking into account how the different parties are involved in a transaction or are registered in an asset. All the transactions that are shown in the container port logistics scenarios, except those related to payments, may be carried out by the PCS on behalf of the main actor or actors that can carry them out.

5.2.1.1.2 Participants and identities

The participants are the members of the business network. Participants can own assets and generate transactions. Participants will be registered in the business network as *Offices* by an authorized identity (usually the network administrator).

A participant will have a unique identifier and it can incorporate other properties that characterize it. A network participant can be assigned to one or multiple user identities that will be the ones that will access the business network.

An identity will be used to execute transactions within the blockchain business network and it will be associated with a participant. An identity is made up of a private key and a digital certificate that allows secure access to the network.

For the network model prepared in the project, only one type of participant has been defined:

- Office

The office will be identified by its tax identification code and the place where the office is located. For example, the Valencia office of COSCO Agency will be identified as A61361796@ ESVLC. Under this model it is important to highlight that the same company or organization could have different participants working in the network, each of them representing a different office.

5.2.1.1.3Concepts and enumerables

Concepts are data structures that represent structured properties of a participant, an asset, a transaction, or an event. For its part, an enumerable is a type of data that can take a value within a predefined set of values.

The following enumerable items are initially identified for the business model:

- Organization types
- Asset states
- Event types
- Event functions
- B/L types
- Payment methods
- Haulage arrangement types
- Container states
- Vessel operations
- Transport modes

For their part, the concepts that have been defined are:

- Concepts linked to the characteristics of an asset
  - Code
  - Address
  - Party involved
  - Reference
  - Required certificate
  - Goods item
  - Package
  - Dangerous goods
  - Equipment details
  - Container data
  - Seal
  - Oversize
  - Exchange rate
  - Charge
  - Amount
  - Measurement
  - Transport details
  - Cargo/Container movement details
- Concepts linked to transactions
  - Vessel port call declaration
  - Cargo summary declaration
  - Shipping agent declaration
  - Bill of lading declaration
  - Booking confirmation

- Container list
- Arrival notification
- Freight charges
- Cargo delivery order
- Transport order
- Container release order
- Container acceptance order
- Customs declaration data
- Preclearance data
- Inspection positioning
- Customs event

Concepts can include a set of properties that can correspond to data, other concepts, or links to network assets or participants. Properties that are lists of these types of elements are also allowed.

The concepts are very useful components for the elaboration of the business network model of this scenario since they allow to be extended in a very simple way and immediately this extension is expanded in all the assets and transactions of the model that use them.

In most cases, all the properties of a concept will be optional, and their use will depend on the specific resources that uses them, which can be a participant, asset, transaction, event, or other concept that includes it.

5.2.1.1.4 Assets

An asset is a tangible or intangible element whose representation is stored in the DLT registries of the World State Database. Assets must have a unique identifier that will allow them to be located and identified, and a set of properties that can correspond to data, concepts, or links to participants or other assets on the network. Properties that are lists of these types of elements are also allowed.

The assets that have been initially identified are:

- Vessel port call
- Bill of Lading
- Booking
- Container
- Movement
- Customs declaration
- Payment

5.2.1.1.5 Transactions

A transaction is the mechanism by which a participant interacts with the assets. The transactions will correspond to the smart contracts or chain code. Within a transaction you can determine the level of access and permissions that a participant has with the assets.

The transactions that have been initially identified are:

- Register a vessel port call
- Cancel a vessel port call

- Notify vessel arrival
- Get a vessel port call
- Add bills of lading
- Change bills of lading
- Remove bills of lading
- Add goods items
- Change goods items
- Remove goods items
- Get bill of lading
- Notify cargo arrival
- Cancel cargo arrival notification
- Set bill of lading charges
- Transfer bill of lading
- Request delivery
- Submit cargo delivery order
- Add booking
- Change booking
- Remove booking
- Set booking charges
- Get booking
- Submit consolidated discharge order
- Cancel consolidated discharge order
- Submit discharge order
- Cancel discharge order
- Report expected discharge
- Report discharge
- Add containers to list
- Change containers to list
- Remove container from list
- Get container
- Get container list
- Register customs event
- Request for authorities' intervention
- Submit intervention actions
- Authorise inspection positioning
- Cancel inspection positioning
- Submit inspection appointment

- Submit end of inspection
- Submit container release order
- Cancel container release order
- Submit container acceptance order
- Remove container acceptance order
- Submit transport order
- Cancel transport order
- Notify transport movement details
- Report container gate out
- Notify delivery of goods
- Notify reception of goods
- Notify container gate-in
- Submit transport subcontracting
- Cancel transport movement
- Get transport movement
- Set transport charges
- Submit VGM request
- Cancel VGM request
- Notify VGM data
- Set VGM charges
- Submit empty containers transfer
- Submit loading Order
- Cancel loading order
- Submit consolidated loading order
- Cancel consolidated loading order
- Report container loading
- Register charges
- Change charges
- Cancel charges
- Notify payment
- Get payment

5.2.1.1.6 Events

An event is a data structure that can be published by transactions to indicate to external systems that a relevant event has occurred in the ledger. Within the events themselves, the participants who can receive these events will be included in such a way that only applications that use authorized identities from these participants will be able to receive the events and get the related data.

Fort the business network a single event data model has been defined:

- Business event (BusinessEvent)

5.2.1.2 Scenario #2. Transport documents

This scenario is focused on sharing transport documents in digital form and complying all characteristics to be recognized by public authorities and regulations as valid transport documents. These documents are being used by shippers, consignees, road hauliers and public authorities in paper form which present several disadvantages in front of digitalized forms. With the latest amendments introduced in the Spanish regulations, these documents are accepted in digital form, however they should comply with certain requirements that will be addressed in this scenario. The general components and participants of this scenario are presented in Figure 5.

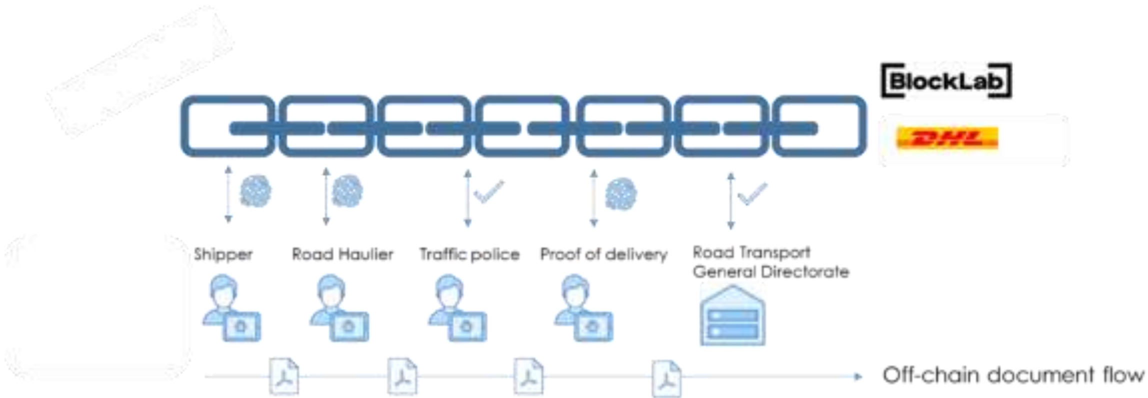

Figure 5. Transport documents scenario

In Spain there are two documents required for the transport of goods by road: the **consignment note** and the **control document**. The characteristics of these documents and the existing regulation up to now were hindering the possibility to move from physical paper documents to digital documents to be used during the transport execution. Recently, the regulation has changed to support both a digital consignment note and a digital control document.

In 2020, there has been approved a procedure by the Directorate of Land Transport administration for the authorities to recognize the digital form of the control document by using PDF formats without the need of a digital signature and it is a mandatory document that must accompany the goods as they move, and it must be carried on board the vehicle that make the carriage. Once the transport has been carried out, it must be kept for at least one year. The consignment note can act as a control document, as they contain equivalent data, but they can also be two separate documents.

On the other hand, for the consignment note to be legally valid it will require the signature by multiple parties and its purpose is:

- To constitute a proof of the receipt of goods, which proves the loading, dispatch and delivery as well as to confirm the normal status of the goods received or the report of any observed issues,
- To constitute a proof of the transport contract between the shipper and the carrier,
- To become part of the invoice from the transport company for the amount corresponding to the service offered, and

Sometimes, it can become a negotiable document or a document that represents the ownership of the goods, but these aspects are not common in road transport and they will not be considered in this use case.

Currently, for the container movements at the Port of Valencia, the data for transporting goods to and from the port is digitalized with the ValenciaportPCS platform, using structured data formats. However, this data is not recognized yet by the authorities as a "legal" consignment note nor as an official transport control documentation for the controls by the authorities during the road movements. Since 2012 a regulation was established for the “legal” requirements for an electronic consignment note, where a digital signature of the shipper and consignee was required, as well as a proof of delivery of the goods at destination. For the control document, it was only possible to use the paper form until 2019 when it was approved the Royal Decree 70/2019 of 15th February, which incorporated the legal possibility that both the consignment note and the control document may have electronic formats. In the Official State Gazette of February 22, 2020, the Resolution of the General Directorate of Land Transport has been published, which establishes the characteristics that must be met by administrative control documents in electronic support required in transport by road.

The electronic consignment note consists of an electronic record of data that can be transformed into legible writing signs. It will contain the same mentions as the traditional document of this type. Any request, declaration, instruction, order, reservation or other communication related to the execution of the transport contract can be made electronically when the parties have agreed to it in this way. The procedure used to prepare the electronic document must guarantee the integrity of the instructions it contains from the moment it has been prepared.

The parties involved in the execution of the transport agreement, the content of which is to be fully or partially documented in electronic format, must agree on the rules to which its operation will be adjusted in relation to:

- The method for preparing and submitting it.
- The guarantees regarding the maintenance of its integrity.
- The way in which the owner of the rights derived from the consignment note can demonstrate that it is.
- The way in which the possibility of corroborating its effective delivery to the recipient will be established.
- The procedures that will allow to complete or modify its content.
- The procedure through which, on occasions, there is the possibility of replacing the electronic document with another made by a different means.

The electronic consignment note must, of course, include the aspects in relation to what is normal in any document of this caliber. In addition, it must be emphasized that the process to be followed regarding the completion of the electronic document will always have to guarantee the morality of the instructions that appear in it from the moment it has been prepared. This will be considered fulfilled in the event that they are still complete, that is, they have not undergone alterations in any case, except unavoidable situations derived from use.

Another aspect to consider is that the instructions of the electronic consignment note must be able to be completed and / or modified with the assumptions generally provided for all consignment notes, so the procedure to follow is to enable the finding any modification, as well as ensuring the maintenance of the main indications.

The use of a blockchain DLT is very well suited for the implementing the electronic consignment note and control document with the data managed currently by the ValenciaportPCS system, taking advantage of the blockchain characteristics of consensus, origin, immutability and finality.

The information of the Single Transport Document (DUT) of ValenciaportPCS will be converted into a PDF/A document, so it will be able to accompany the merchandise electronically using hand-held devices (i.e. smart phone or tablet), not requiring its paper support. The PDF/A document will include all the data required by the consignment note and the control document. PDF/A will be stored off-chain but the blockchain DLT will take care of registering the digital hash of the PDF/A consignment note and the hash of any required amendment together with additional data to manage the characteristics of origin and finality. This additional data will include the digital signatures of the shipper and road haulier and the proof of delivery of the goods. The integrity of the PDF/A document will be always held through the innate immutability nature of blockchain, acting as a digital notary of this documentation.

5.2.1.2.1Participants

For shippers, the consignment note use case will allow to:

- Prepare and submit the consignment note and control document in PDF/A format.
- Complete or modify the consignment note and control document automatically when new data becomes available through smart contracts that establish the procedures, origin and rules for these actions.
- Register the consignment note and control document in a repository connected to an off chain DLT.
- Ensure the integrity of the consignment note and control document using the blockchain DLT capabilities.
- Provide a digital signature to the consignment note using blockchain DLT capabilities and the use of digital identities.
- Check the haulier digital signature and the proof of delivery using the capabilities of blockchain DLT for the proof of origin and finality.
- Provide an audit trail of the documents, signatures, additions and modifications of the consignment note and the control document.

For road hauliers, the consignment note use case will allow to:

- Prepare and submit the consignment note and control document in PDF/A format.
- Complete or modify the consignment note and control document automatically when new data becomes available through smart contracts that establish the procedures, origin and rules for these actions.
- Register the consignment note and control document in a repository connected to an off chain DLT.
- Provide the control document to the authorities whenever required using the regulations established to this end.
- Ensure the integrity of the consignment note and control document using the blockchain DLT capabilities.
- Provide a digital signature to the consignment note using blockchain DLT capabilities and the use of digital identities.
- Check the shipper digital signature and the proof of delivery using the capabilities of blockchain DLT for the proof of origin and finality.
- Provide an audit trail of the documents, signatures, additions and modifications of the consignment note and the control document.
- Speed up the billing of the services carried out.

For transport authorities, the consignment note use case will allow to:

- Verify the integrity of the control document.
- Check the audit trail of the consignment note and control document.

For consignees, the consignment note use case will allow to:

- Provide the proof of effective delivery of the goods and its status.

5.3 Envisioned Business Model & Incentive system for the implementation of the solution/concepts

Transport network and models are changing and being digitized. The aims with the different solutions developed in Planet is to link maritime and terrestrial network, reduce documentation time, and provide paperless and real time access to the information.

