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The BOOSTLOG project consortium consists of:

Part. No	Participant organisation name (short name)	Country
1 (Coordinator)	Alliance for Logistics Innovation through Collaboration in Europe, ALICE AISBL (ALICE)	BE
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
9	FIT Consulting SRL (FIT)	IT
10	FUNDACION DE LA COMUNIDAD VALENCIANA PARA LA INVESTIGACION, PROMOCION Y ESTUDIOS COMERCIALES DE VALENCIAPORT (VPF)	ES
11	TECHNISCHE UNIVERSITEIT DELFT (TU Delft)	NL
12	EUROPEAN ROAD TRANSPORT TELEMATICSIMPLEMENTATION COORDINATION ORGANISATION - INTELLIGENT TRANSPORT SYSTEMS & SERVICES EUROPE (ERTICO ITS EUR)	BE
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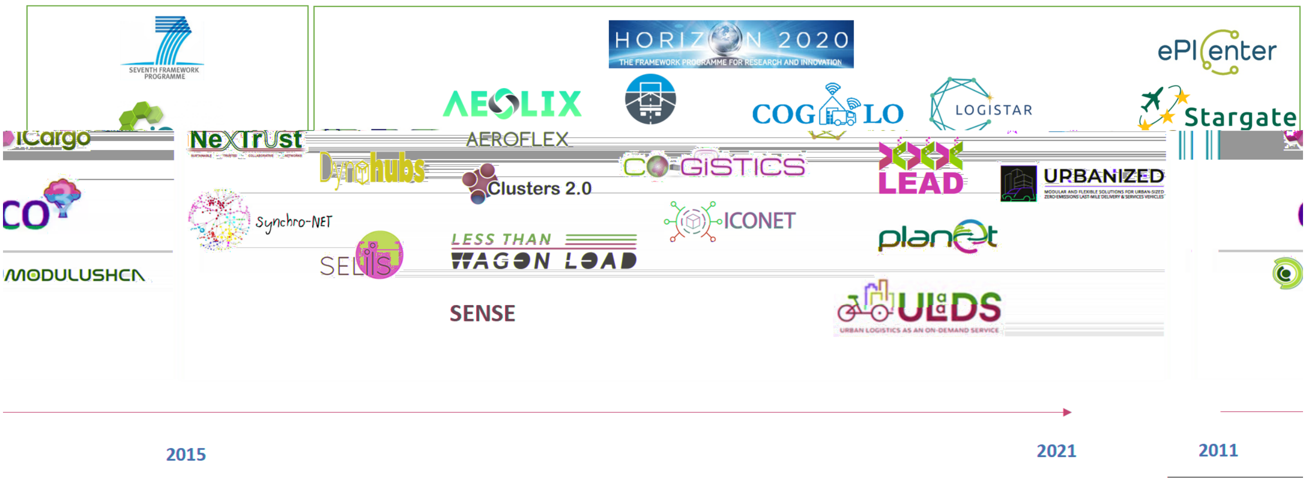
EXECUTIVE SUMMARY

This cloud report focuses on overview development and deployment of the Physical Internet (PI) concept. PI is an ambitious concept and realising Physical Internet needs fully seamless interconnectivity of physical, digital and process of freight transport and logistics services through standardised protocols and automatic transport control. This report provides an overview of the PI concept, current development, challenges and opportunities in the logistics sector for PI in the post-COVID19 era. This report also provides an overview of the current market, particularly business based on the PI concept contributing to new trends or new technologies in the logistics (e.g. vehicle automation, circular economy).

This reports identified 22 research and innovation (R&I) projects funded by FP7 and Horizon 2020 from 2011 to date as shown below that have contributed to the development of PI and/or implemented PI-enabled solutions. The 3 projects funded by FP& have significantly contributed to the development of the PI concept and initiated development of the PI roadmap published by ALICE in 2020 as well following R&I projects on PI (based on outcomes of the SENSE projects). Those projects have laid a solid foundation for future R&I in PI and implementation of the PI concept. ICONET further developed business models and



Outcomes of those projects have been mapped according to the PI roadmap to identify their contributions in realising the roadmap. The mapping has been built on existing literatures as well other BOOSTLOG cloud reports published. Most R&I projects contributed to Generations 1 and 2 of the five areas of the PI roadmap (Logistics Nodes, Logistics Networks, System of Logistics Networks towards the Physical Internet, Access and Adoption, Governance). Projects, AEROFLEX and NEXTRUST have contributed to Generation 3 of Logistics Nodes and Logistics Network.

As other BOOSTLOG cloud reports have mapped projects and identified implementation cases on logistics coordination and collaboration, urban logistics nodes, logistics networks and data sharing, this cloud report focuses on identifying implementation cases access and adaptation and governance. 3 successful examples which are different from implementation cases of other cloud reports have been identified that have significant advanced rollout of the PI roadmap. Of them, 2 are demonstration projects (Access and Adoption), and 1 is for Governance. Implementation path (future actions) is also provided.

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Freight transport and logistics is facing critical challenges to address climate change, to ensure that supply chains are well functioning, and people are served with required type of goods and services. In particular, coping with the expected growth of freight transportation and transition to zero emission logistics up to 2030 requires collaboration and speeding up innovation.

The BOOSTLOG Vision is to transform the European freight transport and logistics R&I ecosystem to perform optimally boosting impact generation out of R&I investment contributing to (1) 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 (2) *s o* sustainability and competitiveness generating value for society.

In order to do so, BOOSTLOG has identified four main areas of action: (1) Increase visibility and support valorisation of R&I projects' results, outcomes and implementation cases in the freight transport and logistics field (2) develop and implement valorisation 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, (3) define high potential & priority R&I gaps to make efficient uses of R&I investments and (4) 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 about 300 EU-funded R&D projects since FP5 in different freight transport and logistics domains (i.e., the Logistics *n*), so as to develop eight comprehensive and industry actionable reports. 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).

Five cloud reports gathering outcomes and implementation cases in specific clouds have been published. They are:

- Cloud Report i: Coordination & Collaboration(D2.2)[1]
- Cloud Report ii: Urban Logistics (D2.4)[2]
- Cloud Report iii: Logistics Nodes (D2.5)[3]
- Cloud Report iv: Logistics Data Sharing (D2.6)[4]

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[1] The first Cloud Report, available at https://www.etp-logistics.eu/wp-content/uploads/2021/12/BOOSTLOG_D2.2-Cloud-report-Coordination-and-Collaboration_final.pdf

[2] The second Cloud Report, available at https://www.etp-logistics.eu/wp-content/uploads/2022/03/BOOSTLOG_D2.4-Cloud-report-Urban-Logistics_final.pdf

[3] The third Cloud Report, available at https://www.etp-logistics.eu/wp-content/uploads/2022/11/BOOSTLOG-D2.5-Cloud-report-Logistics-nodes_final.pdf

[4] The fourth Cloud Report, available at

- Cloud Report v: Logistics Networks (D2.7)[5]

This cloud report focuses on Physical Internet including Modularization and Transhipment technologies. Project mapping will be overlapped with previous cloud reports if those projects play an important roles to development of the PI concept. However, for implementation cases, this report will also look into examples that have contributed to deployment of PI which are different from other cloud reports.

What is BOOSTLOG Cloud Report?

A BOOSTLOG Cloud Report will 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. This basic framework is provided in chapters and . The reports contain clear and companies' actionable items such as cases on how to implement the outcomes or build on the implementation cases.

Cloud of this cloud report on Physical Internet

The Physical Internet (PI) is an ambitious concept and realising Physical Internet needs full and seamless interconnectivity of physical, digital and process of freight transport and logistics services through standardised protocols and automatic transport control. Seamless interconnectivity of the logistic networks will include transport, storage and physical handling operations of load units like containers, swap-bodies, pallets, boxes, etc., as well as associated processes to ensure correct execution of contracts in end-to-end supply chains. Existing transhipment- and distribution-centres, roads, railways, waterways, and airway services must be digitally connected to each other and services are visible and accessible to all users.

PI should be inclusive, open and for the benefit of all stakeholders including SMEs. However, without proper steering and guidance, this transformation may not lead to a desirable future. PI could develop in a different way, for example, as a monopolistic, very-profitable business but not necessarily open, accessible, and supporting sustainable solutions[6].

Through this study, this report is expected to develop a comprehensive understanding of current status of implementation of the PI roadmap, and factors enabling such contributions as well as barriers preventing bigger contributions will be studied by this report.

[5] The fifth Cloud Report, available at https://www.etp-logistics.eu/wp-content/uploads/2023/04/BOOSTLOG_D2.6-Cloud-report-Freight-and-logistics-data-sharing_final.pdf

[6] Dans, E. (2019) *D n S ckn o o* https://www.forbes.com/sites/enriquedans/2019/05/17/the-battle-for-the-physical-internet/#68092e883baa

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In the ALICE Physical Internet roadmap[7], the development path of PI is summarised as five specific areas:

1.
2.
3.
4.
5.

