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Alliance for Logistics Innovation through Collaboration in Europe

INFORMATION SYSTEMS FOR INTERCONNECTED LOGISTICS

Research & Innovation Roadmap

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Executive summary

The ambition of this roadmap is to define research and innovation paths that need to be addressed to achieve real-time (re)configurable supply chains in (global) supply chain networks with available and affordable ICT solutions for all types of companies and participants. In essence, this is a requirement to enable a Physical Internet: an open global logistic system founded on physical, digital, and operational interconnectivity, enabled through encapsulation of goods, standard interfaces and protocols. The aim of the Physical Internet vision is to move, store, produce, supply and use physical objects throughout the world in a manner that is economically, environmentally and socially efficient and sustainable. To achieve this ambition, the following milestones have been defined.

Milestones	
2020	Interoperability between networks and IT applications for logistics.
2030	Full visibility throughout the supply chain.
2040	Fully functional and operating open logistics networks.
2050	Physical Internet.

The major gaps that need to be addressed to meet the vision are:

- The ability to rapidly connect to, and disconnect from, supply networks at two levels; the business level and the technical ICT level.
- The simplification of ICT systems, information interfaces and business models so that domain users are shielded from having to become technology experts and can focus instead on the efficient execution of transport and logistics operations;
- The simplification and standardization of device interconnections so that the rapid connection and disconnection of sensor enabled transport items is facilitated.
- Open cloud based collaboration platforms to facilitate the dynamic and cost effective formation and management of complex supply networks.
- Secure and reliable data management approaches that facilitate the collection and analysis of authorized data so that operational efficiency can be improved while assuring the public that privacy is maintained.
- The development of appropriate standards and data collection systems for reporting commercially and socially important information (e.g., emissions, load factors, congestion levels, etc.) so that proper comparisons can be obtained and informed decisions made.
- The ability to properly manage goods flows so that infrastructures, transport assets, modal nodes and other supply network assets are optimally utilized.
- The adoption, integration and use of smart infrastructures, Intelligent Transport Systems (ITSs), IoT devices and other intelligent edge based technologies in supply chains to increase the efficiency, effectiveness and control of supply networks.

To address these gaps, innovation is required in ICT, but also in business models and data governance. The themes addressed in this roadmap are shown in the figure below.

ICT Innovation

- Intelligent objects, smartdevices, IoT, ITS.
- Big data.
- Data analytics.
- Dematerialization.
- Intelligent information nodes.
- PI support and planning systems.
- Logistics BPaaS.
- Autonomous Logistics operations.

New Business Models

- Increase Asset and Infrastructure Utilization by Sharing.
- Collaboration tools.
- Revenue/Gain sharing.

Data Governance

- Improved security, privacy and trust Services.
- Data ownership and management services.
- Information and data sharing policies and services.
- Supportive legal and regulatory practices.

The document further elaborates on these themes including for each of the bullet points the following:

1. Innovations and expected results from foreseen activities.
2. Drivers for change/Barriers to overcome.
3. Expected impacts.

Roadmap implementation actions and projects are expected to make an extensive use of pilots and proof of concepts and business cases, clearly defining the operational framework assumptions of all new solutions.

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INTRODUCTION

The European Technology Platform, Alliance for Logistics Innovation through Collaboration in Europe (ALICE), was launched on 11 June 2013, and received official recognition from the European Commission in July 2013. ALICE was established to develop a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovations in Europe with the mission: *"to contribute to a 30% improvement of end to end logistics performance by 2030"*.

One of the key elements identified by ALICE as the Vision to achieve this improvement is **The Physical Internet (PI) Concept**. The PI Concept is based on an open global logistic system founded on physical, digital, and operational interconnectivity, enabled through encapsulation of goods, standard interfaces and protocols, with the aim to move, store, produce, supply and use physical objects throughout the world in a manner that is economically, environmentally and socially efficient and sustainable[1]. The Physical Internet

1. Ballot, E., B. Montreuil, and R.D. Meller, *The Physical Internet: the network of logistics network*. PREDIT. 2014: La Documentation Française. 271p.

concept can only be realised by an extensive knowledge of the possibilities and constraints set by information and communication technologies. The realisation of the concept requires harmonised development and deployment of ICT from various stakeholders, and will also require a radical change in business models and organisational relationships within and between stakeholders.

Five different Working Groups, composed of industry, academic and regional stakeholders, have been launched to focus on the transport and logistics domain to further analyse and define research and innovation strategies, roadmaps and priorities to achieve the ALICE Vision and Mission. These Working Groups are:

1. Sustainable and Secure Supply Chains
2. Corridors, Hubs and Synchromodality
3. Information Systems for Interconnected Logistics
4. Supply Network coordination and Collaboration
5. Urban Logistics

This document outlines the research roadmap for the area of ***Information Systems for Interconnected Logistics***. Transport and logistics activities account for approximately 14% of the EU's GDP[2] and approximately 5% of EU employment. These activities also produce approximately 20% of the greenhouse gasses emitted by EU sources. Forecasts indicate that the growth in transport and logistics emissions, as well as equivalent kilometres travelled, will continue to increase at the fastest pace of all sectors unless more efficient business models are employed that employ more efficient transport modes and increase the utilization of assets. While better vehicle technologies can help in mitigating the impacts of increased volumes of transport and logistics activities, it is only through the use of more advanced management, planning and visibility, communication, monitoring, controlling and autonomous systems that sufficient operational improvements will be realized for the industry to meet the EU's objectives of a 30% improvement in performance by 2030.

The goal of this roadmap is to identify research priorities related to Information Systems for Interconnected Logistics based on the actual needs of industry participants that can contribute to the definition of research programs targeted at this sector, including Horizon 2020, the European Programme for Research and Innovation. The implementation of the research topics and activities identified in this document are required to achieve the objectives of ALICE.

Experts from all important stakeholder groups involved in European freight and logistics operations and research activities have been invited to contribute to this work[3].

2. COM(2007) 607 final. *"Freight Transport Logistics Action Plan"* European Commission, Brussels, 18.10.2007
3. See the list of members of the core group and additional experts consulted at the end of the document

1.1

Expected impacts of research and innovation activities

In order to define what research is needed in the area of Information Systems for Interconnected Logistics it is important to decide which impacts are expected from initiatives and projects. In this section, an extensive list of expected impacts from the implementation of the strategy for research and innovation proposed by Alice is included. These expected impacts cover all ALICE areas including Information Systems for Interconnected Logistics. The areas of intervention defined afterwards in this document, and the research initiatives arising from these topics, do not need to contribute to all of the listed impacts. However, these initiatives should have a positive impact on some of the topics and be neutral to the rest.

ALICE's mission is "to contribute to a 30% improvement of end-to-end logistics performance by 2030". The standard approach to societal, environmental and economic improvement used by industry is based on the concept of the "triple bottom line." Therefore, any recommendation for research and innovation should address how the recommendation will impact People, Planet and Profit. The impacts discussed below are separated into one of these three categories for a more intuitive understanding by stakeholders.

Additional work is required in order to define proper measurement units and indicators to determine to what extent the expected impacts will contribute to the 30% improvement of end–to-end logistics performance. Measurements and indicators are required so that the implementation of the recommended innovation and research efforts can be properly assessed in the medium and long term.

The impacts have been divided into primary and secondary impacts. While primary impacts are the ultimate expected impacts, the secondary impacts will have a positive influence on the primary impact. For example, Energy Consumption is a primary impact while increasing load factors of vehicles is a secondary impact that positively influences energy consumption as well as other indicators such as emissions reduction.

These expected impacts are related to logistics performance dimensions. All actions undertaken under the ALICE umbrella should improve one or several of them without sacrificing the others.

Table 1. Expected impacts from the implementation of ALICE roadmaps proposed actions

<table>
<tr><th></th><th>PRIMARY IMPACTS</th><th>SECONDARY IMPACTS</th></tr>
<tr><td>People</td><td>+ Increase customer satisfaction.
+ Products availability.
+ Secure societies.</td><td rowspan="3">+ Load factors: weight and cube fill of vehicles.
+ Volume flexibility (Time to +/- capacity).
+ % Synchromodal.
+ Asset utilization.
+ Supply Chain Visibility.
+ Reliability of transport schedules.
+ Perfect order fulfilment.
+ Transport routes optimization (reducing Kms).
+ Transport actors using automatic data exchange.
+ Cargo and logistics units integrated in the automatic data exchange.
+ Upside / Downside Supply Chain Adaptability and Flexibility.
+ Decoupling logistics intensity from GDP.
- Empty Kilometres.
- Waiting time in terminals.
- Risk factor reduction.
- end-to-end transportation time.
- Travel distance to reach the market.
- Lead times.</td></tr>
<tr><td>Planet</td><td>- Energy consumption (kWh Logistics/GDP).
+ Renewable energy sources share.
- CO_2 Emissions (kg CO_2/tkm).</td></tr>
<tr><td>Profit</td><td>+ Return on assets and working capital.
- Cargo lost to theft or damage.
- Total supply chain costs.</td></tr>
</table>

The use of information and communication systems to improve productivity in all segments of business has been demonstrated by numerous research efforts as well as through anecdotal case studies. In order to achieve the efficiency improvement targets established by the EU for the transport and logistics sector, a step function advance in the use of current and emerging information, computing and communication technologies is required. Currently, the integration of the transport and logistics processes of supply chain participants is limited by the complexity of current systems technologies, the lack of communications and information standards, the dominance of proprietary systems, high costs, conflicting regulatory requirements, incompatible business processes, and outdated business practices.

Improvements in the use of information, computing and communication technologies, via simplification and standardisation, business practice revisions, business process harmonization, and networking and collaboration will allow stakeholders in the transport and logistics domain to more cost effectively integrate their operations, manage the complexities of their supply networks, and improve asset utilization and lower social and environmental impacts. In addition, through better understanding of the benefits, usage and implementation of advanced technologies (such as big data analytics, cloud services, PI, IoT, ITS, advanced communication networks, etc.) additional improvements in efficiency and operations should be achievable.

1.2

Background

The transport and logistics industry is characterized by relatively few large international companies and numerous small to medium sized regional/local players. The structure of the industry is driven by the fact that there are few barriers to entry, but considerable investment required to grow beyond a certain size. The limited number of companies that are of sufficient size to use integrated supply chain information systems has resulted in a systems environment that has few standards and even fewer large scale specialized software and technology providers. Many large industry players have developed their own proprietary systems because of this fact, investing considerable funds each year in the maintenance and updating of these systems. Small scale players have either had to use applications provided by local or niche software providers or, as is quite common in the smaller players in every industry sector, not utilize any applications or technologies beyond normal office applications.

The proprietary nature of most systems in the industry, coupled with a lack of communications standards, has led to the fact that the interconnection of industry players is costly and time consuming. The cost and time it takes to integrate two organizations using EDI discourages small players from connecting in this manner and excludes them from the benefits that better integration would bring. In addition, because only the largest of players can afford the investments necessary to realize efficiencies through modern information technologies and communication protocols (such as EDI, XML), the majority of small players operate in a manner far from the efficiency level that might be achieved if information systems were less complex and costly.

In addition, a large number of ITS technologies (systems and services) are currently available to support or even manage specific aspects of goods movements (e.g., fleet management, traffic operations management, ferry terminal operations, etc.). However, these commercial telematic systems are currently not linked to one another, thus missing the opportunity to optimise the performance of the transport operations they are supposed to manage. In addition to the lack of inter-system communication standards, standards for connecting to smart infrastructures are still being debated further restricting the ability to optimize transport operations. The lack of integration between these systems leaves considerable room for improving certain aspects of goods management (e.g., guaranteeing reliable real-time information exchange for goods movements between transport modes).

