Towards a Shared European Logistics Intelligent Information Space

Collaborative Planning and Synchronomodal Transport

European Green Logistics Strategy nº1

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

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<th>Zaragoza Logistics Center (ZLC)</th>
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## Revision history (including peer reviewing & quality control)

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Executive Summary

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1 Introduction

This white paper introduces one of seven European Green Logistics Strategies (EGLS) in the SELIS project. In a separate white paper, we provide an overview of these EGLS and their interrelationships.

The SELIS project aims at developing a shared European intelligent information space by fostering innovation in different aspects of transport. This will be achieved by means of embracing a wide spectrum of logistic perspectives and creating a unifying operational and strategic business innovation agenda. Moreover, SELIS aims at establishing a research and innovation environment using Living Labs to provide data, and that will enable large-scale adoption of innovations.

In particular, private and public actors involved with transport and logistics will develop new pan European Green Logistics Strategies (EGLS). This white paper serves as a guideline for the further development of one of these strategies: “Collaborative Planning and Synchronomodal Transport” (EGLS1).

EGLS1 is an operational collaborative strategy which determines how logistics resources are synchronized in an optimal way to achieve certain transport performance targets, in particular costs, emissions, and reliability.

A number of aspects of this strategy needs to be highlighted. First of all, it is an operational strategy, i.e., it sets the stage for the planning and execution of transport processes. The extent to which stakeholders involved in the transport processes collaborate and share information is given. An organizational strategy, such as that described in EGLS2, is aimed at creating mechanisms to foster collaboration among stakeholders, which is outside of the scope of the operational strategies. Second, it is a collaborative strategy. In particular, the relevant logistic resources are deployed by multiple organizations that could collaborate, and demand originates from multiple customers. Third, resources are mutually synchronized in an optimal way by horizontal or vertical collaboration, and the supply of logistics services by the use of these resources is also synchronized with demand. Fourth, the logistics services planned and executed as prescribed in this strategy aim at achieving multiple transport performance targets. This meaning that the transport processes will meet given values of costs, emissions and reliability.

In this white paper, we present EGLS1 as an operational collaborative strategy in a generic setting, so that it can be applied to multiple domains, in particular container logistics and urban logistics will be considered here. Both domains have huge potential for improvement, especially when considering the operational planning operations in the transport setting. Container logistics planning and execution are complex processes with many interdependencies, while decisions are made by a large set of actors. Collaboration between stakeholders does not arise spontaneously, with an inefficient use of resources (infrastructure, terminal and transportation equipment, space and employment) as an effect. The set of stakeholders in container logistics includes the container carrier, deep-sea terminal operator, inland transport operator (barge, rail, and truck), inland terminal operator, freight forwarder, depot owner, and warehouse/distribution center operator. Apart from private actors who provide transport, intermediary, terminal and storage services, several public actors are involved, such as customs authority, port authority, inspection agency, and infrastructure provider. Urban logistics, instead, is characterized by fragmented deliveries, important external constraints (e.g. access-restricted areas, congestion) and a variety of stakeholders like shippers, retailers, logistic service providers, warehouse operators, and local authorities (municipalities).

This white paper focusses on operational collaborative strategy and deployment of synchronomodal transport services. Synchronomality represents an innovative business model where transport services are deployed in a more flexible way. In particular, booking a transport service represents a commitment to deliver the goods from an origin to a destination in a timely fashion, without specifying further details of the transport service, i.e., mode, route, departure time, etc. This allows
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the provider of the transport service to deploy his resources in the most convenient way, as long as customer demand is satisfied. Consequently, synchronmodality faces new challenges and involves new collaboration mechanisms between business partners both in the supply of services and in the management of demand. Within this strategy, we are going to develop the logic and models to devise synchronmodal transport plans. Indeed, it is first required to describe how synchronization of logistic resources is obtained to, then, be able to compute its performance. This study will support the development of a Collaborative Synchronmodal Planning Toolbox.

This white paper is structured as follows: an introduction to the problem and the research questions is given in order to prepare a common ground for the forthcoming sections; a review of the academic literature is carried out in Section 2 by distinguishing four main streams of knowledge, while in Section 3 previous projects related to this strategy are compared and described; third, an analysis of the research gap is presented in Section 4, where the practical solutions and guidelines of this research will be presented (Sections 4.3 and 4.4); finally, in Section 5, a framework is presented to help position the research questions and the foreseen innovation of this strategy.

1.1 Problem formulation and motivation.

A European Green Logistic Strategy is defined as a reference cross-domain strategy, customizable to business specific strategies, focused on collaboration and information sharing, for achieving meaningful, measurable, and cost effective emissions reduction. The purpose of EGLS1 and EGLS2 is to change the current freight transport system in a synchronized collaborative freight transport system (Figure 1). In general, the major challenge for future research on transport collaboration lies in the high complexity and diversity of both the transportation requests and allocation of the resources between the collaborating partners. Those two strategies approach transport collaboration from an operational and organizational perspective.