While this report will map all R&I projects that contribute to the five areas to identify their contributions to development and implementation of the PI concept, selection of successful examples will focus on two specific areas that have not been covered by other BOOSTLOG cloud reports: Access and Adoption, and Governance as shown in Figure 1. Detailed description of the two areas are shown below:

- describes the main requirements to access the Physical Internet through a logistics network part of it. It also includes different steps and mind shift required to adopt Physical Internet concepts. Specifically looking into projects that cover:
    - Pooling and alliances
    - Sectorial, regional, seamless, vertical PI demonstrations
    - Large-scale PI demonstration
- includes the developments needed to evolve the Logistics Nodes, logistics networks and the System of Logistics Networks into the Physical Internet, i.e., the rules defined by the stakeholders forming or using them as well as the trust building processes and mechanisms. Specifically looking into projects that cover:
    - Scattered and unbalanced terms, rules and standards
    - Rules and governance for asset-sharing platforms;
    - Foundation of PI governance body

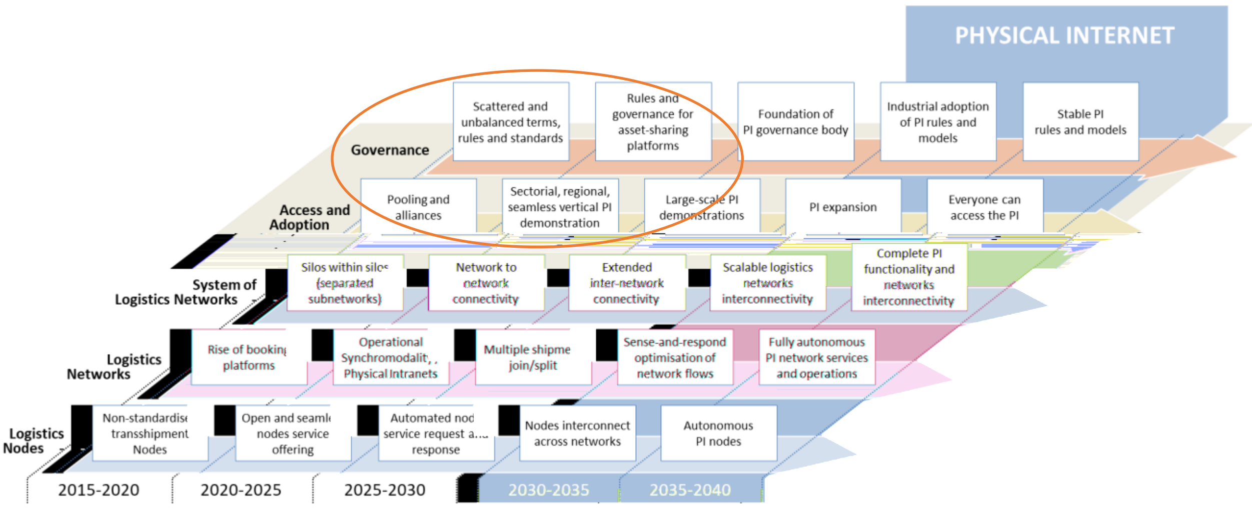

Figure 1. The Physical Internet roadmap

[7] Roadmap to Physical Internet: Executive Summary: https://www.etp-logistics.eu/wp-content/uploads/2022/11/Roadmap-to-Physical-Intenet-Executive-Version_Final-web.pdf

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The main purpose of a Cloud Report is to evaluate the results and Outcomes from R&I projects found by FP7 and Horizon 2020 to understand their contributions to the PI's development and implementation. The methodology for developing a cloud report is shown in Figure 2.

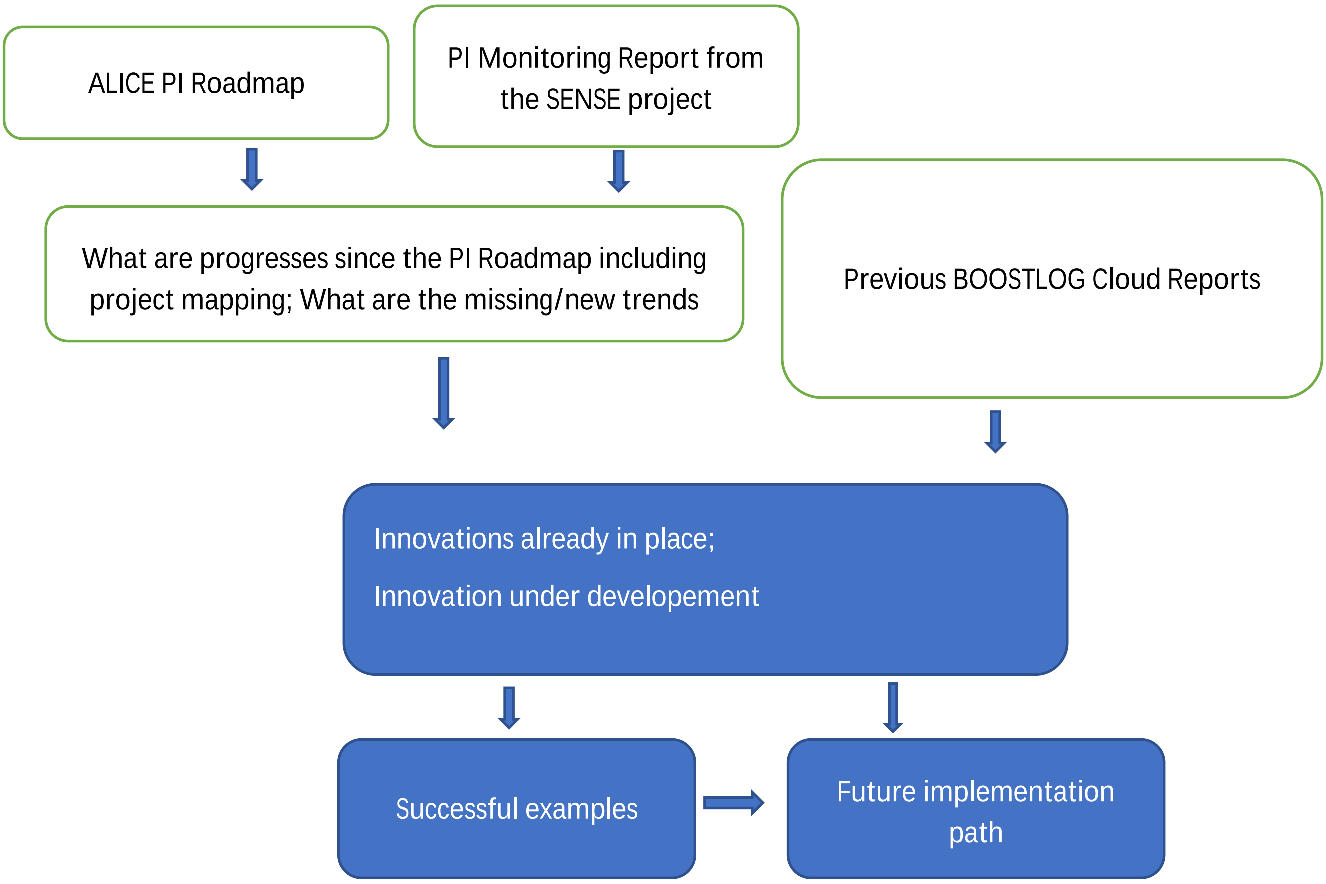

Figure 2. The Methodology of this cloud report (dark blue boxes presenting key contents of this report

This cloud report provides a compilation of current practices which can be considered as 'innovation' in the sense that they contribute to further development and implementation of Physical Internet. Such practices encompass three elements:

- Innovations already in place
- Innovations under development in dedicated projects or research programs

Mapping of the R&I results and outcomes at the cloud level (Chapter) that will also include innovations already in place as well innovations under development in dedicated projects or research programs. The outcomes are then checked for eventual implementation after the project lifetime (Chapter). This investigation step is mainly performed by interviews with key experts, complemented with the desk research on projects deliverables and communications. The draft

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The transport and logistics sector is one of the sectors where emissions are continuously growing. According the European Environment Agency(EEA)'s projection[8], today the transport and logistics sector contributes around 24% of global CO2 emissions, and by 2050, global logistics to account for up to 40% of global carbon dioxide emissions if strong and effective actions are not taken. The business-as-usual logistics sector will no longer be sustainable. Disruptive innovations, such as Physical Internet (PI), are urgently needed to decarbonise the sector while increase efficiency, thus reducing logistics costs.

The Physical Internet (PI) is an ambitious concept that transfers principles of data exchange on the Internet to goods transport in the real world, i.e. in the internet world, data finds a way without human intervention and neither the sender nor the recipient know the path data packets take. PI aims optimum use of vehicles, assets and the existing infrastructure through open and shared logistics networks and flexible routing to maximise efficiency and sustainability in transport and logistics.

In today's logistics world, most of the logistics companies still need to develop their own logistics solutions that include dedicated distribution centres and transport routes. In many cases, such solutions may be efficient in their own network but inefficienct in using all available resources. Low load factors, empty trips, idle capacity in warehouses and terminals are often seen in non PI logistics world. PI is to open the existing dedicated infrastructure, assets and services to make them more available and accessible for use in a fully integrated network of logistics networks. Thus, logistics service providers and freight forwarders could make use of owned or third-party resources to address the consolidated demand of their portfolio of customers, leveraging the full potential of not only their logistics networks, resources, and capabilities, but those of the entire integrated network.

