



NEXT-NET

Strategic Research and Innovation Agenda

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Next-Net project summary

The Next-generation Technologies for networked Europe (NEXT-NET) project aims to put in place a cross-sectoral and cross-technological initiative at European level to increase integration between production and distribution proposing research and innovation priorities for the future of supply chains (SCs).

- Creating a European network reaching a critical mass of relevant stakeholders from the process industry, manufacturing, logistics and distribution
- Identifying future industrial scenarios based on the analysis of trends and their impact on supply chains
- Developing a European strategic research agenda and action plan for the supply chains in 2030.

The project is based on a top-down and bottom-up approach by involving different stakeholders. Companies from the process industry, discrete manufacturing, distribution and logistics, ICT providers, and consumers will be involved.

NEXT-NET is grounded on the analysis of the status of implementation of most important European and national roadmaps, the identification of the most promising enabling technologies for the future industrial scenarios to develop the research and innovation priorities, and on workshops (focus groups, brainstorming sessions next-generation) with experts and stakeholders from more than four supply chains across Europe.

Introduction

The **NEXT-NET Strategic Research and Innovation Agenda (SRIA)** is the result of an intensive work jointly performed by a wide network of stakeholders from the discrete manufacturing, process industry and logistics sectors, where different actors of the innovation ecosystem (i.e. companies, research organisations, DIHs, and policymakers) put forward a vision to strengthen European supply chains for the next decade.

Exponential development of new digital technologies, population growth and urbanisation, customisation, protectionism and political instability, renewable energy sources, climate change and resource scarcity are just some examples of trends shaping and influencing European and world economies and lives. Megatrends are raising multi-facet challenges that companies, production networks, distribution centres and markets need to face in order to maintain and increase their competitiveness and their economic, social and environmental sustainability. Consequently, there is an urgent need to significantly adapt the way companies are organised and interlinked within supply chains. New roles and relationships among all the actors involved in the network are emerging, and an evolution of strategies and configurations of supply chains and new industrial ecosystems is requested.

The SRIA was developed with European research programmes, taking into consideration what has already been set by H2020 and the ongoing process for the definition of the new framework Horizon Europe, to provide guidance for researchers, policymakers and industrial actors. This goal has been pursued by envisioning the next horizons, creating a cross-sectoral initiative at European level to frame future scenarios, identifying research and innovation needs and prioritising actions for the future of supply chains.

The NEXT-NET SRIA includes an overview of the six macro scenarios towards 2030 developed in the project on the basis of the evolution of megatrends, followed by the consequent challenges and a map of the enabling technologies for the supply chains. The SRIA also includes the NEXT-NET vision for European supply chains, with a detailed description of the ten supply chain strategies identified as most relevant, and related research and innovation topics (RITs) as future developments and steps for the full implementation of the strategies. Finally, a set of policy recommendations are proposed, to address the key horizontal issues that are common to most of the strategies and require actions at policy levels.

Next horizons for European supply chains

To address the dynamics of current competitive, economic and political landscape, the NEXT-NET project envisions future European SCs as highly integrated, resilient and sustainable networks. Coordinated actions towards the integration of manufacturing, logistics and process industry are the key to strengthen real economy—and to reinforce the European system in—global challenges. In this sense, the road mapping activity in NEXT-NET has led to the definition of a set of 10 SC strategies aimed at supporting European industries in facing future scenarios, and

the proposal of priority actions with a medium/long term perspective.

The set of strategies highlights the need to develop and implement a series of solutions, approaches and models exploiting the potential of new technologies, collaborative mechanisms and global dynamics where European companies will operate in the next future. Some of these strategies are already well-known and the future trends indicate them as fundamental also for the next ten years. As for the newest strategies, the related challenges ask for innovative and cutting-edge actions to be implemented based on technological and organisational developments.

These strategies can represent a way to keep adding-value activities in Europe in order to enhance solid industrial skills, creativity, and encouraging research and innovation to generate employment and wealth. Through the full implementation of these strategies, European companies should thus invest in tangible and intangible assets to face the opportunities arising from the competitive dynamics of the international context. Transformative paths can be defined by implementing and combining one or more of the identified strategies according to the specific long-term objectives and resources and capabilities, in an effort of continuous renewal for success.



