GRETA

Activity 1.3 Capitalization of previous projects and beyond

D.1.3.2 Conceptual paper on regional collaborative logistics in FUAs

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AUTHORING, REVISION & QA INFORMATION

Deliverable Contributors		
Type of author	Name and surname	Organisation (short name as in AF)
Main author	Riccardo Maratini, Luca Simone	OE
Contributor	Alice Benini, Fahad Anwar	ITL
Contributor	Katja Hanžič, Tomislav Letnik, Ines Pentek	UM
Contributor	Philip Michalk	THWi
Contributor		
Contributor		

GRETA Project

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List of abbreviations

Acronym	Name
ALICE	Alliance for Logistics Innovation Through Collaboration in Europe
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
ASC	Automated Straddle Carrier
BC	Blockchain
BLE	Bluetooth Low Energy
CAGR	Compound Annual Growth Rate
CE	Central Europe
CL	Collaborative Logistics
CNC	Core Network Corridor of the Trans-European Network
DI	Decision Intelligence
DL	Deep Learning
DSRC	Dedicated Short-Range Communications
ETP	European Technology Platform
EU	European Union
FUA	Functional Urban Areas
GenAI	Generative Artificial Intelligence
GPS	Global Positioning System
IoT	Internet of Things
LLM	Large Language Models
LoRaWAN	Long Range Wide Area Network
LPWAN	Low-Power Wide-Area Network
LTL	Less-Than-Truckload
MASS	Maritime Autonomous Surface Ships
ML	Machine Learning
NUTS	Nomenclature des Unités Territoriales Statistiques (Nomenclature of Territorial Units for Statistics)
PI	Physical Internet
PP	Project Partner
RCL	Regional Collaborative Logistics
RFID	Radio-Frequency IDentification
SC	Supply Chain
SCM	Supply Chain Management
SME	Small or Medium Enterprise
TEN-T	Trans-European Transport Network
TMS	Transport Management System
XML	eXtensible Markup Language

WMS	Warehouse Management System
ZE	Zero Emission

1. The GRETA project

GRETA project aims to decarbonize the last mile delivery in Functional Urban Areas (FUAs) in Central Europe (CE) and create liveable and accessible cities for all by 2030. The project seeks to implement joint sustainable solutions in CE FUAs using zero-emission vehicles and cargo bikes and reorganize urban spaces with curb management. The pilot actions in the cities of Maribor, Reggio Emilia, Verona, Poznan, and Budapest (with Berlin FUA as an observer) have the potential to quickly deploy as pop-up measures in combination with existing measures. GRETA provides capacity-building activities, strategies, action plans, and tools for public authorities, enterprises, and relevant organizations to ensure financial, environmental, and social sustainability beyond the project's lifetime.

Last-mile delivery generates negative impacts, including emissions, noise, and congestion. Due to the Covid-19 crisis, global parcel distribution volume almost doubled, further adding inefficiencies in the peripheral areas. GRETA's FUAs recognize the problems that generate pollution, nuisance, noise, and congestion and jointed recognized three main problems: the lack of use of green zero-emission last-mile vehicles, conflicts between freight and public vehicles, and the lack of knowledge and strategies for a flexible and shared use of the curb and public space. Despite having SUMPs/SULPs, FUAs struggle to activate fitting measures while keeping their centres attractive and alive for residents and tourists.

GRETA addresses the common challenges of all CE FUAs by creating the conditions to promote ZE logistics through the use of micro-hubs, cargo bikes, light e-vehicles, and curb management strategies. Additionally, the project also focuses on paving the way to innovative concepts such as regional collaborative logistics, physical internet, and freight curb management. GRETA facilitates the dialogue towards the acceptance of a business and governance as a service model, where cities must equip themselves with a network of innovative services to guarantee seamless experiences for their users and a mobility plan considering different functions and priorities of the services.

GRETA's objective is to support the urban mobility transition in CE FUAs by jointly developing solutions and strategies with a huge potential for decarbonization of the last mile in line with the Green Deal and the Urban Mobility Package, abating congestion, pollution, and nuisance. The project's success relies on capitalizing on previous experiences, exploiting synergies with ongoing initiatives, testing innovative pilots, improving competencies and knowledge among PPs and stakeholders.

2. Executive Summary

This deliverable provides a conceptual paper on Regional Collaborative Logistics (RCL), with the aim of fostering its development within the Functional Urban Areas (FUAs) addressed by the GRETA project and, more broadly, across Central Europe.

RCL represents the application at the regional level of a collaborative supply chain approach designed to unlock synergies among different logistics actors and increase overall system efficiency. More specifically, it consists in a strategic SC practice wherein distinct entities (carriers, shippers, warehouse operators, technology partners) share resources, coordinate operations, and exchange critical information to achieve improved system efficiency.

The benefits of such an innovative approach are evident in terms of both cost reduction and improved sustainability, as RCL seeks to achieve a system optimum that overcomes the limitations of purely competitive strategies.

As part of Activity 1.3 "Capitalization of previous projects and beyond", this deliverable addresses this innovative approach, building upon available knowledge, while further updating and elaborating it. In particular, this conceptual paper draws on an analysis previously conducted in 2022/2023 by the European Network of Logistics Competence Centres (PP 10 - Open ENLoCC) through an active engagement of its members. In particular, it consisted of the responses collected through an ad-hoc questionnaire developed through an iterative process and brainstorming. Relevant aggregated results from this survey are presented and discussed herein.

The outcomes from both this analysis and the literature review allow to ascertain how, despite the evident and widely acknowledged potential benefits of collaborative logistics, its implementation still lags behind. This situation is also related to relevant obstacles in the path towards the achievement of such a strategic organisational and behavioural change. Obviously, this applies in particular in the case of the so-called "horizontal collaboration", taking place between actors belonging to the same tier of the SC, which in many cases could be natural competitors.

To overcome this gap and foster the adoption of this innovative approach, it is crucial to highlight key challenges and obstacles to be addressed. At the same time, promising opportunities are emerging from enabling technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and blockchain, as well as from systemic innovations like the Physical Internet, which proposes a paradigm shift towards open, interoperable, and modular logistics networks.

Consequently, a relevant deal has been paid to outlining key aspects for overcoming this gap and fostering the adoption of RCL. To this end, promising opportunities from different enabling technologies such as AI, IoT, and BC, as well as from systemic innovations like the PI, have been highlighted. Furthermore, the role that can be played by different stakeholders, including the importance of public bodies, has been duly underlined.

Moreover, on the basis of the carried-out analysis, it is possible to outline key aspects in order to contribute to a "favourable ecosystem" fostering the adoption of RCL, as outlined in the previous analysis by Open ENLoCC. In particular, this can include raising awareness and providing shared knowledge by:

- providing different actors with a shared general overview of challenges to be addressed and opportunities to be seized;
- contributing to the dialogue/synergic interaction between public planning and private initiatives, as well as decision support;
- stimulating public support, in terms of planning activities, for the RCL development;
- Fostering know-how and networking among private actors, particularly SMEs, to help them integrate emerging technologies that enable RCL.

3. Introduction

The various elements making up the logistics system, being part of an intensely competitive environment, are constantly subjected to strong pressure towards optimising performances to optimize performances with the primary objective of maximising profits. Moreover, ever-growing concerns about environmental sustainability are also pushing the quest for cost-efficient and less impactful solutions driving the search for cost-efficient and less impactful solutions. On these grounds, it may seem that further gains in efficiency are only achievable through substantial investments in infrastructure realisation and advanced technological innovation.

On the contrary, it is important to emphasise that there is significant room for improvement by leveraging synergies and teamwork among different players within SCs, through the adoption of innovative collaborative approaches in logistics. This corresponds to pursuing a system optimum, thus addressing the limitations and inefficiencies inherent in a purely competitive approach.

However, despite the evident and widely acknowledged potential benefits of collaborative logistics, its implementation still lags behind. To overcome this gap and foster the adoption of this innovative approach, it is crucial to highlight key challenges and obstacles to be addressed. At the same time, promising opportunities are emerging from enabling technologies such as AI, IoT, and BC, as well as from systemic innovations like the PI, which proposes a paradigm shift towards open, interoperable, and modular logistics networks.

Bearing in mind the relevance of these potential innovations for a more sustainable and efficient SC, this deliverable provides a synopsis and conceptual foundation for Collaborative Logistics, with particular reference to the regional dimension.

As part of Activity 1.3 "Capitalization of previous projects and beyond", it builds upon available knowledge, while further updating and elaborating it. In particular, this conceptual paper draws on an analysis previously conducted in 2022/2023 by the European Network of Logistics Competence Centres (PP 10 - Open ENLoCC) through an active engagement of its members. In particular, it consisted of the responses collected through an ad-hoc questionnaire developed through an iterative process and brainstorming. Hence, aggregated statistics resulting from the collected answers are reported and commented on in the following chapters.

As far as the document structure is concerned, the next chapter begins by introducing the key concept of Regional Collaborative Logistics (RCL and elaborates on the relevant aspects of the regional dimension and the related stakeholders to be involved. In this regard, along with the fundamental role played by various types of private actors, it is important to underline the importance of involving public bodies, thus also addressing planning as well as regulatory considerations.

Then, the subsequent chapter, after discussing the obstacles and current limited adoption of the RCL, focuses on outlining key enabling factors and especially technologies.

Lastly, based on this foundation, in chapter 6, a vision pivoting on the main goal of creating a "favourable ecosystem" fostering RCL has been devised.

4. The concept and rationale of Regional Collaborative Logistics

To establish a well-grounded foundation for the present analysis, it is essential to clarify the key concepts underlying the object of study: RCL. As anticipated, RCL refers to the intentional synergy among various SC actors within a defined territory [20] [25], aimed at unlocking efficiency gains and maximising sustainability. Given its complexity and multifaceted nature, a deeper understanding requires breaking down its main components — the collaborative logistics concept and the regional dimension — which will be examined separately in the following paragraphs.

4.1. What is collaborative logistics?

Collaborative logistics (CL) aims to unlock and exploit potential synergies between different actors in the SC in order to maximise the overall system efficiency. More specifically, it consists in a strategic SC practice wherein distinct entities (carriers, shippers, warehouse operators, technology partners) share resources, coordinate operations, and exchange critical information to achieve improved system efficiency.

It is important to emphasise how this entails establishing a well-structured coordination among different actors according to a long-term strategic approach. For this reason, rather than using the relatively generic term 'cooperation,' the term '**collaboration**' is employed to denote such a higher degree of commitment and interrelationship.

