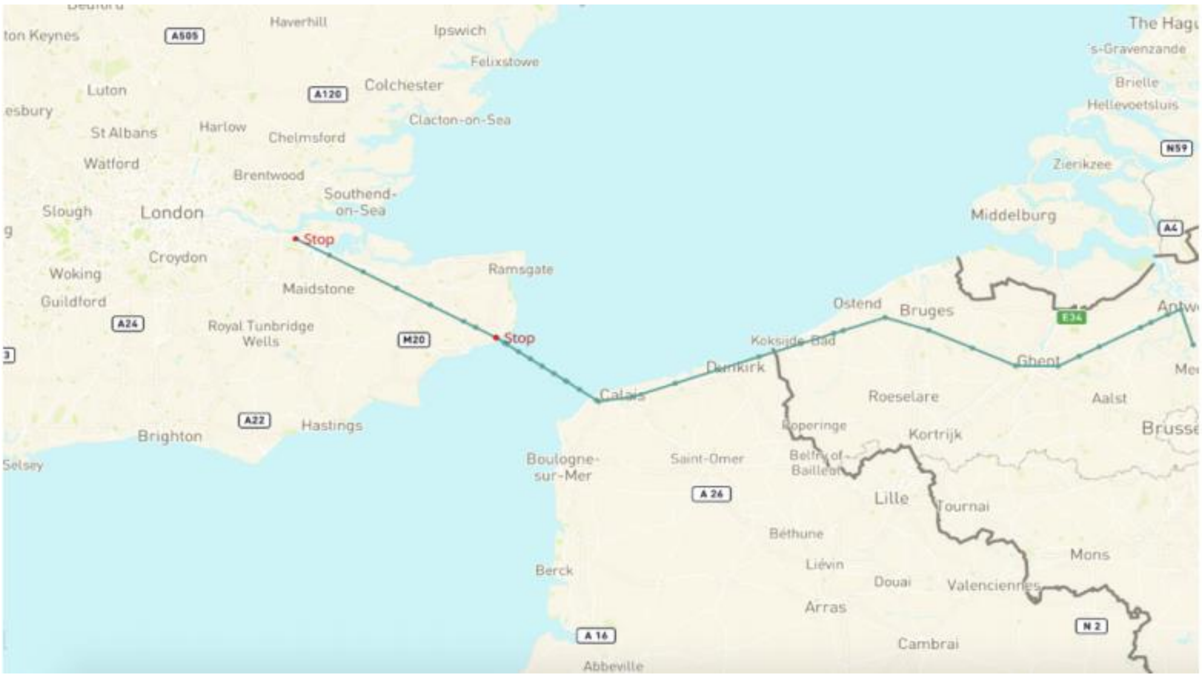

Image: ICONET

Living Lab 2: The potential for high volume transport corridors enabled by the Physical Internet

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Grant Agreement No 690588.

What is ICONET?

ICONET was a consortium led research project that explored what was needed to make the Physical Internet a reality. The Physical Internet describes the application of the principles of the digital internet to real world logistical problems; through digital twinning, the real world is tracked using sensors and consolidated data and replicated as a real-time model that is used to deliver real-time decision making that makes optimal use of logistics capacities and infrastructure for the benefit of all participating users.

The strategic goal of ICONET was to build a cloud-based Physical Internet framework and platform, which utilised leading edge technologies to deploy logistics solutions that demonstrate proof of concept. The 30-month project fulfilled the brief to extend state of the art capability for deployment of the Physical Internet through development of an experimental networked architecture and suite of core services, although having started in September 2018, and concluding in February 2021, the Covid pandemic paradoxically both disrupted the testing of these solutions and reiterated the value that they offer.

The research programme explored new business models that could be enabled by the Physical Internet that enhance intermodal transport, better use of existing port capacity, high volume freight corridor capabilities, warehousing and ecommerce services; these elements together form the basis of a new Physical Internet driven logistics marketplace that makes better use of existing assets and investments, improving the services delivered to logistics users, cutting costs, and reducing environmental impacts.

What is the Physical Internet?

