alice | Alliance for Logistics Innovation through Collaboration in Europe

Sustainable, Safe and Secure Supply Chain research & innovation roadmap

Status: Draft

Version: October 2014

Date: 25.10.2014

Author: ALICE Sustainable, safe and secure supply chains WG

Executive summary

Many of the supply chain principles and logistics solutions applied today were developed in an era in which sustainability, safety and security were not paramount determinants. In this paper we sketch the context in which companies operate their supply chains in the 21st century. We have identified that resource scarcity, demographic trends, safety concerns and security threats at global, regional and local level span the space of feasible supply chain design, planning, control and execution solutions. An important objective is to reconcile economic sustainability with requirements based on ecological and social considerations. The more holistic supply chain point of view we take in this paper implies that we also investigate how to reduce transport without sacrificing value creation. Dematerialization, 3D-printing, postponement of final product assembly, reshoring and local sourcing may all significantly contribute to transport reduction. Apart from pure sustainability aspects, transport reduction may also help to enhance security and safety, after all *"cargo in transport = cargo at risk"* while *"less transport = less accidents"*. Where these concepts fulfill in maintaining the corresponding value chains, the take up and deployment of these transport reduction concepts should be accelerated. In any case, we should aim for sustainable, safe and secure supply chains, including all transport modes. Fundamental in this paper is the notion that the design of sustainable logistic systems not just depends on policies of transport and logistics service providers, but also crucially on decisions made by shippers and manufacturers (local versus global, product modularity, re-use of materials and components, item and package integrity) as well as by authorities' and governmental regulations. The same applies to supply chain security. Supply chain risk management can benefit from collaborative chain controls, contributing to lean, agile and resilient supply chains, whilst border agencies could develop new supervision models recognising this resulting in minimising interventions and burden for these trusted supply chains. In addition, the increasing awareness of society (i.e., the final consumer) on the wide range of activities and operations behind product and services can lead consumers toward more responsible and sustainable choices, with crucial impacts and effects on the sustainability of the whole supply chain.

We have attempted to define a reference framework from which supply chain sustainability, safety and security in a broad sense (i.e. economically feasible, environmentally friendly, climate neutral, safe for workers and society, and well protected against external threats of various kinds) can be systematically addressed, as a basis for further elaboration and finally definition of a comprehensive roadmap. The trends detected are unmistakable and may only increase in the near future. New solutions to design, and manage sustainable, safe and secure supply chain processes are urgently needed, to ultimately contribute to a sustainable and high quality of future life.

Table of contents

Table of figures

1 Introduction

The European Technology Platform ALICE, Alliance for Logistics Innovation through Collaboration in Europe, was launched on June 11, 2013, and received official recognition from the EC in July 2013[1]. ALICE has been set-up to develop a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovation 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.** PI is pursuing an open global logistic system founded on physical, digital, and operational interconnectivity, through encapsulation, interfaces and protocols design, aiming to move, store, realize, supply and use physical objects throughout the world in a manner that is economically, environmentally and socially efficient and sustainable.

ALICE has identified five different areas that need to be specifically analysed and addressed in terms of future research and innovation needs to achieve its mission. These areas are:

- Sustainable, Safe and Secure Supply Chains
- Corridors, Hubs and Synchromodality
- Information Systems for Interconnected Logistics
- Global Supply Network Coordination and Collaboration
- Urban Logistics

Five different Working Groups have been launched, one in each of these areas to further analyse and define research and innovation strategies, roadmaps and priorities agreed by all stakeholders to achieve ALICE Vision and Mission.

This document is the research roadmap in the field of ***Sustainable, safe and secure supply chains.*** Note that certain safety and security risks, as well as sustainability topics are strongly transport related and hence will also dealt with by other, primarily transport oriented, roadmaps. However, whenever decisions at earlier and later stages in the supply chain have a profound impact on sustainability, safety and security, they will be the topic of research in this roadmap.

While ALICE is a European Platform all efforts should be made to open up the scope of every project to International Collaboration. Moreover, projects addressing research areas identified in this roadmap should comply with the following characteristics:

- Extensive use of Pilots and Proof of Concepts.
- Clear definition of the operational framework assumptions of all new solutions.

[1] STRATEGY FOR EUROPEAN TECHNOLOGY PLATFORMS: ETP 2020. SWD (2013) 272 final. Brussels, 12.7.2013

- Information and results sharing of projects to clearly map advances in roadmap implementation and new gaps identified. This process should be supported by ALICE.

In this document, we describe a vision on Supply Chain sustainability, safety and security in view of a number of societal developments that are challenging both the public and private sector, and in particular Global Supply Chains and Logistics. These challenges are briefly summarized in key words such as resource scarcity and pollution, demographic changes and increased safety concerns and security threats. Sustainable and resilient/robust global supply chains are a key condition to maintain and distribute welfare and prosperity to both developed and developing countries and hence we have to find ways to cope with these challenges.

That research in this area is urgently needed is also demonstrated by some key figures. While the European Committee has set clear targets to reduce Greenhouse Gas Emissions (GGE) in 2015 to 60 % as compared to 1990, we observe that the percentage of transport related GGE has increased from 25 % in 1990 to 36 % currently. Intensified global logistics has also increased security vulnerability, as outlined in detail Section 2.2 of this paper, while both volume and speed increase has introduced additional safety risks. A unifying approach to all these challenges is that successful solutions are almost always characterized by a combination of addressing and mitigating the (sustainability or security) threats, as well as delivering lean, agile, sustainable, resilient and profitable supply chains for business. In other words, sustainability, security and economy need to go hand in hand.

Based on this vision, subsequently a first roadmap is drafted that may serve as a basis for projects aiming to develop sustainable, safe and secure supply chains that effectively address these challenges. This roadmap is primarily intended to show a likely path to develop, implementing and making better use of concepts and innovations supporting sustainable supply chains and handling the challenges identified in the scoping paper for WG1. These innovations should be nurtured by extensive scientific research, based on excellent education for all ages and for all professions.

Managing Transportation

Before describing a vision on sustainable, safe and secure supply chains, it is important to clearly outline where our starting point differs from those of primarily transport oriented roadmaps. The more holistic supply chain point of view we take in this paper implies that we also investigate how to reduce unnecessary transport without sacrificing value creation. Dematerialization, 3D-printing, postponement of final product assembly, reshoring and local sourcing may all significantly impact to transportation. Apart from pure sustainability aspects, careful management of transportation may also help to enhance security and safety, after all *"cargo in transport = cargo at risk"* while *"less transport = less accidents"*. From a supply chain and logistics point of view, the use of transportation where it is really

necessary should be a driving force. In any case, we should aim for sustainable, safe and secure supply chains, including all transport modes.

Fundamental in this paper is the notion that the design of sustainable logistic systems not just depends on policies of transport and logistics service providers, but also crucially on decisions made by shippers and manufacturers (local versus global, product modularity, re-use of materials and components, item and package integrity) as well as by authorities' and governmental regulations. In addition, we emphasize the often neglected role of society in supply chain management. The increasing awareness of society (i.e., the final consumer) on the wide range of activities and operations behind product and services can lead consumers toward more responsible and sustainable choices, with crucial impacts and effects on the sustainability of the whole supply chain.

Structure of the document

This document is structured as follows. We start with some terminology and definitions on supply chains and logistics, to clearly define the scope of both concepts and as such to provide a common understanding. Next, we briefly highlight the various faces of sustainability and safety/security, after which we discuss major societal trends and challenges that will have a profound impact on global supply chains and logistics. The main part of this document consists of a proposal for an initial framework to address these challenges, to be further discussed within ALICE and particularly WG1.

1.1 Expected impacts of research and innovation activities in Information Systems for Interconnected Logistics

In order to define what research is needed in the area of Sustainable, Safe and Secure Supply Chains, 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. Theses 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.

	Primary Impacts	Secondary impacts
People	+ Customer satisfaction + Products availability + Secure societies	+ 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
Planet	- Energy consumption (kWh Logistics/GDP) + Renewable energy sources share - CO_2 Emissions (kg CO_2/tKm)	

Profit	+ Return on assets and working capital - Cargo lost to theft or damage - Total supply chain costs	+ 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

The use of information 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 and computing 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, high costs, conflicting regulatory requirements, incompatible business processes, and outdated business practices.

Improvements in information and computing technologies, via simplification and standardization, business practice revisions, and business process harmonization 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 how these networks are used (through better data analytics), additional improvements in efficiency and operations should be achievable.

1.2 Background

1.2.1 Supply chain and logistics systems

A supply chain concerns the entire production and distribution chain from raw materials to final customer and finally "reverse logistics": taking back products and possible re-use of materials or components (the so-called closed loop supply chain). A logistic system is a way to view logistics operations as a system of processes and activities, whereby the interaction and interrelation between those processes is explicitly considered. This integrated approach towards logistics, and supply chains, and for that matter, business operations, is a core insight of logistics and supply chain management.

It is important to also consider the relationship between supply chains, logistics chains and transportation. Decisions in the supply chain may severely influence the nature of logistics and the need for transport as well as transport efficiency. This is depicted in Figure 1.

Note that there is an influence from top to bottom, since decisions at the supply chain level (where to produce, which markets to serve and where) determines the requirements for logistics, and for transportation. There is also a relationship from bottom to top, because the physical and technical possibilities of transportation and logistics determine the scope of supply chain management solutions.

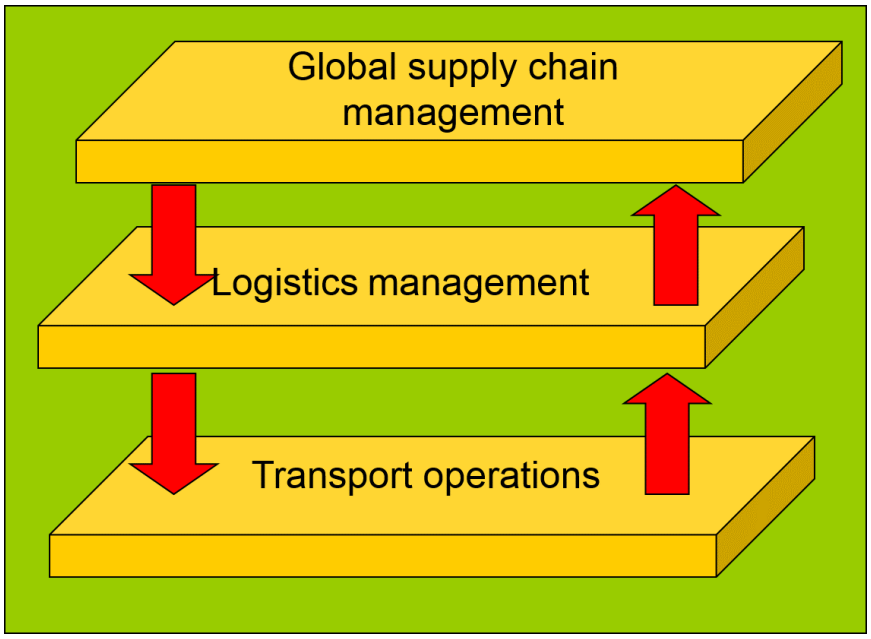


Figure 1: **Hierarchy of supply chains, logistics chains and transportation**

1.2.2 Societal developments and challenges

Supply chains are indispensable to integrate production, trade and consumption, and are therefore a key source to economic prosperity in both developed and developing countries and a key competitive force for businesses. However, logistics and supply chains also put burdens on society and environment. Supply chains should *mitigate* their negative impacts, for instance: 1) reduce the environmental impact, including reduction of the "carbon footprint" and more local effects like stench, noise, unsafety and land use; 2) reduce the demand for non-renewable resources, including fossil fuels; 3) improve external safety and labor conditions and 4) address the vulnerability of logistics activities for criminal interference. All this requires investments in innovation, ICT and physical infrastructure,

collaboration and coordination, etc., while still remaining profitable for all stakeholders involved.

