ROADMAP TO THE PHYSICAL

INTERNET

EXECUTIVE VERSION

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Authors and main contributors
Eric Ballot, Sergio Barbarino, Bas van Bree, Fernando Liesa, J. Rod Franklin, Dirk 't Hooft, Andreas Nettsträter, Paolo Paganelli, Lóránt A. Tavasszy

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About ALICE-ETP

The European Technology Platform (ETP) Alliance for Logistics Innovation through Collaboration in Europe (ALICE) is set up to develop a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovation in Europe. The platform supports and assist the implementation of the EU Program for research: Horizon 2020 and Horizon Europe.

Contact

Fernando Liesa, Secretary General, ALICE
info@etp-alice.eu
www.etp-alice.eu

Illustrations

Physical Internet video (ALICE, 2020) ©contextman.

This report aims to bring together the views of a wide range of stakeholders and experts in order to contribute to a Roadmap that could help stakeholders in logistics to define their own research and innovation agenda as well as market strategies in support of this roadmap realization. The views expressed in this report are a collection of those of the different stakeholders involved in ALICE and in the different activities carried out such as workshops, surveys, etc. As such, not everyone involved in this initiative may necessarily fully support all the views expressed in the report. All the stakeholders involved do share a common interest however: speed up decarbonisation while remaining fully competitive and supporting logistics innovation for a sustainable and competitive industry.

ROADMAP TO
THE PHYSICAL INTERNET

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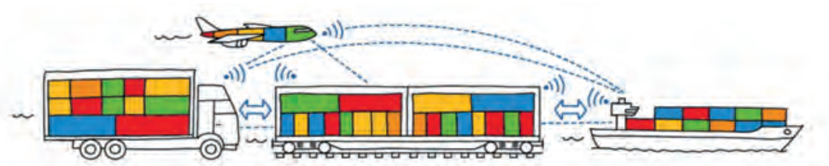


Executive summary

In response to the Paris Agreement, more and more governments, associations, and businesses are setting bold climate targets. As set out in the European Green Deal, the ambition for the European Union is to be the first climate-neutral continent in the world by 2050. This will be achieved with a two-step approach designed to reduce CO_2 emissions by 50%, if not 55%, by no later than 2030[1].

The deployment of greener and cleaner freight vehicles, trains, barges, ships, and airplanes as well as low emission energy solutions is forecasted to be too slow to deliver on the European Commission's 2030 climate change targets. In parallel to the development of lower and zero tailpipe emission vehicles and low emission energy, it is fundamental to leverage opportunities for increased logistics efficiency. We envision large gains and benefits to all stakeholders by doing more with less in the freight and transport industry. The existing idle capacity of assets in all modes of transport and storage could be better utilised, and flows could be managed in a more consolidated way using and combining transport modes and other logistics assets smartly. Open and interconnected logistics services and networks (building the Physical Internet[2]- PI) will maximise the capacity utilisation meeting current and future demands. Value creation through efficiency should be used to speed up the transition to greener and cleaner assets, instead of price reductions and margin erosion resulting from the use of current assets.

Indeed, in a scenario in which all identified potential efficiencies are achieved, the forecasted 300% increase in transport demand[3] could be reached with an increase of only 50% in assets[4]. Environmental sustainability could be achieved in an economical and socially feasible way.

Physical Internet will support the transition towards Zero Emissions Logistics

The Physical Internet is probably the most ambitious concept towards efficiency and sustainability in transport logistics. It stands for a far-reaching transition of freight transport and logistics so assets and resources can be used in a much more efficient way. The PI builds on the extensive and systemic consolidation of flows and the network of networks concepts. The Physical Internet proposes a full consolidation of logistics flows from independent shippers (e.g. extended pooling and shared networks). Additionally, and to deliver customer value, the Physical Internet proposes to pool resources and assets in open, connected, and shared networks (i.e. connecting existing (company) networks, capabilities and resources) so they can be used seamlessly by network users and partners. By pooling demand and resources to answer that demand, it is expected that the usage of the resources is more efficient. The Physical Internet includes transport, storage and physical handling operations of load units such as containers, swap-bodies, pallets, boxes, etc.

This document is a comprehensive roadmap towards the Physical Internet (PI). The roadmap sketches a path from now to 2040 showing important milestones, required technologies and first implementation opportunities for the PI. Advanced pilot implementations of the Physical Internet concept are expected to be operational and common in industry practice by 2030, contributing to a 30% reduction in congestion, emissions and energy consumption from the transport sector.

1. U. von der Leyen (2019) A Union that strives for more. My agenda for Europe
2. Ballot É., B. Montreuil, R. Meller (2015), The Physical Internet: The Network of Logistics Networks, Documentation Française. For more information: visit www.etp-alice.eu and watch a video.
3. OECD (2019. ITF Transport Outlook 2019.
4. Barbarino (2018). Towards Zero Emissions via Physical Internet: Opportunities, Challenges & perspective. IPIC 2018.

1

ROADMAP TO THE PHYSICAL INTERNET

The SENSE project developed a Physical Internet roadmap (*Figure 1*) to explain the development of the PI over the next twenty years around five areas of development:

1. **From Logistics Nodes to PI Nodes** – In Logistics Nodes, goods are consumed, stored, transformed, or transhipped from one transport mode to another. Ports, airports, logistics hubs, terminals, distribution centres, warehouses, depots are examples of Logistics Nodes. The Physical Internet envisions the development of the Logistics Nodes into Physical Internet nodes in which the operations are standardised and the usage of a family of standard and interoperable modular load units from maritime containers to smaller boxes is extensive. Services in PI nodes are visible and digitally accessible and usable including planning, booking and execution operations.

2. **From Logistics Networks to Physical Internet Network**s – Logistics Networks include Logistics Nodes as well as the transportation services connecting the Logistics Nodes and reaching to the destination. Logistics Networks are under the control of a single company either a shipper, a freight forwarder or a logistics service provider reaching their value chain (i.e., customers and suppliers). PI Networks are expected to build seamless, flexible and resilient, door-to-door services consolidating and deconsolidating all shipments within a logistics network in which all assets, capabilities and resources are seamlessly visible, accessible and usable to make the most efficient possible use of them;

3. **Developing the System of Logistics Networks towards the Physical Internet** – Includes individual logistics networks that are interconnected. Therefore, the assets, services and resources of the individual logistics networks can be accessed by all logistics networks owners. The System of Logistics Networks forms the backbone of the Physical Internet and requires secure, efficient and extensible services for the flow of goods, information and finances across logistics networks;

4. **Access and Adoption** – This area describes the main requirements to access the Physical Internet through a logistics network part of it. It also includes different steps and the mind shift required to adopt Physical Internet concepts.

5. **Governance** – Governance 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.

Developments in each of the areas have already started (2015-2020) and show the possible developments in *"generations"* until 2040. Generations define possible evolutions towards the PI and can be scenarios or parts of PI-like implementations. Generations at medium- and long-term involve more technical, operational, and business complexity. In some cases, generation can be jumped, i.e. stakeholders or companies may directly address the 3rd or 4th generation without necessarily passing through the previous one.

PI-like operations will be well established by 2030. The shown developments from 2030 to 2040 focus on improvements on the way to achieve autonomous, open and shared PI operation.

The five areas with the defined generations will be explained in detail in the following sections.