Figure 1: Image reference required here is necessary; please, refer to author



Hyper-Connected Supply Chain (HCSC) strategy

The transformation of the SC will allow the development of services to become more valuable, accessible and affordable. It is expected that HCSC will not only integrate physically but also include information and finance flows (Büyükközkın, 2018); it also allows the synchronisation of interactions between the organisations supported by intertwined digital technologies for nodes and edges integration.

HCSC will enable end-to-end visibility and collaborative relationships through a massive data disposal. The aim of the HCSC is to create a collaborative and integrated eco-system where actors from all the different levels of the SC are involved in the process of transforming data into value to improve the performance of the whole network.

Specific challenges for HCSC:

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- 1 Technology integration for seamless connection (SCH#11-13-19, TCH#G-H)
- 2 Dealing with complex data environments (SCH#19)
- 3 Real-time visibility and traceability in HCSC (SCH#15)
- 4 Role of humans in a hyperconnected environment (SCH#14)

The most important research and innovation topics for the HCSC strategy are:

- RIT_HCSC.1** Towards the implementation of a data-driven approach
- RIT_HCSC.2** Platform-based SC to support the creation of collaborative and integrated ecosystems
- RIT_HCSC.3** Future transportation within connected SC
- RIT_HCSC.4** Methods and approaches for traceability and transparency of SC processes
- RIT_HCSC.5** Cybersecurity to enable protection of data in SC
- RIT_HCSC.6** New approaches to face increasing uncertainty and complexity

Disaster Relief Supply Chain (DRSC) strategy

Disaster relief and humanitarian SC are employed in disaster scenarios. They have a short and unstable existence providing emergency aid as well as longer-term development aid depending on the scale of the disaster (Oloruntoba, 2006). The DRSC can have non-profit objectives and involves logistics that account for 80% of relief operations (Van Wassenhove, 2006) and are primarily reactive, being performed through ad hoc design with extensive advance planning (Dubey, 2016). Given the increasingly unstable conditions characterising the coming years, the DRSC is not only useful to face humanitarian emergency, but industrial networks can also apply it in order to reduce the disruptive impact of uncertainties and unpredictable events on production and distribution.

Specific challenges for DRSC:

- 1 Improved collaboration in facing emergency (SCH#1)
- 2 Develop 'leaner' and more flexible SC (SCH#4)
- 3 Identifying talents in SC during the first aid (SCH#9)
- 4 Facing inventory and shipping problems integrating 3PL capabilities (SCH#22)
- 5 Managing risk and disruption of unexpected events (SCH#21)

Research and innovation topics for DRSC:

The most important research and innovation topics for the DRSC strategy are:

- RIT_DRSC.1** Multi-actor collaboration platforms for emergency
- RIT_DRSC.2** Crowd-help open platform for first aid
- RIT_DRSC.3** Models and tools to assure prompt response after emergency
- RIT_DRSC.4** Models and tools to handle valuable data for prevention and forecast

Global Supply Chain (GSC) strategy

The global sourcing strategy requires multiple suppliers in worldwide locations, where companies consider procurement and purchasing across a global network, which provides lower costs and improves reliability, quality and access to technologies and new markets (Van Dijk, 2013). On the downstream of the supply chain, a complex distribution network brings products to customers using multiple distribution modes and channels in a multi-echelon system (Onstein, 2018).

Looking at the downstream SC, with omnichannel sales strategy and multimodal distribution, global SCs are capable of providing decentralised distribution while holding multiple possibilities of customer-service channels (Onstein, 2018). In addition, the sustainability of the global SC is also considered with regards to distribution, where an attempt to promote 'green' logistics—through the implementation of reverse logistics, emissions' assessments and sustainable logistics' procedures—is consciously made.