4.1.1. Typologies of collaborative logistics

Different typologies of collaboration can be classified according to the mutual positioning of the involved actors in the SC. In this regard, a key distinction can be made between collaboration taking place between actors either at different or at the same stage of the production and distribution process.

The first case, called **"vertical collaboration"** [21] [25], occurs when the involved actors belong to different tiers of the SC, such as suppliers, manufacturers, distributors, and retailers. Since it is usually managed and regulated by the contracts ruling the relationships between suppliers and clients, it takes place more naturally. Typically, it regards joint production planning, inventory synchronisation, and end-to-end shipment optimisation. In practice, common activities include Collaborative Planning, Forecasting, and Replenishment (CPFR), which integrates joint business planning, demand forecasting, and replenishment across SC partners, and Vendor Managed Inventory (VMI), where the supplier assumes responsibility for managing inventory levels at the customer's location through shared data and, more in general, real-time coordination of inventory management processes.

The second form of collaboration, defined as "**horizontal collaboration**" [19] [25], takes place between actors at the same tier of the SC — for example, multiple carriers, competing retailers, or logistics service providers. As these actors are frequently natural competitors, horizontal arrangements are more challenging and require sophisticated consensus-building and trust. Obviously, this implies a higher need for developing a shared understanding as well as awareness and, consequently, represents the key focus of the present activity. Practical implementations include the pooling and joint management of transport resources, consolidation of partial shipments (Less-Than-Truckload (LTL)), shared warehousing, and real-time data exchange through integrated IT platforms.

Furthermore, the full picture nowadays includes a whole set of different hybrid situations and approaches, combining both vertical and horizontal elements, enabling flexible, optimised structures across complex supply networks.

4.1.2. Benefits of collaborative logistics

The benefits of CL are evident considering the fragmentation affecting, in many cases, the SC, which leads (among other things) to inefficiencies in freight transport (e.g. empty runs) as well as related costs and externalities [22] (e.g. air and noise emissions, congestion, accidents, etc.). Hence, by maximising the efficiency of the SC, CL is both beneficial in terms of increased productivity and sustainability. Correspondingly, operators implementing collaborative logistics could expect direct benefits in terms of increased incomes or savings due to improved efficiency and, in case, also through incentive schemes arising from public funding.

In this regard, over the last decades, research simulations and case studies have highlighted the potential of logistics collaboration.

Moreover, the survey carried out by Open ENLoCC has also highlighted the benefits of (Regional) Collaborative Logistics related to addressing relevant issues of the regional SCs. In this regard, Figure 1 shows the key issues identified to be addressed, along with their average importance ratings obtained from questionnaire responses. The ratings range from 1 (not important) to 5 (absolutely important). Positively, these issues can be regarded as challenges to be actively pursued through the opportunities and technologies described in the next chapter.

The results indicate that all identified issues received quite high ratings, exceeding 4.

Looking in greater detail, it is worth noting that RCL is fundamentally linked to the need to enhance the optimisation and efficiency of logistics processes. However, in addition to this more evident and immediate outcome (benefitting directly, in the first place, the private operators), further and more general positive impacts (for the wider context) can be highlighted. These include contributions to environmental sustainability and the economic development of regions as a whole.

Moreover, a (potential) improvement can be specifically addressing the SMEs in facilitating their access to the worldwide SC. Furthermore, even though resilience is deemed relevant, the way it can be linked with RCL may not be so immediate and easily perceived. Hence, it is further discussed in the following ad-hoc paragraph.

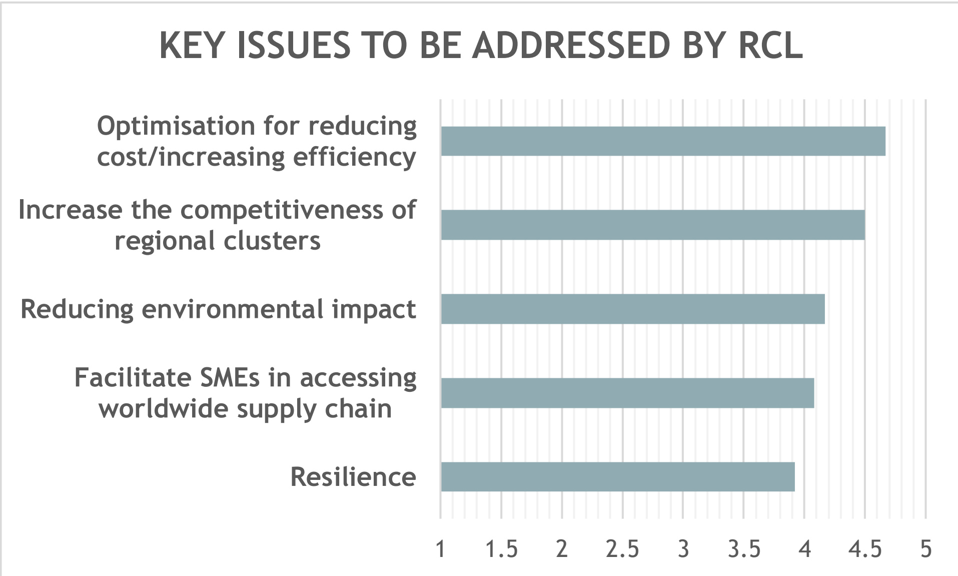

Figure 1 - Rating of the key issues to be addressed by RCL according to the responses from the questionnaire. Source: Open ENLoCC, 2022

Focus on resilience

As previously noted, RCL is expected to play a significant role in enhancing SC resilience.

In recent years, the term resilience has become increasingly used (maybe even excessively). Nonetheless, being essentially the opposite of vulnerability, the concept of resilience represents a fundamental quality for withstanding critical threats and disruptions. Hence, it represents far more than just a buzzword.

Because resilience becomes most visible only when low-probability, high-impact events occur, its relevance can be difficult to recognise and assess in the context of everyday operations. However, when such events do take place, its crucial importance quickly becomes evident. In this regard, collaborative practices can play a key role, as shown during natural disasters such as the floods in Wallonia or the earthquake in Emilia-Romagna, when shared infrastructure enabled smaller companies to continue operating despite losing access to their own assets.

More in general, through stakeholders' collaboration, resilience against any typology of risk (from those natural hazards, such as floods, to emergencies due to a war or geopolitical tensions, etc.) can also be achieved pre-emptively. In fact, RCL can be a very efficient answer to these risks, also in terms of a strategic approach that changes the way companies operate and interact mutually, thus increasing their overall competitiveness as well [23].

Another interesting fact to recall is how the resiliency concept was foundational in the development of relevant technology, starting from the (digital) internet (which, among other things, is an inspiring paradigm for the PI) up to BC innovative solutions. In fact, these technologies share the idea of a distributed network approach. Besides, these technologies are also relevant (see in the following as "enabling technologies") for the RCL itself.

However, the analogy with the Internet, stemming from the ARPANET network developed in such a hierarchically structured context as the military one, allows emphasising how this requires agreed governance and rules. In the case of the SC, encompassing different private actors also acting in a competitive market, these aspects could be particularly challenging to establish and implement. Once again, this lets us to highlight the importance of a deliberated and committed synergy as foreseen by a collaborative approach.

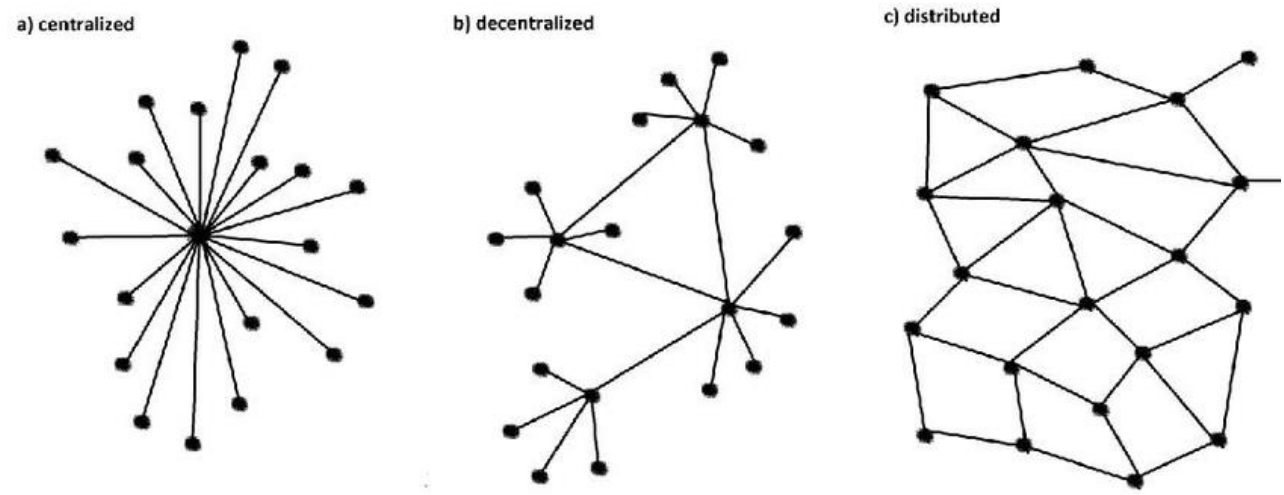

Figure 2 - Centralised, decentralised and distributed networks. Source: ([L. Fichtner, 2015](#))

From what was discussed above, it is evident how resilience and collaborative logistics can be mutually associated. In order to further elaborate on this, the questionnaire requested the respondents to qualify the relationship between resilience and RCL.

As from the obtained outcomes (see the following image), a key role of RCL in establishing a distributed network and achieving resilience is clearly acknowledged. Moreover, RCL is mainly considered beneficial for reducing vulnerability through certain optimisation processes. On the other hand, an optimisation aiming to reduce costs also by lowering the safety margin could eventually increase the vulnerability. In this regard, it must be recalled that every optimisation (including those carried out through the RCL approach) is made with reference to certain aspects to be maximised and taking into account relevant constraints. Hence, a good optimisation in the SC must explicitly take into account, among other things, the need for ensuring adequate safety margins and resilience.

The underlying idea of different ways to achieve resilience could also be further elaborated on, taking into account the way in which resilience can be bolstered: either by building in redundancy or by pivoting on flexibility.