The metaphor of PI is designed from use of the Digital Internet (DI) which a well-established and widely-accepted technology. Digital Internet transfers digital data in packets seamlessly among users and the Physical Internet transports physical objectives smoothly through an open and interconnected logistics network. There are many studies have been done to highlight potential benefits of the PI including BOOSTLOG Cloud Report on Coordination and Collaboration (D2.2) that has summarized expected impacts from deployment of Physical Internet.

Europe has been leading research and innovation of the PI through pioneering projects funded by FP7 and later Horizon 2020 that have successfully engaged with technical experts, academic researchers and policy makers. All the projects have strong links with industry that stepping up with creative ventures and innovations. Results of those projects have been influencing theoretical research of the PI. Numerous books, conference and journal papers, as well as PhD theses that have been further elaborating the overall PI concepts and enriching foundations of PI, defining the Logistics Web, key PI components and conceptualising

[8] European Environment Agency (EEA): https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-3

PI implementation as well as the additive, containerised, distributed, mobile, modular, on-demand, outsourced and hyperconnected production concepts[9].

Despite potential benefits and enormous literature, the PI has received serious criticisms. Sternberg and Norrman (2017)[10] , among others, have challenged the PI by questioning a lack of developed business models that can illustrate how to move from the concept to its adoption. Their thoughts coincide with others, for example, Cimon (2014)[11], that the implementation of the PI remains a challenge. While growing numbers of strategies, blueprints and roadmaps have been developed, PI specific theories focusing on the advancement of the PI concept are also lacking. So far, the research on the PI has primarily focused on its conceptual development and the promised effect thereof. How to move from the current business models of the logistics to the adoption of PI concept is still not well understood. Knowledge on the operationalization of the PI is considered as limited.

It is no doubt that the PI is still in its infancy stage, even though it has been increasingly gaining transdisciplinary attention from researchers, industry practitioners and policy makers. Reviewing activities, achievements and impacts of PI-related R&I projects will help us to understand the current status and help to define future R&I strategies that can stimulate further progresses in PI research and implementation, as well as engage with critical actors to build a stronger community for the adoption of the PI concept.

In the current context of post-COVID and energy crisis era, the logistics sector has been facing new challenges and emerging new trends. Discussions on how to use of Physical Internet to address such new challenges and response to new trends are much needed by the logistics sector and beyond. Several notable trends and associated challenges should be considered by the logistics R&I community that will have potential impacts on implementation of the PI[12]:

Vertical Integration in logistics

Vertical integration is a business strategy where the business itself controls the supply chain and multiple stages of its production process, thus eliminating or reducing third-party vendor dependencies. For logistics, vertical integration varies: from no integration, where the company outsources all logistics services, to a fully vertically integrated supply chain, where the company need not rely on outside entities for transportation at all. Full vertical integration is an approach that allows a company to consolidate its operations by taking

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[9] Editorial Physical Internet and interconnected logistics services: research and application, International Journal of Production Research, Vol 55 (9), 2017

[10] Sternberg and Norrman, 2017, The Physical Internet – review, analysis and future research agenda, *o o o n o n S ckn ch o N ck O o o* , Vol. 47 (8)

[11] Cimon, Y. 2014. "Implementing the Physical Internet Real-World Interface: Beyond Business Models, the Devil Is in the Details". In First International Physical Internet Conference. Quebec City, Canada.

[12] Inputs were collected at the BOOSTLOG in-person event held on 1 March 2023: https://www.etp-logistics.eu/boostlog-in-person-workshop-on-identified-priorities-for-ri-in-logistics/

complete ownership of various stages of its logistics process in the supply chain rather than relying on external service providers.

Vertical integration has been seen as a consequence of the COVID-19 pandemic as the pandemic has disrupted severely operation of logistics operation including closed distribution centres, warehouses and borders. Although after restrictions have been removed, many business has decided to take logistics matters into their own hands, e.g. Coca-Cola. Because of a lack of shipping containers as well as ocean going carrier capacity, Coke has chartered bulk shipping vessels to transport their manufacturing materials. Other retailers, e.g. IKEA[13] are among the many companies who are also chartering private cargo ships just for the privilege of moving their goods.

This trend has made the conventional boundary between shippers and logistics service providers disappearing. Amazon has set a good example of a company which realized the strategic importance of logistics before the pandemic. While historically Amazon has widely used professional logistics providers such as USPS, FedEx, and UPS to delivery their parcels, in recent years Amazon has been developing their own in-house logistics capability and vertically integrate this sector, reducing their reliance on third party service providers. In addition to their own fleet of delivery trucks and shipping containers, in 2021 Amazon has purchased 11 jets from Delta and WestJet to strengthen Amazon Air's network[14]. Following the purchase, Amazon also launched its first-ever international air hub at Leipzig/Halle Airport in Germany. Amazon delivers as many parcels in the UK as some of the largest carriers operating in the country.

According to a recent conversation with retailers[15], some of them have pointed out that e-commerce delivery service has been considered as part of their brand imagine and therefore they need to have a full control. Therefore, the distinction between shippers and logistics service providers have become blurred as some retailers have been developing delivery capabilities, thus becoming logistics service operators themselves. Therefore, white-label delivery options will face great challenges and their markets may be reduced. That would have great negative impacts on implementation of the PI.

<u>Fasting growing e-commerce and associated last mile delivery in cities</u>

According to OECD (2020)[16], the unprecedented COVID-19 crisis accelerated an expansion of e-commerce towards new customer behaviours and types of products. The COVID-19 crisis has expanded the scope of e-commerce, including through new consumer segments (e.g. elderly people) and products (e.g. groceries) and new business models and companies (e.g. Gorillas grocery delivery in minutes). E-commerce has been expanded towards everyday' necessities. Those changes in the e-commerce landscape have led to long-term changes in daily life for many individuals as well business and cities.

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[13] https://supplychaingamechanger.com/logistics-at-risk-charter-outsource-or-vertically-integrate/

[14] https://www.aboutamazon.com/news/transportation/amazon-purchases-11-aircraft-from-delta-and-westjet-to-join-amazon-airs-network

[15] POLIS- ALICE POLIS and ALICE Webinar Series 2023 – Consumer Engagement: Provision Consistent Information on Sustainability held on 3rd March 2023: https://www.etp-logistics.eu/polis-and-alice-webinar-series-2023/

[16] E-Commerce in the Time of COVID-19, available at: https://www.oecd.org/coronavirus/policy-responses/e-commerce-in-the-time-of-covid-19-3a2b78e8/

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In 2022, 91% of people aged 16 to 74 in the EU had used the internet, 75% of whom had bought or ordered goods or services for private use. The proportion of e-shoppers grew from 55% in 2012 to 75% in 2022, an increase of 20 percentage points17. The continuing increase in e-commerce has brought many challenges to cities of delivery. While many of these challenges existed before COVID-19, the current crisis and the new role of e-commerce for individuals and businesses has heightened the need for policy action. For example, increased freight traffic and associated congestion, double parking for delivery and associated congestion and safety issues have been known before COVID-19. However, the fast grocery delivery has used micro-hubs as urban consolidation centres, so called 'dark store', that have been banned by many cities due to complaints from local residences and businesses[18].

Such notable challenges have not been overlooked by municipalities who have taken various measures to address them. Cities use various policy measures to mitigate negative impacts on transport and environment while maintaining competitiveness of the cities. Barcelona is the first European city to implement taxation on home delivery, 'Tax on the special use of public space by large postal operators for distribution of e-commerce', also called 'Amazon Tax'. The proposed tax is aimed to reduce home delivery, and encourage in-store shopping, parcels pick-up, as well as transition to zero emission urban delivery vehicles[19]. In USA, Colorado has imposed since 1st July 2022 a retail delivery fee on all deliveries by motor vehicle to a location in Colorado.

Many cities have taken actions to facilitate use of innovative solutions to reduce negative impacts of last mile delivery on transport and environment. Innovative solutions include use of zero emission vehicles including cargo bikes, collaborative logistics hubs, combination of passengers and freight transport etc. Overall, such innovative solutions aims at maximising efficiency and optimising spaces and vehicles which are consistent with the concept of the PI. For example, in Antwerp, several retail businesses in city centres have formed Collaborative Urban Logistics and Transport (CULT) that consolidates all delivery using zero emission delivery means while maximising efficiency[20]. The CULT is a perfect example of implementation of the PI in urban logistics. At EU level, the New Urban Mobility Framework[21] published in December 2021 also recommended the use of collaborative logistics hubs in cities[22] which will also advance implementation of the PI.

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[17] EUROSTAT: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230228-2

[18] https://www.euronews.com/next/2022/02/24/dutch-cities-temporarily-banned-10-minute-delivery-dark-stores-then-one-company-threatened

[19] https://www.etp-logistics.eu/wp-content/uploads/2023/02/Taxa_POLIS030323.pdf

[20] https://www.cultcitylogistics.be/

[21] EC, The New Urban Mobility Framework, available at https://transport.ec.europa.eu/system/files/2021-12/com_2021_811_the-new-eu-urban-mobility.pdf

[22] Y. Li (2022), 'How to make freight transport sustainable - What does the EU's New Urban Mobility Framework mean for the logistics sector', https://www.intertraffic.com/news/how-to-make-freight-transport-sustainable

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This chapter will focus on innovations already in place by presenting a selected examples of disruptive businesses offering the PI aligned logistics and supply chain services. Businesses will be mapped according to the ALICE Physical Internet Roadmap. Some businesses may address more than 1 topic and only the main topic will be considered in the mapping. Policy measures and actions will also be identified that have been in place to enable the PI implementation.

