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BOOSTLOG PROJECT

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2	STICHTING SMART FREIGHT CENTRE (SFC)	NL
3	FUNDACION ZARAGOZA LOGISTICS CENTER (ZLC)	ES
4	STICHTING TKI LOGISTIEK (TKI Dinalog)	NL
5	HACON INGENIEURGESELLSCHAFT MBH (HACON)	BE
6	INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS (ICCS)	GR
7	Vlaams Instituut voor de Logistiek VZW (VIL)	BE
8	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V. (Fraunhofer)	GE
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are persons with extensive knowledge or ability in an area of study or work.

are the main deliverables, publications etc. out of the projects. For EU Horizon 2020 projects, they are available through CORDIS projects pages.

are products, services or solutions for business applications aiming at addressing Pain Points and other value-added results potentially impacting the market (by creating it or transform it), the Companies operations as well as polices and regulation. Results that could set direction in Companies and Governments are considered Outcomes too.

are concrete examples in which causal links between public R&I funding and technology, organizational or process innovation in a specific logistics area can be established.

are used in BOOSTLOG to refer in a generic way to a freight transport and logistics domain providing flexibility in the way complex problems are defined and addressed

EXECUTIVE SUMMARY

In order to optimise European investments in R&I projects in the field of transport and logistics, BOOSTLOG will carry out a thorough evaluation process of concluded Research and Innovation (R&I) projects financed with EU-funds.

This evaluation is conducted from the perspective of different key domains of transport and logistics (T&L), (defined by BOOSTLOG as clouds) to identify R&I gaps in T&L and prioritise the needs to be addressed in future research programmes, thus contributing to develop an innovation ecosystem for the logistics sector that also contributes to the EU policy objectives.

This deliverable focuses on logistics nodes, showing the main results and impacts derived from European-funded projects on this area. More specifically, the evaluation of more than 160 concluded EU-funded R&D projects - from the 5th Framework Programme up to H2020 - has resulted in the selection of 21 projects (see Figure 1), as these are considered key projects with important contributions to the progress and evolution of the logistics nodes.

Figure 1.

On the other hand, it has been distinguished that the main results of the logistics nodes' projects revolved around four main themes:

1. Safety and traffic management of logistics nodes;
2. ICTs for optimizing container/intermodal terminal processes and operations;
3. The new generation of logistics nodes: Governance, Collaboration and Business models;
4. Transition to more efficient and sustainable vehicles and machineries.

The study has also shown that most of the projects in the scope of the cloud logistics nodes are linked to the Horizon 2020 programme, reason why few implementation cases have been identified. However, as evidenced in the reports of Coordination and Collaboration and Urban Logistics clouds, it is expected that implementation cases will emerge in the coming years. Ideas and results from projects linked to this programme need to mature, links need to emerge, outcomes need to be connected between completed and upcoming projects, etc. before the results, outcomes and findings can be implemented in the market.

BOOSTLOG has recognized the following 5 Implementation cases that significantly impacted logistics nodes. Most of them are linked to ports (four of the five implementation cases addressed focus on these infrastructures) and selected projects in this cloud (COREALIS, PIXEL and Clusters 2.0 are EU funded R&I Projects, while Tebets is an R&I project financed by Italian funds):

- 5G Port of the Future.
- PREDICTOR Asset Management.
- Port Environmental Index.
- Slot Booking App.
- Port rail Shunting Optimization Tool.

Additionally, the report describes 5 companies and market initiatives that are also tackling key points in the logistics nodes to improve its efficiency and effectiveness of its operations and processes.

In Table 1, the targeted impacts of the projects and the assessment of their readiness level (not just technical but also market, operational, etc) is layered into 6 levels: Not demonstrated (ND), Theoretical Demonstration (TD), Proof of Concept (PoC), Implemented Small Scale (including Niche Markets) (ISS), Implemented Medium Scale/Several Companies (IMS), Implemented Large Scale/Mainstream in Industry (ILS). More detailed information can be found in Annex II – Evaluation of the projects' status.

Table 1.

TARGETED IMPACTS	NR. OF PROJECTS	STATUS
Decrease of environmental and climate impact	11	18% TD 73% POC 9% ISS
Reduction of congestion on the road network	1	100% POC
Modal shift	5	20% ND 80% POC
Decrease cost of transport & overall logistics	6	33% TD 50% POC 17% ISS

Increased transport reliability and responsiveness	2	100% POC
Increase management capacity of terminals and productivity	5	20% TD 60% POC 20% ISS
Improved operations, terminal capacity utilization and efficiency in terminals	2	100% TD
Improve energy consumption	2	50% TD 50% POC
Improve the performance of the European Transport	3	100% POC
Improve long distance-city distribution connectivity	1	100% POC

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1. Introduction and methodology

1.1. BOOSTLOG project

BOOSTLOG Vision is transforming European freight transport and logistics R&I ecosystem to perform optimally boosting impact generation out of R&I investment contributing to i) EU policy objectives towards climate neutrality, pollution, congestion and noise reduction, free movement of goods, internal security, digital transformation of logistics chains and data sharing logistics ecosystems and ii) sustainability and competitiveness generating value for society.

In order to do so, BOOSTLOG has identified 4 main areas of action: i) increase visibility and support valorisation of R&I project Results, Outcomes and Implementation Cases in the freight transport and logistics field ii) develop and implement valorization strategies and guidelines to speed up the technological and organisational innovation uptake, including the creation of the Innovation Marketplace and issue recommendations to increase impact of R&I public funding, iii) Define high potential & priority R&I gaps to make efficient uses of R&I investments and iv) Strengthen R&I impacts communication and Stakeholders engagement in the innovation process.

In the framework of the first of those actions, BOOSTLOG has mapped and assessed more than 160 EU-funded R&D since FP5 in different freight transport and logistics domains (i.e., the Logistics), so as to develop at 8 comprehensive and industry actionable reports. The third issue of those reports is the present document, that will focus on logistics nodes.

These industry-oriented reports will be later complemented by deliverables on valorisation strategies and guidelines for public R&I uptake (WP3), an innovation marketplace for R&I uptake (D3.3) and the identification of high priority and potential R&I gaps that need to be prioritized in future R&I actions targeting policymakers (WP4).

1.2. Scope of this deliverable

In the framework of BOOSTLOG WP2, "From R&I projects results to impact generation", Task 2.1 focused on the analysis of the EU funded projects: gathering Outcomes, Implementation Cases in specific Clouds. The present deliverable shows the third report stemming from task 2.2, i.e., focussed analyses on selected Clouds: i) freight and logistics data sharing, ii) coordination & collaboration[1] iii) urban logistics[2], iv) logistics nodes, v) multimodal freight, corridors & transport networks, vi) modularization and transhipment.

The present report focuses on the logistics nodes Cloud identified under the framework of BOOSTLOG. Specifically, the report concentrates on five specific infrastructures and three types of improvements, showcasing both outcomes and implementation cases directly contributing to the innovation in the field. To avoid overlaps, some cases with a minor impact on this cloud have been left out of this report as they have been earlier (such as urban logistics) or will be later showcased in future cloud reports (logistics data sharing).

1 D2.2 Cloud report – Coordination and Collaboration: https://www.etp-logistics.eu/wp-content/uploads/2021/12/BOOSTLOG_D2.2-Cloud-report-Coordination-and-Collaboration_final.pdf

2 D2.4 Cloud report – Urban Logistics: https://www.etp-logistics.eu/wp-content/uploads/2022/03/BOOSTLOG_D2.4-Cloud-report-Urban-Logistics_final.pdf

Logistics Nodes are centres of freight transport where a large activity of cargo logistics and related services are concentrated with different degree of added value. Located at strategic points of interconnection along the main supply chain routes, logistics nodes cover maritime, river, inland ports, airports, intermodal terminals as well as other hubs such as distribution centres or warehouses.

They are facilities characterised by its geographical strategic location and by the infrastructures, assets and activities involved, which enhance the transport process with added-value services focused on the final customer. They usually involve large areas where both public authorities and business agents cooperate under co-opetition schemas to facilitate and optimise transport and logistics operations along the supply chains. Thus, this report also focuses on the main barriers hindering the logistics nodes and how the organizations comprising logistics nodes – including all technology and process providers that supports handling and transhipment in logistics nodes - could address them. Insights about barriers faced by logistics nodes projects, as well as positive framework conditions, are not part of the scope of this report and can be found in the forthcoming deliverable D2.9.

Logistics nodes can be classified considering different criteria. In the current Cloud Report, some logistics nodes will be categorised as focal infrastructures, whereas others will be considered in the borders of this Cloud and, as abovementioned, overlapped with other BOOSTLOG Clouds. Therefore, the focal infrastructures of Logistics Nodes are defined as following:

- **Maritime and River Ports**: Defined as logistics hubs characterised for their land, maritime and river infrastructures interfaces. They are composed by a combination of public authorities and business agents that perform coordinated operations following specific governance and operational models.

  In 2019 at intra-EU level the maritime transport represented the 29,6% of the total transport performance and the inland waterway the 4,2% (Eurostat, 2021a)[3] - data calculated on the basis of transport performance (tonne-kilometres) of the five key transport modes -, while road, air and rail transport accounted for 53,4%, 0,4% and 12,3% respectively. As a result, ports, mainly maritime ports, have become strategic nodes in the logistics chain.

  The infrastructures of main interest in this case are the port terminals, defined as logistics hubs in charge of accommodating the different maritime (or inland navigation) transport flows with the local hinterland.

- **Inland ports and hubs:** Described as intermodal freight terminals located within a country or economic region that connects through railway and road networks with maritime or river ports and/or main consumption areas (e.g. highly populated regions and cities). A key specification of this node is the ability of carrying out customs clearance (inland port) or not (inland hub). These nodes are usually tightly connected to its neighbouring maritime or river ports and its development is essential to promote intermodality as they attract volumes and operations of many companies. They usually combine the management of intra-European flows on top of the maritime container flows.

3 Eurostat (2021a). . Eurostat. <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Freight_transport_statistics_-_modal_split#Modal_split_in_the_EU> [02/02/2022]

This logistics node therefore pursues one of the central elements of European transport policy: the intermodality, which is a critical instrument for achieving sustainable and efficient mobility that combines optimally the various modes of transport.

- **Airports**: Transport infrastructures composed of runways, facilities and services for aircraft traffic. The relative share of air transport in EU transport is low - in terms of tonne-kilometres performed, air transport plays only a marginal role in intra EU freight transport, with a share of 0.4 % (Eurostat, 2021a) - but in value terms air transport accounted for 25,6 % of the EU's exports and 21,1 % of its imports (Eurostat, 2021b)[4].
- **Intermodal terminals:** Represent the middle or end points along transport corridors involving both railway or road transport, where loading or unloading of cargo takes place. They can be part of maritime, river and inland ports, airports or inland hubs or be a connection/close to last mile key distribution centres such as cities.

  Intermodal freight transport has increasingly become an important activity for the logistics sector, as well as a political priority as previously mentioned. Consequently, in order to make this intermodal transfer possible, intermodal terminals have become essential infrastructures and are therefore crucial logistic nodes.
- **Container depots**: Defined as a place where maritime containers are stored or held in transit once unloaded from maritime (or river) services. This structure is relevant for shipping and logistics companies as a way to keep the containers under controlled and safe conditions until it is time for using them in next transport services.

In opposition, the border element considered in the current Cloud is Warehouses. These logistics nodes are described as infrastructures for storing end user goods before they are sold, used, or transported and of critical importance for supply chains functioning. However, they are reasonable related to the last mile distribution, considered in a specific BOOSTLOG Cloud of the project.

Following the previous approach, when looking for projects focused on logistics nodes, these should address areas focused on improving the focal infrastructures. Specifically, three main areas have been identified to which improvements can be applied: Operational Efficiency, Operational Safety & (Cyber-)Security Sustainability & Environmental Impacts. These areas are detailed in section 1.5.

1.3. Introduction

Despite the efforts of Governments and Companies, greenhouse gas emissions from the EU's transport increased in 2018 and 2019 and have not followed the EU's general decreasing emissions trend. National projections compiled by the European Environment Agency suggest that transport emissions in 2030 will remain above 1990 levels, even with measures currently planned in Member States[5].

4 Eurostat (2021b). Eurostat. <https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=494356#Trade_by_mode_of_transport_in_value_and_quantity> [07/02/2022]

5 (2020). <https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases-7/assessment>

According to Alan McKinnon[6] freight transport will be the hardest economic sector to decarbonize because it relies very heavily on fossil fuels and the demand for freight transport is expected to rise sharply over the next few decades. Total freight transport in the EU is projected to further increase by 51% during 2015-2050 under current trends[7]. The objective for transport, that accounts for a quarter of the Union´s GHG emissions, is to achieve a 90% reduction in emissions by 2050.

Logistics nodes - from container depots to inland, maritime and river ports, airports and intermodal terminals - are indispensable in international freight trade as they act as interconnection points in the respective transport networks, multimodal nodes and commercial places, linking with other transport modes, hinterland connections and integrating with cities[8].

According to the International Transport Forum[9], door-to-door freight transport involves several modes of transport connected by various nodes, thus logistics nodes are important parts of the whole freight transport chains.

Past events such as the blockage of the Suez Canal in March 2021 – the blockade in one of the world's most critical transit routes led to delays in the arrival of ships and diversions of freight to other logistics nodes (transfers between them as well as to other types of logistic nodes) - or the current congestion in the port of Shanghai put the logistics nodes in the spotlight.

Any problem triggered in any of them will have a ripple effect along the entire supply chain, just as any shock affecting the actors upstream of logistics nodes will have an amplified effect on these infrastructures. Each transition risks creating friction, waiting times and transaction costs, hence logistics nodes have the potential to increase the efficiency of freight transport chains and to reduce emissions from them.

Logistics nodes are strategic points of high relevance in the transition towards zero carbon supply chains and, consequently, to accelerate the green transition and the achievement of the objectives declared by the European Commission through the European Green Deal (EU climate neutrality by 2050 and reduction of greenhouse gases by at least 55% by 2030).

Recognising that maritime and river ports and airports are highly potential for sustainable, smart and multimodal mobility, the EU boost research and implementation of innovative solutions and concepts in these logistic nodes: Green airports and ports as multimodal hubs for sustainable and smart mobility (LC-GD-5-1-2020)[10].

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6 McKinnon, (2018)A. D ; Kogan Page, London, UK

7 SWD (2018) 183 final - PART 1/2. <https://www.eumonitor.eu/9353000/1/j4nvgs5kjg27kof_j9vvik7m1c3gyxp/vkol7hhee5y5/f=/9060_18_add_2.pdf>

8 European Commission. (2020). Funding & tender opportunities. . <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-gd-5-1-2020>

9 ITF (2021). International Transport Forum Policy Papers, No. 91, OECD Publishing, Paris. <https://www.itf-oecd.org/sites/default/files/docs/zero-carbon-supply-chains-hamburg.pdf>

10 European Commission. (2020). . <https://cordis.europa.eu/programme/id/H2020_LC-GD-5-1-2020/fr>

However, while the EU Strategy for Sustainable and Smart Mobility (EUSSSM) 2020 and the related action plan[11] highlighted the transport sector as key to achieving the objectives established under the European Green Deal, EU has not stressed enough the role that logistics nodes play and should play in facilitating this change. These infrastructures are essential to achieve many of the objectives set out in the European mobility strategy mentioned above. For example, if ships are to be encouraged to reduce their polluting emissions during docking time, ports must adapt their docks by electrifying them. Nonetheless, there is still a lack of strong and clear policy and regulatory guidance and incentive that reflects and prioritises a common response in each of the logistics nodes.

As a result, through Climate Strategies, logistics nodes have opted to initiate their own change and anticipate future tougher regulations and policies by setting their own emission reduction, energy efficiency and climate neutrality targets[12].

Additionally, logistics nodes also act more focused on their own interests, focusing on improving their performance, from a cost-benefit but also environmental perspective.

One of the key components empowered by Europe and pursued by nodes is the digitalization. Being a key for resilience and technological transition, it is included in both European calls and nodes strategic plan. Some of the European Commission's targets include the digital transformation of businesses and the enhancement of the interconnectivity[13].

The maritime sector and its need for standardization and interoperability have convened the work of a considerable number of organizations. The United Nations Conference on Trade and Development (UNTCAD) highlights the relevance of the standards in order progress towards this aimed digitalization.

For that end, the International Port Collaborative Decision Making Council (IPCDMC) boosts the collaboration of the maritime sector, establishing the guidelines on ports processes and procedures. This is possible under the central axis of the PortCDM, an organizational concept which targets the optimum forecasting of the timings and operations in maritime transport thanks to the use of unified and standardized data exchange protocols[14].

The digitalizing effort will be multidirectional, since the optimization of processes derived from it will also help other measures regarding, for example, the reduction of GHG emissions.

On the other hand, the airline industry is also encouraging the paradigm shift through projects like (SESAR – Single European Sky Air Research) addressing the modernisation of air traffic management (ATM). The claimed benefits range from the increase of operational efficiency and safety to the optimization of capacity and the

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11 European Commission (n.d.). . <https://transport.ec.europa.eu/transport-themes/mobility-strategy_en>

12 For example, the Hamburg Port Authority has already set emission reduction targets for its own activities, most recently in the document “Klimastrategie 2.0 – Klimaschutz und Klimaanpassung”.