The Physical Internet, abbreviated frequently to PI, is a way to organize physical flows analogous to the way data flows are organised through the internet: encapsulation of goods in standard modules (e.g. containers, pallets or boxes) is the equivalent of the data packets, warehouses are the equivalent of data memory bank and finally the transport network is the equivalent of communication cables. The result is that the transport of goods can be self-organised and self optimised, and so able to respond to real time demand and supply at large scale and complexity. A PI system can also, via real-time tracking, overcome and respond much better to real world transport constraints and delays.

Physical Internet services

The aim of ICONET was to create a suite of experimental Physical Internet network services that optimise the flow, cost, and environmental performance of freight traffic, responding in real time to current network capacities, demands and constraints whilst complying with pre-agreed governance rules and service level agreements (SLAs) as determined by logistics service providers, their clients and relevant legislation. Orders are translated into physical transactions which are fulfilled and reconciled, and the process supported by established administrative processes (order, poof of delivery, invoice), in reference to pre-agreed conditions for trade (contractual terms and operating standards, service level agreements).

The ICONET vision is built upon three key pillars:

- To build new business models and the associated governance and other enablers required to facilitate collaborative Physical Internet operations by a range of supply chain actors;

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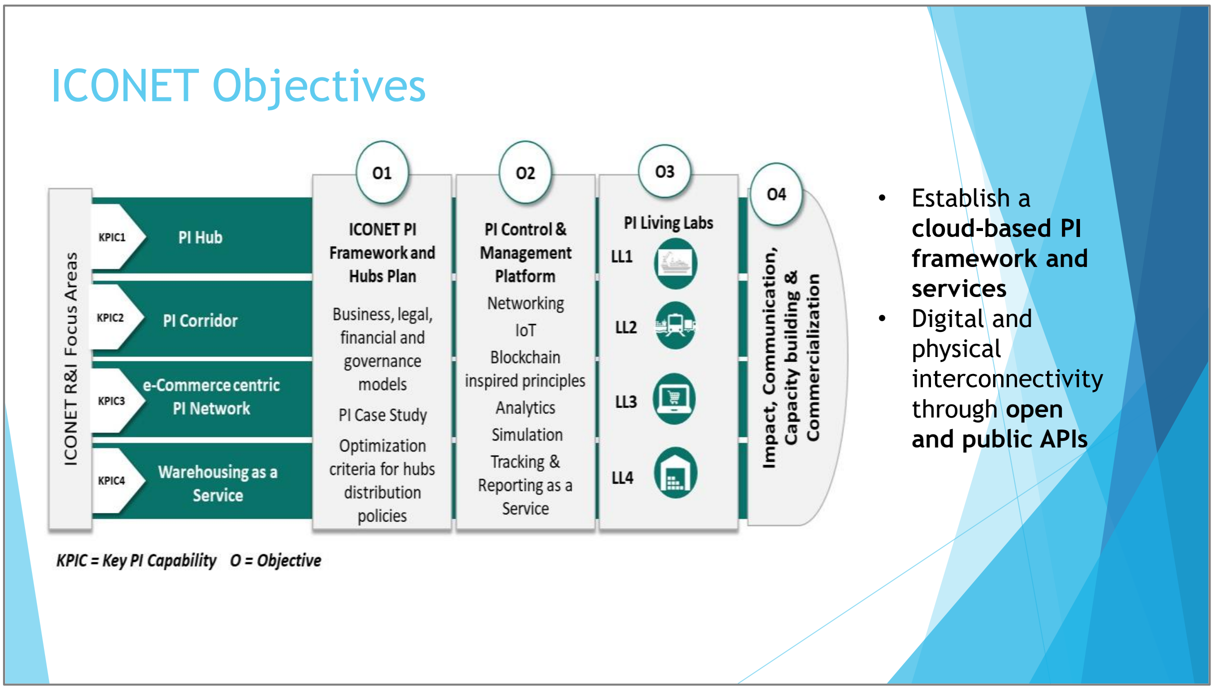
- Generic case studies that would also be used to build simulation models for Physical Internet network design, so exploring the factors behind the number and placement of nodes or hubs such as ports;
- The design and testing of an open reference system architecture and platform for enabling the digital connectivity required to track, trace, and replicate the real world in order to deliver optimised solutions in real time.