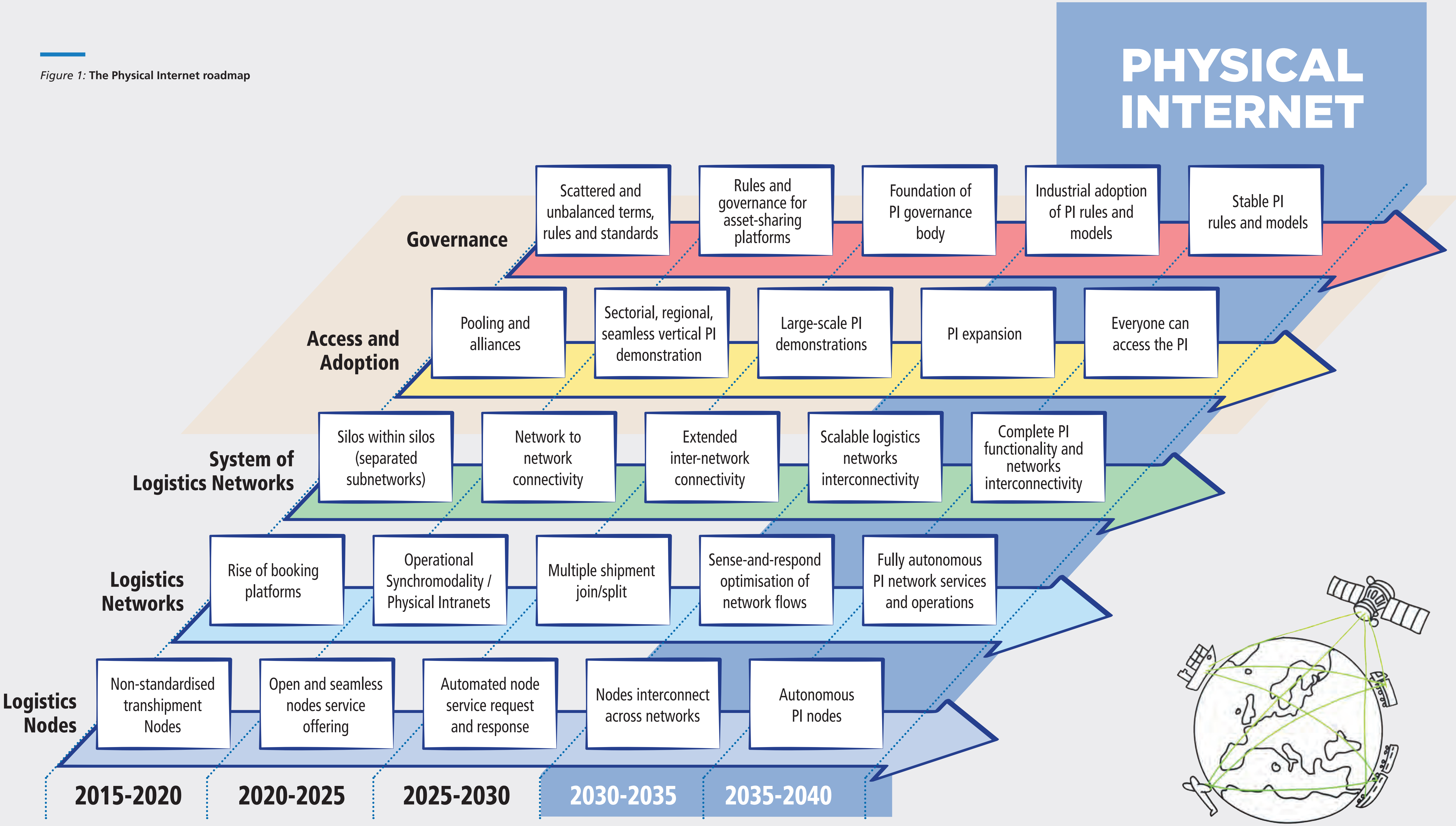


Figure 1: **The Physical Internet roadmap**

1.1

Logistics Nodes

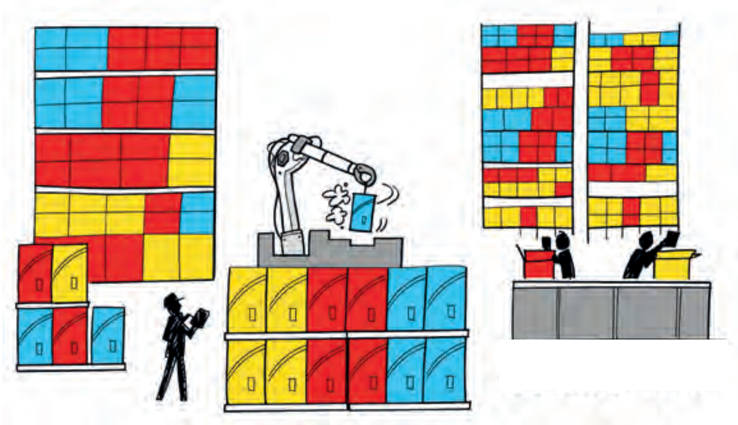
Logistics Nodes are physical locations, such as depots, warehouses, distribution centres, ports, airports, inland hubs, and terminals or even cities in which goods are consumed, stored, transformed, handled, or transhipped from a transport mode to another. These have different characteristics and settings that determine the operations and services provided (e.g., execute customs, sanitary, or other procedures, co-packing, etc.).

Consolidation and deconsolidation of goods needs to be done seamlessly so operational costs are largely offset by gains in transport. Additionally, idle warehouse, terminal capacity as well as transportation slots could be opened to other companies, through digital services and standard procedures. Stakeholders have access to relevant data as input to optimize their own operations (e.g. next transport leg plan may impact the position of a container in a terminal).

In this direction, the main focus points are: improvement of the services' visibility; implementation of solutions enabling the accessibility and usability of the services in a standardised automated/ digital manner; full automation of the nodes/ terminal processes and procedures, starting from terminal services booking, up to the services execution.

Automated standardised and connected processes and procedures in nodes belonging to logistics networks

Figure 2: **Representation of PI nodes**



The Physical Internet envisions the development of the Logistics Nodes into Physical Internet nodes in which services definition and operations are standardised. Services in PI nodes are visible, digitally accessible to companies, and address planning, booking/transactions, execution and information sharing.

What do we want to achieve by 2030/2040?

1. **Further standardisation of modular loading units** (boxes in particular) and development of further compatibility across transport and handling units (e.g., maritime containers, swap bodies, intermodal units, pallets, trays, boxes, etc.).
2. **Standard processes and procedures** for automated material and cargo receiving/handling/transhipment.
3. **Standard services definition** and information sharing across actors enabling higher efficiency in the use of nodes services and resources.
4. **Full visibility, accessibility, and usability of nodes services** to companies in a digital/automated manner.
5. **Business models** supporting autonomous interactions and provision of nodal services.

How could the steps look like for the next five years?

1. **Sharing of characteristics, capabilities, and services** of nodes to create visibility and accessibility for stakeholders, to realise ease of booking for cargo owners or service providers to services provided in the nodes. Definition and implementation of standard processes and interfaces.
2. Develop the framework and **implement the federated network of platforms[5] concept at nodes level**.
3. **Extensive adoption of standardised boxes used in multi-retail/multi-manufacturers networks** to create maximum use of assets.
4. **Develop and implement advanced transhipment technologies** to facilitate intermodality and organise goods handling.
5. **Identification and definition of business models** for the collaboration and interconnection of nodes.

5. See DTLF (www.dtlf.eu) for more information.

Generations of **Logistics Nodes**

The roadmap defines five generations for the development of Logistics Nodes into PI nodes (see *Figure 3*).

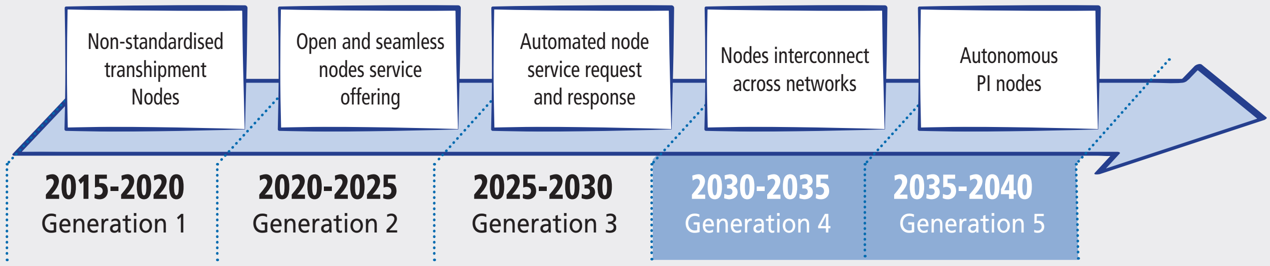


Figure 3: **: Overview on generations (possible development steps) for Logistics Nodes**

Generation 1: **Non-standardised transhipment Nodes (current status)**

Nowadays, the logistics nodes are characterised by structured processes dealing with a multitude of well-known and used standard loading units. Pallets and containers have enabled huge efficiency gains at the levels they can be used (e.g., maritime transport, palletised goods transport). However, the interaction between different units (e.g., pallets and maritime containers, maritime containers and road transport) as well as between transport modes (lack of efficient and seamless transhipment, e.g. non-crane proof trailers and swap bodies, lack of alternative transhipment technologies) is far from being standardised and seamless creating inefficiency and barriers for a truly integrated transport system[6].