Over the years the desire to improve the performance of the transport and logistics industry has been reflected in the numerous research programs funded by the EU that have focused on this industry. A quick search of the EU's CORDIS archives using "transport" as the search term yields over 14,000 reports. Refining this search to include "information" reduces the number of funded reports to slightly more than 7,500. Finally, including "systems" in the search string reduces the number of reports to just less than 5,000. Clearly, the amount of effort that has been expended to address the needs of this sector has been considerable. The list below is a short compendium of the more relevant recent programs that the EU has funded that have focused on improving the information systems within the transport and logistics domain.

1. Collaborative Information Services for Container Management, COMCIS.
2. Common assessment and analysis of risk in global supply chains, CASSANDRA.
3. Intermodal global door-to-door container supply chain visibility, INTEGRITY.
4. Smart container chain management, SMART CM.
5. Intelligent Cargo in Efficient and Sustainable Global Logistics Operations, iCargo.
6. European e-freight capabilities for co-modal transport, e-freight.
7. Container Security Advanced Information Networking, CONTAIN.
8. Digital Supply Chains for European SMEs based on the Freightwise Framework, DISCWISE.
9. RIS services for improving the integration of inland waterway transports into intermodal chains, RISING.
10. European inter-disciplinary research on intelligent cargo for efficient, safe and environment-friendly logistics, EURIDICE.
11. The Internet of Transport and Mobility, MOBINET.
12. Deployment of cooperative intelligent transport systems (C-ITS) applied to logistics, CO-GISTICS.
13. FREIGHTWISE – Management Framework for Intelligent Intermodal Transport.
14. EasyWay/EIP – Harmonized deployment of ITS services on the Trans-European Road Network, including services for freight and logistics.
15. Lean Secure and Reliable Logistic Connectivity for SMEs, LOGICON.

The rapid advance in the capabilities, structure and operational models of modern information and communication systems has created opportunities to reconceive how ICT supports the transport and logistics domain. Computer systems based on the "cloud computing" paradigm promise to simplify access, integration and collaboration while reducing overall computing costs. Advanced data analytics, applied to the massive amounts of data generated in the transport and logistics sector, promises to improve the planning and execution activities in the domain as well as the profitability of industry players. The "Internet of Things" (IoT) provides the opportunity to track every item being transported allowing players to dynamically manage assets, goods and environments in real time increasing the reliability of supply chains while reducing risks, congestion and increasing security. IoT capabilities also facilitate the interaction of instrumented devices with one another allowing these systems to self-organize, operate autonomously, and improve logistics flows dramatically. The capabilities of cooperative ITS technologies allow for continuous communication between infrastructures and vehicles (also between vehicles themselves and vehicles to Cloud), facilitating the communication and cooperation between transport vehicles and their surroundings. These capabilities are being extended by the introduction of new automation concepts in different parts of the logistics chain including vehicles and operations. Cyber security systems and technologies for data access provide assurances that external parties (e.g., competitors or government agencies) cannot abuse these ICT innovations to gain unauthorized access to, or perform malicious attacks on commercially sensitive data.

The establishment of an integrated transport "info-structure", relying notably on vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications, but also on the availability of open and high quality transport data is needed as one of the initial steps in realizing the vision of a Physical Internet. Co-operative Intelligent Transport Systems (C-ITS)[4] can provide substantial improvements to freight operations allowing for the advanced organization of freight transport demand; for example by optimizing routes, rescheduling delivery times and reducing empty runs by bundling supply chains and by the creation of ad hoc collaborative environments between the stakeholders of a specific logistics scenario.

In terms of technology(ies), ITS and different ICT (e.g., Radio Frequency Identification (RFID)), wireless sensor nodes and localization systems play vital roles in improving the performance of the freight transport system by saving energy, reducing service costs and increasing cargo throughput. To achieve these requirements, the application of reliable **heterogeneous communication systems** among all communicating objects becomes a paramount objective.

All of these advances, and numerous others, provide opportunities to rethink how the sector operates so that step function improvements in efficiency, emissions, social impacts and financial performance can be envisioned. These advances provide the impetus for the ALICE vision of the Physical Internet and form the foundation of many of the research and development recommendations that the ALICE ETP is focusing on.

4. ETSI, Intelligent Transport Systems (ITS) Communications Architecture,
http://www.etsi.org/deliver/etsi_en/302600_302699/302665/01.01.01_60/en_302665v010101p.pdf

1.3

General expectations, scope of the roadmap and approaches

The implementation of this roadmap should contribute to supply chains that are fully integrated and coordinated (supply networks) through the use of ICT. The roadmap focuses on solutions that can be made available to, and affordable for, all types of companies and participants, whether large or small. These technologies address the emerging requirements of supply chain participants to rapidly setup and tear down supply chain networks, collaborate, share assets and services, and generally improve operations as their needs change to meet a highly dynamic marketplace. This document identifies and defines research and innovation challenges and topics, including the development of technologies and standards that facilitate the closure of gaps in current ICT systems and their application to supply chains. The intention of the research agenda that is outlines is to arrive at an ICT landscape for the transport and logistics sector that creates opportunities for the very best performance in the execution of supply chain activities for all industry players, whether large or small.

Modern supply chains are complex networks of independent organizations working together to produce, transport, store and distribute goods from locations of lower value to ones of higher value. The complex nature of these networks requires that the various actors operating in them coordinate their actions in a highly integrated manner if desired outcomes are to occur. Unfortunately, the current state of ICT systems are such that only the most technology savvy and capital rich organizations can successfully participate in, or manage, these complex networks. The high cost of current ICT systems for logistics, and the level of technical sophistication necessary to integrate and operate them, excludes all but the largest logistics players. These factors work to the disadvantage of SMEs who have neither the capital resources necessary to purchase the sophisticated ICT required, nor the technical resources necessary to operate these systems.

Besides disadvantaging SMEs, the current state of ICT in the logistics industry also discourages innovation. Once supply chain partners have managed to setup a network, integrating participants and establishing rules for their management, it is very difficult for them to change their processes. For this reason, novel technologies, such as auto ID technologies or other sensor based tools, are generally ignored since they would require fundamentally changing the networks that have been established through the costly efforts of the current partners.

The situation that the transport and logistics industry currently finds itself in calls out for a new approach to the building and managing of supply chains. What is required are new business models, tools and standards that allow all participants, whether large or small, to collaborate, share resources and rapidly setup and tear down supply networks. Such tools should focus on issues such as:

- **Large scale harmonized interoperability between supply chain partners that facilitates the rapid and simple connection and communicatio**n of all partners and systems, including governmental agencies, customs authorities, shippers, third party service providers, transport network managers and any other entity required to ensure the proper functioning of the supply chain.
- **ICT and ITS tools and services** that will enable the creation of ad hoc collaborative environments allowing the real time, transparent and seamless interconnection, networking and information exchange between the stakeholders of a specific logistics scenario or use case.

- Simple and **cost effective sensors or smart devices** that operate using common and readily available communications technologies that reduce the cost of usage and encourage their integration into supply chains.
- Open and standardized **visibility and event management systems** that allow supply chains and networks to be managed efficiently and effectively.
- Secure and trustworthy **data governance and management** approaches that ensure that an organization has the ability to positively manage its data without intrusion by unauthorized third parties.
- **Auditing and built-in controls** to track factors important to society such as carbon emissions, energy consumption, food/product safety, and parameters necessary to assure security and limit risks.
- **Planning, optimization and revenue management tools** that facilitate the optimal use, routing and management of transport assets so that vehicle load factors are increased, congestion is minimized and revenues are appropriately shared between asset owners.
- **Dynamic flow management systems** that allow urban, suburban and corridor managers to optimize transport flows avoiding congestion delays and flow bottlenecks.
- **"Control tower" systems** to facilitate the synchronization and integration of transport modes, nodes and hubs so that the goal of "synchromodality" can be achieved as described in that roadmap.
- **Coordinated and harmonized governmental border control procedures** across the different inspection agencies (e.g., customs, product- and food safety, etc.) that facilitate the dynamic flow of goods across borders.
- **Business models** for return on investments in logistics ICT innovations have to be developed for SMEs as well as large international companies.
- **Data access/sharing protocols, supporting data policies, and Cyber security** technologies to assure that parties cannot abuse these ICT innovations and networks to gain unauthorized access to commercially sensitive data of their competitors or government agencies.
- **Autonomous logistics operation systems** that facilitate integrated V2V, V2I, single vehicle, AGV, and other facility, vehicle and material handling activities that occur within, between and across supply chains.

The stakeholders included in the scope of this roadmap are all stakeholders participating in supply chains, including ICT stakeholders delivering solutions for the logistics and supply chain sector. To address the needs of these organizations, new business models for ICT companies will also be taken into account as part of the scope of this roadmap.


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1.4

Complementarities with other ALICE roadmaps

This roadmap is focused on the development of ICT to enable supply chains to work in a smarter and more efficient manner. Therefore, the research activities addressed by this roadmap provide the ICT foundations required to properly implement research areas identified in the other four ALICE roadmaps.

Figure 1 graphically depicts the interdependencies of the working group roadmaps to achieve the vision of ALICE.

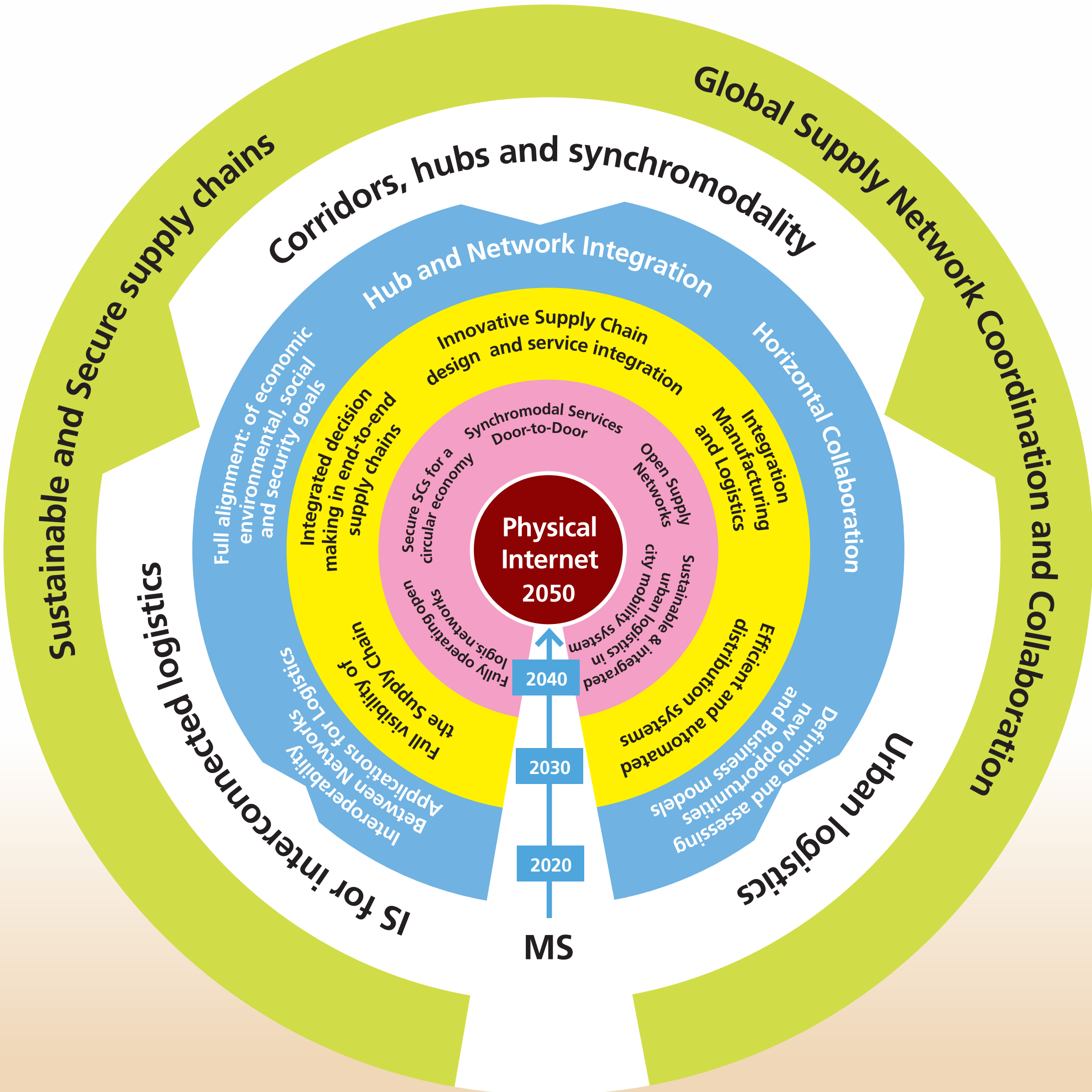


Figure 1: **Interrelation between roadmaps**

Figure 2 depicts the areas that need to be supported by ICT so that the ALICE vision can be realized.