Table 6. LL1 Business Model

Key partners	Key Activities	Value Propositions	Customer Relationships	Costumer Segments
Rail Operators will share data related to inland transport services by rail as well as route information related to schedules, costs, etc. Truck transport companies will share data related to cargo transportation services by road, including loading and unloading operations inside the port and terminal facilities. Shipping Agencies will share the documentation and data needed to carry out transport services in maritime and terrestrial domains. Shippers and carriers will provide documentation and data related to shipping operations. Consignees will be involved in the exchange of data performed in blockchain. Container owners will provide access to shipping containers as well as the permissions for sensorizing them. Port authorities will give access to the port infrastructure and will grant the permissions needed to access PCS data and validate digital documentation developed. Terminals will give access to the port terminal infrastructure where	Manage container availability. Sensor manufacturing, data collection and transfer. Develop blockchain and identify users, permissions and roles. Move into production the BC applications. Use of AI and Blockchain for Smart Contracts Identify intelligent nodes and guarantee their interconnection. Develop intelligent algorithms based in the information exchange and the decisions made by the different stakeholders in logistics operations. Develop the Demand Forecast algorithm model Data Analytics and Machine Learning Digital Clones Simulations	Optimise container transport in real-time. Each intelligent node/logistic hub will take decisions and re-route taking into account level of service, time and costs. Assess impact of changing maritime routes & re-routing inland transport of shipment. PI Network to simulate optimal routes to deliver goods, including ports, warehouses and city-hubs. Paperless transactions & transport event registration between logistics community through blockchain, inter-connected with existing blockchains. Monitoring transport with sensors, taking information about location, velocity, humidity and temperature, etc. Improve transport service level Increase customer satisfaction	Shipping agencies, port authorities and terminals and hauliers will ease the access to the existing data sets. This data will be exploited by Big Data and ML-based prediction providers.	Shipping agencies (COSCO Shipping Lines Spain S.A) and other actors belonging the port community (e.g., port authorities, port terminals, hauliers, freight forwarders) that are interested in the data collected. Secondary customers: Insurance companies that are interested in the data for offering their services to the primary customer segments.
	Key Resources		**Channels**	
	Sensor installation in the container. Antenna / Data receptor to transfer sensor data. Transportation of the sensorized shipping container. Hardware needed for blockchain and AI decision making infrastructure.		The best channel used to approach customers would be a marketing strategy by offering a free trial of the inter-modal asset tracking and blockchain solution or organizing a demonstration at different events; offering a free demo	

trucks will enter and exit for the loading or unloading of cargo and will give information about different movements and additional data. Technology providers will develop and maintain the technological solutions developed in LL1. Customers will test the different solutions and contribute to perform cargo tracking. Warehouse: crossdocking node needed to prepare the last mile delivery “Green” Carrier: carrier with electric vehicles to execute the LMD in a sustainable way.	Technologies (Hyperledger Fabric, Bluetooth, Python, NodeJS, Typescript, MongoDB) Human Resources Financial Resources		with the route optimization solution. The good position of DHL, COSSP and FV in maritime and inland transport, satellite and logistics industry could play a key role for engaging new customers.	

Cost Structure	**Revenue Streams**
Procurement truck to transport Planet Sensor. Procurement and installation of IoT tracking sensors. Blockchain development. Integration with other systems and existing blockchains Intelligent Algorithm development	Revenue comes from reducing time process, route optimization, reduce costs of transport and human resources needed Decrease incidents and related costs Reduce human errors Customer extra pay for located container, automatic documentation, digital and optimized transport.

5.4 Logic,rules and available data for intelligent decision making

LL1 will exploit intelligent decision-making algorithms for addressing specific needs in both maritime and terrestrial segments for UC1 and UC2. The business logic and available data for performing these tasks are the following:

Identify assessment needs of route changes (UC1)

In UC1, the intelligent algorithm will evaluate the time and cost impact of changes in the maritime routing of ships departing from China and considering Valencia, Barcelona and Algeciras as potential destinations. In general, vessels departing from China will select Valencia as initial destination (decision 1) and during the trip will assess the viability of keeping or changing the port of destination depending on time and cost factors that could be affected by the predicted ETA, the availability of equipment and services at the terminal, the congestion and the number of vessels attending at the port and the terminal, the distance to the port of destination, the size of the vessel, the destination of cargo aboard the vessel, etc. the whole process is shown at Figure 6.

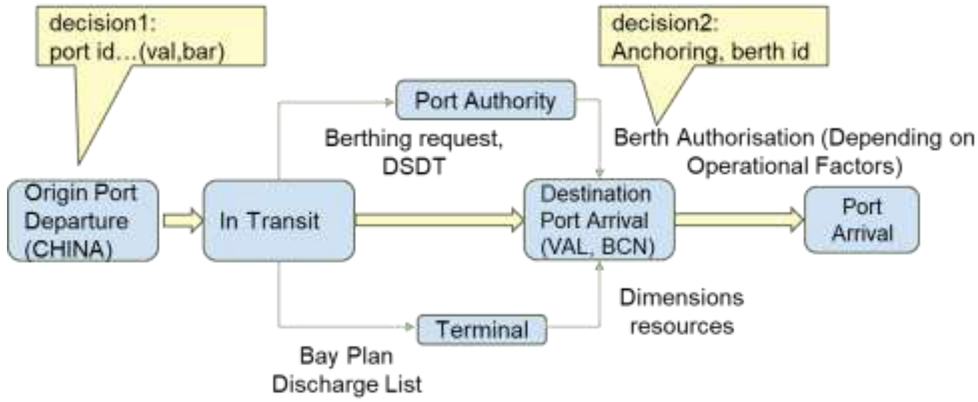

Figure 6. Maritime Operational Processes

To start identifying the factors that may affect the route modification, it is crucial to understand the operational process associated to the vessel departure and arrival.

1. At the port of origin, the port of destination for a specific vessel is decided as part of the scheduled maritime route.
2. When the vessel is in transit, different flows of information are sent by the shipping agency to both the port authority of destination and the terminal.
    a. In particular, the port authority receives: (i) the associated berthing request where the shipping agent informs about the ETA, the crew list and the possible presence of dangerous goods or residues on board, and (ii) the Summary Declaration of Temporary Storage (DSDT), which provides a detailed declaration of all containers and goods on board of the vessel, providing a relationship between the Bill of Lading (B/L) and the shipments.
    b. The terminal receives: (i) the bay plan, where details about the container location inside the vessel and different container characteristics like the container number, container type, weights, etc. are given, and (ii) the discharge list, which provides the list of containers on board that are required to be discharged at the terminal. This document helps the terminal to plan and schedule all the operations and resources required to unload arriving vessels.
3. After receiving these flows of information, Port Authorities generate the berth authorisation in case operational factors allow the arrival of the vessel, e.g. there are docks available, time window is free, etc. In this process, the Port Authority decides if anchoring is needed and the specific berth assigned to the vessel. At the same time, terminals get ready for the arrival of the vessel by dimensioning resources.
4. Finally, the ship arrives to the port and the container discharge operation is performed.

Considering these steps and the streams of information exchanged between the different partners, different factors could influence the decision taken by the intelligent algorithm on omitting the port call or modifying the itinerary. These factors are split into operational and economic factors:

Operational Factors

- **Availability at the requested time window:** Container terminals have a specific time window assigned for each shipping line for docking purposes. Depending on the ETA, vessels may be out of the specified time window at the terminal. This information is known by the shipping line.
- **Port call scheduling and anchoring:** Depending on the level of congestion at the port and the terminal (number of port calls scheduled for a specific day), the vessel could have to wait for the cargo discharge at the anchoring zone. Port call scheduling information is known by the terminal and the Port Authority. Anchoring information is not digitalized.

- **Availability of technical-nautical services:** Depending on the level of congestion at the port (number of port calls scheduled for a specific day), the vessel could have to wait for the receiving technical-nautical services. This information is not digitalized.
- **Terminal capacity, availability and congestion at a specific time:** Depending on the level of congestion at the port terminal (number of port calls scheduled for a specific day and size of vessels), the terminal could not be able to provide discharging services for a specific vessel. This information is known by the terminal
- **Distance to the port of destination:** Depending on the distance to the port of destination, changing the maritime route could be more feasible or less. This information is known by the shipping line.

Economic Factors

- **Port costs:** Includes port taxes, technical-nautical costs and stowage costs associated to the ports of destination.
- **Terminal costs:** Costs associated to the operational work carried out by the terminal at the port of destination.
- **Fuel costs:** Costs associated to the fuel consumption of a vessel and the distance to the port of destination.

Based on these factors, the alternatives for a vessel coming from China are the following:

1. Vessel arrives to Valencia and waits at Valencia port until the slot is released.
2. Vessel changes the rotation of the port.
3. Vessels omit the expected port call at Valencia port and discharge containers at Barcelona or Algeciras port.

Inland transport planning (UC1)

Once ships have arrived and docked at the Port of Valencia, and containers have been discharged and stored at the terminal YARD, the shipping agency has to decide which is the best way for transporting the container to the DHL warehouse in terms of time. For this casuistic, as shown in Figure 7, two main transport options are considered: truck and train (Decision 3).

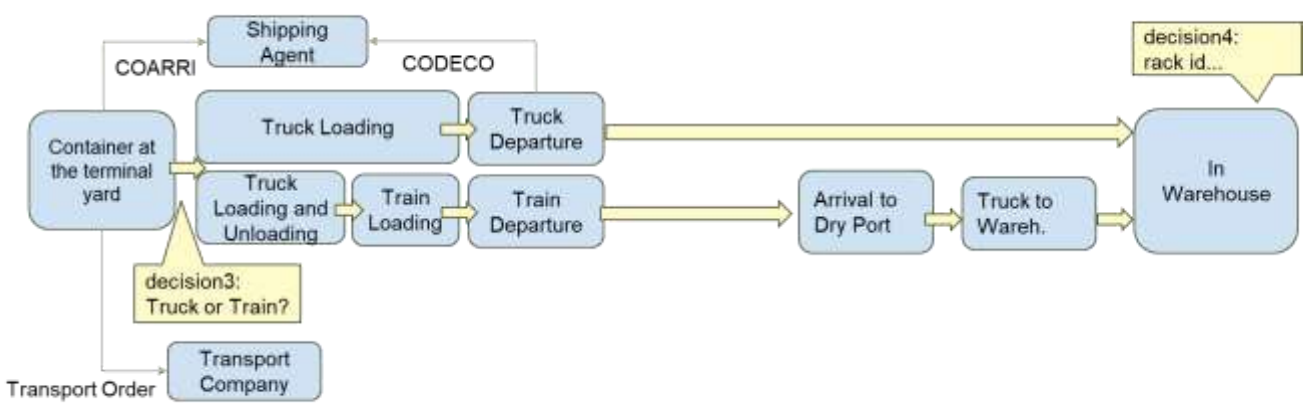

Figure 7. Inland Operational Processes

Firstly, for taking a decision and assessing the operational impact in time, it is necessary to understand the operational process associated to both transportation means.

1) In an initial stage when the container is located at the terminal yard, the terminal sends a COARRI message to the shipping agent, which provides the date and time of the discharge operation.

2) Either truck or train transportation is selected as the preferred option, the terminal also sends the transport order to the transport company. The transport order provides information about the cargo inside the container (weight, container type, TARIC, destination, etc.).
3) If truck transportation is chosen as the preferred option, the container is loaded on the truck, which leaves the terminal towards the inland warehouse. At the moment of leaving the terminal facilities, the terminal sends a CODECO message to the shipping agent, providing the date and time of departure from the terminal.
4) In case train is selected, first the container is loaded on a truck and taken to the rail terminal. There, the container is unloaded from the truck and loaded on the train. When the train departs the rain terminal the train container list is sent from the railway undertaker to the railway company and the terminal. After that, the train arrives to the dry port, where the container is unloaded and loaded on a truck, which takes the container to the inland warehouse.

Considering these steps and the streams of information exchanged between the different partners, different factors could make an impact on the decision taken by the intelligent algorithm:

- Type of cargo: Depending on the type of cargo, trains or trucks can be seen as the most suitable transportation option. This information is available at the transport order.
- Location of the warehouse and the final customer: Depending on the location of the cargo destination, one transportation option could be more suitable than the other due to better connectivity. This information is available at the transport order.
- Quality of the port-to-hinterland infrastructure and transit time: Quality of the road or rail infrastructure could make an impact on the transit time of both transportation services.
- Requested delivery date and time: Depending on the date and time, traffic levels or transport scheduling may vary.
- Train and truck availability depending on the scheduling: The time scheduling for trains at the port terminal and the availability of trucks in specific time frames is known by the shipping agency.

For improved predictions and warehouse operations planning (UC2)

For generations, companies have lived with a lack of visibility in terms of demand volumes, seeing it manifest as bloated inventories, obsolescence, no or low stock, production delays, shutdowns, customer service breakdowns, delayed product launches and a myriad of other recurring and costly problems. Predictive analytics and data science can change that. Instead of simply reacting to events that occurred weeks or months ago, predictive supply chains see and analyse events as they are happening, and use this information to anticipate, predict and direct the future being able to dimension the needs of the supply chain, something of great value for the tactical and strategic planning of the logistics operations.

To this aim, DHL has provided a dataset of the warehouse package/pallet flow data for a period of 3 years. The most relevant features from this data for the models are Date, Process and Quantity. This data was used to train the warehouse flow prediction model. The purpose of the prediction model is to help logistics operators to make precise decisions to proactively streamline operations. As AI becomes more intelligent, predictive technology could take logistics players a step further into the territory of anticipatory hiring models for transports and personnel needed.

The prediction model will improve supply chain efficiency by anticipating an estimation of the volume flow into the warehouse. Compare to current situation (DHL knows volume for next day only 24 hours in advance), the algorithm will provide a prediction of the volume for the next days. Therefore, we will be able to plan transport and human resources needed in advance.

The following factors could make an impact on the decision taken by the use of an intelligent algorithm:

Transport side:

- Hire Transport resources in advance especially in peak seasons: along the year, a range of heterogeneous events generates peaks in the transport market (National and regional bank holidays, strikes, fairs, demonstrations, celebrations, sales periods such as Cyber Monday or Black Friday, or promotional campaigns of the clients themselves). By using a prediction model, a logistics company is able to assess their needs in terms of transports, and will benefit from it in a double sense. On the one hand, they will ensure the service to its customer (by having enough vehicles to execute the transports) and on the other hand, by lowering the prices of the transport avoiding to pay high prices in the last minute.
- Plan Transport routes according to the volumes forecasted with a better timeframe: logistic planner will have more time to plan transport increasing service level and decreasing errors and costs.
- Optimize transport (Truck Loads, Closed loops, etc.).
- Improve and ensure Transport Service Levels

Warehouse side:

- Plan and adjust Human Resources according to the volumes forecasted considering the AGV (Assisted Picking robots) resources for optimization orchestration. Based on the prediction model, a warehouse manager will know in advance volume coming into the facility, allowing him to hire the exact number of persons needed for the next day. This way, a company will no waste resources, will reduce costs and will ensure the execution of the different tasks inside a warehouse (receiving, picking, put away, etc.)
- Improve operational efficiency
- Increase asset utilization

In addition, the demand forecast open the door to two new to two new optimization possibilities:

- Based on the algorithm’s outputs, we will apply simulations for optimization possibilities in terms of resources and warehouse operations.
- Such a demand could automate the initialization of an AI Smart contract in the Blockchain with a transportation company such as CityLogin. A similar model for the prediction of availability of transportation resources could determine whether CityLogin will have the required transportation resources available. Based on this information, an automated contract could be issued with an already scheduled collection route set.