Logistics can also be an instrument for *"greening" the society*, for example by: 1) efficiently accommodating "reverse flows" to enable the re-use of components or parts and other "waste" materials, as well as flows of returned products; 2) accommodating the use of alternatives for (traditional) fossil fuels, such as solar and wind energy, and biomass to power logistics and supply chain operations.

Demographic and geographic trends have to be considered when designing robust and sustainable supply chains. Although the EU population will remain more or less stable in the next 50 years, in some countries, in particular in Eastern Europe, population will shrink considerably. Even worse, the well-known population pyramid of the 20th century will reverse in the years to come. In 2050 almost 30% of the EU population will be over 65, implying that an ever smaller working population must generate the wealth of an ever growing inactive population (note however that already now legislation is changing, causing people to work longer till e.g. the age of 70). In addition, urbanization continues: since 2007 more than half of the world's population lives in urbanized regions, in a number of western countries this percentage is already well above 70%. This places considerable demand on the design of smart, sustainable and secure supply chains, increasing the need of advanced and innovative technologies to plan and execute logistics, with a high level of automation and robotisation. We will come back to this when discussing the *Physical Internet* paradigm.

Supply chains and in particular logistics systems play an important role in the security debate. Organized crime, by the nature in which it is conducted[2], has a detrimental effect on the performance of logistics systems. The 2001 terrorist attacks in the USA ("9/11") and continuing threats triggered an avalanche of governmental programs and regulations to mitigate the risks from terrorism in global freight transport. Consequently the cost of preventive security for the private sector has increased.

A further societal challenge that needs to be mentioned here is the rapid rise of e-commerce, and the resulting pressure on logistics systems. Supply chains needs to take the development of e-commerce opportunities into account, but e-commerce itself will also influence the logistics networks that perform the physical activities related to e-commerce. These two challenges are more and more felt, not only in logistics operations, but also on the side of government regulation. For the latter, the current supervision approach for express companies is no longer suited for the much larger volumes of e-commerce related packages.

[2] Theft, hi-jacking of vehicles, smuggling, counter-feiting, and so on, often take place in a transport or logistics context.

The challenge will be to demonstrate that environmental responsibility, safety and security, efficiency and profitability may go hand in hand by defining smart supply chain solutions. In this type of solutions, *there is a business case that reconciles* these seemingly conflicting goals. To that end, the impact of choices at each phase of the supply chain on logistics, and of logistics on transportation, in terms of sustainability, security and profitability has to be reviewed. In particular the role of new and advanced technologies and their impact on logistics and supply chains need careful examination.

1.2.2.1 Scarcity and sustainability

Imbalances of natural resources: Natural resources are scarce, and are not evenly distributed in terms of type and geographical location in the world. The management of supply chains that enable the distribution of water, food and devices from the stage where materials are extracted from the earth to the people's homes and nearby stores must be supportive to these developments. Current supply chains and logistics systems are global, primarily because of labor rate differences between emerging economies and mature economies. Future supply chains will be ***glocal****: global when needed, local when possible*. The amount of labor needed for high tech products in particular is diminishing, while wage rates are moving upwards also in a number of Far-Eastern countries, leading to a tendency of re-shoring production facilities. Global supply chains, however, will remain inevitable in cases where conditions for growing food ingredients are only satisfied in some regions in the world, or when minerals are only locally available. Global supply chains will also continue to exist in cases where material processing consumes such an immense amount of energy that this is only sustainable at places where energy is abundantly and sustainably available, such as locations with geothermic energy, locations with water-powered energy generation, and locations with long periods of sunshine.

Technology that enables 'local': Local for local production and distribution is enabled by technologies like 3D-printing, micro-manufacturing and the urge to reduce waste of energy and materials, or alternatively local energy generation. Many of these developments address the scarcity of physical infrastructure and transport capacity, especially in densely populated areas. These developments will have a profound impact on the re-design of products, as well as on the logistics requirements of handling these products. Supply chain and logistic managers should be leading in identifying and stimulating developments in transportation and handling technology that enable shifts to more sustainable modes of transport, as well as encompass break-through technology adoption such as unmanned transportation.

1.2.2.2 Demographic trends

Larger and older population calls for competence development: The current world population of 7.2 billion is projected to increase by 1 billion over the next 12 years and reach 9.6 billion by 2050, according to a recent United Nations report launched. Within

Europe, the population size is predicted to be stable but a severe shift in population movements is expected from Eastern to Western Europe. Ageing continues, meaning that people in general will work longer in order to maintain a reasonable standard of living. Europe-based companies should be prepared for scarcity of human resources and should be able to provide working conditions that extends the working life of employees. As the human resource pool is reducing, the quality of these resources must be improved. This can be done by better education and training. In parallel productivity can be improved by better support tools, easier access to relevant information, and finally further automation of both technical processes (robotics) and decision making. These are all developments that will benefit from an integrated, supply chain, view of business activities in Europe. This implies that the EU should heavily invest in lifelong learning programs (e.g. LOG2020, 2013) and should stimulate research and development of decision support tools for supply chain management.

Urbanization: The development of wealth in Asia and Latin America results in a huge shift from agricultural and nomadic forms of living to urban life. More and more cities with more than 10 mln inhabitants will emerge requiring different modes of transport and logistics systems than available today. There is an increasing interdependency between supply chain design and management and urban planning or land-use management. It is not yet clear whether mega cities are sustainable when wealth increases to the levels currently accessible for the European population. Innovative sustainable, safe and secure logistics might inspire agencies and institutions toward new patterns of sustainable urbanization.

Health care services and humanitarian logistics: An older and larger population requires more resource-efficient health care systems, where principles of logistics and supply chains are used to manage effectively the patient flow, from diagnosis to treatment and beyond. In addition, logistics serve a key role in natural disasters and other societal disruptions; humanitarian logistics is required to connect relevant providers of humanitarian aid at different stages of a disaster, ranging from preparedness and immediate response to reconstruction.

1.2.2.3 Supply chain safety and security

Supply chains and logistics systems remain complex, and therefore vulnerable. As part of an FP7 EU Security Project, "Development of a strategic roadmap towards a large scale demonstration project in European logistics and supply chain security" (LOGSEC, 2010-2011), a roadmap on supply chain security was published, focusing on crime and illegal activities. The types of crimes committed by various illicit actors in the supply chain are manifold. Economic crimes for example may include: theft (robbery, larceny, hijacking, looting, etc.), organized immigration crime (human trafficking, illegal immigration), IPR violations and counterfeiting and customs law violations (tax fraud, prohibited goods). But one may also think of ideologically or politically motivated crimes or simply vandalism. See Hintsa (2011) for an extensive list of crime types as well as its impact on the private sector and the wider society.

A legislative framework safeguards society against these unwanted practices. This framework provides a mandate to a range of government authorities to govern (parts of) it. The challenge will be to find a good balance between required inspections and interventions, and the economic interests of shippers and logistic service providers who wish to minimize delays, inefficiencies and additional costs. To some extent, these objectives are actually aligned, and control measures are executed both by business and government authorities. This challenge therefore requires technological and supply chain innovations, but also new insights in the monitoring of control measures by business and government.

Part of the challenge is that this legislative framework, but also the supply chains and logistics systems that are burdened by security threats are truly global. Therefore, solutions and the underlying research must also be global in nature. This roadmap will focus on the European agenda, but extension of both the stakeholder group, as well as the research agenda to a global level is required in due course.

Another aspect of supply chain security is supply chain resilience, of which many definitions circulate. A comprehensive one is the ability to maintain, resume, and restore operations after a disruption (Gaonkar & Viswanadham, 2007). This is a critical aspect of supply chain risk management and generally seen as one of the major future challenges. Disruptions to supply chains can prove costly, as highlighted most recently by Hurricane Sandy. According to research conducted by Accenture, significant supply chain disruptions have been found to cut the share price of impacted companies by 7% on average.

Supply Chain Resilience was one of the key themes on the World Economic Forum in 2012, with strong concern about external threats to supply chains (such as natural disasters and demand shocks) and systemic vulnerabilities (such as oil dependence and information fragmentation). Additionally, growing concern around cyber risk, rising insurance and trade finance costs also point to the need for a harmonized resilience framework.

1.2.3 The Physical Internet concept

Future supply networks require a synchromodular transport system, in which shipments are to a large extent automatically routed in an optimal way. The optimization process should consider many viewpoints simultaneously. In a market economy, effectiveness and efficiency will always prevail, but resilience and various safety, security and environmental perspectives must be taken into account as well. No general high level security & safety frame can be required from all kinds of supply chains as economic and societal goals must be balanced. The motto is as secure, safe, green or resilient *as needed*, not as possible.

When designing the best (= most economical, safe, secure and green) networks to move goods that really need to be transported, the concept of a "Physical Internet" has been proposed as a possible (and radical) way to reconcile these goals (ref. Montreuil, 2012).

The Physical Internet is defined as a transport system in which modular packages are routed from source to destination through a network of hubs and spokes. Major elements of such a transport network are more or less existing for parcels, pallets, containers and "swap bodies". Carriers of these types of loading units do optimize between various alternative routes in their networks, e.g. by bypassing hubs, either in advance through offering more time definite services, or real time during the actual transport. A full-fledged physical internet may be built upon all these elements with the holistic integration of these existing elements and concepts as the main challenge.

However, the forces of market economy usually prevent holistic optimization as many providers of transport and logistics services are "locked-in" their current ways of working and acting. To get to the next levels, shippers (manufacturers, retailers), carriers and other providers of logistics services should take the broader sustainability goals into the economic equation. This requires ways to base decision making in the system on financial and market criteria but also on safety, security and environmental/ecological aspects. In particular, transnational governance and regulation is needed to achieve such a cultural shift, and to encourage collaboration, coordination and horizontal partnerships.