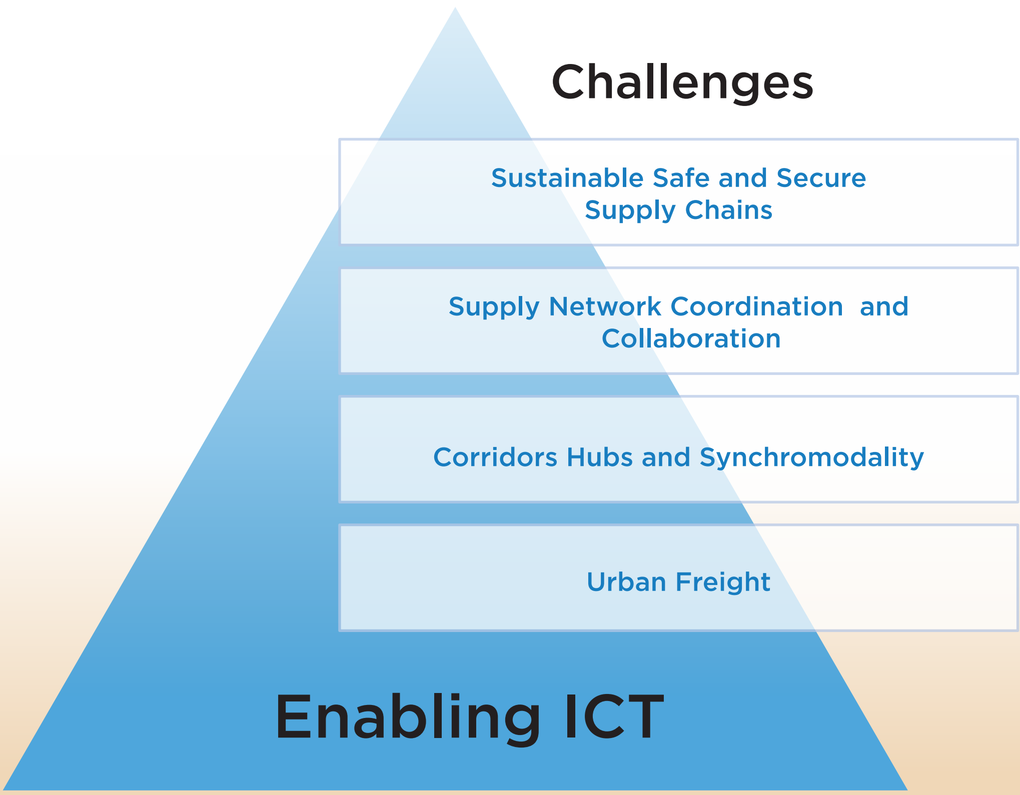


Figure 2: **Information Systems for Interconnected Logistics is an enabler to meet challenges**

2

CHALLENGES AND THEMES

Based on the current state of ICT support for the industry, the major gaps that will need to be addressed are:

- The ability to rapidly connect to, and disconnect from, supply networks at two levels; the business level and the technical ICT level. As previously noted, current supply networks tend to be "hard wired" by large industry players excluding participation by smaller, potentially more innovative, service providers and inhibiting novel new network and business models.
- The simplification of ICT systems, information interfaces and business models so that domain users are shielded from having to become technology experts and can focus instead on the efficient execution of transport and logistics operations.
- The simplification and standardization of device interconnections so that the rapid connection and disconnection of sensor enabled transport items is facilitated.
- Open cloud based collaboration platforms to facilitate the dynamic and cost effective formation and management of complex supply networks.
- Secure and reliable data management approaches that facilitate the collection and analysis of authorized data so that operational efficiency can be improved while assuring the public that privacy is maintained.
- The development of appropriate standards and data collection systems for reporting commercially and socially important information (e.g., emissions, load factors, congestion levels, etc.) so that proper comparisons can be obtained and informed decisions made.
- The ability to properly manage goods flows so that infrastructures, transport assets, modal nodes and other supply network assets are optimally utilized.
- The adoption, integration and use of smart infrastructures, Intelligent Transport Systems (ITSs), IoT devices and other intelligent edge based technologies in supply chains to increase the efficiency, effectiveness and control of supply networks.

2.1

ICT Innovation

While each of the prior sections have addressed issues that will need novel ICT support, specific ICT innovation to achieve the ALICE vision is required. A supply chain model based on concepts analogous to the digital Internet requires substantial changes in the types of ICT employed to operate supply chains. In the new model, ICT will be required to manage and control access to infrastructures, manage routing and congestion, ensure proper shipment disaggregation and aggregation, manage quality of service, collect costs and revenues and manage allocations, optimize collaboration, manage sorters and storage areas, etc. Such a model should be developed so that issue areas can be surfaced early and research and development projects developed accordingly. In addition, data generated through the use of supply networks will need to be analysed so that better decisions can be made by network operators and users. Thus, the major themes that will need to be addressed are:

- **Intelligent objects, smart devices, IoT and ITS: data capture and communication**. Current devices and systems utilize non-standard connection and communication protocols making it difficult to cost effectively implement these technologies. For IoT, ITS, smart objects and intelligent objects to become pervasive and commercially useful, standards and interoperability across different platforms are required so that these impediments are overcome. In addition, device-to-device communications require standards so that edge based intelligent devices can autonomously connect to create ad hoc networks so that better operation of production, traffic, logistics, transport and other systems can be realized. Therefore, the following areas need to be addressed:

  - Security, privacy and trust approaches to managing the capture of data and communication between intelligent devices to ensure that only authorized individuals or devices are able to access the data.
  - Interface standards to facilitate rapid connect/disconnect of objects, smart devices, IoT components and collaborative ITS solutions.
  - Intelligent inter-device and system communication processes to facilitate automated inter-device/system network setup and integration. (e.g., Container Security Devices (CSD), RFID, telematics systems, road based sensors, cargo monitoring, etc.).
  - Intelligent tools that enable the automated reconciliation of technical, syntactic and semantic differences between business actors and communities wishing to connect and collaborate.
  - Further development of energy-efficient smart devices and systems to manage their energy use (e.g., promotion of energy harvesting techniques for smart devices).

- **Big data**. Development of IoT, ITS, and other intelligent technologies will exponentially increase volume, variety and velocity of data handled by ICT systems in the domain. Current data management systems are focused on historical, structured data models making them inadequate for handling the large volumes of high velocity, unstructured data that will be available via fully enabled intelligent infrastructures. Therefore, the following areas need to be addressed:

  - Llinking of data from heterogeneous sources, including semantic matching.
  - Visualisation and analytical services for high volume, high variety, static data.
  - Visualisation and analytical services for “real time” high volume event services.

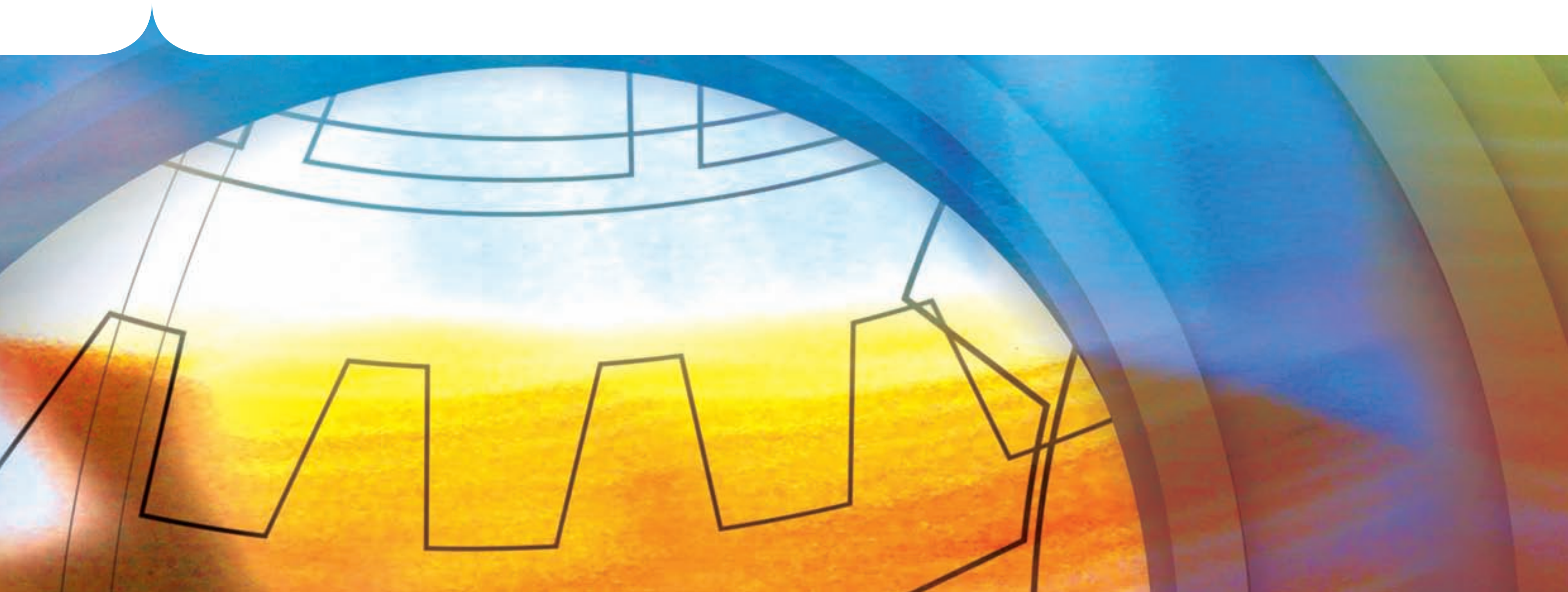
- Processing, storing and indexing capabilities to manage the inflow of sensor information on a scale significantly beyond what is seen today.
- Standardisation in data collection and storage approaches to cope with distributed processing.
- Real time context enriched decision making tools.