Last mile delivery (UC2)

Logistics operations in the urban environment are subject to uncertainty that arises from road traffic, limited parking availability, and handover unreliability. Such externalities can cause significant delays to last mile operators that typically account for around 30% of the total transport costs[2]. Last mile operators utilize some means for vehicle and parcel delivery tracking, as well as planning tools that offer vehicle routing solutions with local accessibility constraints. Such tools and solutions enable tracking through dashboards and efficiently recognizing delays that arise, however, there is little support for actuation, which is typically undertaken manually.

Building on individual last mile operators tracking capability, the Physical Internet principles of openness and smart decision-making, enables the identification of dynamic collaborative solutions. In the context of PLANET, delivery status updates are circulated and stored in a data platform, from one or more operators, that are then analysed to identify collaboration options between vans or operators. The intelligent decision-making algorithm, builds on predictive traffic modelling tools, and:

- identifies suitable help candidates from the vans operating nearby,
- for the optimal help van, it reshuffles the parcels to assist the late running van,
- identifies a meeting point for exchanging the parcels, and

[2] Department for Transport (DfT), 2019. Better delivery: The challenge for freight. National Infrastructure Commission.

- reroutes both vans through the meeting point, and all the delivery locations.

To account for the lack of dynamic delivery round data, a simulation has been developed for tracking parcel delivery progress and applying randomized traffic congestion delays based on the static vehicle routing plans. The algorithm is applied in a case study, in central Madrid, Spain utilizing a static vehicle routing plan dataset provided by PLANET partner, CityLogin.

The identification of vans available to help is based on the Expected Time of Completion (ETC) prediction, as well as by measuring the proximity of the centroids of all delivery locations for each van. ETC is typically available from the operator's dashboard, but a prediction based on the current vehicle location and pending parcel deliveries is also possible in the EGTN platform. This enables the creation of a shortlist of candidate vehicles, that are then analysed to identify the optimal help round in terms of proximity. The Figure below illustrates all the delivery locations that are used for the round centroid calculation for the late running round (leftmost light blue) and the five candidate help rounds. The figure confirms visually the algorithm's quantitative finding, that the round depicted in pink is operating at proximity to the late running round (light blue) and is therefore considered as the ideal assistance option.

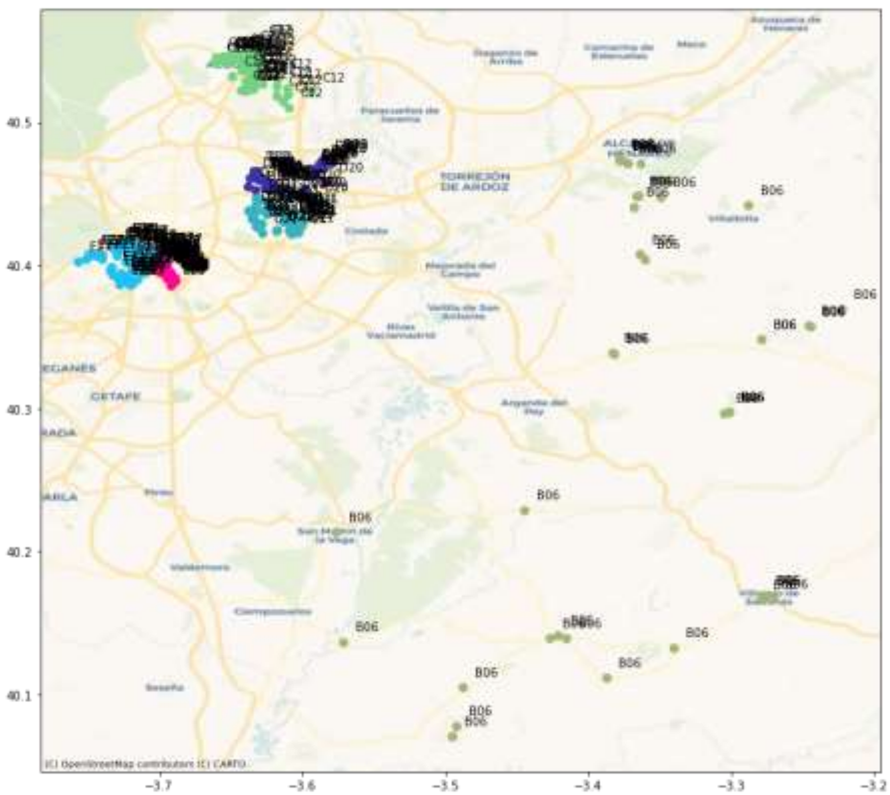

Figure 8. Pending delivery locations for the later rounds and the five candidate help rounds

For the help round to be of any assistance, it is required to shoulder the delivery load of the late running van. The algorithm initially addresses this by reshuffling the parcels in terms of delivery locations. The aim of this task, is to identify which of the pending parcels of the two rounds, should be delivered by which vehicle, to alleviate overall delivery delay. This is achieved by utilizing a Machine Learning K-means clustering algorithm that assigns all deliveries to two clusters. The K-means algorithm utilizes a calculation based on the moving centroid of its cluster using the straight-line distance as the criterion of vector separation, to determine to which cluster a node will belong. The Figure below illustrates how the boarder for the delivery locations of the late running and helping delivery rounds changes before (dashed line) and after (continuous line) the parcel reshuffling step of the algorithm. The delivery locations boarder for the help round, which is operating at the bottom right of the Figure, moves further north claiming the shaded area that after the parcel reshuffling is served by the help round.

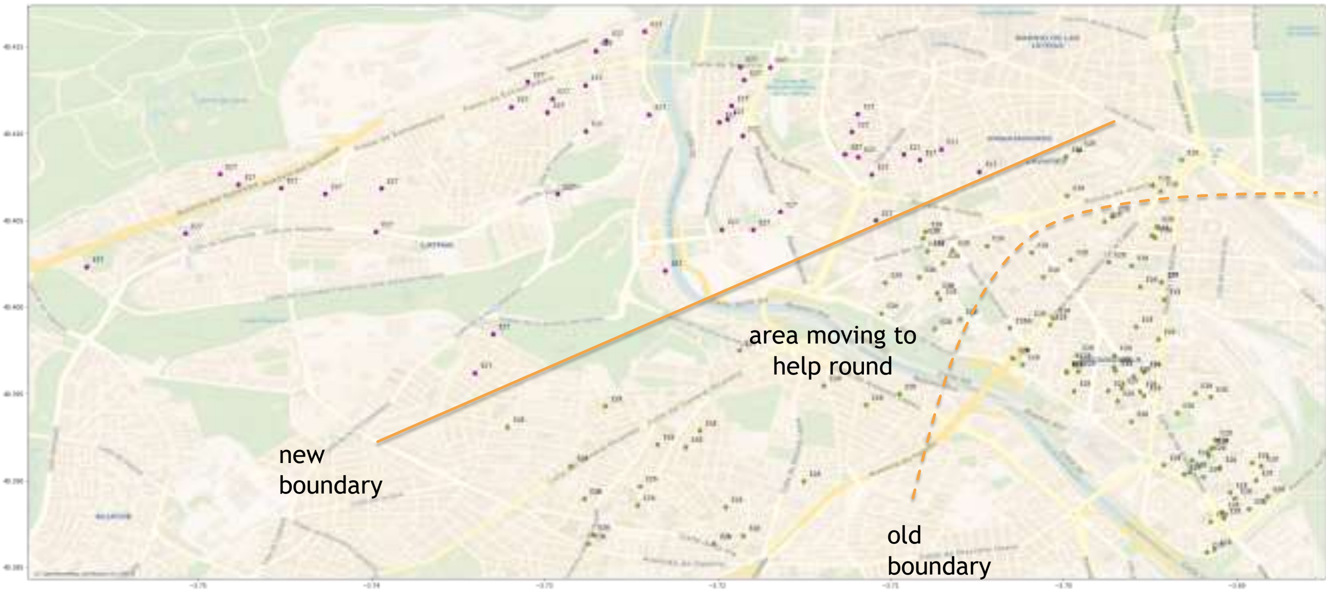

Figure 9. Area extension served by the help round after parcel reshuffling

To operationalize the parcel reshuffling output, the vehicle routing plan requires to be updated for both vehicles. In effect, this includes the identification of a meeting point where the parcel exchange will take place, and the optimal vehicle routing through the updated delivery locations and the simultaneous meeting point. The meeting point is identified considering the distance between all pending delivery locations of both rounds. Once the meeting point is identified a time window is assigned to it, that applies to both vans. To produce the vehicle routes, a Travelling Salesman Problem with time windows is solved for both vehicles. The Figure below illustrates, the two updated delivery rounds that meet simultaneously (at 12:18 which is the start of the time-window), to exchange the parcels, and then the help round (shown as blue) delivers the additional parcels.

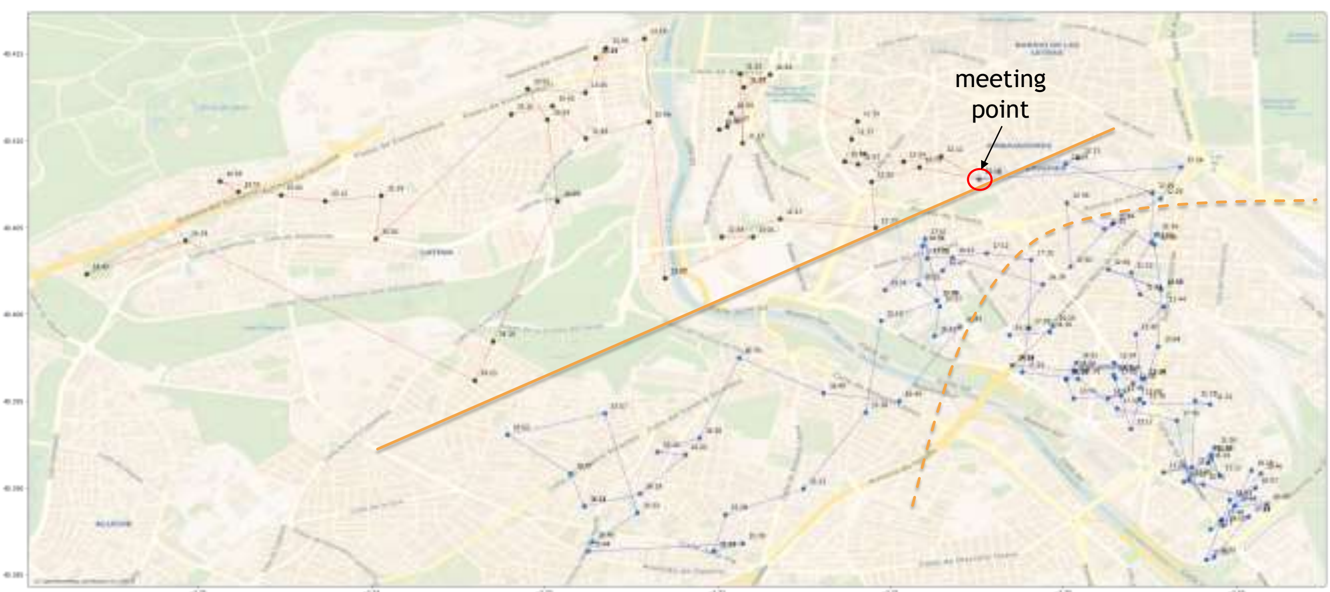

Figure 10. Meeting point to exchange parcels

The proposed dynamic algorithm offers a solution to the last mile delivery round delays and it also meaningfully applies the PI principles for enabling collaborative last mile logistics.

Warehouse operations

In a PI Hub context, multiple terminals and warehouses operate in proximity, that facilitate transshipment, processing, and storage capabilities. In practice, all warehouse and terminal operations are constrained by space, infrastructure, and workforce limitations. In the context of the Physical Internet, warehouse and terminals are openly accessible infrastructure capable of both optimizing their operations as well as accurately predicting their utilization rate and future availability.

A simulation and optimization model enables the optimal warehouse resource management, for both vehicles and human resources. The intelligent decision-making algorithm utilizes static information such as the warehouse layout, inflow and outflow processes, the mechanical and human resources available and their productivity rates, as well as dynamic information such as the predictions of the inflow and outflow quantities based on historical inflow/ outflow data. For each available resource, the decision-making tool identifies an optimal plan of detailed actions/ jobs to undertake. The optimization algorithm ensures that efficient routes and high utilization and productivity rates are maintained, and it also optimizes the assignment of resources at various posts and processes in the warehouse ensuring sufficient throughput throughout the in-warehouse process chain.

Considering the utilization rate established and the total available resources, a maximum throughput capacity is also determined that is communicated to the centralized Physical Internet platforms. If there is spare capacity, the terminal or warehouse is further considered for routing cargo. The process improves the efficiency of in-warehouse operations, as well as the potential attractiveness of cargo. This decision-making tool can also be linked to pricing strategies, for further attracting cargo, and increasing the utilization of the warehouse.

The development of AI based predictive models continues in this phase of the Planet project. The predictive models are one of the core components to automate further services for different applications that are relevant, and that are considered within the project for the development of the TEN-T. The predictive models are based on machine learning AI algorithms that enable the forecasting of information to enable the user to make more informed decisions.

The development of the AI based algorithms are to be further completed using data gathered from sensors using the IoT infrastructure and brought to the EGTN platform for its usage within the application services considered in the project. The data made available within the platform is to be further processed by being aggregated with other data sources such as weather data. These additional data aggregation tasks can become rather relevant for additional considerations for services and applications such as for the reduction of CO2 emissions, and developing models for transport volumes, transit time, transport costs, delays, and incidence of trade.

There are several data sets made available within the Planet project that were used to carry out preliminary test of predictive models for the forecasting of inflow of pallets and containers to warehouses and ports respectively. There are other datasets, some of them in the form of samples, that have been considered to build additional predictive models that could be relevant for services linked to transport models and last mile delivery route optimisation applications. Other data considered include data regarding train services that could be relevant in applications of synchromodality for transportation, and other related services to be considered within the living lab scenarios and carried out within the WP2.

There are other additional data sources considered that are related to the POD activities, events, and schedules within ports. Other data considered as potentially relevant that could be available includes round sequences for the last mile route optimisation service. Other data that might be made available is the one in the form of knowledge graphs which might include information from datasets regarding holidays, news, social media, customs rules, import regulations, weather alerts and forecasts, railroad routes and timetables, marine traffic, and air freight.

Using AI based data analytics to generate the forecasted information will require the determination of additional rule-based processing to shape the forecasted data to use it for enabling other services or, display it to the user in a consumable fashion.

Such additional requirement and rules, for instance, are even more relevant for the application of smart contracts in which it is needed to determine rules involving thresholds and quantities of pallets or containers within specific time frames, that are relevant to determine in a timely manner the need of future resources in warehouses or ports. Such resources can take the form of area layout configurations for storage, transportation, or personnel (or automated robots) to carry out the “pick-up” processes. Once the required information is determined the contracts could (or not) be digitally signed to allocate the resources required across port and warehouses when a significant number of pallets are about to arrive.