EGLS1 is an operational strategy which determines how logistics resources are synchronized in an optimal way to achieve certain performance targets, in particular (cost) efficiency, emissions, and reliability. EGLS2 is an organizational strategy which determines how incentives are to be aligned in such a way that the intended collaboration can be achieved. Both strategies aim at synchronized collaborative freight transport systems (Figure 1). Both strategies can be formulated generically, and then applied to the domains of container logistics and urban logistics.

Figure 1 the two European Green Logistics Strategies moving towards a new state of the transport system
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We consider the problem of deploying synchronodal transport as a result of a collaboration between different stakeholders. At the current state of the art, synchronized freight systems have been studied and implemented only from the perspective of a central planner that owns transport means and uses subcontracted services (B. Van Riessen 2013; Bart van Riessen, Negenborn, and Dekker 2015; Behdani et al. 2014). Collaboration is believed to bring benefits, and this is often the case as pooling resources helps to better hedge for uncertainties and enables the flexible deployment of those resources that are best fit to meet demand (Cruijssen, Cools, and Dullaert 2007). In other words, a larger coalition of actors in the transport system join their resources, and has more opportunities to deploy those resources to meet joint demand, which enables better performance in terms of costs, emissions, and reliability.

In this perspective, EGLS1 is an operational collaborative strategy that reaps the potential of the given level of collaboration and improve performance. In line with the SELIS project, the particular interests and perspectives of each stakeholders should not be neglected and, therefore, system performance cannot be reduced to the viewpoint of a single stakeholder. This reduction takes place often when considering collaborative planning approaches (Krajewska et al. 2007): a unique central solution is imposed on the shared assets without accounting for the effect of such modelling choice on the single stakeholders’ performance. Indeed, even when the stakeholders in a transportation system aim a seamless and synchronized transport solution, the operators of transport subsystems measure their performance in different ways, not necessarily amounting to a consistent overall performance. For instance, a terminal operator usually measures its performance by the throughput of its container terminal, while an inland transport operator aims to improve the utilization of her assets. This is a first problem: (1) how can we define, compute and operate different measures of cost efficiency and reliability of a network when those are seen from different perspectives?

Collaboration is the action of working together towards a result. It, therefore, requires information sharing and reciprocal visibility of partners’ systems. In return, collaboration will produce benefits that need to be shared to incentivize the stakeholders to collaborate. Those elements and the relation between them is set up and defined in a collaborative agreement, which is going to affect the operational synchronization of tasks. One can compare the effect of different collaborative agreements on the performance of the network which is jointly orchestrated and coordinated. This is the second problem: (2) what is the impact of different collaborative agreements on the network performance?

1.1.1 Motivation: container transport

In this section, we focus on the container transport from a deep-sea terminal to the hinterland. In what follows, we first describe the sequence of handling operations that brings a container from a deep-sea vessel to its final destination. This is often referred to as the import flow as goods are moving from the seaside to the inland, coming from foreign locations. We will focus on this flow because of the intrinsic high level of consolidation due to the high capacity of the liner, but also, because of the high level of uncertainty associated to the release time of containers. Indeed, oversea transport is well known for its low levels of predictability that stresses inland transport and requires for improved ways of organizing it.
Collaborative Planning and Synchromodal Transport

![Synchromodal Transport Diagram](image)

*Figure 2 Deep sea terminal operations (Vis and De Koster 2003).*

Containers are first unloaded from the container ship onto vehicles (automated or not) that will bring the containers to the stacking yard (Figure 2). The quay cranes will be used for the first unloading while stack cranes will bring the containers from the vehicles to the stack. During these first two steps, information on the positions of the container, both on the vessel and in the stack, is used to guide the loading and unloading operations. Containers are placed in the stack, to be forwarded to the inland transport means that will pick them up. The containers are moved from the stack to the truck, train, or barge by means of a stack crane, and when applicable, internal transport means. The inland transport by means of barge and train usually includes transhipment at inland terminals. Usually, the final leg of the container journey will be performed by truck to deliver the container to the consignee’s warehouse. Modes of transport differ in terms of cost per container and transport speed, but also the operational constraints differ: truck transport can be arranged quickly and is extremely flexible, while train transport is rigidly scheduled as the infrastructure is shared with public transport, and barge transport faces congestion at the deep sea terminal where it shares the berth with deep sea vessels that have priority. Synchromodal transport abstracts from the mode-specific operations going assuming no mode commitment should be planned ahead and all modes should be looked at indifferently from the point of view of transport capacity. This is one visualizations of a key prerequisite of synchromodal transport: a-modal booking. Namely, transport demand should be mode agnostic, therefore, no commitment to a specific mode should be required in advance. We should think of containers movement between the successive nodes with all operations being synchronized.