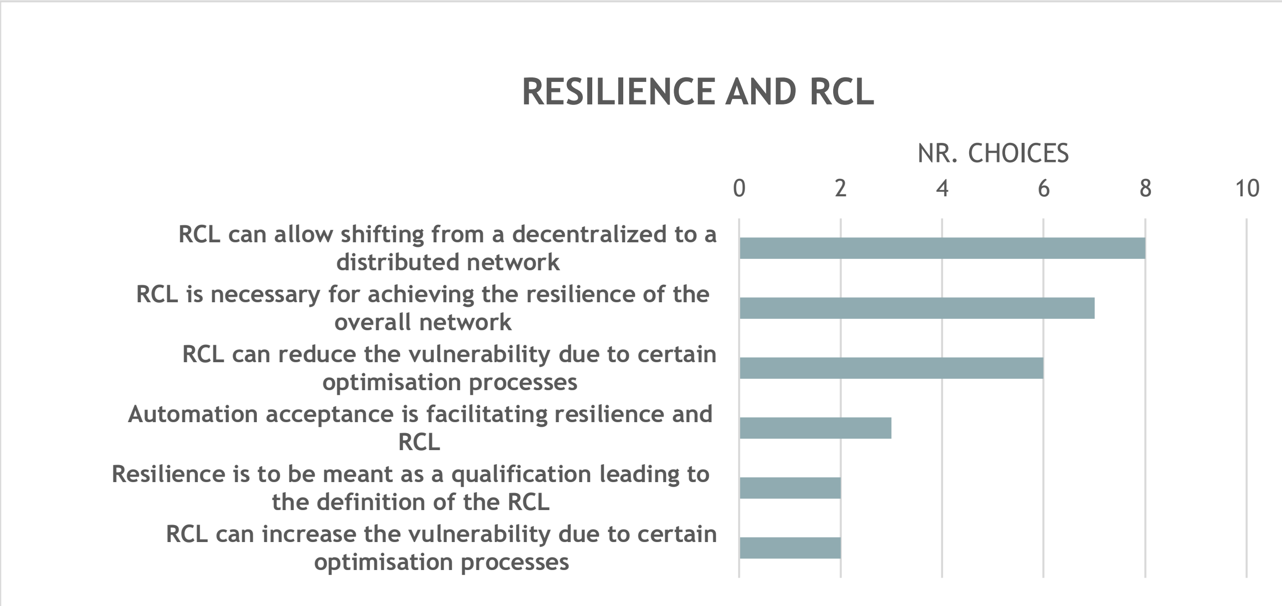

Figure 3 - Resilience and RCL. Source: Open ENLoCC, 2022

4.2. Understanding regional logistics: what is regional?

The other key aspect to be considered in the concept of RCL is the (apparently trivial) issue of a possible definition of what is "regional". In principle, it can be characterised by making reference to two different viewpoints: administrative subdivisions and functional clustering. In turn, both these two viewpoints present different aspects to be considered and a certain level of heterogeneity in relation to different territorial contexts. In fact, the administrative classification depends on the different legislative frameworks, which (for instance) in the EU also encompass States with or without legislative powers at the sub-national level.

In this regard, an important harmonising effort is represented by the NUTS classification. In this regard, it is worth noting that, in general, the regional level is represented by the NUTS2 level, even though certain differences can be seen when comparing different States, also taking into account the existence of relevant planning bodies and activities at this specific (NUTS2) level.

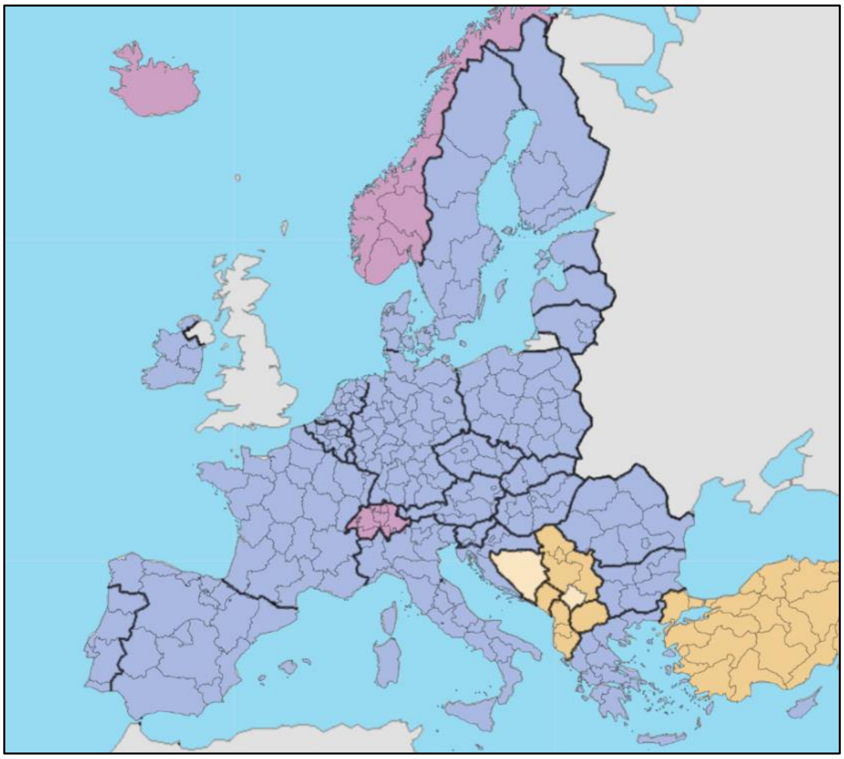

Figure 4 - NUTS 2: basic regions for the application of regional policies

The functional viewpoints, instead, imply dealing with the role played within the logistic networks by various elements, even beyond administrative and national borders, and their mutual relations. In this regard, intermodal nodes play a key role, but it is also important to recall that the related terminology (especially with reference to those located in the inland areas) is somewhat fuzzy and heterogeneous.

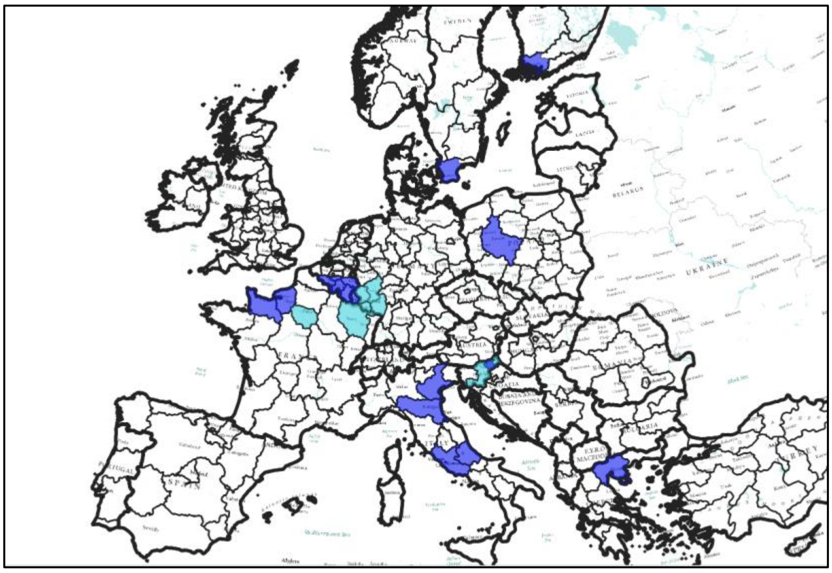

Figure 5 – Examples of functional regional areas for collaborative logistics in relation to Open ENLoCC Members regions. Source: Open ENLoCC, 2022

In this regard, a key indication can be obtained through the analysis of the flows associated with transport and logistics demand. In particular, four types of transport and logistics demand can be identified:

1. Demand generated inside the region and consumed outside the region (at the national/international level)
2. Demand generated inside the region and consumed inside the region (in urban and non-urban areas)
3. Demand generated outside the region and consumed inside the region
4. Transit demand.

All these types of demand use the same regional transport and logistics capacity, sometimes leading to shortcomings due to conflicting infrastructure usage and a lack of smooth integration (which would allow overall resource efficiency). In this regard, RCL can be understood as the (needed) collaboration between the SC actors (both through horizontal and vertical dimensions) for better use of infrastructure and services, thus achieving sustainability and operational efficiency goals.

On the other hand, usually, long-distance transit flows are a very important characteristic for the hubs networks, consuming transport and logistics capacities, as well as for economic development by providing accessibility to the worldwide SC and markets. In this regard (with reference to the long distance), a certain level of optimisation can already be ascertained.

Taxonomy of Logistics Clusters

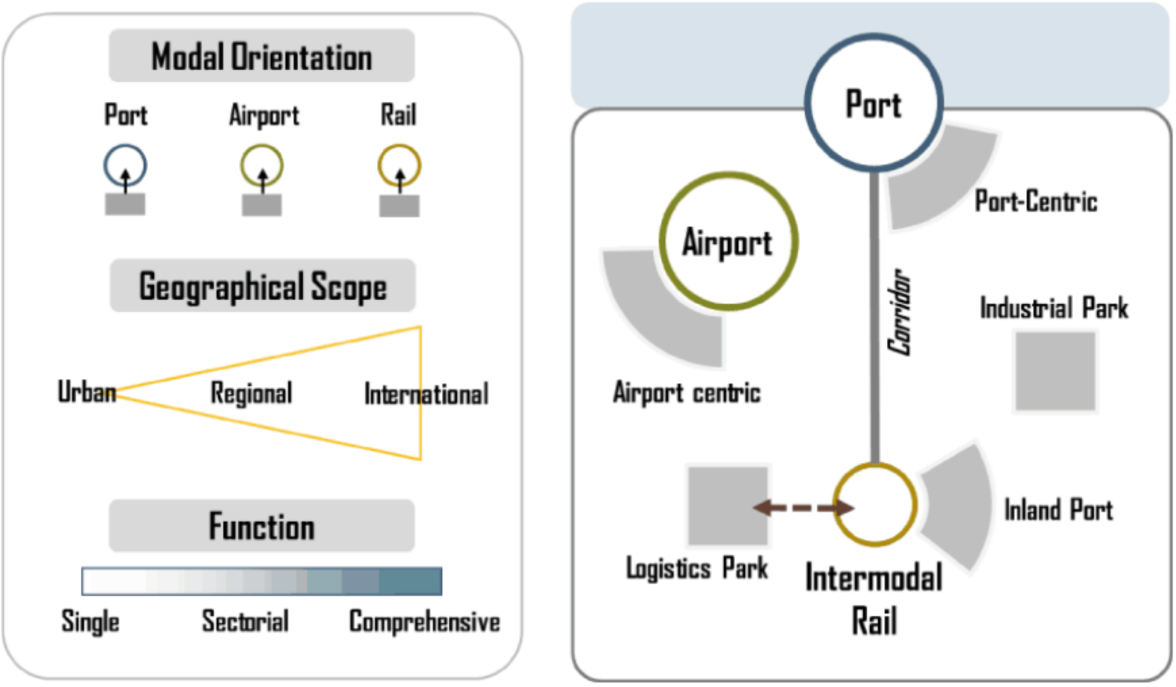

Figure 6 - The Taxonomy of Logistics Clusters. Source: "The geography of transport systems" J.P. Rodrigue elaboration on the "logistics clusters Delivering Value and Driving Growth" by Y. Sheffi (2012)

For instance, LTL (less-than-truckload) services already provide optimised solutions for consolidating shipping with similar paths (see also groupage). At least partially, this can be already achieved through commercial freight-sharing platforms. However, coordinating at the regional level and pivoting on logistic nodes for aggregating demand could foster new intermodal solutions by reaching critical "mass" and thresholds.