Living Labs as opportunities for proof of concept and collaborative learning

The business models were tested as Living Labs, which involved business partners willing to support the development and testing of Physical Internet concepts within their logistics operations and value chain. Each Living Lab tested the Physical Internet services and infrastructure required to make the Physical Internet a reality and simulated wider deployment to demonstrate the anticipated benefits. In doing so, each lab generated quantifiable realisable benefits to stakeholders, valuable insights enablers and barriers to implementation and success. The project set out for business cases for deployment of Physical Internet solutions:

- Living Lab 1: PI Hub - Port integration and network optimisation.
- Living Lab 2: PI Corridor - High volume corridors to test Synchro-modality as a service.
- Living Lab 3: E-commerce focused PI network solutions.
- Living Lab 4: PI enabled Warehousing as a Service (WaaS).

For each of the four labs, the ICONET project was tasked with making use of leading-edge technologies to build a test scenario deploying the control and management platform, services, and algorithms.



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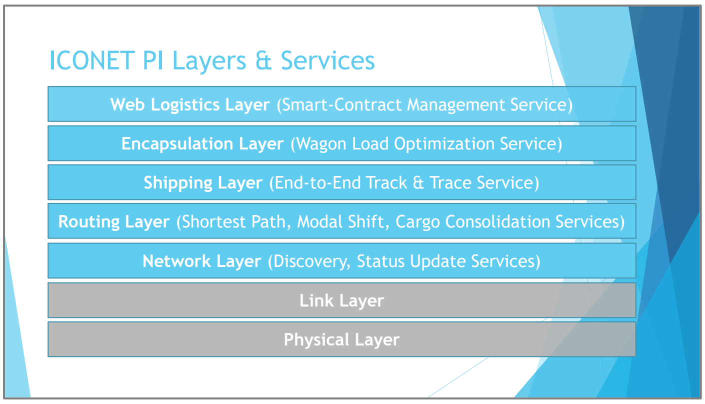
Measurable Outputs of ICONET

The project delivered the Physical Internet framework, four tested and calibrated designs and templates for establishing hubs, corridors, e-commerce and WaaS. To facilitate deployment of the assessment tools developed, a generic simulation model was made available for any interested party to use, in order to allow them to assess, design and test bespoke applications for Physical Internet services. The simulation is available on request and a video explaining how the simulation can be used is available here.

The project also produced a control and management platform, containing the services and functional capabilities shown below; the open standards architecture forms a blueprint that can be copied and reproduced to support any Physical Internet platform.



Each living lab delivered solutions that improved efficiency and efficacy of operations for end users, cut costs for participating companies, and reduced the CO_2 footprint of goods stored, handled, and transported. Beyond the demonstration of proof of concept, ICONET examined the pathways to commercialisation of the ICONET solutions, which included the development of education and knowledge transfer, the generation of detailed business case assessment tools, the establishment of an Advisory Board which brought industry experts together to guide and support the research, and wider outreach to other organisations, initiatives, and expert forums.

Living lab 2: Enhancing high volume transport corridors within a Physical Internet enabled network

The EU Trans-European Transport Network (TEN-T) policy aims to create a Europe-wide multi-modal transport network, integrating railways, roads, inland waterways, maritime shipping routes, ports, airports, and railroad terminals; the objective is to "close gaps, remove bottlenecks and technical barriers, as well as to strengthen social, economic and territorial cohesion in the EU"[1]. In addition to the construction of new and enhanced infrastructure, the policy also supports the development of innovative technologies and digitisation to deliver "improved use of infrastructure, reduced environmental impact of transport, enhanced energy efficiency and increased safety." The aim is to fully integrate the core network shown below by 2030 and create a much denser network that covers all EU regions by 2050. Perception of unreliability has long been cited as a barrier to adoption of multi-modality, (meaning the use of at least two transport modes for a single contracted end to end transport solution), and, equally, digitisation and connectivity have long been identified as a core solution to this problem, and so European Commission project funding has long focused on enabling tracking and synchronisation of multi-modal transport