At a different level, retailers have proprietary and not standardised handling systems (boxes and trays) that add complexity for manufacturers and logistics companies. This issue has been addressed by the Modulushca project[7] (FMCG and retailers' networks) and it is currently being partially within the GS1 MTV project[8]. The Physical Internet envisions the usage of the PI-containers that are universal[9] and can be easily combined.

Generation 2: **Open and seamless nodes service offering (2020 – 2025)**

Concrete Benefits
Better information about inbound and outbound flows and capacities; better information quality e.g., for planning; decrease of lead-time; reduced inefficiencies by using standard boxes (retailers + manufacturers networks) and reduced hurdle for transhipment across modes and nodes.

6. ACARE, ALICE, ERTRAC, ERRAC and WATERBORNE. (2017) A truly Integrated Transport System for Sustainable and Efficient Logistics. http://www.etp-logistics.eu/?p=1298
7. Landschützer, C. Ehrentraut, F. & Jodin D. (2015) *Containers for the Physical Internet: requirements and engineering design related to FMCG logistics*. Logistics Research 8.
8. GS1 MTV project is addressing this issue. See Haubenreißer, M. (2019). *Transparent, sustainable and cost-effective: the GS1 SMART-Box in manufacturers to retail networks*. IPIC 2019.9.
9. Montreuil, B. Ballot, B. Tremblay, W. (2015) *Modular Design of Physical Internet Transport, Handling and Packaging Containers*. Progress in Material Handling Research: 2014, 13, MHI, 2015, International Material Handling Research Colloquium, 978-1-882780-18-3. ffhal-01487239f

In Generation 2 logistics hubs and nodes start to act and offer services to their users in an open and digitally accessible way, their characteristics and capabilities are published. The definition of services and capabilities evolve to be more standard/interoperable and broadly adopted by nodes and users. Users may book and enter in business operations by accessing those services with much less administrative and negotiation burden than it is the case today.

Generation 3: Automated node service request and response (2025 – 2030)

Concrete Benefits

Faster response time; automated (re-) planning; Increase of opportunities for reconfiguring and re-planning; higher throughput and extensive use of modular standard boxes in the logistics network. Standard process definitions are widely adopted and systems interfaces in place for seamless access to node services.

In Generation 3, the nodes functionalities and their role within a Logistics Network will take a further step by preparing the ground (infrastructures and procedures) for more automated operations. In Generation 3, Logistics Nodes will interact with the Logistics Networks (e.g., freight forwarders, shippers and the LSPs) by answering services requests (storage space capacity, cargo handling, cargo transport…) in an automated manner, creating seamless booking systems backed by smart contracts.

For this purpose, standard protocols and operations will be defined facilitating easy access to nodes services and resources.

The Logistics Nodes will ensure a smooth integration with LSP's IT solutions; this action allows each node to interact as a single entity within the Logistics Network and along the chain. Logistics Nodes such as ports or hubs develop and valorise collaboration opportunities across partners and users of the Logistics Nodes (e.g. consolidation of cargo, definition of new services, etc.).

Generation 4: Nodes interconnect across networks (2030 – 2035)

Concrete Benefits

Expansion of reach; increase of scale and scope of activities (especially for service provider).

Logistics Nodes will be certified and comply with the rules and standards defined in previous generations so they can form part of the Physical Internet as a PI node.

The Generation 4, as result, will ensure: i) Full visibility and accessibility to the services offered in the nodes belonging to the PI; and ii) Automated management and handling of the cargo in the Logistics Nodes.

Generation 5: Autonomous PI Nodes (2035 – 2040)

Concrete Benefits

Gateway to PI; One-stop-shop to take orders and guarantee deliveries (network functionality); autonomous reaction to local changes in network (congestions, breakdowns, etc.).

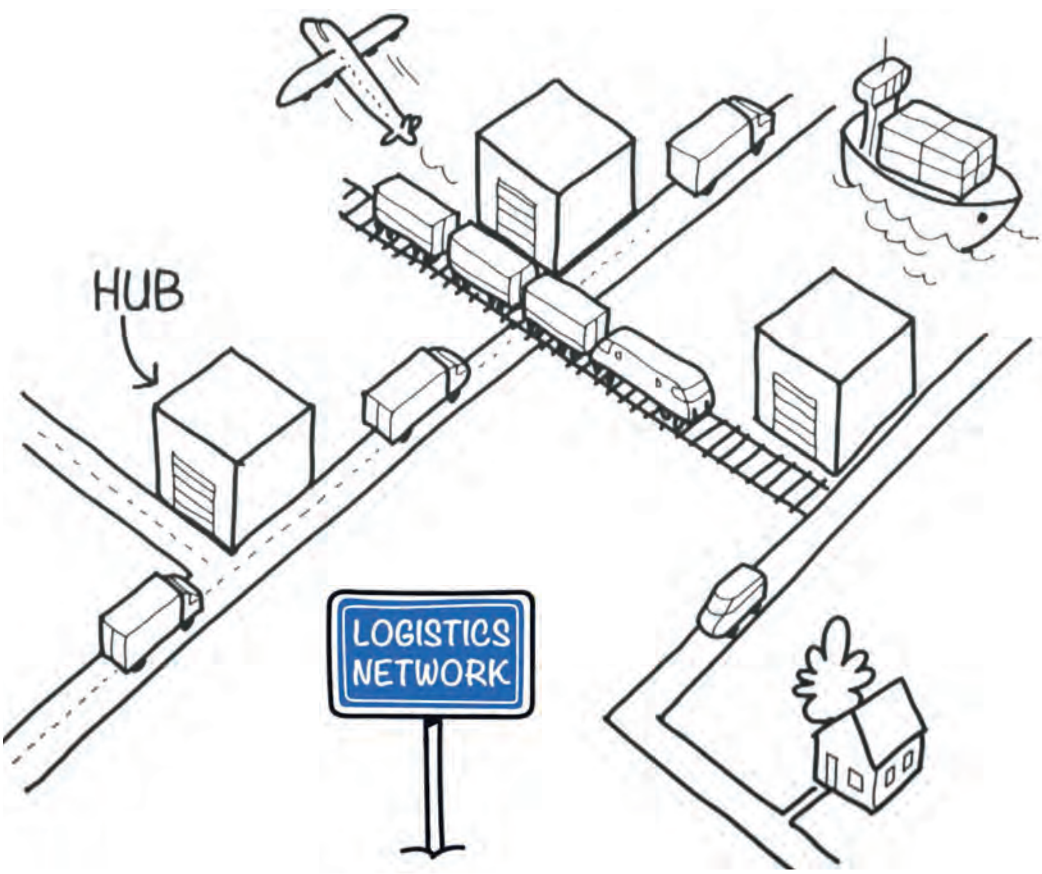
The main objective of Generation 5 phase will be to bring the PI node at full scale, thus enabling autonomous interaction, both physical and digital, between the nodes in the System of Logistics Networks. The System of Logistics Network, formed by various subnetworks, will cover and serve the world as geographical area and will involve LSP's and nodes worldwide.

1.2

Logistics Networks

Logistics Networks include the Logistics Nodes and the (transportation) links and services connecting them. Logistics Networks are currently mostly under the direct control of a single company whether a shipper, a retailer, a logistics service provider, or a freight forwarder reaching their value chain (i.e., customers and suppliers) but with no visibility beyond the boundary of its supply network. Logistics Networks may involve many companies under the orchestration of a single company in charge of the inventory management, transport planning, routing, and capacity management. Networks are expected to build seamless, agile, flexible and resilient, door-to-door services consolidating and deconsolidating all shipments within a logistics network in which all assets, capabilities and resources are seamlessly visible, accessible and usable within the logistics network to make the most efficient and effective use of resources. These logistics networks could be potential physical intranets (or PI based logistics networks) if they are compliant to PI fundamentals (e.g., full visibility and accessibility of resources and capabilities to serve a pooled demand from a broad portfolio of customers).

Seamless, flexible and resilient, door-to-door services for all shipments



What do we want to achieve by 2030/2040?

1. **Door-to-door:** the network allows the user to state his primary transport demand requirements between origin(s) and destination(s), leaving the execution of the service to the service provider – to focus offerings on user level service quality[10].