A major challenge is to design a multifaceted decision support system for the physical internet, with partly automated execution via intelligent agents. Radical new business models based on openness and sharing or resources are required, as opposed to the current local ownership and control of resources. Note that this notion of openness is almost in contrast with the core of e.g. supply chain security. Therefore, the adoption of a Physical Internet will require radical changes with respect to the roles and responsibilities of many stakeholders. Achieving such a combination of physical and electronic infrastructure is just one step, stimulating shippers and logistics operators to connect to it, is an even bigger challenge. And obviously, bulk freight flows lend themselves less easily to a Physical Internet approach.

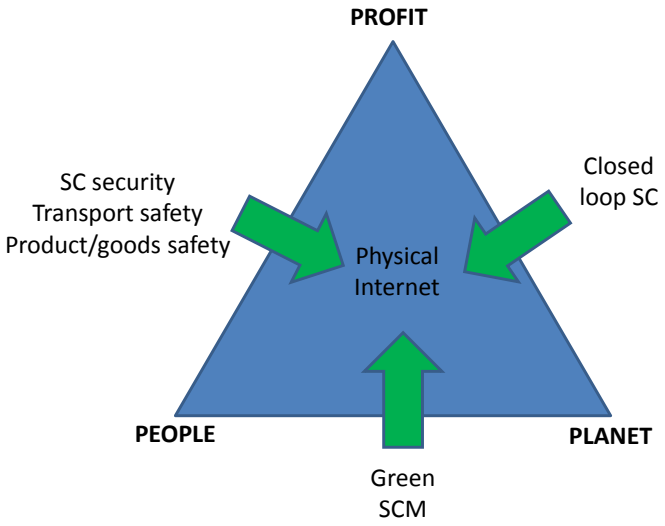


Figure 2: **The Physical Internet concept related to the multi facets of sustainability**

Figure 2 is an attempt to integrate the <people, planet, profit> view on sustainability and to position closed loop supply chains, green supply chains and safety and security properly. Safety and security are positioned between people and profit. Similarly, Green SCM is mainly positioned between planet and people and closed loop SC (in a circular economy) is positioned between planet and profit. The concept of the Physical Internet is integrating the 3 Ps, whereas the other three require a dedicated vision and innovation roadmap.

Next, we turn to a more detailed framework and set of objectives and actions for sustainable and secure supply chains. Note that transport safety as such will not be elaborated in much detail in this paper, this topic is covered by other Working Groups within ALICE, as well as by other ETP's.

1.3 General expectations, scope of the roadmap and approaches: Sustainable and secure supply chains

Sustainability is most easily defined as "doing more with less" and pertains to avoiding waste, using less energy, exploiting renewable resources wherever possible, and advancing re-use of products and materials. In a broader sense, sustainability has three dimensions, corresponding to the "people, planet, profit" paradigm, i.e.

- ✓ Economic dimension: efficiency, cost-effectiveness, quality, responsiveness
- ✓ Environmental dimension: emission and waste reduction, natural resources utilisation, materials/products recycling
- ✓ Social dimension: safety and security enhancement, noise reduction, healthy working environment.

A key tension is the use of natural resources such as water and non-renewable fossil fuels that are used for industrial production and movement of goods across the various stages of the supply chain. This usage of natural resources, which influences the balance of the eco-system, is strongly shaped by key performance objectives (e.g. time, speed, quality, flexibility, and cost) and design of the supply chain (e.g. global/local, degree of centralisation). The imbalance in the eco-system materialises in scarcity of natural resources and natural disasters such as flooding and hurricanes. These events in the eco-system are becoming frequent and have severe disruptive impact on industrial operations and the safety and security of the wider supply chain (Halldorsson and Kovács, 2010). More relevance should be given on the assessment of the social and environmental impact of global supply chains. The design of more resilient supply chains offers important chances towards a more sustainable development.

Following these definitions, safety and security are part of sustainability (avoiding accidents, avoiding risks for human life, etc.) but also constitute separate working fields (with respect to counter terrorism and crime, including cybercrime, for instance). Besides,

in view of the challenges listed in the introduction (resource scarcity and pollution, demographic changes, and security threats), specific attention to secure supply chains is warranted.

1.4 Complementarities with other ALICE roadmaps

In figure 3 the interdependencies of the roadmaps to achieve the ALICE vision are included. In particular, we see the following links with other ALICE roadmaps:

- **Roadmap on Corridors, Hubs and Synchromodality**
  Increased efficiency and severe reduction of energy use and CO_2 emission through bundling of freight on large carriers (barges, freight trains). Networks such as Ten-T and ultimately the PI may severely contribute towards more sustainable transport.

- **Roadmap on information Systems for Interconnected Logistics**
  Use of information to enhance safety and security through information transparency, while at the same time designing less intrusive inspection methods.

- **Roadmap on Global Supply Network Coordination and Collaboration**
  Both horizontal and vertical collaboration and coordination may lead to higher carrier loads and hence contribute to more efficient, hence more sustainable transport, in particular when extended to the coordination of forward and reverse flows

- **Roadmap on Urban Freight**
  Urban Freight typically concerns last and first mile logistics which offers enormous potential for efficiency improvement, as well as emission and congestion reduction, by smart collaboration and coordination, and hence reducing the number of freight vehicles in urban areas.

In addition, other ETP's concentrate on technical solutions to achieve more sustainable transport, e.g. through the use of alternative fuels or cleaner engines (both in road and water transport). However, each of the four roadmaps above concentrate on how to implement smarter transport, without questioning the loads itself. The supply chain view offered in this roadmap addresses exactly that point of view, by concentrating not only on how, but in particular on what to transport.

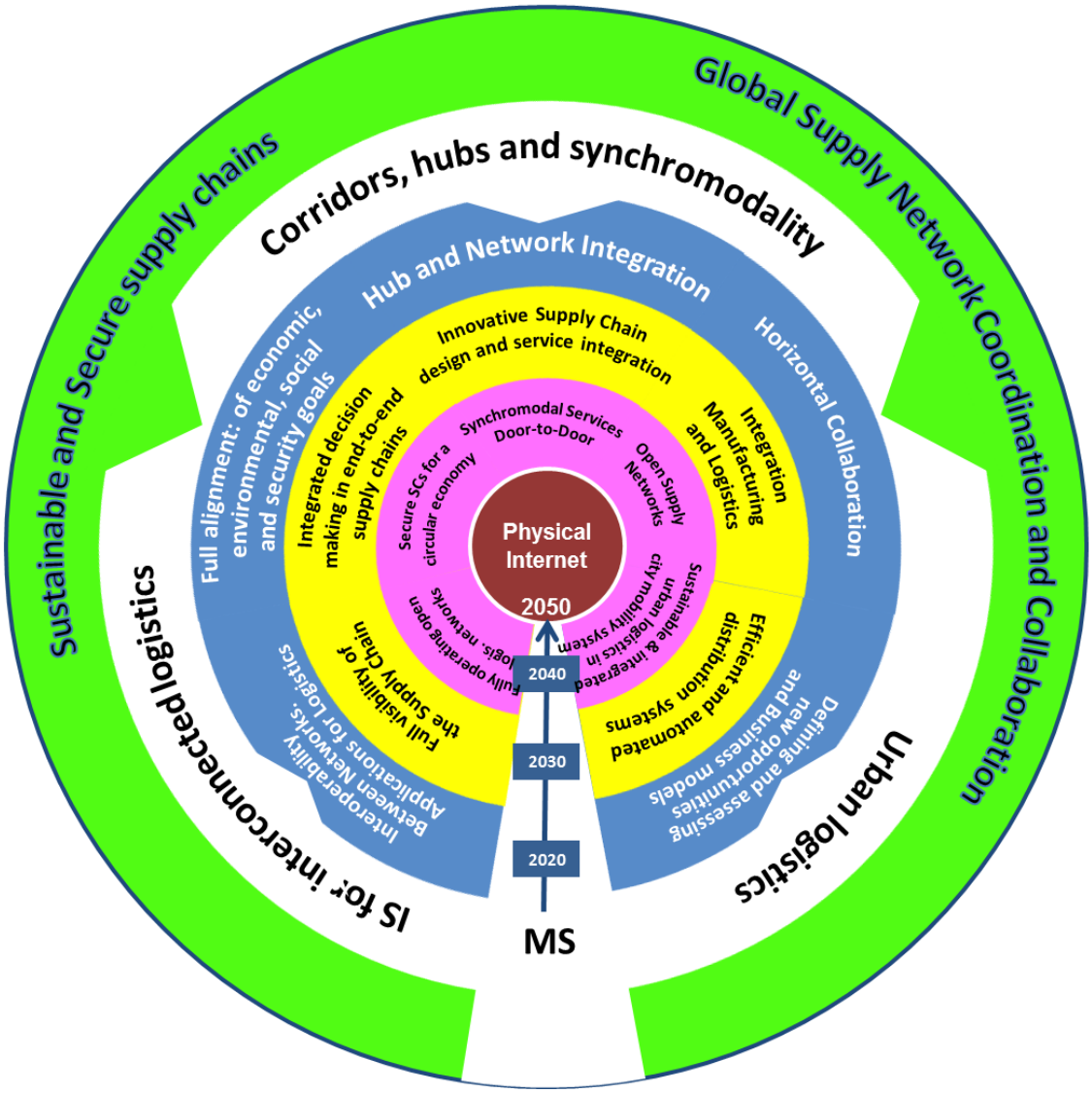


Figure 3: Interrelation between roadmaps

2 Challenges and themes

In this chapter we discuss various perspectives on subsequently supply chain sustainability and supply chain safety and security. Each of these perspectives deserve further study, as outlined in detail in the following sections.

2.1 Design of a roadmap for supply chain sustainability

As noted earlier, the vision of 'sustainable supply chains' is to do more with less: to ensure that growth, competitiveness, innovation and industrial leadership does not take place at the cost of environmental sustainability in supply chains. This roadmap envisages that operational practices and theoretical principles of logistics and supply chain management serve as key mechanisms in: *reducing dependence* on non-renewable energy resources (oil dependency), *minimising emission* of greenhouse gasses, *advancing re-use* of products and materials, and *transformation* of supply chains towards a low-carbon economy.

The overall vision includes the ambition to prevent any unnecessary transport, and to reduce flows as much as possible, resulting in both financial and ecological benefits. In addition to avoiding or at least seriously diminishing transport, resource use should be minimised and logistics networks should be transformed into ones that are sustainable and resilient.

With the combined commitment and assumption of responsibility by all stakeholders concerned, logistics should become 50% more efficient by 2030 compared with 2014. This target is translated into four main areas and a number of indicators with corresponding guiding objectives.