[1] https://ec.europa.eu/transport/themes/infrastructure/ten-t_en

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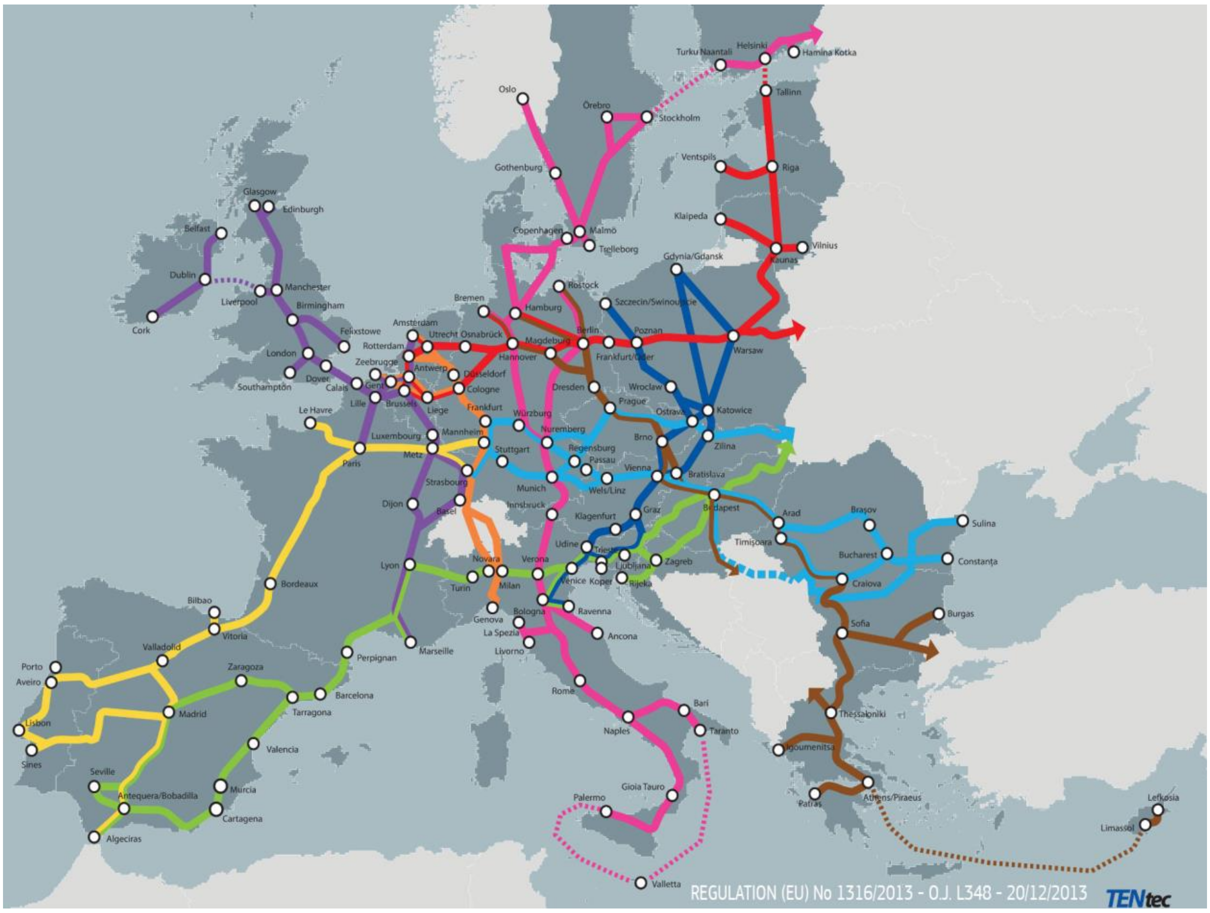
activity[2]. The aim of Living Lab 2 is to support and contribute to the TEN-T policy initiative through modelling the transformation of TEN-T corridors into Internet-of-things (IoT) enabled Physical Internet (PI) corridors.



The core Network Trans-European Transport Network (TEN-T)
(image source: https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/map/maps.html)

What did the Living Lab do?

The aims were to test the Physical Internet enabled tracking of intermodal freight through high volume corridors and to model the optimisation solutions that this makes possible; the IoT enabled supply chain was deployed as pilot technology, allowing ICONET project partner Procter & Gamble to test synchro-modality solutions (synchro-modality being defined as where transport modes are synchronised using real time tracking and coordination capabilities).

To do this, the team deployed IoT devices and a tracking service, along two high volume routes for the P&G supply chain; the first corridor was from Belgium to the UK, and

[2] Irina Harris, Yingli Wang, Haiyang Wang, ICT in multimodal transport and technological trends: Unleashing potential for the future, International Journal of Production Economics, Volume 159, 2015, Pages 88-103. https://www.sciencedirect.com/science/article/pii/S0925527314002837

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the second was from Belgium to Italy, combining short sea shipping, road and rail, using 45-foot pallet wide containers.