• **Data analytics**. Intelligent edge based systems (IoT, ITS, smart objects, etc.) will provide supply chain partners with access to information that historically did not exist. This information contains valuable business information that, if analysed correctly and in a timely manner, could improve performance, competitiveness and service. Current approaches to analysing these data require significant expertise and decision support tools to enable implementation. Therefore, the following areas need to be addressed:

- Simple to use tools for the rapid analysis of large volumes and varieties of transport and related data.
- Easy to use software for predictive analytics that can be integrated into IoT, ITS and sensor generated data flows.
- "In line" tools to facilitate dynamic configuration and operational changes based on real time IoT data;
- Visual data analytics tools and approaches to facilitate rapid decision making.
- Robust assessment techniques for data certainty and trust.

• **Dematerialization**. Capabilities to produce end-user products and/or spare parts at the site of their consumption (3D printing) will influence the flow of (raw) material, including recycling of materials, changing how products and parts are distributed and requiring innovative logistic concepts supported with information flows to be developed. Therefore, the following areas need to be addressed:

- Systems for managing highly distributed and disaggregated production operations to ensure that printed components are produced as required.
- Distributed quality control systems that can monitor 3D printing processes, check items that are printed and determine/ensure their quality level based on producer specifications.
- IP management systems that can monitor the use of IP and ensure that proper payment is made to IP owners.
- Automated material ordering, delivery planning, and delivery systems to ensure that the highly distributed production operations enabled by dematerialization processes can be operated and logistically supported in an economical and environmentally sound manner.



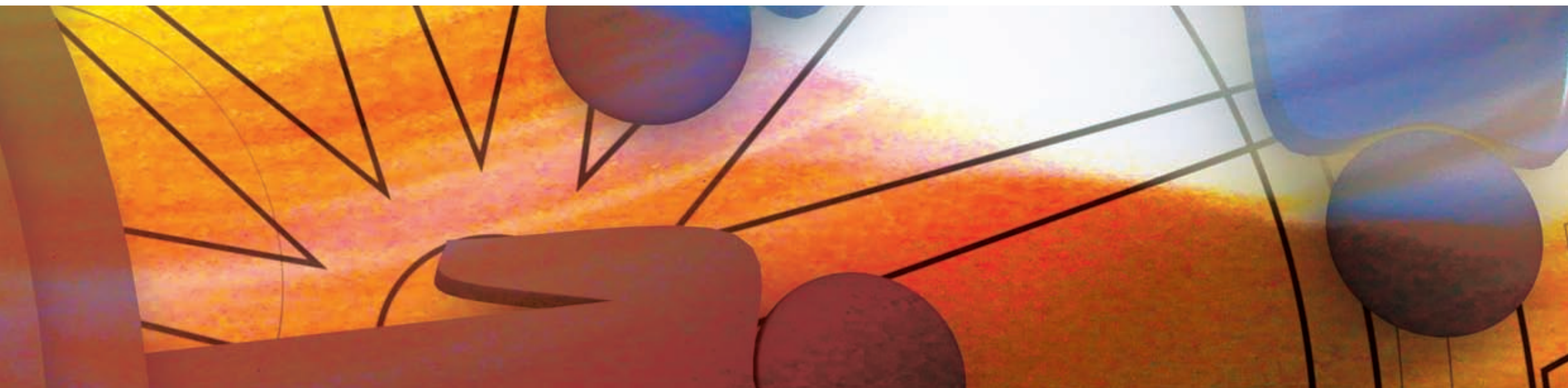
- **Intelligent information nodes**. Congestion, pollution and cost are all driving a need for more efficient mode utilization from transport and logistics operations. Unfortunately, most switching/transfer points for mode switching (hubs) are operated under historical business systems that do not allow them to facilitate "flow through" operations and provide data to the stakeholders operating and coordinating the different transport modes. This must change in order for the vision of synchromodal activities to be realized. Flow synchronization through the various modal switching nodes involved in a supply chain requires new approaches to managing the inflow, outflow and operations within these nodes. Whether the goal is synchromodal operations or the Physical Internet, switching nodes become the locus for ensuring efficient supply chain operations. Software must be developed that allows these switching/transfer points to act like routers and switches in the Internet enabling the implementation of the Corridors, Hubs and Synchromodality roadmap and laying a foundation for the Physical Internet. Therefore, the following areas need to be addressed:

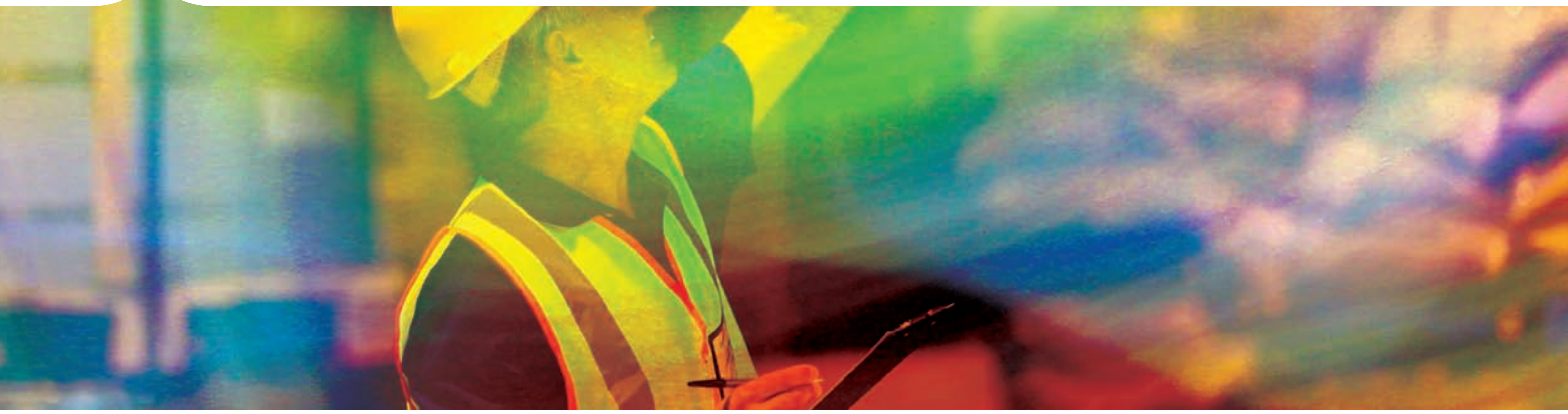
  – Node management software is required to facilitate the efficient and synchronous flow of goods through the various nodes in a network.
  – Routing and planning software to properly route shipments in a dynamic manner across appropriate infrastructures and nodes.
  – Dynamic matching algorithms to rapidly match (changed) goals with available services and capacity.

- **PI support and planning systems**. The PI vision requires a radical rethinking of how supply chains are operated and managed. Systems must be developed that mirror for physical goods movements the movement of packets on the Internet. However, unlike the Internet, these systems must ensure that the physical goods, flowing like packets, do not get lost while in transit. To realize this vision, considerable analysis and research is required. As an initial step in determining what the Physical Internet implies and requires, the following areas need to be addressed:

  – An understanding of the ICT challenges of implementing the PI must be developed. This will require initially:
    - A workable architecture for the PI.
    - Requirements definition for PI related systems.
  – Dynamic human resource management systems to properly assign personnel operating vehicles or node activities to the next scheduled action required by the PI shipment and the system of shipments currently being moved through the network.
  – A layered system model for the management of the PI.
  – Software at each layer, analogous to the digital Internet, for the proper routing, management, flow control, assembly/disassembly of shipments, etc.

- **Logistics BPaaS**. Logistics Business Process as a Service (BPaaS) facilitates the bundling together of several logistics cloud services, or single business processes from different clouds, vendors and providers, to produce a directly useable logistics turnkey application. These services can work across multiple industry sectors, are





highly configurable, scale globally, and are of high performance. BPaaS services require a blend of software and data services, again from different cloud services and providers. The development of robust commercial BPaaS services is in its early stages. Significant work is required to move from the current state to a more flexible and mature state. To accomplish this movement requires the following areas to be addressed:

- BPaaS services need to be developed so that they can operate on federated cloud environments or platforms that can be configured by end-users.
- Software for the dynamic configuration, automated provisioning and orchestration of logistics services needs to be developed.

- **Autonomous logistics operations.** The logistics industry is a promising domain for the use of autonomous systems within controlled areas and corridors, in public spaces and in cooperation with humans. However, for these types of systems to be used in a safe and effective manner, significant technical obstacles need to be overcome. To address these technical issues requires the following:

  - Automation of transport, specifically road/self-driving vehicles, within controlled and public areas to provide a foundation for Automated Transport Systems (ATS)[5].
  - Autonomous technologies in warehousing and for yard logistics, and then for last mile delivery focused on low speed operations.
  - Autonomous logistics for all modes: self-driving vehicles, trucks, trains, ships and planes (long distance and short distance (drones)).
  - Automated transport services based on V2I communications (convergence of connectivity with automation).
  - Automated traffic regulation from traffic management services to enable smoother logistic operations (e.g., platooning).
  - Automated operations for managing the entry and exit of intermodal hubs (e.g., entering, billing, tolling, loading, etc.).
  - Convergence of electro-mobility and automation for logistic operations.
  - Goal modelling across different dimensions (e.g., enterprise internal, across enterprise boundaries, governance by authorities).
  - Development of prescriptive analytics and anomaly detection (machine learning) algorithms to control the actions of autonomous vehicles and robots.

5. An Automated Transport System (ATS) is an innovative holistic mobility concept, where all its different elements (i.e. vehicle, travellers, public transport, infrastructure and operations.

Table 2. ICT Innovation challenges, expected results, drivers, barriers and impacts

RESEARCH CHALLENGES	INNOVATIONS AND EXPECTED RESULTS	DRIVERS FOR CHANGE/ BARRIERS TO OVERCOME	SECONDARY IMPACTS	PRIMARY IMPACTS
Intelligent objects, smart devices, IoT, ITS	Standard communications protocols for inter-device/system communications. Standard interface specifications for rapid connection to Cloud connection "ports". Easy to use tools for connecting and integrating IoT devices/ systems to one another and the cloud. Increased use of IoT devices for the monitoring and management of transport and logistics activities. Handling large amounts of events generated by IoT, including human interaction (collaborative ITS).	Technology improvement reducing cost of this kind of devices as well as other technologies enabling identification of opportunities to increase efficiency. Lack of standards for connection and communication of devices prevent from effectively implements these technologies. Modelling the capability to process large amounts of events generated by IoT and collaborative ITS. Barriers to data sharing – data sharing policies and tools.	+ Supply Chain Visibility. + Asset utilization. + Load factors. + Reliability of transport schedules. + Perfect order fulfilment. + Transport actors using automatic data exchange. + Cargo and logistics units integrated in the automatic data exchange. + Transport routes optimization. - Risk factor reduction.	- Energy consumption. - CO_2 Emissions (kg CO_2/tkm). + Return on assets and working capital. - Cargo lost to theft or damage. - Total supply chain costs.
Big data	Development of simple to use and implement tools for the access and storage and access to data characterized by high velocity, variety and volume. More rapid acceptance and deployment of IoT devices in real applications. New business products based on enriched knowledge gained through data. The ability of all industry players (including SMEs) to gain value out of the use of IoT devices. Easy setup and manage of big data infrastructures.	Development of IoT. Development of Big Data as a concept with applications in many other fields. Finding the right business models to share and use data. Reluctance to share data due to lack of trust and IPR liability, and commercial sensitivity.	+ Supply Chain Visibility. + Asset utilization. + Load factors. + Reliability of transport schedules. + Perfect order fulfilment. + Transport actors using automatic data exchange. + Cargo and logistics units integrated in the automatic data exchange. + Transport routes optimization. - Risk factor reduction.	- Energy consumption. - CO_2 Emissions (kg CO_2/tkm). + Return on assets and working capital. - Cargo lost to theft or damage. - Total supply chain costs.