Each service considered for development in the Planet project will likely need some sort of rules to be applied to post-process the forecasted information and summarize more effectively the information that the user needs to take decisions required.

The sensor data gathered and made available by means of IoT technologies, including the GS1 and EPICIS for its transmission and storage within the EGTN platform, will be used to validate further the currently forecasting models tested. Services such as the corridor route optimization and other transport models’ implementations are to be used to build decision support systems, perhaps, at least on simulation settings. The value to the industry that the decision-making algorithms can bring to the transportation logistic network industry includes higher levels of decentralisation in terms of being able to gather relevant data across the network to visualise and share relevant historic, present, and future data in a more standardised way.

5.5 Digital Clones business drivers

While the digital clones concept has existed since the start of the 21st century, the approach is now reaching a tipping point where widespread adoption is likely in the near future. That is because a number of key enabling technologies have reached the level of maturity necessary to support the use of digital clones for enterprise applications. Those technologies include low-cost data storage and computing power, the availability of robust, high-speed wired and wireless networks, and cheap, reliable sensors.

As explained before, Digital clones could have a significant impact on the design, operation, and optimization of logistics infrastructure such as warehouses, distribution centres, and cross-dock facilities. Warehouses and distribution centres make up just a fraction of all logistics infrastructure. The flow of goods from source destination depends on the orchestration of multiple elements including ships, trucks and AGVs, order and information systems, and, above all, people. At these facilities today, the challenge of efficient operation is exacerbated by imperfect systems for information exchange, with many participants reliant on offline processes that can be subject to errors and delays.

Perhaps the most compelling argument for using digital clones in warehouses and similar facilities is their contribution to continuous performance improvement. Comprehensive data on the movement of inventory, equipment, and personnel can aid the identification and elimination of waste in warehouse operations, from congestion in busy aisles to low productivity or picking errors by personnel. Before making changes on the ground, simulation using digital clones can enable facility managers to test and evaluate the potential impact of layout changes or the introduction of new equipment and new processes. In environments such as e-commerce fulfilment that must accommodate rapid changes to volumes and inventory mix, digital clones can also support dynamic optimization of operations. Stock locations, staffing levels, and the allocation of equipment can be continually adjusted to match current or forecasted demand.

The goal of using digital clones is to enable a graphical digital clones (warehouse) representation to emulate the humans’ behavior and operating equipment using human input and advanced AI to drive optimization.

To this aim, by utilizing DHL existing digital clones’ infrastructure outputs, we will be able to drive:

- Pre-assessment & Optimization of Warehouse Processes: Through the execution of What-If scenarios/simulations, we will be able to know the consequences of a process change before it takes place.
- 3D visualization: The ability to visualize what is happening in the warehouse to analyze behaviors and to take the right decisions.
- Spare capacity assessment: Integration with IBM's forecasting model to calculate the spare capacity of the warehouse.
- Decision Support System: Outputs will be used in DSS for the Last mile delivery optimization.

Key Benefits:

- Ability to immediately visualize 3D representation of any warehouse making information more accessible and easier to interpret from a distance
- Used as communication mechanism to understand and explain the behavior of an individual asset or a collection thereof
- Experiment with design and optimize operational processes to simulate various conditions that are impractical to create in real life
- What if analysis – driving product quality and innovation using real-world data learned from existing equipment and processes

5.6 Impact Assessment of adopted innovations including metrics

To assess the impact of the innovations adopted as part of the Living Lab roadmap, the project has defined a set of Key Performance Indicators (KPIs) that will allow to quantify the benefits introduced by the different technological solutions. KPIs are defined and classified according to the technology innovations and compared to existing baseline measurements as follow.

For UC1, all baseline measurements are estimated and average values, and they are capturing a trip of inland leg from Valencia to Madrid area. Some of them are currently not in place or not monitoring in COSSP operations, therefore value captured is equal to zero or indicated as not available.

Table 7. UC1 KPIs

Key Performance Indicator	Technology	Baseline measurement	PLANET Target
KPI 1: Delivery lead time in inland transport.	PI and Digital Clones	4 days	10% reduction
KPI 2: Time of interactions between supply chain stakeholders.	PI and Digital Clones	2 days	20% reduction
KPI 3: Access to temperature, humidity, bump, gate opening and tracking in shipping containers and pallets.	Internet of Things	N.A.	Real-time access thanks to IoT tracking devices
KPI 4: Operating costs in transport and logistics.	Artificial Intelligence	800 €	7% reduction thanks to forecasting, planning and AI routing decisions.

KPI 5: CO2 emissions related to transport and logistics operations. (TTW & WTW)	Artificial Intelligence	0,45 t/CO_2eq	15% reduction thanks to forecasting, planning and AI routing decisions.
KPI 6: Number of transport orders shifted to rail	Artificial Intelligence	0	15% thanks to the AI-based decision making algorithm
KPI 7: Number of transport orders fulfilled through Blockchain	Blockchain	0	5% of use of BC platforms
KPI 8: Customer satisfaction	Blockchain	N.A.	Qualitative increase
KPI 9: Cost of paper-based processes	Blockchain	150 €	15% reduction
KPI 10: Ratio of disputes	Blockchain	18%	10% reduction

Table 8. UC2 KPIs

Key Performance Indicator	Technology	Baseline measurement	PLANET Target
KPI 1: Transport cost reduction	ML & Data Analytics	(*)	10% reduction
KPI 2: Operational cost reduction	ML & Data Analytics	70 workers	3% reduction
KPI 3: Operational efficiency (delivery time reduction)	ML & Data Analytics	(*)	7% reduction
KPI 4: Increase speed of collaboration decisions -automation in routing decisions	ML & Data Analytics	(*)	20% increase
KPI 5: CO2 emissions related to transport and logistics operations.	ML & Data Analytics	(*)	15% reduction
KPI 6: Decrease disruptions of the Supply Chain (in the hiring process in the spot market for specific vehicle)	AI & Blockchain	(*)	7% increase
KPI 7: Increase speed of inventories	Digital Clones	N.A (**)	Visibility to the spare capacity
KPI 8: Access to temperature, humidity, bump, gate opening and tracking in shipping containers and pallets.	Internet of Things	N.A (**)	Real-time access thanks to IoT tracking devices

Note:

(*) Baseline in these cases is not yet available, as we need first to agree between all the parties the specific scenario to be executed in the pilot. Material will be collected in DHL warehouse, then transported to a city hub in Madrid area, and then delivered in final destination. We need to identify a real transportation case in order to execute the demonstration with similar conditions (as much as possible). The final destination will determine the midpoint (city hub) to be selected.

(**) Not applicable as Digital Clones and IoT sensors are not in place currently in DHL's real operations (in the case of Digital Clones only as a pilot project)

UC2 Calculation methodology:

- **KPI 1: Transport cost reduction.** We will compare AS-IS situation to TO-BE situation (measure in €):
  - AS-IS: Cost of the transport from warehouse to final destination, without using demand forecast and LMD collaboration algorithm.
  - TO-BE: Cost of the transport from warehouse to final destination using demand forecast and LMD collaboration algorithm. Demand forecast will reduce hiring cost, as we will be able to book vehicles in advance avoiding peaks in demand transport with higher prices. With the LMD collaboration algorithm we will be able to avoid wrong routings, therefore less km travelled, reducing transport costs.
- **KPI 2: Operational cost reduction.** We will compare AS-IS situation to TO-BE situation(measure in FTE):
  - AS-IS: we will consider the total personnel cost of the warehouse considering 70 workers (in a normal day) without using demand forecast to predict volume into warehouse and therefore total number of personnel needed.
  - TO-BE: We will use demand forecast to predict volume into warehouse and therefore total number of personnel needed. It will allow DHL to hire exact number of persons (full-time/part-time) avoiding excess or lack of human resources needed for a specific day. Excess will create extra cost, and lack will decrease productivity and service level, and at the same time last minute hiring with potential extra cost.
- **KPI 3: Operational efficiency (delivery time reduction).** We will compare AS-IS situation to TO-BE situation (measure in minutes):
  - AS-IS: We will consider time from collection point to delivery point without using LMD collaboration algorithm.
  - TO-BE: We will consider time from collection point to delivery point using LMD collaboration algorithm, which will provide new routing solutions for traffic problems reducing delivery time,
- **KPI 4: Increase speed of collaboration decisions -automation in routing decisions.** We will compare AS-IS situation to TO-BE situation (measure in minutes) :
  - AS-IS: we will consider time while managing a transport from origin to destination without using LMD collaboration algorithm and smart contracts.
  - TO-BE: we will consider time while managing a transport from origin to destination using LMD collaboration algorithm and smart contracts, which will reduce management time and increase automation in routing decisions.
- **KPI 5: CO2 emissions related to transport and logistics operations.** We will compare AS-IS situation to TO-BE situation (measure in t/CO_2eq):
  - AS-IS: we will consider transport from origin to final destination with standard truck.
  - TO-BE: we will consider transport from origin to final destination with green vehicle for the last mile distribution, which will reduce CO_2 emissions in LMD.
- **KPI 6: Decrease disruptions of the Supply Chain in the hiring process in the spot market for specific vehicle.** We will compare AS-IS situation to TO-BE situation (measure in minutes):
  - AS-IS: we will consider the hiring process in the spot market for urgent transports or specific vehicle's needs without using smart contracts.

  - TO-BE: we will consider the hiring process in the spot market for urgent transports or specific vehicle's needs using smart contracts.
- **KPI 7: Increase speed of inventories.** We will use Digital Clones and simulations to calculate the spare capacity and stock level as there is no Digital Clones in DHL's real operations.
- **KPI 8: Access to temperature, humidity, bump, gate opening and tracking in shipping containers and pallets.** We will use IoT sensors to measure different parameters and to track shipments, as we are not using IoT sensors in DHL's real operations.

5.7 Alignment with EGTN objectives

The Integrated Green EU-Global T&L Network (EGTN) is defined as an advanced European strategy that implies the development of a Smart, Green and Integrated Transport and Logistics Network of the future to efficiently interconnecting infrastructure (TEN-T, Rail-Freight Corridors) with geopolitical developments, as well as to optimize the use of current & emerging transport modes and technological solutions, while ensuring equitable inclusivity of all T&L participants, increasing the prosperity of nations, preserving the environment, and enhancing Citizens quality of life.

In this context, PLANET defines the Attributes of the future EGTN as following:

- Geo-economics aware: A European T&L network that is aware of the geo-economics aspects driving the development of new trade routes and flows to/from Europe and their impact on the TEN-T;
- Innovation: A European T&L network that takes advantage of the potential of innovative logistics concepts (e.g. PI) and enabling technological innovations (Industry 4.0, blockchain, IoT, 3D printing, etc.) in its operation;
- Impact: A T&L network that is more economically, environmentally and socially sustainable than the existing TEN-T:
- Integrated: An EU T&L network integrated with the global network both in terms of hard & soft infrastructure;
- Inclusive: Accessible to disadvantaged regions, supporting the development of workforce skills & knowledge.

The LL1 ecosystem is aligned with the definition and attributes of EGTN, as:

- Geo-economics aware. LL1 will support geo-economics awareness by fostering the formation of Principal Entry Nodes (PEN) and guaranteeing their connection with global corridors. LL1 examines the role of new technologies to optimize European strategic transport with China supported by use case 1. This is done through the use of open data and smart algorithms, that increase the robustness and resilience of the global corridor connectivity to the EGTN enabled TEN-T. At operational level, tools are being developed to optimize inland and maritime routes (Synchro-modal route optimization and Maritime route change and inland re-routing).
- Innovation. LL1 promotes innovation applying innovative logistics concepts (PI) and technologies (ML, BC, AI, IoT) in its operative context. The implementation of synchro-modal transport algorithms, the deployment of predictive algorithms that enable the as-a-service operation of warehouses and PI hubs, and dynamic collaborative last mile solutions all contribute to innovation.
- Impact. The LL1 has an impact on the three pillars of sustainability, with a special focus on greener operations, with the use of green vehicles, implemented in the use case 2.
- Integration. LL1 demonstrates integration with the global network by testing blockchains interoperability and IoT standards, implementing synchro-modal transport and predictive algorithms and using dynamic collaborative last mile solutions. The LL will also demonstrate Secure Data Sharing Infrastructures for Globally Interconnected Supply Chains.

- Inclusive. All solutions applied in the LL promote efficiency, sustainability and robustness, also contribute to inclusiveness. Therefore, the clustering of PENs promotes inclusiveness. The proposed last mile logistics solution promotes the dynamic engagement of any urban distribution actor, connected to the EGTN regardless of financial or technological capacity. Finally, the use of open-source technologies and adherence to standards further allow “smaller” and “cost-sensitive” actors to easily be part of the PI network.

6 Technical Requirements

6.1 Link with the EGTN technological framework and infrastructure designed in WP2

The EGTN platform is a platform for sustainable, integrated and multimodal freight transport that engages diverse stakeholders of the T&L supply chain and enables them to interoperate and exchange data through a secure ICT infrastructure. It supports decision making, ensures transparency and equity to all stakeholders, improves operational procedures and goes one step further towards the materialization of the PI concept. The EGTN platform is cloud-based and integrates services for interoperable logistics by exposing secure interfaces for data ingestion, data management, data governance and data visualization.