13 European Commission (2021, March 3). . <https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en>

14 UNCTAD. (2020, February). (Series No 13). TRANSPORT AND TRADE FACILITATION. United Nations, Genova. <https://unctad.org/system/files/official-document/dtltlb2019d2_en.pdf>

reduction of costs. These include a large part of the objectives of companies, which, as can be seen, are achievable through this digitalized change[15].

Another focus of the European Union's attention is the promotion of railway as a decisive transport mode in the future. Initiatives like Shift2rail from Europe's Rail or institutions like the European Union Agency for Railways (ERA) reflect that effort[16] [17]. The truth is that a key element for the enhancement of the railway are the intermodal connections at the nodes. These are the connection between the different modes of transport, and they will be the ones who can facilitate the boosting.

For all these reasons, this report is made focused exclusively on the logistics nodes, a critical domain that deserves and needs to be studied separately.

In particular, this deliverable aims to study the effects of European projects to date, the current market and the implementation cases that have been carried out. At the end, brushstrokes are given on the path that the policies of the nodes are taking and where their future is headed.

1.4. Why improving Logistics Nodes? Expected positive impacts

Logistics nodes 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 logistics nodes 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, Logistics Nodes 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 ecosystem of agents that operate along global supply and logistic chains. This fact leads to the current inefficiencies and bottlenecks at operational level: unnecessary waiting times, increased energy consumption and generation of greenhouse gas (GHG) and pollutant emissions are some examples of the inefficiencies mentioned.

In this context, its objective is to facilitate and improve the control and performance of all activities necessary for the transport of goods, including services, processes and procedures from planning to performance. Therefore, they are fundamental infrastructures needed for accommodate the trade and offer-demand flows of goods, being a critical part of the supply chain. Therefore, generating benefits in the nodes implies improving the entire supply chain.

In this regard, this section identified the impacts that are expected to be achieved, according to the programs of the projects studied. There are in total 11 general impacts, broken down into their corresponding KPIs (see Table 2).

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15 AIRPORTS COUNCIL INTERNATIONAL (2019). . ACI Europe. <https://www.sesarju.eu/sites/default/files/documents/reports/SESAR%20digital%20transformation%20europe%20airports.pdf>

16 (n.d.). <https://shift2rail.org/>

17 (n.d.). <https://www.era.europa.eu/agency/_en>

It is clear that, in the programs studied, the main focus is the caring for the environment and the consequent reduction of CO2 emissions. This is followed by modal shift, cost decrease and terminal capacity increase.

Table 2.

EXPECTED IMPACTS	KPIs	PROJECTS
Decrease of environmental impact	GHG emissions	CARGO ANTS, CLUSTERS 2.0, COFASTRANS, COREALIS, DOCKStheFUTURE, ECOHUBS, INTERFACE, INTERMODEL EU, PIXEL, RCMS, SMARTSET
	Local pollutants	PIXEL, RCMS
Reduction of congestion on the road network	Reduced vehicles movements / Nr. of vehicles	CLUSTERS 2.0
Modal shift	Efficient connections with other transport modes	CLUSTERS 2.0, COREALIS, DOCKStheFUTURE, PIXEL, RCMS
Decrease cost of transport & overall logistics	Fuel cost	CHINOS
	Cost/unit of transport	ARCC, COFASTRANS, COREALIS, DOCKStheFUTURE, PIXEL
Increased transport reliability and responsiveness	% On time	ARCC, CHINOS
Increase management capacity of terminals and productivity	Better capacity management with reduced costs	COFASTRANS, COREALIS, CHINOS, DOCKStheFUTURE, ECOHUBS, PIXEL, RCMS
Improved operations in terminals	Improve the operations	COFASTRANS, CHINOS, LOGIMATIC
Improved terminal capacity utilization and efficiency	Improve the efficiency	COFASTRANS, COREALIS, LOGIMATIC
Improve energy consumption	Energy consumption/unit of transport	CHINOS, CLUSTERS 2.0, SMARTSET
Improve the performance of the European Transport	Hyperconnected	ARCC, CHINOS
	Increase door to door	CHINOS
Improve long distance-city distribution connectivity	% Decrease in operational handling	CLUSTERS

1.5. Defining the scope of intervention and the potential actions

Innovative aspects will be key, both to overcome the barriers faced by logistics nodes and to achieve further improvements in them. Some clear examples are efficiency improvements, automation and standardisation of processes and procedures, saturation reductions and reduction of waiting times.

The core challenges or areas of intervention are shown in Figure 2, covering six main topics: digitalisation, operations and processes, infrastructures, intermodality, green vehicles and machineries, governance and network.

Special emphasis should be made on the inclusion of automation in the diagram. However, since this is a transversal aspect for many topics, it is not included as one arrow more.

The same situation occurs for human factor and training, which needs to be improved in order to progress in the rest of topics. Increasing the skills of workers can help to face challenges on digitalisation, safety, etc. Likewise, it is necessary to have a general knowledge of the situation at all levels, not only to create ideas but to be able to favour innovation and make use of it in more markets.

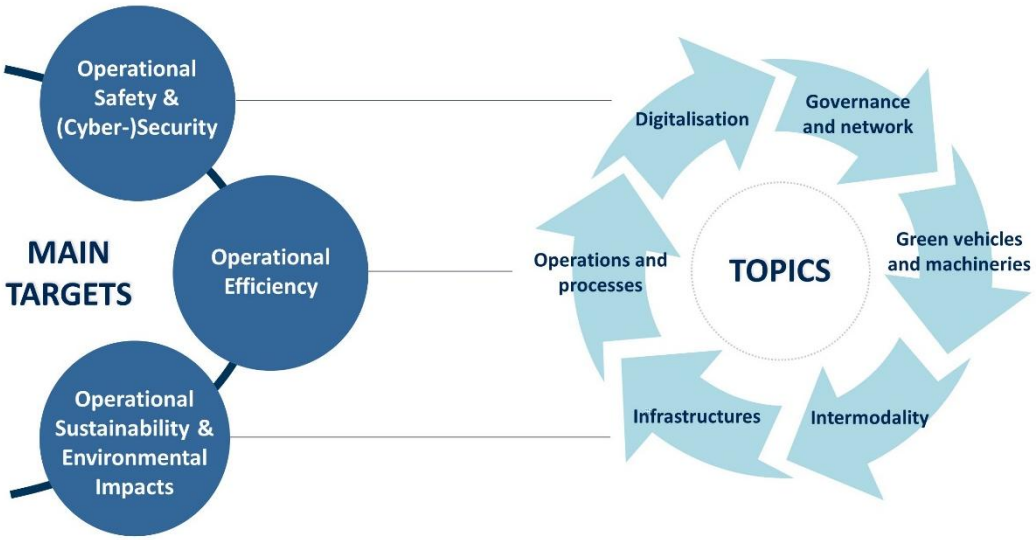

Figure 2.

Based on the three areas of intervention above mentioned, Table 3 outlines the main objectives (improvement goals) identified, as well as the relevant actions required or to be addressed to achieve a better performance of logistics nodes.

Table 3.

AREAS	OBJECTIVES	ACTIONS
Operational Safety & (Cyber-)Security	• Reduction in fraud practices. • Increase the human-machine interaction capabilities while guaranteeing safety conditions. • Define safety areas around the spaces where machines and humans operate. • Increase the cyber-security capabilities of logistics nodes to self-protect internal networks and systems against external cyber-attacks.	• Develop early warning systems to detect in advance potential risks linked to daily activities. • Use smart digital solutions and intelligent transport systems to increase safety operations. • Develop resilient systems able to recover quickly in case of cyber-attacks.
Operational efficiency	• Reduce administrative costs in transport and logistics. • Facilitate the electronic exchange of information between the economic operators themselves (paperless freight transport). • Increase the support for efficient decision making, making available added-value information to assess operations status in real-time. • Optimal coordination of traffic flows for logistics nodes to timely prepare investments. • Increase interoperability among existing logistics nodes data sharing platforms. • Improvements of facilities/spaces for efficient management of transport mode shifts. • Reduce silos of information. • Increase process visibility and synchronisation.	• Goods and container tracking, getting insights about the container arrival and departure and cargo status. • Standardize, control and planning of multimodal transport operations. • Real-time communication between equipment/machineries of each logistics node to detect operational bottlenecks in advance and improve operational processes. • Integration of multimodal transport systems. • Progress towards process and data sharing standardisation.
Operational Sustainability & Environmental Impacts	• Climate change mitigation and adaptation. • Protection of water and marine resources. • Transition to a circular economy. • Pollution prevention and control. • The protection and restoration of biodiversity and ecosystems.	• Substitute conventional fuels by near zero or zero emission solutions such as 100% renewable electrification, green Hydrogen, biofuels, etc. • Low- and zero emission vehicles and machineries. • Measurement of GHG emissions from freight cargo equipment and/or transport

		modes to calculate and monitor the carbon footprint generated in logistics nodes. • Identification of real-time air quality and noise measurements above certain tolerance levels, key to making decisions to mitigate these impacts. • Design of flexible adaptive climate resilient logistics node operations and infrastructures.

1.6. Barriers and guidelines to achieve the benefits of logistics nodes

Logistics nodes are linked to a great diversity of actors and factors that make their operation and performance very complex. More recently, distortions on the demand and supply side have challenged the highly interconnected global supply chains. This, together with other causes linked to the way of producing and managing production - ability to establish new strategies in real time, commercial route and transport used, extension of the supply chain, etc. -, have significantly altered the performance of all logistics nodes, revealing the high risk to which they are exposed and experienced as strategic points of the entire transport and logistics chain.

The vulnerability of the nodes has manifested itself in the form of episodes of congestion and container storage capacity issues. However, there are several other barriers that prevent more efficient and sustainable logistics nodes. These will be further addressed in Table 4.

Table 4.

DESCRIPTION	SOLUTIONS & GUIDANCE
Climate change risks	
Climate change will have a negative impact on logistics nodes, either by worsening existing risks or by introducing new ones. Some of the direct and indirect impacts of climate change that will affect them and require them to adapt their infrastructures, assets, operations or systems are detailed below[18]: • Atmospheric changes - fog or other reduced visibility (e.g., due to blizzard conditions or sandstorms); extreme cold, ice or freezing; wind speed, direction or duration; extreme heat or humidity; water flow conditions; reduced or drought water supply, etc. - will mainly impact the	• Develop adaptation pathways for each anticipated impact on a critical asset, operation or system in collaboration with stakeholders, if appropriate. • Be flexible in terms of measure implementation, modifications and interventions to be developed to avoid maladaptation. • Make decisions based on the observed changes (meteorological, hydrographic or oceanographic observations) as they act as an early warning system. This will support both long-term and short-term decisions by enabling a rapid adaptation response.

18 Inland Navigation Europe (2020, January 20). <https://www.inlandnavigation.eu/pianc-launches-climate-change-adaptation-guidance/>

following areas: navigation zone, protection infrastructures, and manoeuvre area and berthing at ports, load/unload areas, cargo handling equipment, and hinterland connections. • Variations in other industry sectors, generating changes in the performance and operation of logistics nodes. The range of potential impacts is very wide: changes in the types of vessels berthing at maritime or river ports leading to variations in the specifications of berthing or storage facilities, a demand for more seasonal capacity, a reduction in the volume of trade or a shift from export to import activities (or vice-versa), etc. • Modal shift to help reduces GHG emissions from road transport.	
Scepticism or lack of ability to invest in new solutions and technologies	
The lack of investment in this type of improvements and innovations is an obstacle to the competitiveness of logistics nodes. Its digitalization is slowed down as well as aspects such as interoperability, data collection, aggregation and analysis, and the standardization of processes with it. Consequently, the implementation of future innovations has been hindered by lacking a necessary prior basis, but also activities as varied as: the monitoring of tasks, machinery and load units, the measurement of the efficiency of the processes or the synchronization and coordination of the use of vehicles.	• Demonstrate integration of new solutions with operations, green and smart logistics and infrastructures and promote the benefits achieved. • Promote the implementation of improvements from organizations such as Port Authorities or external organizations. For example, providing a space for the testing of new technologies or technologies in the development phase. • Policy makers should encourage, advise and help develop and implement these innovations through their policies, fiscal instruments and regulations. • Perform pilot activities to demonstrate the positive effects of digitalisation. Particular examples could cover the connection to automated vehicles and cranes, intelligent systems and dynamic traffic flows in order to improve the forecast of the routing and scheduling[19].
Plurality of participating organizations and the hardware used (infrastructures, vehicles and other assets)	
This results in low collaboration between actors and in less efficient operations and operations management.	• Focus on aligning the stakeholders in the area to improve the business climate, reach goals and increase cohesion with cities or other core zones.

19 European Commission. (2020). .
<https://cordis.europa.eu/programme/id/H2020_LC-GD-5-1-2020/fr>

The non-exchange of information on transport and the use of infrastructures hinders decision-making on the planning and coordination of operations and management of assets and infrastructures in logistics nodes, but also the standardization of processes. This non-exchange of data linked with operational incompatibility present a big missed opportunity on a more collaborative, efficient and sustainable cargo handling.	• Exchange knowledge to improve the competitive position. • Promote and participate in cooperation from all types, from simple cooperation agreements to full joint ventures or mergers[20]. • Generate working groups to build trust between the parties and find solutions that benefit all parties. • Logistics Nodes should progress to define and adopt common standards so that lowering costs of implementation of new solutions
High costs (time and money) to adapt the infrastructures t as a barrier to entry to the market	
The need for adaptation of maritime & river ports is very visible. Due to the growth in the size of ships over the past decade, priority has been given to ports already adapted to deep-draft vessels in international maritime trade. Ports with non-adapted infrastructure increase transport and, therefore, trade costs, being considered less efficient ports (operational inefficiencies) and less eligible.	

the logistics nodes, will be included in D2.9. Further, guidelines or concrete actions to be follow in order to overcome these barriers will also be listed.

1.7. Methodology

These include a brief highlight of the main Challenges, past and current specific Pain Points in a given Cloud, key R&I results, that have resulted in Outcomes and key milestones achieved such as Implementation Cases establishing causal links between the R&I funding and innovation supporting the seamless integration and harmonization of transport modes, the more efficient management of physical, information and financial flows as well as reducing negative impacts such as decarbonization, emissions and congestion reduction, ensuring the free and seamless movement of goods and digitalization. The reports contain clear and companies' actionable items such as cases on how to implement the Outcomes or build on the Implementation Cases.

The methodology to develop such reports can be seen in Figure 3. First of all, BOOSTLOG analyses the R&I Results and Outcomes at Cloud level. The Outcomes are then analysed based on the TRL of the project results and further development TRL achieved.

The organizations with most prominent participation in projects for each Cloud are then identified, as well as individual people from those organizations participating in the projects contacted (i.e., the experts).

Semi-structured interviews (see Annex IV– Semi-structured interview guide) have been performed to key experts, with the ultimate goal of validating the identified outcomes and gather additional ones, as well as to investigate which Outcomes have resulted into Implementation cases (i.e., they have been implemented and adopted by the freight transport and logistics stakeholders).

The interviews are the main input for the cloud report, complemented with the desk research on projects deliverables and communications, market/sector current practice analysis and the market solutions implemented and adopted including examples of Implementation Cases. The draft report is then shared with the experts for further input and discussion through an online workshop for validation of the report. The experts validated report will be then presented in a webinar with ALICE members and other stakeholders through BOOSTLOG partners networks.

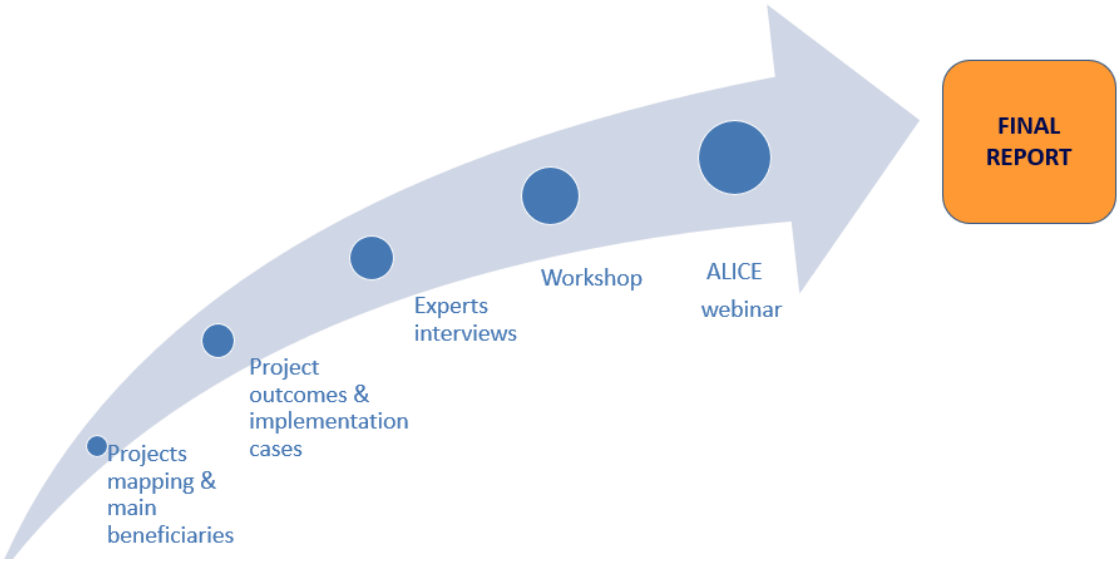

Figure 3.