The smart tracker illustrated below was designed, installed, and tested by sensor manufacturer and project partner Next Generation Sensors (NGS) SRL, on a container moving within the Belgium to UK corridor, and the cargo tracked with information relayed to the Procter & Gamble back-end system; the tracking visibility was successfully delivered, as shown in the image on the front page of this paper.

The Micro-Flexx board, an NGS designed and deployed sensor and tracking device (Image source: NGS).

The sensor was also designed to monitor the condition of the cargo and so was able to support 'Smart Contract' monitoring, meaning that conditions that impact on specific categories of cargo - such as temperature or vibration – can be measured, and any breaking of agreed conditions and associated service levels are recorded and added to the digital record of the contracted activity. The 'Smart Contract' makes use of blockchain so that this record of actual movement and monitored exceptions to agreed conditions, are captured alongside the initial requirements of the transport order and any remedial activity or changes to that transport order as it is executed, so all information is updated and collated as a single source of truth that all parties can reference. In the simulation of the Belgium to UK corridor, the sensor monitored vibration on a container that carried simulated fragile goods, the tracking service transmitted any vibration over a pre-defined threshold, and as

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the vibration exceeded those defined with the targeted logistics Service Level Agreement (SLA), the virtual shipment could then be redirected to a warehouse to allow for inspection for damage.

The real-time tracking updates provided by the sensors were also used to demonstrate via simulation the benefits of dynamic rerouting. For example, in one test where the modal choices included both road and rail, the tracking data was combined with road traffic flow data which showed long delays due to an accident; the smart container sensors communicated a shift in the temperature of the delayed carried goods outside defined limits. The team were able to reroute the container to an alternative mode, in this case train, thereby minimising the impact of the delay and damage to cargo. Alongside rerouting, the team also demonstrated the ability to prioritise containers that were in risk of violating service level agreements in any way, including the risk of failure to meet on-time delivery. The Belgium to Italy corridor simulation also demonstrated the ability to consolidate and optimise the total flows within the corridor, and in doing so help shift more freight from road to rail, thereby delivering the environmental impact savings that rail can bring; to do this, the consolidated tracking data was used to enable automated value stream mapping – in other words, the overall lead time and process execution was analysed and redesigned.

What were the results and what was learnt?

As described, the sensors were successfully deployed and the relayed data utilised in simulations to reroute, reschedule, and resynchronise activity along the supply chain, for example, within receiving operations within a destination warehouse. The data also allowed a more strategic rethink of the supply chain design and operation. Sensors and tracking, along with the capability to do something with that data, resulted in improved delivery reliability, improved service quality (understanding of incidences of temperature or vibration exceeding agreed limits), and overall service lead time and design (via the data enriched value stream mapping). The lab also successfully demonstrated the value of Smart Contracts in recording and allowing a single source of truth when activity is not going to plan, and the value of synchro-modality in responding to exception reporting (through the dynamic rerouting of transport and rescheduling of receiving operations at destination warehouses). A range of IoT sensor and data sharing solutions were considered by ICONET, and together they can be combined to generate a powerfully granular and robust picture, of both the journey of an individual container, and the wider logistics operation and flow of which it is a part (as illustrated below).