One of the current challenges in container transport is to understand and plan reliable intermodal transport solutions. Shippers are requesting reliable intermodal transport (Bontekoning and Priemus 2004; Eng-Larsson and Kohn 2012) but intermodal transport is still not being planned explicitly taking reliability in account, in the academic literature, and practitioners often introduce slack time or capacity to improve their reliability. Moreover, industry partners involved in SELIS Living Lab 2 are further supporting such an investigation on reliability by requesting a Network Reliability Tool (see Section 4.4.1). This tool will provide business value to stakeholders by enhancing the visibility on the reliability of different transport services. An additional challenge in container transport is that of reaping the benefits of synchromodal transport. Synchromodality has been proposed as a concept for organizing hinterland container transport, but so far, no educated insights are available to describe how collaborative synchromodal plan can be produced and executed.

Our research will address both issues by developing a framework for collaboratively deploy synchromodal transport solutions. This framework will further support the investigation on the problem considered here. Moreover, the research questions described in Section 1.2 will further guide the development of those models.
1.1.2 Motivation: urban distribution

The second example of application is that of urban distribution. In what follows, we present the main operational differences between hinterland container and urban transport. First of all, scarce standardization of operations and transport units is a major difference. The high heterogeneity of organizations reflects also a high variety of transport means and transport solutions: trucks of different sizes are used, as well as, vans, cars, motorcycles and bicycles. All of those modes of transport have different properties in terms of costs, speed, capacity, responsiveness and practicability in the urban landscape. There is also diversity in the delivery destinations and their physical layout, which is increasing the complexity of optimal planning: from warehouse and distribution centres, to deliveries at the road level where parking lot should be found first or not. Moreover, different transport units are also used leading to the question of how to efficiently use transport capacity: pallets, boxes and packages of different sizes and shapes increases the complexity of handling operations.

Secondly, from the point of view of the operational planning level, the class of Vehicle Routing Problems is appropriate for the urban distribution domain. Indeed, vehicles performs tours to serve customers and have to come back to their depot. In the case of container transport, we can instead mainly consider the flow from origin to destination rather than the routing of means in the network, even if the routing problems are used at the operational level for port visit problems for barges and drayage operations.

Applications of EGLS1 to this setting comes from the stakeholders involved SELIS Living Lab 3 who are operating in city distribution themselves. Even in this domain, execution of transport in a reliable manner is important and synchromodality is seen as a valid solution for this issue. Moreover, cooperation and information exchange between stakeholders has not yet been fully accomplished despite it is seen as a source of potential business value.

1.2 Research questions

In the two following sections, two sets of research questions for EGLS1 will be provided and described shortly. A complete analysis of the research gap and discussion of the research questions is given in Section 4.

1.2.1 Impact of level of collaboration on synchromodal transport performance

EGLS1 aims at multiple performance targets, in particular costs, emissions, and reliability. Collaborative planning and execution of logistic operations result in certain values along these performance measures. As soon as one aims to improve or even optimize overall performance, trade-offs between reliability and efficiency need to be made. Zuidwijk and Veenstra (Zuidwijk and Veenstra 2015) expressed the value of information in container transport as improved trade-offs between transport reliability and efficiency. The level of collaboration among stakeholders includes the extent to which stakeholders share information, and therefore the performance of the transport operations. Research questions are:

1. How does one define reliability of synchromodal transport processes?
2. What is the impact of the level of collaboration, and in particular the level of information sharing, on reliability and efficiency of synchromodal transport processes?
3. How are planning and execution processes designed to capture the potential value of collaboration and information sharing?
4. In the trade-off between reliability and efficiency, what is the “price of reliability” for synchromodal systems?

In the first set of research questions as described above, we focus on the level of collaboration and information sharing, i.e. to what extent do stakeholders collaborate (e.g. arms-length or at strategic
level) and exchange information (quality of information shared). In the second set of research questions, we focus on the structure of collaboration, i.e., who is collaborating and exchanging information with whom, and its impact on performance of the synchromodal transport processes. These research questions address the need for “collaborative contracts” that define who collaborate with whom and under what conditions, incentive alignments for example.