Objectives of sustainable supply chains

The effects of the strategies proposed in this roadmap are measured by means of the following objectives:

- Transport reduction (percentage of overall value)
- Improved carrier/ULD utilization (volume/weight)
- Emission reduction
- Increased re-use
- Supply chain cost reduction
- Supply chain service improvement (quality and due date reliability)

In table 1 an overview is presented of the milestones and targets on the way towards sustainable supply chains. A categorisation of research and innovation domains and an approach towards supply chain sustainability is elaborated in the subsequent section.

Table 1: Milestones and targets on the way towards sustainable supply chains

	Milestone 1: 2020 **Alignment**[3] **strategy**	Milestone 2: 2025 **Replacement strategy**	Milestone 3: 2030 **Integrated strategy**
Vision	Sustainability is *complementary* to the traditional logistics/SCM focus on costs and service.	Traditional logistics/SCM concepts are *replaced* by an alternative approach to cope with the environmental and social aspects.	Efficiency and effectiveness in logistics /SCM is fully consistent with environmental sustainability.
Task for stakeholders	Adapt existing practice	Transform existing practice	Integrate in *supply chain*
High-level concepts	Supply chains as business systems	Consumer responsibility	Supply chains as eco-systems
Overall objectives	• Transport: reduce by 10% • Carrier/ULD utilization: improved by 10 % • Emission: reduce by 10% • Advancing re-use: increased by 10% • Supply chain cost: reduction by 10% • Supply chain service: improved by 10%	• Transport: reduce by 10% • Carrier/ULD utilization: improved by 20 % • Emission: reduce by 30% • Advancing re-use: increased by 20% • Supply chain cost: reduction by 20% • Supply chain service: improved by 10%	• Transport: reduce by 30% • Carrier/ULD utilization: improved by 20 % • Emission: reduce by 50% • Advancing re-use: increased by 40% • Supply chain cost: reduction by 30% • Supply chain service: improved by 10%

Prospects and approaches for sustainable supply chains

In a few years, better and faster systems will enable new forms of collaboration. Dynamic and flexible interrelations between value chain actors will characterize the logistics market just as transparency, traceability and rapid response systems. Flexible and adaptive ICT systems in the cloud will dominate the market and logistics service providers will be able to respond quickly to changing market requirements caused by the booming e-commerce for example.

There is a need to focus on changing the way supply chains are designed and operated in order to meet both economic and environmental, as well as safety and security requirements. This also involves the development of business models supporting the implementation of new logistics concepts and technical solutions. At the same time, we note that roles are changing. Companies may decide not just to outsource only logistics functions but the entire sourcing and procurement function as well. Enlarging the scope to fully include decisions made at the supply chain level means considering not only "how to transport" but also "what to transport". That is, we do not only view (multimodal) transport as such but also strategic decisions on a supply chain level that strongly influence the very need for transport as well as its economic, ecological and social effects.

[3] *This categorization is based upon Halldorsson, Kotzab and Skjoett-Larsen (2009)*

The design, organisation and control of supply, production and distribution networks will influence not only the cost and service but also the environmental impact from both production and transport. The organising of supplier relationships and sourcing strategies determines the structure of a supply network. In turn, this influences the need for, and design of, sustainable transport and logistics. Furthermore, research on transport demand requires analysis of the interaction between manufacturers' and traders' production and materials planning and control models – and the transport system design and planning processes.

There is a need for new approaches where shippers´ planning and control processes and models are coordinated with transport actors´ capacities and processes, and vice versa. Various kinds of network approaches may also support a holistic analysis.

Research on collaborative logistics management is important to define new roles for different actors, shippers as well as service providers in different contexts. Flexible information management is key to implementing logistics solutions that can support sustainable supply chains. The use of information systems will influence the way logistics partners reshape and optimise their integrated supply chains by for instance recognising alterations in inventory levels, market demands, and transport constraints.

The transformation to sustainable logistics solutions will require changes in business models regarding both demand and supply. Greater cooperation makes it possible to focus, simultaneously, on customisation, business process integration and sustainability. Knowledge about the relationships between shippers' demand specification and their needs is crucial in understanding the requisites of transport services. Such information would make it possible for logistics service providers to fully utilise the potential of their systems.

Below, we discuss an approach towards sustainability along four different dimensions (Figure 6). The knowledge required to achieve the goals outlined above will be generated by research in each of these dimensions. Education and training is crucial in order to disseminate the research results, achieve market introduction of new technologies as well new working methods and routines in order to achieve the goals. This is not only about traditional university education but also lifelong learning programs with a bi-directional interaction between research and practice. Even though the importance of education cannot be overemphasised it is outside the scope of the activities in Working Group 1 and therefore not explicitly included in the roadmap, although this aspect has to be kept in mind when carrying out the proposed activities.

Increased awareness and knowledge about sustainability and environmental issues among European companies, especially those transporting large volumes of goods, is also a prerequisite for the development of sustainable supply chains. This will be important for companies who want to develop and retain their competitive position in a global market.

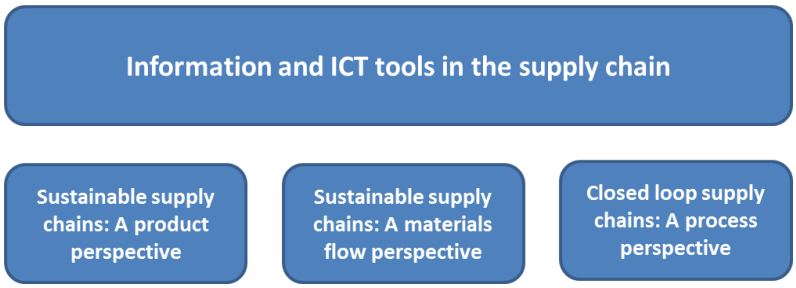


Figure 4: Four different dimensions of an approach towards supply chain sustainability

2.1.1 Product focus

There is a need for a holistic view of the customer offering, the product including the packaging and associated services, which are expected to constitute a larger part of the customer offering. In fact, a number of businesses have discovered the (after sales) product service market as an important additional source of revenues. This trend is often referred to with the term "servicization", a shift from product oriented to service oriented business models, see e.g. Cohen et al. (2006).

To realize the vision of a seamless logistics flow, different challenges along the supply chain have to be tackled like product size, shape and packaging, modularisation and postponements of product customization. The latter will result in a flow of components instead of finished products and when the final product configuration is postponed until close to the customer. Such a decision clearly contributes to sustainability in a broad sense, by reducing cost and environmental impact as well as increasing service due to less inventory investments, and increased transport efficiency used due to higher packing density.

This is also supported by the redesign of products such that more products can be stored on a pallet. Alternative packaging solutions again help to both increase efficiency and to reduce environmental impact (energy usage, carbon emission). Improved packaging also reduces waste due to damaged or deteriorated products, as well as the need for packaging material.

Products, components and raw materials are flowing along the various links within the supply chain, orchestrated via ICT systems, but also by means of intelligent packaging (bar coding, RFID, optical recognition a.o.). Autonomous systems, as in the Physical Internet, will have to go hand in hand with smart packaged products and goods. A further step would be a product design, in which 'products-in-use' can communicate effectively with resources and actors in the wider logistics- and transport system.

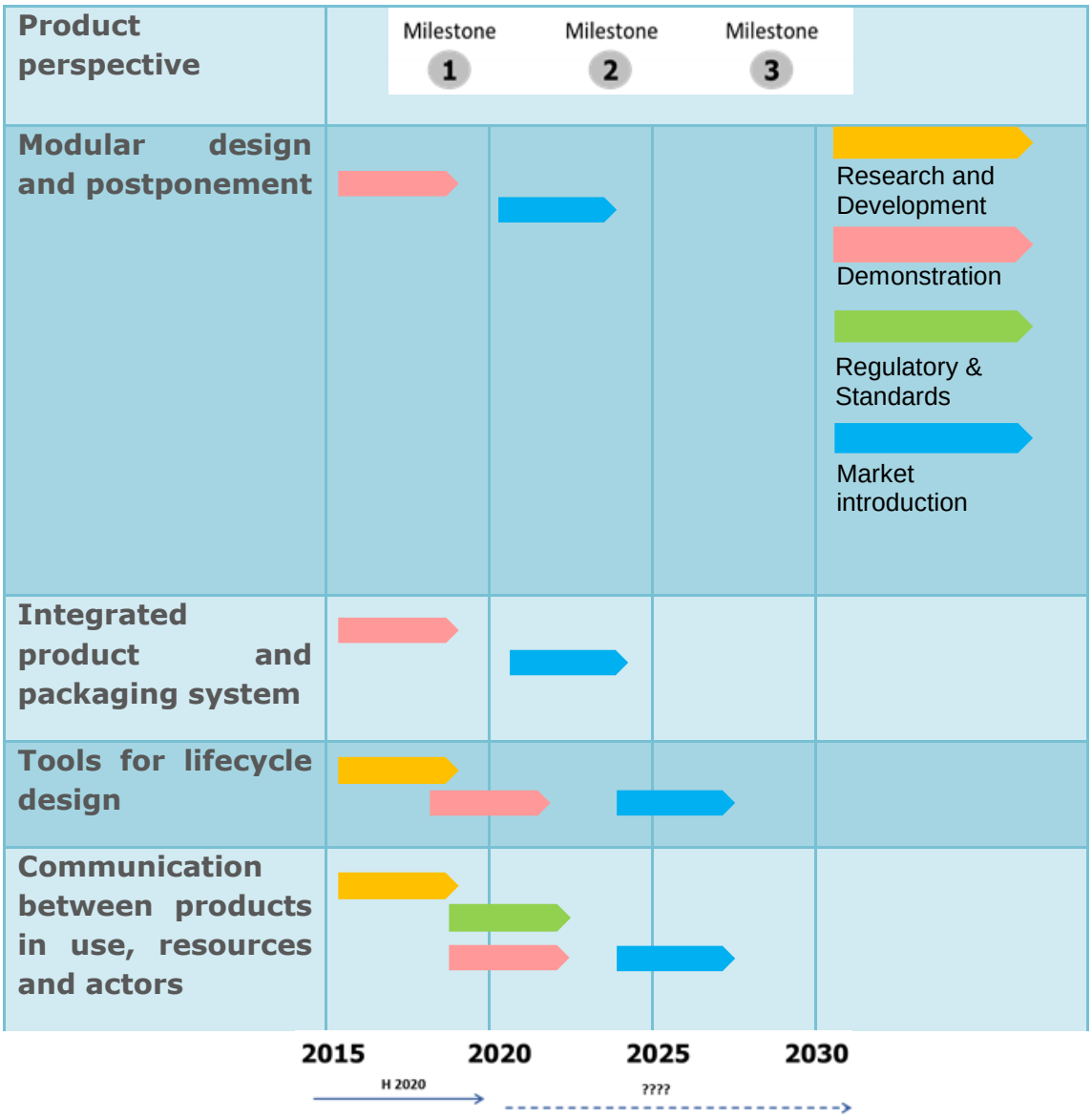
Not only the physical aspects of product and packaging influence the sustainability of supply chains. Sourcing strategies and supplier selection across different tiers in the supply chain is also of great importance. In order to monitor progress and support effective supply

chain management there is a need for improved tools for 'total cost of ownership' analysis and optimization across the entire supply network. Increasingly, sourcing strategies will also require supply chain wide and real-time documentation of resource use and emissions.