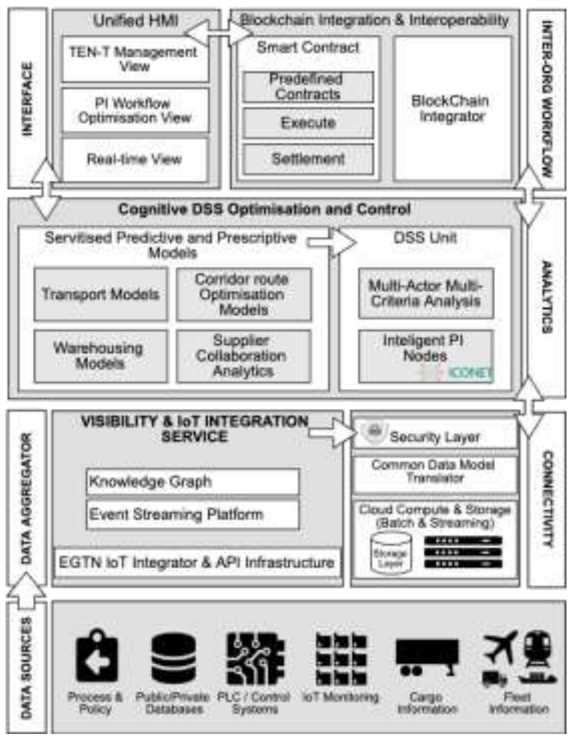

Figure 11. PLANET high-level architecture

The EGTN platform features a modular, multitier architecture (shown in Figure 11) and brings together cutting-edge technologies such as IoT, 5G, AI and Blockchain. Among others (see more details in D2.1), it offers:

- A secure Big Data infrastructure for data ingestion, storage and fast access to raw data. Heterogeneous data are aggregated in real time from various sources, such as IoT networks and are ingested through an event streaming framework (Kafka Cluster of 24TB). The end-to-end network and storage encryption prevents potential eavesdroppers and other strict rules such as ACL in the Kafka topics and the on-demand provision of accounts guarantee security and privacy. Data are consumed directly by stakeholders or by other EGTN components to be used as input in the analytics algorithms, the smart contracts or the EGTN visualization dashboards.
- Analytics components with access to GPUs for training of big datasets in the Amazon's Cloud. The analytics engine aims to empower all EGTN actors with better decision-making tools, so that they can in turn optimise planning and pre-planning considering a plethora of goals and limitations, such as lowest-cost route, fastest route, low-carbon route and so on.
- A blockchain service that connects backend blockchain systems of T&L stakeholders and enables them to share transactions and events in a transparent, immutable, trusted, and efficient manner. The

blockchain service exposes a frontend interface to share transactional events for monitoring of the entire supply chain by everyone involved in the network.

- Dashboards for visualizing datasets and useful analytics results to assist in decision making, monitor the impact of the EGTN infrastructure development and finally to perform specific functions on the platform such as managing the supply chain or route planning.

6.2 Cloud-based Open EGTN Infrastructure Technical Requirements (incl. performance capabilities)

The architecture of the EGTN Infrastructure has been designed in the context of T2.1 Cloud-based Open EGTN ICT Infrastructure Architecture and has been described extensively in D2.1 Open EGTN Platform Architecture v1.

In terms of data storage, LL1 needs fast and secure storage to support a vast amount of data coming from the IoT Platform that tracks the pallets, containers and warehouses in the two UCs of LL1, as described in section 6.4. The EGTN infrastructure ensures the secure and scalable ingestion of data coming from the IoT Platform deployed in both LL1 use cases (see section 6.4). The data are coming in the infrastructure through the event-streaming service and the data aggregator that has been already deployed. More details on the security aspects of the data aggregator can be found in D2.1.

In addition, a blockchain front-end needs to be deployed in the EGTN infrastructure to connect existing blockchain systems hosted by LL1 stakeholders. The blockchain front-end needs to support the connection to multiple blockchain frameworks to ensure flexibility and scalability, but most importantly needs to support the connection with Hyperledger Fabric which is the framework used by both the shipper's community (UC1) and the Freight Forwarders community (UC2). The initial version of the EGTN Blockchain Interoperability Service is already deployed in the EGTN servers and connects the blockchain network of the LL1 UC1 with the blockchain network of the LL1 UC2, increasing the visibility of the entire supply chain.

6.3 Blockchain Requirements

SR1: PLANET LL1 blockchain should ensure immutability and permanent availability of the shared data, allowing organizations to perform a trusted data exchange, easy dispute resolution, accountability and verifiability of business processes within the network.

PLANET will set up a blockchain network based on Hyperledger Fabric blockchain technology, including an immutable and untamperable ledger, orderer and peer nodes to ensure consensus, CA nodes to allow certification, and channels to allow data privacy.

SR2: In PLANET LL1 blockchain, organizations must be able to join a new or existing blockchain network including network components such as endorsing, validating and anchor peers, orderer nodes, and CA to provide appropriate certificates to member components, end-users and applications.

When adding a new organization to the existing blockchain network: PLANET network will configure a new CA node, add the organization with appropriate access roles to network configuration and join organizational peer to channels.

SR3: PLANET LL1 blockchain must include a consensus mechanism to assure integrity and security at the network when validating transactions and ordering functionalities for the network.

PLANET blockchain network will exploit a validated and known consensus algorithm in its core for setting up the ordering service of blockchain network, i.e. RAFT.

SR4: PLANET LL1 blockchain must include strict authentication and authorization protocols for enabling transparency and trust when sharing and accessing data, configuring access roles, handling malicious participants, withstanding security attacks, etc.

PLANET will design a specific CA and MSP configuration for each project use case in order to ensure a proper certification, organizational access roles in network and channel configuration, and encoding attribute based access restrictions.

SR5: PLANET LL1 blockchain must enable the connection with organizational and client applications, and end users via secure APIs to share, access and consume data. To do so, connections must be carried out in an authenticated manner to ensure that only approved parties are allowed to access the PLANET network.

PLANET will use Fabric CA to provision certificates and Fabric authentication mechanism for enrolling and registering those certificates. Additionally, the project will use authorization mechanisms (resource level ACLs, for managing which orgs/users can add organizations to network, which can access channel data) and smart code level authorizations (such as role-based authorization for users determining who can read/write what data) to determine access to on chain data.

SR6: PLANET LL1 blockchain must be able to allow the creation of multiple business networks where organizations could share data or business logic under private conditions with selected entities, or at least be able to keep data private for different participants.

PLANET will define a single blockchain networks for developing use cases involving stakeholder organizations to share data in the network. Additionally, the project will define different channels between network participants who need to share data in an invisible manner to other participants.

SR7: PLANET LL1 blockchain must allow organizations to maintain a shared and single distributed source of truth, i.e. blockchain ledger, for registering all transactions within the network. Organizations must should also be able to store their own copy of it.

PLANET LL1 blockchain infrastructure will enable the creation of channels for ensuring privacy of data within the blockchain network. For each channel, the infrastructure will allow the addition of peers of organizations that need a separate copy of the ledger for reasons of security, performance, regulations, etc.

SR8: PLANET LL1 blockchain network must allow organizations to develop and execute agreed upon business logic in an automated manner for validating and signing on transactions and achieving transparency and accountability across the network.

PLANET blockchain solution will provide execution runtime to allow execution of business logic contracts, i.e. smart contracts, in the considered blockchain network.

SR9: PLANET LL1 blockchain network must allow organizations to endorse transactions by executing a specific business logic agreed as a bounding contract between the different network organizations.

PLANET LL1 blockchain solution will allow organizations required to endorse transactions to add endorsing peers to the appropriate channels. With these capabilities, organizations will be able to sign on transactions, achieving transparency and adding accountability across the network.

SR10: PLANET blockchain must allow organizations to set new data governance and business rules and update or reinforce the existing ones.

PLANET LL1 blockchain will provide functionalities to add and query new data governance rules for off chain data as well as to ensure that on-chain data for data sharing scenarios have policies and access roles in place to govern access to the data.

SR11: PLANET LL1 blockchain must include mechanisms for allowing organizations to get information about other participants and querying them.

PLANET LL1 blockchain will integrate a mechanism for allowing organization to retrieve information about other participant organizations as well as to query them for assigning sharing and governance rules.

SR12: PLANET must provide unified interfaces to interconnect different blockchain systems for seamless Global Trade.

PLANET will provide common interfaces that will allow access to multiple blockchain platforms hosted by different EGTN actors.

SR13: PLANET must allow organizations to redirect transactions and consume events from/to different blockchain systems.

PLANET will enable organizations to submit transactions which will have effect to blockchain installations of different EGTN actors. Moreover, events coming from a blockchain installation will trigger actions and/or smart contracts in ledgers hosted by different organizations.

SR14: PLANET blockchain should enable EGTN actors of different ecosystems to share data and functionality in order to operate in a unified and consistent way.

PLANET will deploy the infrastructure that will allow EGTN actors to share data and functionality in a unified way.

SR15: PLANET blockchain must collect external data coming from AI predictive models via a REST API.

PLANET blockchain should trigger smart contracts employing "if-then' rules based on external data coming from AI predictive models.

SR16: PLANET blockchain should support a further integration with other disruptive technologies such as IoT or AI.

Planet blockchain should support the further integration of technologies such as IoT, and AI based predictive modelling by aggregating forecasted information to enable services for connectivity and monitoring, traceability, visibility, and interoperability of paperless applications such as smart contracts, and possibly for routing optimisation and Human-machine-interfaces.

6.3.1 Blockchain Interoperability Workflow

Interoperability is the capacity of computer systems to exchange and use data, but also the capacity to transfer an asset between different systems while keeping the state and uniqueness of the asset consistent. In the context of blockchain, it plays a pivotal role at enabling the communication between separate blockchain networks. Within PLANET the overall objective is to simplify, standardise and streamline interorganizational workflows.

As presented earlier, in LL1 the communication between different blockchain systems aims at simulating a transport scenario in which COSSP manages shipments from Asia to Spain (Port of Valencia) while the inland transport is managed by DHL Spain and CityLogin.

As Figure 12 illustrates, the information flow is triggered by COSSP once a container arrives at the port terminal. All relevant information, such as cargo details etc., needs to be shared with the Port Community blockchain either directly or through the shipper's blockchain if there is one. The Port Authority is expected to confirm that they have received the container; this information needs to be fed back to the shipping community. At the same time the freight forwarder blockchain receives the information that the container is at the terminal.

Once the freight forwarder, namely DHL, picks up the container, they send to the blockchain of the port community the pick-up confirmation, they transmit the container to their warehouse and send to the freight forwarder Blockchain the proof of delivery.

The final step of the workflow is the inland shipment, sending the container from the DHL warehouse through CityLogin for the last-mile delivery to Madrid.

The idea behind this blockchain workflow is that information is shared in a transparent and trustful manner between all stakeholders involved. This is a rather important point, since a critical element of the Physical Internet (PI) is the sharing of information between multiple actors in an open and trustful manner. For instance, information such as Expected Time of Arrival (ETA), or information regarding a potentially empty DHL truck ready to be filled with cargo should be visible to all stakeholders throughout the network.

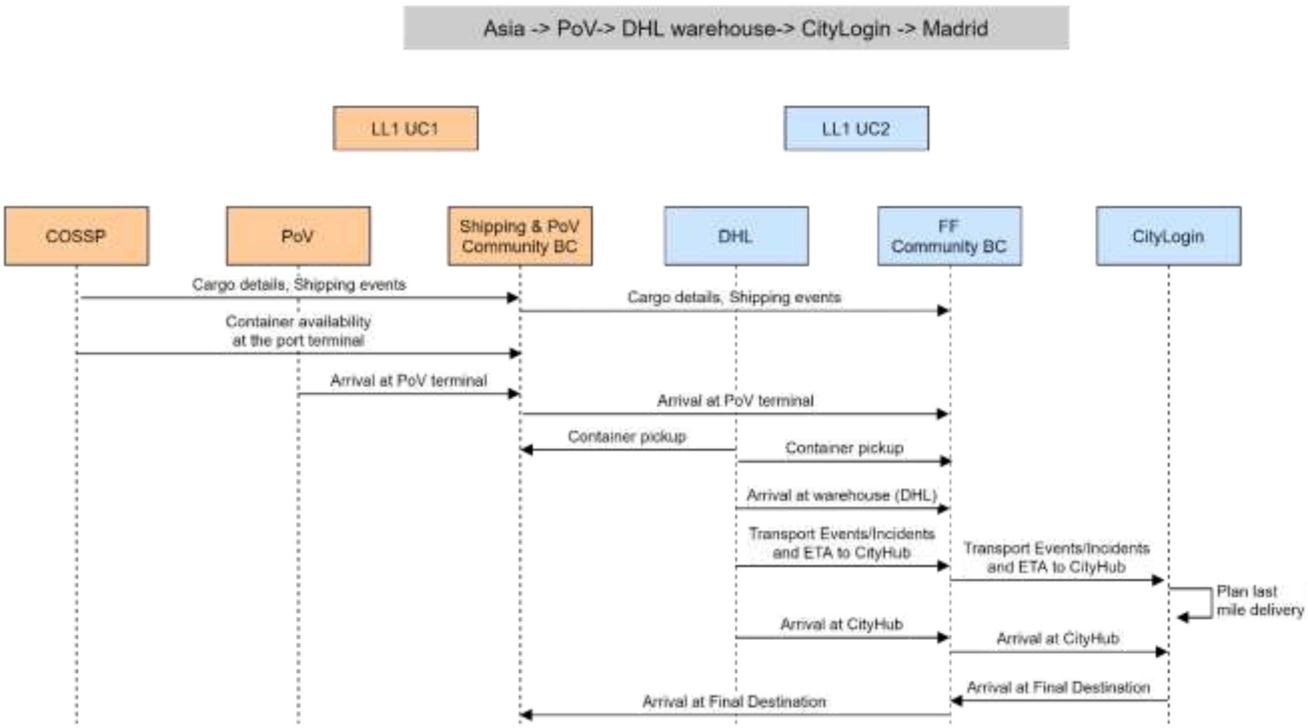

Figure 12. Exchange of Transport Order Blockchain Interoperability Workflow

6.4 IoT Requirements

The main challenge to address in the realization of the IoT environment in LL1 is to enable the **complete visibility of the supply chain**. In line with the findings of D1.6 of the ICONET project and in line with UN/CEFACT guidelines (1), we propose to realise an open scalable, interoperable plug-and-play and easy-to-use IoT framework tailored for smart logistics, where the following technical requirements must be satisfied:

- **IoT enablement**. The IoT devices and components must be capable of enabling IoT environments, thus connecting the physical world with the digital one, implementing the digital clones' functionalities.
- **Composability and pervasiveness**. IoT must allow the PI-packets encapsulation, implementing the Recursive Gateway-mediated Edge Connectivity and Management pattern. This configuration must allow a hierarchical monitoring of PI-goods, PI-containers and PI means. IoT must allow a pervasive monitoring (e.g., also inside the container, where the wireless/5G connectivity are un-available), thus answering the questions "What?", "Where?", "When?" and "How?" for all the encapsulation levels (Table 9. "Where?", "When?" and "How?"), and enabling the supply chain complete visibility.
- **Interoperability**. The IoT environment must be interoperable with different set of IoT protocols (i.e., technical interoperability) and with the stakeholders' platforms (i.e., syntactic and semantic interoperability).
- **Easy use maintenance and integration.** The installation and the data access must be easy and plug&play, the maintenance reduced, thus the battery duration is an essential point.
- **Cloud based platform,** capable to implement the functionalities of data persistence and analysis, as well as a catalogue of APIs for easy integration into different platforms.

Table 9. “Where?”, “When?” and “How?”

What?	What type of goods?	Providing information regarding the producer and the type of goods encapsulated, e.g., considering the standardized coding by GS1.
Where?	Where are the goods located?	Providing information regarding the position of the goods, also adding information regarding the encapsulation.
When?	At what time?	Provide information regarding the date and the time of the sampling.
How?	How is their status?	Provide punctual added value measurements regarding the storage of the goods.