1.2.2 Impact of collaborative agreements on synchromodal transport performance

The development of a synchromodal network involves multiple suppliers of transport and handling services. For instance, as pointed out by (Bart van Riessen, Negenborn, and Dekker 2015), the problem of developing a synchromodal network when subcontractors are involved has not yet been studied. Network design and network service design problems have predominantly been studied for network operators that act as single decision makers (B. Van Riessen 2013; Bart van Riessen, Negenborn, and Dekker 2015; Behdani et al. 2014). The case when multiple decision makers (for instance, a logistic service provider, multiple carriers and inland terminal operators) want to implement synchromodal transport brings along the question of how these various stakeholders will collaborate. Each stakeholder will balance the benefits of its independent strategic position and the operational benefits of collaboration. Synchronizing the deployment of logistic resources at the operational level requires a certain level of collaboration, in particular information sharing between stakeholders. For instance, logistic service providers are not sharing the actual shippers’ transport requirements to the network operators that are going to physically fulfil shippers’ demand. This missing information exchange constitutes a barrier against the deployment of synchromodal transport solutions. Indeed, a dynamic information exchange on the actual demand requirements and the current state of the network is required to achieve the level of planning flexibility necessary for synchromodal transport. However, carriers and terminal operators may not have aligned interests: for example, terminal operators may want to be informed well in advance about the hinterland transport mode and route of particular containers to optimize yard operations, while carriers may prefer to defer such allocation decisions to the last moment, as synchromodality prescribes.

Understanding the value of operational information sharing between stakeholders will help the construction of collaborative agreements that can effectively enable synchromodal planning and execution. Research questions are:

1. What is the impact of the various collaborative agreements between stakeholders on synchromodal transport performance?
2. What is the effect of competitive behaviour on synchromodal transport performance? (What is the price of anarchy?)
3. Which collaborative agreements add the most value to the planning and execution processes?
4. What operational issues require incentive alignment between different stakeholders?

Observe that these questions do not address the issue of designing coordination mechanism to align incentives, but more aim at assessing the value of aligned incentives that establish certain modes of collaboration between stakeholders.

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1 “Network development in a cooperative synchromodal transportation setting is more complex than the intermodal network design problem. Each addition of a new node or connection may influence the loads on existing ones. However, the sub-contractors of individual connections will aim for stable flows for economic operation. How can the network be expanded in a stable way, without jeopardizing the operations of individual sub-contractors? To our knowledge, the problem of stable development of synchromodal network over time has not been studied, yet.”
1.3 Foreseen innovation

Finding an answer to those questions will have double impact of both academic and practical relevance. First, this research will produce planning methods for collaboratively organize synchromodal transport solutions. Indeed, in order to analyse performances of a synchromodal transport network, it is required to have a mathematical description for such a type of transport solution. Second, consultants and stakeholders can have managerial insights into how collaborative agreements should be designed to be successful in terms of synchronization of resources, and what are the possible operational dynamics that can be expected when certain agreements have been made (see Section 4.3). Third, the academic community will find a framework that can be used to further dissect cooperation in container transport. Setting a ground for formal research will have a positive effect to stimulate different fields. Moreover, this white paper poses research questions that remained unresolved, as the research gap analysis will demonstrate in Section 4.

1.4 Business relevance

Businesses will benefit from the findings of this research. We noticed that various stakeholders are interested in synchromodal transport but, at the same time, the benefits and risks of engaging in synchromodal solutions and collaboration have not been quantified and are not yet well understood. This may cause stakeholders to be conservative in embarking on synchromodal transport solutions and collaboration. Therefore, addressing the research questions may also favour the adoption of synchromodality and collaboration by the various stakeholders.
2 Literature Review

The concept of synchromodal transport emerged in 2010 in an advice to the Dutch government by the Strategic Platform Logistics. The report states that Synchromodality brings considerable logistics improvements (Strategisch Platform Logistiek 2010).

The present literature on synchromodal transport is at an early stage, mainly based on local (Dutch) studies, in the context of port-related container distribution. A few definitions co-exist. We summarize four commonly used definitions from earlier papers:

- (Tavasszy, L., Van der Lught, L., Janssen, G., & Hagdom - Van der Meijden 2010): Synchromodality is the synchronization of transport demand across the multi-modal transport system. Shippers make use of different modes of transport, in function of the transport demand, and switch between modes is possible;
- (TNO 2011): The coordination of logistics chains, transport chains and infrastructure, in such a way that, given aggregated transport demand, the right mode is used at any point in time;
- (Gorris, T., Groen, T., Hofman, W., Janssen, R., Meijeren, J. Van, Oonk, M. 2011): Synchromodality occurs when the supply of services from different transport modes is integrated to a coherent transport product, which meets the shippers’ transport demand at any moment in terms of price, due time, reliability and/or sustainability. This coordination involves both the planning of services, the performance of services, and the information about services;
- (Behdani et al. 2014): Synchromodality is an integrated view of planning which uses different transport modes to provide flexible transport services (Error! Reference source not found.). However, the horizontal integration of the modes is the key distinctive feature of synchromodal transport (Error! Reference source not found.).