2. **Seamless network:** The network usage adapts to minimize negative impacts and changes in modes and routes through effective combination of transport and storage resources. Physical Intranets are created in which the focus is on maximizing the network performance and ensuring service level:

   - The Logistics Network can **adjust assignments and routings** to satisfy changes in demand and reduce empty miles and is able to adjust routings to absorb disturbances in performance, to be flexible for demand changes and resilient to disturbances in supply.
   - **All shipments:** in principle, the above service is provided for any shipment, anywhere, anytime, with the agreed service levels, to create a simple and attractive, one-stop shop service pooling various customers' demands in an efficient delivery network.
   - **Inventory is positioned closer to consumption**. Logistics Networks allow and demonstrate the benefit of decentralised inventory positions in the pooled logistics network allowing low speed transport for (re)-positioning stock levels and answering short term lead times with closer to consumer inventory positions (e.g. full visibility of inventory positions in retail networks extended to suppliers and logistics service providers).

How could the steps look like for the next five years?

1. **Develop and adopt widely agreed standard network operation protocols**, that allow services to be executed in a more flexible and less proprietary way (e.g., pooled demand in the logistics network, shared warehouses and inventory positions).

2. **Develop and adopt new business models** that allow to offer new synchromodal forwarding services as well as flexible transport capacity sourcing and sharing.

3. **Develop and adopt advanced ICT systems necessary to run a synchromodal transport system** including, for example, ICT for planning, booking, execution, network sensing, customs and other admin procedures, performance management and reporting as well as to manage flexible lead times in ERPs.

4. **Consider the non-economic, external impacts of the network** (environmental and social impacts, local and global) during the design of the above and prepare responsibility structures and proper mitigating measures, including correcting incentives.

5. **Identification of potential regulatory barriers for the execution of freight transport and logistics services in an optimal way within a network making efficient use of the resources** (e.g., cabotage rules[11]).

10. As mentioned, service quality should be understood in a broad manner as a set of requirements to apply to the unit load: it covers not only lead-time, but also, temperature, packaging…

11. https://ec.europa.eu/transport/modes/road/haulage/cabotage_en

Generations of **Logistics Networks**

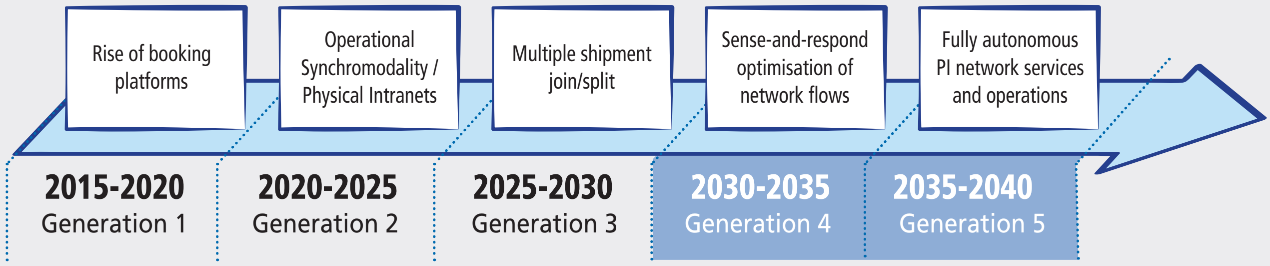


Figure 4: **: Overview on generations (possible development steps) for Logistics Networks**

Generation 1: **Rise of booking platforms (current status)**

The **digitalisation** of logistics processes has spurred the automation of planning, booking and administration processes. In the past five years, we have seen a rapid development of digital booking platforms for logistics services.

On the **physical** side of logistics, breakthroughs can be observed in the composition and provision of transport services. Collaborative networks for road transport have been created that can compete with major carriers. Synchromodal services have been developed for container transport, effectively postponing the choice of mode until briefly before time of departure of ships or trains. Alliance formation amongst maritime carriers has progressed to a level not seen before: the major ocean carriers are now grouped into only 3 major alliances, 15 less than 20 years ago.

Generation 2: **Operational Synchromodality / Physical Intranets (2020 – 2025)**

Concrete Benefits

(Full) load flexibility; booking of door-to-door services (not only single modes); more resilient and flexible use of logistics networks; use of transport modes with less emissions, faster integration of suppliers and customers.

The second generation will entail a continuation and consolidation of the current trend. Logistics Service Providers and Freight forwarders start to be digital platforms for service management and offering. Major logistics service providers and forwarders will develop internal connections between their departments responsible for different modes and logistics services (e.g., warehousing, etc.) and will develop systems and technologies to create full visibility and management capability to access resources (owned or contracted) seamlessly, into the so-called "physical intranets". These will allow managing flows and services in a more seamless way by shifting freight quickly between modes of transport, using common waybills and synchronised schedules, internal to the company or their close partners, use empty transport capacity[12] or relocate inventory positions closer to consumption.

12. See for example CHEP initiative on Eradicating empty transport miles: https://brambles.com/zero-waste-world/eradicating-empty-transport-miles.html

Generation 3: **Multiple shipment join/split (split-in-transit and remerge-in-transit) (2025 – 2030)**

Concrete Benefits

Shipment flexibility; get higher fill rate; better combinations of parts of load; better control of parts of the loads (or even load units).

The third generation is marked by a stronger vertical connection between the service providers (including their transport suppliers and carriers) and shippers. Strings of platforms and/or forwarders and/or carriers can easily provide guaranteed and flexible schedules door-to-door. Digital transportation documents or better, trusted sharable information sets are developed in a way that they are not mode-specific or can be managed in a more flexible way to allow intermediate, unplanned, third- or fourth-party handling or in route change of mode. Digitisation of transport administration (e.g., eFTI[13]) will accelerate this development.

Generation 4: **Dynamic, sense-and-respond optimisation of network flows (2030 – 2035)**

Concrete Benefits

Predictive control of the network itself; real-time adjustments; more accurate timing, more flexibility and reliability.

Vertically connected networks can now provide seamless services door-to-door in a full synchromodal and pooled way. In addition, dynamic capabilities for real-time management are developed. The sense-and-respond propositions of the network, creating robustness against supply disruptions and flexibility for demand change can now be fully developed.

Generation 5: **Fully autonomous PI network services and operations (2035 – 2040)**

Concrete Benefits

Planning is replaced by proactive and responsive network; Savings (because of no planning); higher flexibility; decrease of response time.

This requires the creation of a vertical integration that brings together proprietary processes and information from those that can conditionally be shared, and from those that are public and with whom supply chains can be composed in a fully autonomous way with predefined smart contracts and execution protocols being proactive in the smart use of resources and capabilities.

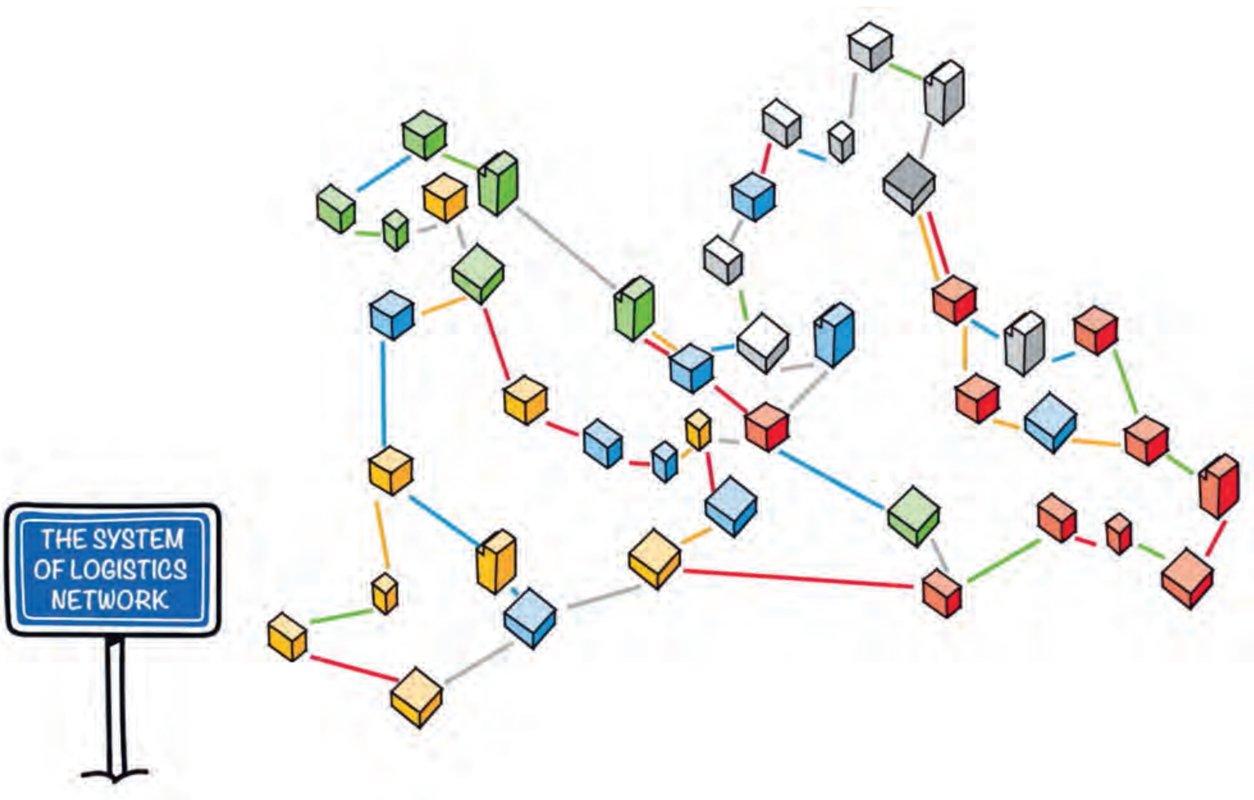
13. Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on electronic freight transport information. COM/2018/279 final - 2018/0140 (COD)