More generally, nodes, being essentially the locations where interactions take place, are increasingly acknowledged as a key hub for a wider set of operations and viewpoints, complementing and going beyond the intermodal function.

In this regard, it is important to highlight how the recent EU Ports Strategy initiative and calls for a renewed focus on the role of ports within their regional ecosystems. Correspondingly, ports are no longer considered as isolated infrastructures: they are viewed as embedded in a network of logistics competence centres, SMEs, inland terminals, and regional transport operators that co-shape the European SCs. Furthermore, to unlock the full potential of ports, a stronger integration between port innovation and regional logistics capabilities should be pursued. This also includes recognising the role of inland and secondary nodes that support port activities, facilitating seamless hinterland connectivity, and addressing the needs of regional ecosystems.

Within this framework, collaborative and shared logistics could help achieve a better balance between long-distance and regional flows or even integration of them for improved operations and better match of transport and logistics demand to supply. On the other hand, city logistics is affected by specific constrained related to the urban environment conditions. Moreover, it has already been tackled by various regulations and studies.

Within this overall picture, the regional dimension is characterised by its collocation as a middle ground between the long-distance and the urban/local dimension (esp. city logistics), which is often not adequately focused on. However, RCL must be acknowledged as a core enabler of EU competitiveness, resilience, and decarbonisation due to its relevance per se as well as in relation to the other two layers.

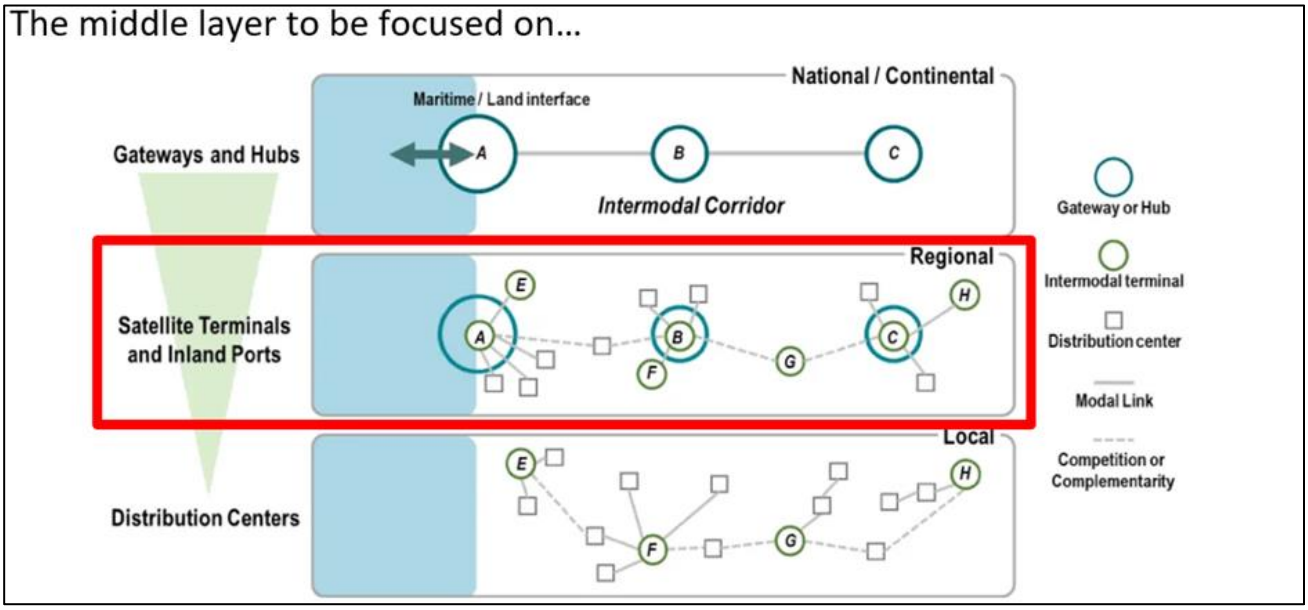

Figure 7 - The regional dimension as a “middle layer” positioned between the long-distance and the urban dimensions. Source: adapted from “The Geography of Transport Systems” by Jean-Paul Rodrigue (2020)

Looking at the local level, the main urban areas —comprising a densely inhabited urban core together with neighbouring municipalities that are economically and socially integrated through daily commuting patterns— are delineated and classified as Functional Urban Areas (FUA). These FUAs represent a harmonised territorial unit reflecting the actual metropolitan extent of a city and its surroundings by capturing the functional labour market and service area linked to the urban centre. Therefore, they are a key reference also for transport and logistics planning.

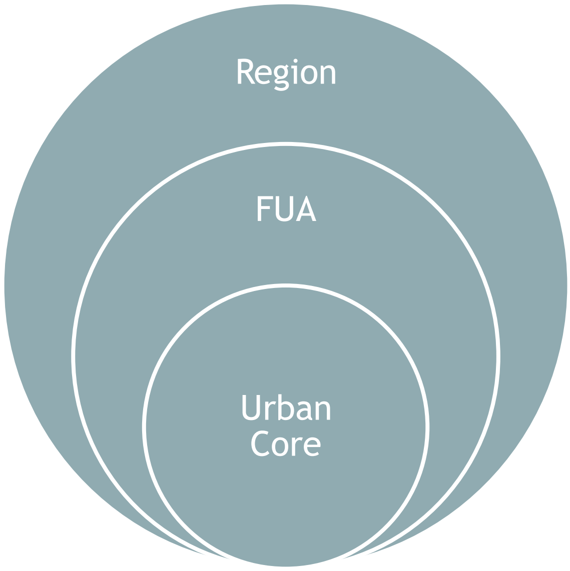

Figure 8 - Different levels from Regions to Urban core.

Looking at the European perspective, a key reference remains the TEN-T network, which has recently been revised and expanded through the Regulation (EU) 2024/1679. The previous dual-layer approach has evolved into a three-layer structure encompassing:

- A Core Network – providing the key strategic nodes and links that enable concentration of transnational traffic and long-distance flows, to be completed by 2030;
- An Extended Core Network – a new intermediate layer, aiming at broader connectivity across regions, to be completed by 2040;
- A Comprehensive Network – the densest layer ensuring accessibility throughout the continent, to be completed by 2050.

Furthermore, the traditional 9 Core Network Corridors have been transformed into broader European Transport Corridors, with extended geographic reach, supported by dedicated governance measures to streamline coordinated implementation. The overall development of the TEN-T network remains fundamental to ensuring the connectivity and strategic positioning of regions within the broader European and global transport system.

Interestingly, the role of urban nodes along the TEN-T corridors has been reinforced: 431 major urban nodes are now designated, each required to develop Sustainable Urban Mobility Plans (SUMPs) by 2027 to promote zero- and low-emission transport modes and foster integration between cities and their surrounding functional urban areas. This implies a reshuffling of the urban role, encouraging cities to grow by leveraging resources from their regional contexts.

Moreover, at the international level, the trend towards logistics regionalisation—shifting from globalisation to more regional and sustainable SCs over the coming 10 to 15 years—is increasingly supported by EU policies considering their environmental and strategic implications.

4.3. Who are the relevant stakeholders/actors?

In order to be developed, RCL calls for the involvement of different typologies of actors and stakeholders playing a role (directly or indirectly) in logistics and SCM management and planning.

Obviously, they belong to different fields and encompass both private and planning bodies.

In particular, the following figure presents the number of relevant actors identified by the Open ENLoCC Members with reference to their own regional contexts.

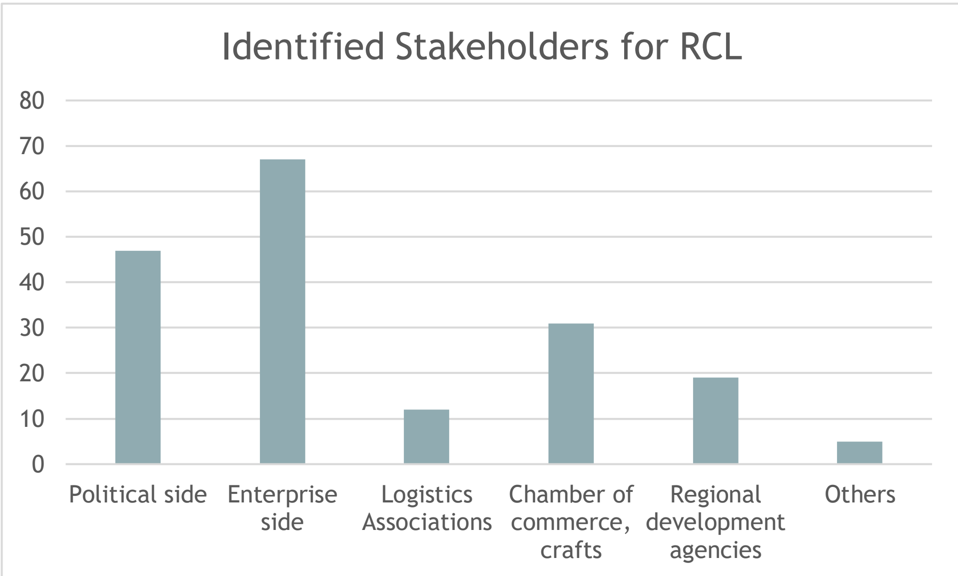

Figure 9 - Typologies of identified stakeholders by the Open ENLoCC Members. Source: Open ENLoCC

Obviously, enterprises and logistic operators are primarily and directly involved in the development of RCL. On the other hand, the role of public bodies should not be underestimated as well. In fact, they are particularly relevant in planning processes with reference to infrastructure realisation as well as other aspects related to governance, regulations and any other ancillary or supporting measure creating favourable conditions for the RCL. In between, there are different kinds of “Institutions for collaborations”[1], playing “a special public-private role” in clustering and coordinating, such as chambers of commerce, industry associations, etc. They are particularly relevant since, being composed of interacting members sharing a common purpose, they are particularly keen on exchanging information and knowledge, conducting joint campaigns and also fostering collaboration by creating formal mechanisms going beyond mere asset sharing[2].