2. Market current practice analysis

The fight against climate change involves the shift towards renewable energy, energy efficiency plans, the reinforcement of modal shift for freight toward train and ship, speed-up the de development of key infrastructures to promote the efficiency of freight transport and modal shift.

In this regard, just as transport has become an elemental part of reducing the carbon footprint of the logistics chain, logistics nodes – mainly ports and container terminals - are other important players.

Their present and future are strongly shaped by the evolution of transport regulations, leading to the adaptation of logistics nodes infrastructures, operations and policies. Nevertheless, logistics nodes also have the potential to take advantage of this struggle and transition developing zero-emission areas.

Currently, a clear point to achieve this relates to container handling equipment. By making use of hybrid technology, energy regeneration, electrification, etc., pollutant emissions from this equipment can be eliminated or significantly reduced. However, other practices aimed at reducing inefficiencies and helping to execute decisions – for example, those related to port call process or berth plan – will also be decisive and are already being implemented.

Linked to this point, as part of the **Mobility Strategy**[21], one of the pillars is **Creating zero-emission airports and ports**. The focus is placed primarily on two areas: (1) Converting ports and airports into multimodal mobility and transport nodes with links to all relevant modes, thereby improving local air quality; (2) Turning both maritime and river ports into new clean energy nodes for integrated electricity systems, hydrogen and other low-carbon fuels, as well as testbeds for waste reuse and the circular economy.

Under this strategy, the European Commission emphasises that measures will be aimed at developing clean logistics nodes. Among its priorities are:

- Incentivising the deployment of renewable and low-carbon fuels;
- Promoting the refuelling of stationed ships and aircraft with renewable energy;
- Incentivising the development and use of new, cleaner and quieter aircraft and vessels;
- Revising airport charges;
- Greening ground movements within airports, as well as port services and operations;
- Optimising port calls and through more widespread use of intelligent traffic management.
- Achieving the establishment of comprehensive Emission Control Areas in all EU waters, with the aim of zero air and water pollution from maritime transport, for the benefit of sea basins, coastal areas and ports.

Finally, although the achievement of greener logistics nodes is a critical point that is strongly driving the development of new companies and solutions, there are other relevant aspects for the improvement of these infrastructures that generate them. Simplifying, optimising and improving the (cyber-)security, processes, procedures and tasks is also driving new practices in the market.

21 European Commission (2020). COM(2020) 789 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3a52020DC0789&msclkid=65a43f7ecf6311ecb6701ad97f99e5f7>

As a result, new technologies and solutions are being developed and implemented in them, improving their carbon footprint, overcoming operational and process inefficiencies and supporting sustainable development.

The Physical Internet is a concept that has burst into Logistics Nodes very strongly in recent years. The Roadmap to the Physical Internet in the SENSE Project[22] explains the development of the PI in multiple areas, among which are the Logistics Nodes. Its outlook is framed in the demand to increase efficiency and standardization of processes, so as in overcoming the current rigidity, complexity and fragmentation of the services, processes, procedures, and information flows. The main objectives addressed are the visibility of the services and the standardization and automation of them, along the entire value chain of the node.

22 ALICE (2020). <https://www.etp-logistics.eu/wp-content/uploads/2020/11/Roadmap-to-Physical-Intenet-Executive-Version_Final.pdf>

Document elaborated with the support of the BOOSTLOG project has received funding from *the European* under grant agreement No 101006902

The

Figure 4 shows the expected implementations in the following twenty years, as well as its benefits.

Non-standarized transshipment Nodes	**Open and seamless nodes services offering**	**Automated node service request and response**	**Nodes interconnect across networks**	**Nodes interconnect across networks**
2015 – 2020 Generation 1	2020 – 2025 Generation 2	2025 – 2030 Generation 3	2030 – 2035 Generation 4	2035 – 2040 Generation 5
	OBJECTIVES			

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In the framework of Logistics Nodes Cloud and as part of the market practices, BOOSTLOG has recognised 5 Implementation cases that significantly impact and improve logistics nodes. A summary of them has been included in the Figure 5, and an in-depth explanation is available in Section 4 Implementation cases.

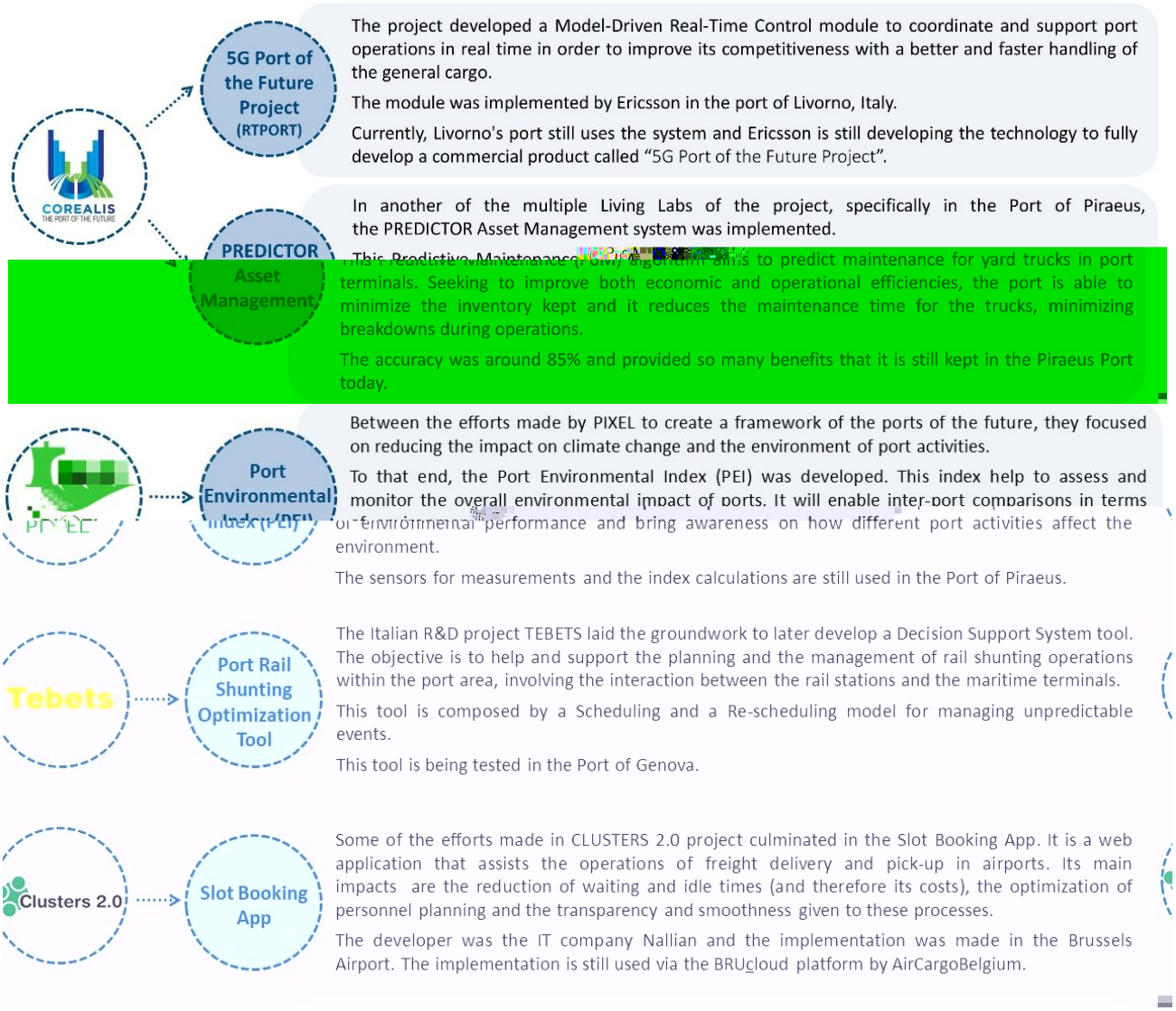

Figure 5.

Even though the number of implementation cases in this cloud report is not high, there are some cases close to the definition of implementation case worth to be mentioned. The innovation does not only come from R&D funding, but also from other initiatives. Some examples are:

- Resulting from the CEF projects STM and MonaLisa, the PAULA platform and the developer SEAPorts, both of which are explained in Chapter 2.3 Maritime & River Ports
- The implementation of electronic T2L for customs, paperless lifting control and a rail module in PCS, coming from the projects MOS4MOS and B2MOS. They were part of a global project consisting of establishing a European network of integrated transport chains of Motorways of the Sea, ensuring that the best use is made of the current connections and maritime infrastructures, and connecting the maritime, road, and rail resources in the optimal manner.

- The WiderMos project, part of the TEN-T programme, which developed a Corridor Management Platform to manage the information flow throughout the entire supply chain between the port and inland terminal, involving all operators and interfacing with the Customs Agency systems.

Additionally, being Logistics Nodes such an important aspect today, there are currently many other projects ongoing related to them. These projects were not included in the research since it is difficult to determine to what extent they have fulfilled their objectives without having been carried out completely. However, it is very important to mention them, as they reflect the steps that are currently being taken in the area of logistics nodes and from which the next implementation cases are expected to emerge. The most important ongoing projects and a brief description of them are listed in Table 5.

Table 5.

PROJECT		DESCRIPTION AND RELEVANCE FOR LOGISTICS NODES
AWARD Scaling autonomous logistics	All Weather Autonomous Real logistics operations and Demonstrations	This project focuses the logistics operations occurring in the logistics nodes. The aim is to promote the driverless transportation throw safe and efficient connected and automated heavy-duty vehicles in real-life logistics operations. The solution, valid for any environmental situation, requires multiple sensor modalities and a fleet management system for optimised logistics[24].
DataPorts Data Platform for the Connection of Cognitive Ports	A Data Platform for the Cognitive Ports of the Future	The project focuses on a data platform for ports, involving topics also related to other clouds such as data sharing or collaboration. This platform, the main outcome of the project, offers services from the different actors related to the seaports. It will also focus on the safety and reliability of the data sharing and trading, so as offering powerful services of data analytics[25].
ePICenter	Enhanced Physical Internet-Compatible Earth-frieNdly freight Transportation answER	This project focuses on the efficiency and sustainability of the global supply chains, with the help of AI, digitalisation, automation and other innovations[26].
MAGPIE SMART GREEN PORTS	sMArt Green Portsas Integrated Efficient multimodal hubs	This project focuses on the maritime ports and their connections with the different links of the supply chain. It faces this from an efficient, green and smart point of view focusing on the digitalization, automation and decarbonization of port-related transport[27].

24 <https://cordis.europa.eu/project/id/101006817>

25 (n.d.). <https://cordis.europa.eu/project/id/871493>

26 (n.d.). <https://cordis.europa.eu/project/id/861584>

27 (n.d.). <https://cordis.europa.eu/project/id/101036594>

LGA hOListic Green Airport	Holistic & Green Airports	This project focuses on the airports as logistics nodes and aims to develop solutions supporting the carbon neutrality EU's ambition so as the life quality of the citizens. It targets the reduction of emissions, the improvement of energy efficiency, air quality, biodiversity and waste management[28].
PIONEERS	PORTtable Innovation Open Network for Efficiency and Emissions Reduction Solutions	The project concentrates on the ports and the challenges they face to reduce their environmental impact while remaining competitive. These challenges are aligned with the main objective of the European Green Deal, making Europe climate neutral by 2050. In order to reduce the impact, the solutions approached will involve clean energy production and supply, the deployment of electric, hydrogen and methanol vehicles, sustainable port design, modal shift and flows optimisation, and digital transformation through AI- and 5G-based digital platforms[29].
planet	Progress towards Federated Logistics through the Integration of TEN-T into A Global Trade Network	This project analyses, demonstrates and assesses EU global T&L networks (EGTN) while facilitating the transition to the PI and other technologies such as IoT and blockchain. It is related to the corridors, but also to the logistics nodes themselves. Indeed, PLANET aims to develop smart hubs or Intelligent PI Nodes by researching and testing innovative solutions, concepts and technologies that can improve warehouses and maritime ports, as well as cargo processes and operations, improving efficiency along the door-to-door transport chains and coordinating complex supply chains[30].
PortForward	Towards a green and sustainable ecosystem for the EU Port of the Future	This project gives a holistic approach to a smarter, greener and more sustainable port ecosystem featuring IoT and socio-economic analysis of the supply chain. The bases for the Port of the Future want to be settled regarding the development, management of resources and the operative strategic capability[31].
Stargate	SusTainable AiRports, the Green heArT of Europe	The project[32] concentrates its efforts in offer specific short- and medium-term green solutions for European airports at the level of day-to-day operations, covering cross-cutting aspects like the minimisation of noise and emission. Among the solutions are: developing digital twin technology to map operational processes by generating 3D models of airports; building a

28 (n.d.). <https://cordis.europa.eu/project/id/101036871>

29 (n.d.). <https://cordis.europa.eu/project/id/101037564>

30 (n.d.). <https://cordis.europa.eu/project/id/860274>

31 (n.d.). <https://cordis.europa.eu/project/id/769267>

32 (n.d.). <https://cordis.europa.eu/project/id/101037053>

		biofuel blending facility to increase the use of biofuels and decrease reliance on fossil fuels; optimising terminal operations, for example with the deployment of a Terminal Command Centre.
TULIPS	DemonsTrating lower pollUting soLutions for sustaInable airPorts acrosS Europe	This project [33] focus on airports and aims to accelerate the implementation of innovative and sustainable technologies targeting reduced GHG emissions at airports, moving towards climate-neutral aviation. The project will roll out 17 demonstrations of green airport technological, non-technological and social innovations at different airports. Then, TULIPS will measure and quantify the benefits of these technologies and, considering economic, geographical, and political scenarios across Europe and beyond, forecast their impact on EU climate goals should they be implemented extensively across European airports. As a result, the project will be able to present a roadmap on how these technologies and concepts should be deployed in different types of European airports.

Finally, beyond those mentioned above, several companies and market initiatives that bring market solutions to the logistic nodes have been identified. These are detailed and explained on the following pages, covering 4 of the 5 logistic nodes addressed in this report.

2.1. Airports

CharterSync

CharterSync is a trusted, award-winning digital air cargo charter business bringing overdue disruption to the market to the benefit of freight forwarders and airlines. CharterSync simplifies, accelerates, and streamlines the air cargo charter process by removing the need for inefficient emails and phone calls, centralising all stages of cargo charter into one easy-to-use system.

The solution is a digital air cargo charter booking platform that marches cargo loads to the most suitable aircraft in real-time. Combining innovative tracking technology with sophisticated performance algorithms, the platform can identify, locate and calculate suitable aircraft for immediate air freight charter flights in a matter of minutes – from an initial charter request, the technology can locate suitable aircraft in less than 30 seconds –, offering time savings for air cargo charter flights and transforming the way that freight forwarders and airlines work. It is a seamless, end-to-end system with all information instantly accessible and in one place.

The digital platform sets new standards in booking speed, operational process and transparency, reducing costs and driving efficiencies. As a result, CharterSync offers freight forwarders and airlines a new and better way of working.

[33] (n.d.). < https://cordis.europa.eu/project/id/101036996>

CharterSync is a member of The Air Charter Association, Neutral Air Partner and TIACA. In its first year of trading, it won the logistics UK Award (2021) for 'Most innovative product of the year'. CharterSync also received the award for 'Supply Chain Operations – Best use of Technology (2021)'[34].

2.2. Container Terminals

Navis

Navis is a provider of operational technologies and services that unlock greater performance and efficiency for leading organizations throughout the global cargo supply chain. The company has developed the Navis Berth Window Management (BWM) solution, enabling terminal operators to digitize their berth plan[35].

Navis BMW is designed to improve berth planning and execution decisions and reduce inefficiency. The primary product focus is to equip the marine planner and berth planner with a more powerful and easy to use tool that draws on a broader data set and more real-time data. The secondary product focus is to enable data to be shared with ocean carriers to improve vessel network planning and operations.

As a result, a terminal can easily plan berths against proforma, comparing and managing vessel port stays against vessel timestamps. The service also enables terminals to share their real-time berth plan with key customers, partners and authorities to enable self-service, allowing the terminals to make data-driven decisions to reduce the waste of time, fuel and resources throughout the port and add greater certainty to the overall berthing process.

The most recent implementation of this solution can be found at the SGTD Doraleh Container Terminal moves to digital berth planning[36].

Terberg

Terberg is a company specialised in automotive solutions in the world of transport and logistics, offering more efficient vehicles and working according to the highest quality requirements and applicable laws and regulations. For years Terberg has been applying the most modern transport and ICT technologies and has been building electric vehicles. In fact, the company is manufacturing a new and improved generation of electric vehicles and is particularly active in hydrogen technology[37].

Its progress and commitment to this type of vehicle was materialised a few years ago in the GREENCRANES project, funding by Connecting Europe Facility (CEF) Programme. The project aimed to be an innovative

34 Logistics Manager (2021, December).

35 . (2022). <https://www.navis.com/en/products/smart-apps>

36 Smart Maritime Network (2022, March 9). . <https://smartmaritimenetwork.com/2022/03/09/container-terminal-sgtd-moves-to-digital-berth-planning/>

37 . (2022). <https://www.royalterberggroup.com/en/about-us/>

initiative by demonstrating that alternative fuels like liquefied natural gas (LNG) can effectively be adopted by ports for heavy-duty vehicles, contributing to enhanced energy efficiency in port container terminals [3839].