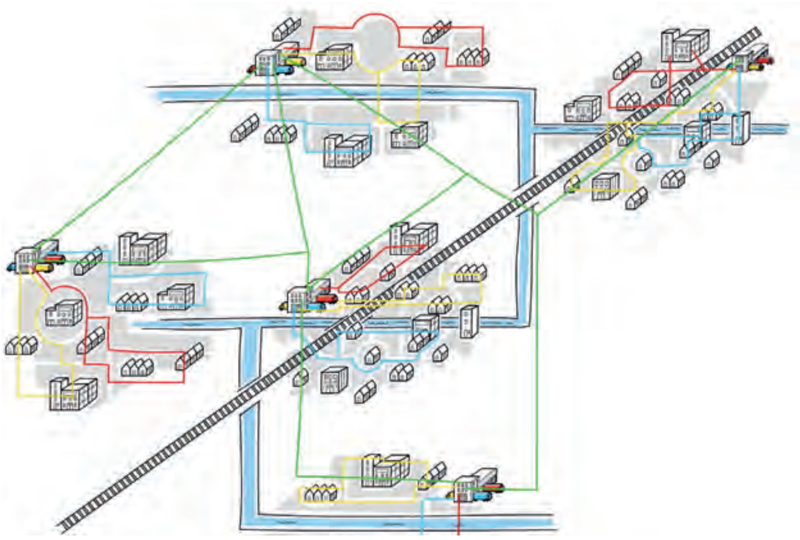
1.3

System of Logistics Networks

Within this area the System of Logistics Networks towards the Physical Internet is developed. Indeed, we foresee further connectivity across logistics networks that will require specific functionalities. These will be expanded so there is an organic growth of interconnected logistics networks as described in the previous chapter finally creating a Physical Internet when there is a standard- and industry-agreed procedure to be part of that System of Logistics Networks. Meantime, Systems of Logistics Networks will be created in which services, assets and resources will be seamlessly accessible by multiple networks.

Secure, efficient and extensible services for the flow of goods, information and finances across logistics networks





What do we want to achieve by 2030/2040?

1. **Secure protocols and services** are developed to ensure security, privacy and trust so logistics networks are interoperable, and resources are accessible to users and partners in the system.

2. **Protocols and services** designed to ensure operational efficiency of freight movement irrespective of mode, nodal operations, and freight characteristics to increase the efficiency and effectiveness of the transport and logistics systems.

3. **Extensible protocols and services** designed to be extended as new business models, uses, and services to be able to address the unknown future in an agile and resilient way accommodating innovative freight and logistics models.

4. **Accommodating goods, information and financial flows:** protocols and services designed to handle not only the secure and seamless flow of physical goods, but also the flow of information and payments in an end-to-end manner to allow users to track, analyse, contract, declare and clear goods as well as to make and receive payments.

How could the steps look like for the next five years?

1. Development of **operational protocols implemented in marketplaces and/or a small number of logistics networks** (starting with two independent logistics networks) for the secure management of flows over a System of Logistics Networks.

2. Deployment of **layered protocol stack to facilitate common management of lanes, nodes and insertion points** to ensure end-to end service consistency.

3. Continual **testing of end-to-end flows across different logistics networks** to improve protocols, identify gaps, and design new coordination mechanisms that will pave the way for new business models from the industry.

4. Continued **development and adoption by lead service providers of the new and/or improved protocols** as their formal requirement for interconnecting with other service providers.

5. **Monitoring of the performance of the System of Logistics Networks to assess if the benefits originally envisioned are realised**.

Generations of **System of Logistics Networks**

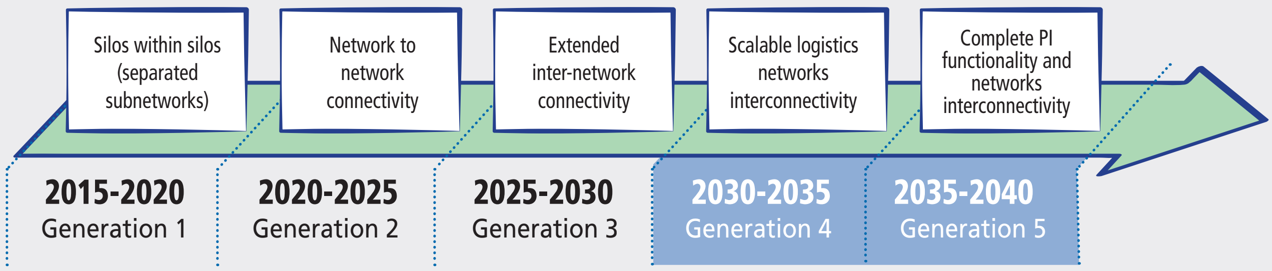


Figure 5: **: Overview on generations (possible development steps) for System of Logistics Networks**

Generation 1: **Silos within silos (separated subnetworks - current status)**

The current "as is" state of global freight transport is highly fragmented with individual organisations either forced to develop their own transport networks or outsource this activity to a freight forwarder asking for dedicated resources. Freight forwarders, in turn, have either developed their own global networks to manage multiple customer requirements for transport or banded together to form partnership networks in which local partners perform parts of the transport operation and then hand over the shipment to a partner organisation for further movement of the freight. Still, these global networks are not interconnected and the goods cannot seamlessly flow across them.

Generation 2: **Network to network connectivity (2020 – 2025)**

Concrete Benefits

Less interfaces; more consistent processing of shipments across networks; more accurate and timely information about shipments; comparability between different networks; better use of resources.

Interconnection protocols are developed over the next several years to enable current proprietary and dedicated logistics networks to experiment with connecting to one another or to new partners. These protocols should allow organisations to replace hard coded connections to internal partners with open, standards-based protocols and connectors including services, location, processes definitions.

Generation 3: Extended inter-network connectivity (2025 – 2030)

Concrete Benefits

Faster integration of logistics networks and resources into the System of Logistics Networks; quicker response time; better use of resources and move to greener assets is facilitated by increased usage benefiting electric and renewable energy based assets.

The protocols and attendant operational systems will be improved and made ready for actual use in inter-company network operations. During this period, groupage/pallet or other type of logistics services networks will start to work based on digitally and fully interconnected protocols and procedures including tools and solutions to plan and execute multiple customer shipments into the pooled system of logistics networks.

Generation 4: Scalable logistics networks interconnectivity (2030 – 2035)

Concrete Benefits

Sharing of resources across different networks; easy to scale and expand network interconnectivity; extended multiparty connectivity between logistics service providers; higher utilisation rates, bigger network reach; lower costs, kick off autonomous operations across logistics network.

Up to this point the protocols will provide basic services interoperability and data transfer between a few network partners addressing specific sectors or geographical areas. Moving forward to more sophisticated protocols generating large networks of logistics networks will need to be developed to allow the models and relationships tested to this point to scale and increase in scope (geographical and services covered) in an organic way.