6.4.1 The complete visibility of the supply chain

Figure 13 depicts the scenario that the PLANET IoT environment plan to realise, enhancing the supply chain visibility, thus implementing an improved granularity Track&Trace&Monitor (T&T&M) continuous services on both containers' and last mile logistics. In the following, the realisation of the Smart PI Container is detailed, as enabling brick of such services. Moreover, the concepts' definitions of Smart PI Pallet and Smart PI Packet are provided, improving the goods tracking and monitoring granularity, and enabling the instantiation of scalable set of special functionalities and services, tailored for the specific commodities sector. An interoperable environment will be designed following the main standard available in the logistics sector.

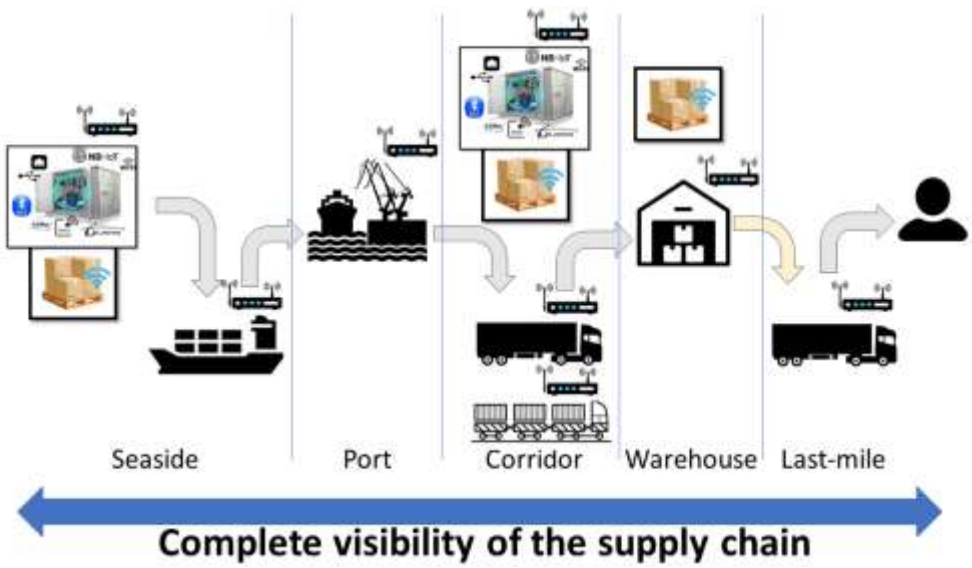

Figure 13. Supply chain complete visibility

6.4.1.1 The realisation of the Smart PI Container – The Smart PI Pallet and the Smart PI Packets

The Smart PI container is the cornerstone to realise the T&T&M services. In fact, it enables the realisation of the IoT environment capable to answer to the three questions of Table 9. A **Smart PI container** can be defined *as a connected PI container that can establish (inside and/or outside itself) local IoT networks for data collection, and it is capable to dispatch remotely the gathered information.* Such a solution can enable an improved scalability on the amount and types of IoT sensors capable to provide added value information.

In this scenario, the smart PI container will be capable, to monitor the goods encapsulate inside itself, and to be encapsulated in a Smart PI-mean, as exemplified in Figure 14Figure 14. It allows the data collection regarding:

1. The **general status of the container**, in term of position and time, as well as aggregated data as bumps, T/H and light.
2. **A distributed set of devices capable to monitor in a pervasive manner inside and outside the container**. Added value functionalities can be added to monitor the presence or the punctual status of the goods, or the container itself status (door open/closed, sealed/not sealed). In the following the concepts of Smart PI Pallet and Smart PI packet will be defined.

Figure 14. Smart PI-container

The smart PI-container must communicate remotely toward the IoT Cloud platform dispatching all the information collected. Following the DCSA guidelines the IoT device can exploit different paths toward the Cloud, selecting the most convenient between the available.

The Smart PI Container allows the definition of **Smart PI Pallet**, see Figure 15. *The Smart PI pallet is a connected PI pallet equipped with sensors capable to implement special functionality and services measuring data from specific sensors, generating added value information regarding the encapsulated goods: for example, presence, bump, temperature.*


Figure 15 The Smart PI Pallet

The Smart PI Pallet can monitor, eventually, **Smart PI Packets** *encapsulated on it and dispatch remotely the collected information participating of the proposed architecture.* Particularly, it can cooperate with higher level IoT devices or operate in stand-alone manner if equipped with mobile connectivity.

The concepts of Smart PI Pallet and Smart PI Packet introduce a set of functionalities capable to improve the performance of the supply chain and its related assets. In fact, in this manner several business requirements are realised, implementing:

1. **A unique and standardized goods identification** for container and pallet using ISO and GS1 coding respectively: see also Figure 16. Regarding the Smart PI Pallet case, 2 different codes will be considered to identify the whole consolidated packet and the asset (SSCC and GRAI respectively, see (GS1, 2013))

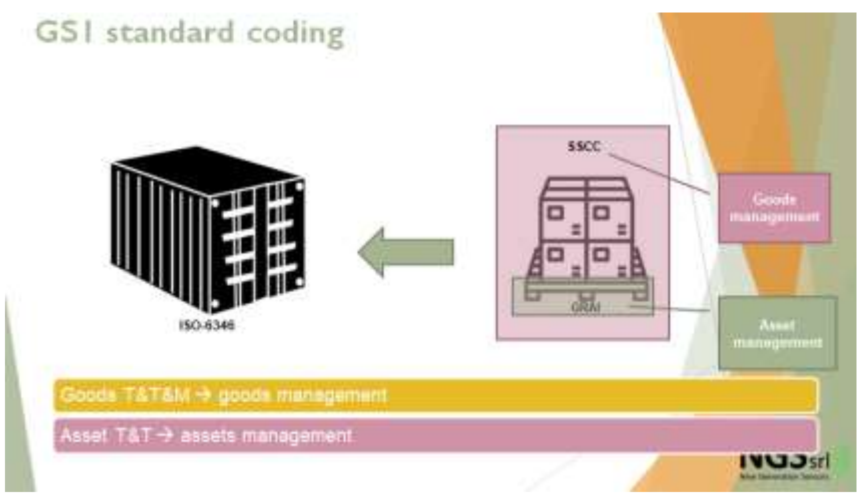

Figure 16. Standardised goods identification

2. **An improved granularity in the goods tracking and monitoring**. In this manner, the tracking and the monitoring services can be done at the level of the pallet or of the packet, supporting more punctual

operations of routing and decision making. This service can, for example, support logistics operators that implement groupage policies (e.g., the transport of wine, where punctual temperature and bump is very important), or the improvement of last mile logistics services. Particularly, certain special edge functionalities can be implemented, only introducing a special IoT device though for that sector (no other configuration required).

3. **The possibility to implement improved assets monitoring and management service**. Having available the big picture of the availability of assets (e.g., container and pallet), the optimisation of their usage can improve their efficiency, thus reducing the costs.
4. **An enablement for the implementation of circular economy services**. This point is the direct consequence of the previous one. In fact, having the big picture regarding the position and the availability of the assets (in this case the attentions are focused on pallets, kegs, baskets, …) efficient and low-cost asset-as-a-service solutions can be implemented. In this scenario, the re-use of assets is encouraged, thus reducing the environmental impact.

6.4.2 Use cases' realisation

Following the guidelines detailed in the previous section, the objective of LL1 is to provide a ubiquitous connected environment capable to track and trace and monitor the goods flowing along the supply chain, from the sender toward the receiver. The collected data will be ingested by the Cloud IoT platform, stored, processed, and made available in secure and ad-hoc to all the stakeholders involved in the considered logistics transaction.

Particularly, LL1 will consider the realization of the following 2 use cases:

1. **UC 1** in charge of improving container cargo operations between China and Spanish hinterland. In this UC, the IoT environment will implement functionalities of T&T&M with improved granularity, giving the possibility to users to collect focused information related to a certain pallet, instead of the whole container. This UC will take care of tracking goods encapsulation, detecting consolidation and deconsolidation operation.

2. **UC 2** in charge of optimizing warehouse operations and automation and last mile deliver efficiency and sustainability. Regarding the IoT side, this UC will oversee collecting the presence and the specialized information regarding pallets after the container deconsolidation (or before the container consolidation). Presence and specialized monitoring of certain set of pallets in the warehouse will be realised and last mile transport T&T&M service implemented.

To implement such data collection and sharing infrastructure, the following two main sub-systems (see also Figure 17) are required to implement it:

1. **On the premises IoT environment**, to collect the data from the goods and the environment.
2. **Cloud IoT Platform**, to collect, store, and make available the data to the logistics stakeholders.

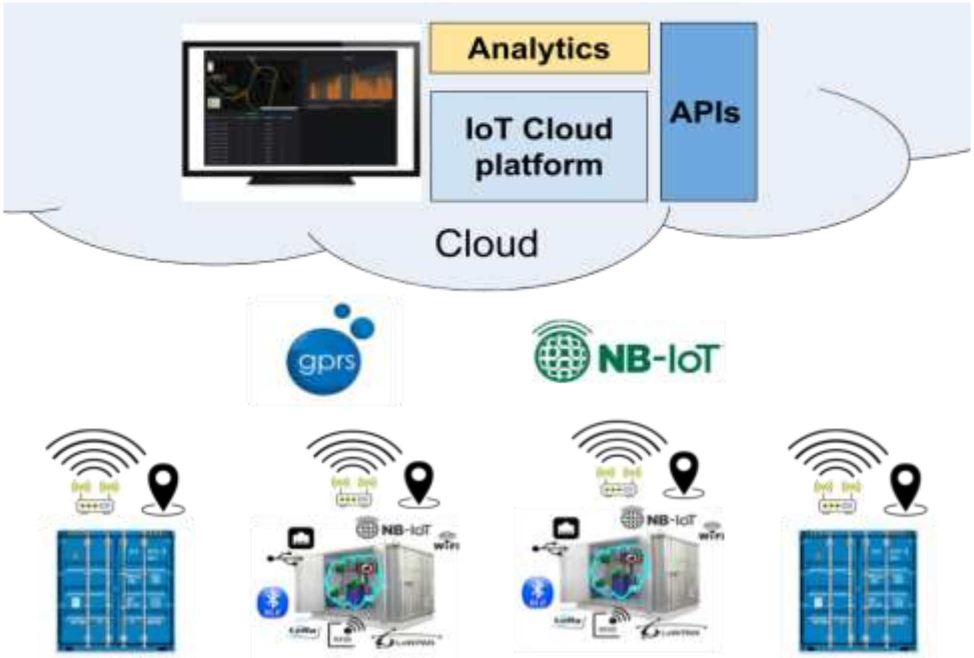

Figure 17. LL1 General IoT Architecture

6.4.2.1 *Use case 1: T&T&M of cargo containers with improved granularity*

This use case considers the T&T&M of goods and containers, as well as following their encapsulation/decapsulation. It will oversee:

1. Configuring the encapsulation, consolidating/de-consolidating the composition of the container, and evaluating the correct inventory of the goods.
2. Monitoring and tracking the goods with improved granularity along the supply-chain, until the arrival toward the destination hub.
3. Making available the data in a secure and ad-hoc manner to all the stakeholders involved in the considered transaction, exploiting standardized data models.
4. Enabling the generation of metadata and statistics to characterize the shipment or the corridor.
5. Providing a GUI capable to visualize the evolution of the shipment, or course providing ad-hoc access to all the stakeholders involved in the considered transaction.

Figure 18. Use case 1 scenario

In Table 10 and Table 11 the main functionalities of the Smart Pallet and the Smart Container respectively are detailed.

Table 10. Smart PI Pallet functionalities

FUNCTIONALITIES	DESCRIPTION
	SMART PI PALLET
GS1 STANDARD CODING	Considering standardised coding (GS1 SSCC and GRAI)
REAL TIME INVENTORY	Detecting the presence of the encapsulated goods
DISTRIBUTED MONITORING	Collect distributed information regarding the goods (Temperature, Humidity, Pressure, acceleration)
SPECIAL EDGE FUNCTIONALITIES FOR CERTAIN GOODS	Each device on goods/pallets has intelligence
CONNECTIVITY	BLE and NFC (for GS1 code configuration)
POWER SUPPLY	Battery

Table 11. Smart PI Container functionalities

	SMART PI CONTAINER
ISO STANDARD CODING	ISO-6346
POSITION AND TIME	Equipped with GPS
DATA COLLECTION	Temperature, humidity, acceleration, light, battery level, open/close door)
EDGE FUNCTIONALITIES	Bump, movement, stop, open/close door, thresholds exceedance, low battery
CONNECTIVITY	For data collection (BLE, IEEE802.15.4) For remote communication (Cooperative: BLE; Stand-alone: 2G and NB-IoT/LTE-M
POWER SUPPLY	Battery

6.4.2.2 Use case 2: T&T&M in warehouses and last mile logistics

This use case considers the monitoring and tracking of goods immediately after the container's deconsolidation operations (or before its consolidation): the goods handling on the warehouses and the last mile logistics. Thus, after the de-consolidation between of the Smart PI container, the Smart PI Pallets can authenticate their encapsulation connecting with the gateways installed in the warehouse or in the last-mile logistics vehicles, as depicted in Figure 19 and Figure 20 respectively. In this scenario, the Smart PI Pallet will implement the same functionalities of inventory and specialized monitoring as in UC1, while the gateway will complete the information adding geo&time references.

Figure 19. Smart Pallet in a warehouse

Figure 20. Smart Pallet in the last mile logistics

6.4.3 Data collection and sharing: interoperability, data usability and standardisation scenario

The IoT environment in the premises must implement an interoperable framework to accommodate different IoT service providers devices that cooperate in an open and scalable architecture. For these reason, IoT environment must expose interoperable protocols and data-models capable to satisfy up to the semantic interoperability level (see also (IoT-EPI, 2018)). Regarding this scenario, we reference the DCSA standard, released in May 2020 (see (DCSA, 2020)).

IoT sensors provide data in real time and allow the review historical data. The benefits of data collected are the following:

- Estimate container real arrival at port during the maritime transport, in real time, to prepare land transport, know delays and other stops (e.g.: Ship delays ETA, omission a stopover to accomplish schedules, longer stop in other ports, etc.)
- Estimate container real arrival at the destination during the inland transport, in real time, to prepare next activities (e.g.: open customer warehouse/factory and prepare workers for discharge container, goods available to continue the production chain, prepare other transports to distribute goods)
- Report possible delays in arrival and modify ETA of section. (e.g.: traffic jam, weather effects that force to reduce the speed, velocity decrease to save fuel, etc.)
- Test goods temperature and know if it is outside a range, necessary for it to be considered useful (e.g.: food and pharmaceuticals products, technological devices, etc.)
- Advise if humidity varies from a range is useful to control goods that need specific environmental conditions and can give information of possible container damage and if it isn't watertight (e.g.: Wood products, food, medicines, textile, etc.).