![Figure 3 Integrated view of freight transport planning (Behdani et al. 2014).](image)
For a systematic literature review on the topic of synchromodal transport we refer to (Singh, van Sideren, and Wieringa 2016) and (Reis 2015). Although different definitions exist and the need for a good definition of synchromodal transport is stressed by (Reis 2015), the purpose of this literature review is not to come up with a new definition, but to give a description of the four characteristics, concepts and/or enablers related to the concept of synchromodality that will support our research. Below, we will discuss (1) its dynamic character, (2) collaboration between stakeholders as a condition, (3) performance measures of synchromodal networks, and (4) information sharing and supply chain visibility as a condition.

2.1 Collaboration of stakeholders as key prerequisite

Collaboration is a prerequisite for enabling synchromodal transport. The study of Pfoser et al. (Pfoser, Treiblmaier, and Schauer 2016) showed that collaboration is categorized as key enabler for a synchromodal transport chain. Tavasszy et al. (Tavasszy, Behdani, and Konings 2015) stress that coordination can be even more challenging for a “synchromodal” system in which the operation of different chains must be synchronized simultaneously. Failure to coordinate may cause logistical problems and hinder the value of synchromodality. Nevertheless, cooperation between stakeholders in supply chains does not always develop spontaneously. With the focus on port-related transport, Van der Horst & De Langen (Van Der Horst and de Langen 2015) state that coordination is hindered due to several reasons like imbalance between the costs and benefits of coordination, a lack of willingness to invest, and the strategic considerations of the actors involved. These reasons, together with information asymmetry, lead to poor performance in the whole chain (Cachon et al. 2001), and other coordination problems (Van Der Horst and de Langen 2015).

The literature comes up with several research streams to improve the level of collaboration. We will discuss three streams that are relevant to EGLS1. First, Macharis et al. (Macharis et al. 2010) state that a comprehensive analysis of relevant stakeholders is necessary to identify the different interests in the whole transport network. Second, Van der Horst & De Langen (Van Der Horst and de Langen 2015) argue that either one of the following coordination mechanisms in hinterland transport need to be put in place: incentive alignment, alliance, or vertical integration. Ypsilantis et al. (Ypsilantis 2016) developed a mathematical model for Port-Hinterland intermodal barge network design. Their results show that cooperation between dry-ports could significantly reduce the costs and increase the service quality. These contribution fit in a wider range of research that seeks mechanisms to improve the efficiency of “intermodal” transport chains. Intermodal transport is defined as “unitized freight transport by at least two transport modes” (Saiedi et al. 2017). For example, Veenstra et al. (Veenstra, Zuidwijk, and van Asperen 2012) investigate transport network integration by extending the deep sea terminal gate to the gate of the hinterland terminal. They argue that these extended gates relieve congestion both at the deep sea terminals and in the transport corridors. Woxenius
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(Woxenius 2007) suggests a generic framework for flow consolidation and routing principles in a transport network. Saeedi et al. (Saeedi et al. 2017) explain different range of business consolidation strategies in intermodal freight transport, from vertical to horizontal integration, and from light to heavy consolidation. They also explain how these strategies could change the market structure, and reduce competition. Anti-trust authorities consider reduction of competition harmful to customer interests, and may therefore block integration. Third, there is a recent research stream, including the contributions Tavasszy et al. (Tavasszy, Behdani, and Konings 2015), and Behdani et al. (Behdani et al. 2014), that stresses the issue of contract design in synchronomodal transport. New contractual agreements need to be developed, that enable collaboration and the exchange of information between parties.

The most common type of collaboration in urban freight transport is subcontracting of the last mile operations. Indeed, many parcel operators subcontract their delivery operations in highly congested areas. For example, while DHL only subcontracts 10 percent of its activities in small towns, it outsources most of them in Paris (Ducret and Delaitre 2013). Another type of horizontal collaboration is the convened horizontal collaboration (Köhler and Groke 2003; Thompson and Taniguchi 2001). In this collaboration model, the shippers or the carriers participating in the collaboration are the initiators and the owners of the collaboration and keep control over the scheme. For example, a neutral freight carrier collects goods from five freight carriers and delivers them to shops in the inner city. Crujissen et al. (Crujissen et al. 2005) developed a model that has been referred to as the insinking model. In this type of scheme, a logistics service provider is the initiator and the owner of a collaborative network. This type of approach can be met in practice, especially among specialist last mile operators that are focusing on specific delivery areas and that tender among multiple clients in order to reach sufficient volume. An example of such a case can be seen in Brussels, where a green logistics provider SUMY consolidates flows from several shippers. The logistics service provider collects part of the goods among the shippers, and delivers the remainder at their consolidation platform. Quak & Tavasszy (Quak and Tavasszy 2011) investigate the potential savings for carriers linked to the use of the network of urban consolidation centres in the Netherlands through vehicle routing, based on real delivery data for two large carriers. Rocca-Riu & Estrada (Roca-Riu and Estrada 2012) use continuous approximation methodologies in order to compare two distribution strategies for a series of carriers having equal market shares: independent delivery by each carrier, or the use of an urban consolidation center. Crainic et al. (Crainic, Ricciardi, and Storchi 2009) focus on the analysis of collaborative urban freight transportation networks involving a two-tiered distribution structure, whereas Crainic et al. (Crainic, Ricciardi, and Storchi 2004) develop a model for a distribution system based on satellite platforms. Gonzalez-Feliu (Gonzalez-Feliu 2011) combine a demand generation model with a route optimization algorithm to simulate the resulting routes of individual or collaborative distribution schemes.