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RESEARCH CHALLENGES	INNOVATIONS AND EXPECTED RESULTS	DRIVERS FOR CHANGE/ BARRIERS TO OVERCOME	SECONDARY IMPACTS	PRIMARY IMPACTS
Data analytics	Simple to use tools to visualize, analyse, query and understand large volumes of unstructured data. Simple to use tools to develop predictive and prescriptive models, integrate multiple closed and open data sources, and to link to high velocity data streams. New service offerings developed by understanding, in detail, how supply chains are operating and by integrating real time supply chain information with other "open" data sources. Improved operations, efficiency, service levels and costs through a better understanding of drivers of inefficiency in supply chains.	IoT systems will provide supply chain partners with access to information that historically did not exist. Lack of expertise to analysing these data in areas that most supply chain professionals have no background.	+ Asset utilization. + Load factors. + Perfect order fulfilment. + Transport actors using automatic data exchange. + Cargo and logistics units integrated in the automatic data exchange. + Transport routes optimization. - Risk factor reduction. - Lead times. - Empty Kilometres. - Waiting time in terminals. + Upside / Downside Supply Chain Adaptability and Flexibility.	- Energy consumption. - CO_2 Emissions (kg CO_2/tkm). + Return on assets and working capital. - Cargo lost to theft or damage. - Total supply chain costs.
Dematerialization	Faster material lay down speeds to increase productivity. Advanced nozzle and deposition heads to increase capabilities for complex design builds. New material technologies to increase range of possible items produced. Simplified design tools to facilitate rapid design development by novice users. Standards for design software to allow broad sharing of design files.	Advanced printing, sintering, forging and casting technologies promise to deliver lighter, stronger and more complex parts for new, as well as aftermarket and repair markets. Slow speed, complex design tools, limited materials and a lack of design standards create barriers to broad adoption and use.	- Storage space and costs. + Innovations. - Lead times. + Service levels. - Transport requirements.	- CO_2 Emissions (kg CO_2/Km). + Return on assets and working capital. - Capital requirements. + Revenues. - Congestion. - Total supply chain costs.
Intelligent nodes	Lower transfer/switching facility footprints due to higher velocity flow through of goods. More efficient consolidation of goods and routin.	Congestion, pollution and cost are all driving a need for more efficient mode utilization from transport and logistics operations.	+ Reliability of transport schedules. + Transport routes optimization. - Risk factor reduction. - Lead times. - Empty Kilometres. - Waiting time in terminals. + Asset utilization. + Load factors. + Supply Chain Visibility.	- Energy consumption. - CO_2 Emissions (kg CO_2/tkm). + Return on assets and working capital. - Cargo lost to theft or damage. - Total supply chain costs.

RESEARCH CHALLENGES	INNOVATIONS AND EXPECTED RESULTS	DRIVERS FOR CHANGE/ BARRIERS TO OVERCOME	SECONDARY IMPACTS	PRIMARY IMPACTS
PI support and planning systems	Knowledge of the capabilities of a pan-European PI like operation. Development of capabilities of nodes and arcs (/corridors/spokes) for the PI in Europe. Development of an understanding of what would be required to operate a PI like approach to transport and logistics. Develop an understanding of whether a PI like approach is feasible, not only with respect to potential barriers, but also on its stability as a complex system. Develop an understanding of the systems requirements necessary to manage a PI like system. Develop an understanding of how a protocol stack might look for a PI like system. Develop preliminary working models of how the PI might be managed and operated.	e-commerce, new manufacturing technologies including industry 4.0 require for a reviewed logistics system. Big data, robotics, automated transport, etc. will be ready to use technologies supporting a paradigm change. Environment, energy saving and materials scarcity will be drivers to move forward to a more efficient logistics model. A number of current innovations in the market are contributing already to deployment of PI solutions in specific chains (postal services) and operations (e-booking systems, synchromodal services, etc.). Identify appropriate long hanging fruits and short/medium term milestones for PI realization. Many obstacles currently stand in the way of realizing the PI. Much like the development of the Internet, the PI will require considerable research into the management and control approaches employed to ensure the safe, secure, timely and cost effective delivery of goods over shared infrastructures using shared transport, storage and transfer facilities. PI is a breakthrough for logistics impacting on business models and operations. Mental shift and change reluctance.	All listed in table 1.	All listed in table 1.
Logistics BPaaS	Logistics turnkey solutions based on business processes offered from a huge variety of vendors, operators and providers. Development of an ecosystem of platforms/ community systems integrating with peer-to-peer solutions. Development of tools to dynamically configure such a platform to meet customer objectives. Development of an open innovation infrastructure to provide collaborative (involving end-users) applications.	High investment costs for inflexible logistics software. Standards, intrefaces and a common understanding about logistics services, objects and processes are needed. Protocols for interconnection of solutions provided by suppliers (COTS – Commercial Of The Shelf – and open source). Acceptance of a IT as a service. Cyber security (e.g. intrusion detection, identification, etc.).	+ SME involvement. - Congestion. + Load factors. + On time delivery. - Transit times. - Customs delays. + Synchromodality.	+ Revenue. - Risks. + Security. + Collaboration. + Data sharing. + Innovative services. - Integration costs. - Inventory. - CO_2 emissions (kg CO_2/km). - Supply chain costs.

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RESEARCH CHALLENGES	INNOVATIONS AND EXPECTED RESULTS	DRIVERS FOR CHANGE/ BARRIERS TO OVERCOME	SECONDARY IMPACTS	PRIMARY IMPACTS
Autonomous logistics operations	Autonomous operation of logistics systems especially in cooperation with human workers. Self-driving vehicles for all transport modes. Handling large amounts of events generated by all (relevant) logistics and supply chain stakeholders. Development of predictive and prescriptive analytics to improve one's decisions. Development of completely distributed solutions to decrease TCO of solutions with minimal governance. Development of a governance infrastructure piggy backing on trader data.	Communication technology price and connection to the Internet. Reliability and redundancies required to allow robust logistics operations. Communication and process protocols to manage operations such as transhipment, handover of product, loading… High investment costs for static logistics infrastructure. Cost pressure for manually operated vehicles and lack of skilled operators. Interoperability issues across different supply chains and different companies. Legislative framework to allow for automated functions and services on public networks. Proprietary systems that allow little room for services on-top. Evolutions on automated transport wrt vehicle technology, V2V and V2I concepts and services. Interoperability issues related to communication networks and information platforms. Sensors networks, lack of plug and play concepts for sensors, high cost. The ability to create a stable system based on individual decisions of stakeholders. Protocols and rule languages to configure all individual stakeholders. Adoption of solutions by all relevant stakeholders. The ability for seamless, predictable trade flows. To handle increased volumes of trade flows within the boundaries of the current system (e.g. port/hub facilities, transport corridors, transport capacity).	+ Load factors: weight and cube fill of vehicles. + Volume flexibility (Time to +/- capacity). + Asset utilization. + Supply Chain Visibility. + Reliability of transport schedules. + Perfect order fulfilment. + Transport routes optimization (reducing kms). + Transport actors using automatic data exchange. + Cargo and logistics units integrated in the automatic data exchange. + Upside / Downside Supply Chain Adaptability and Flexibility. - Empty Kilometres. - Waiting time in terminals. - Risk factor reduction. - End-to-end transportation time.	+ Increase customer satisfaction. - CO_2 Emissions (kg CO_2/tkm). + Return on assets and working capital. + Overall increase on efficiency and optimisation of Logistic operations. - Cargo lost to theft or damage. - Total supply chain costs.

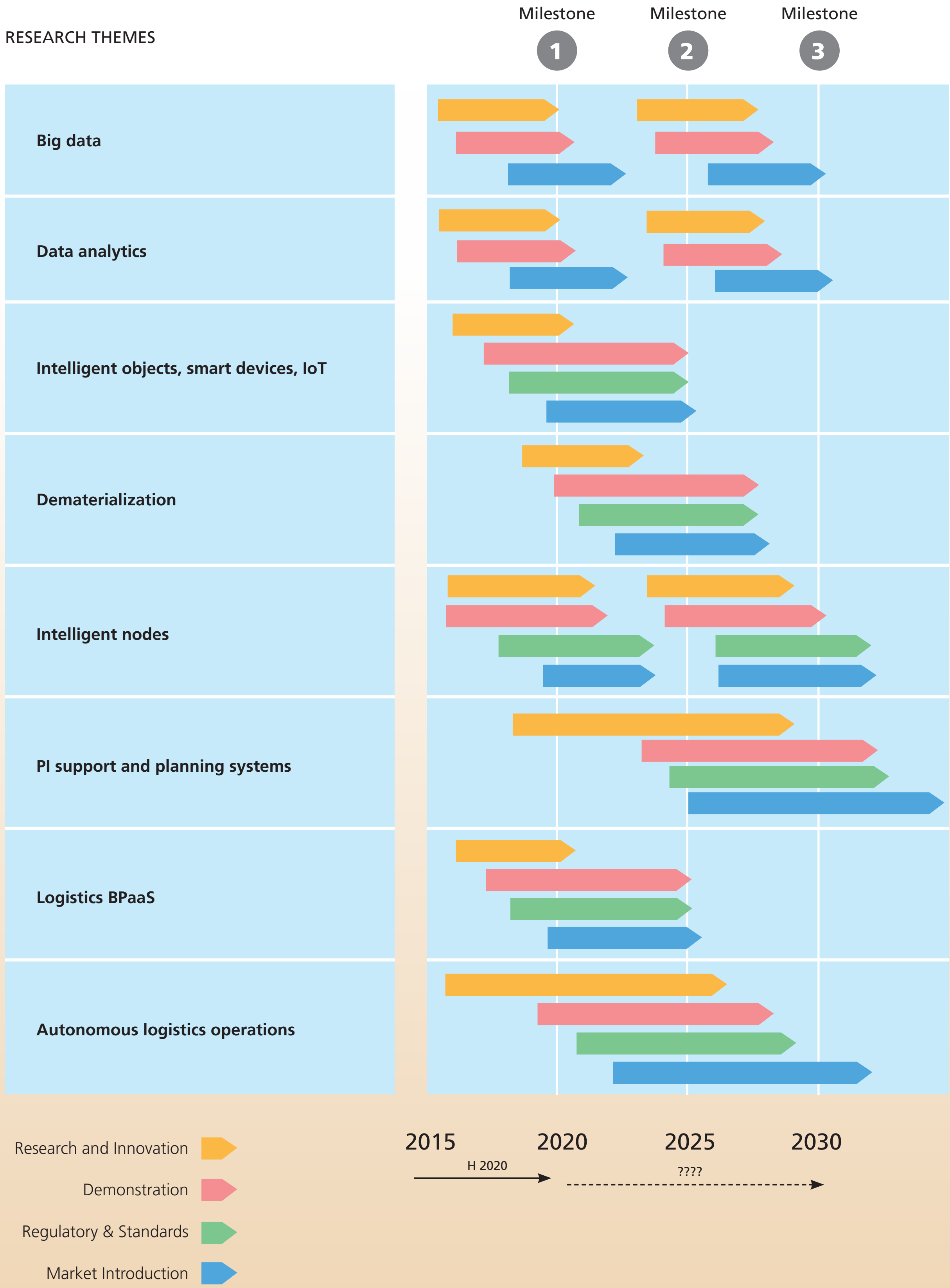

Figure 3: **ICT innovation timelines**

2.2

New Business Models

Today's approach to the management of ICT systems can best be described as a private ownership approach. Each individual player in a supply chain operates their own ICT systems connecting to external systems through bilaterally agreed connectivity (EDI) links. This structure to the management of ICT has benefited the software industry, as well as those domain participants with the financial and technical resources necessary to employ this business model. Unfortunately, new business models and governance will be required in the future as proposed in Global Supply Network Coordination and Collaboration roadmap if the goals set for the industry are to be achieved. To improve operating efficiencies and lower social and environmental impacts will require the industry to better utilize assets, improve coordination, openly share information and generally operate in a more collaborative manner. Models will need to be developed on how assets are to be shared, how asset owners are to be compensated for asset use, how access to infrastructures is to be managed, how nodal/chain/corridor/network operators are to coordinate flows through their nodes/chain/corridor/network, and how logistics customers are to bundle their supply flows. These requirements lead to the following themes that will need to be addressed to achieve the goals of the industry stakeholders developing appropriate ICT to support the following areas addressed from the organizational perspective in the Global Supply Network Coordination and Collaboration roadmap:

- **Increase asset and infrastructure utilization by Sharing**. Business as usual will not result in the dramatic reductions in resource usage that is required to meet mandated improvements in logistics operations. Sharing of assets to improve their utilization and lower requirements for additional assets (pooling) is needed if there is to be any chance of meeting these targets. To achieve a shared asset model will require significant business model and process modification, which may not be possible given existing approaches to measuring business performance. ICT will need to support this change by developing:

- Pooling, controlling and asset management tools.
- Open systems management tools.
- Nodal management systems (e.g., warehouse and port nodal systems) constructing an information network for logistics and supply chains.
- Corridor, suburban and urban flow management systems.

• **Collaboration Tools**. New interoperable platforms for collaboration are required so that assets can be shared and compensation for use realized. These collaborative platforms need to be easy to use, to integrate communication and information sharing services, operate in a quick to connect manner, and provide appropriate tools so that collaborators can accomplish their tasks in a convenient and timely manner. Therefore, the following areas need to be addressed.

- Marketplace and matchmaking tools (including algorithms).
- Service/business capabilities repository.
- Detailed assessment of strengths, weaknesses, opportunities, and threats for PI within present market structures and business models.
- Process innovation (models & best practices) that show how a transition from present to large-scale collaboration (involving PI) can be made.
- Analytics, trust rating, and performance tools to rapidly assess trustworthiness of a stakeholder.
- Open collaboration platforms for dynamically establishing collaborations.

• **Revenue/Gain sharing**. New systems will be required to determine how to fairly distribute revenues from shared assets and any bonuses or penalties incurred during the execution of a supply chain activity. Potential examples are the systems used in mobile telecommunications where service providers collect information on roaming usage of their networks and cross bill "home" providers.

- Tools to manage and control sales, use and share revenue and costs.
- Contract development and management tools.
- Inter-platform/inter-community management and revenue sharing tools.

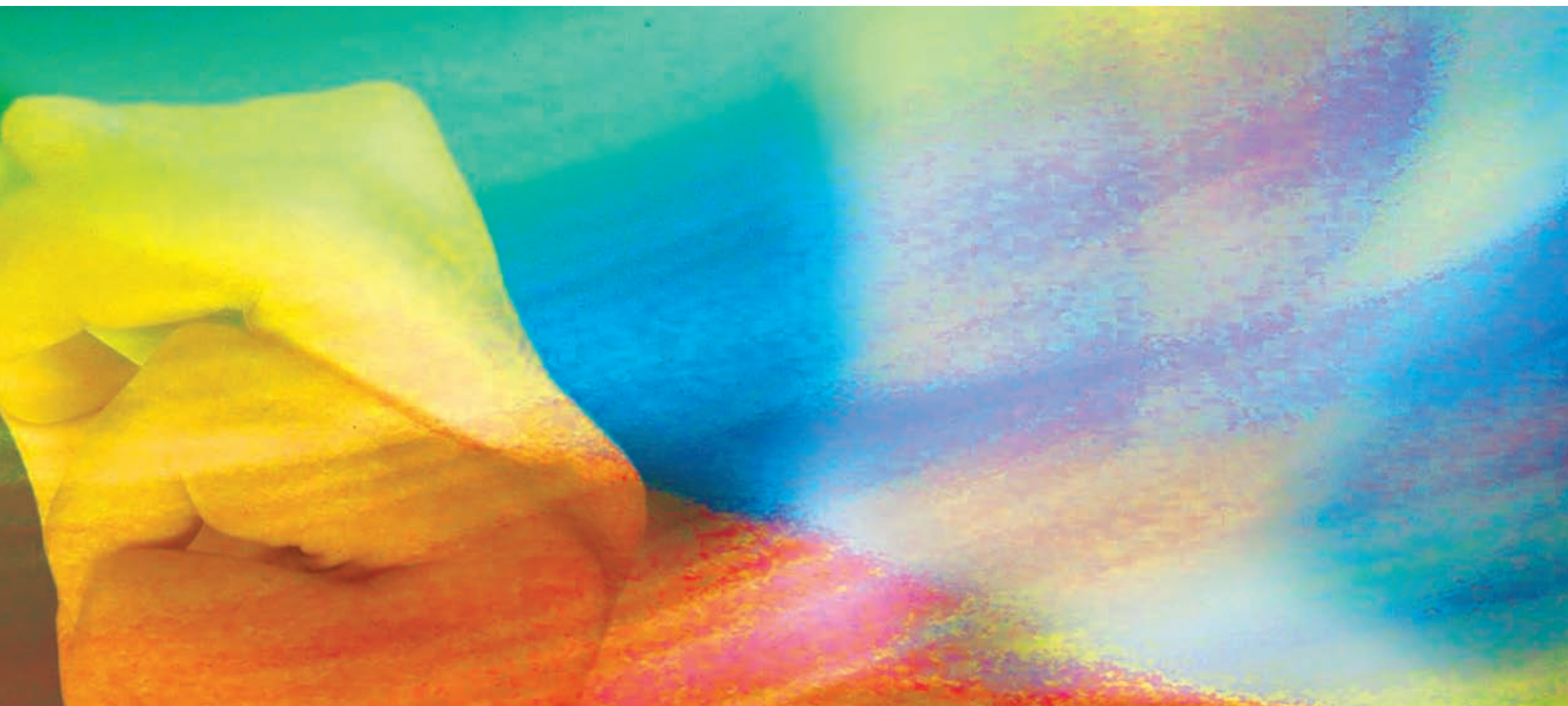

Table 3. New business models challenges, expected results, drivers, barriers and impacts

RESEARCH CHALLENGES	INNOVATIONS AND EXPECTED RESULTS	DRIVERS FOR CHANGE/ BARRIERS TO OVERCOME	EXPECTED SECONDARY IMPACTS	EXPECTED PRIMARY IMPACT
Increase asset utilization by sharing	ICT supporting business models that address existing concerns about sharing assets, comingling of competitor goods, integrating and synchronizing operations and sharing the value from a shared asset approach to business. ICT supporting implementation of business models to share assets within and across supply chains.	Increase of fuel prices, scarcity of resources. Trust building.	+ Asset utilization. + Load factors. + Transport routes optimization. - Empty Kilometres.	- Energy consumption. - CO_2 Emissions. + Return on assets and working capital. - Cargo lost to theft or damage. - Total supply chain costs.
Collaboration Tools	New platforms for collaboration are required so that assets can be shared and compensation for use realized. These platforms need to be easy to use, operate in a quick to connect manner, and provide appropriate tools so that collaborators can accomplish their tasks in a convenient and timely manner. Development of new partners and novel approaches to provide logistics services. Expansion of networks for SMEs logistics horizontal collaboration. Better deployment of IoT devices to enhance the management and control of ad hoc collaborative supply chain operations. Open solutions for trust building and performance indicator.	Businesses have spent considerable sums on building their proprietary and closed networks. The advantages to open, collaborative platforms for conducting supply chain operations will have to be clearly demonstrated to gain their support for such a different model of business. Increased willingness to share assets based on a mutual understanding of benefits, ease of use, and flexibility of operations.	+ Asset utilization. + Load factors. + Transport routes optimization. - Empty Kilometres.	- Energy consumption. - CO_2 Emissions. + Return on assets and working capital. - Cargo lost to theft or damage. - Total supply chain costs.
Revenue/ Gain sharing	Increased trust between partners. Reduced asset accumulation. More efficient use of existing and future resources. ICT tools for the implementation of shared asset business model: Fair and equitable distribution of revenues, bonuses and penalties to supply chain partners.	Without a proven system for obtaining appropriate compensation for the shared use of assets, asset owners will not share their assets. There must be a clear and demonstrated approach that is fair, robust and trusted if this concept is to be accepted.	+ Asset utilization. + Load factors. + Transport routes optimization. - Empty Kilometres.	- Energy consumption. - CO_2 Emissions. + Return on assets and working capital. - Total supply chain costs.