Research, development and implementation of solutions related to the product is important in the following areas:

- Modular product design in order to facilitate postponement, maximize availability and uptime and support continuous upgrade,
- Products designed to optimally fit load units and transport means,
- Increased supply chain service through an integrated product/packaging system approach,
- Effective packaging for increased efficiency and reduced resource use,
- Increased traceability and transparency in the supply chain through intelligent packaging,
- Innovative solutions for the after-sales market segment,
- Sourcing strategies integrating sustainability in supplier selection and –assessment across several tiers in the supply chain,
- Partnership-like agreements to facilitate learning and adoption across different tiers in the supply chain,
- Tools for lifecycle design, focusing on 'total cost of ownership' across various industrial contexts,
- Sourcing strategies that take a holistic approach, integrating purchasing of products (incl. raw materials and components) and transport services,
- Product design, in which 'products-in-use' can communicate effectively with resources and actors in the wider logistics- and transport system.
- Product design focusing on the end-of-life processes (i.e., collection, disassembling, recycling) to reduce waste and increase efficiency of closed-loop supply chains.

Below, we present an example of a timeline and milestones related to some of the above areas:



2.1.2 A material flow perspective

The supply chain, i.e. the materials flow through a number of nodes, manufacturing, warehouses and distribution centres will increasingly affect a company's competitiveness. The design, organisation and control of supply, production and distribution networks will influence not only the cost of shippers and logistics service providers, but also the environmental impact of both production and transport, and of course customer service. Furthermore, research on transport demand requires analysis of the interaction between the shippers' production philosophy, planning and control models – and the transport system design.

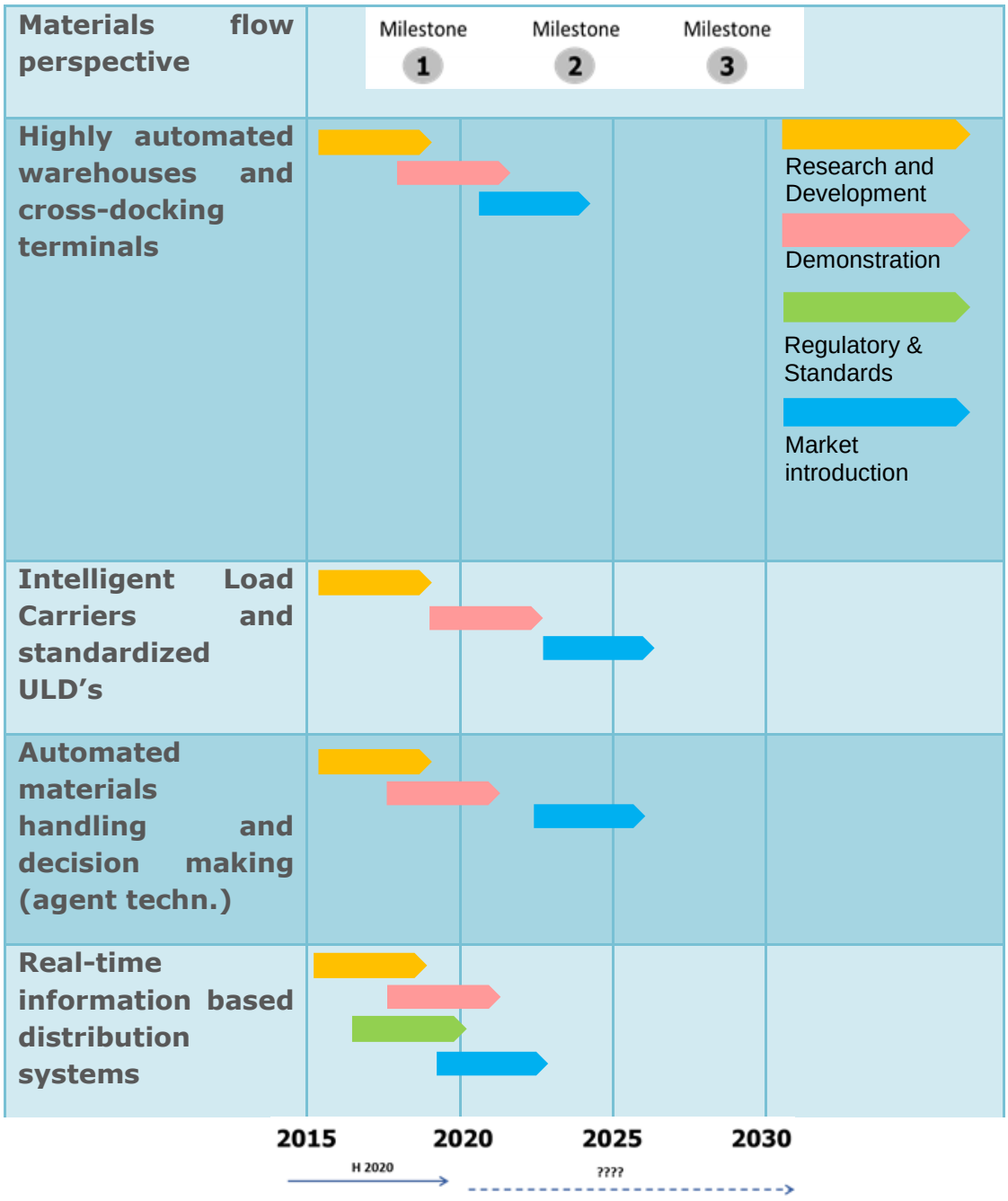
In view of these goals, there is a need to develop capabilities in a number of areas (part of these will also be covered by WG2: Hubs, corridors and synchromodality, and WG4: Supply Network Coordination and Collaboration). Here we feel, the concept of a Physical Internet may provide a highly desirable alternative. It requires package and/or load standardization and modularization, procedures for mode-free booking, automatic routing (via intelligent agents) and fast and accurate cross-docking facilities. Research, development and implementation of solutions related to a material flow perspective is important in the following areas:

- The design and implementation of fully automated, energy efficient warehouses and cross-docking terminals.
- New material flow technologies and intelligent load carriers, standardized ULD's.
- Vertical collaboration between shippers and logistics providers that allows for mode-free booking.
- Horizontal collaboration within transportation for better utilisation of capacity.
- Use of less *energy-intensive* distribution strategies.
- Design of effective materials supply methods (continuous supply, batches, kitting, sequencing..) including efficiently preparing and present materials.
- Development and implementation of integrated planning processes, including demand shaping and capacity planning, with financial and interorganisational supply perspectives.
- Design and implementation of materials control processes for supply chain optimised cost, inventory turnover, service and environmental impact.
- Mitigation and management of supply chain disruptions (see also Section 2.2).
- Development of material flow performance indicators and analysis models.
- Distribution systems based upon real-time information about condition of equipment (after-market products) and consumption (new products).
- Use of distribution strategies that are to a higher degree based

upon use of renewable energy resources.

- Seamless, intelligent automated operations at multimodal nodes and hubs.

Below, we present an example of a timeline and milestones related to some of the above areas:



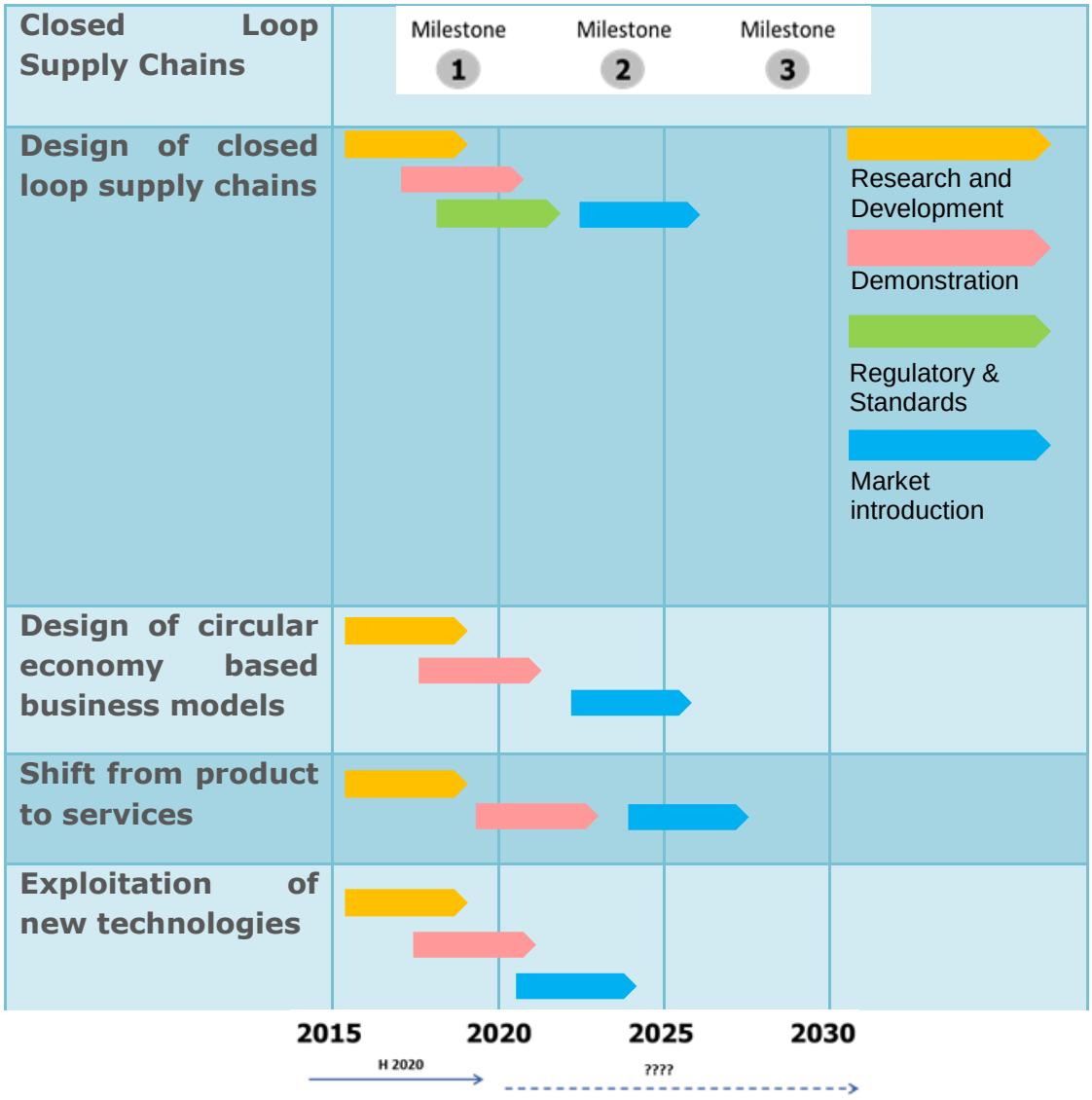
2.1.3 Closed loop supply chains: A process perspective

A process perspective may be applied on the whole supply chain in how all the links in the chain are connected in a closed-loop and can contribute to sustainability, efficiency and effectiveness. Shifts from product to service offerings, but also from ownership to functional usage of the product, are becoming visible in different sectors and markets.