Specific challenges for GSC:

- 1 Managing global financial flows and international agreements (SCH#15-16-19-21, TCH#7)
- 2 Increasing sourcing and distribution complexities (SCH#3-8-18-21-22)
- 3 Achieving seamless integration in long SCs (SCH#11-19, TCH#8-10)
- 4 Promoting sustainable industry competition (SCH#17-20-23, TCH#10)
- 5 Lack of standardisation for the use of technologies (TCH#5)

Research and innovation topics for GSC:

- RIT_GSC.1** Global SC management with real-time optimisation and simulation
- RIT_GSC.2** Achieving integration through seamless interoperability
- RIT_GSC.3** Global Shared Transportation Platforms

Urban Supply Chain (USC) strategy

USC is built and oriented towards urban production to answer to specific needs, mostly driven by the local context and peculiarities of customers' demand. The proximity of the end-users largely influences the strategy related to this SC. Citizens have more demanding expectations, in terms of customisation, availability and sustainability. Thus, the focus will be on small scale manufacturing systems in urban areas, with extended customisation possibilities. The expansion of the urban environment involves a growing complexification of the city logistics, impacting the different flows (assets, people, vehicles etc.). Due to this complexity and to the proximity of all the actors, the logistics must ensure efficiency and sustainability. With the multiplication and the intensification of the different flows, it is of first importance to optimise the last mile delivery which can be performed with autonomous vehicles and drones. The location of facilities in the city will force companies to be more environmentally friendly and more resource-efficient too.

Specific challenges for DRSC:

1. Opening with the constantly changing urban context (SCH#5)
2. Optimise circulation of flows among different and inter-connected urban areas (SCH#5)
3. New user needs due to development and transformation of the urban web (SCH#7)
4. Managing new entrepreneurial generation in urban context (SCH#9)

Research and innovation topics for USC:

- RIT_USC.1** Big data analytics for evaluating urban manufacturing impacts
- RIT_USC.2** New approaches for smart distribution in smart cities: optimisation of city logistics and of shared transportation platforms
- RIT_USC.3** Networked modular facilities and technologies for local manufacturing
- RIT_USC.4** Autonomous transportation systems in urban manufacturing and rise of awareness for their acceptability

Resource-Efficient Supply Chain (RESC) strategy

While addressing all the dimensions of triple-bottom-line and mutually reinforcing elements of sustainability, RESC strategy envisions the cost- and eco-efficient integration of both open- and closed-loop life-cycle systems (i.e. product design, material sourcing/selection, manufacturing processes, delivery of the final product, product return and end-of-life management of the product). The implementation of RESC strategy aims to increase the strategic compatibility, collaboration and inter-organisational awareness among supply chain partners.

Specific challenges for RESC:

1. Resource-efficient innovation modelling for end-to-end solutions (SCH#2)
2. Energy and emissions management in the manufacturing and distribution of products and technologies (SCH#10)
3. Limitations of regulatory frameworks for successful implementation of RESC (SCH#16)
4. Improving energy systems and diversifying eco-efficient energy power sources for full exploitation of digital technologies (TCH#2)
5. Feedstock supply due to the dependence of raw material (TCH#13)

Research and innovation topics for RESC:

- RIT_RESC.1** Zero-waste production and logistics
- RIT_RESC.2** Traceability and management of product and processes information for resource efficiency
- RIT_RESC.3** New models and technologies for resource-efficient transportation
- RIT_RESC.4** Monitoring & management of energy consumption
- RIT_RESC.5** New approaches to energy storage
- RIT_RESC.6** Improving data mining processes

Human-centred Supply Chain (HSC) strategy

The aim of the human-centred SC (HSC) strategy is the conception and development of SCs enabling the integrated and inclusive valorisation of humans, in order to contribute to employee satisfaction and well-being and to keep a central role of humans in production and distribution. This SC strategy shall be based on defining workplace to provide each employee with a suitable working environment. Therefore, humans are the central element at all the levels and dimensions throughout the whole SC implementing also diversity and equity policy. The human-centred technology change in the manufacturing process could result not only in cost efficiency and process flexibility but also in extended corporate employee responsibility by fostering socially and inclusive responsible practices (European Commission, 2015).