[1] See the overview of “the wide variety of organizations other than firms, government ministries and regulatory agencies, and universities that may have significant effects on competitiveness” provided by Porter, Michael E., and Willis M. Emmons III. "Institutions for Collaboration: Overview." Harvard Business School Background Note 703-436, January 2003.

[2] See Sheffi, Yossi. Logistics Clusters: Delivering Value and Driving Growth. The MIT Press, 2012.

Looking at the current state of play of actors' involvement, (at present) there are few initiatives specifically addressing RCL, while it is sometimes mentioned in general planning documents concerning logistics and transport. Moreover, the search for actors already playing an active role in RCL in the regional context has allowed identifying only a limited number of examples.

5. Implementing the RCL: obstacles and opportunities

Researchers and practitioners have been investigating and addressing the theme of Collaborative Logistics for more than twenty years. Nonetheless, in spite of some interesting examples and evident benefits highlighted in the previous chapter, collaborative logistics is far from spread diffusion and mass adoption. Therefore, after discussing and delving into the definitional aspects of the main object of the analysis (RCL), in this chapter relevant aspects to be considered in the light of gaining momentum and provide favourable conditions for implementing RCL are focused on.

To this end, a brief assessment of the state of play together key obstacles to be addressed are highlighted. Then, opportunities to be seized in order to foster the development of RCL are focused on. These aspects allow us to begin specifying the main issues and possible options to be taken into account. Hence, they represent a key starting point in the development of the vision fostering RCL that will be further discussed in the next chapter.

5.1. Obstacles to be addressed and the current situation

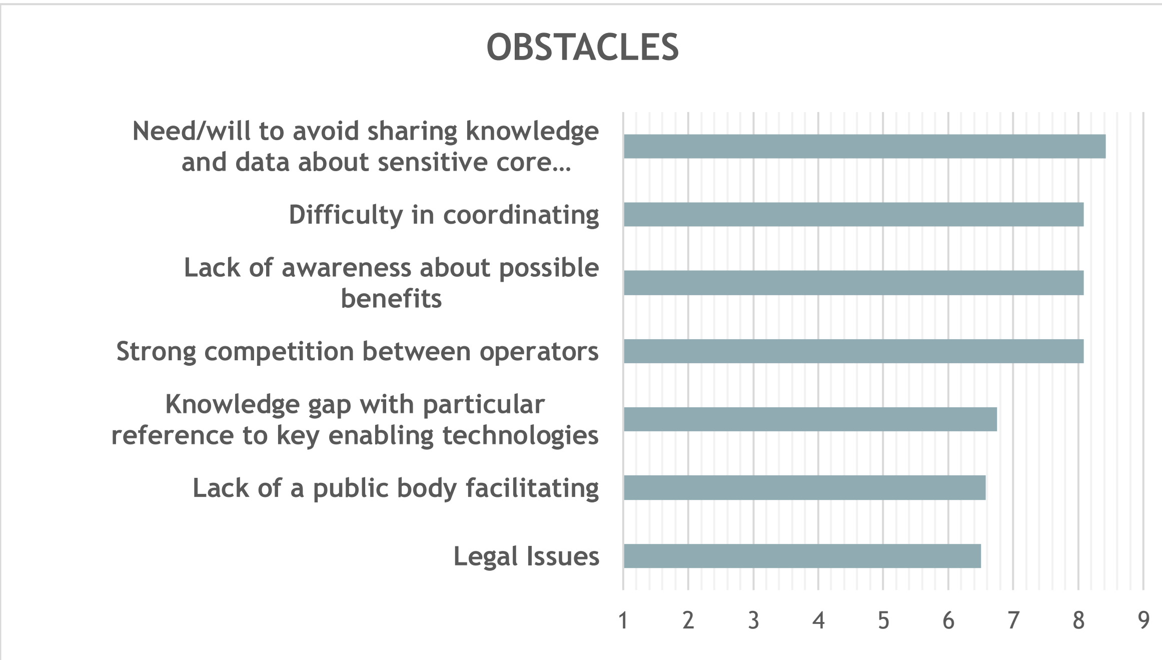

Figure 10 - Obstacles to be addressed for the development of RCL. Source: OPEN ENLoCC, 2022

The relevant obstacles in the implementation of RCL have been outlined in the survey carried out in the previous study by Open ENLoCC, where an evaluation of the main identified obstacles was requested through the questionnaire. The related outcomes are shown in Figure 10.

The picture that emerges from these outcomes allows to underline the difficulty of sharing and coordinating in a mainly competitive environment, which presumably could be contrasted through raising awareness about possible benefits.

Then, these first barriers are overcome, other factors that must be considered include knowledge gaps and other aspects that imply a key role of the public sector (both acting as a facilitator and in addressing legal issues).

More generally, these outcomes testifying relevant obstacles are also related to the need for a behavioural change to be overcome find correspondences in the literature.

Obviously, these obstacles must be assessed bearing in mind the current level of collaboration in the SCs, especially at the regional level. Then, in order to appropriately assess the current state of play, the participants in the questionnaire were asked, with particular reference to horizontal collaboration (esp. between SMEs), to rate the current level of sharing (0 = no sharing, … 4= complete).

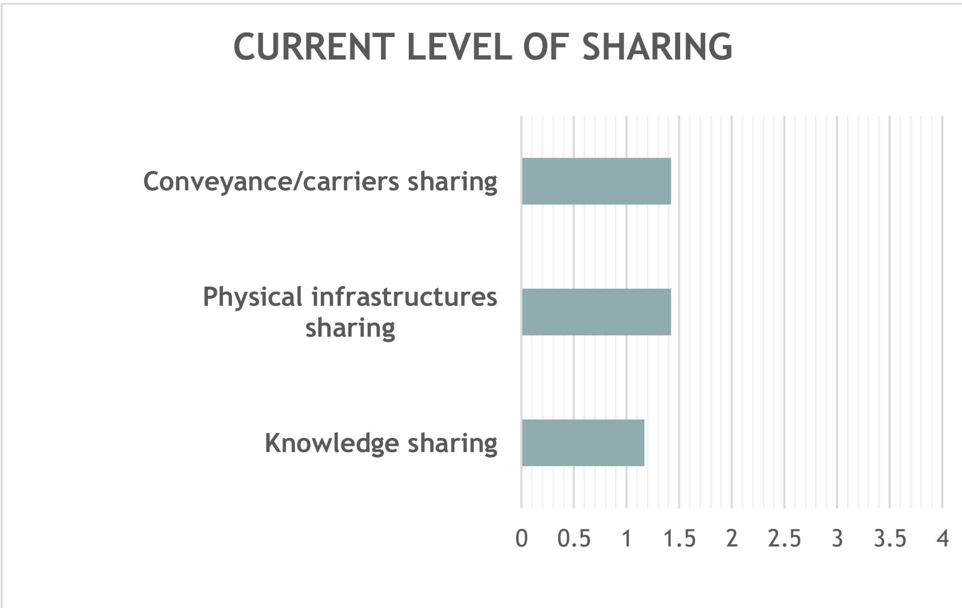

Figure 11 - Current level of sharing in the SC of the Open ENLOCC Members regions. Source: OPEN ENLoCC, 2022

The obtained outcome highlights a low level of sharing even in the more operational side of conveyance/carriers sharing. It is quite understandable that, in such conditions, the knowledge sharing level is marking an even lower value.

More in general, implementing collaborative logistics demands consensus on organisational setup and operational schemes—ideally progressing beyond the sharing of single transport modes (e.g., trucks) toward more integrated and multimodal solutions. Hence, currently, the majority of collaboration projects remain limited to tactical or operational levels, such as truck sharing and less-than-truckload (LTL) consolidation; more advanced strategic integration remains rare.

5.2. Opportunities from key enabling technologies

Various drivers could contribute to gaining momentum and unlocking the development of this promising and innovative approach. On the one hand, a relevant factor could be represented by raising awareness (to be pursued through activities as the present deliverables and the GRETA project) and policy instruments, as discussed in the following. On the other hand, remarkable and increasing opportunities could be provided by new innovative technologies and approaches being progressively made available, also in the light of general paradigms as Industry 4.0/5.0. These novelties, apart from benefitting the logistics system in general, could play a specific role in facilitating and, (in case) "enabling" collaborative logistics.

Different "enabling" technologies (IoT, BC, big data, digital twin interoperability, etc.) have been investigated in the previous study carried out by Open ENLoCC. In particular, the following figure presents the rating obtained by a list of technologies identified during the interactive discussions held with the Open ENLOCC Members.

In general, all the identified technologies are considered relevant for the development of RCL. Probably, a higher value registered in certain cases is due to a deemed higher value of maturity or more immediate applicability.

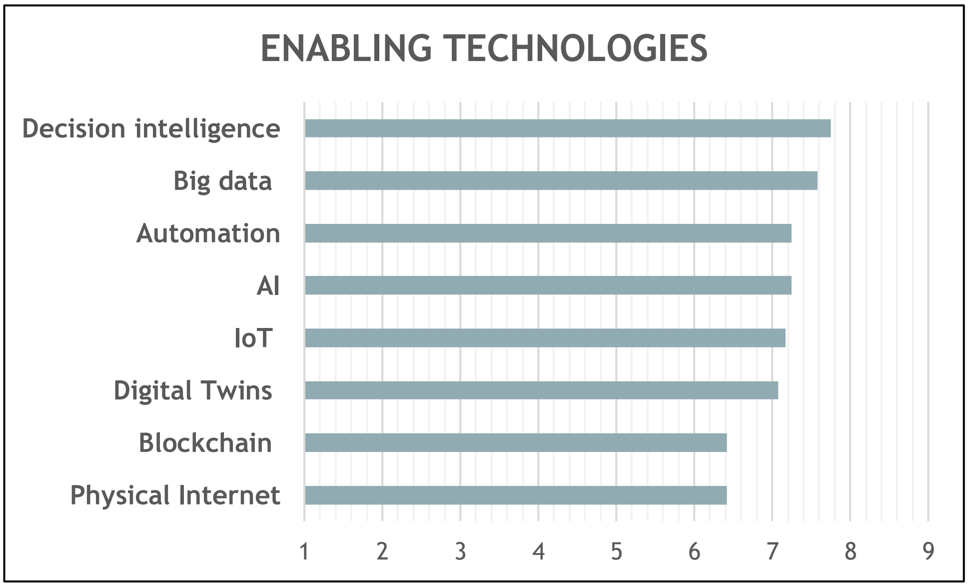

Figure 12 - Evaluation of identified enabling technologies for RCL. Source: OPEN ENLoCC, 2022

Each one of these technologies/innovations (together with some additional ones) is further discussed in the following paragraphs in order to understand their possible role in facilitating RCL. To this end, after briefly introducing them (see also Annex 1 for a more complete, though still synthetic, introduction to the key characteristics of single technologies), their development trajectory together with the possible contribution to RCL is discussed. In many cases, they are umbrella terms, including different technologies and entailing relevant specific differences that should be distinguished in the light of a practical implementation. Furthermore, it is important to underline that in many cases different technologies are mutually synergic, as will be clarified in the following.