In the framework of this project, Terberg provided an LNG-powered Terminal Tractor (TT) designed to reduce GHGs emissions and increase energy efficiency. And, although the TT was tested in the Port of Valencia, the machinery did not remain there since the price of fuel did not make the investment in these TTs profitable. Nevertheless, the TT designed, developed and tested was marketed in the Port of Turkey, where the price of LNG is considerably cheaper than diesel and there is an LNG filling station close to the container terminal of the port[40].

As a result, fuel costs can be reduced by as much as half by replacing diesel with LNG. Further, LNG reduce environmental impacts, with carbon dioxide emissions significantly cut and heavy metal emissions almost eliminated.

2.3. Maritime & River Ports

HHLA

HHLA has developed a software, the HHLA Sky drone system, that allows to simultaneously control and monitor more than 100 automated drones (Unmanned Aircraft Systems, UAV) and concurrently transmit their video streams, image and sensor data to multiple clients in real time.

Every drone task can be managed from this control centre: one single system for transports, inspections, and surveillance flights. Although every transport flight must first be planned, in time the system sets up individual routes. A second operator double-checks the routes to ensure flight and system safety. After approval, the drone can be loaded a launched with a single click.

Using drones and the HHLA Sky control station, large fleets of automated unmanned aerial systems can be controlled simultaneously, significantly speeding up industrial logistics or security monitoring processes. Possible operating locations include ports, oil and gas refineries, chemical plants and large demarcated areas.

In the port area, drones are used to increase security by reducing the number of people in dangerous areas, and to collect very different kinds of data using mobile teleoperated sensors. The drones and the HHLA Sky control station have already been in use at the Port of Hamburg since 2019. In the area of inspection, UAS are used to check tank farms for leaks or to inspect port's container gantry cranes. These crane systems are between 100 and 130 metres high, and their metal structure has to be inspected regularly. Previously, industrial climbers were used for this, requiring up to two days for one crane, but with the UAS, time is reduced to less than four hours. Drones fly over the metal structures with high-resolution cameras according to the specifications of the maintenance department. The recordings are then available via a central media archive for evaluation and further processing. Finally, also in the Port of Hamburg, HHLA is currently programming an

38 Cadena de Suministro (2013, May 30). . <https://www.cadenadesuministro.es/noticias/el-proyecto-greencranes-permitira-reducir-las-emisiones-de-gases-de-efecto-invernadero-en-las-terminales-de-contenedores/>

39 Port Technology International (2019, August 27). . <https://www.porttechnology.org/news/greencranes_ushers_in_new_era_for_industry_sustainability/>

40 Offshore Energy (2014, July 8). . <https://www.offshore-energy.biz/terberg-nets-lng-tractor-order-in-turkey/>

artificial intelligence system to monitor and evaluate the aging process to increase the service life of the crane[41][42][43].

HHLA Sky nominated for both the German Innovation Award 2022 and the TOP 100 innovator award 2022. For the German Innovation Award, which took place on 24 May in Berlin, HHLA Sky received the award in the category “Excellence in Business to Business – Aviation & Maritime Technologies" for their outstanding innovation performance. The top three winners of the TOP 100 award will be announced by science journalist Ranga Yogeshwar on 24 June in Frankfurt am Main, in three categories for different company sizes[44].

SEAPort Solutions

SEAPort Solutions is a Spin off promoted by Fundación Valenciaport, Infoport and Hiades and resulted of several CEF projects (MonaLisa, MonaLisa 2.0 and STM). It offers IT services and develops technical solutions from the family of PortCDM systems (where CDM is the acronym of Collaborative Decision Making) and its objective is to favour the communication between different agents in the port in order to gain efficiency and reduce costs of ship calls[45].

Pilot testing of the PortCDM concept, as part of the STM (Sea Traffic Management) Validation reflected that only between 40% and 65% of the time of stay in port, depending on the type of vessel, is dedicated to loading and unloading processes, highlighting the potential for improving operations linked to the scales of the ships in port with the support of technology.

In this regard, PAULA (Platform for Automatically Linking Agents) is the main technological solution that is being developed and commercialised by SEAPorts to optimise this process. PAULA is a collaborative platform for data exchange relating to port call processes. The agents involved in these processes will be correctly informed, having information when each one of them requires it, and prepared to provide their services by having high precision predictions and real-time information.

The platform will improve the efficiency and cost-effectiveness of ships' port calls thanks to the digital information captured and exchanged between the different actors. Furthermore, the solution enables communication port-port and ship-port.

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41 HHLA (2022). <https://hhla.de/en/magazine/with-a-faresighted-system-to-the-future>

42 VDMA (2022).

43 Smart Maritime Network (2022, January 17). . <https://smartmaritimenetwork.com/2022/01/17/port-of-hamburg-to-introduce-automated-drones/>

44 HHLA Sky (2022). . <https://hhla-sky.de/en/company/news/detail-view/hhla-sky-nominated-for-both-the-german-innovation-award-and-the-top-100-innovator-award>

45 SEAPORT Solutions (2022). . <https://seaport-solutions.com/tag/paula/>

3. Project Results and Outcomes

In the framework of BOOSTLOG WP2, "From R&I projects results to impact generation", task 2.1 focused on the analysis of more than 160 EU funded projects. These projects cover several R&D funding programmes from the last 21 years. In this section the projects related to Logistics Nodes and its outcomes will be identified.

The selection of 21 projects can be seen in the Figure 6, where these projects are shown on a timeline and categorized according to the European fundings program. This diagram reveals that many of the projects selected in the Logistics Nodes Cloud are part of the latest innovation programme, Horizon 2020. Consequently, it was expected that this cloud will not show many implementation cases, a statement supported by the other BOOSTLOG clouds in which projects took more than 10 years to reach an implementation case.

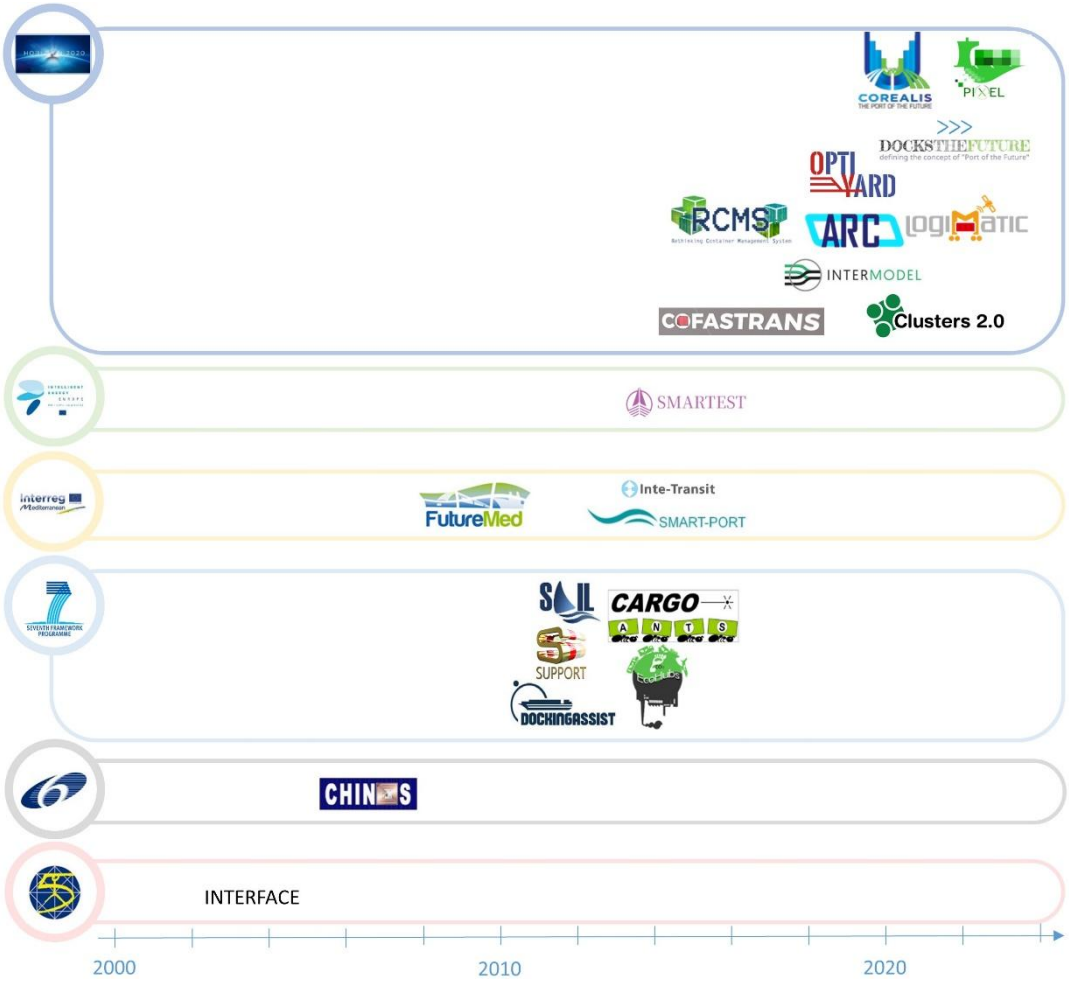

Figure 6.

Nevertheless, as it has been said, setting the boundaries between the clouds is an arduous task. Clouds are interdependent with each other, and most projects affect more than one cloud, to a greater or lesser extent. Offering a vision of the projects that uniquely or mainly affect the cloud of Logistics Nodes is surely not fair or faithful to reality.

Among these overlaps, there is a high number of projects taking place in Logistics Nodes related to data sharing. Digitalization, big data and IoT are crucial issues, and they are very useful tools for improving ports in

all their aspects, as well as increasing the efficiency of their logistics operations. This sharing of data sometimes also implies the need to collaborate and coordinate, causing the project to also affect this topic. Some of these projects are: FEDeRATED, FENIX, COG-LO or 5G-LOGINNOV.

On the other hand, it is also difficult to separate the Logistics Nodes as part of the transport network. A network needs its nodes to connect its corridors. Making a change in the network usually implies, more directly or indirectly, some change in its nodes as well. Therefore, there are also other projects affecting the nodes that study the transport or the corridors network. Some of them are: BONVOYAGE, CONTAIN, CORE, Freight4all, Integrity, SynchroNet or Transforming Transport.

Similarly, there are other projects affecting topics such as urban logistics (PORTIS or VitalNodes) or modularity (LessThanWagonLoad) that have not been included either.

Once the selection of the projects to be addressed in this cloud was completed, BOOSTLOG then identified the organisations with the highest level of involvement in these 21 projects, a very relevant factor for understanding and monitoring projects outcomes as well as the implementation cases derived from them. As a result, a total of 10 organizations were identified as the most recurrent in the logistics nodes projects chosen, among which companies – Fundación Valenciaport, BMT, Circle and MARLO - were the most frequently involved and logistics nodes the least –Piraeus Port Authority - (see Figure 7).

Figure 7.

BOOTLOG also proceeded to classify the outputs of the projects in order to better understand what the most predominant outcomes of these completed projects were. The outputs were divided into four different groups: Technology, Policy, Business Model or Service/Product.

Figure 8 includes the percentage of projects generating each type of results, showing that almost half of the projects generated a Service/Product. Making new Technology available was also in almost a third of them,

while it was harder to find projects in logistics nodes resulting in Business Models or Policies. The data collected to obtain the figure is included in Annex III - The projects outcomes.

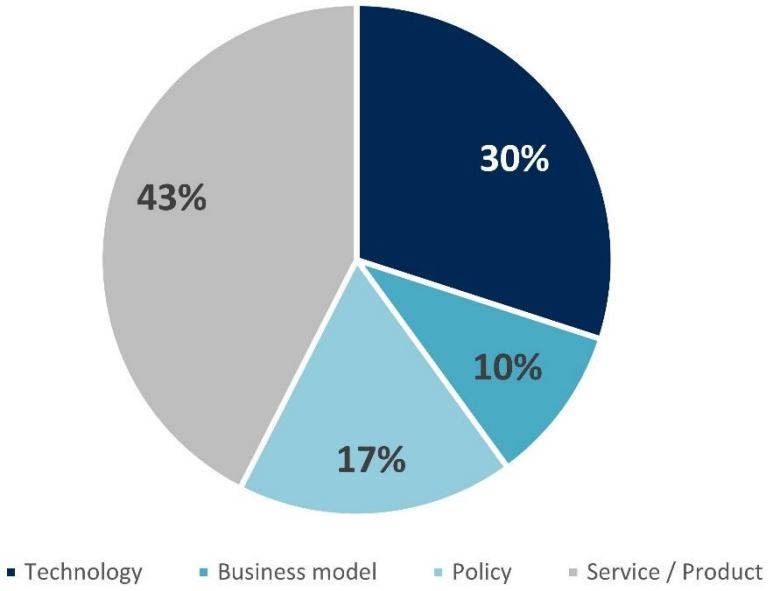

Figure 8.

Finally, regarding the studied projects, they have been categorized into four different categories depending on their focus in the logistics nodes. These categories are Safety and traffic management of logistics nodes; ICTs for optimizing container/intermodal terminal processes and operations focused on deports and intermodal terminals; The new generation of logistics nodes: Governance, Collaboration and Business models in order to improve efficiency in any logistics node from a cost-benefit, operational and environmental perspective; and Transition to more efficient and sustainable vehicles and machinery in any logistics node.

3.1. Safety, security and traffic management

In the field of logistics nodes, (cyber)security and protection are fundamental aspects to guarantee their correct performance.

As key infrastructures in world trade, they are susceptible to all kinds of attacks or dangers, such as terrorist attacks or those related to the illegal trafficking of people or drugs. In addition, the development of new technologies and information and communication systems has generated another type of threat to logistics nodes: intangible threats, known as cyber-attacks.

Moreover, logistics nodes are spaces that bring together a large number of infrastructures, vehicles and people in the same space, thus the security within these spaces and surrounding areas is another critical point. The DOCKINGASSIST project is a good example of this. The ship location and monitoring system developed will enable more efficient management of port traffic, reducing its environmental impact.

The SUPPORT project has fully understood that solutions need to be developed to better protect ports, both assets and people. On the one hand, it has developed solutions to overcome two types of threats: divers in ports (physical threat) and non-port sensors (intangible threat). On the other hand, it also focused its efforts on improving both the training of port facility security and safety staff through an Education, Training and Examination module, and on the next generation port security solutions through its ICT platform.

Improved Port Efficiency And Safety Using A Novel Wireless Network And Differential Global Navigation Satellite System Providing Enhanced Vessel Navigation (DOCKINGASSIST)

DOCKINGASSIST will create a centralised, cost-effective, real-time, accurate vessel location and monitoring system, providing the necessary centimetre positioning/speed accuracy. This solution will also result in improving port traffic management, and reducing operating expenses, CO2 emissions and fuel usage, so as its environmental impact.

These improvements will impact the EU maritime sector reducing the danger in ports and improving their capacity and efficiency.

For that, the project presented the DOCKINGASSIST system, which consisted of two main parts: (i) a DOCKINGASSIST Base Station (BS) installed at the harbour, and (ii) a Portable Pilot Unit (PPU) installed on the ship(s).

The DOCKINGASSIST Base Station (BS) is composed of three different elements: (i) the GNSS/RTK (Global Navigation Satellite System/Real-Time Kinematic) receiver to obtain the GNSS reference (correction) data, (ii) the WiMAX BS in order to communicate with the vessels, and (iii) a control software to manage the GNSS/Differential Global Positioning System (DGPS)/RTK receiver and the WiMAX BS. The software oversees transmitting the correction data through the WiMAX downlink, and of receiving the accurate position, heading, and ROT data from the vessel through the WiMAX uplink[46].

Security UPgrade for PORTs (SUPPORTS)

SUPPORT is aimed at building on these achievements by engaging representative stakeholders to guide the development of next generation solutions for upgraded preventive and remedial security capabilities in European ports.

This project also aims to reduce the potential threats on port facilities upgrading preventive and remedial security capabilities in ports.

One of the main outcomes of the project is the AUV (Autonomous Unmanned Vehicle) for diver detection in ports and SSID (Sea Side Intruder Detection) an analysis of all the different sensors available in the port.

Another outcome was the SUPPORT Port Security Management System (PSMS), which contains a - Education, Training and Examination module. This web-based module is based on best practices of ISPS related Maritime security education and offers an education / training part a manual for drills & exercises and an examination module. PFSO's can test knowledge of Port Facility Security Personnel and Port Facility Personnel with specific security duties by a pre-loaded exam module containing multiple choice questions, thus keeping track of the knowledge level of all members of the security organization.

The last outcome was an ICT Platform for designing, developing, deploying and maintaining next generation security solutions for large and small-to-medium ports. The platform aimed to utilise a collaborative peer-to-peer architecture for the different port security organisations[47].

46 (n.d.) <http://www.dockingassist.eu/>

47 (n.d.). <https://cordis.europa.eu/project/id/242112>

3.2. ICTs for optimizing container/intermodal terminal processes and operations

Optimal planning of schedules, yard operations and terminals are objectives pursued by all logistics nodes, leading to reduced inefficiencies (reductions in downtimes, bottlenecks, costs, environmental impacts, etc.).