Generation 5: Complete PI functionality and networks interconnectivity (2035 – 2040)

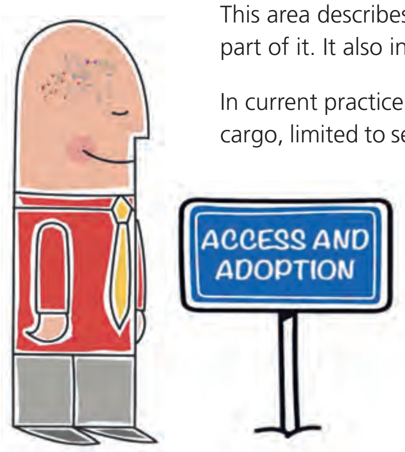
Concrete Benefits

Plug-and-play connectivity for users and providers; seamless access to PI; new networks can become part of PI or leave PI any time.

PI functionality originally envisioned is made available to partners and users. Global systems of logistics networks will be interconnected, and services will be provided on top of them. Additional functionality will continually be added and enhancements to operational services will continue to be made. At this point in time the maturity of the PI will be such that an accurate appraisal of its real impact on the environment and society can be determined and its operational benefits understood.

1.4

Access and Adoption



This area 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.

In current practice, we see relatively small networks exist, with a limited scope of activities (pooling of cargo, limited to sectors, etc.). Many companies are not able to organise networks on their own or get access to existing networks. This especially is true for SMEs. For big companies, still there are many silos in terms of access to services and offerings.

One of the main objectives is to show companies within their current business setting that cooperation, even with competitors in logistics, is not only a good idea but it is also easy to execute and implement directly or through logistics service providers. It is also important to help companies to make first steps in this respect. There are new ways of sharing assets, services and resources between stakeholders in vertical integrated supply chains and in horizontal collaborative networks.

A mind shift towards an easy accessible, non-discriminatory PI

What do we want to achieve by 2030/2040?

1. **Easy, secure and trusted connection** to global logistics networks and System of Logistics Networks **to all users, including SMEs**. Low threshold plug-and-play access points to logistics networks are available.
2. **Logistics Service Providers and Freight Forwarders are willing to collaborate in the formation of systems of logistics networks** with standard procedures and protocols making it easy for them to access pooled resources and capabilities.
3. **Stakeholders in main logistics hubs pool their services and resources into Logistics Nodes platforms**.
4. **Shippers and retailers move from dedicated supply and logistics networks services to shared supply networks** clearly defining service level and quality agreements and giving more freedom to LSPs in the execution of logistics operations (so they can organise the usage of the assets).
5. A **clear framework of benefits for every stakeholder** in the supply chain which makes sure that adoption of PI makes business sense and contributes to societal challenges such as climate change.

How could the steps look like for the next five years?

1. Identification and development of **digital access points to Logistics Nodes, logistics networks and System of Logistics Networks** (including SMEs).

2. Demonstrate the **benefits of building Physical Internet capabilities at company, logistics network and governmental levels**.

3. Show the benefits to shippers and retailers of **going beyond dedicated and proprietary logistics solutions**.

4. Realise **education and training programmes** for logistics professionals on **network integration, shared resources and capabilities and pooling of goods** in real business practice.

5. Develop advanced **simulation tools and models to visualise** how operations, roles and governance models could look like.

6. Broad **advocacy and pioneering companies** in each logistics function moving to PI functionalities.

It is important that all stakeholders further define and elaborate the Physical Internet concept, see the potential benefits and realise them in practice. The benefits will become clearer and clearer as more examples of cases of sharing assets, vehicles, warehouses and infrastructure are implemented. Therefore, the burden to understand basic PI concepts needs to be reduced. There is a great need of modelling and visualisation of PI, which in each generation has different requirements.

The realisation of the PI will require the following:

- A mental shift is needed at different levels:
    1. from ***retailers and shippers*** so they rely more on the capabilities of the logistics service providers and freight forwarders being less prescriptive and demanding of dedicated assets, services and infrastructure in the way the services are delivered with emphasis in service level and quality,
    2. ***logistics service providers and freight forwarders*** to openly give access to services and rely on services of other logistics networks to build on their capabilities, assets and resources defining common and standard processes that could facilitate interoperability of services and networks and,
    3. From ***people to ease cooperation among humans and autonomous systems*** in logistics, defining the roles for each of them. In relation to the latter, the development of the autonomous handling of goods, the definition of functions and services of hubs are topics of interest and to be further developed under the area of Logistics Nodes.

- There is a need to increase **education and skills related to Physical Internet** concepts such as serious games, models, and simulation tools to communicate the functioning and benefits of shared logistics networks providing services for pooled demands (i.e., the Physical Internet).

- New theories, mechanisms and practical examples need to be developed on how to **build trust among partners and users of shared networks, platforms, collaborative and autonomous systems**.

- The **information/data sharing mechanisms** are not well defined and described thus fuelling all kinds of speculation about business impacts. At this level, the Digital Transport and Logistics Forum[14] is addressing this challenge in a wider perspective. The DTLF developed the concept of the federated Network of Platforms[15] that is consistent with the PI vision and its decentralised architecture. EU funded projects FENIX[16] and FEDERATED[17] are implementing these concepts in practices and could be the foundation of data sharing principles for the Physical Internet.

14. The Digital Transport and Logistics Forum is an Expert Group Launched by the European Commission in 2015 (https://www.dtlf.eu/)
15. DTLF 2018. *Enabling organisations to reap the benefits of data sharing in logistics and supply chain*.
16. https://fenix-network.eu/
17. http://www.federatedplatforms.eu/

Generations of **Access and Adoption**

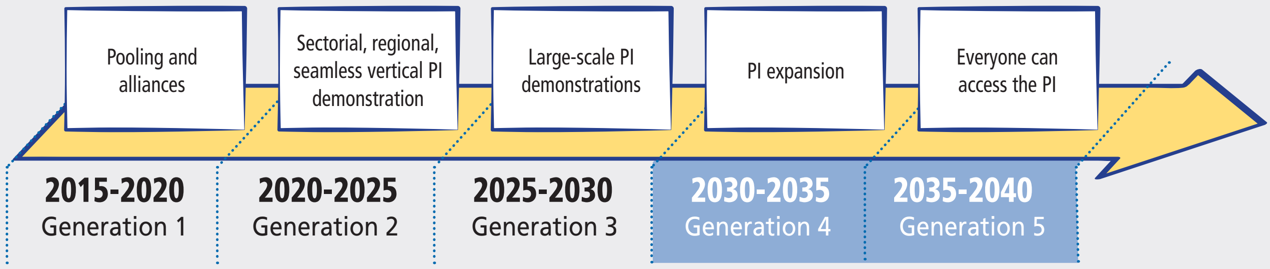


Figure 6: **: Overview on generations (possible development steps) for Access and Adoption**

Generation 1: **Pooling and alliances (current status)**

The logistics sector is currently showing first signs of network integration and embracing digitalization and giving first steps on interconnectivity. However, the larger part of the sector is still organised in vertical supply chains which operate independently from each other and still with many interconnectivity barriers with suppliers and customers. Stakeholders within a chain cooperate based on existing operational contracts, they act independently from each other with a minimum of information sharing. The coordination function within supply chains is fragmented and differs among different chains. At the professional level we see a wide awareness of the need for cooperation. However, trust and sharing of information are still barriers to achieve further integration.

Generation 2: **Sectorial, regional, seamless vertical PI demonstration (2020 – 2025)**

Concrete Benefits
Increased connectivity for all stakeholders within a vertical supply chain or a logistics network; Better understanding of operational benefits through evidence based vertical integrated supply chains.

The value of cooperation is widely acknowledged within the sector, which is demonstrated in the increasingly intrinsic motivated managers working on closer collaboration within the specific supply chain setting.

Generation 3: **Large-scale PI demonstrations (2025 – 2030)**

Concrete Benefits
Clear operational synchromodal benefits for integrated supply chains are defined. Easy-to-adopt decision support tools for integrated vertical supply chain planning and first demonstrators of operational systems of logistics networks.

The integration and collaboration between logistics networks lead to a wider scale, which leads to more efficient decision making based on larger volumes, that are consolidated, resources and capabilities to serve the demand. The benefits are that modal shift can be realised for a larger pool of supply chains. In this generation we will see operational synergies with significant impact on CO_2 footprint of supply chain activities. Asset utilisation will be a common objective and moving towards real asset sharing between supply chain stakeholders. Shippers will deal with more reliable and flexible logistics systems.