2.2 Performance measures of a synchronomodal transport network

Different stakeholders in the synchronomodal chain benefit from Synchronomodality. For the design and the performance measurement of synchronomodal supply chains, multiple performance measures must be identified (Behdani et al. 2014). The definition of synchronomodality from TNO (2011) articulates this: “Synchronomodal Transport is [...] deployed in such a way that: (1) the shipper is offered the transport service that suits its competitive strategy; (2) a profitable exploitation is possible for the terminal operator, (3) the infrastructure and available space are used to the full, and (4) the (whole) chain performance in terms of sustainability is optimized. Reliability, (cost) efficiency and sustainability (emissions) are important performance measures, not only from the perspective of individual stakeholders, but especially from a transport network or system perspective. The interests from different individual stakeholders in the sustainability of the supply chain is not obvious. In the assessment of the intermodal value proposition offered by shipping lines, Van den Berg & De Langen (Van den Berg and De Langen 2015) conclude that both shippers and forwarders still have a rather limited interest in sustainability. Forwarders attribute the lowest importance to
sustainable operations. In the explorative study of Eng-Larsson and Kohn (Eng-Larsson and Kohn 2012), the shippers’ perspective on modal shift for a greener logistics is analyzed. They notice how emission reduction is taken as collateral benefit of modal shift, rather than a target on its own. However, As stressed by Pfoser et al. [8], it is important that stakeholders undergo a mental shift, i.e., develop an open eye for the benefits of synchromodality. In their study on Critical Success Factors, mental shift is the second most mentioned factor.

From a system perspective, Zhang and Pel (Zhang and Pel 2016) developed a model that considers the dynamics in demand and supply, and enables strategic decision-making based on the system performance evaluation from governmental perspective. The model uses (1) total system costs, total system time expense, and capacity occupancies of service lines as economic indicators, (2) network flow concentration, and road traffic as societal indicators, and (3) carbon dioxide emissions as environmental indicator. Applying the model to the hinterland of the port of Rotterdam, they found that from an economic perspective, the synchromodal system has very limited benefits compared to the intermodal system. The synchromodal system could impose higher risks due to additional transhipments, and higher coordination costs among different modalities. Because of the shorter waiting time, the synchromodal system featured shorter delivery times. Moreover, the synchromodal system yielded an overall reduction in CO2 emissions.

### 2.3 The dynamic character of synchromodal transport

As proposed by the Dutch Institute for Advanced Logistics (Dinalog) (discussed in Zhang and Pel (Zhang and Pel 2016)), synchromodal transport entails that a shipper agrees with a service operator on the delivery of products at specified basic requirements, such as costs, quality, and sustainability. The service operator has the freedom to decide on how to deliver according to these specifications. He can optimize transport processes and utilize available resources in an efficient and sustainable way. An important aspect on the supply side of synchromodal transport services is that the choice for the transport mode is made along with the provision of the transport service, based on real-time information on the current conditions of the transport system (e.g. delays, congestion, reliability, transit times, pricing, availability of transport, infrastructure and terminal and warehouse capacities). According to Tavasszy et al. (Tavasszy, Behdani, and Konings 2015), synchromodality can be briefly summarized as a network of well-synchronized and interconnected transport modes (supply side), which together cater for the aggregate transport demand (shipper perspective), and can dynamically adapt to the individual and instantaneous needs of network users. The issue of adaptation and dynamic planning is also pointed out by Pfoser et al. (Pfoser, Treiblmaier, and Schauer 2016). They state that sophisticated dynamic planning, simulation of transport routes and transport patterns are essential Critical Success Factors to create a functioning synchromodal transport network.