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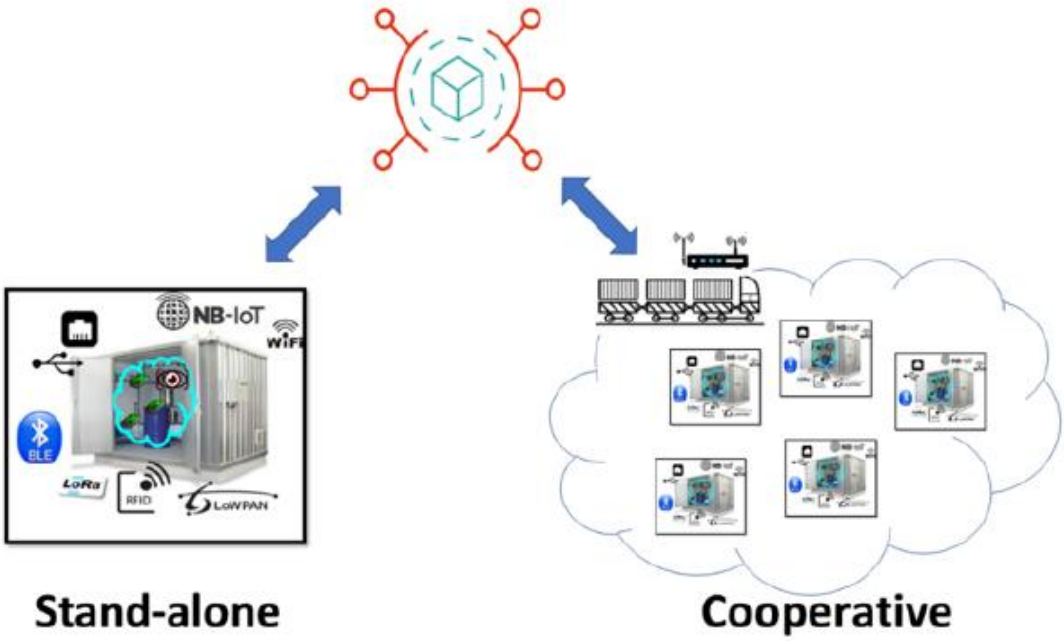

The performance data for all tests bore out these improvements: increase in percentage of cargo tracked, of end-to-end distance tracked, and an increase in accuracy of estimated arrival time. The real time updates allowed faster response time to disruption such as traffic, including a cut in late delivery resulting from both prioritisation and rerouting. The holistic and systemic benefits from these improvements included cuts in both cost and environmental impact, including the long-term gains resulting from a redesign of flows and the subsequent opportunity to shift more flow from road to rail.

The increased visibility of intermodal transport alone would be considered a significant breakthrough. This is in fact the only form of continental transport for which no visibility solution is currently provided (with a few proprietary exceptions) and addressing this gap would help dissipate the perceived doubts about the reliability of intermodal logistics (defined as using containers and routes that allowed for multimodal transport). What was less expected until the data was finally made available was the longer-term strategic value arising from the accumulated visibility and tracking data; the rich and more granular data can be used to better understand bottlenecks and other issues causing delays or damage to process flow and goods in transit, and so support continuous improvement of processes, end to end optimisation, and more holistic and wide-reaching strategic redesign of the supply chain: for example, the data can be used to improve the management and utilisation of containers, as from the real world data, 70% of the time the containers that were tracked were empty and idle in a container park. Within the simulation work, the team were able to use the data to help justify the decision to move even more freight from road to rail for distances over 300km, and so contribute to meeting corporate CO_2 emission targets.

Demonstrating the value derived from the sensors and IoT solutions itself represents a significant step in overcoming reluctance to consider intermodal and multimodal solutions and the barriers to embracing the enablers to synchro-modality, including overcoming

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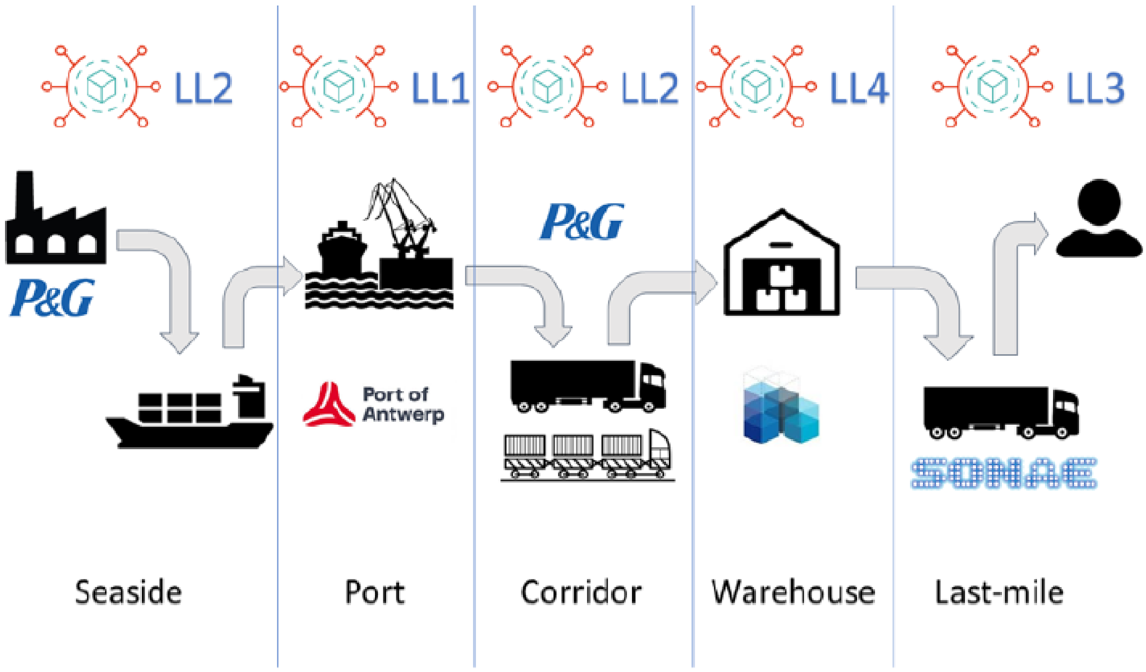
unwillingness to share existing legacy information flows, allow sensor-based monitoring, or make use of IoT devices more broadly.