In this sense, within the present cloud, the following two projects are worth highlighting: LOGIMATIC and RCM. LOGIMATIC developed an advanced real-time vehicle location system in port container terminals. This technology allows to increase the speed of tasks and operations and to improve their safety, while at the same time boosts the automation of port vehicles. On the other hand, RCM focused on trying to make a more efficient use of infrastructures and to anticipate future challenges linked to the next generation of vessels. To this end, it developed a Robotic Container Management System at terminals reducing the need to create more container storage space (capacity improvements), useful for both ports and inland terminals.

The ARCC project addressed the objectives abovementioned in the specific case of rail terminals, helping to achieve improvements in the use of assets and spaces within this logistics node through its Real-time Yard Management System (real-time scheduling, tracking and control to optimise yard operations). OPTIYARD also played an active role, developing tools to digitise and automate yard operations at rail terminals.

For the case of ports and dry port areas, SAIL was able to develop a Decision Support System (DSS) and a Discrete Event Simulation (DES). Both solutions were designed to support the management of port intermodal facilities, used to connect seaports with dry ports, a growing practice due to the lack of available space in the first ones.

Finally, automatic damage documentation and automatic container identification is another way to optimise processes within logistics nodes. CHINOS developed an electronic system that predominantly achieved this, as well as monitoring containers remotely. These tools not only facilitated the automation of the container identification process at the logistics hubs, but also provided additional information on the status of the container, i.e., whether it had been damaged at the logistics hub or not, helping to determine and clarify responsibilities.

Tight integration of EGNSS and on-board sensors for port vehicle automation (LOGIMATIC)

LOGIMATIC develops an innovative location and navigation solution for the automation of the operations of straddle carriers in container terminals.
With this project, the European ports will see their efficiency and accuracy improved while reducing its errors, times and costs.

Among all the results obtained in the project, those that affect the logistics nodes, the ports, are:

- An advanced automated navigation solution based on the integration of Global Navigation Satellite Systems (GNSS) and sensors onboard the SC vehicles, which includes a security strategy to withstand cyber-attacks and GNSS-related threats.
- A GIS-based control module compatible with existing Terminal Operating Systems (TOS) for optimized global (yard level) route planning and fleet management[48].

Rethinking Container Management Systems (RCMS)

48 (n.d.). <https://cordis.europa.eu/project/id/687534>

RCMS aims to improve the terminals performance in terms of efficiency, reliability, capacity, performance indicators (travel times, average speed, etc.) and impacts (noise and air pollution). For that, the systems to manage containers are rethought and a new one is created.

This project addresses the upcoming challenges of larger ships, so as the actual problems in terminals, such as the efficient use of infrastructure.

The main outcome, with the same acronym as the project, is the Robotic Container Management System. It is a robotic parking system able to manage and handle more containers per square metre than any traditional handling system used in terminals before, both ports and inland terminals[49].

Automated Rail Cargo Consortium: Rail freight automation research activities to boost levels of quality, efficiency and cost effectiveness in all areas of rail freight operations (ARCC)

As its name says, the Automated Rail Cargo Consortium (ARCC), joint with Shift2rail members, aims to boost quality, efficiency and cost effectiveness in rail freight operations of the European railway sector. The research activities are developed in three different areas: Freight via automated trains, automated support processes at the nodes and advanced timetable planning.

The main outcome of this project is the demonstration scenarios developed for a Real-time Yard Management System which obtained considerable improved results in terms of European interoperability, efficiency, punctuality, energy, costs and capacity[50].

Optimised Real-time Yard and Network Management (OPTIYARD)

OptiYard is a project aiming to design optimised processes for managing marshalling yards and terminals, considering their interaction with the network.

This project supports the Commission's 2011 White Paper ambition of expanding rail's modal share by 2050. This objective is also mentioned in the programms Horizon 2020 and Shift2Rail (S2R).

The main outcomes of the project are:

- A Simulation Environment, which creates an environment to simulate the processes involved in both real-time yard operations and real-time network operations.
- A Communication System, to establish and verify the protocol through which the various actors communicate with each other, both within the OptiYard ecosystem and with the wider rail system.
- A Decision Support System, which comprises the tools developed and make available to actors to enable them to make optimal decisions in real-time, and allowing for an increasingly digital railway and an increasing level of automation in future yard operations[51].

ICT System addressed to integrated logistics management and decision support for intermodal port and dry port facilities (SAIL)

49 (n.d.). <https://cordis.europa.eu/project/id/636158/es>

50 (n.d.). <https://cordis.europa.eu/project/id/730813>

51 . (2019, July 22). <https://optiyard.eu/>

SAIL aims to support the flow of logistics chain and the business operations in ports and dry port areas. For that end, an ICT tool will be developed.

This project will benefit the intermodal transport while reducing the cost and the environmental impacts of these European ports.

The main outcomes the project generated are a Discrete Event Simulation (DES), for which UML (Unified Modelling Language) were developed to study dynamic parts of the system; and a Decision Support System (DSS) for supporting the management in operational, tactical, strategic decision levels[52].

Container Handling in Intermodal Nodes - Optimal and Secure (CHINOS)

CHINOS is a project that supports operators in the process of automation by employing innovative IT technology solutions like RFID (Radio Frequency Identification) and automatic damage documentation for container handling in order to optimize processes.

In these terms, this project works for an improvement on the traceability and security in the supply chain while improving the efficiency in the nodes, particularly, in ports.

The system consists of four main elements: an automatic container identification unit (ACIU) consisting of container identification system (CIS) and electronic seal system (e-seal), a damage documentation system (DDS), a chain event manager (CEM), and a communication controller (CC).

The performance consists of an electronic radio-frequency-identification (RFID) transponder (also referred to as a tag) attached to the container, able to provide positive unambiguous identification of a container. An electronic seal (e-seal) uses the current mechanically robust door seal mechanisms but adds the electronic RFID technology to enable seal identification and additional tamperproof electronic security to the device[53].

3.3. The new generation of Logistics Nodes: Governance, collaboration and business models

As a strong response to meet the new needs that have emerged in the organisations that interact and ultimately comprise the logistics nodes, a large number of projects have addressed the way forward for these infrastructures in the future.

The focus has mainly been on opportunities for collaboration, management and governance and new business models, all involving a wide range of actors, both public and private.

Committed to improving the resources and asset management in logistics nodes, CLUSTERS 2.0 developed several IT tools and applications, and, focused on the progress and improvement of intermodality, a new modular loading unit for horizontal train-truck transhipment.

In the framework of Ports of the Future, several projects have tried to assess the key aspects needed to define a roadmap or to develop/exemplify solutions and responses necessary to achieve this transformation. COREALIS worked on identifying the challenges, enablers and barriers of the Port of the Future and, along the same lines, DOCKStheFUTURE defined the concept of 2030 Ports, covering most of the 10 environmental priorities of European ports identified by ESPO for the year 2021. PIXEL went a step further in defining the

52 (n.d.). <https://cordis.europa.eu/project/id/251589>

53 (n.d.). <https://cordis.europa.eu/project/id/31418>

ports of the future and, using a wide range of technologies and concepts, generated different solutions for more efficient use of resources in ports, achieving environmental, operational and cost improvements.

To achieve greater transparency and better interoperability of ports, INTE-TRANSIT considered digitalisation as a critical point, making use of new information and communication technologies to manage containers, yard equipment and personnel within the facilities.

Focusing on environmental issues, ECOHUBS put its efforts on the development of green hubs, but also provided models and tools to foster cooperation and communication between green hubs' stakeholders, including multimodal terminal stakeholders. SMARTSET also addressed this area through the exemplification of best practices and the construction of a terminal-focused regulatory framework to help achieve European emission reduction targets.

Aimed at improving the competitiveness of the port-hinterland system by reducing operational and administrative inefficiencies, FUTURMED devised a system for real-time freight and passenger management and digitised communications both within and between ports.

On the other hand, SMART-PORT specifically sought to improve the competitiveness of Southern European container ports by identifying their strengths and weaknesses, showcasing the strategic plans of other European ports and developing plans to follow in order to become a smart port and position itself in the market.

Another important point as a preliminary step to the digitalisation and environmental improvement of the logistics nodes is the design of their facilities. In this sense, to improve the construction of intermodal terminals, INTERMODEL EU developed a methodology and ICT tools for advanced simulation of intermodal railway logistics platforms models to support tasks related to both design and planning phases.

Open network of hyper connected logistics clusters towards Physical Internet (CLUSTERS 2.0)

One of the objectives of CLUSTERS 2.0 is to develop a network which optimizes and promotes intermodality within European nodes. It is expected to observe a great reduction in costs as well as in energy use and emissions while increasing intermodality and productivity.

This project aims to help to reach the EU objectives on modal shift for all transportation and making optimal use of an Open Network of Logistics Clusters and hubs.

There were multiple outcomes generated in this project. The ones relevant for the logistics nodes itself are:

- Developing a new modular Load Unit (NMLU) at sub-container level for the horizontal transhipment from train to truck.
- Cluster Community System (CluCS), an IT platform managing the resources which includes a Slot Booking Application.
- Dynamic Terminal Management System improving efficiency and productivity by predictive and optimization models.
- An assessment tool for clusters collaboration, so as a methodology[54].

54 . (2017). <http://www.clusters20.eu/>

Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era (COREALIS)

COREALIS project aims to define the future era of the European ports proposing a strategic, innovative framework. It will be supported by disruptive technologies, including IoT, data analytics, next generation traffic management and 5G in order to face the future capacity, traffic, efficiency and environmental challenges.

These innovations are focused to major ports so as mega-vessels, but they can also get to affect medium sized ports.

The main outcomes regarding Logistics Nodes are:

- A Just-In-Time Rail Shuttle Service feasibility study.
- The identification of the Port of the Future challenges, enablers and barriers.
- The Living Labs implemented and deployed in real operating conditions in Piraeus port, Valencia port, Antwerp port, Livorno port and Haminakotka port[55].

Developing the methodology for a coordinated approach to the clustering, monitoring and evaluation of results of actions under the Ports of the Future topic (DOCKStheFUTURE)

This project aims to define the 2030 ports concept, covering topics such as dredging, emission reduction, energy transition, electrification, smart grids, port-city interface and the use of renewable energy management.

Projects like DOCKStheFUTURE seeking to improve European ports do also favour international trade and the role of maritime transport in global supply chains.

Between the relevant outcomes, should be stood out:

- The Port of the Future DSS Tool, a software tool aiming at resuming critical elements related to port related investments.
- R&D and Policy recommendations.
- Port of the Future Road Map 2030, to guide Stakeholders towards objectives related to the Port of the Future.
- Port of the Future Network of Excellence, a platform aimed at following up the results of the project in order to have a proper unique interface to carry on towards the Port of the Future targets.
- Port of the Future training package, as a means of transferring know-how on the developed concept of Port of the Future, the current state of the art and the impact that such an innovative project could have on the future of European ports and port cities to each and every one of the participants[56].

Port IoT for Environmental Leverage (PIXEL)

The PIXEL project aims to go a step further in the definition of Ports of the Future. Making great use of the available technology, the project targets many topics such as collaboration, intermodality, efficient use of resources, economic growth and environmental impacts.

The project is in line with the Horizon 2020 calls claiming a higher utilization of capacity, so as the importance of hubs as a key role for a more competitive, reliable and safer freight transport.

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55 . <https://www.corealis.eu/>

56 . <https://www.docksthefuture.eu/project/>

The project generated several outcomes, but those focused on logistics nodes are more Information Hub, a Dashboard for decision making, Infrastructure Recommendations and Operational tools (models of processes, algorithms to effectively improve their operations)[57].

Integrated and Interoperable Maritime Transit Management System (INTE-TRANSIT)

INTE-TRANSIT is a project which main focus are the Mediterranean ports. It aims to improve its organization, cooperation and personal training for all the relevant stakeholders.

This will lead to more efficient ports, better interoperability and a relevant improvement of the flow of goods, cargo traceability, visibility and transparency.

The outcomes are:

- An automated container management system by using modern Information and Communication technologies such as Differential DGPS receivers, RFID readers, GEO-location servers.
- And a management platform, whose function is to monitor the process inside the terminal. It has a user-friendly visualisation tool for yard equipment positioning, offering mapping capabilities, a container search functionality and real-time remote access[58].

Environmentally COherent measures and interventions to debottleneck HUBS of the multimodal network favoured by seamless flow of goods (ECOHUBS)

ECOHUBS is a project focused on green hubs so as its cooperation, collaboration and carbon footprint.

Between the important outcomes for the hubs are:

- A Transport & Terminal Services Publisher (T2SP) for detailed terminal services.
- Proximity Network Management (PNM) which enables the collaboration among terminals.
- Repair Services Publisher (RSP), to share equipment for improved wagon repair services and MetricHub a system for capturing, calculating and sharing metrics which allows customers to drive continuous improvement among collaborative networks.
- Container Interfacing and Consolidation System (CCIS), a system for sharing information in order to increase the capacity of the port without any investment in Physical infrastructure.
- Ecohubs Truck Appointment & Unit Reporting Status Services (ecoTAURuS), a system for optimising operations in and around the terminal through truck appointments systems and consolidation of Unit status information.
- Intermodal Terminal Eco-Efficiency Calculator (ITEC), a tool that bridges the knowledge gap of other CO2 calculators[59].

Sustainable MARketdriven Terminal Solutions for Efficient freight Transport (SMARTSET)

SMARTSET focuses on the efficiency and sustainability of freight terminals in Europe. This project will help to achieve the European 20-20-20 targets for reducing emissions and energy usage.

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57 (n.d.). <https://pixel-ports.eu>

58 TRIMIS (2013, January 1). . <https://trimis.ec.europa.eu/project/integrated-and-interoperable-maritime-transit-management-system>

59 (n.d.). <https://cordis.europa.eu/project/id/314786>

The core outcome of this project involving the terminals is the development of three business models for cooperation. Regulations and incentives to favour terminals are also elaborated[60].

Freight and passengers sUpporting infomobiliTy systems for a sUstainable impRovEment of the competitiveness of port-hinterland systems of the MED area (FUTUREMED)

FUTUREMED is a project that aims to improve the competitiveness of port systems. For that, the project will define and implement sustainable middle- and long-term development strategies focused in removing current barriers for accesibility, promoting integration, intermodality, infomobility and efficiency.

The main outcomes of the project regarding Logistics Nodes are:

- A dynamic system for freight and passenger management in real-time. It reduces congestions and bottlenecks between ports and related territories.
- Digitalization of communications between intra-EU port-to-port and port-to-operators' related to bureaucratic duties[61].

Action Plan towards the Smart port concept in the Mediterranean Area (SMART-PORT)

SMART-PORT addresses the Southern European containers ports challenges of reducing traffic congestion, bring the socio-economic gap with other UE ports closer, so as improving its competitiveness in the operational, energy & environmental aspects.

This project helps the Mediterranean ports to consolidate as the main entrance door to the great European centres of consumption.

The achieved results are:

- An Analysis of the current situation of Mediterranean Ports, which will allow ports to approach and plan their strategies and will pave the way for future challenges within the frame of the new programming period.
- Map of the smart port criteria, showing operational, energy, and environmental aspects.
- Map of competitive advantages and disadvantages, detailing barriers, gaps and trends.
- Strategic action plan towards the smart port concept, aimed at exploiting the existing potential and at the same time, contributing to the decision-making process[62].

Simulation using Building Information Modelling Methodology of Multimodal, Multipurpose and Multiproduct Freight Railway Terminals Infrastructures (INTERMODEL EU)

INTERMODEL EU focuses on the intermodal railway terminals. With the help of ICT tools for advanced simulation, it will support tasks related to both design and planning phases.

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60 TRIMIS (2013, May 1). <https://trimis.ec.europa.eu/project/sustainable-marketdriven-terminal-solutions-efficient-freight-transport>

61 Fundación Valenciaport (2020, May 6). <https://www.fundacion.valenciaport.com/en/project/futuremed-freight-and-passenger-supporting-infomobility-systems-for-a-sustainable-improvement-of-the-competitiveness-of-port-hinterland-systems-of-the-med-area-2/>

62 Keep EU (n.d.) <https://keep.eu/projects/17593/Action-plan-towards-the-Sma-EN/>

A remarkable result of this projects is the Integration Platform, which gives terminal stakeholders an option to improve decision-making considering multimodal terminals. It takes into account 3 perspectives: operational, economic and environmental.

The added value is the ability to gather knowledge of different expertise areas in a common environment. Questions are jointly discussed, and improved, so quantitative predictions are given based on the developed holistic and integrative approach[63].

3.4. Transition to more efficient and sustainable vehicles and machineries

Logistics nodes are points at which cargo is transferred between modes of transport, handling different types of cargo and using specialised machinery. In order to be able to carry out such complex operations and improve cargo handling capacity, technological advances and innovation have been developing for years in the field of machinery and transport.

If we focus on the land side, the need to optimise the flow of goods in ports has led to the use of free-travelling smart vehicles. Cargo-ANTs aims precisely at creating Automated Guided Vehicles (AGVs) and Automated Trucks (ATs), considered a safer, more efficient and more environmentally friendly freight transport that can cooperate in port cargo terminals.

Also within the port area, one of the major obstacles faced has been the progressive increase in the size of vessels. This evolution has generated two major challenges for ports and container terminals: 1) the need for greater cargo handling capacity of transports and machinery; 2) the need to adapt machinery and port equipment to the new dimensions of vessels. COFASTRANS has recognised both problems by offering, instead of the existing cantilever cranes and long straight-line berths, an innovative solution with a portal crane and an indented berth.