The role of supply chain stakeholders will change as shippers are open to share assets and resources to deliver their products and logistics service providers are able to coordinate flows of goods from different customers over several networks within industry verticals.

Personnel and organisations are sharing best practices without barriers. Supply chain professionals are sector specialists that move between several supply chains and see synergies outside the boundaries of their organisation.

Generation 4: **PI expansion (2030 – 2035)**

Concrete Benefits

Cross-network analysis and integration tools; entry- and exit-strategies for actors; possibilities to share assets, personnel, capacity within horizontal integrated supply chains.

International reach and multisectoral horizontal and vertical integration characterise the fourth generation of access and adoption in which logistics networks are fully integrated with full capability to manage own resources and assets and access to external services in an open and standardised way. Opportunities for economies of scale in integration with larger volumes enabling the optimal use of all transport modes and logistics locations are fully utilised. Standardisation of assets, protocols and procedures as well as practices and data communication are standardized, and eases network integration and flexible and agile logistics solutions can be realized. Governance reaches beyond sectors enabling and safeguarding the operation of the multi-sectoral Physical Internet.

Logistics Service Providers are part of and operate the Physical Internet based on standards and protocols and shippers provide shipment scenarios. The assignment of operators is a logical outcome of the information and options within the own resources and services and with those made available through the Physical Internet.

Generation 5: **Everyone can access the PI (2035 – 2040)**

Concrete Benefits

Open access to PI network, leading to autonomous optimal re-allocation of goods and assets between networks; adoption of PI is embedded in professional’s way of working and plug-and-play connectivity is available for all.

In generation 5, the Physical Internet is fully accessible and widely adopted. Here, all logistics modes and services can be combined by main logistics service providers operating the Physical Internet and are accessible to users of the Physical Internet. The Physical Internet is enabled by a unified digital data network building on the federated network of platforms concept (DTLF).

1.5

Governance

Governance 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.

There are different approaches to define the Physical Internet governance.

- A **bottom-up approach** where Logistics Nodes, networks and systems of logistics networks develop their own governance mechanisms, growing and progressing in an organic way. Companies and consortia develop governance for their networks and convergency is created as the models are advancing. This could lead to the creation of islands or subsets of Physical Internets with their own standards and protocols.
- A **top-down approach** where there might be two options:
  - Public lead. A central body plans and organises the Physical Internet under the supervision of governments that consider transport and logistics as a universal and public service/infrastructure, even if services are provided by companies in a fully regulated framework. This approach would require a strong public-sector action at European/global level, supported by massive investments, to enforce standards and ensure that market competition rules are not infringed.
  - Industry lead. Big corporations integrate with each other's and/or build strong logistics networks capabilities that afterwards open to other stakeholders as a service. These digital logistics platforms can deliver services to all type of companies and users up to end consumers making, and organising use of their network and partners resources and capabilities. More details on potential development scenarios are described by Dans (2019)[18].

The bottom-up approach is considered as the only viable one for organic growth of the PI, as it will ensure a more gradual and business-driven creation of the Logistics Network. It is also likely that other forms of governance appear (e.g., mixed models compared to the ones described above).

Governance concept, bodies, rules and trust building measures

18. Dans, E. (2019) The Battle For The Physical Internet https://www.forbes.com/sites/enriquedans/2019/05/17/the-battle-for-the-physical-internet/#68092e883baa

What do we want to achieve by 2030/2040?

1. Governance processes for different layers/areas (system, data, operations...), comprising both centralised vs. federated governance models, to establish a trustworthy business ecosystem.

2. Implement rules for letting the network open, favouring bottom-up development with the support and supervision of public bodies (EC) in high-level governance (following the 4G and 5G example), to ensure participation in networks of all types of stakeholders: large companies, SMEs and public authorities.

How could the steps look like for the next five years?

1. **Mapping and analysis of governance models of current asset-sharing networks** in freight transport and logistics (postal, pallet networks, groupage networks, etc.) and in utility sectors (telecommunications, energy) their forms and business models as well as possible pathways for adoption and or scalable models.

2. Definition of harmonised **terms and rules for vertically integrated networks** that are scalable to easy integrate external stakeholders.

3. Definition of **asset-sharing, service access and competition rules in systems of logistics networks**.

4. Definition of **governance processes and body** for defining the rules, addressing barriers and support companies willing to move to open, shared and connected logistics networks.

A proper governance structure will ensure a "network of networks" approach, building on existing (private) networks and freight transport and logistics services offering. A good governance ensures that:

- The **Logistics Nodes/logistics network/System of Logistics Networks evolution is managed cooperatively**, ensuring that all involved organisations are properly represented in decision bodies on the network extension and on the update of rules, agreements, and governance structures.

- **The System of Logistics Networks is open to all types of organisations** (shippers, LSPs, services providers), based on shared rules and protocols for operations which companies need to agree upon and fulfil.

- **Service levels are defined, and their accomplishment is mapped to ensure that basic quality-of-service standards** are met/delivered by/to all participants.

- **Routing of cargo through the network and service assignments are managed transparently** according to common agreed rules, to ensure fair allocation of costs, risks and responsibilities among the involved providers.

Generations of **Governance**

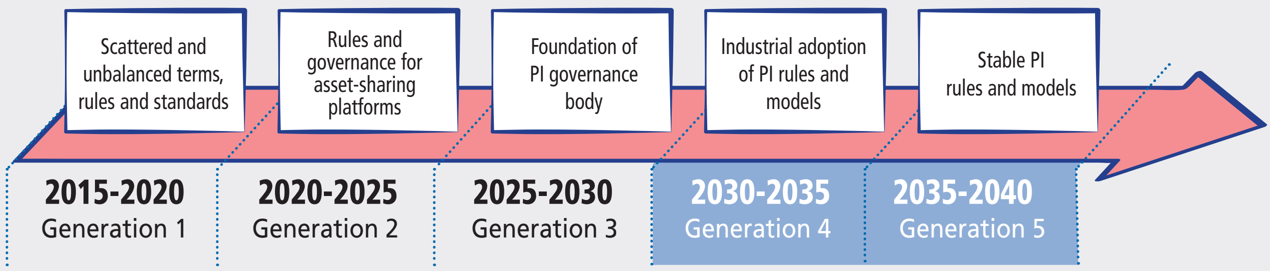


Figure 7: **: Overview on generations (possible development steps) for Governance**

Generation 1: **Scattered and unbalanced terms, rules and standards (current status)**

The current state of play concerning governance of Logistics Nodes, logistics networks and Systems of Logistics Networks is characterised by a scattered and unbalanced set of terms, rules, standards and regulations. There is not yet a harmonised reference agreed governance framework. However, the Digital Transport and Logistics Forum is developing governance models for the creation of a federated network of platforms that could indeed be a seed for a potential Physical Internet governance structure together with other initiatives such as the International Data Spaces Association.

Generation 2: **Rules and governance for asset-sharing platforms (2020 – 2025)**

Concrete Benefits

Simplified, easier and safer asset-sharing on existing platforms, thanks to specific rules setting services providers liabilities, security, and documentation standards.

In generation 2, a limited initial first step will be taken towards a shared governance framework for interconnected networks. These initial Logistics Networks will emerge from the existing asset-sharing or service platforms that are currently growing and developing their business models, see VINTURAS[19] for example.

Evolution from the current ad-hoc trustee-based models is expected, leading to a replicable set of rules and tools addressing all aspects of asset sharing, from mutual liability to gains redistribution.

19. https://www.vinturas.com/

Generation 3: **Foundation of PI governance body (2025 – 2030)**

Concrete Benefits

Raise consensus and pool interest on the Physical Internet development and governance definition. Growth of vertically integrated intermodal logistics networks thanks to harmonised terms and rules.

The governance structure will be defined by the organisation in control of the logistics networks and in agreement with customers and suppliers. Harmonised terms and rules for vertically integrated synchromodal logistics networks including sharing of transport and warehouses will be developed.

Additionally, a body for the definition of the system of logistics networks governance will be created.

Generation 4: **Industrial adoption of PI rules and models (2030 – 2035)**

Concrete Benefits

Growth of integration across different supply chains and systems of logistics networks generation, thanks to commonly accepted asset-sharing rules and business models, protocols for connected logistics networks.