Specific challenges for DRSC:

1. Need of identification and development of SC skills (SCH#9, TCH#9)
2. Lack of training programs for workers in SC environments (TCH#9)
3. Socio-cultural acceptance and awareness of future technologies (SCH#14, TCH#4)
4. Lack of safety in the work environment (TCH#6)
5. Need for a socially sustainable SC (SCH#14)

Research and innovation topics for USC:

- RIT_HSC.1** New tools to enhance work environment
- RIT_HSC.2** Cyber and physical safety in new work environments
- RIT_HSC.3** Technologies to identify, improve and assess workers' skills
- RIT_HSC.4** Management of ethical issues in new models of human-machine collaboration



Closed-Loop Supply Chain (CLSC) strategy

Closed-loop supply chains (CLSC) are networks that "include the returns processes; the manufacturer has the intent of capturing additional value and further integrating all supply chain activities" (Guide, 2003). CLSC is strictly interconnected with circular economy, with productive systems simultaneously considering forward and reverse SC operations (Webster, 2015).

CLSCs include traditional forward SC activities and the additional activities of the reverse SC: (i) product acquisition from the end-users; (ii) reverse logistics to move the products from the points of use to a point(s) of disposition, (iii) testing, sorting, and disposition to determine the product's condition and the most economically attractive reuse option, (iv) refurbishing to enable the most economically attractive of the options: direct reuse, repair, remanufacture, recycle, or disposal, and (v) remarketing to create and exploit markets for refurbished goods and distribute them.

Specific challenges for CLSC:

- 1 Strong collaboration along the closed chain (SCH#1)
- 2 Efficient resource management in return process (SCH#2)
- 3 Secure and reliable information management in industrial symbiosis (SCH#2-19)
- 4 Rethink regulation for Circular Economy processes (SCH# 16-23)
- 5 Technology development for reverse logistics, waste management and recycling, reusing and remanufacturing (TCH#1)
- 6 Lack of shared KPIs for the sustainability evaluation (SCH#16)

Research and innovation topics for CLSC:

- RIT_CLSC.1** Reverse logistics for recycling, reusing, remanufacturing in circular economy
- RIT_CLSC.2** Industrial symbiosis and other mechanisms for collaborative SC
- RIT_CLSC.3** Digitalisation supporting closed-loop SC
- RIT_CLSC.4** Optimisation of waste management operations
- RIT_CLSC.5** Standardisation of methodologies and KPIs for assessing sustainability.

Customer-Driven Supply Chain (CDSC) strategy

A customer-driven supply chain should orchestrate the different elements of supply to satisfy demand wherever it occurs. Each decision along the SC shall be driven by customers' needs, expressing their own singularity in terms of products and services. Customer-driven strategies mainly rely on the agility concept, which aims for demand and production alignment, and fast production and quick delivery of products in response to change in customer demands (Medini, 2019). To put in place such an approach, actors of a supply chain should be aligned, and information should be shared through all the nodes in the chain.

Specific challenges for CDSC:

- 1 Collaboration and orchestration to meet customer needs (SCH#1)
- 2 Leaner and flexible responsible SCs (SCH#4)
- 3 Personalised shipping drives changes in the SC (SCH#6)
- 4 Matching custom demand (SCH#7)
- 5 Developing new business models (SCH#13)
- 6 Assuring SC traceability for customer trust (SCH#8-13)

Research and innovation topics for CDSC:

- RIT_CDSC.1** New models and tools to understand customer needs
- RIT_CDSC.2** New technologies and SC models enabling personalised production
- RIT_CDSC.3** New models and tools for dynamic customer-driven SC

Service-Driven Supply Chain (SDSC) strategy

The service-driven SC aims at the establishment of an increased service business orientation and the addition of services or a focused combination of goods, services, support, self-service and knowledge until reaching a service-centric structure. The capability of offering services as complements—or even substitutes—for available products, enabling new business models, requires a capability to deal also with local specificities, needs and partnerships with service providers.

Moreover, companies traditionally linked to product manufacturing are progressively embedding digital services in physical products. Digital technologies are transforming the SC structure and the power dynamics in both downstream and upstream network, due to reductions in production and transport costs, and the identification of different ways to engage with customers (Vendrell-Herrero, 2016).