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		cluster driven implementation of the Physical Internet.
	Full visibility, accessibility, and usability of nodes services to companies in a digital/automated manner - Shared Warehouse	The Directory of London Construction Consolidation Centres[23] & Wilson James that operates Construction Consolidation centres in London.
System of Logistics Networks	***Protocols and services*** *o o* ***operational efficiency*** *y o s ck y o n s o o ck ck ck ock ck ock o ck y o o s o n ck*	LMAD offers a platform enabling logistics operation with autonomous delivery robots. Rail-flow offers a digital ecosystem for rail freight and intermodal transport, covering the entire logistics process from purchasing and sales; contract, order and transport management to invoicing.
Access and Adoption	***Easy, secure and trusted connection*** *n ch nn ck o o N ck* ***to all users, including SMEs*** *N n sn o sn ckk s o n ck o y n chm .*	INNOVANDO offers a cloud-based waste management platform that improves an overall operative information flow, capable of tracing all movements in a real time mode, guaranteeing full transparency of all processes, as well as the workflow optimization, providing KPIs (Key Performance Indicators) essential for different monitoring, planning and reporting needs.
	Shippers and retailers move from dedicated supply and logistics networks services to shared supply networks ***clear framework of benefits for every stakeholder***	Collaborative Urban Logistics & Transport (CULT), initiated by TRI-VIZOR in June 2021 is smart consolidation of the volumes of the companies of the CULT community at the periphery of the city (e.g. in Antwerp). Via Palletto has set up scheduled services on the East-West and North-South axes of the Flemish waterway network, whereby loads of building materials are combined on pallet ships. www.todostuslibros.com, a platform in which 600+ Spanish book shops owners are pooling their book stock and making

[23] The Directory was published in 2016. However, construction logistics have not been covered by the SENSE project.

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		this pooled stock accessible to their customers in their networks with the support of a courier company.
Governance	***Governance processes for different layers/areas***	The Open Logistics Foundation promotes the collaborative development and commercial use of open source logistics software and hardware with the help of a unique Innovation Community. The Foundation operates the Open Logistics Repository, an open and neutral platform over which all components are developed and made available for any company interested.
	Implement rules for letting the network open	Micro logistics hub in Madrid's Plaza Mayor Car Park by City of Madrid and CityLogin Revised Trans-European Transport Network (TEN-T)

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The development, testing and demonstration of the Physical Internet is among the EU priorities for research and innovation in the field of logistics following the recommendations from ALICE. Many projects have been funded addressing different aspects of the Physical internet. Some projects, e.g., MODULUSHCA, ATROPINE, CLUSTERS 2.0, SENSE and ICONET were funded to develop the basis and increase credibility on the benefits to advance towards the concept of PI. For example, ICONET project developed 4 case studies addressing senior decision makers within logistics service providers, logistics service users, trade organisations, professional institutes, government regulators and policymakers demonstrating the benefits of the Physical Internet[24].

The pool of projects has evolved for 10 years, starting with only 3 projects in FP7, Modulushca, CO3 and iCargo projects and increasing significantly in the subsequent Horizon 2020. Horizon 2020 projects have started the implementation path for the PI while continuingly contributing to the development of the concept of the PI, such as ICONET and Clusters 2.0 projects. Of them, a Coordination and Support Action (CSA) project, the SENSE project, has developed the PI roadmap that has provided a comprehensive guidance for future development of the PI. PLANET or ePICenter are running project building further on the previous projects. Currently there are several projects in execution such as, focussed on synchromodal transportation and interconnected corridors addressing global and European transport networks as well operations in nodes, e.g. Stargate which is supporting the implementation of the PI in air cargo operation. Some Horizon 2020 projects, e.g. the AEROLEX project, integrate the PI concept with energy transition and connected and automated vehicles, facilitating a paradigm shift that is building upon zero emission logistics.

ALICE also promoted the implementation of the PI concept to contribute to sustainable urban mobility, resulting in ongoing projects such as LEAD and ULaaDs, and recently started projects URBANE and DECARBOMILE that have been funded by the Horizon Europe programme.

Figure 3 shows all projects mapped by this cloud report including FP7 and Horizon 2020 projects that have contributed significantly to the development of the PI concept and implementation of the concept. Contributions of those projects to development and implementation of the PI concept will be mapped following the PI Roadmap shown in Figure 1.

In addition to the EU funded projects, at the national and regional level, Austria is supporting the development of the PI through the ATROPINE and the running project PHYSICAL. Flanders in Belgium has found several projects, e.g. the DIsPatch project and the PILL project that provides PI Living Labs. As this report focuses on EU funded R&I projects, those national and regional projects will not be included in the mapping.

Horizon Europe projects, e.g. the MULTIIREOLAD and FOR-FREIGHT projects, continue focussing on the multi-modal PI Nodes. Additionally, URBANE is to demonstrate PI-enabled urban logistics solutions in several European cities. Horizon Europe projects that only started in 2022 and 2023 will be discussed separately as they have not yet produced any concrete outcomes and results.

[24] ICONET project case studies (https://www.iconetproject.eu/case-studies/)

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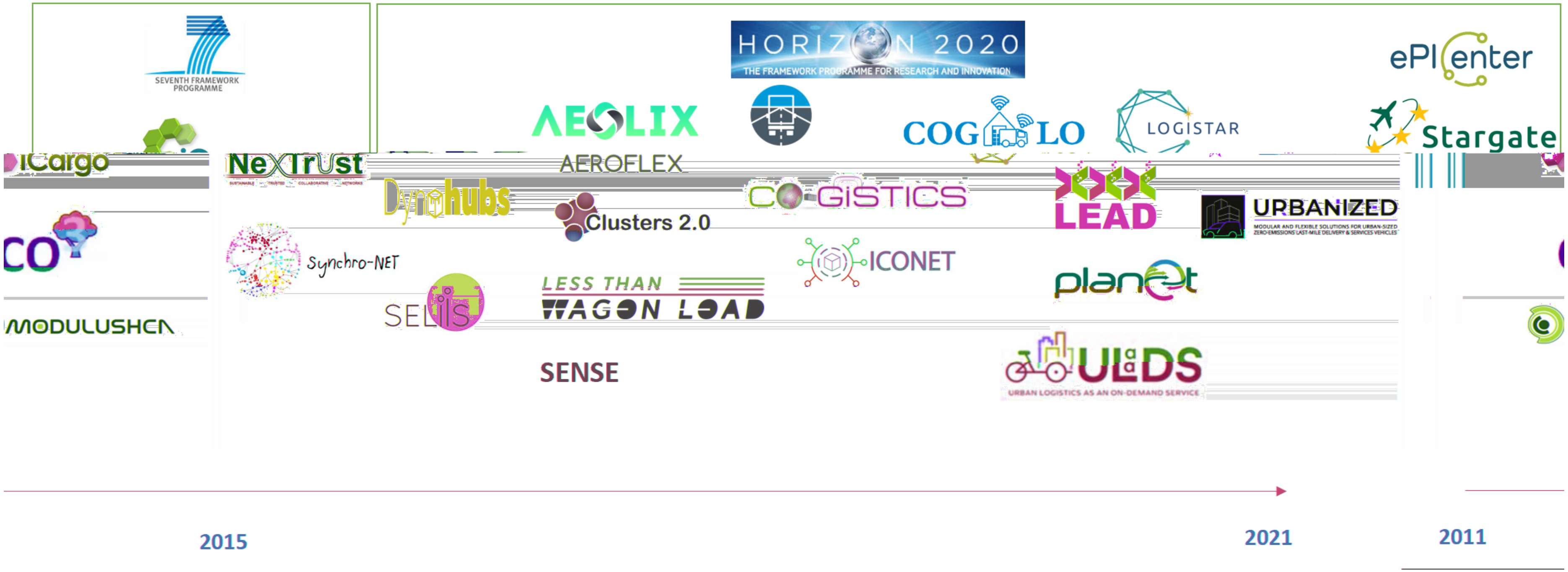

Figure 3. Main R&I Projects funded by FP7 and Horizon 2020 that have contributed to the development and implementation of PI.

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This section presents the main results and outcomes stemming from the projects that have made contributions to development of the PI concept. Those projects have contributed all of the areas included by the PI roadmap, from logistics nodes to governance models. Those projects laid a foundation to the research and development of PI in Europe and beyond. Those projects have not only significantly developed theoretical models, tested and evaluated them in real-life conditions in order to provide tangible benefits of application of the PI concept, thus generating extensive impacts on the logistics sector.

The three FP7 projects mapped in Figure 3 have brought revolutionary changes to the European logistics innovation community. They put the concept of PI into practice and laid a foundation for the future PI roadmap. They also resulted in start-ups (e.g. MIXMOVE, TRI-VIZOR) and standard modular cargo units (e.g. Smart Box). Those achievements have been recognised in the first ALICE Innovation Award. More detailed can be found in the first Cloud Report on Coordination and Collaboration (D2.3).