Cargo handling by Automated Next generation Transportation Systems for ports and terminals (CARGO ANTS)

Cargo-ANTs aims to create smart Automated Guided Vehicles (AGVs) and Automated Trucks (ATs) that can co-operate in shared workspaces for efficient and safe freight transportation in main ports and freight terminals.

Halmstad's contributions is an integrated planning framework (software) for task allocation, global path planning and local trajectory planning.

An autonomous driving system was also developed for AGVs and ATVs for container transport in ports and cargo terminals. It was accompanied by demonstrated planning, decision, control and safety strategies for these vehicles.

Finally, a robust grid-independent positioning system and an environmental perception system were also built to improve operational safety [64].

A Fast And Eco-efficient Transhipment System For Ultra Large Container Vessels (COFASTRANS)

COFASTRANS is a project which objective is helping to operating larger container vessels reducing also the operating time.

63 (n.d.). <https://cordis.europa.eu/project/id/690658>

64 (n.d.). <https://cordis.europa.eu/project/id/605598>

For that, the project creates, together with Konecranes, a system for loading and unloading larger container ships in international container ports using an innovative portal crane and indented berth, instead of the existing cantilever cranes and long straight-line berths. With this, the project will substantially improve the efficiency of container transportation in terms of time, cost and environmental impact. For that, the project creates, together with Konecranes, a system for loading and unloading larger container ships in international container ports using an innovative portal crane and indented berth, instead of the existing cantilever cranes and long straight-line berths. With this, the project will substantially improve the efficiency of container transportation in terms of time, cost and environmental impact[65].

4. Implementation cases

Implementation Cases are concrete examples in which causal links between public R&I funding and technology, organizational or process innovation in a specific logistics area can be established. Indeed, Implementation Cases are outcomes where research results have been further developed and have been deployed as commercial solutions, have generated a new market or have contributed to new policies.

BOOSTLOG has identified 5 Implementation cases in the framework of Logistics Nodes by developing any logistics model or solution.

These are mainly focused on improving ports, due to the importance of maritime transport nowadays. But there are some also targeting airports and railway terminals. While some of them remain in the testing area after the project ending, there are others that have attracted companies to further develop them aiming to obtain a commercial product.

5G Port of the Future

Ports are the major gateway for both import and export flows. The 90% of the international trade (45 TUSD) is carried by sea. The volume of traffic for marine ports is expected to increase. The increasing demand collides with actual inefficiency. Today, the 80% of ports still rely on paper-based processes for general cargo. Freights on the yard are not tracked, there is no knowledge on where the specific freights are positioned, and all the port operations are still manual and left to the experience of port's operators.

This leads to many inefficiencies with significant waste of time and the consequent increase of costs, fuel consumption and associated CO2 emissions. For this reason, Port operators are urgently looking to solve these problems with smart, scalable, and sustainable solutions. The 76% of ports see the need to optimize terminal operations, the 67% see costs as a concern and the 50% of the ports have the reduction of their greenhouse gas emission as target, in line with the Paris Climate Agreement and scientific recommendation, to halve the emissions by 2030.

Digital technologies are crucial in addressing these challenges and transforming port operations.

The port of Livorno, in Italy, implemented a Model-Driven Real-Time Control module, also called RTPORT. This model managed to improve the port competitiveness with a better and faster handling of the general cargo. Summing up, it aimed to increase the efficiency and sustainability of logistics operations.

65 (n.d.). <https://www.cofastrans.com/>

The public fund by EU for the COREALIS Project supported the ideation and experimental implementation and testing of the RTPORT solution in the early PoC in the Port of Livorno, covering the different phases related to the handling of a freight from its arrival in the port to its transfer onto the ship.

The main three use cases implemented covered the freight registration and its arrival in the port, the transfer to the storage area and the loading on the ship under the control of the developed Logistics Management system coordinating all the operations.

The idea developed in the COREALIS project reduces operation time, costs, risks and the environmental impact through a preventive optimization of the storage and loading operations and a context aware intelligent management of operations relying on continuous monitoring of the activities using cameras, GPS and other sensors.

The model made use of a 5G network as well as some disruptive technologies (IoT, AI, AVR…) with the objective of coordinating and supporting port operations in real time. These technologies created the core of the module, a digital twin with a 5G/LTE Network that reproduces the current situation in the seaport terminal.

The fact that data is collected via yard operators and implanted sensors can be misleading about whether it is an implementation case of Logistics Nodes or Data Sharing. Nevertheless, it fits the Logistics Nodes scope as data is collected in order to obtain some improvement in the terminal. In this case, the main objective is to increase the speed rate of the operations, reduce operational costs, so as fuel consumption and machine working hours with a positive environmental impact. This will be done thanks to taking operating decisions based on real-time analytical processing.

The partner in charge of the development was Ericsson. They began to develop the Port of the Future use cases in COREALIS Project assessing and testing the new 5G innovative solutions and exploring how these can optimize port operations and produce economic and sustainability value.

They are still studying these outcomes by a project named the 5G Port of the Future. Regarding this Implementation Case, Ericsson collaborated with this report in the dissemination of the case by providing all the necessary information.

One of the main aspects they highlighted was how they covered the gap between the project results and reaching the market, which was indeed by the further support from Ericsson to finance next steps of the solution evolution. Nevertheless, the leverage on the Port network and connected stakeholders addressing the solution to market need also helped it. Along this path, the main hurdles faced were finding the right partners and developing a business model.

But thanks to that interest and development, key results were obtained. RT Port proved its potential in Livorno in early deployment showing interesting figures. It reduced inefficiencies of 13% for vessel operations time, 28% for unloading and storage operations and 17% for the forklift usage, with a consequent 8% reduction in CO2 emission.

The characteristics of the potential market also helped to move from R&I results to an actual implementation. The market for the General Cargo automation is very broad. Digitalization is essential for the terminal operators to improve their business. Automation of key assets, new technologies integrated with a fast an efficient 5g network, interworking of IoT applications are the key factors towards the Port of the Future concept for a more sustainable world.

They believe their impacts, aligned with the United Nations' 17 SDGs, can inspire other ports and serve as a foundation for business scenario and replicability analyses in other ports and transport hubs around the world. With this project, they are moving technological boundaries forward and creating the biggest innovation platform ever.

The outcome and the project concept have also been shown in different competition and appeared on scientific releases:

In 2019 at the UN Congress on Sustainability the Port of Livorno project has been selected for its contribution to Sustainability (direct impact in 8 SDGs).

In 2020 at the Mobile Word Congress in Barcelona the Livorno use case has been shortlisted in the section Tech4Good, mentioned in the 5 most valuable projects. In addition, in 2020 at Hannover Messe Livorno project won the Industry Energy Efficiency Award.

PREDICTOR Asset Management

This implementation case also comes from COREALIS, a project aiming to define the future era of European ports using the latest technology available in order to face the greatest challenges on the agenda such as efficiency or environment.

Within this project, several pilots were implemented to test their outcomes. In this case it is of particular interest the pilot in the Port of Piraeus. Within this Living Lab, they tested the COREALIS Predictor Asset Management tool.

This kind of preventive maintenance is costly and does not capture asset-specific conditions. To overcome these issues, predictive maintenance (PdM) considers the operating conditions of vehicles by leveraging data collected from individual assets to predict failures in future. In this way, repairs can be done only when it is required (and avoided when it's not required).

It can be seen as a 3 steps process showed in the following figure:

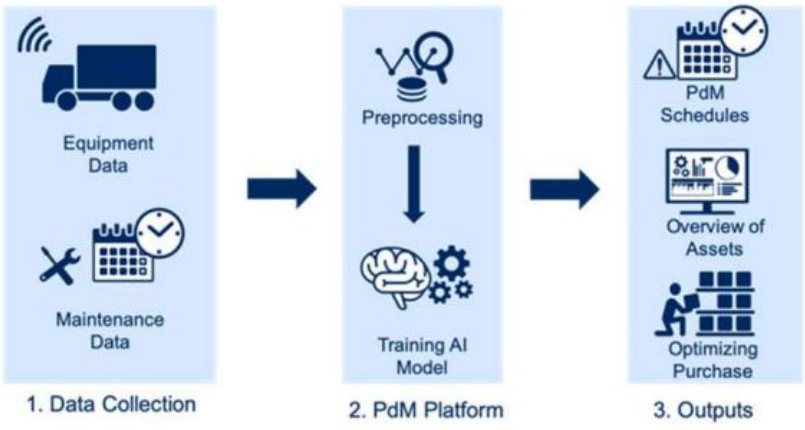

Figure 9.

The data comes from a module which collects real-time equipment data and maintenance historical. It is processed in a platform with an AI algorithm, which obtains benefits on reducing the asset timing and the

66 COREALIS (2021, July). (D3.2).

maintenance cost while optimizing the Spare Parts Inventory. Therefore, the Predictor Asset Management is formed of the equipment List, the maintenance schedule and a learning algorithm. The spare parts inventory will be based on the predictive maintenance schedule with a JIT inventory.

In other words, it is a machine learning tool based Just in Time inventory with the objective of extending the lifecycle of yard equipment, improve its availability and reduce inventory cost and size.

The tool monitors and predicts dynamically the life-cycle cost of port assets. It is made by an algorithm that predicts maintenance for yard trucks. It had an accuracy of 85/90% as the break down is concern. Using these results, the port can minimize the inventory that it keeps, and it manages better the maintenance time for the trucks as well as minimize the breakdowns during the operations.

This tool was designed and developed in the project by NEC.

Currently, the system is kept in the port of Piraeus, and it is bringing multiple financial and operational benefits. It increases the efficiency of processes and its planning, and reduces costs, energy consumption and GHG emissions.

Port Environmental Index (PEI)

The following implementation case was developed as an outcome of the PIXEL project (Port IoT for Environmental Leverage) aiming to manage an efficient use of resources in ports, sustainable development and green growth of ports and surrounding cities/regions.

Within the outcomes, PIXEL developed an index named Port Environmental Index (PEI), which is a quantitative indicator of the environmental performance. The index is believed to be very challenging as it represents a huge progress in combining diverse sciences to achieve the results.

It aims to create a comprehensive, standardized, and transparent methodology to quantify most relevant environmental aspects of ports and its related impacts into a single metric (flexibly adaptable to comprise different impacts depending on the port concerns) . The added value of this metric is that it is a self-assessment procedure, and it is an automated real-time data collection system obtained through IoT which obtains a quantitative result that can be compared with other ports.

The PEI is calculated through the KPIs of the following figure:

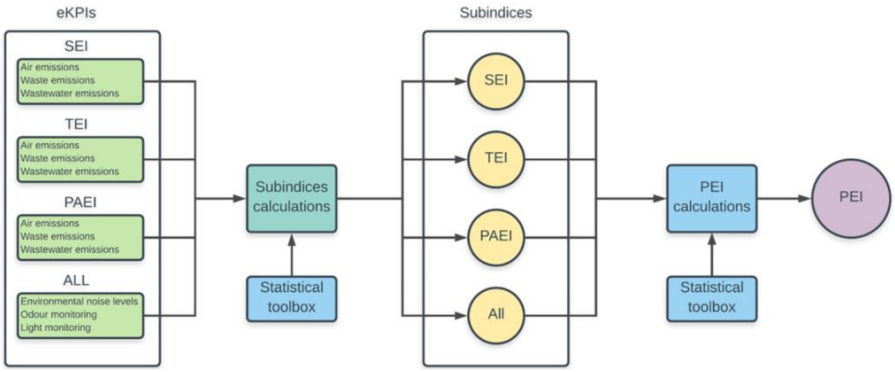

Figure 10.

[67]

67 PIXEL (2021, November).

As it can be seen, it originally includes atmosphere emissions but also those regarding noise or odours, as well as the light pollution generated. Moreover, it considers the production of waste and the water waste, so that a complete vision of the environment is offered. Besides, flexibility is given so that other relevant considerations such as dredging impact or the repercussion on biodiversity could be included, following a determined methodology and guidelines.

The index presents an elevated degree of innovation because it is:

- The first IoT-based environmental performance assessment tool using the existing sensor and server infrastructure enhanced to a baseline.
- Monitored real-time environmental KPIs focusing 6 initial domains selected based on the real needs and limitations of ports.
- Built on robust scientific methodology allowing for an accurate and comprehensive monitoring based on well-established workflows.
- Taking into consideration the complex variations of ports and their needs, and the variability of the data they can access and load

The benefits that this solution brings to the ports are:

- A quantitative real-time measure of the port environmental performance using the existing sensor infrastructure.
- It can satisfy the intention of measuring ports' performance and environmental impacts and to track it during the years
- It may serve as a benchmark that ports can use to evaluate their environmental performance and to compare it to the other ports
- It can be used as a tool to understand the beneficial impact of measures implemented in ports (e.g., LNG-propelled machinery or off-shore energy supply).
- Comprehensive and flexible Big Data Information Hub with APIs.

Within the framework of the project, the index and its algorithms were developed thanks to the effort made by the Polytechnic University of Valencia (UPV). From the project living labs, the index remained in three of the four ports: currently is still being used in the ports of Bordeaux, Mont Falcone and Thessaloniki.

The PEI is currently an open-source software available to all interested parties. In fact, there is a transfer contract between the UPV and the Spanish port of Vigo that allows this technology to continue expanding. The brief time passed since the end of the project and the success of adding Vigo to the ports that have the technology, highlights its importance and opens the door to future implementations.

Port Rail Shunting Optimization Tool

Circle Spa is a consulting company for management and processes, innovative technological solutions in the port, intermodal and logistics field. Their high participation in European projects allows them to have a deep knowledge and to make significant headway like the current implementation case.

The Port Rail Shunting Optimization System is the result of collecting the outcomes of an R&D project and implementing them in a CEF one.

The innovation project from which the idea comes is TEBETS, an Italian R&D project within the national competence centre on critical infrastructure. This project, which is an acronym for , supported the design of a Digital Twin that was also applied in the CEF e-BRIDGE project in a logistic node (shunting area in a port), speeding up the implementation phase and provided the right consolidations/refinements until arriving the current pilot phase.

As a member of both projects, Circle enabled the transfer of knowledge and facilitated the subsequent development: a digital platform consisting of a system composed by a Decision Support Systems Tool and a Digital Twin. They also collaborated in the elaboration of this document by confirming its case and providing further information.

The solution developed is a Decision Support System for helping and supporting the planning and the management of rail shunting operations within the port area. This part focuses of the ports freight transfer made from the railway station to the maritime terminals, and vice versa. It consists of a scheduling module which finds the best starting and ending time for each considered shunting operation of every train to manage, and a re-scheduling module for unpredictable events such as delays.

The logical processes of those two modules are shown in the following figure, which provides an updated plan:

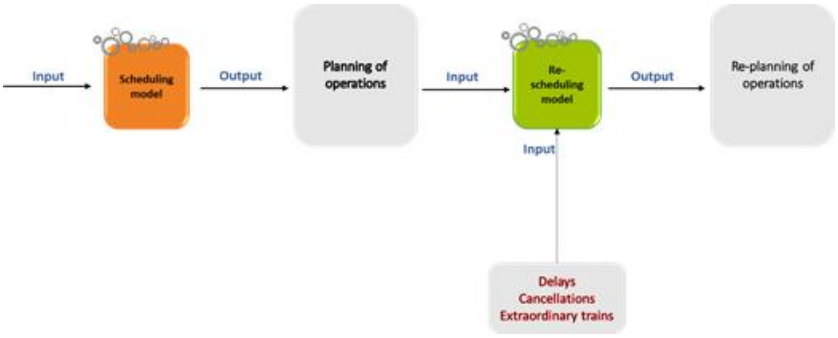

Figure 11. [68]

This optimisation tool is already deployed for the “scheduling” in an integrated manner with the software used by the shunting operator in the port of Genova. Currently, this module is in test & pilot phase. In the next months will be extended to the “rescheduling”.

On the other hand, the Digital Twin is developed for visualizing railroad shunting operations using discrete events of which we are aware as input. It can be made available to different process operators for simulating and monitoring the state of the infrastructure over time. It uses Stop and Regression Points on the Geographic Information System (GIS) map.

It is a part of the overall optimization of the shunting node, coupling simulation with real time information in terms of replanning the planned operation based on real time info coming from ground.

68 CIRCLE Group (2022). . LOB Optimization 4.0.

Along with the tool, it is built for the shunting area of the port of Genova. Even the simulation part is already working, and the system is prepared for the real time feedback from the ground, this is still not available. Therefore, this part is not concluded, and it will be finalized when real time data is available.

A key success factor for this solution was definitely having a specific and deep knowledge of the processes. Nevertheless, knowing the main operators of the chain/process and having a collaborative and cooperative modality of work also helped, as well as the context in which both the project and the solution were developed, with the rail transport mode being in a growth phase.

From the above, it is also possible to identify three main beneficiaries of the of platform: The Port Authority, for testing and taking strategic/tactic decisions and for monitoring the infrastructure; the Shunting Manager, for having a support in the organization of the activities; and the Maritime Terminal operators, for collaborating in the research of the optimal efficiency of the port system and for visualizing the infrastructure state.