Moreover, as background for the analysis, it is important to consider what is needed to effectively establish RCL, taking into account different perspectives, from the strategic level down to the operational one (see the following figure). Generally, the potential contributions of technologies to the operational level are quite evident (or even obvious). Beyond that, it is also valuable to understand whether these contributions could impact the higher, more strategic levels (e.g., trust), even if such effects are indirect and positive.

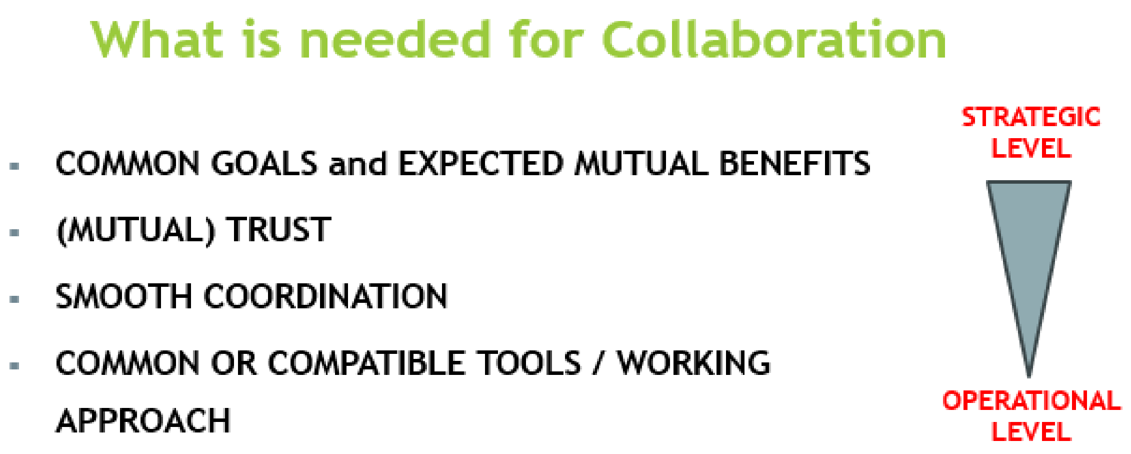

Figure 13 - Elements needed for establishing collaboration. Source: Own elaborations

5.2.1. Blockchain and distributed ledger technologies (DLT)

Description

A blockchain is a digital distributed ledger accessible by many users, ensuring the immutability and security of its contents through advanced cryptographic functions [17].

Morphologically, as the name suggests, a BC consists of a sequence of data blocks linked together, making it a specific subset of the broader category known as distributed ledger technologies (DLT). Various types of BCs exist — public, private, permissioned, or anonymous — offering different solutions tailored to specific needs. Among its key features, some BCs support "smart contracts," which are self-executing agreements containing conditional rules that automatically trigger actions when predefined criteria are met.

Relevance for Regional Collaborative Logistics

By implementing a trust mechanism by design for the stored content, BC is ideal in contexts such as logistics and commerce where there is a practical need to efficiently and securely store transactions between different parties. On the other hand, the specific features of a type of BC must be checked against the requirements of a specific application or context (which, for instance, are in contrast with features of public BCs). This implies a specific deal paid to assessing and identifying the specific characteristics of a BC for a given application.

With particular reference to RCL, the "trust mechanism by design" inherent in BC addresses a core driver of collaboration at both a deep and strategic level. At the operational level, BC enhances collaboration and traceability with fewer complexities, fitting well within logistics ecosystems. Furthermore, automated smart contracts cut manual processes and speed payments, improving efficiency.

Development prospects

So far, the implementation of BC in transport and logistics has been tested in specific and interesting use cases across various projects. However, despite its promising features, mass adoption still does not seem imminent. A significant obstacle could be related to the disruptive nature of this innovation, which makes gradual step-by-step implementation difficult.

5.2.2. Decision Intelligence (DI)

Description

DI is a practical discipline focused on improving decision-making by engineering and modelling how choices are made, and outcomes are evaluated, managed, and refined through feedback.

It integrates data, analytics, AI, and cognitive science into a unified framework that supports, automates, and augments complex organisational decisions. By combining predictive analytics and real-time data, DI provides users with optimal actions to take in complex scenarios, reducing risks and increasing operational efficiency. Its goal is to replace intuition-based decisions with confident, data-driven ones, utilising AI and other technologies discussed later in this document.

Relevance for Regional Collaborative Logistics

DI brings substantial advantages to logistics and is particularly transformative in collaborative logistics approaches. By leveraging AI, analytics, and decision science, DI enables organisations to plan production and distribution more efficiently, optimise inventory, and forecast demand or disruptions using real-time data.

Obviously, DI is particularly beneficial when applied to collaborative logistics, as it fosters better coordination, joint decision-making, and resource optimisation across multiple organisations. Automated workflows support rapid responses, shared visibility, and smarter routing or shipment scheduling, while DI integration with systems like WMS and TMS offers unified control over complex SCs. The result is more agile, adaptive, and informed collaboration that drives efficiency and reduces risks throughout regional logistics networks.

Development prospects

Driven by the companies' need to increase the level of automation and to establish a predictive decision-making process, the adoption of DI systems in logistics is expected to grow rapidly in the near future. Some of the main applications will be on anticipatory risk management, inventory optimisation, and adaptive distribution and transport planning, integrating other innovative systems such as IoT and AI.

5.2.3. Automation

Description

Automation consists in the use of technology to perform tasks traditionally carried out by humans, enhancing accuracy, speed, and efficiency.

It encompasses a diverse array of tools, including robotics, autonomous vehicles, automated management systems, and IoT-enabled devices. Hence, a key strength of automation lies in its synergy with other technologies such as AI, IoT, and BC (see related chapters). This integration enables smarter, adaptive workflows through predictive analytics, continuous optimisation, and secure real-time operations [13]. Together, these interconnected technologies create more intelligent, resilient, and cost-effective processes across organisations.

Relevance for Regional Collaborative Logistics

Automation significantly benefits RCL by enhancing efficiency, accuracy, and reducing human error, enabling organisations to focus on higher-value tasks and make better decisions. It streamlines processes such as inventory management and transportation planning, fostering faster, more reliable operations. Automation also supports collaboration among logistics operators by reducing carbon footprints and traffic congestion, especially when regional institutions promote data sharing and invest in shared infrastructure. This coordinated approach drives stronger cooperation, improves resource utilisation, and advances sustainability in regional SCs.

Development prospects

Automation application in logistics began in the early 1990s (e.g.: Delta/Sea-land Terminal in Rotterdam). Since then, interest in automation has grown significantly within the logistics sector, becoming one of the main levers to improve the operational performance of logistics nodes, warehouses, and transport systems. The deployment of advanced robotics [12], the exponential growth of e-commerce, and decreasing costs for initial investments in automation have encouraged more logistics operators to automate their processes. This trend also responds to emerging challenges such as labour shortages in logistics and new social and environmental sustainability directives and regulations.

Looking ahead, the combination of technologies such as 5G, IoT, and advanced robotics could lead to fully autonomous SCs.

5.2.4. Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Generative AI (GenAI) and Large Language Models (LLM)

Description

AI refers to computer systems capable of performing complex tasks that historically only humans could carry out, such as reasoning, decision-making, and problem-solving. AI is commonly used as an umbrella term that encompasses a range of technologies, sequentially nested as a subset of the previous one:

- Machine learning (ML), where models are created by training through data, and algorithms to make predictions or decisions.
- Deep Learning (DL) making use of (multilayered) artificial neural networks, which are computational models inspired by the structure and functions of the human brain.
- Generative AI (GenAI) aimed to generate new content by learning from large datasets.
- Large Language Models (LLM), specifically trained to understand and generate human-like text.

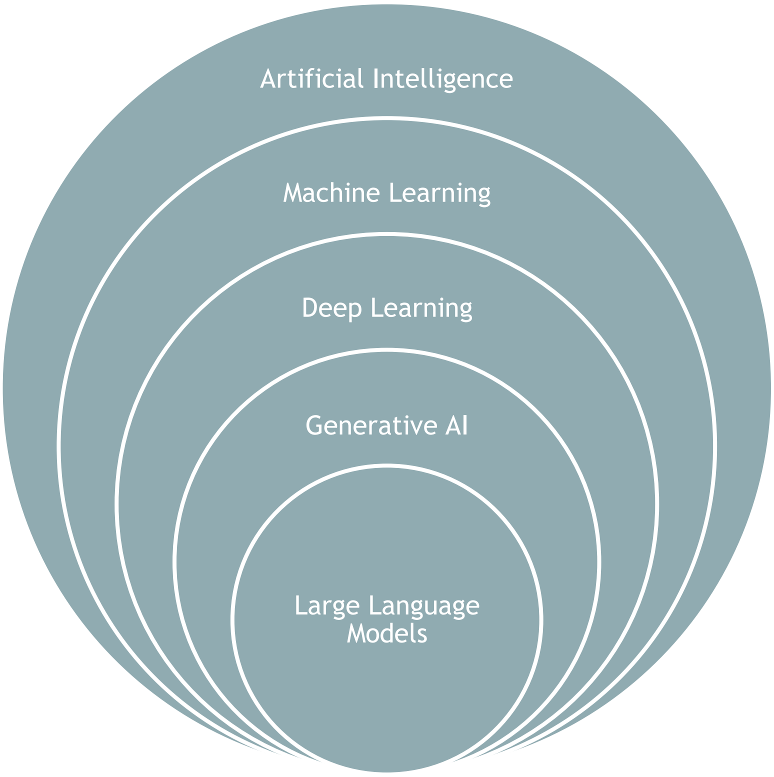

Figure 14 – Relationship between different technologies related to AI

Development prospects

AI has seen remarkable advancements in the last years, especially after LLMs have driven its surge, making it widely recognised by the general public (esp. since 2022-2023).

Obviously, the rapid pace of AI evolution makes it difficult to precisely predict the future extent of its adoption, but current trends clearly highlight a remarkable and rapidly growing pattern.