When applying a process perspective on closed loop supply chains the following is important to take into consideration:

- Define roles and responsibilities for all companies in the supply chain (manufacturer, shipper, logistics provider, user) the 'closed-loop supply chain'.
- Supply chain design for 'closed-loop supply chains', with efficient, cost-saving and environmental-friendly options for disposal (re-use, repair, remanufacturing, refurbishing, recycling, landfill).
- Development of circular business models that help manufacturers, shippers, logistics providers and users to achieve their sustainability objectives.
- Opportunities in reverse logistics needs to be transformed into true 'closed-loop supply chain' business models, in which environmental- and business 'eco systems' are integrated.
- How to take the increased importance of functionalities of a product as compared to the ownership into account
- Supply chain design supports 'through-life management' of equipment, facilities and products
- How to take advantage of new technology and trends like shorter product life cycles or the demand for more customization against the background of closed-loop supply chains.
- Holistic logistics performance measurement

Below, we present an example of a timeline and milestones related to some of the above areas:



2.1.4 Information and ICT tools

Technological innovations will play a key role in yielding sustainable processes, products and services. Working group 3 in ALICE will develop research and innovations related to ICT systems and data sharing capabilities in supply chains. This will have an impact on the development of sustainable supply chains, WG1, but there are some areas that will be

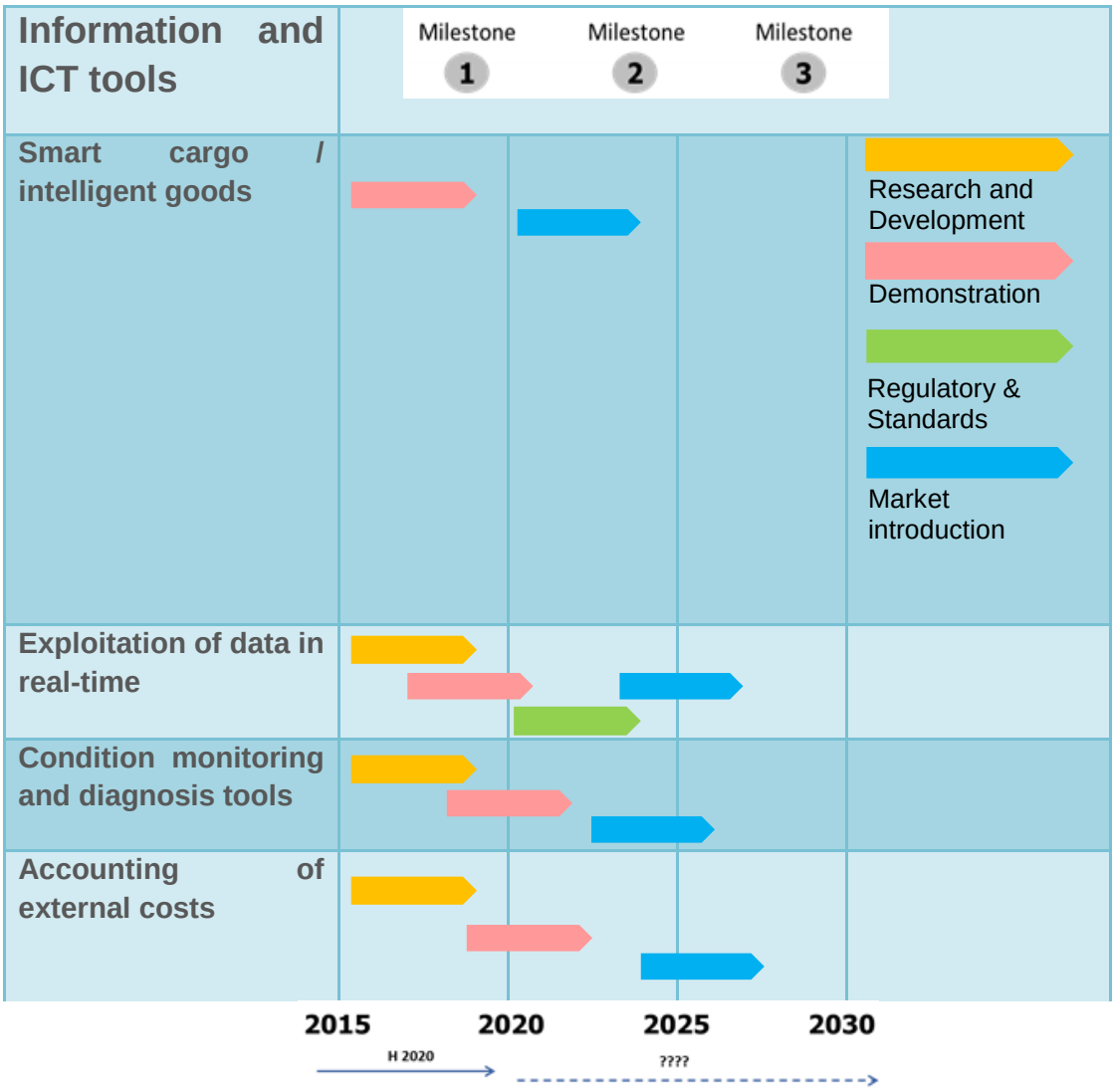
more explicitly handled in WG1. Among these are the use of RFID technology and sensor technology, which creates context-aware autonomous products and packaging. Improved tools for tracking and tracing will support rapid response systems. A number of sources for "Big data" is expected and in WG3 methods for collecting and processing will be developed. However, in order to take advantage of this it is necessary to develop capabilities supporting the exploiting of data in real-time, i.e. making sure that decisions are carried out in the physical system. To make this possible, we need sophisticated communication systems, supporting organizations and a system's perspective as well as change management capabilities.

This should enable shippers and logistics service providers making better strategic and real-time decisions that result in a "real differentiating" competitive advantage.

To meet the expectations regarding improved management of the supply chain, the use of smart and seamless inter-operative ICT tools and systems needs to be developed. Research, development and implementation (including seamless integration) of solutions related to information and ICT tools is important in the following areas:

- Smart cargo/ intelligent goods, connected goods
- Exploitation of data in real-time. This includes collection, processing and decision making in real-time, often based on complex (and "big") data sources.
- Continuous condition monitoring and diagnosis supporting condition-based maintenance of products-in-use, effective re-use and refurbishment. This is supported by a supply chain design that allows for an effective allocation of products towards repair, re-use, refurbishment, remanufacturing and recycling.
- Internalizing external costs (i.e. environmental effects)

Below, we present an example of a timeline and milestones related to some of the above areas:



Final note: the Physical Internet revisited

The above classification contains a large number of elements that may help to also validate and elaborate the value of the concept of the Physical Internet (as outlined in Section 4.1) for the European economy and society. It will be important to quantify the various sustainability goals in such a way that they can be offset against the economic decisions taken by shippers and logistics operators. Concepts and design and testing tools should be developed to support decision making, including event management, revenue optimization, futures market mechanisms, etc. Linking the optimization analysis to automatic execution tools (intelligent agents) and developing real time monitoring tools for all (economical, safety, security and green) criteria may all help to pave the road towards the ultimate realization of the physical internet. Assessment of the legal, financial, liability, privacy and contractual aspects of the systems and tools that are needed for the physical internet will

however still present a formidable challenge, requiring interdisciplinary approaches (e.g. logistics, economics, law and social sciences).

2.2 Design of a roadmap for supply chain security

The key issue in supply chain security is how to better balance societal and business driven objectives in supply chain management. In other words, how to enhance the efficiency, speed and reliability of legitimate trade and logistics whilst enhancing the effectiveness of supervising global trade and safeguarding supply chain safety and security and other societal challenges related to global trade and logistics. As such, security in supply chains is a priority topic in several Directorate Generals in the EU, most particularly, MOVE (transport), TAXUD (customs) and HOME (security cities).

Most safety aspects will be dealt with in the transport oriented working groups of ALICE, as well in transport oriented ETPs. Note that adequate safety measures are essential to all supply chains while for some supply chains such as pharmaceuticals, food, feed and chemicals supply chains, product safety is even more important. Incidents and accidents in those supply chains might have a direct impact on public health and safety. In this roadmap we will deal with issues primarily related to measures shippers and the logistics community can take in securing their supply and logistics chains.

Business objectives focus on the realization of lean, agile, resilient, sustainable, compliant and trusted supply chains. Societal objectives focus on enhanced supply chain security levels and safeguarding society against illegitimate trade and criminal threats associated with international trade and logistics. Security has indeed managed to come up as one of the main concerns among managers of modern supply chains requiring urgent attention.

Currently, a holistic integrated vision is lacking resulting in attempts to independently safeguard supply chain security at different levels causing unnecessarily high costs and disturbances in global supply chains. The ALICE vision is that with the right multidisciplinary and integrative approach, the knife cuts on both sides, i.e. both groups of objectives can be realized simultaneously. This, however, would require two major transitions. First, supply chain actors have to reconsider their supply chain risk management portfolio (4Ts: Transfer, Tolerate, Terminate and Treat), leading to a shift from transfer and tolerate risks towards better control. Though many companies already apply effective internal control measures for crucial enterprise risks, the potential of collaborative chain controls is underutilized. Innovation is aimed at awareness raising, changing perception and tooling to simplify collaborative implementation. The second transition is aimed at supervision authorities. They need to truly understand supply chain dynamics, redesign their supervision strategies and apply their control and supervision

instruments accordingly. This will not only improve the effectiveness of their work, it also has a major impact on the reduction of trade transaction costs and supply chain predictability. This provides the basic vision behind the Innovation Agenda.

This Innovation Agenda has been developed within the FP7-CORE project. That project will also contribute to the realization of these two transitions and the deployment of the 7 concepts accelerating these transitions (see later). Whereas CORE is a large project, it still has limitations in scope (70 project partners and 16 demonstrations), duration (4 years), and impact. ALICE can stimulate complementary research and technological development, initiate support policies and adjustment of framework conditions, and apply a comprehensive transition management approach.