The concept of PI has been further developed by a following project, ICONET, funded by the Horizon 2020 that has developed the PI governance models. Then the SENSE project has successfully summarised all achievements of R&I projects and developed the PI Roadmap that accelerates the path toward fully implementation of the PI.

Project	Key contributions to the concept of PI
MODULUSHCA	Developed business models considering the Physical Internet approach to use modular cargo units. The project's results have been mapped by the Cloud Report on Coordination and Collaboration with an implementation case identified.
CO3	Developed a model framework with legal and operational guidelines for collaborative projects in the supply chain, a key contributions to PI's system of logistics network; CO3 results have been mapped by the Cloud Report on Coordination and Collaboration with an implementation case identified.
iCargo	Developed a system architecture, based on access points, to allow publishing and integration of logistic-service data and functionalities in a distributed network of services providers, a first and important contribution to the PI system level architecture. iCargo results have been mapped by the Cloud Report on Coordination and Collaboration with an implementation case identified.
ICONET	Significantly extended state-of-art of research and development of the PI concept in pursuit of a new networked architecture for interconnected logistics hubs that combine with IoT capabilities and aiming towards commercial exploitation of results. It aimed to achieve the end commercial goal of allowing shipments to be routed towards final destinations automatically, by using collaborative decisions inspired by the information centric networking paradigm and optimizing efficiency and customer service levels across the whole network.
SENSE	Published Physical Internet roadmap and monitored development of PI including collecting a comprehensive list of PI related SMEs and innovative companies, as well as R&I projects funded by the EU, national and regional programmes. The

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	project also developed recommendations for future research that have helped the EC, national and regional programmes to fund R&I projects towards PI implementation.

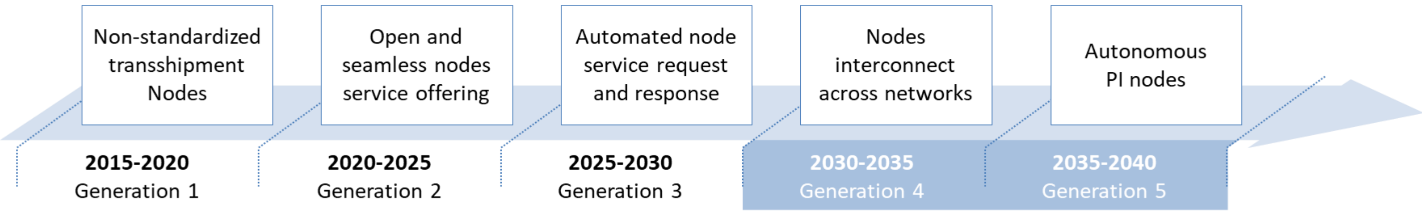

Figure 4. Overview on generations (possible development steps) for Logistics Nodes

Many R&I projects have contributed to the transition from logistics nodes to PI nodes by *o o n n o o o y ns o ck s chn ck os o o no o .*

Project	Key contributions to '*from logistics nodes to PI nodes*'
AEOLIX	The platform developed and tested by AEOLIX in 12 Living Labs to create capabilities for open service offer of nodes. A Software Development Kit (SDK) provided by the project allows for a generic node (e.g. a Port or a Terminal operator willing to share data or expose its available services) to easily integrate its internal technological infrastructure in order to register and insert their services in a global ecosystem (generation 2). Implementation cases from the project have been identified in the Cloud Report on Logistics Data Sharing.
AEROFLEX	Developed the "Smart Loading Units" concept. It aimed to design cargo units that can be used interchangeably in different transport modes (road, rail and sea), and to enable both vertical and horizontal handling. The "Smart Loading Units" can reduce friction and increasing efficiency in logistics nodes, thus enabling a higher level of transport modes harmonization (generation 3).
Clusters 2.0	The CargoStream solution works on bundling of freight volumes introducing the concept of a neutral and open platform. this example can be taken as horizontal collaboration (Generation 2). It has resulted a slot booking app, identified as an implementation case by the Cloud Report on Logistics Node.
ICONET	Successfully demonstrated of technologies and protocols testing PI based tools and approaches in order to facilitate further adoption of the PI paradigm of logistics node operation (Generation 1).
SELIS	Created the SELIS Community Nodes, applied and tested to a hub in north Germany and demonstrated the suitability to develop features such as connection to several resources, data sharing, supply chain visibility (generation 1).

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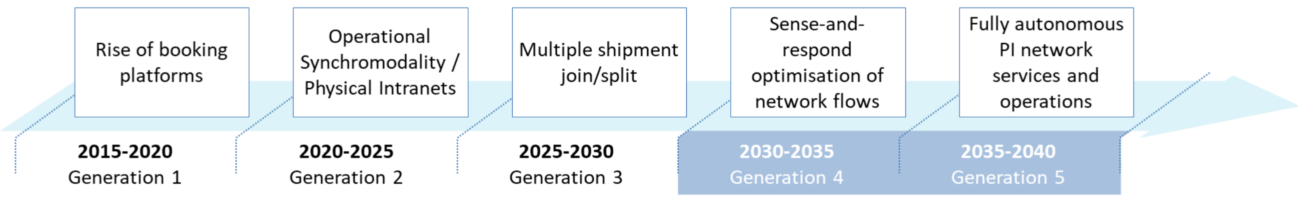
Stargate	Developing, testing and implementing innovative solutions that make the airport ecosystem more sustainable including developing digital twin technology to map operational processes by generating 3D models of airports and building a biofuel blending facility to increase the use of biofuels and decrease reliance on fossil fuels and deploying Terminal Command Centre (generation 2).
URBANIZED	future proof urban-readiness by solving the trade-offs between "one size fits all" and "design for purpose" approaches to sustainable last-mile delivery in the design of modular all-electric LCVs. We develop and demonstrate the next generation of modular vehicle architectures for urban-sized commercial e-vehicles, satisfying design principles of optimization and right-sizing vehicles for their mission (generation 2).



Project	Key contributions to '*from logistics networks to PI networks*'
AEROFLEX	Developed both flexible load units for different modes and modular load units, that will allow to optimize all the freight transport operations, and especially those which are carried out in logistics platforms related to modal exchange and load consolidation / deconsolidation. Progress that will entail a higher level of load unit standardization and modularization will considerably simplify the operations associated with the modal exchange, thus paving the way towards the concept of real synchromodality (generation 2).
COG-LO	Defined new collaborative models integrating the Digital and Physical Internet and using the new concepts of Cognitive Logistics Objects, Cargo Hitchhiking and Cognitive Advisor using Artificial Intelligence and data analytics tools (APIs), that can lead to more resilient and flexible use of transport modes (Generation 1) and better combinations of part loads and better control of parts of the load (generation 2).
LEAD	Developed and demonstrated integrated last-mile logistics with demand-supply matching platforms (generation 1) and demonstrated urban consolidation centres using car-parks and shared urban space for loading areas (generation 2).
LOGISTAR	Developed a real-time decision-making tool and a real-time visualization tool of freight transport that can deliver information and services to the various agents involved in the logistic supply chain, enabling effective planning and optimising of transport operation (generation 1).

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NEXTRUST	Addressed fundamental aspects for the development of optimized transport operations: vehicles load factor improvement, reducing empty journeys, and therefore the number of kilometres travelled; multimodal service design (road, rail, maritime), which allows the definition of railway services better adapted to customer needs; last mile distribution optimisation, reducing the associated costs and increasing user satisfaction (generations 2 and 3).
SELIS	Developed data exchange structure to enable visibility, resource publishing/subscription, consolidation for both short-distance (including urban distribution) and long-distance (generation 1).
SYNCHRO-NET	Developed integrated optimisation and simulation models incorporating real-time synchro-modal logistics optimisation (e-Freight-enabled), slow steaming ship simulation systems as well synchro-modal risk/benefit analysis statistical modelling (generation 2).

Project	Key contributions to '*system of logistics networks towards the PI*'
CO-GISTICS	CO-GISTICS developed a single, horizontally integrated platform for CO2 estimation that managed real time communications between in-vehicle devices and entities in in collaboration with the local logistics needs, proposing interoperability of system of logistics networks (generation 2).
DYNAHUBS	Used a crowd-sourced approach to realising the PI concept and tested the technology and the business model to provide a new way of connecting routes and increasing capacity for door-to-door cargo and freight logistics (generation 2).
ePIcenter	Addressing Integrating Global and TEN-T Networks – Physical, Logistics and Information Layers, optimising multimodal freight flows throughighetwo73(k)1

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PLANET	Addressed the challenges of assessing the impact of emerging global trade corridors on the TEN-T network and ensuring effective integration of the European to the Global Network by focusing in two key R&D pillars: A Geo-economics approach, modelling and specifying the dynamics of new trade routes and its impacts on logistics infrastructure & operations, with specific reference to TEN-T, including peripheral regions and landlocked developing countries; and an EU-Global network enablement through disruptive concepts and technologies (IoT, Blockchain and PI, 5G, 3D printing, autonomous vehicles /automation, hyperloop) (generation 2).
SELIS	Developed "SELIS identity and access management services" as part of the communication layer and also foreseeing the use of Blockchain technology for facilitating the trusted federation of multiple nodes (generation 1).