Specific challenges for SDSC:

- 1 Developing collaborative models to support the shift to SDSC (SCH#1)
- 2 Need of workforce with expertise in services and digital technologies (SCH#9, TCH#9)
- 3 Managing IP protection issues, information sharing and cybersecurity in product-service systems (SCH#9-12, TCH#7)
- 4 Dealing with drivers and implications of servitisation on the SC, also in terms of digitalisation and sustainability (SCH#13)

Research and innovation topics for SDSC:

- RIT_SDSC.1** Managing digital servitisation of the SC
- RIT_SDSC.2** Dealing with changes in business concepts and SC processes in servitised SC
- RIT_SDSC.3** Open innovation and value co-creation for integrated product-service offer;
- RIT_SDSC.4** Technological developments of autonomous transport systems for integrated product-service solutions
- RIT_SDSC.5** New models and tools for secured and transparent data sharing and big data analytics in the service-centric SC

Biointelligent Supply Chain (BIOSC) strategy

BIOSC requires parallel concept developments of circular economy and bio-based transformation as well as digital transformation. The latter falls short of creating a process on the way to a sustainable economy while circular economy omits essential aspects of manufacturing industry and society (ManuFUTURE, 2018). Thus, the combination of digitalisation and circular economy creates a basis and empowers a sustainable, biointelligent economy.

BIOSCs follow a twofold aim. Firstly, it follows an ecological goal, in which production processes avoid harmful material and it aims to implement more and more green concepts that enable emission neutral SC processes. Secondly, BIOSCs follow an efficiency goal by imitating concepts from nature for decentralised control and self-organisation and self-configuration of the SCs implementing a biological transformation of the chain. This strategy employs nature-identical and nature-analogue processes and technologies to improve production and communication for efficient value creation along the network that should be able to spontaneously and autonomously restructure the configuration to achieve resilience.



Specific challenges for BIOSC:

- 1 Technology maturity (TCH#1)
- 2 Collaboration in a decentralised environment (SCH#1)
- 3 Organisational settings in a distributed context
- 4 Flexible, responsive SC availability (SCH#4)
- 5 Resource management in a BIOSC (SCH#2)
- 6 Personalised shipments (SCH#5-6)
- 7 IT integration and interoperability (SCH#11, TCH#8)

Research and innovation topics for BIOSC:

- RIT_BIOSC.1** Organisational change towards a new taxonomy for biointelligent SCs
- RIT_BIOSC.2** Nature-inspired symbiotic SC models
- RIT_BIOSC.3** Ecosystem for biointelligent SC
- RIT_BIOSC.4** New SC processes to realise biointelligent SC paradigms
- RIT_BIOSC.5** Coordination and decision-making within biointelligent SCs.

Policy recommendations

The policy recommendations propose targeted actions for the sustainability and excellence of future European SCs grounding on the identification of key horizontal issues (KHI) as a combination of cross-cutting topics, such as standardisation, training, and infrastructure, which encompass—and are common to—all SC dimensions and strategies.

Each KHI entails critical processes and resources and requires interventions at different levels. The nature of the issues makes them especially relevant for the potential impact they have in a vast number of SC strategies and sectors, ranging from distribution to process industry and discrete manufacturing. Moreover, they represent core building blocks that should be addressed in a complementary manner, through the definition of a set of policies and collective actions both in terms of content and structure. Therefore, the rationale is proposed here for an integrated, holistic and proactive involvement of all the stakeholders and a clear understanding of expected outcomes and relative roles and responsibilities.

The identified policy recommendations are suggested to the responsible public/private actors and may come in the form of: (1) a policy, understood as a course of actions or plans that is used as a basis for making decisions and represents a long-term commitment; (2) a project, which is a temporary effort with the purpose to create a specific solution; or (3) a programme, which can be defined as a set of interrelated projects managed in a coordinated way in order to obtain broader benefits. The recommendations may also demand new mechanisms or instruments for the European Commission.

The set of policy recommendations has been framed into specific policy briefs (one or more per each recommendation), as shown in Table 1.