First, there is underutilization of the potential of applying the current State of the Art. The State of the Art includes effective implementation of good practices, such as well-functioning National Single Windows, well-developed collaboration models for business-government interaction, joint inspection approaches, harmonizing control procedures between control agencies, effective supply chain controls, successful implementation of non-intrusive security technologies, horizontal supervision approaches. But most of these practices are not applied on a broad scale. Recently, this was implicitly acknowledged by the European Commission in a Strategy & Action Plan for Customs Risk Management. Here, it requires strategies for wider deployment of these best practices through awareness raising, best practice exchange and effective support policies.

Second, there is a strong belief that these two clusters of business and societal objectives can be realized simultaneously by deploying some key innovative concepts. See Table 2 for a short targeted explanation.

The challenge of European RTD is to accelerate the full concept development cycle of such innovative concepts. Such a concept development cycle includes the following phases:

a) Identify weaknesses and gaps. The LOGSEC study results provide a good starting point for this.

b) Further specify and concretize the key innovative concepts; Further specification of abstract concepts is needed for further development, implementation and take up.

c) Develop the capabilities needed to implement the key concepts;

d) Create the solution environment to apply the concepts;

e) Implement the concepts and show proof of concept in real-life living labs

f) Assess the effects of the concepts and modify them where needed (feedback loops for continuous improvement)

g) Accelerate further adoption and deployment, scaling the solutions and provide suggestions for improved framework conditions (e.g. support policies)

Table 2. Targeted explanation of the key concepts

Key innovative concepts	**Targeted explanation**
Supply chain visibility	Awareness of and control over end-to-end supply chain information – including insight in sources of data and whereabouts of goods – enabling lean, agile, resilient, sustainable as well as compliant and trusted supply chains. This also includes risk visibility, making explicit where risks and vulnerabilities can manifest and how these risks are being managed and controlled.
Seamless interoperability in information exchange and data sharing	The ability of making systems and organizations to work together smoothly, both in B2B, B2G and G2G domains of international trade and logistics, including data standardization and governance of data sharing.
Advanced Supply Chain Risk Management	This concept aims to enhance the maturity level in the way SCRM is being executed, and builds further upon SC risk visibility: awareness of the options (terminate, treat, transfer, tolerate) and visibility of corresponding control strategies (preventative, corrective, directive, detective controls). It involves the application of SCRM metrics and corresponding monitoring capabilities, as well as capabilities to implement integrated chain controls and evince others your supply chain is in control in order to get recognition for having a trusted supply chain.
Coordinated border management	Alignment of controls and formalities to be carried out by different enforcement agencies at logical moments and places in the supply chain and recognize each other's security programs and risk assessments. It also includes the deployment of Single Window environments for efficient information exchange between economic operators and governments.
System based supervision	Maximize piggy backing on the business and chain control mechanisms already in place in the commercial domain
Integration of effective and less-intrusive security technologies in supply chains	Deploy innovative security technologies such as next generation scanning technology, container security devices and tracking and tracing technologies in less-disruptive ways, resulting in minimum disturbance of supply chain processes and minimum impact trade

	transaction costs
Supply chain resilience	Increase the capacity of the supply chain ecosystem to respond to disturbances by resisting damage and recovering quickly

The key innovations concepts can be clustered into three categories, following three perspectives, see

Figure 5: Clustering the key innovation concepts in supply chain security

5.

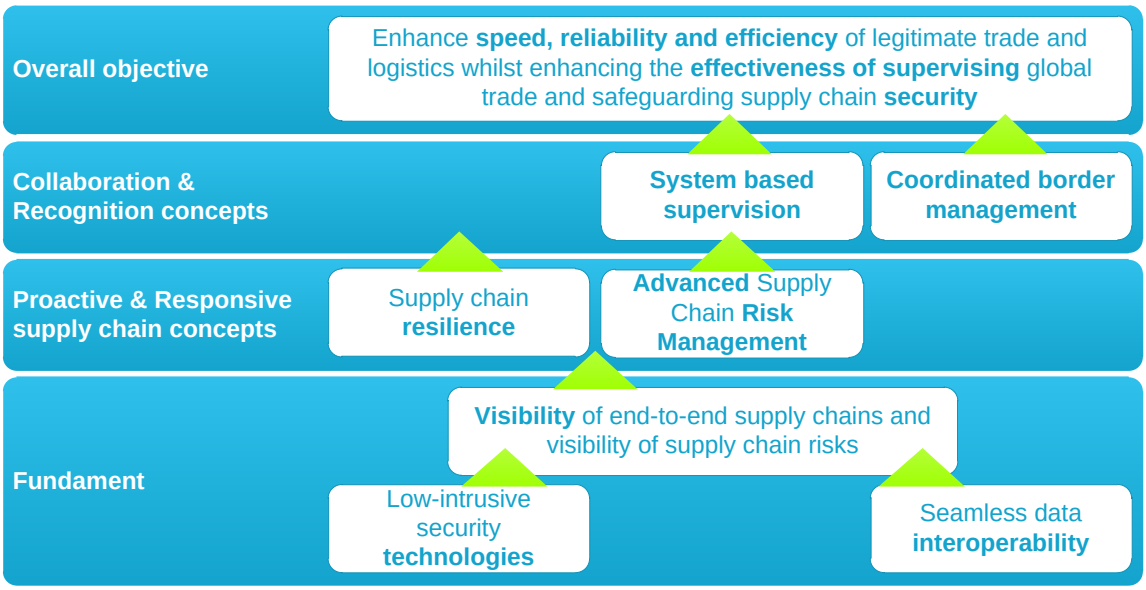


Figure 5: Clustering the key innovation concepts in supply chain security

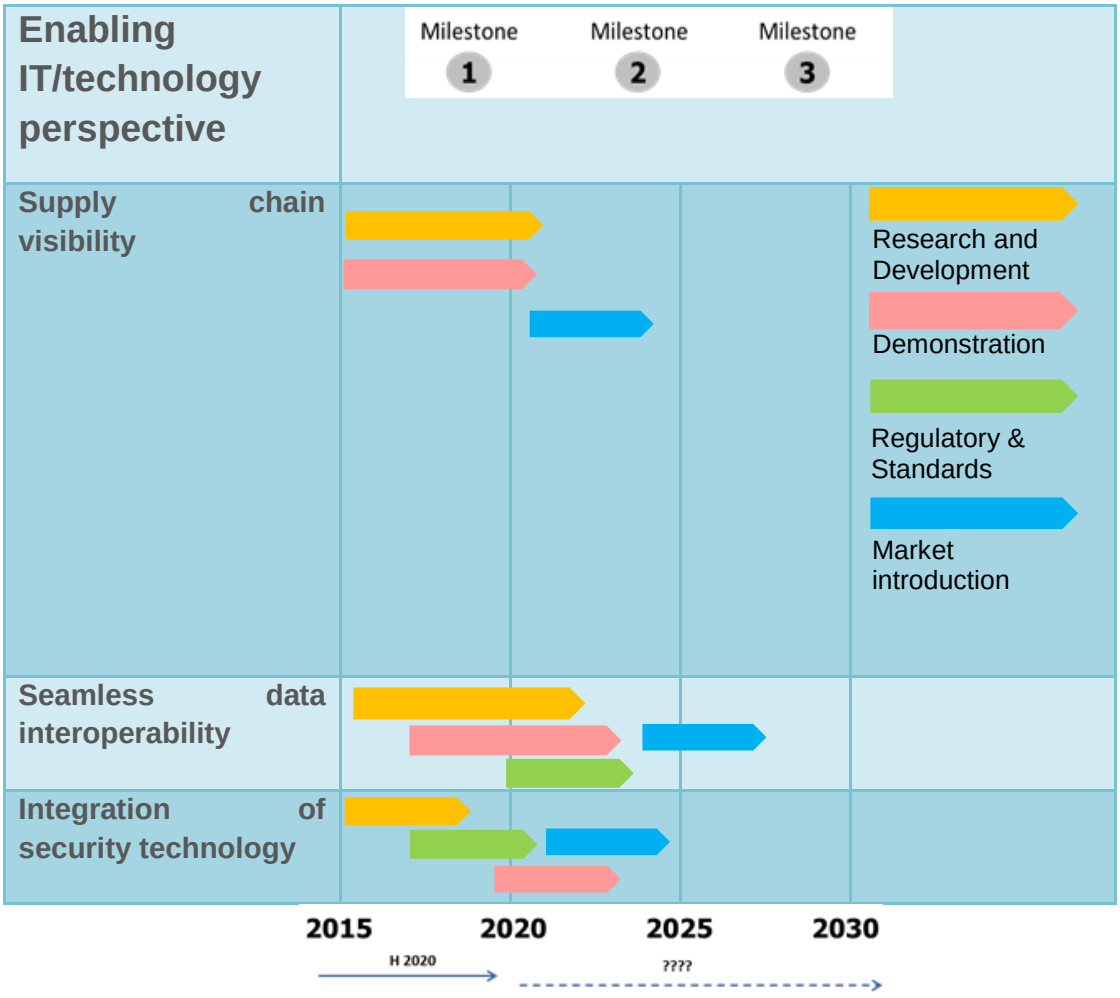
2.2.1 The fundament - An enabling IT/technology perspective

The primary purpose of supply chain visibility is to improve company performance, also by supporting the decision-making process.

A recent study by TNO identifies the cost of lack of interoperability in multimodal transport in Europe equal to € 12 billion. The IATA eFreight business case shows similar findings for air cargo transport. Lack of data interoperability also manifests in data exchange between businesses and government.

Technologies such as scanning technology, container security devices and other tracking and tracing technologies have undoubtedly huge potential to contribute to supply chain security. However, the impact it has on seamless supply chains strongly depends on the

contextual situation. In many cases there might be better alternatives to realize similar levels of security in less disturbing ways.