Project	Key contributions to '*Access the Physical Internet through a logistics network and mind shifts requi*[illegible]

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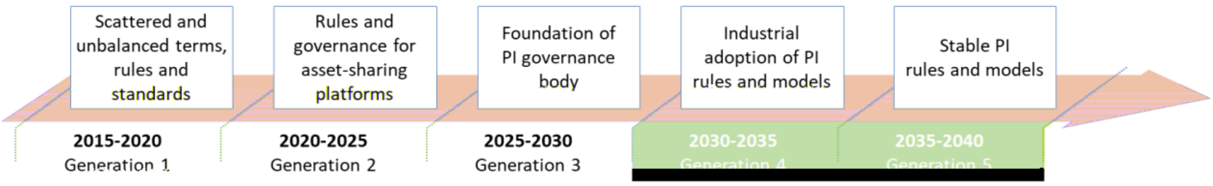
SENSE	Enhanced, and stabilized a solid framework for industry, research and public bodies to share advances, barriers, opportunities and best practices regarding Physical Internet implementation to facilitate the mind-shift to adopt the concept of PI. It build awareness and raise wide consensus on the Detailed Roadmap towards the Physical Internet developed in the frame of the project (generations 1 and 2).



Project	Key contributions to the concept of PI
AEOLIX	AEOLIX worked on a platform business model (PBM) for identifying how to create value from the developed solutions that excised the PI's bottom-up model to create logistics networks and systems of logistics networks (generation 2).
ICONET	Developed basic PI node and inter-node operational models to enable testing of the cloud-based interconnection platform and protocols including basic governance forms that can serve as foundations for more robust PI governance models in the future (generation 1).
NEXTRUST	Implemented multimodal networks and legal frameworks, creating a basis for the definition of rules and governance models that include all agent profiles involved in the supply chain (from shipper to customer), with the aim of creating a trustworthy scenario that simplifies and speeds up the operation (generation 2).

a.

Several Horizon Europe projects starting in 2022 and 2023 will advance the implementation of the PI roadmap. Four Horizon Europe projects are mapped as:

Horizon Europe projects	Project overivew	Potential contributions to the PI roadmap
URBANE	Demonstration of PI-enabled innovative solutions on urban logistics with . A key component of the project is the replication of its results and lessons learned. This will facilitated by its URBANE Innovation Transferability Platform comprising	Access & Adoption – Generation 2 Sectorial regional, seamless vertical PI demonstration

	Digital Twinning Tools, open models, smart contracts governed by blockchain technology and a data-driven Impact Assessment Radar.	
DECAROMILE	Demonstration of the full potential of decarbonised last mile logistics facilitated by the creation of a collaborative urban consolidation logistics framework that will include a digital platform, methodologies for collaboration, and ICT and IoT tools. This common framework, along with tailored innovative business models and recommendations on local policies, will allow for a strong collaboration during the project, allow to learn more about the end-users' needs and behaviours.	
Green-Log	Accelerating systemic changes in last mile delivery ecosystems for economically, environmentally and socially sustainable city logistics. The project establishes city platforms comprising of inclusive stakeholder Urban Living Labs for nurturing social innovation, designing and deploying innovative delivery solutions while allowing the most effective exchange of ideas, the development of robust, harmonized regulatory and policy frameworks, and cooperative business models that build upon effective public/private-sector collaboration and joint investments.	
MULTIIREOLAD	MultiRELOAD focusses on using inland ports as multimodal freight nodes to shifting a substantial part of freight carried today by road to inland waterways and rail.	Logistics nodes – Generation 2 Open & seamless nodes service offering
FOR-FREIGHT	FOR-FREIGHT helps realise this green transition by utilising multimodal freight transport that integrates legacy logistics systems with new technologies. This novel solution will allow better monitoring of goods and emissions throughout the transport process, improved logistics that make freight transport more cost-efficient and sustainable, and decision support for better resource efficiency and adaptability in the changing market.	Logistics networks – Generation 2 Operational synchoromodality/physical internets

SARIL[25]	SARIL aims to complement the classic definition of resilience, which focuses on threat prevention, robustness and system recovery, by green aspects. Key performance indicators will be defined which quantify both, the system resistance against disruptions as well as the environmental burden of freight transport. Adopting three different scenarios on different geographical scales (regional, national and international/EU), models will be developed which are able to capture the unperturbed system operation as well as the behavior in case of a disruptions. While the regional (Italy) and national (Spain/Portugal) scenarios focus on natural hazards which become more threatening due to climate change, the international scenario (Northern/Central Europe) considers the disruptions due to pandemics (like Cov19) or wars (like the Russian war against Ukraine). Although the three scenarios will be modelled with varying levels of detail, SARIL aims at a universal understanding of green resilience by using a common framework. The results for the three scenarios will be used to assess similarities and differences between the three geographical scales.	
ReMuNet[26]	ReMuNet identifies and signals disruptive events and assesses their impact on multimodal transport corridors. ReMuNet orchestrates route utilization, suggests transshipment points and optimizes capacity allocation, minimizing damage and shortening the recovery time. As trailblazer for the Physical Internet, ReMuNet pursues the vision to enable and incentivize synchro-modal relay, transport on European rail, road, and inland waterways to increase the holistic network resilience. It significantly reduces emissions and boosts freight transport corridor efficiency in case of disruptive events. It uses real-time data for dynamic synchromodal alternative route planning, develops model and evaluate alternative courses of action, providing the basis for a self-learning, adaptive multimodal European freight transport and logistics network.	System of logistics networks towards the PI Generation 3 Extended inter-network connectivity

[25] The project (Grant Agreement No. 101103978) has not started yet so no information is publicly available yet.

[26] The project (Grant Agreement No. 101104072) has not started yet so no information is publicly available yet.

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One of the main barriers to the application of PI is the shortcoming of exiting models and algorithms that meet the real world requirements. Forthcoming projects, such as SARIL and ReMuNe, will address this and develop models and algorithms using real-time data.

In the recently closed calls as well in the coming calls of Horizon Europe, new projects are expected to contribute to the implementation of the PI roadmap. Potential contributions of those projects are mapped as shown below.

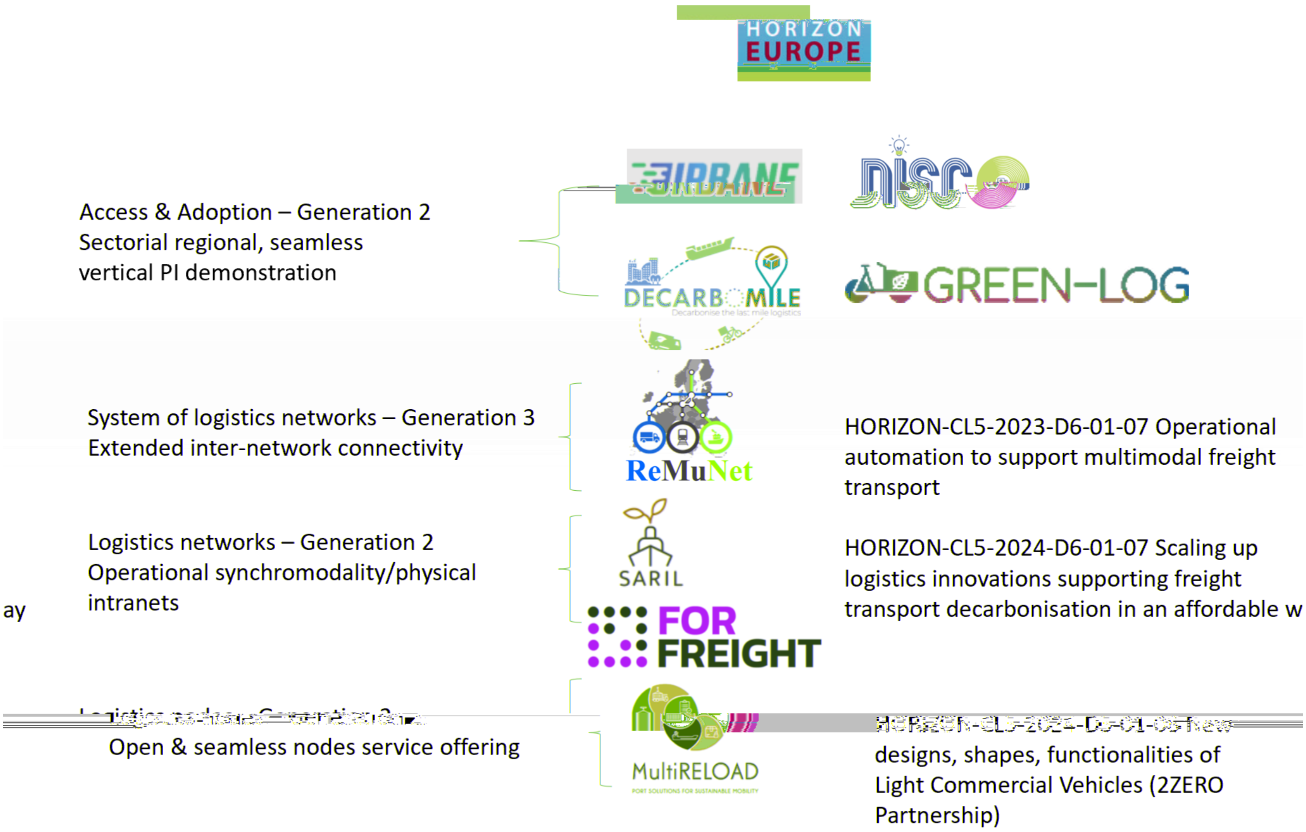

Figure 5. Potential contributions from Horizon Europe Projects to the PI roadmap

The following table will summarise the contributions of R&I projects funded by FP7, Horizon 2020 and Horizon Europe projects. The figure has mapped projects' contributions to different generations of the five areas in the PI roadmap. A project may address several areas for various generations. Although Generation 3 is expected in 2025 – 2030, several projects have already worked on achieving visions of Generation 3.