Policy Recommendations		Policy Briefs
1	Assuring appropriate standards and legislation for European SCs of the future	1.1. Fostering harmonisation of legislation and standards on European SCs
		1.2. Disseminating standards among European SC stakeholders
		1.3. Facilitating and boosting multimodal transportation
2	Educating and training professionals for the future SCs	2.1. Developing the workforce for the SCs of the future
3	Drafting of international agreements aiming at future European SCs	3.1. Promoting bi- and multi-lateral agreements that consider an overall SC perspective
		3.2. Supporting the establishment of R&D networks for advancements and dissemination of SC-related topics
4	Supporting and fostering incentives and funding schemes	4.1. Enhancing collaboration based on European Projects results: creation of a platform for data repository
		4.2. Establishing a prize to support and spread best practices in the SC
		4.3. Creating synergies between public and private sectors in funding
5	Promoting reference bodies for European SCs	5.1. Creating a European SC knowledge hub for sustainable, resilient and inclusive SCs
6	Establishing infrastructure for fostering of future European SCs	6.1. Upgrading infrastructures for low-emission supply chains
		6.2. Promoting 5G and autonomous vehicles (AVs) to improve urban supply chains

Table 1: Policy recommendations

PR1. Assuring appropriate standards and legislation for European SCs of the future

- Regulations and standards play an important role for future SCs, influencing processes and transactions and highly impacting European competitiveness.
- Different legislation and standards among EU countries generate additional costs and harm transparency of transactions; there are still a high number of non-harmonised industry sectors as well as sectors where the harmonisation is limited to essential requirements.
- Current regulation does not favour the use of multimodal transportation.

PR2. Educating and training professionals for the future SCs

- Training and education are crucial factors for the maintenance and improvement of the competitiveness of European SCs, as they represent the base of knowledge required to face current and future challenges.
- A misalignment between current SC professionals' competences and skills

and companies' needs can often be observed.

- Future European SCs require a set of competences and skills which are not sufficiently addressed by current education and training programs.

PR3. Drafting international agreements for European SCs

- There is the need to increase engagement, joint efforts and collaboration between the several European countries (and with other key non-European countries) to facilitate and improve research and innovation actions with a focus on 'whole SC' and thus ensuring transparency, industrial competitiveness and sustainability of European SCs.
- There is a lack of a systemic perspective on the overall SC in the existing agreements.
- With growing globalised SCs, research and innovation efforts should be opened outside European boundaries for competitiveness and excellence.

PR4. Supporting and fostering incentives and funding schemes

- Focus should be on incentives and funding schemes comprised of support actions that encourage demonstrations and pilot-tests of technologies in real contexts, as well as their large-scale application involving SC actors to test them in a connected way (TRL 7 and above).
- There is a need for fostering effective collaboration with established and future projects, thus ensuring projects' continuity, especially on SC-related topics.
- There is a lack of common definition of SC best practices, as well as sharing and implementation among European companies.
- The need for new funding schemes combining public and private sectors' efforts is required for fostering faster and greater improvement of SC activities at European level.

PR5. Promoting reference bodies for European SCs

- The dissemination of useful information and knowledge on innovative technologies and practices is needed in order to improve the competitiveness of European companies and SCs.
- Existing information and knowledge in a variety of topics are often difficult to find and access, resulting in the lack of a proper background for decision making by SC managers, professionals and policymakers.
- Information and knowledge have to be provided and disseminated to all stakeholders and must be available timely and in clear and easy formats.

PR6. Establishing infrastructure for fostering of future European SCs

- Physical and digital infrastructure plays a crucial role for the competitiveness and preparedness of European SCs for current and future challenges.
- Contemporary cities have been suffering with huge traffic jams and pollution. At the same time, logistics companies have faced a paradoxical challenge, being required to deliver as fast as possible and as 'greener' as possible.
- An expressive improvement of route planning, traffic flow and integration of logistics companies with other important entities requires real-time data exchange.

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SUMMARY

The NEXT-NET project creates a cross-sectoral and cross-technological initiative at European level to increase integration between production and distribution proposing research and innovation priorities for the future of supply chains.

PROJECT LEAD PROFILE

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