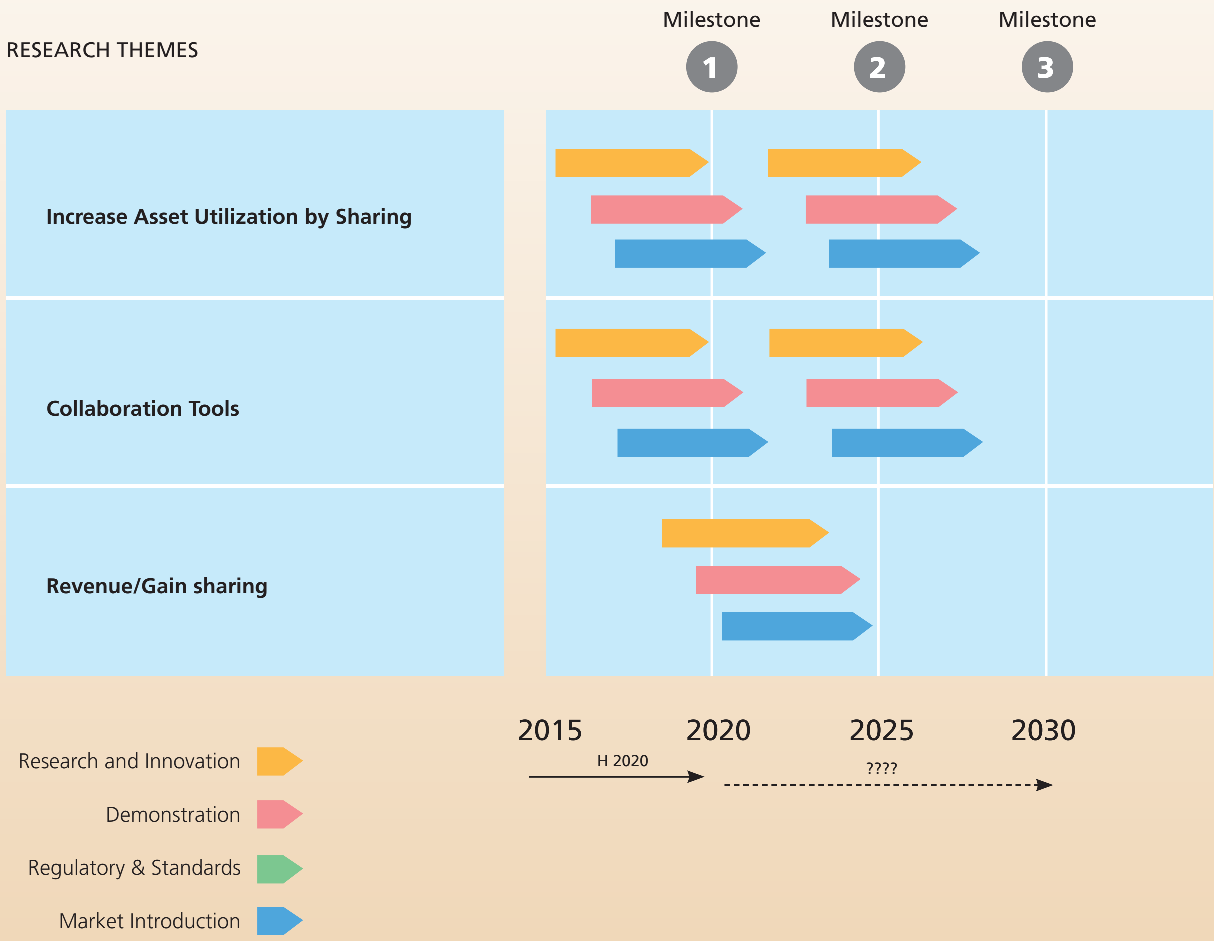

Figure 4: **Business Models timelines**

2.3

Data Governance

The requirement to more efficiently utilise assets leads to a more collaborative approach to operations and, therefore, to the more open sharing of data between supply chain partners. For partners to agree to share the information needed to make this business model work, they must feel that their data is being securely managed and that only those organizations that are authorized to view the data have access to it. This means that significant work must be done on the issues of security, privacy and trust or domain players will not be willing to provide the data needed to make the collaborative business model envisioned in ALICE work. The following themes will need to be addressed to ensure domain participants that their data is secure:

- **Security, privacy and trust**. To allow novel new interactions between supply chain partners, it is crucial to ensure conditions to achieve trust in open systems. Therefore, the following confidentiality, integrity and authentication (CIA) areas need to be addressed.
  - Access and authentication services.
  - Data Integrity and recovery, roll back and resumption services (non-repudiation services).
  - Data privacy and security.

- **Data ownership**. To be able to identify any opportunities and/or barriers in sharing data and events across the boundaries of an organization.
  - IPR management services.
  - Data rights management services.
  - Data location reporting and management.
  - Liability and commercial sensitivity.

- **Information & data sharing policies**. Establishing policies with respect to sharing data and events across the boundaries of an organization. Different data/event classifications can be established, e.g. open/public, restricted to a community in a specific area (terminals in a port or a particular authority), restricted to a specific relation, or only accessible within an organization.
  - Tools for the collection, distribution, management, and analysis of data.
  - Information semantics and ontology systems.
  - Protocols for establishing data/event sharing.
  - Data access rules, encryption and authentication/authorization.
  - Service Level Agreement (SLAs).
  - Data/event classification services.
  - Information sharing through ITS.
  - Data quality and metadata services.

- **Supportive legal and regulatory practices**
  - Legal/Policy frameworks (e.g., Union Customs Code, SAFE Framework of Standards).
  - Cross border data requirements.
  - Common and transparent behavioural rules.
  - Trusted trader certificate programmes (e.g., AEO, C-TPAT).
  - Coordinated Border Management (CBM).
  - System-Based Control/Audit.

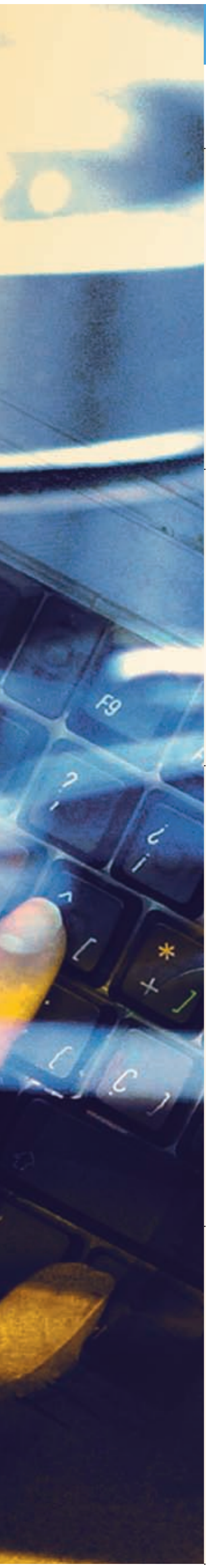

Table 4. Data Governance innovations expected results, drivers, barriers and impacts

RESEARCH CHALLENGES	INNOVATIONS AND EXPECTED RESULTS	DRIVERS FOR CHANGE/BARRIERS TO OVERCOME	EXPECTED SECONDARY IMPACTS	EXPECTED PRIMARY IMPACT
Security, privacy and trust	Improved security for inter-firm transmission of data. Improved reliability of cloud based services for transmission failures and proof of message delivery. Greater security and privacy in the transmission of confidential company information. Greater willingness of corporate users to use open platforms for the conduct of business.	Current cloud based security approaches are not trusted for the transmission of sensitive data. This has to be overcome for commercial entities to accept the use of open platforms for the operation of their supply chains.	- CO_2 emissions (kg CO_2/km). + SME activities. - Risk. - Legal involvement.	+ Collaboration. + Data sharing. + Innovative services. + Revenue. - Operating costs. - Supply chain costs.
Data ownership	Accurate definition of ownership is needed to enable data sharing without compromising business privacy. Capability to assess the impact of data sharing. Understanding of the impact on sustainability, synchromodality, and compliance on data sharing. Business models for data sharing, addressing aspects of third party data.	The ability to disclose any commercial sensitive and liable data based on data of different sources. Multi attributes data to share among users where some of them are discovered during the operations. Automatic inheritance and transfer of ownerships among supply chain actors.	- CO_2 emissions (kg CO_2/km). + SME activities. - Risk. - Legal involvement.	+ Collaboration. + Data sharing. + Innovative services. + Revenue. - Operating costs. - Supply chain costs.
Information & data sharing policies	Capability to configure and manage data sharing with partners. Different levels of data sharing: open/public data, data shared with one. Revenue Sharing mechanisms for data sharing among parties in the supply chain. Guidelines for setting up neutral private-public governance boards to support agreement on revenue sharing mechanisms for data sharing among all parties in the supply chain ((e.g. freight forwarders, carriers, stevedores, shippers, port community systems, border control agencies etc.).	Protocols for data – and event sharing. Willingness by organizations to share data. Ease of use of data based on semantics and infrastructure capabilities (transformation services). Data sharing between various parties in the supply chain will not happen unless adequate revenue sharing mechanisms are agreed to by these parties. Typically this agreement can only be achieved by establishing a (national) neutral private-public governance board.	- CO_2 emissions (kg CO_2/km). + SME activities. - Risk. - Legal involvement.	+ Collaboration. + Data sharing. + Innovative services. + Revenue. - Operating costs. - Supply chain costs.
Supportive legal and regulatory practices	Propose amendments in legal frameworks (e.g., Union Customs Code, WCO SAFE Framework of Standards) to ease restrictions on data sharing among supply chain partners (including government agencies) when that supports more efficiency in the supply chain (e.g. better planning, synchromodality etc.). enable re-use of business data for government control purposes; which enables system-based auditing, coordinated border management and AEO.	Cross border harmonization of regulations will increase trade and lower overall costs for supply chain operations. Differences in country perceptions of data security and privacy requirements create significant hidden barriers to efficient supply chain operations and reduce the willingness for LSPs to collaborate.	- Legal costs. + SME involvement. + Customer service.	+ Collaboration. + Data sharing. + Innovative services. + Revenue. - Supply chain costs.