In generation 4 the governance framework will be extended to support scalable governance models to increase the reach of existing systems of logistics networks. This will allow asset sharing and route planning and re-planning of shipments through Logistics Nodes belonging to different networks.

Also, generation 4 will address the issue of unexclusive participation of shippers and logistics services providers to multiple Logistics Networks, enabling future transition towards more open Logistics Network configurations. To this purpose, the PI governance framework will have to consider socio-economic impacts of asset-sharing, especially on fair competition and anti-trust issues.

Generation 5: **Stable Physical Internet rules and models (2035 – 2040)**

Concrete Benefits

Sustained growth of PI network(s) thanks to globally established rules framework and governance bodies.

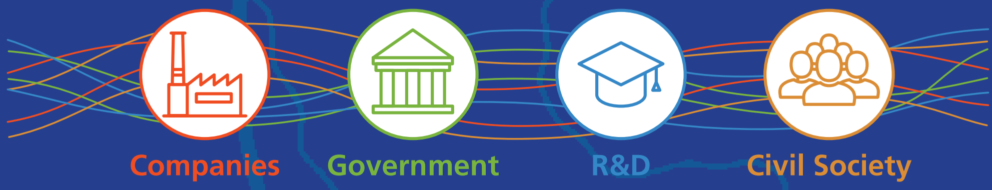
In generation 5 the governance framework will be fully designed and implemented, including all required governance processes and a well-established body for defining the rules and addressing barriers for establishing shared and connected logistics networks building the Physical Internet.

The generation 5 governance framework will cover all relevant business and regulatory aspects that must be addressed to make Logistics Network nodes and services available to the global business community, including:

- Establish PI governance in a global context.
- Identification of global regulation incompatibilities as barrier of the PI development

2 RECOMMENDATIONS

In this chapter, recommendations towards relevant stakeholder groups are provided.
The stakeholders group targeted are:



The Quadruple Helix (Carayannis & Campbell, 2011)
Roadmap Towards Zero Emissions Logistics 2050. ALICE (2019) www.etp-alice.eu

2.1 Recommendations for **Companies**

TOPICS	ACTIVITY DESCRIPTION	MAIN ACTOR	REQUIRED PUBLIC-PRIVATE COOPERATION
System of Logistics Networks	Definition of plug and play collaboration, business and service models for connected and shared logistics networks.	LSPs	Carriers, Manufacturers, Retailers, R&D
	Definition of governance processes, bodies and rules for open global logistics networks.	LSPs, Forwarders, Carriers	R&D & Government
	Publish mechanisms and practical examples on how to build trust among users of shared networks, platforms and collaborative systems.	LSPs, Forwarders, Carriers, Shippers	R&D
	Plug and play access to logistic networks based on standard processes and services.	LSPs	Shippers
Nodes	Open publishing of nodes capabilities and services for easy booking.	Ports, airports, warehouses and logistics platforms	Transport carriers
Standard setting and adoption	Expansion and adoption of standardised modular boxes and packaging units that are used everywhere by all type of stakeholders.	Shippers (Manufacturers & Retailers)	LSPs
	Identify regulatory barriers for fully autonomous Logistics Network services and operations.	LSPs, Forwarders, Carriers	Shippers, R&D, Government
	Implementation of flexible contracts giving freedom for design and operation of multi-modal transport networks to avoid fixed specifications for routes, modes, inventory locations and timeslots.	LSPs, Forwarders, Carriers, Shippers	R&D
	Seamless modal transhipment processes and technologies	Cargo handling companies	R&D, intermodal terminals, transport modes

2.2

Recommendations for **Government**

TOPICS	ACTIVITY DESCRIPTION	MAIN ACTOR	REQUIRED PUBLIC-PRIVATE COOPERATION
Rules & policies	Explore the development of supportive rules and policies that allow collaborative and shared logistics networks to function.	European Commission	Companies and their associations
	Implement European wide frameworks and standards for data-sharing and electronic transfer of freight documents (eFTI and beyond).	European Commission	Member States, Companies and their associations
	Integration of Physical Internet as an integral part of the European mobility system.	European Commission	

2.3

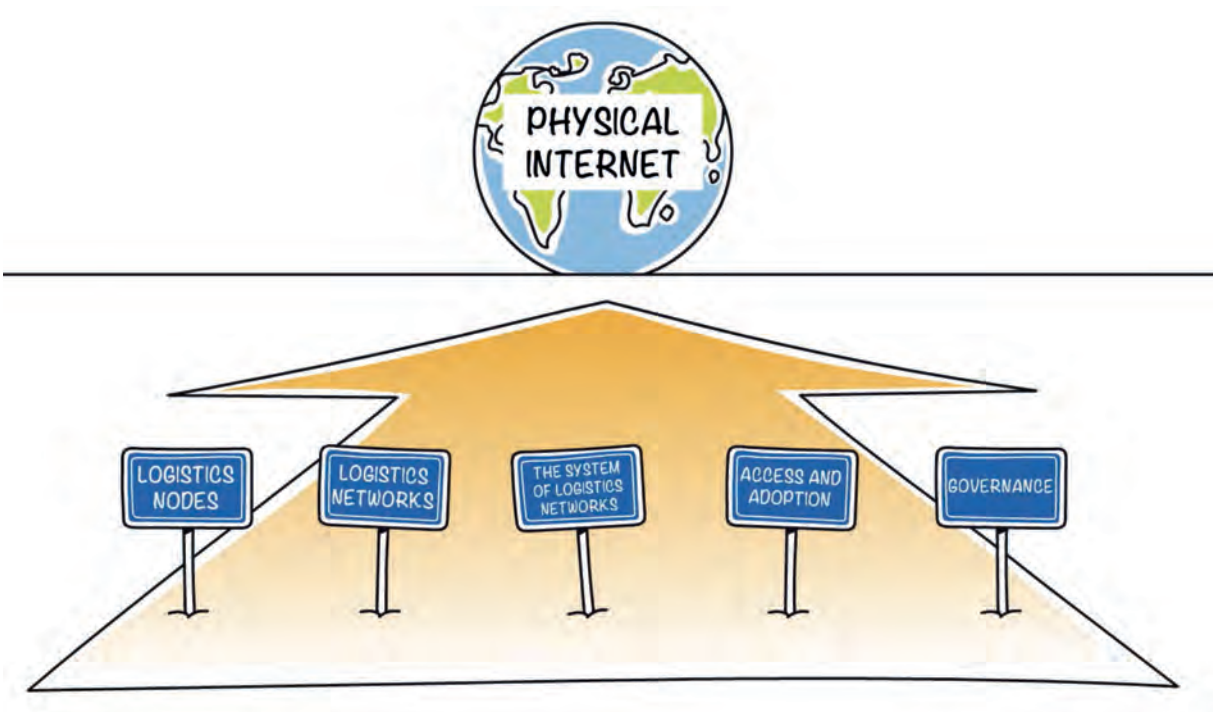
Recommendations for **Research & Development Partners and Academia**

TOPICS	ACTIVITY DESCRIPTION	MAIN ACTOR	REQUIRED PUBLIC-PRIVATE COOPERATION
Identification of impact	Further investigate the economical and societal impact of PI.	R&D	Government
	Document the performance of connected and shared logistics networks and compare to actual forecasted performance.	R&D	Companies
	Identify increases in resilience of the freight transport and logistics systems using PI concepts.	R&D	Corridors, Infrastructure Managers
Technology development	Develop rapid electronic data interchange translation tools available to all.	Technology Centres, IT R&D	Companies
	Development of reference IT architecture, layered protocol stack and operational protocols for the secure management of all flows, lanes, nodes and insertion points over logistics networks.	R&D	Companies and Government
	Address physical interoperability barriers between manufacturing end of line, the family of modular load units from boxes to (intermodal) containers and intermodal transport & transhipment	R&D	Load units pools, logistics handling equipment and transhipment

2.4

Recommendations for **Civil Society**

TOPICS	ACTIVITY DESCRIPTION	MAIN ACTOR	REQUIRED PUBLIC-PRIVATE COOPERATION
Training and awareness raising	Promote the net benefits of the PI based on the concept of the triple bottom line: people, planet, profit.	Civil society	Government, Companies and their Associations
	Realise education and training programs for logistics professionals to increase the level of network integration skills in real business practice.	Training and Education providers	Companies and their Associations



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