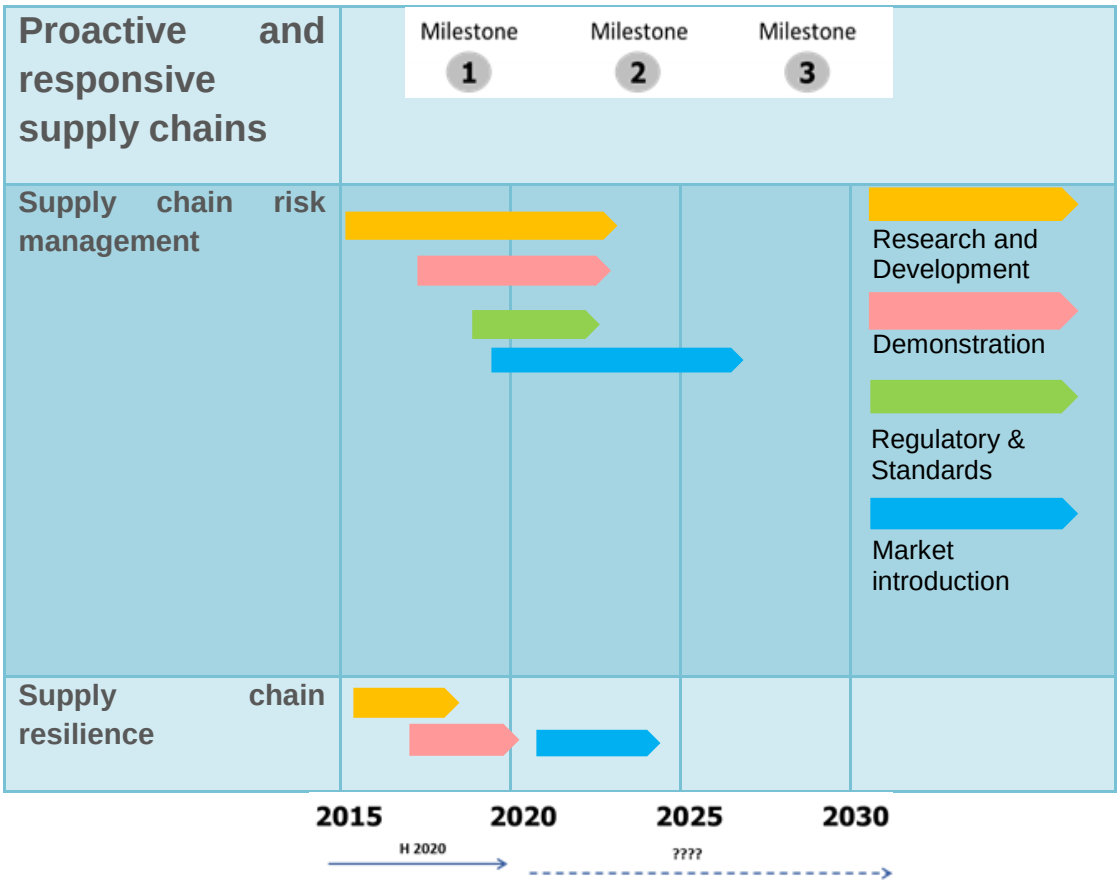
2.2.2 Proactive and responsive supply chain concepts

This perspective covers security along the full end-to-end supply chain aimed at enhancing a chain of custody based on supply chain risk management, including both internal controls and chain controls.

The presumption is that applying supply chain risk management (SCRM) is far from mature, thus leaving room for considerable improvement. Innovative funding and lending mechanisms applied at the supply chain level are part of SCRM, but are also just being introduced, and currently focus exclusively on a small group of multinational companies.

There is economic justification for being in control of the value chain, which is *the intrinsic commercial value of a trusted and integrated supply chain*. Gartner identifies this as the key trend under Supply Chain Leaders in 2014. Becoming trusted is seen as the right way enabling businesses to compete for the future and rethinking the design of their global supply networks.

The supply chain resilience framework includes four components and type of requirements: partnerships, policy, strategy and information technology (IT).

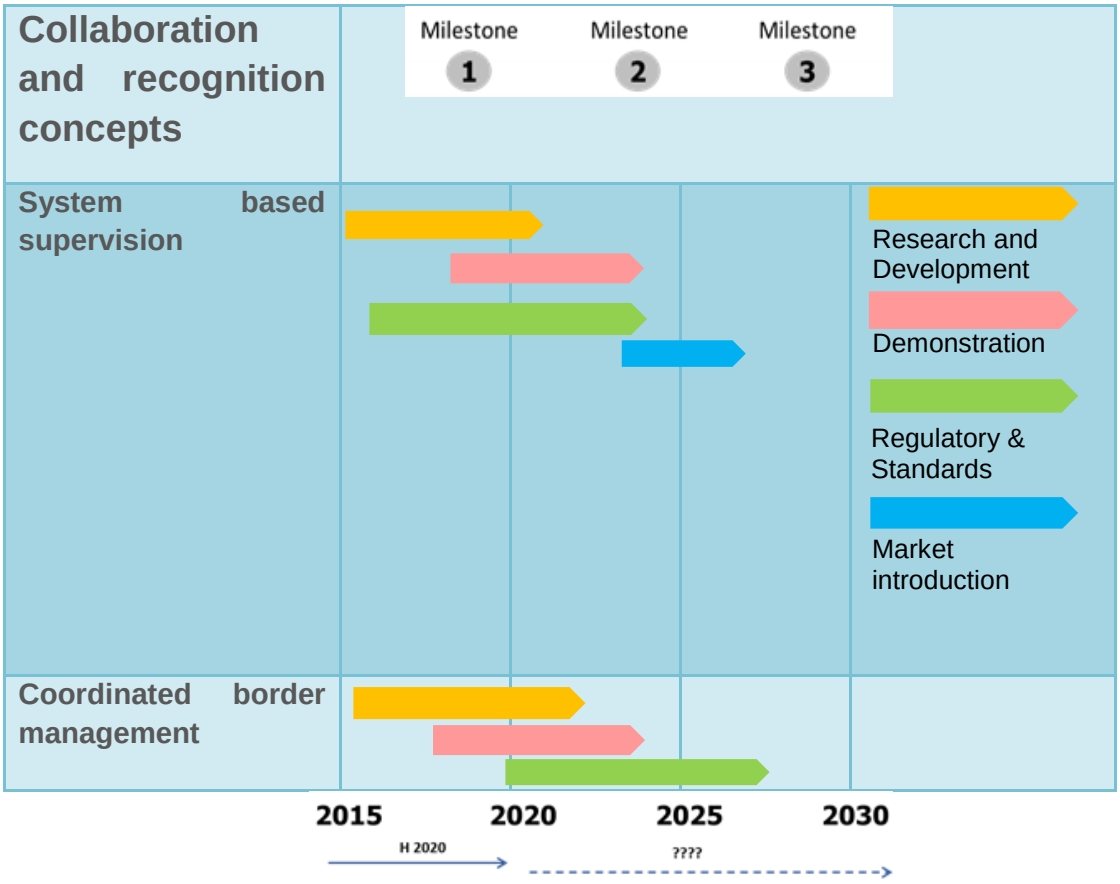


2.2.3 A collaboration and recognition perspective

It is important to recognize the effectiveness of the control mechanisms already in place in the commercial domain by customs and other control agencies: system based supervision. The AEO already recognizes economic actors to be trustworthy, auditable through transparency of their internal control frameworks and corresponding monitoring systems. This would allow for maximum piggy-backing control mechanisms in the commercial domain, not only internal controls, but moreover chain based controls.

Coordinated border management (CBM) refers to a coordinated approach by border control agencies, both domestic and international, in the context of seeking greater efficiencies

over managing trade and travel flows, while maintaining a balance with compliance requirements. CBM will result in eliminating contradictions and redundancies between different policies, thus enhancing their effectiveness. Lack of coordination in processes and procedures results in excessive delays at borders and high costs to comply, particularly for cargo subject to both customs and product/food safety compliance authorities.



References

Bolstorff, P. and Rosenbaum, R. (2003). *Supply Chain Excellence: A Handbook for Dramatic Improvement Using the SCOR Model*. AMACOM Div American Mgmt Assn. ISBN 0-8144-0730-7.

Cohen, M., Agrawal, N. and Agrawal, V. (2006). *Winning in the aftermarket.* Harvard Business Review 84 (5), pp. 129-138.

Gaonkar, R.S. and Viswanadham, N. (2007). *Analytical Framework for the Management of Risk in Supply Chains*. IEEE Transactions on Automation Science and Engineering, 4(2): 265-273.

Halldorsson, A., Kotzab, H. and Skjoett-Larsen, T. (2009). *Supply chain management on the crossroad to sustainability: a blessing or a curse?* Logistics Research, vol 1, no. 2, pp. 83-94.

Halldorsson, A. and Kovacs, G. (2010). *The sustainable agenda and energy efficiency: Logistics solutions and supply chains in times of climate change.* International Journal of Physical Distribution & Logistics Management 40 (1/2), pp. 5-13.

Hintsa J. (2011). *Post-2001 Supply Chain Security – Impacts on the Private Sector.* Doctoral Thesis, Chapter 7. HEC University of Lausanne.

LOG2020 (2013). *Logistics and Supply Chain Management 2020: training for the future. WP2: Positioning Paper.* ERASMUS LLL Project ID: 527700-LLP-1-2012-1-NL-ERASMUS-EMCR.

LOGSEC (2012). *Development of a strategic roadmap towards a large scale demonstration project in European logistics and supply chain security*. FP7-Security project, PR 24167.

Montreuil, B. *"Physical Internet Manifesto, version 1.11.1"*, CIRRELT Interuniversity Research Center on Enterprise Networks, Logistics and Transportation, Quebec, 28 November 2012.

Ponomarov S.Y. and Holcomb M. (2009). *Understanding the concept of supply chain resilience*. The International Journal of Logistics Management, Vol. 20 No. 1, 2009, 124-143.47.

World Economic Forum / Accenture 2013. *Building resilience in Supply Chains*. An Initiative of the Risk Response Network In collaboration with Accenture, Geneva, 2013.

Zomer, G. (2014). CORE D1.3 (draft v0.3) – *CORE Innovation Agenda*, Delft, 2014.

Zijm, H. and Douma, A. (2012). *Logistics: more than transport.* In S. Weijers and W. Dullaert (eds.), Proceedings of the 2012 Freight Logistics Seminar, Venlo, the Netherlands. ISBN 978-94-6197-088-6.

ANNEX 1 – Contributors and persons consulted

1. Core group:

Henk Zijm, Dinalog-ALICE
Vincent Santacroce, Poste Italiane
Ben Radstaak, Air Cargo Netherlands
Gerwin Zomer, TNO
Joachim Kochsiek, Fraunhofer IML
Fernando Liesa, ENIDE-ALICE
Albert Veenstra, Dinalog
Dan Andersson, Chalmers University
Arni Halldorsson, Chalmers University
Michael Archer, CHEP
Herman Journée, ECOSLC Foundation

2. Additional experts and stakeholders invited to contribute and consulted

Benoit Montreuil, Laval University
Nicolette van der Jagt, CLECAT
Annette Meijer, DHL
Niels Beuck, DSLV
Juan Alcarez, ITENE
Joost de Bock, EC-DG RTD
Emilio Gonzalez Viosca, ITENE
David Gonsalvez, Zaragoza Logistics Center
Werner Jammernegg, WU Vienna
Tina Wakolbinger, WU Vienna
Antonio Torregrosa Maicas, Fundación Valenciaport
Riccardo Accorsi, Universitá di Bologna
Hans Westerheim, SINTEF

ANNEX 2 – Overview of relevant projects and initiatives

Acronym	Full Title	Description	Duration	Website	EU/ National initiative
LOGSEC					
CORE					
CASSANDRA					
LOG2020					

Project ended