In this scenario, the Cloud IoT Platform will be the instrument for ingesting the data collected from the premises, then store visualize, and process it. Finally, it will oversee feeding standardized repository capable to expose standardizes, secure and ad-hoc interfaces to all the stakeholders involved in transactions. GS1 EPCIS 2.0 seems to be the most promising standardization path capable to make available the data in a common language thought for logistics transactions.

6.5 Digital clones Requirements

The digital clones should be able to address the following requirements:

SR1: Digital Clones should be able to visualize 3D representation of the warehouse making information more accessible

PLANET LL1 Digital clones will have the ability to visualize what is happening in the warehouse to analyze behaviors and to take the right decisions.

SR2: Digital Clones should be able to execute Pre-assessment & Optimization of Warehouse Processes

PLANET LL1 Digital clones will have the capability to execution What-If scenarios/simulations to know the consequences of a process change before it takes place.

SR3: Digital Clones should be able to improve the warehouse layout

PLANET LL1 Digital clones will provide enough data and visualization to improve the design and layout of facility.

SR4: Digital Clones should be able to calculate the spare capacity

PLANET LL1 Digital clones will integrate the IBM's forecasting model to calculate the spare capacity of the warehouse.

SR5: Digital Clones should be able to provide valid data to analyse of products

PLANET LL1 Digital clones will be provide valid data for data analysis in terms of product quantity, location, etc.

SR6: Digital Clones should be able to optimize the last mile delivery

PLANET LL1 Digital clones will use their outputs for the DSS to improve/optimize the last mile delivery.

6.6 Decision making intelligent algorithms (based on AI machine-learning)

<u>Assessment of the impacts of route changes (UC1)</u>

Considering the factors described in Chapter 5.4, the Intelligent Algorithm should be able to address the following requirements:

SR1: Intelligent algorithm should be able to assess the transit time to different port destinations, in this case, Valencia, Barcelona and Algeciras.

PLANET LL1 intelligent algorithm will integrate functionalities able to estimate the transit time to Valencia, Barcelona and Algeciras ports for a specific vessel. This calculation will be one of the factors used to suggest the port of destination.

SR2: Intelligent algorithm should be able to calculate the costs associated to changing the port call on the fly for different port destinations, i.e., Valencia, Barcelona and Algeciras. Costs should cover port, terminal and fuel aspects.

PLANET LL1 intelligent algorithm will integrate functionalities able to estimate the cost of port calling in different port destinations such as Valencia, Barcelona or Algeciras. Cost calculation should integrate port, terminal and fuel aspects. This calculation will be one of the factors used to suggest the port of destination.

SR4: Intelligent algorithm should be able to assess the operational time associated to the transportation of a specific cargo type by both truck and train transportation means considering a fixed destination.

PLANET LL1 intelligent algorithm will integrate functionalities able to estimate the transit time for terrestrial transportation in truck and train modalities considering specific inland destinations. This calculation will be one of the factors used to suggest the best terrestrial transportation option.

SR5: Intelligent algorithm should be able to recalculate the operational time associated to the transportation of a specific cargo depending on the warehouse or customer destination.

PLANET LL1 intelligent algorithm will integrate functionalities able to recalculate the operational time associated to the transportation of cargo to different warehouse and customer destinations.

SR6. Intelligent algorithm must ingest data related to the truck and train schedulings in order to define a specific time estimation depending on the requested delivery date and time.

PLANET LL1 intelligent algorithm will ingest data related to truck and train schedulings in order to estimate operational times for any delivery date and time.

SR7: Intelligent algorithm should be able to suggest a transportation type depending on the cargo type, final destination, transportation scheduling, etc.

PLANET LL1 intelligent algorithm will integrate functionalities able to suggest the terrestrial transportation mode depending on the cargo type, the final destination of the cargo and transportation schedulings.

For improved predictions and warehouse operations planning (UC2)

Considering the factors described in Chapter 5.4, the Intelligent Algorithm should be able to address the following requirements:

SR1: Intelligent algorithm should be able to provide the volume flow into warehouse for next days

PLANET LL1 intelligent algorithm will provide a prediction on the volume flow into the warehouse for the next days.

SR2: Intelligent algorithm should be able to assess number of vehicles needed for next days

PLANET LL1 intelligent algorithm will provide a prediction of vehicles for next days in order to hire transport in with a better time frame and to reduce subcontracting costs.

SR3: Intelligent algorithm should be able to assess number of persons needed in the warehouse for next days

PLANET LL1 intelligent algorithm will provide a prediction of persons needed in the warehouse for next days in order to hire the exact number of workers to accomplish the different tasks.

SR4: Intelligent algorithm should be able to provide valid data to carry on simulations

PLANET LL1 intelligent algorithm will be used to apply Simulation for optimization possibilities in terms of resources and warehouse operations.

SR5: Intelligent algorithm should be able to provide valid data to create Smart Contracts

PLANET LL1 intelligent algorithm will be used to create an AI enabled Smart contract service for vehicle booking/hiring personnel.

7 Simulation-based Designs for the LL's EGTN

Supply chain simulation is a scientific method by which users employ a model to observe the operation of an entire supply chain and conduct ''what-if'' analyses for multiple scenarios. There are several kinds of supply chain simulation methods, including agent-based simulation [2]. Agent-based modelling uses a bottom-up modelling approach and is widely considered as a valuable approach for decision support in supply chain [3]. Each entity in the system is modelled as an "agent" that has its own states and interests and makes decisions based on a series of rules (Bonabeau, 2002). Agents are also able to interact with each other, perceive their environment, and respond to changes. Agent based models are flexible and scalable. The complexities of models can be manipulated by modifying the number of agents and the rules for their actions and/or reactions, learning, and interaction [4].

Therefore, the purpose of the use of simulation in this Living Lab is to evaluate and compare different virtual scenarios to assess the impact that the different innovations have on maritime and inland operational processes. The simulation models are used to quantify this impact based on economic (transport and handling costs), business/operational (lead time) and social (CO2 emissions) indicators. Also, they are a powerful tool to visualize the movement of products over a PI network, including flows from different companies.

7.1 LL Modelling

In this project, the different agent-based simulation models have been developed from the basic elements (model agents) of the Physical Internet:

- Nodes: the nodes in the PI network represent the places where goods are stored, transferred, or manipulated between movements in the network. In the models, the main nodes are port and inland terminals, intermediate TEN-T nodes, warehouses, and city-hubs.
- Transporters: the transporters convey or handle containers within and between the nodes of the Physical Internet. In the models, the main inland transporters are trucks and trains, which ship containers between inland nodes. On the other hand, vessels agents ship containers between port terminals.
- Orders: an order is the element of information that causes products to move within PI. The order is associated with a set of containers, which must be transported from a point of origin to one (or several) destinations.
- Containers: the container is fundamental for the Physical Internet; it is the metaphor of the Digital Internet. By analogy with data packets, the goods are encapsulated in intelligent containers of easy-to-interconnect modular dimensions, called PI Containers, designed to flow efficiently in hyper connected networks of logistics services.

Each of the agents described above has been modelled according to their current process diagrams. Two examples are shown below. The modelling of the "truck" agent (Transporter) and the modelling of the "port terminal" agent (Node). The blocks represent the current state in which the agent is. These blocks are parametrizable and actions can be executed (modifying the agent's characteristics, communicating with another agent...) within them. To move between states, it is necessary to trigger transitions (black arrows), which can happen when a certain amount of time passes, when a condition is met or when the agent receives a certain message.

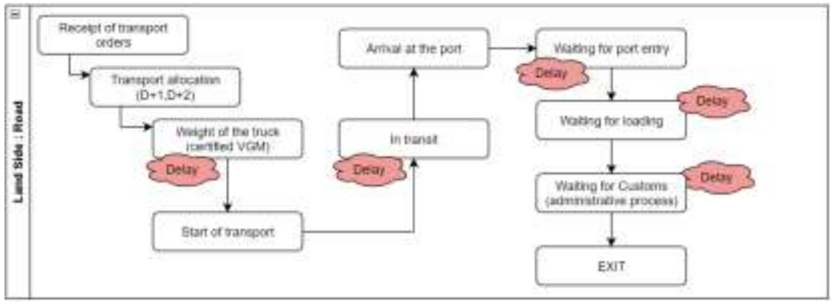

Figure 21. AS-IS Truck agent process diagram

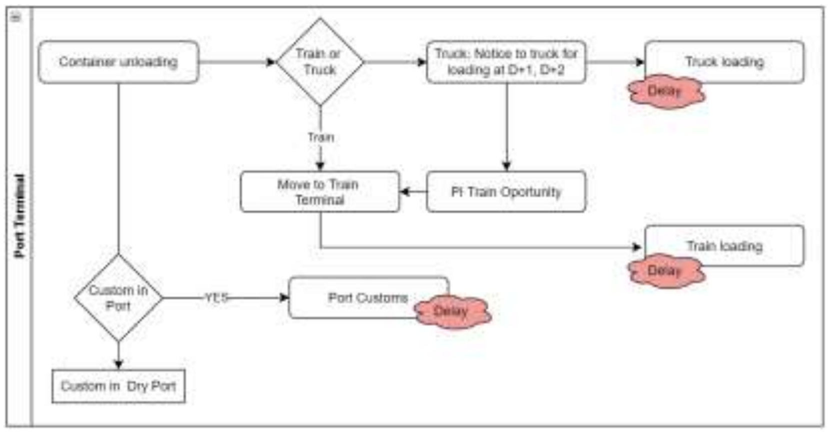

Figure 22. AS IS Port Terminal process diagram

The impact of EGTN innovations can be transferred to models through simulation parameters, by adding new transport agents (e.g., Cargoloop) or modifying current process diagrams. For example, it is expected that the adoption of blockchain smart contracts will reduce the time trucks spend in customs or that the use of IoT sensors in the containers will eliminate the weighing stage. In addition, certain algorithms could be tested during the simulation runtime, such as routing or the port choice model for cargo ships. All these innovations are expected to have a positive impact on transport cost, end-to-end visibility, cargo safety and many others. As an example, for the “truck” agent, the blocks (processes) where an impact of any of the EGTN innovations (PI, IoT, BC...) is expected, have been marked with a green circle (see Figure 23).

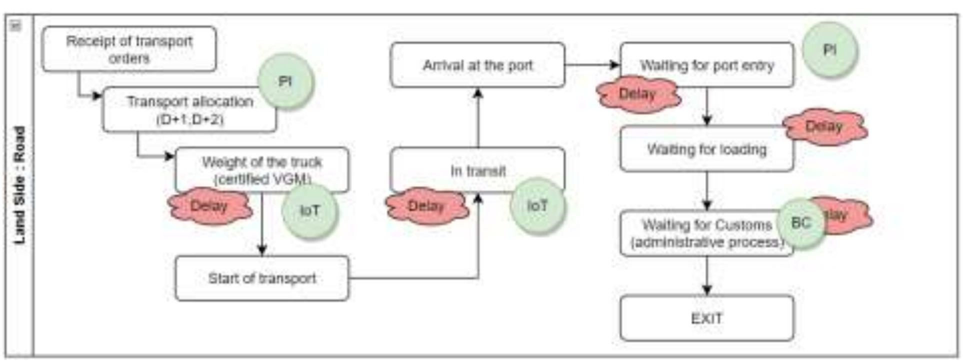

Figure 23. TO BE Truck agent process diagram

8 Living Lab Organisation & Planning

LL1 aims at evaluating how new technologies (IoT, AI and blockchain) and concepts (Physical Internet) can improve processes, operations and efficiency along the door-to-door transport chains linking the Maritime Silk Road with EU internal corridors. This chapter describes the main actors, activities and roles involved in LL1 (Section 8.1) as well as the test execution plan (Section 8.2), starting at M21.

8.1 Living Lab Organisational Structure (roles & responsibilities)

To achieve the living lab objectives, LL1 work is structured to cover two different use cases:

- **Use Case 1** is focused on import/export door-to-door transport chain of containerized cargo between China and Spain to evaluate how the combination of IoT (for real-time monitoring of logistics assets), AI (for better forecasts and intelligent decisions based on machine learning algorithms) and blockchain (for paperless transactions and the register of transport events), can contribute to a better management of the transport chain. The development of the PI paradigm is also investigated in UC1 where intelligent logistic nodes or hubs play a key role in transport decisions and are optimized based on real time events/information and historical data.
- **Use Case 2** focuses on warehouse operations and explores how new IoT, AI, AR and automation technologies can contribute to the development of intelligent automated logistics nodes of the EGTN/PI network. This use case complements Use Case 1, particularly on how to integrate smart Warehouse Nodes for EGTN routing decisions, ultimately creating PI Warehousing Nodes.

To carry out and demonstrate the work envisaged in both use cases, LL1 has also defined a set of five activities where different technological solutions will be developed:

- **Activity 1:** This first task addresses the simulation-based specification and testing of a PI network including entry nodes (ports), warehouses (DHL) and city-hubs (CityLogin) (use cases 1 and 2) using the EGTN Architecture designed in WP2. It provides a specification of a PI network in Spain, by providing intelligence to the entry nodes to take decisions and linking them to the automated warehouse nodes that will then be connected with the city nodes.

- **Activity 2:** The second task addresses the intelligent decision making at transport and logistics hubs (operations and routing) by performing: (i) Simulation and assessment of a real-time synchromodal planning approach aligned with PI principles where the port-terminal logistics hubs provide optimized dynamic routing of containers through the network considering capacity, level of service and cost of the multiple modes of transport available (use case 1); (ii) Application of intelligent algorithms (based on AI machine-learning) for the detailed assessment of the impact of route changes of large oceanic container ships on terminal operations, considering the necessary inland transport re-routing of shipments (use case 1); (iii) Application of AI/Analytics for improved predictions and warehouse operations planning (use case 2); (iv) Application of new augmented reality solutions for order picking in warehouses (use case 2).

- **Activity 3:** The third task covers the design and implementation of interoperable blockchain platforms: connecting the blockchain platform in the Port of Valencia with DHL blockchain network, which will be developed by FV and KNT respectively. In addition to the investigation of smart contracts, this task also addresses the management of multiple interactions and transactions with a large number of different stakeholders, public and private in different counties, including port and maritime authorities, customs and other inspection bodies, transport companies, port and rail terminals, freight forwarders, importers and exporters, etc.