Relevance for Regional Collaborative Logistics

As in many other fields, developments in AI are offering remarkable opportunities and improvements in (urban) logistics as well. Their advanced capabilities for managing complexity and enhancing efficiency translate into significant benefits across various applications, including advanced and flexible routing, resource allocation, inventory management, automation, etc. In particular, AI can enable RCL by providing the ability to analyse data and make predictions and recommendations. Its key features, such as Machine Learning and DL tools (e.g. neural networks), can process data and identify patterns and trends, which can improve logistics operations such as transportation planning, inventory management, demand forecasting and more.

5.2.5. Internet of Things (IoT), Smart (Device) Connectivity and Cloud Computing

Description

The IoT refers to a network of physical objects – the so-called "things" -, which can include various types of devices, vehicles, appliances, and other items embedded with sensors, software, and network connectivity. Hence, objects are able to collect, process, and exchange data. Each one of these three functions is addressed through a dedicated paragraph in the following[3].

1. Sensors

Sensors are the foundational elements of IoT, enabling continuous monitoring of physical and environmental parameters. This is made possible by a wide variety of sensor types, including GPS, RFID, temperature and humidity sensors, cameras, accelerometers, proximity sensors, and more. Moreover, in cases such as computer vision, their capabilities are significantly enhanced by AI and embedded or edge computing (see also the next paragraph).

2. Embedded Computing, Edge Computing, and Cloud Computing

Efficient and effective data processing, often in real time, to enable smart, responsive systems can be achieved through combining three different and complementary computing paradigms:

- Embedded computing is integrated directly into devices to perform dedicated tasks with high efficiency and reliability.
- Edge computing extends processing capabilities beyond individual devices by placing more powerful computing resources at the "edge" of the network.
- Cloud computing provides centralised, scalable computing resources and long-term data storage.

It must be underlined that cloud computing represents a relevant technological innovation per se, also independently of IoT.

3. Connectivity

Connectivity is the backbone of IoT in general, as it ensures data exchange and complex operations through reliable and low-latency networks. Different connectivity technologies offer varying trade-offs in range, bandwidth, power consumption, and cost, influencing their suitability for specific logistics applications.

[3] In this case, a hetereogenous set of different, though complementary technologies is grouped together. Hence, in spite of the effort for syntetising, this paragraph is longer than others, since it encompasses various sub-paragraphs.

Key wireless technologies include:

- Cellular Networks (4G/5G): Wide-area, high-speed, low-latency connections for real-time tracking, video, and critical applications.
- Low Power Wide Area Networks (LPWAN): Long-range, low-energy networks like LoRaWAN and NB-IoT, ideal for battery-powered sensors and asset tracking.
- Wi-Fi: High-speed local connectivity in warehouses and hubs, with Wi-Fi 6 improving capacity.
- Bluetooth and BLE: Short-range wireless for indoor tracking and low-power sensor communication.
- Vehicle and Infrastructure Communication: DSRC enables direct, short-range communication between vehicles and infrastructure for safety; C-V2X extends this with cellular-based, longer-range communication connecting vehicles, pedestrians, and networks.

Together, these form a flexible connectivity ecosystem supporting diverse IoT applications, from monitoring to autonomous decision-making, driving smart urban logistics.

Relevance for Regional Collaborative Logistics

In general, IoT applications are manifold, and among the many related to the industrial sector, a wide range of IoT uses provide relevant benefits to transportation and logistics systems. In fact, equipping vehicle fleets with IoT devices enables dynamic, real-time management and re-routing of vehicles, as well as monitoring specific conditions (e.g. temperature control for sensitive commodities). This is especially relevant in urban logistics, which is characterised by complex, dynamic environments and increasing delivery demands. While IoT is already deeply integrated into modern logistics, its combination with advanced analytics and cloud computing is paving the way for next-generation smart logistics systems that are adaptive, resilient, and customer-centric.

More specifically, the IoT can play a vital role in RCL by providing real-time data and allowing organisations to track and monitor logistics operations. By connecting devices and equipment, IoT can help organisations to improve SC visibility and make more informed decisions.

Development prospects

IoT is continuously growing thanks to the relevant developments in its different components.

Innovation in sensors is keeping and, overall, the growing sensor network enables comprehensive situational awareness and data-driven optimisation of logistics processes.

Concerning computing technologies, while Cloud computing is now a well-established technology, widely applied in logistics, while embedded computing is extensively used and continues to evolve. Edge computing remains in its early stages but is rapidly gaining traction, with widespread adoption expected in the medium to short term (e.g., within five years).

In terms of connectivity, in addition to the remarkable developments already experienced in recent decades, Next-generation wireless technologies, especially 5G and LPWAN, are expanding smart logistics capabilities by enabling scalable, flexible, and secure data transmission. Moreover, private 5G networks and Wi-Fi 6E deployments further enhance performance in logistics facilities.

5.2.6. Big data and advanced analytics

Description

The term "big data" refers to extremely large and complex datasets that are generated at high speed from a wide variety of sources (e.g. sensors, social media, business transactions, and connected devices). Their key characteristics can be summarised through the so-called "three Vs":

1. Volume: The sheer amount of data, often measured in terabytes, petabytes, or more.
2. Variety: The diversity of data types, including structured (databases), semi-structured (logs, XML), and unstructured (text, images, videos).
3. Velocity: The rapid rate at which data is created, collected, and processed, sometimes in real time.

Additional properties often include Veracity (trustworthiness of data) and Value (the usefulness of insights derived from data).

The real added value of big data lies in its ability to quickly uncover patterns, trends, and correlations, thus supporting advanced business intelligence and decision-making through advanced analytics.

Relevance for Regional Collaborative Logistics

In logistics, big data is already transforming the sector by contributing (together with synergic technologies as IoT) to enhanced real-time tracking and route optimisation, predictive maintenance for vehicles and equipment, demand forecasting to better align inventories, and greater warehouse automation. Big data can be a crucial technology for RCL as it enables organisations to collect, store, and analyse large amounts of data from various sources. This can help organisations make better decisions, optimise logistics operations, and improve SC visibility [11]. Hence, rather than being relevant per se, it provides the basis for carrying out well-grounded analyses in the decision-making and management of SCM activities.

Development prospects

Looking ahead, the usage and development of big data technologies are expected to continue growing and supporting innovation in logistics, also through an increasingly closer integration with other technologies, such as IoT and AI.

5.2.7. Digital Twins

Description

Digital twins are virtual replicas of physical assets, systems, or processes powered by real-time data, IoT, AI, and machine learning. They enable dynamic monitoring, simulation, and optimisation of complex operations without interacting with the physical counterparts. Valued at USD 12.8 billion globally, the digital twin market is growing rapidly, with Europe as a significant player driven by new regulations and sustainability goals.

Relevance for Regional Collaborative Logistics

Digital twins transform logistics by enhancing real-time visibility, predictive insights, and efficient resource management, ultimately boosting SC resilience and sustainability. Their integration into the logistics sector has grown significantly, covering multimodal transport, warehouse operations, terminal automation and last-mile delivery planning processes.

In particular, Digital Twins can enable RCL by providing a virtual replica of the physical world, which can help organisations to jointly optimise logistics operations and improve shared decision-making [16]. By simulating logistics processes, Digital Twins can help organisations to identify potential issues and thus promptly intervene to avoid critical situations and to improve efficiency.

Prospectives

Future developments in digital twin technology foresee tighter integration with AI, machine learning, and edge computing to enable autonomous decision-making, disruption prediction, and continuous optimisation. Digital twins are expected to work with blockchain-based platforms to secure and streamline the exchange of transport documents. In last-mile delivery, combining digital twins with augmented and virtual reality can improve operational management and reduce urban congestion, fostering an intelligent and resilient logistics ecosystem.

5.3. Physical Internet (PI)

The Physical Internet (PI) is an innovative and transformative concept envisioning (according to a long-term perspective) a hyperconnected global logistics system designed to enable seamless sharing of assets and consolidation of goods flows worldwide [18]. It is built upon the establishment of a fully collaborative network based on standardised encapsulation, openness to participation from diverse actors, modularisation, protocols, and interfaces. This intense level of interconnectivity — captured by the term “hyperconnected,” where resources such as transport vehicles and warehouses are openly shared among multiple users — is inspired by the Digital Internet, in which data packets travel through a shared global network.

In particular, at the core of PI are standardised, modular containers called “π-containers” that encapsulate goods, facilitating their universal handling, storage, and transport through interconnected physical networks such as roads, rail, air, and waterways. Unlike traditional shipping containers, which come in a limited range of standardised sizes (primarily 20-foot and 40-foot units), π-containers are highly modular units that can vary widely in size and be dynamically combined or split. Moreover, these containers are endowed with unique digital identities linked to smart tags enabling real-time tracking, route optimisation, and information exchange among various stakeholders, while ensuring data privacy and security.

Therefore, in this system, logistics service providers perform a role analogous to internet service providers in the digital world by routing π-containers through a global network of physical corridors and nodes (intermodal terminals), which enable seamless switching between transport modes. As a result, the overall logistics system and SCs become more efficient and capable of adapting dynamically to changing demands and disruptions, much like how the digital internet flexibly routes data through various physical media without user intervention. Hence, by enabling optimised asset sharing, standardised operations, and open collaboration, the PI will establish more sustainable logistics practices and create resilient SCs capable of addressing future global challenges.

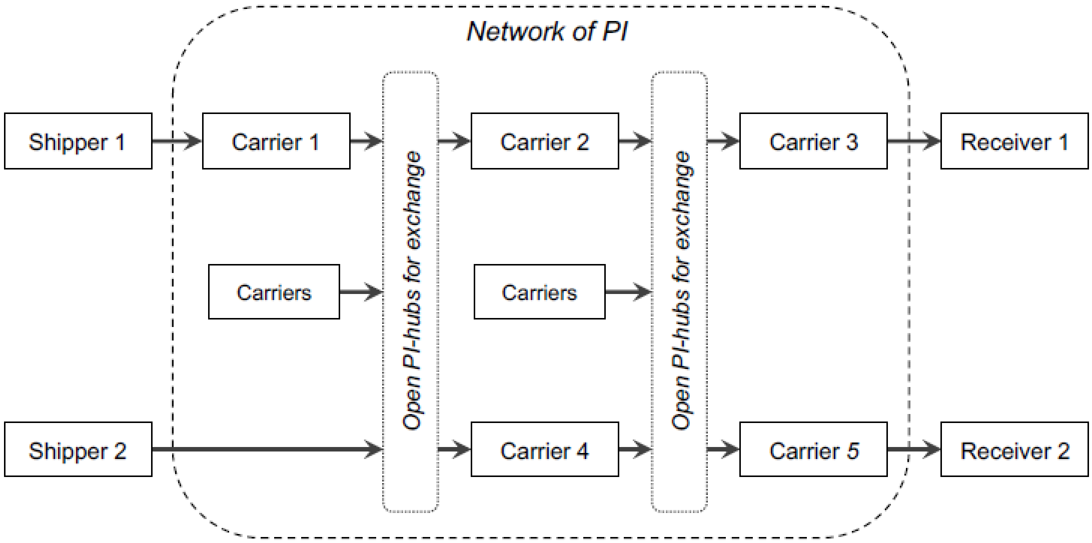

Figure 15 - Physical Internet collaboration scheme. Source: Horizontal collaborative transport: survey of solutions and practical implementation issues by Pan et al. - International Journal of Production Research (2019)

It is important to underline that the PI, unlike the other elements mentioned in this chapter (such as IoT devices, BC, etc.), is not a single technology by itself. Rather, it is a concept that leverages a combination of technologies — including many of the aforementioned ones — to improve SC visibility, reduce costs, and increase efficiency. Therefore, it represents a comprehensive collaboration scheme strongly based on interconnecting independent transport networks.