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From Logistics nodes to PI nodes	Non-standardized transhipment Nodes 2015 – 20230 Generation 1 ICONET SELIS	Open and seamless nodes service offering 2020 – 2025 Generation 2 AEOLIX Clusters 2.0 Stargate URBANIZED MultiRELOAD	Automated node service request and response 2025 – 2030 Generation 3 AEROFLEX
From Logistics Network to PI Network	Rise of booking platforms 2015 – 2020 Generation 1 LOGISTAR SELIS CO-GISTICS	Operational synchromodality/ Physical intranets 2020 – 2025 Generation 2 AEROFLEX COG-LO LEAD NexTrust FOR FREIGHT	Multiple shipment Join/split 2025 – 2030 Generation 3 NexTrust
System of logistics networks toward PI	Silos within silos (separated subnetworks) 2015 – 2020 Generation 1 ICONET SELIS	Network to network connectivity 2020 – 2025 Generation 2 CO-GISTICS	Extended inter-network connectivity 2025 – 2030 Generation 3

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Access and adoption	Pooling and alliances 2015 – 2020 Generation 1	Sectorial, regional, seamless vertical PI demonstration 2020 – 2025 Generation 2	Large-scale PI demonstrations 2025 – 2030 Generation 3
Governance	Scattered and unbalanced terms, rules and standards 2015 – 2020 Generation 1	Rules and governance for asset-sharing platforms 2020 – 2025 Generation 2	Foundation of PI governance body 2025 – 2030 Generation 3

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In BOOSTLOG, the definition of Implementation Case is that 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. In the previous 5 cloud reports, 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. However, in this cloud report, as indicated before research and development on PI is at the infancy stage, implementation cases in the framework of realising PI are focused on realising the PI roadmap. Therefore, in this cloud report, successful examples whose efforts significantly contributed to realising the PI roadmap will be summarised to replace implementation cases. A successful example may not be related to one specific project but several projects that have contributed to the development of PI.

Successful examples' descriptions below following the implementation case template of BOOSTLOG (see in Annex C). The descriptions have been benefited from interviews with 'owners' of the each case.

Three examples have been identified:

- Implementation Case I: Open Logistics Foundation (interview with Andreas Nettsträter, CEO of Open Logistics Foundation)
- Implementation Case II: Use of the PI concept to enable flexible use of urban space for sustainable urban Logistics and planning (interview with Paola Cossu, CEO of FIT Consulting)
- Implementation Case III: Developed demonstration projects using PI-enabled urban logistics solutions - the URBANE project (interview with Ioanna Fergadiotou, Head of Innovation, Inlecom Systems

	The Open Logistics Foundation is a non-profit operating foundation advocating the promotion of open source applications in logistics. The Foundation's primary goal is to facilitate collaborative development of open source solutions to existing problems in logistics and supply chain management. Our Innovation Community develops common standards, tools, and services, which can be used commercially by any player in the industry. Collaborative development and the use of open source software and hardware ensures high process efficiency. The Foundation offers various possibilities to participate.
Established/launched	2021

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Building on previous projects	SENSE

In many operational aspects of the logistics industry similar assets such as trucks, pallets, warehouse systems, are in use and sometimes even shared. One major issue however has been the differentiation in supply chain processes and their related IT solutions. This results in the major problem that close collaboration between companies is often made impossible just because the used processes and IT-systems and procedures are just not compatible. This is also one of the reasons why there are so few IoT and AI scale-up companies and solutions in logistics even though this would be an ideal playing field: start-ups can have a perfect solution for a process but if they want to implement it at another company, there are slight differences, because everyone's process is (perceived to be) unique even though the differences are minimal and not fundamental). There are just so many heterogeneous solutions out there. If the ambition is to increase efficiency through collaboration there's a clear need for streamlined solutions to overcome the barrier of nobody wanting to use IT-solutions outside of their own framework.

To overcome this, there was a need for a collaborative framework in which there is not a single party dominating all the others. Hence the concept of an open collaborative logistics platform. A common umbrella that provides free access and the opportunity to install updates. The Open Logistics Foundation has been set up by Fraunhofer IML as an open source community in which there cannot be one party dominating it. Through the Foundation, a large Logistics Service Provider (LSP) can share a process in the open source but if there are a number of others that want to adjust such process and there is a strong alignment on the modified process then it is the modified process that prevails. This is certainly new for the bigger parties but very interesting for the smaller ones.

The Physical Internet philosophy is completely embedded in the Foundation and it is also following major logistics trends. The project outcomes mapped by the SENSE project and the PI roadmap developed by the SENSE project has inspired founders of the foundation. To implement the PI, streamlining or interoperability of processes and software is essential. Such open source developed solutions enabled by the foundation will be the building blocks of the PI.

To respond to this question it is perhaps interesting to highlight how the foundation is structured. The members are gathered to commit to collaboration and creating an open source community. They are believers of that sustainability is something that can only be achieved together. This is also true for social sustainability from a digital perspective. Fully optimised processes can still result in suboptimal substantiation of single solutions, in which case you need to collaborate for which you need streamlined interoperable processes and the software to support it.

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	DISCO[27] (Data-driven, Integrated, Syncromodal, Collaborative and Optimized urban freight meta-system for new generation of urban logistics and planning with data sharing at European Living Labs) is a Horizon Europe project that supports more efficient and flexible use of urban space towards zero emission urban logistics.
Established/launched	2023
Building on previous projects	SENSE, ULaaDs

For logistics service providers (LSP) the challenge consists of reducing the high cost of the last mile. For city or communal authorities, the challenge consist of providing an urban ecosystem that enables distribution of goods within a safe, optimised, and ecological context, according to priorities. To create such an environment, cities require smart solutions and tools. In the concept of the Physical Internet, data are the fundamental key enabler to work towards an integrated and digital urban planning. Efficient operational activities are driven by real time data to make the correct and sustainable choice, especially dealing with urban logistics. The optimally located micro consolidation hubs and drop and pick-up zones are suitable nodes in an integrated network, and the different operation systems of the LSPs operating in the urban environment can be considered networks connecting to the network of networks.

MODULUSHCA has prepared the ground for digital transition in logistics and urban logistics projects, such as ULaaDs, translated the PI concept into innovative urban logistics solutions such as ad-hoc micro-hubs and urban consolidation centres, collaborative last mile delivery, flexible use of urban space, etc. Those projects demonstrate that the PI concept can contribute to a harmonised ecosystem enabling movement and access of people and goods. Those projects have extensive influences on current landscape of practices in urban logistics, to enable collaborative services and use of infrastructure and spaces. For example, functional needs in different areas in a city can change during the course of a day and subsequently be managed in a flexible way including the dynamic access controlling for curb side management to assign priority lanes to different vehicles / service in a dynamic way (e.g. public transport, cycling) towards a flexible use of urban space.

The PI-enabled concept has been embedded in the fundaments of the DISCO project. Whereas in the music industry the product used to be provided by a physical carrier in vinyl, magnetic tape or plastic, this transfer now happens through dematerialisation of products which is only retrieved from a data platform, sharing

[27] The project is funded by Horizon Europe with Grant Agreement ID 101103954 but the information is not yet available on CORDIS.

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royalties, when there is a desire to do so, as a commodity (and no more by a traditional music company), that can be massively used by everyone, wherever they are and whatever music one would like to listen (Music as a service). The same principle will be also applied for urban logistics (e.g. Logistics as a service). Whereas in logistics goods are mostly delivered in a urban environment through smart and digital and dynamic planning, governed by high quality service-oriented co-designed solutions that meets the specific functional priorities of a city, in which the operational networks are Synchromodal and hyper-connected. This is the way to come to truly PI-led urban logistics in Functional Urban Areas. The DISCO ambition is to accompany the PI-led digital transition process in urban logistics operation and planning. The transition will enable flexibility of use of urban space for urban logistics including loading zone management, micro hubs, and urban consolidation centres to increase efficiency and improve road safety while meeting demand of residents and businesses in cities.

To consider the city or municipality as an integrated network, it is important for the city to clearly understand stakeholders' needs. A harmonised ecosystem enabling movement and access of people and goods should be considered proportionate in terms of these needs. Different areas of the city serve different functions. Certain neighbourhoods will have a more residential function and will clearly require a different approach than a part of town that serves as a mobility access point, business district or residential area. It is essential to have a deep understanding of use of urban space in different areas during different time periods. Developing such understanding will create a solid foundation to implement PI in cities.