According to the solution owner, the main pain point faced while generating this solution was involving different stakeholders with a not full digitalized management of activities. A simplification of the process was needed in order model in an optimization approach only the main aspects while taking into consideration the necessities of all the stakeholders. In parallel, another pain point was the specific context in which some innovations and supports provided by Artificial Intelligence (AI) are still difficult to completely comprehend and accept.

On the other hand, by focusing on the expected positive impacts, improvements in both the optimization and programming of operations are achieved. A more detailed list of expected effects is provided bellow:

- Support for the prior sizing of resources needed to perform the service;
- Support for the scheduling of activities;
- Assignment of available resources to scheduled activities in order to regularly perform the service;
- Real-time re-scheduling to better address the management of extraordinary operations and unpredictable events;
- System status monitoring.

All these benefits contribute to pursue the increase of the rail transport mode share while reducing the road one, and then the negative externalities that it involves, both in port contexts, in port cities, and, in general, in the territories.

Therefore, even though the current market is Italy, considering the benefits abovementioned, it is expected that the potential clients will extend to the whole of Europe.

Slot Booking App

Clusters 2.0 is a Horizon 2020 project setting up the potential of European Logistics Clusters for a sustainable, efficient and fully integrated transport system.

It relies on the Ten-T Network of Logistics Clusters promoting the intermodality and supports local and European development, while keeping neutral the local impacts such as congestion, noise, land use and local pollution levels.

This project facilitated the roll out, implementation and test for market fit of the Slot Booking Application. Slot Booking is a web application that assists the operations of freight delivery and pick-up in airports. The main

impacts of its use are the reduced waiting and idle times (and therefore its costs), the optimization of personnel planning and the transparency and smoothness given to these processes. The interface is shown below for better understanding:

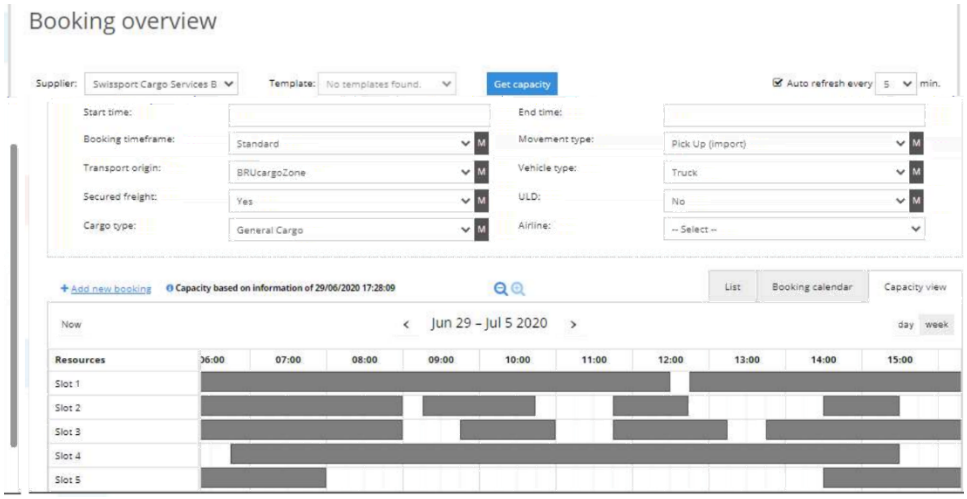

Figure 12. [69]

The users are Freight Forwarders as long as they can access an easy booking and avoid waiting, the Ground handlers because their capacity is smoothened and their processes are faster, and the Airport, which has more insight and a better performance.

Many companies contributed in the roll-out and implementation of the tool, but was Nallian who continued to market and promoted to other airports and continued adding new functionalities and improvements. This tool is now part of its Truck Visit Management Solution. At the same time Air Cargo Belgium further support the Brussel community towards 100% of the application. Both Nallian and Air Cargo kindly shared and confirmed the results of this report and also provided further information.

Truck Visit Management represents a solution to coordinate and communicate with freight forwarders and trucking companies online and in real-time with a three-step process: A fast registration of the drivers and the shipment, the slot management itself, and the sharing of data to facilitate the exchange of freight details between trucking companies, freight forwarders and ground handlers.

This solution can be adapted to any business by selecting one of the packages of the Figure 13.

69 AirCargoBelgium (2020).

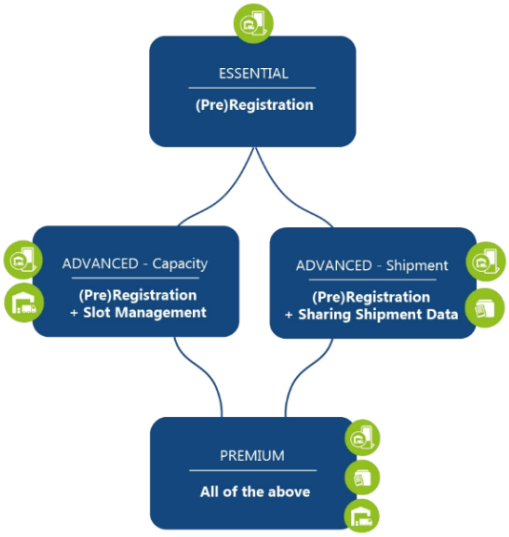

Figure 13. [70]

The project was implemented in the Brussels Airport community, where it's made available on BRUcloud, the Brussels Airport Company implementation of the Nallian data sharing platform. On BRUcloud, several functionalities are offered to the Brussels Air Cargo community. The overview can be seen in the picture below (see Figure 14). The Slot Booking App is highlighted.

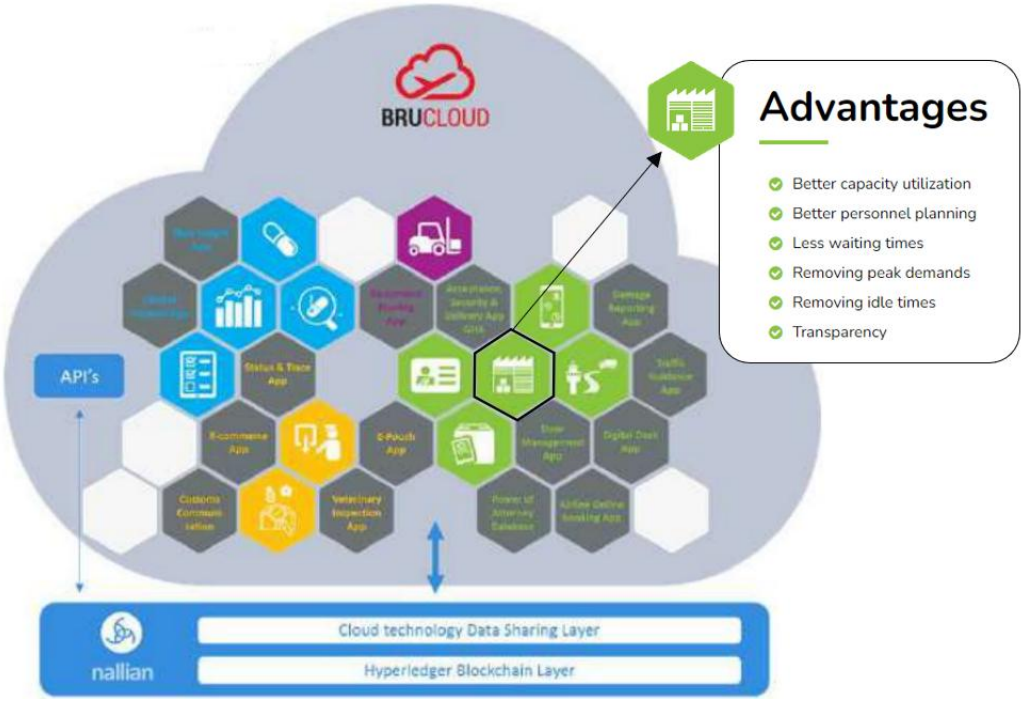

Figure 14. [71]

70 Nallian (n.d.).

71 Brussels Airport (2020). . CLUSTERS 2.0.

As has been discussed throughout the explanation of this implementation case, the application addresses pain points of different dimensions. Some of them are: congestion of the cargo hub, truck waiting times and inefficient resource planning among others.

After the project, the Brussels Airport community has further adopted and expanded the use of the application with support of Air Cargo Belgium.

During the project 15 companies joined and the solution has significantly reduced the waiting times, saving up to hours at peak times. The number of companies involved grew up to more than 50 after the Clusters 2.0 project. Currently, the BRU-achievements have been implemented in other airports internationally and are active now in Singapore (Changi), US (DFW, LAX) and Liege too. Further potential implementations planned in a number of big international airports and global rollout for a leading ground handling agent. The benefits and claims are more than frequent. Some of these claims are:

> "With the Slot Booking app we achieved a 50% drop in waiting times on export and 25% on import, together with an immense cut in overtime for the drivers."
>
> EXPEDITORS | Bart Hauwaerts, Warehouse Manager

5. Potential implementation paths

During the interviews with experts, many CEF projects were named when asking for projects which efforts are related to innovations and focused on the enhancement of logistics nodes. Therefore, even though many projects have been selected regarding Logistics Nodes, not as many implementations have been found.

In the last years, CEF projects have been the ones that have really fostered innovation in the logistics hub sector, showing innovation programmes are not alone contributing to its improvement. BOOSTLOG identify that there are multiple cases that are clear examples of innovation but that are financed by other funds totally remote from R&D. Some of these examples have been mentioned before (see Section 2 Market current practice analysis).

To identify potential implementation paths, it is also worth mentioning the results obtained from the experts interviewed in terms of the most relevant trends and social drivers for the logistics nodes, as they will significantly condition the issues to be addressed by future projects and, therefore, the types of implementation cases that may result from them (see Figure 15).

Figure 15.

The most repeated factor was the digitalization, followed by resilience and environmental concerning such as climate change or sustainability. They are believed to be factors with long term effects with a wide influence range.

Digitalization has been around for some time, but it has been speeding up in the last years due to the COVID-19 pandemic. This situation has proven its need and has stimulated its implementation in companies of any level. It is also highly related to automation and standardization of processes at different levels: technological, operational, skills, etc. In this sense, there is a risk that future projects continue developing isolated solutions, or non-aligned, then being difficult to re-use or adapt in a wider scale.

On the other hand, climate change and sustainability are mainly triggered by policies and usually affect Logistics Nodes in a more indirect way.

There are other external factors such as reshoring, e-commerce and non-predictable impacts that were also commented due to the situations that the world has faced in recent years. The most reported examples are the global pandemic that has paralyzed all countries and other unpredictable impacts related to the rise of energy costs or geopolitical conditions, that is affecting multiple countries and having huge changes and uncertainty in container traffic. These factors address the Logistics Nodes more directly, as they somehow concern its location and performance.

Finally, the regulatory framework as well as the trade and economic conditions will also affect the different targets and topics identified. The normative and geopolitical context under which logistics nodes operate and develop is also a decisive factor in the evolution of these complex infrastructures, acting as barriers or drivers.

Thus, these trends' cloud helps to picture the present and future of the logistics nodes which involves a digital and green transformation, but also an understanding of the different sectors and players that comprise the entire logistics hub community.

Furthermore, in addition to the trends seen, other research conducted for this Cloud Report can contribute to clear the way forward for upcoming projects. Barriers to be addressed and statistical analysis of the projects' characteristics and outcomes are some of the aspects addressed that dictate the steps to be taken for projects to be successful and lead to the next implementation cases.

As it has been seen in Sections 2 Market current practice analysis and 3 Project Results and Outcomes, the interest of innovation projects in the logistic nodes scope is considerably recent. On the one hand, from the 21 concluded projects selected in this Cloud, 47.61% were financed under the Horizon 2020 programme. On the other hand, there are currently many ongoing projects whose potential to generate implementation cases is very high and that are a clear indicator of the present and future path of the logistics nodes. Therefore, even though few implementation cases have been found, many are expected in the coming years. This a picture of the current situation, but the scene is dynamic.

Particularly important in this regard has been the work undertaken by ALICE, acting as a promoter and developer of a comprehensive strategy for research, innovation and market deployment of innovation in logistics nodes in Europe, but also connecting relevant stakeholders.

Focusing on the level of involvement of the logistics nodes themselves in the projects covering this Cloud, we found that their participation was very limited in the completed projects. This has improved in ongoing projects, which means that truly interested stakeholders are more engaged.

On the other hand, if we analyse the evolution of the projects over the years in terms of topics and challenges covered, there have also been significant changes.

Following the same classification that has been used in these completed projects selected, the Figure 16 also includes the ongoing projects, capturing the work conducted in the past but also the current steps being taken in the domain of logistics nodes.

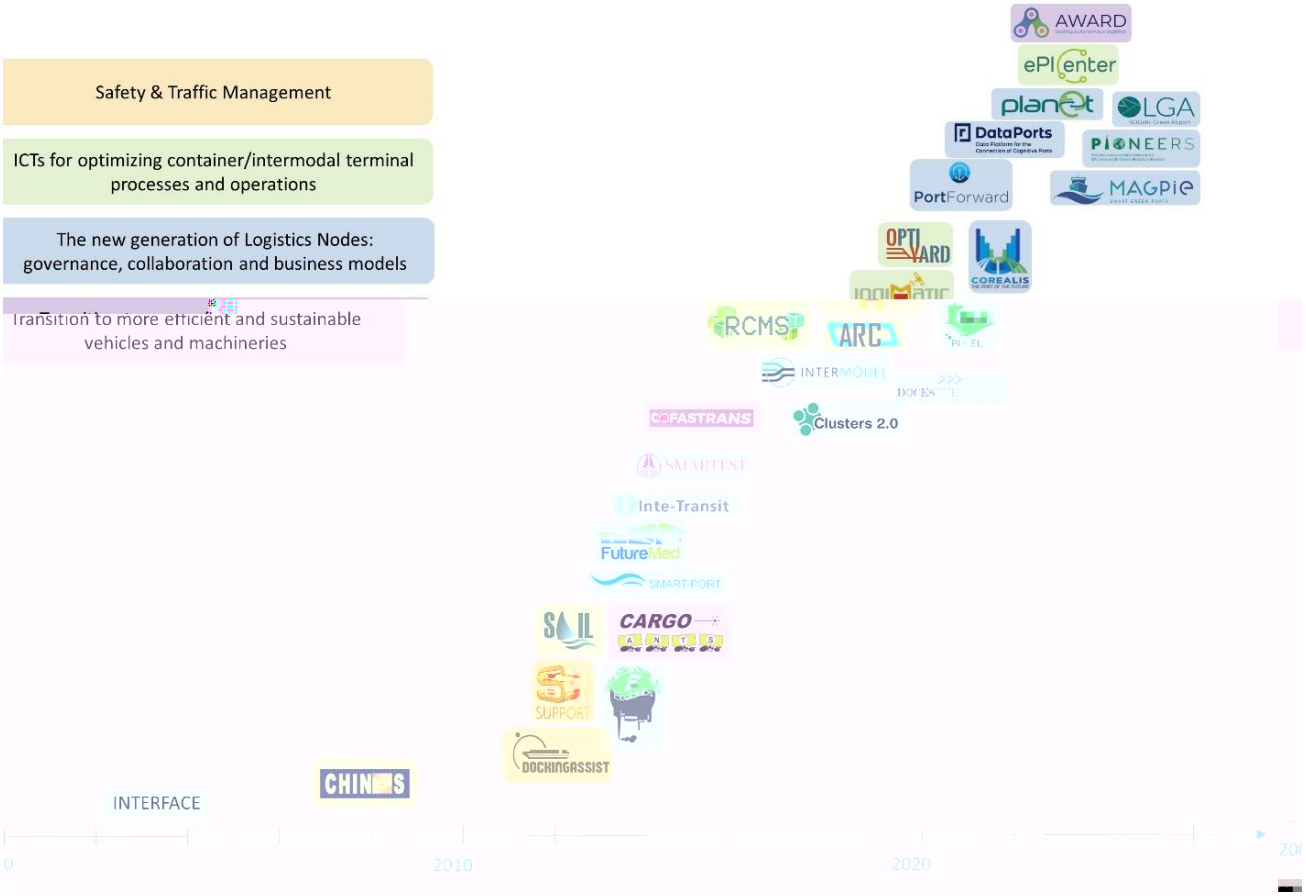

Figure 16.

The topic ICTs for optimizing terminal processes and operations is currently contemplated by one project, EPICENTER. The innovation of this project comes with the introduction of PI and disruptive technological concepts to the nodes, such as AI. It highlights the importance of being up to date with the progress of the technology to apply it and benefit from all its advantages.

The new generation of Logistics Nodes remains the main focus with the highest number of projects. There are two topics that stand out within the new generation of nodes and these, as expected, coincide with the results obtained as key trends in Figure 15. They are digitalization and climate change.

Regarding digitalization, DATAPORTS' project is a good example. It is a project which focuses on the transition to the digital era of the ports and boosts the connection with actual and future digital infrastructures. PLANET is heading in a similar direction, applying technologies such as IoT or Blockchain on the study of the new trade routes and transportation trends affecting Europe. It aims to prepare the nodes for the new logistic distribution since changes in trade flows, patterns to/from and within Europe and entry points of trade along the TEN-T network are expected. It guides the nodes to what should they invest in, or what mode would have

a bigger importance in order to adapt the ports and terminals, overcoming infrastructural bottlenecks, congestion problems and capacity shortages.