What should happen next?

Although more research will be required on building physical internet infrastructures, the learnings of the living lab should help inform the design and installation of IoT and Physical Internet enabled long distance corridors. Firstly, the self-reinforcing and wide-ranging value added that was delivered by the lab - in reducing lead time, reducing damage, reducing late delivery, cost, and environmental impacts - should help convince more supply chain partners as to the value that can be realised from sharing information and making operations more visible. The insight on what can be done to deliver operational improvement and a faster and more agile transport solution, and perhaps more significantly, the opportunity to use the automatically generated data to support more strategic change, all contribute to the RoI (Return on Investment) case for spending on IoT and Physical Internet capability.

The creation of more visible, dynamic, lean and agile transport flow also has knock-on effects for the wider supply and logistics chain; the Physical Internet logistics environment envisioned by ICONET means that more dynamic synchro-modality within the transport network means a more dynamic, efficient and effective wider logistics chain; last mile delivery as modelled by living lab 4, Warehousing as a Service as modelled by living lab 3, and greater integration of the services provided by major hubs such as ports with their customers and partners all combine with end to end transport corridor visibility to allow for a more integrated and holistically optimised system. The benefits to the workings of the system as a whole should be of an order of magnitude many times greater than the benefits to the individual components, operations, and providers.



How Living Lab 2 contributes to the overall ICONET vision

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The clearest opportunity is to widen the scope and scale of the physical internet enabled transport corridors trialled in this lab. Firstly, the more that ports, modal service providers, and end to routes can be integrated in this way, the more the benefits can be shared to create a more robust and seamless flow of goods and information. Secondly, the more users that can collaborate and share the high-volume corridors, the more efficient the TEN-T network will be; the lab did not explore the wider possibilities of shared user long distance flows, but this trial demonstrates the opportunity for logistics service providers and users to build the trust and reliability required to overcome doubts about sharing transport, and sharing the information required to reveal hidden wastes and mutually advantageous solutions. The growth of shared transport services will facilitate new markets, new pricing and contract management solutions, and should, like many digitised platforms such as AirBnB, enable a better balancing of supply and demand through improving the utilisation of existing logistics assets and capabilities, and expanding the scope and range of uses and users of such services.

Finally, it is clear that 'Tracking and Reporting as a Service' is itself a secondary market that will grow to support a shift to Physical Internet enabled logistics. Large and small businesses alike can benefit from contracting out supply and logistics chain visibility to a third party, to create the data that is valuable to all participants, so that who pays for that data, and on what basis, will be addressed as the secondary market evolves and grows. But first movers will have a competitive advantage in uncovering, understanding, and addressing the wastes and opportunities they can unlock to transform their business.

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ICONET Partners

For more information, please visit our website, www.iconetproject.eu
More detail is also available in the project's Transferability Framework that is available for download here: https://www.iconetproject.eu/transferability-framework-capacity-building-programme/

If you wish to ask further questions of the teams involved in this project, please contact Stephen Rinsler (steverinsler@elupeg.com). The views expressed in this document are not necessarily those of the EU Commission; the Consortium and the EU Commission/INEA are not responsible for any use that may be made of the information contained within this report.

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