In the literature on freight transport, three planning levels are usually identified: strategic, tactical and operational (Crainic and Laporte 1997). With the main difference being the time horizon considered and the inherent change of perspective on the planning. We consider the operational planning, i.e., the day-to-day planning of transportation. From the literature, important operational planning characteristics emerge like the adaptive mode choice, flexible planning, and real-time response or switching in case of disturbances and disruptions. In the works of Van Riessen et al. ((B. Van Riessen 2013), (B Riessen et al. 2015), (Bart van Riessen et al. 2015), (Bart van Riessen, Negenborn, and Dekker 2016)), two aspects of operational planning are required to enable synchromodal transport. First, the real-time dimension of intermodal transport. Van Riessen et al. (B. Van Riessen 2013) consider the combination of intermodal planning with real-time switching. Real-time switching refers to changing the container route over the network in real-time to cope with transportation disturbances, such as service delays or cancellations. Second, there is a need for an integrated transport planning using self-operated and subcontracted services. Their work takes the perspective of a central planner.
SteadieSeifi et al. (SteadieSeifi et al. 2014) mention that synchromodal transport is the next step after intermodal and co-modal transportation. With adopting the operational planning characteristics like adaptive mode choice, flexible planning, and real-time response, it can be argued this is true. The same position is taken by Haller et al. (Haller, A. et al. 2015). They state that synchromodality fits in the evolution of inter- and co-modal transport concepts, where stakeholders in the transport chain actively interact within a collaborative network to flexibly plan transport processes and to be able to switch in real-time between transport modes tailored to available resources.

2.4 Information sharing and supply chain visibility

The dynamic character of synchromodal transport decisions requires the continuous monitoring of planning and execution in real-time. As noted by Behdani et al. (Behdani et al. 2014), unexpected events like the late arrival of trucks, trains, or the late release of containers frequently occur during operations. According to the authors, these unforeseen events are incorporated in synchromodal network planning. Adjustments in real-time planning require insights in the availability of transport, terminal and infrastructure capacity. This calls for information sharing with the transport, terminal, and infrastructure related stakeholders. Providing high quality and standardized data as well as sharing and mutually exchanging information are seen as key enablers of synchromodal transport.

Data pipelines combining information from different stakeholders have to be available in such a way that all stakeholders within the transport chain are able to properly use them. Furthermore, it is essential to implement ITS and ICT systems in order to dynamically provide data and to be able to optimize transport planning. Long-term and automated planning need to take into account the crucial role which data and information play in a synchromodal supply chain. Additionally, issues dealing with data security and data protection must be solved (Pfoser, Treiblmaier, and Schauer 2016).
3 Already existing/ previous projects

There are some other European projects which - to some extent - concern about the synchronization of the logistic activities in a collaborative manner. In this section we shortly explain their main purpose. We follow the same structure as in the review of the academic literature.

3.1 Collaboration of stakeholders as key prerequisite

There are projects in which the collaboration between stakeholders is highlighted. For example, the SMART-RAIL project is developing business and governance models that will enable collaboration with different stakeholders in the supply chain. The ULTIMATE project explores the new ideas for cooperation between different multi-modal operators by developing the extended gate concept for use in the hinterland. The Platoon (2-Truck Platoon matching) project will introduce new logistics concepts in the Supply Chain. This project addresses the industrial challenge to be able to schedule platoons or dynamically form platoons on-the-fly, by realizing a collaborative matching and planning competency. TIGER (Transit via Innovative Gateway concepts solving European intermodal Rail needs) project aims to develop the Rail transport in competitive and co-modal freight logistics chains.

3.2 Performance measures of a synchromodal transport network

The CO2REOPT project aims at developing methods and tools for full external transport integration where suppliers, manufacturers and customers share a fully integrated and optimized intermodal supply chain. In CO2REOPT, the robust and dynamic re-planning of timetables, optimal disruption management, and design of cross-border synchromodal transport chains, will be studied from a supply chain perspective. In this project, there is also attention for reliability of scheduled services and carbon emission reduction.

3.3 The dynamic character of synchromodal transport

Some of the European projects are about applying or developing intermodality and synchromodality on European networks. The ISOLA project supports the development of the multimodal transport system in the Netherlands, and by extension in Europe, into a truly synchromodal transport system, in which infrastructure use, transport services and operations are aligned with market demand. The ISOLA project considers sourcing of transport capacity for synchromodal services, articulation of the demand side, revenue management applied in synchromodal context, and the use of real-time information. Implications of automated driving in freight transport is one of the concerns of EU decision makers; the STAD project is about automated driving, and is based on an integrated approach combining spatial economics, passenger and freight transport, traffic safety and multimodal transport networks. One STAD subproject focuses on platooning. Real-time planning is one of the main characteristics of synchromodal transport. In SYCHRONET project, a software for real-time synchromodal logistics optimization is developed.

3.4 Information sharing and transport chain visibility

There are different EU projects which are developing new methods and platforms for information sharing between actors in transport supply chains. These information sharing platforms will lead to more visibility in the transport networks.