- **Activity 4:** This fourth addresses the IoT deployment for worldwide tracking of containers and other load units and logistics assets: (i) Testing with specific Asia-Europe shipments of the innovative solutions proposed and developed within PLANET (T2.2) (use case 1); (ii) Testing low cost sensors for tracking and tracing materials in warehouses (use case 2).

- **Activity 5: This fifth task focuses on the development of d**igital clones in order to carry out design-planning, operation and optimization of logistics infrastructure in warehouses. These clones combine a 3D model of the facility with IoT data collected in connected warehouse platforms, as well as inventory and operational data including the size, quantity, location, and demand characteristics of transport cargo.

The development of these activities will be carried out and tracked through the definition of four different subtasks, as part of T3.1 execution o LL1 PI and Blockchain for optimised door-to-door Asia-EU corridors:

- **ST3.3.1 LL AS-IS analysis and detailed specification and plan** will provide an in-depth analysis of the current situation, including infrastructure analysis for the corridor as the basis for: (i) the identification of main needs and problems affecting global transport corridors, warehousing and last mile distribution, and the final selection of the specific problems that will be addressed in the LL; (ii) the definition of tests based on new technologies and concepts proposed and supported by PLANET's EGTN approach in order to overcome the selected problems; (iii) the final selection of specific supply chains or transport flows to perform the tests, affecting specific shippers, corridors, logistics nodes and transport and logistic operators. After this, this subtask will provide a complete definition of organization and planning of the LL1, LL2 and LL3. More specifically, (i) the purpose of the test; (ii) the actors and systems involved; (iii) the link with the EGTN technological framework and infrastructure designed in WP2; (iv) the plan and calendar for the preparation and execution of the test, as well as for the analysis of results; (v) the business model, data sharing, rules for intelligent decision making and incentive system for the implementation of the solution or concept being tested; (vi) the related KPIs for evaluation; (vii) the expected results and (viii) specification of surveys from LL actors to ascertain impact KPIs as specified in section 3.1. Simulation based designs of each LL EGTN of a PI-inspired network including entry nodes (ports or inland terminals, warehouses, intermediate TEN-T Nodes and city-hubs) will be produced.
- **ST3.3.2 Installation and technical validation of the PLANET Cloud-based Open EGTN Infrastructure in the LLs:** The necessary components for container-based infrastructure deployment in the cloud, to enable concurrency in use-case execution, to quickly match specific LL configurations and to easily deploy the EGTN Infrastructure in the LLs. The infrastructure will be setup, configured and validated prior to LL deployment, to ensure proper operation, concept verification and usability testing. Test procedures description and acceptance tests execution to verify proper functioning of all developed components will also be provided. An evaluation of the performance capabilities of the EGTN Infrastructure will be conducted after each testing cycle, to be able to perform potential incremental improvements in the functionality and performance of the infrastructure. This subtask will also produce the EGTN Infrastructure system technical documentation containing detailed guides to allow successful service delivery, indicating necessary physical requirements, minimum hardware, software and guidelines of use from both, tool and technical service interface, where the consortium will create substantial and clear documentation to allow end-users from LLs to make use of the system.
- **ST3.3.3 Testing:** This subtask involves developing the battery of tests designed and planned in the previous subtask following the appropriate procedures in order to compile the necessary information for a proper assessment of the results. This will require the involvement and coordination of all those participating in the test and will require a previous training when the test requires the use of new tools or systems. Complete impact related surveys.
- **ST3.3.4 Analysis and results:** This subtask involves the detailed analysis of each of the tests developed in the previous subtask, calculating the KPIs previously defined and assessing the impact of the real implementation of the solution and/or technology that has been tested. Analysis will be also carried to

impact user surveys. This subtask will consolidate a report with all the results, conclusions and recommendations.

According to this task structure, the role and responsibilities of each partner as part of LL1 work is the following:

- **COSCO SHIPPING Lines (Spain) S.A.** coordinates LL1, and takes specific ownership for UC1 to: (i) set up the LL and manage hinterland side data and operations; (ii) evaluate the current situation of barriers and bottlenecks along the transport chains and how the introduction of the blockchain technology could improve processes along the corridor, especially in the hinterland side; (iii) evaluate how big data analytics and ML can contribute to intelligent decisions based on a PI approach; and (iv), evaluate benefits of the new technologies and logistics concepts for end-to-end monitoring of goods and in supporting customer experiences by bringing trust, transparency and collaboration.
- **DHL Supply Chain Spain** is the responsible for UC2, specifically to evaluate automation using robotics (piece-picking robots, automatic guided vehicles, etc.) and/or unmanned aerial vehicles with realistic data in one of the DHL warehouses located in Spain.
- **Fundación Valenciaport** is the responsible for the development and adaptation of the technical solutions (AI, Blockchain) towards a PI approach. In particular, the tasks carried out by FV are: (i) develop the PoV blockchain network and integrate it with the existing information systems, including writing intelligent contracts according to actual requirements, (ii) to test the benefits of interoperable blockchain infrastructures by enabling connectivity with DHL blockchain in collaboration with KNT, (iii) to analyse the data required by supply chain management in the corridor and design the data services, and (iv) to support the development of AI for the dynamic assessment of the impact of potential route changes.
- **CityLogin** with a strategic focus on urban logistics and commitment to the Physical Internet Vision, supports the linking of Valencia node to the Madrid node, integrating last mile to end-to-end supply chains particularly operating under PI principles.
- **Itainnova** is responsible for modelling the transport and supply processes in the living lab from a collaborative point of view within the framework of Physical Internet. The processes are analysed and it is evaluated which aspects can be influenced by the different innovations of the planet project, such as artificial intelligence, blockchain or real-time information through IoT sensors. Based on these simulation models, different scenarios will be simulated to measure the impact of all these innovations from an economic, operational and environmental point of view.
- **IBM** focuses on supporting the development of the EGTN solutions for the Living Labs scenarios to enable opportunities for higher levels of global connectivity and automation, by using AI approaches and leverage Big Data sets to generate services and reinforce paths towards new T&L business models.
- **Konnecta** aims at interconnecting separate Blockchain systems from different T&L stakeholders, so that these systems can interoperate, exchange data and functionality. More specifically, Konnecta is responsible for the development of the EGTN Blockchain Service, which connects the Port of Valencia blockchain network with the one from DHL. In the same context, it is working towards the connection of the Port of Rotterdam blockchain (LL2) with the previous two blockchain networks. Apart from the, efficient contract negotiation in the DHL warehouse shall be achieved through the automated trigger of smart contracts based on AI outputs.
- **VLTN** supports the technological development of green logistics and supply chains and is dedicated to research and development of innovative solutions that harness the Cloud to simulate, digitize and transform transport and logistics processes and data into optimized green networks. VLTN employs techniques such as large-scale cloud-based simulations for sustainability, security and business process modelling and optimization, and massive graph databases to mine intelligence from security and

business data and to utilize them in situation awareness, economic and environmental performance optimization and other insights.

- **Zaragoza Logistics Center (ZLC)** is WP3-PLANET Living Labs leader, coordinating the activities in the three LLs towards the project objectives and the interaction and links with other WPs.

8.2 Implementation Plan

Based on the task structure previously described and project GA plan, the Gantt diagram below details the implementation plan designed to drive Living Lab's subtasks and activities. As regards the assessment approach this will be based on the KPIs defined under Section 5.6 and it is planned to be covered in the next release of this deliverable (D3.2).

The table below, pinpoints key milestones established to enforce discipline in LL1's implementation roadmap.

Table 12. LL1 Milestones

M5a	Detailed Textual Business Case Description (incl. KPIs)	jul-20	M2
M5b	Detail IoT/AR Requirements (required devices, existing services, etc.)	ago-20	M3
M5c	Identification of involved Data Flows, Sources and Access method	sep-20	M4
M5d	PoV & COSCO Blockchain Technical Specifications & exchanged data	oct-20	M5
M5e	Detail Intelligent Decisions (AI) Requirements & Goals	nov-20	M6
M5f	Detail Blockchain Interoperability & Smart Contract Requirements	dic-20	M7
M5g	Simulation Model Specifications	ene-21	M8
M5h	LL1 EGTN Infrastructure Requirements & UCs Testing and KPIs measurement method	feb-21	M9
M5i	Implement Tracking for Asia-Europe shipments and Warehouses	mar-21	M10
M5j	Implement initial Intelligent Decision (AI) Algorithms	abr-21	M11
M5k	Initial Simulation Model Setup in local Simulation Environment	may-21	M12
M5l	LL1 Initial EGTN Infrastructure Setup	jun-21	M13
M5m	Initial Simulation Execution on EGTN Infrastructure	dic-21	M19
MS5	Installation and technical validation of the EGTN Infrastructure in the LLs	feb-22	M21
MS6	First phase testing in LL complete	jun-22	M25
MS7	Second phase testing in LL initiated	oct-22	M29

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No 860274.

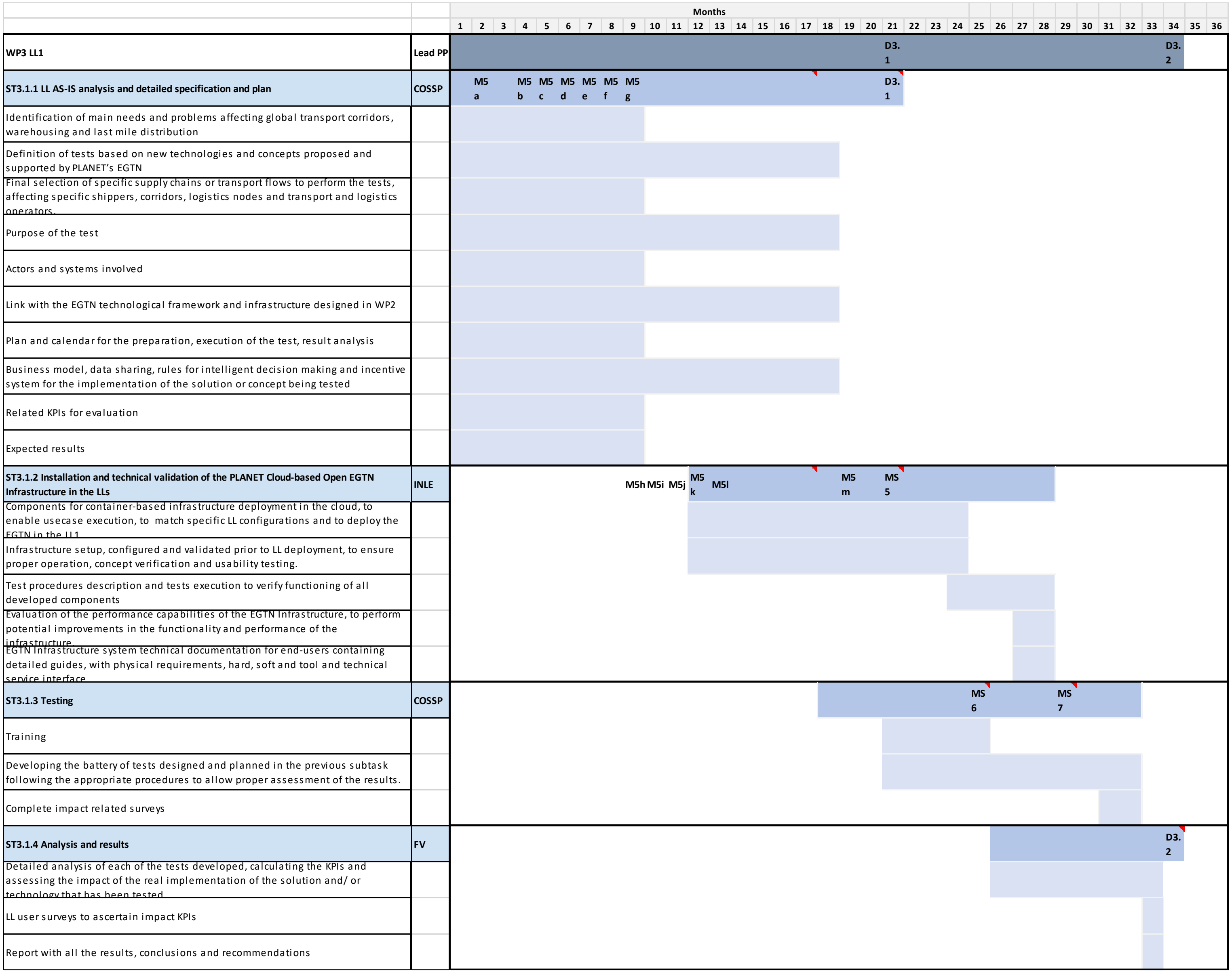

Figure 24. LL1 Gantt chart

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9 Conclusions

Deliverable D3.1 provided an overview of LL1 specifications and baseline measurements for the implementation of innovative solutions planned to be engaged through the project to optimise the door-to-door logistics in the Asia-Mediterranean corridor. Chapter 3 to Chapter 5, have detailed LL1's scope of work, the AS-IS situation and envisioned goals establishing baseline measurements, target indicators and a set of technologies used to optimise the logistics processes, i.e. the physical internet (PI), blockchain, artificial intelligence (AI), and the Internet of Things (IoT). These chapters were used as the base for the drafting the three following sections, where technical requirements, simulation-based designs and a first version of testing aspects are addressed for each of the aforementioned PLANET technology solutions.

Although it is premature to draw any solid conclusions on LL1, preliminary indications based on under-development simulation models and observations, a set of high expectations has be established:

- The application of AI, for the optimization of synchro-modal routes and maritime route change and inland re-routing, is expected to allow COSCO along with all involved logistic actors, to save time and reduce operational costs along with the environmental footprint,
- The use of Blockchain will certainly facilitate the reduction of paper-based processes, efficient exchange of real-time secure data and significantly improve customer experience. Through blockchain every stakeholder has access only to the information that he needs and is authorized to have. Blockchain interoperability is also explored, as a breakthrough approach for exchange of information in between different and independent Blockchains.
- IoT devices, already deployed in the production environment, will allow relevant stakeholders know beyond container location in real-time, and the cargo status broadcasting all registered events to all interested actors.
- Data Analysis combined with Machine Learning will provide demand forecast for engaging Transport and Human resources in advance for a better logistics planning.
- Digital Clones & Simulations will improve the warehouse management and model potential logistics scenarios to face unforeseen Supply Chain disruptions.

This first deliverable compiles the progress made until M21. In the coming months, the consortium partners will jointly work on further refining these initial baseline measurements in parallel with the construction of the project's technology solutions and the execution of testing activities. PLANET LL1 final work will be included in the follow-up deliverable D3.2, including a more detailed analysis of actors and systems, the application of EGTN Solution and KPIs results, including a survey specification (from LL actors to ascertain impact KPIs).

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