On the other hand, a big number of projects, larger than expected on the Figure 15Figure 13, focus on sustainability. These look for the so-called green terminals in which GHG emissions and energy consumption are reduced to the minimum or completely disappear.

Among these types of projects is OLGA. It brings to the airports concepts of other areas that had hardly been contemplated such as the care for the biodiversity, the air quality, or the waste management.

Although there is a need of projects whose main objective is the approach of these new concepts to the nodes, there must be other projects that can address the new trends without losing sight of the other important objectives of the ports. This is the example of PIONEERS, a project that targets the reduction of GHG emissions in ports while making great emphasis on safeguarding competitiveness.

There are some projects which focus on both trends. It is the case of MAGPIE, which aims to make ports both greener and smarter, meaning more digitalized, or PortForward, which points at the port ecosystem but also from the smart, green and sustainable perspective.

While the category of projects mainly focused on the Safety and traffic management of logistics nodes disappears, the interest on the vehicles and machinery in the nodes also lowers. Nevertheless, there is one project, AWARD, which still keeps it alive. This project is possible because it takes a step further and develops autonomous driving system (ADS) capable of handling adverse environmental condition. It does not only face the scepticism of Autonomous Vehicles (AVs) driving around in everyday traffic, but also continues the path taken by projects such as CARGOANTS. That project developed Automated Guided Vehicles and now, with AWARD, the nodes can go beyond and allow them to be not only automated but autonomous, giving them intelligence and independence and approaching the — probably upcoming — self-driving.

To conclude, experts expect an increase in digitalization, automation and standardization, in line with the trends described above. Regarding these trends, future logistics nodes should be developed under the paradigm of hyperconnection in terms of digitalisation and with zero-emission impact in terms of sustainability. Another highlighted aspect was the link between societal pressure and the license to operate, meaning that a lack of innovation and interest in being sustainable might end in a license withdrawal to operate as a node. Society will therefore gain importance as a stakeholder compared to past situations where it was not even counted as one and determine the transformation that nodes will undergo and the needs that projects will address in the future.

Annex I – Implementation case template

1. Main R&I projects which have developed results/outcomes based on which you developed this implementation case
2. Main Implementation Case/product or Solution:
   - Overview and key pain point addressed/Market addressed/Users/How the implementation case impacts on EU Policies
3. How Public funded supported the Implementation Case development and in which stages?
4. How you Covered the Gap between the project Results & reaching the market?
5. Which have been the main hurdles to overcome:
   - Financing for further development
   - Finding right partners
   - Value proposition towards customers
   - Business models
   - Other
6. Which have been the key success factors to move from R&I results to an actual implementation?

Annex II – Evaluation of the projects' status

The following table has been completed considering the last known status of the projects, beyond their official completion date.

TARGETED IMPACTS	NR. OF PROJECTS	STATUS	
Decrease of environmental and climate impact	11	CLUSTERS 2.0	POC
		COFASTRANS	TD
		COREALIS	POC
		Docksthefuture	TD
		ECOHUBS	POC
		INTERFACE	POC
		INTERMODEL EU	POC
		PIXEL	ISS
		RCMS	POC
		Smartset	POC
		FUTUREMED	POC
Reduction of congestion on the road network	1	CLUSTERS 2.0	POC
Modal shift	5	CLUSTERS 2.0	ND
		COREALIS	POC
		Docksthefuture	POC
		PIXEL	POC
		RCMS	POC
Decrease cost of transport & overall logistics	6	ARCC	POC
		CHINOS	POC

		COFASTRANS	TD
		COREALIS	ISS
		Docksthefuture	TD
		PIXEL	POC
Increased transport reliability and responsiveness	2	ARCC	POC
		CHINOS	POC
Increase management capacity of terminals and productivity	5	COFASTRANS	TD
		COREALIS	ISS
		Docksthefuture	POC
		PIXEL	POC
		RCMS	POC
Improved operations, terminal capacity utilization and efficiency in terminals	1	COFASTRANS	TD
		CHINOS	POC
Improve energy consumption	2	Smartset	POC
		CLUSTERS 2.0	POC
Improve the performance of the European Transport	3	ARCC	POC
		CLUSTERS 2.0	POC
		INTERMODEL EU	POC
Improve long distance-city distribution connectivity	1	CLUSTERS 2.0	POC

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Annex III - The projects outcomes

PROJECTS ACRONYM*	OUTPUTS			
	Technology	**Business Model**	**Policy**	**Service / Product**
ARCC				• Real-time Yard Management System.
CARGO ANTS	• Planning Software. • Localization and Mapping Software (SLAM).			• Autonomous driving system for AGVs and ATVs for container transport in ports and cargo terminals.
CHINOS				• System encompassing the container status monitoring parameters and ensuring the compatibility with the upcoming container traceability standard proposals.
CLUSTERS 2.0	• A new modular Load Unit (NMLU) at sub-container level			• Cluster Community System (CluCS), IT platform managing the resources and the synchronization. • Slot Booking Application. • CluCS technical architecture, the software modules development and CluCS test phase specification. • Cluster Community System Tool.
COFASTRANS				• System for loading and unloading large container ships in international container ports using an innovative portal crane and indented berth, instead of the existing cantilever cranes and long straight line berths.
COREALIS		• Just-In-Time Rail Shuttle Service feasibility study.	• Port of the Future challenges, enablers and barriers.	• COREALIS LLs Final Progress Report.
DOCKINGASSIST	• Base Station to transmit the data and of receive the accurate position. • Portable Pilot Unit (PPU) receiving the reference data and transmitting the accurate position.			• The DOCKINGASSIST system consisting of: (1) a DOCKINGASSIST Base Station (BS) installed at the harbour, and (2) a Portable Pilot Unit (PPU) installed on the ship(s).
DOCKStheFUTURE	• Port of the Future DSS Tool to resume main critical elements related to port related investments to exploit Port of the Future solution.		• R&D Recommendations, Policy Recommendations. • Port of the Future Road Map 2030 to guide Stakeholders towards 2030 objectives.	• Port of the Future Network of Excellence, a platform to carry the Port of the Future targets. • Port of the Future training package.
ECOHUBS	• Transport & Terminal Services Publisher (T2SP). • Proximity Network Management (PNM).			• Container Interfacing and Consolidation System CCIS. • Ecohubs Truck Appointment & Unit Reporting Status Services (ecoTAURuS).

	• Repair Services Publisher (RSP).			• ITEC (Intermodal Terminal Eco-Efficiency Calculator) tool.
INTERMODEL EU				• Integration Platform.
INTE-TRANSIT	• An Automated Container Management System.			• A Management Platform to continuously monitor the container storage process.
LOGIMATIC	• GIS-based control module compatible with existing Terminal Operating Systems (TOS) for optimized global (yard level) route planning and fleet management.		• A security strategy to withstand cyber-attacks and GNSS-related threats.	• An Autonomous Navigation Advanced solution based on the integration of Global Navigation Satellite Systems (GNSS) and sensors onboard straddle carrier vehicles for port automation.
OPTIYARD	• OptiYard Simulation Environment. • OptiYard Communication System. • OptiYard Decision Support System. • OptiYard KPI.			• OptiYard eco system.
PIXEL	• Operational tools: models of processes and algorithms.		• Infrastructure recommendations for heterogeneous sources data acquisition.	• Information Hub. • Dashboard for decision making.
RCMS				• Robotic Container Management System (RCMS).
SAIL	• Decision Support System (DSS) Discrete Event Simulation (DES).			• An integrated ICT tool able to support logistic chain of goods flow and all business operations provided in the port and the dry port areas.
SMART-PORT		• Analysis of the current situation of Mediterranean ports.	• Map of the smart port criteria. • Map of competitive advantages and disadvantages. • Strategic action plan towards the smart port concept, aimed at exploiting the existing potential and at the same time, contributing to the decision-making process.	
SMARTSET		• 3 business models to be set up after the project period.		
SUPPORT	• AUV (Autonomous Unmanned Vehicle). • SSID (Sea Side Intruder Detection)		• Education, Training and Examination module.	• ICT Platform for designing, developing, deploying and maintaining next generation security solutions for large and small-to-medium ports.

*FUTUREMED and INTERFACE had no data available.

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Annex IV– Semi-structured interview guide

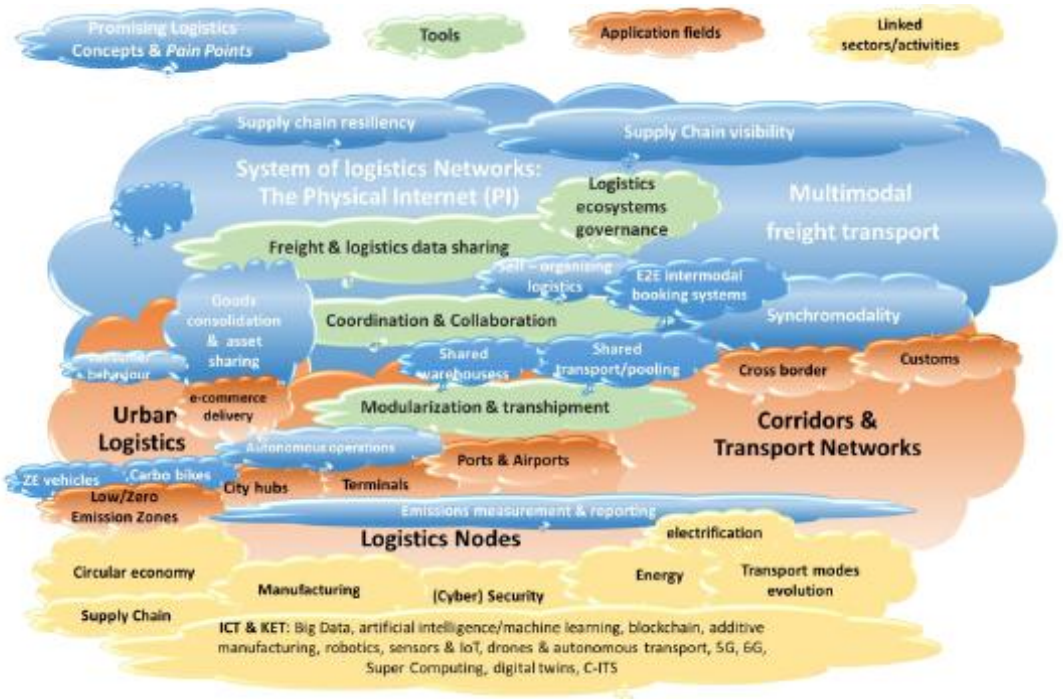
1. Project introduction

For more than two decades EU has invested in research and innovation (R&I) through various Framework Programmes, e.g. FP5 (1998-2002), FP6 (2002-2006), FP7 (2007-2013), and the ongoing HORIZON 2020 (2014 – 2020). This has contributed to the development of the logistics sector through the creation of new companies, implementation of concepts in practice and through science based regulation. The BOOSTLOG project aims to boost impact generated from future EU funded R&I projects to contribute to EU policy objectives, address societal challenges and increase EU's competitiveness. The project will map more than 160 projects funded by FP5, FP6, FP7 and Horizon 2020, and identify successful implementation cases into the market and regulations and will develop actionable reports on various subjects prioritized by stakeholders. The project will assess the impacts generated, identify gaps and priorities for future funding programmes.

Logistics Nodes are centres of freight transport where a large activity of cargo logistics and related services are concentrated with different degree of added value. Located at strategic points of interconnection along the main supply chain routes, its objective is to facilitate and improve the control and performance of all activities necessary for the transport of goods, including services, processes and procedures from planning to performance. In the current Cloud Report, five infraestructures are taken into account: Maritime & River Ports, Inland Ports, Intermodal Terminals, Container Depots and Airports; excluding Warehouseses since they are reasonable related to the last mile distribution, considered in a specific BOOSTLOG Cloud of the project.

Following the previous approach, when looking for projects focused on logistics nodes, these should address areas focused on improving the focal infrastructures. Specifically, three main areas have been identified to which improvements can be applied: Operational Efficiency, Operational Safety & (Cyber-)Security Sustainability & Environmental Impacts.

2. Cloud and subclouds diagram



- Do you miss any important cloud/subcloud?

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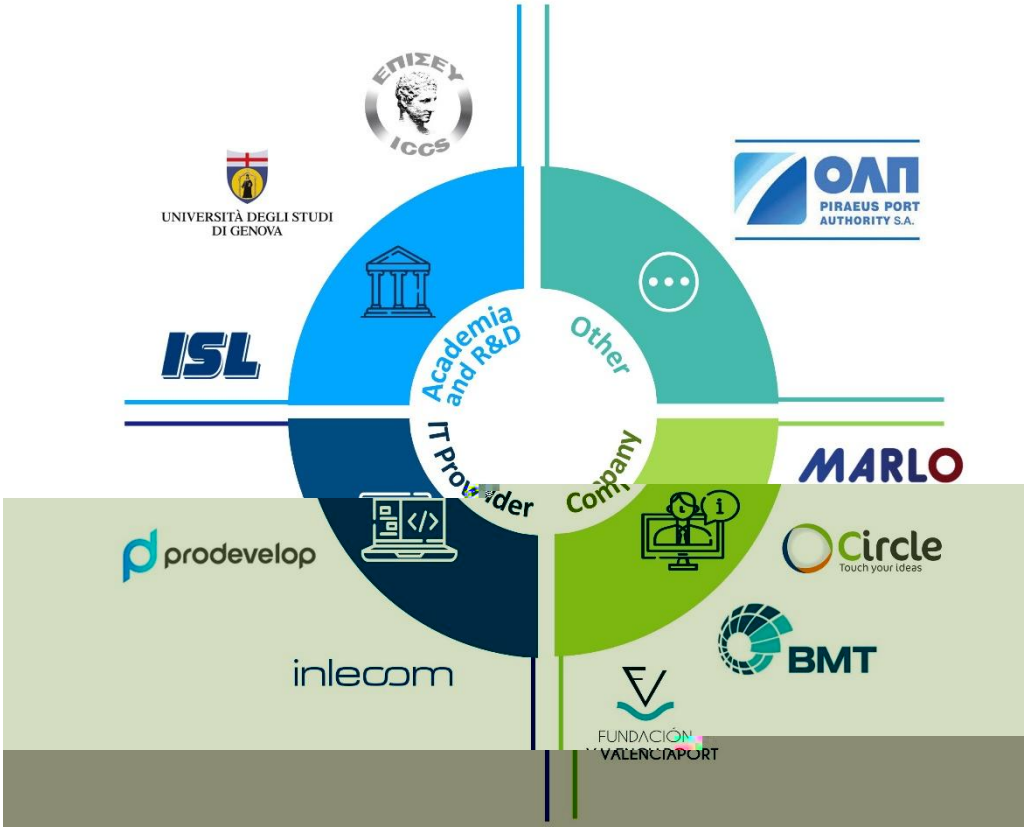
3. Most relevant projects in the cloud

- Do you miss a relevant R&I project not included here?

4. Organizations with highest participation in relevant projects in the cloud



- Do you miss an important/relevant organization with good R&I results in this area?
- If yes? Which organizations and for which results? Who is the contact person?

5. Trends and societal drivers relevant/addressed for the Cloud

LIST of trends and societal drivers:

Climate change, urbanization, individualization, digitalization, demographic change, resource scarcity, circular economy, driver shortage, online shopping, COVID-19

- Do you agree with this list of External Factors?
- Which are for you the 2/3 most critical/relevant?
- Which are the specific consequences to the logistics sector (e.g. online shopping means fragmentation of flows, instant deliveries/speed, last meter delivery)?

6. Relevant EU policies addressed

LIST of policies addressed by the cloud:

- **The European Green Deal**
- **Promoting our European way of life**
- **A Europe fit for the digital age**

- Which other policies you know are also relevant?
- Which is the EU policy this area has a greater impact?

7. Project participation of your organization per Cloud

- Have your organization participated in other relevant projects? Which ones? Could you share some information references?
- Which are the most Relevant/Key R&I results project deliverables for each project? Could you share them with us?
- Which have been the key partners on those projects à Generating results/outcomes and after project implementation?
- Overall, which is your conclusion on the projects in terms of:
    - Progress made
    - Level of adoption of results
    - Which have been for you the 2/3 key barriers for adoption?
    - Which would you think is the best (or best 2 projects) and why?

8. Project Outcomes

- Do you have any outcome out of these projects in this field?
- If a research center, is it your ambition to transfer/implement the Knowledge?
    - How your organization address that?
        - Through Market agreements on Knowledge Transfer to Companies.
        - Spin offs
        - Other
- What is the main barrier to reach the market you faced:
    - Financing for further development.
    - Finding right (industry) partners
    - Value proposition towards customers.
    - Business models.

  - Other?
- Do you have outcomes out of R&I projects in other BOOSTLOG CLOUDS?

9. Implementation Cases

Implementation Cases are concrete examples in which causal links between public R&I funding and technology, organizational or process innovation in a specific logistics area can be established.

Implement Cases are that research results have been further developed and have been deployed as commercial solutions, have generated a new market or have contributed to new policies and will stablish causal links between research funding and impact.

- Do you know any Implementation Cases out of these projects?
- If yes, which entity was the R&I/Outcome owner and which entity was the Innovation Seeker.
- Would you like ALICE/BOOSTLOG to promote the Implementation Case?

10. Final comments

- How could we improve the interviews?
- Would you like to join a workshop in which we will share the aggregated results and discuss conclusions with your peers?
- Any further comment.