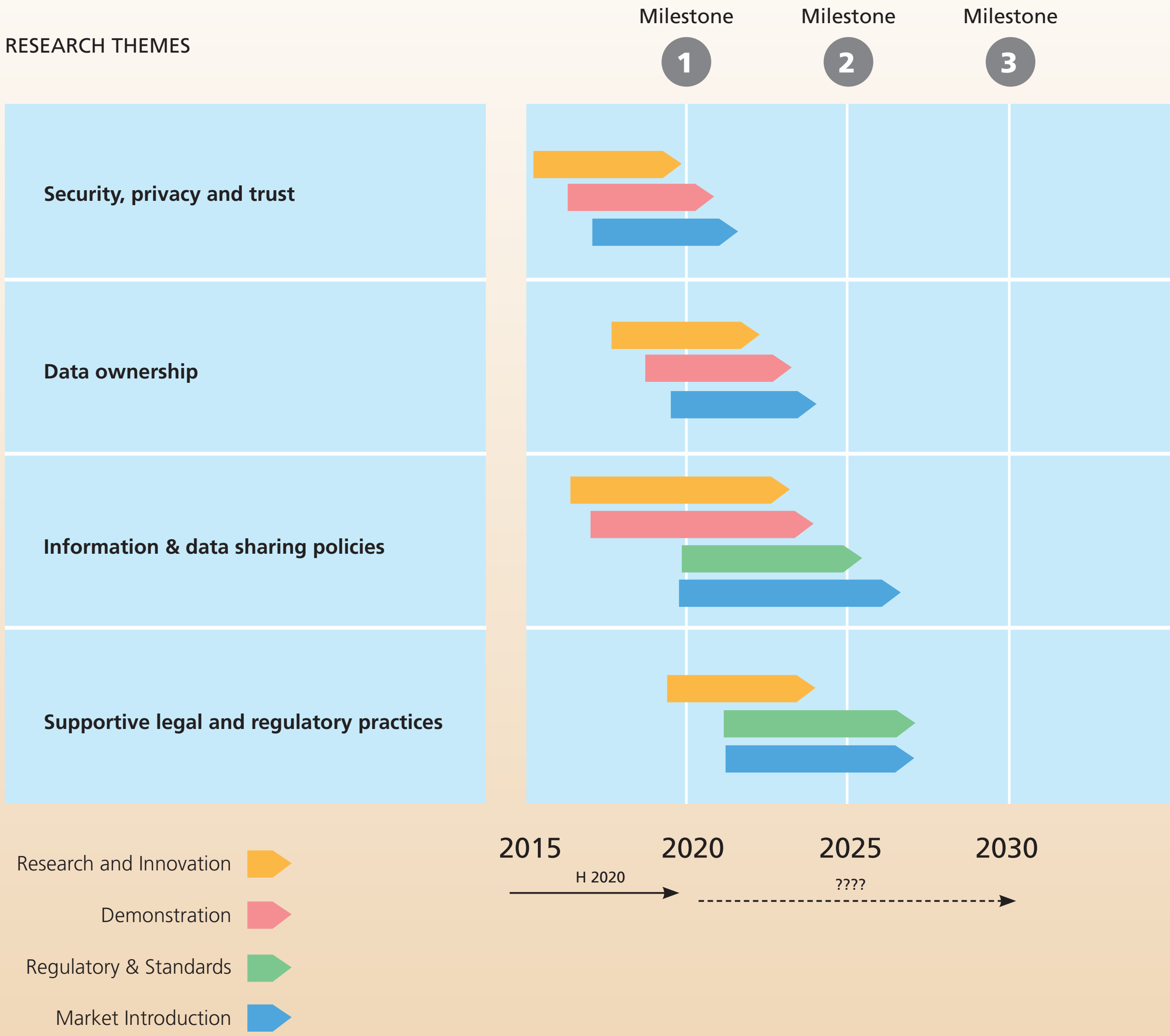

Figure 5: **Data governance timelines**

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Annex 1

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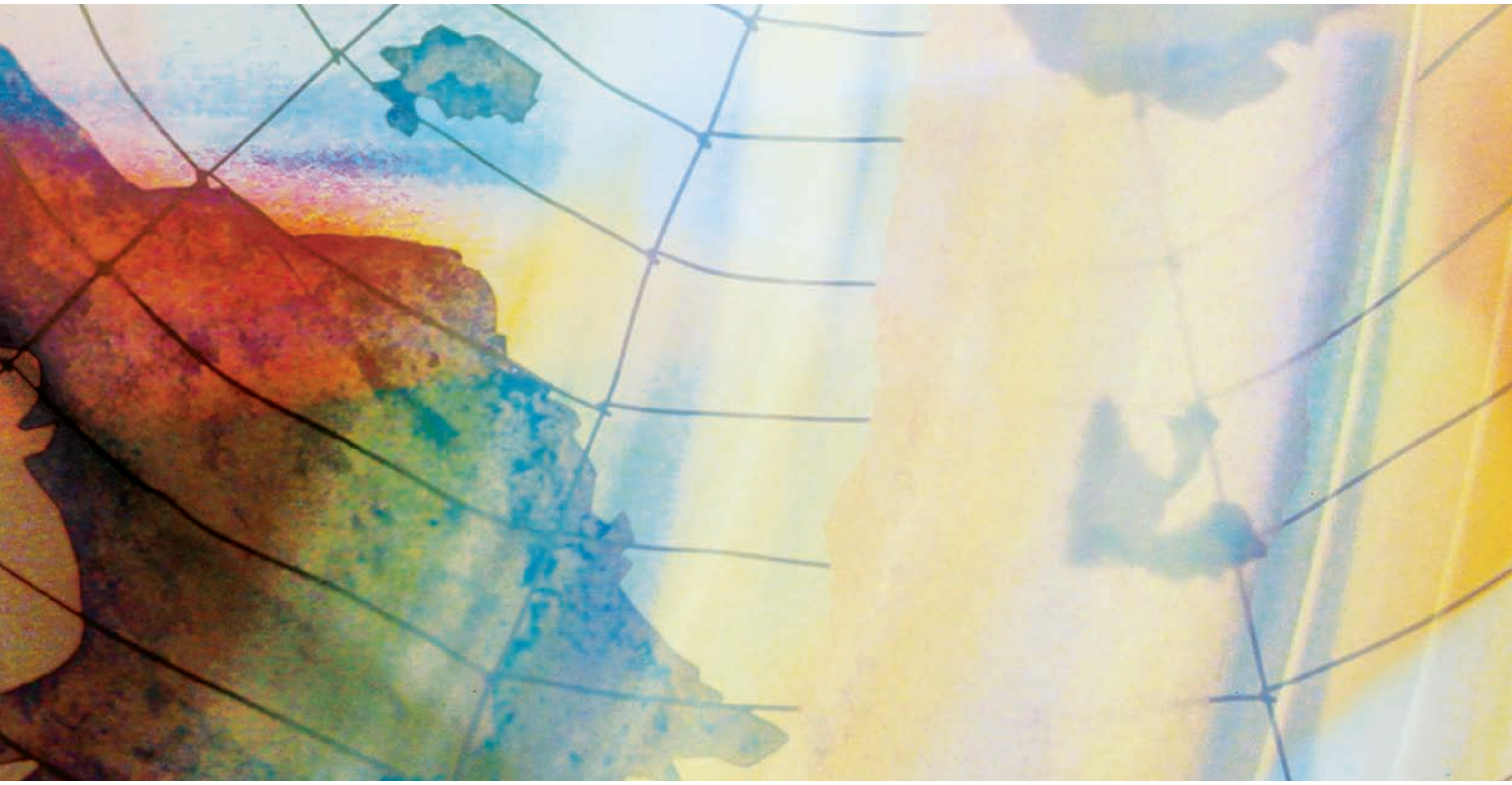

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Annex 2

Overview of relevant projects and initiatives

ACRONYM	FULL TITLE	DESCRIPTION	DURATION	WEBSITE	EU/ NATIONAL INITIATIVE
COMCIS	Collaborative Information Services for Container Management.	COMCIS is a collaborative project between multiple transport and logistics actors that generates situational awareness along global supply chains in support of enhanced logistics services. Intelligent Cargo capabilities demonstrated in a number of cases: Cargo status monitoring, Exception management, Automated security check, Parking management, Theft protection.	2011-09-01/ 2013-08-31	www.comcis.eu	EU-FP7
CASSANDRA	Common assessment and analysis of risk in global supply chains.	The CASSANDRA worked to make container security more efficient and effective. The project addressed the visibility needs of both business and government in the international flow of containerised cargo by developing a data sharing concept that allows an extended assessment of risks by both business and government. CASSANDRA builds on previous EC FP7 projects INTEGRITY, SMART-CM and ITAIDE.	2011-06-01/ 2014-08-31	www.cassandra-project.eu	EU-FP7
INTEGRITY	Intermodal global door-to-door container supply chain visibility.	INTEGRITY intended to significantly improve the reliability and predictability of door-to-door container chains. Kernel of the project was the development of the so-called Shared Intermodal Container Information System (SICIS) allowing authorised companies and authorities to access planning and status information of selected transports.	06-2008 / 10-2011	www.integrity-supplychain.eu	EU-FP7
SMART CM	Smart container chain management.	SMART CM aimed to make trade and transport more efficient, secure, visible and competitive across the world in a global intermodal context, working along with existing initiatives such as that of AEO and the Green Lanes implementation. It includes two real-life demonstrators: • Corridor A: Antwerp-Port Said - feeder service to Thessaloniki – Dubai - NAVA SHEVA / Mundra. • Corridor B: Antwerp-Singapore - feeder service to Laem Chabang in Thailand and Ningbo in China.	2008-08-01/ 2011-10-31	www.smart-cm.eu	EU-FP7

ACRONYM	FULL TITLE	DESCRIPTION	DURATION	WEBSITE	EU/ NATIONAL INITIATIVE
iCargo	Intelligent Cargo in Efficient and Sustainable Global Logistics Operations.	The iCargo project aims at advancing and extending the use of ICT to support new logistics services that: • Synchronize vehicle movements and logistics operations across various modes and actors to lower CO_2 emissions. • Adapt to changing conditions through dynamic planning methods involving intelligent cargo, vehicle and infrastructure systems. • Combine services, resources and information from different stakeholders, taking part in an open freight management ecosystem.	2011-11-01/ 2015-04-30	i-cargo.eu	EU-FP7
e-freight	European e-freight capabilities for co-modal transport.	It worked to create the appropriate framework to allow tracing goods in real time, ensure intermodal liability and promote clean freight transport: 1. A standard framework for freight information exchange covering all transport modes and all stakeholders. 2. A single European transport document for all carriage of goods, irrespective of mode should be developed along with all the necessary legislative support. 3. A single window (single access point) and one stop shopping for administrative procedures in all modes.	2010-01-01/ 2013-06-30	www. efreightproject. eu	EU-FP7
CONTAIN	Container Security Advanced Information Networking.	CONTAIN aimed at specifying and demonstrating a European Shipping Containers Surveillance system in a global context which will encompass regulatory, policy and standardisation recommendations, new business models and advanced container security management capabilities.	2011-10-01/ 2015-03-31	www. containproject. com	EU-FP7
DISCWISE	Digital Supply Chains for European SMEs based on the Freightwise Framework.	DiSCwise was a European demonstration action aiming to improve the competitiveness of the transport & logistics sector in Europe, through the smart use of ICT. It seeks to improve the supply chain management in the sector and get stakeholders more connected, in particular smaller sized enterprises, by assisting their integration into efficient co-modal supply chains. This will help smaller enterprises in the transport and logistics sector to connect efficiently with key market actors and thus emerge to global business players.		www.discwise. eu	EU
RISING	RIS services for improving the integration of inland waterway transports into intermodal chains.	RISING has the overall objective of identifying, integrating and further developing information services such as River Information Services (RIS) in order to efficiently support Inland Waterway Transport (IWT) and logistics operations.	2009-02-01 / 2012-01-31	www.rising.eu	EU-FP7

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ACRONYM	FULL TITLE	DESCRIPTION	DURATION	WEBSITE	EU/ NATIONAL INITIATIVE
EURIDICE	European inter-disciplinary research on intelligent cargo for efficient, safe and environment-friendly logistics.	EURIDICE was an Integrating project that set out to create the necessary concepts, technological solutions and business models to establish an information services platform centred on the context of individual cargo items and their interaction with the surrounding environment and the types of users. The project is built upon the Intelligent Cargo (IC) concept, in which services can be instantly combined in relation to the capabilities of self awareness, context awareness and connection through a global telecommunication network to support a wide range of information services. This leads to a paradigm change, and will have a large impact on organisational structures within the supply chain. The implementation of an innovative technology and new organisational structures generates new requirements in the competencies of involved staff.	02-2008 / 10-2011	www.euridice-project.eu	EU-FP7
FREIGHTWISE	Management Framework for Intelligent Intermodal Transports.	FREIGHTWISE's overall objective was to support the modal shift of cargo flows from road towards intermodal transport using short sea shipping, inland waterways and rail; facilitated by improved management and exchange of information between large and small stakeholders across all business sectors, transport modes and administrations.	2006-10-30 / 2010-04-29	http://freightwise.tec-hh.net	EU-FP6
EasyWay	European ITS Platform.	The EasyWay project included the road authorities from 27 member states. The main objective was to facilitate a harmonized deployment of ITS services on the Trans-European Road Network. The European ITS Platform (EIP) is the follow-up project.		http://www.easyway-its.eu	European Commision, DG Move
MOBINET	The Internet of Transport and Mobility.	It is an Internet-based network linking travellers, transport users, transport system operators, service providers, content providers and transport infrastructure. It connects users (people, businesses, objects) with suppliers (operators, providers, systems), and brokers (or helps to broker their interactions). At its core is a "platform" providing tools and utilities to enable those interactions, with components both for users and for suppliers.	2012-11-01/ 2016-08-31	http://www.mobinet.eu	EU FP7

ACRONYM	FULL TITLE	DESCRIPTION	DURATION	WEBSITE	EU/ NATIONAL INITIATIVE
CO-GISTICS	Cooperative logistics for susainable mobility of goods.	CO-GISTICS is the first European project fully dedicated to the deployment of cooperative intelligent transport systems (C-ITS) applied to logistics. CO-GISTICS services will be deployed in 7 logistics hubs, Arad (Romania), Bordeaux (France), Bilbao (Spain), Frankfurt (Germany), Thessaloniki (Greece), Trieste (Italy) and Vigo (Spain).	2013-02-01/ 2016-01-31	http://cogistics.eu	
LOGICON	Lean Secure and Reliable Logistic Connectivity for SMEs.	LogiCon aims at setting up, testing and facilitating the adoption of low-cost, low-barrier data connectivity solutions. The above activities will be carried out in four national living labs, each one with specific objectives, dealing with three main challenges: 1) enabling connectivity; 2) engaging communities, either cargo communities around port and inland terminals or business networks run by large companies,; 3) prepare for cooperation in a global freight management ecosystem, foreseen for the future, where capacity will be optimized and flows will be synchronized among the different involved actors.	2013-09-01 / 2015-08-31	http://www.logicon-project.eu	EU FP7

Project ended

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