URBANE	URBANE (Upscaling Innovative Green Urban Logistics Solutions Through Multi-Actor Collaboration and PI-inspired Last Mile Deliveries), is a Horizon Europe project that supports the transition path towards effective, resilient, safe and sustainable last-mile transport, through four Lighthouse Living La Labs and following cities.
Established/launched	2022
Building on previous projects	SELIS, LEAD

SELIS created the framework of data sharing and collaborative modes among various stakeholders. The LEAD project developed digital infrastructure, e.g. the Digital Twin Platform, to enable test and evaluate various scenarios. Use of those projects' outcomes, the first demonstration project using PI-enabled innovative solutions for the last mile delivery was successfully granted by the Horizon Europe, the URBANE project.

URBANE stands for Upscaling Innovative Green Urban Logistics Solutions Through Multi-Actor Collaboration and PI-Inspired Last Mile Deliveries. It is a 3.5-year project (2022-2026) on novel, sustainable, safe, resilient and effective last-mile delivery solutions, combining green automated vehicles and shared space utilisation models. The project will test high TRL level (TRL7/8) innovative solutions that can achieve efficient, replicable and sustainable last-mile delivery in four Lighthouse Living Labs (LL) in Helsinki, Bologna, Valladolid and Thessaloniki. Two Twinning LLs will be undertaken in Barcelona and Karlsruhe, demonstrating their own solutions using the Digital Twin Platform developed by the LEAD project. URBANE's commitment to upscaling is further strengthened by the engagement of six early adopters (Follower Cities) in feasibility studies of the innovations' adoption, thus stimulating the formulation of new LL communities across Europe. Analyse the physical, digital, social and business dimensions of complex last-mile logistics delivery systems.

The project analyses the physical, digital, social and business dimensions of complex last-mile logistics delivery systems based on the PI principles and existing practices of innovative urban logistics. It has developed a PI's practical guide to LLs to enable LLs to transfer their logistics nodes and networks by analysing what can be digitalised, what can be automated, what can be shared or collaborative, what kind of contracts and for what.

The term of 'data sharing' is often not well understood by the private sector, particularly LSPs who work in a very competitive environment. Their concern is often that 'data sharing' may result losing commercially confidential data. However, when using the term of 'cooperation' or 'collaboration', it is more likely to be accepted by LSPs. For example, in URBANE, the consortium members include large LSPs such as DB SHENKE which was not often involved in big collaborative R&I projects. How to demonstrate tangible benefits of 'data sharing' or 'collaboration' is a key to enable logistics companies to open doors to collaboration.

The concept of PI, PI roadmap and literature on PI are too theoretical for practitioners including city authorities in urban logistics to understand, thus reducing opportunities for real application. There is a need to describe the concept of PI in a language which can be easily understood by urban logistics practitioners including policy makers. Only by this way, PI can be further exploited by more R&I projects, thus being widely used in urban logistics.

From the interviews conducted it may be concluded that those who are able to implement projects' results on the PI are very familiar with the concept and understand how to benefit from the PI roadmap and projects' results. Therefore, to enable further implementation, more practical information and use cases as well benefits are needed. In addition, research into business models should be given a focus with involvement of logistics service providers, particularly key players in the sector. Engaging with partners and funding opportunities are key to develop appropriate projects, particularly for demonstration projects.

Implementation path is identified by this cloud report as:

<u>From theorical descriptions to practical descriptions of the PI concept</u>

Although there are many literatures on the PI and many PI related research projects, the PI concept is still not widely and well understood. The PI concept remains abstract, and is detached from practices. The literatures on PI concentrate on modelling which often lack possibilities of being implemented and validated, leading to few interests from the logistics industry. Researchers should cooperate with the logistics industry to develop models that are based on real data and scenarios and can solve real pain points the industry face. Literatures on the PI should describe its practical applications and benefits of applications of the PI concept. Such literatures can therefore attract attentions from the logistics industry players, thus advancing implementation of the PI.

<u>Evaluation of PI's impacts</u>

Monitoring of implementation of the PI roadmap in this report is project-oriented. Impacts of implementation of PI that can cover a wide range of topics such as economic, environmental, organisational, regulatory would be beneficial to help logistics stakeholders and policy makers to understand the concept, thus leading to more implementation. As indicated by this report, PI is still at the infancy stage, implementation is still fragmented. A unified methodology to evaluate impacts of implementation of PI would be useful to help researchers and industry practitioners to cooperate for projects.

<u>Research into business models and demonstration of social and economic benefits</u>

Implementation cases with individual customers that demonstrate tangible benefits (particular in economic aspects) to companies can stimulate more implementation of PI. Research into business models of various PI-solutions that can help companies to reduce costs and achieve their sustainability ambitions is much needed. Such research should be based on the implementation cases and data form real life operation. In the coming years the focus should be on reducing cost of transition from conventional logistics to the PI enabled logistics, to ensure that the logistics stakeholders implementation of PI can lead to social and economic benefits at short, medium or long terms. Such business models may also cover implementation maps for various stakeholders (e.g. shippers, logistics service providers etc) to help them to proactively look for opportunities to implement PI to address their pain-points in daily business.

<u>Working with key players to maximise influence</u>

The early projects on PI (e.g. MODULUSHCA) have engaged with important players (e.g. P&G) that have great influence in this sector. Such projects created a solid foundation for PI research, leading to the PI roadmap. However, R&I projects founded by Horizon Europe have involved with mainly research organisations, SMEs or less influential logistics players. Although they can successfully demonstrate benefits of PI, their influences are

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limited. Engaging with key players can significantly raise awareness of the PI, thus advance more implementation.

Continue working with cities and urban logistics stakeholders

Two implementation cases (i.e. the demonstration projects DISCO and URBANE) focus on urban freight transport. With the sharp rise in e-commerce and associated home deliveries, urban freight transport faces many new challenges. There are also many disruptive innovative solutions developed and deployed for urban logistics (e.g. delivery robots, cargo bikes, flexible micro-hubs and pick-up points). Shippers, logistics companies, and city autorities look for business models and policy measures that can meet the increased demand and guarantee competitiveness of the cities. Applications of PI in city logistics, e.g. collaborative freight transport, collaborative urban consolidation centres etc, are very promising and their benefits are well known. Therefore, it is expected that there will be more opportunities for PI-enabled urban logistics solutions. Continuing monitoring development of those projects and communicating their achievements will provide a real boost to PI implementation.

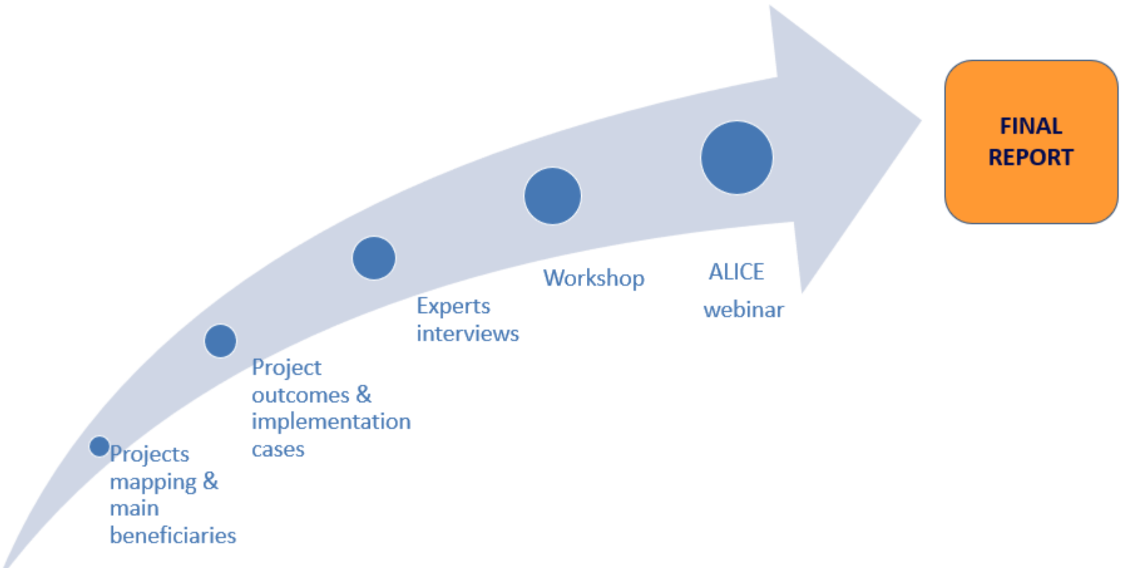
These *clo s* include a brief highlight of the main Challenges, past and current specific Pain Points in a given Cloud, key R&I results, that have resulted in Outcomes and key milestones achieved such as Implementation Cases establishing causal links between the R&I funding and innovation supporting 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 below. 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 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.



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√ means only mapping project outcomes by the cloud report

√√ means implementation cases also identified by the cloud report

Projects	Mapped by other BOOSTLOG Cloud Reports				
	Coordination and Collaboration	Urban Logistics	Logistics Nodes	Logistics Data Sharing	Logistics Network
AEOLIX	√			√√	
CO3	√√				
CO-GISTICS					
COG-LO	√				
Clusters 2.0	√		√√		
iCargo	√√			√	
ICONET	√			√	
ePIcenter			√		
LessThanWagonLoad					√
LOGISTAR	√			√	√
MODULUSHCA	√√				
NEXTRUST	√	√			
PLANET			√		
SELIS				√	
SYNCHRO-NET				√	√

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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?