6. The way forward: a vision for collaborative logistics

In the previous chapters, the key characteristics and benefits of RCL have been presented. Then, the current state-of-play has been discussed as regards to both its limited implementation and obstacles. On the one hand, relevant opportunities to be exploited, especially from relevant enabling technologies, have been outlined as well.

Needless to say, in order to fully unlock these potentials, a key driver relies on awareness, willingness and commitments from different stakeholders. This is particularly important, recalling how RCL implies, differently from occasional synergies, a strategic commitment bringing together different players, including natural competitors. Furthermore, the goal of aiming for a kind of "system optimum", encompassing sustainability goals, implies the participation of a wide and heterogeneous set of actors belonging to both the public and the private sector.

Hence, the following paragraphs focus on a way forward aimed at fostering the actual implementation of RCL in the regional contexts of Central Europe FUAs and beyond through the active participation of a wider set of stakeholders.

To this end, the following paragraphs outline a vision fostering RCL, also emphasising the possible role of initiatives that, as Open ENLoCC, are aiming to create the ideal conditions and foster this transformative approach.

6.1. A shared vision fostering RCL

As anticipated, to effectively address the complex challenges and opportunities in regional logistics, a shared vision for RCL must actively involve all key stakeholders (see chapter 4.3).

This vision is well framed with widely recognised patterns in logistics development: SC have progressively evolved from isolated, atomistic operations through integrated systems towards more collaborative models. Looking forward, in the long term, this process is paving the way to the achievement of the PI, where universal standards and dynamic interconnectivity transform logistics processes on a global scale.

In turn, each phase in this evolutionary journey represents a simplified overview of a complex sequence of intermediate steps and maturity stages, shaped by regional context and stakeholder engagement. Hence, different subsequent steps in Collaborative Logistics implementation in general, as well as RCL are to be envisaged. In fact, it is rather likely to be developed according to a (more or less) gradual process going through various intermediate stages, also depending on the specific territorial context and involved actors (i.e. it is not happening instantly and simultaneously everywhere).

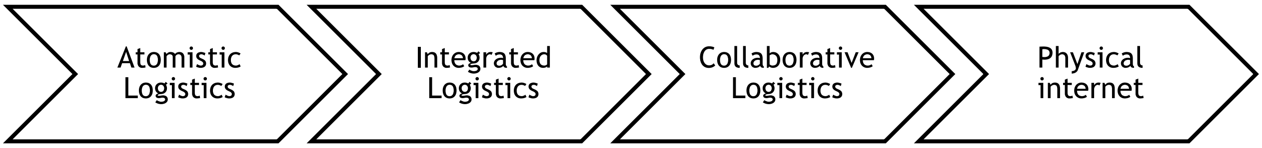

Figure 16 - Framing Collaborative Logistics within the overall long-term development process of Logistics. Source: own elaborations on Montreuil, B. (2011).

In doing so, some key central/focal aspects must be adequately focused on, especially in what concerns the dialogue and agreements (necessary for allowing a smooth and effective implementation of RCL). In particular, notwithstanding the already ascertained importance of the challenges, obstacles and technologies mentioned previously, it is important to outline aspects related to exchanges both in physical and information flows, such as

- Role of logistic nodes, recalling the existing different typologies and their contribution to the network as a focal point for interchange and consolidation, enabling intermodal operations and reaching critical mass; in this regard, it is important to recall how generally nodes are the elements of the SC networks where interactions (and consequently collaboration) occur. This general remark is at the basis of increasing acknowledgement, for instance, of the role of ports as innovation and data sharing hubs (see paragraph 4.2)

- (Open) data sharing and related standards and agreements (which represent key drivers in order to provide an appropriate environmental condition for the RCL); in fact, sharing data and information are the fundamental prerequisites for collaboration between different organisations and institutions. As evident from what was described in the previous chapter, the key limiting factors to be addressed are related to the willingness of the different actors and the trust mechanism to be established.

These general issues are related to a strategic and medium/long-term perspective. This strategic level must be addressed not only through a general viewpoint but also by elaborating on specific aspects related to each regional context (e.g. its positioning and accessibility with respect to the TEN-T network and related nodes). In this regard, it is important to emphasise the importance of taking into account the theme of RCL in the planning and regulatory processes. Obviously, as regards RCL, the key reference should be the regional dimension, but also the interrelationships with other levels, ranging from the TEN-T network to the local level, addressed by SUMPs or SULPs should be taken into account. In this regard, it is worth noting that these instruments are already characterised, but the holistic approach and attention to participatory processes, including all relevant (public and private) stakeholders that is central in RCL.

Moreover, while moving to aspects relevant for activating the actual implementation of RCL [22], it will be necessary to deepen more tactical[4] and operational-level decisions [24]. In this regard, it is important to highlight the importance of innovative approaches that could be seen as organisational enablers of RCL. For instance, the tactical level can encompass profit allocation mechanisms between participants in the RCL, inventory decisions, and distribution organisation. The operational level, instead, is related to aspects more related to the short-term, such as joint vehicle route planning, inventory /stock control, etc. Furthermore, it will be important to in specific opportunities and catalysts for innovation. As from the literature, remarkable conditions are related to context where the particular need for catering limited efficiency or profitability of current processes (e.g. low demand rural areas) or the already ascertained role of microhubs as catalysts for RCL.

Last but not least, this process should be supported by adequate funding, especially (though not exclusively) for testing innovative solutions through pilots.

6.1.1. Facilitating and fostering RCL

As explained previously (see chapter 4.3), the contribution from different kinds of (public and private) stakeholders is needed for fully and properly exploiting the potential of RCL.

In any case, there is a need for an active role of initiatives supporting the transition process to such a transformative approach as collaborative logistics and, further on, the PI.

In particular, this would imply creating the favourable "environment" conditions (rather than directly implementing) and also pivoting on key enabling technologies.

To this end, a first key question is how to reach these objectives. In general terms, the following typologies of activities can be envisaged:

- analysing best/worst practices;
- getting in touch with the actors (to be) directly involved;
- knowledge transfer and setting up think tanks (at regional as well as international levels).

For instance, Open ENLoCC, starting from the previous analysis already mentioned within the present report, is contributing to foster RCL by:

- providing different actors with a shared general overview of challenges to be addressed and opportunities to be seized;
- contributing to the dialogue/synergic interaction between public planning and private initiatives, as well as decision support;

[4] In supply chain management the tactical level decisions are usually related to medium-term and concern aspects such as the definition of the actual transport or distribution solutions, their frequency, the size of the shipments, the inventory management, the gain sharing, etc.

- stimulating public support, in terms of planning activities, to the RCL development (mainly in relation to interactions with public bodies, but in doing this, Open ENLoCC could also facilitate private actors in bringing to a wider audience their viewpoint);
- know-how and networking, with particular reference to private actors (e.g. SMEs), thus helping them in keeping up to date with emerging technologies supporting the RCL.

Obviously, other initiatives, at different levels and according to their specific character and focus, are also playing a relevant role in fostering RCL. In this regard, it is definitely worth mentioning the European Technology Platform ALICE, also considering its commitment towards SC and logistics innovation. Among various other initiatives and networks that can effectively contribute (with particular reference to their own regional contexts), the various regional clusters brought together in the ALICE Logistics Clusters Group can be highlighted.

7. Conclusions

The presented deliverable provided a conceptual paper analysing the theme of RCL with the aim of fostering its development throughout different contexts making up the FUA addressed by the GRETA project and, more in general, Central Europe.

In particular, the present report has duly outlined the complexity of the multifaceted phenomenon represented by RCL. This analysis has been supported by both desk research and the capitalisation of a previous study made by PP10 - Open ENLoCC, which also included the results from a questionnaire filled in by the Network Members.

The resulting picture allows to clarify the remarkable potential benefits deriving from the synergies that are unlocked by adopting a collaboration approach between the different actors of the SCs at different levels, including the regional ones. Importantly, even informal collaboration (e.g. through freight exchange platforms or short-term leasing of storage spaces) can provide tangible benefits by enhancing efficiency, resource utilization, and flexibility. However, fully realizing the potential of more strategic and profound organizational or behavioural change depends on overcoming existing barriers and the current reluctance to engage in collaboration. Obviously, this applies in particular in the case of the so-called "horizontal collaboration", taking place between actors belonging to the same tier of the SC, which in many cases could be natural competitors.

In this regard, it is worth recalling how, despite the evident and widely acknowledged potential benefits of collaborative logistics, confirmed by a vast literature ascertained on collaborative logistics and spanning throughout various years, its implementation still lags behind.

Consequently, a relevant deal has been to outline key aspects for overcoming this gap and fostering the adoption of RCL. To this end, promising opportunities from different enabling technologies such as AI, IoT, and BC, as well as from systemic innovations like the PI, have been highlighted. Furthermore, the role that can be played by different stakeholders, including the importance of public bodies, has been duly underlined.

Moreover, on the basis of the carried-out analysis, it is possible to outline key aspects in order to provide conditions for a "favourable ecosystem" fostering the adoption of RCL, as outlined in the previous analysis by Open ENLoCC. In particular, this can include raising awareness and providing shared knowledge by:

- providing different actors with a shared general overview of challenges to be addressed and opportunities to be seized;
- contributing to the dialogue/synergic interaction between public planning and private initiatives, as well as decision support;
- stimulating public support, in terms of planning activities, to the RCL development;
- fostering know-how and networking, with particular reference to private actors (e.g. SMEs), thus helping them in keeping up to date with emerging technologies supporting the RCL.

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9. Annexes

- **ANNEX 1 – Presentation of the key enabling technologies trends**
- **ANNEX 2 – Description of the key enabling technologies**