Boxreload is an innovative, easy to use web-based platform to allow trucking companies to cooperate by safely sharing certain information and enabling better transport planning. Boxreload helps trucking companies of all sizes to combine loads with the aim of replacing two journeys by two
trucks, each with an empty leg, by one return journey with a single truck. In the INTEGRITY project, the core of the project was the development of the so-called Shared Intermodal Container Information System (SICIS) allowing authorized companies and authorities to access planning and status information of selected transports. Proactive planning following the Supply Chain Event Management (SCEM) approach allows to forecast problems well before they might occur. The AEOLIX (Architecture for European Logistics Information Exchange) project is running to overcome the fragmentation and lack of connectivity of ICT based information systems for logistics decision making. The iCargo project aimed to advance and extend the use of ICT to support new logistics services to synchronize vehicle movements and logistics operations across various modes and actors. The vision of the CELAR (Automatic, multi-grained elasticity-provisioning for the Cloud) project is to provide automatic, multi-grained resource allocation for cloud applications. FIWARE project is developing Core platform of the Future Internet. The FIWARE mission is to build an open sustainable ecosystem around public, royalty-free and implementation-driven software platform standards that will ease the development of new Smart Applications in multiple. In addition, the Flspace is a business-to-business (B2B) collaboration platform. While EfficienSea project aimed to prepare and mature maritime authorities for major future investments needed to implement e-Navigation in the Baltic Sea region, PROPS project promote and develop short sea shipping, and to extend SSS operations to encompass inter-modal and co-modal transport.

ASAP and PortDial are two other platforms which develop frameworks for information sharing. The ASAP research project develops a dynamic open-source execution framework for scalable data analytics. The underlying idea is that no single execution model is suitable for all types of tasks, and no single data model. The PortDial will result in a commercial platform for quick prototyping of interactive spoken dialogue applications to new domains and languages, the corresponding multilingual collections of concepts-services-grammars for specific application domains (marketed separately), and a multilingual linked-data ontological corpus that can be freely used for spoken dialogue research and prototyping for non-commercial purposes.

There are other projects which develop new technologies that could help to extend the concept of information sharing in multi-actor networks. COGNIMUSE will undertake fundamental research in modelling multi-sensory and sensory-semantic integration via a synergy between system theory, computational algorithms and human cognition. CAPER project is investigating the authentication of pervasive devices - how can a user be guaranteed that the device they associate with is indeed the device in front of them.

3.5 State of the practice

The current state of practice features a variety of collaborative arrangements in container transportation. For example, European Gateway Services is offering intermodal transport services integrated with container handling services in the deep-sea port and in the hinterland dry port (Veenstra, Zuidwijk, and van Asperen 2012). Some hinterland terminals collaborate by sharing terminal capacity or barge capacity to better utilize resources (ypsilantis 2016). Also, shippers join forces to create sufficient volume to exploit intermodal transport solutions. Samskip is offering on some of its corridors in Europe synchronomodal transport solutions where the actual mode and route of transport is left to the discretion of the intermodal operator. Usually, these transport solutions may have some features in common with the synchronomodal transport solutions outlined in this white paper. However, state of practice does not feature the level of collaboration and information exchange required for full synchronomodal service deployment. The question is what benefits can be obtained when collaboration and information exchange are enhanced and in which types of enhancements are most effective.
4 Research Gap

In this section, we provide evidence of the research gap present in the current literature by presenting the two main research directions of this first European Green Logistics Strategy. The scope and domain of this research, both at the academic and at the application levels, is presented in Section 4.1. A description of the methodological approach is given in Section 4.2, while Section 4.3 maps out the intermediate steps required to bring innovation from this academic research to the business level. Getting closer to practice, the outcome of this research in terms of managerial insights and tools for implementation is illustrated in Section 4.4. Finally, Section 4.4.1 lists IT solutions to be developed as a consequence of the guidelines presented.

In what follows, the research gap is presented by organizing it into two different directions. The first one deals with the issue of assessing the effect of different collaboration levels on synchromodal network performance, e.g., costs and reliability. The second direction, instead, looks into how different collaboration agreements affect the execution of synchromodal transport. This division provides support to the two sets of research questions that were presented in Section 1.2. To enter the description of the two directions, we first need to distinguish the concept of collaboration levels from that of collaborative agreement. On the one side, a collaboration level can be defined by looking at the operational properties of a collaboration, namely, how information is shared, the role of participating actors and the planning level where cooperation occurs (Barratt 2004). On the other side, a collaborative agreement is related to the precise terms by which collaboration is put into practice, for instance a benefit sharing mechanism, or an arrangement that aims at coordinating and synchronizing the actions of multiple organizations.

Different levels of collaboration can be distinguished by looking at how information is shared, what actors are sharing information and the planning level (strategic, tactical or operational) where coordination takes place (Barratt 2004). Variety in levels of collaborations relates also to different coalitions of stakeholders: because multiple heterogeneous organizations operate on the same network, diverse collaborations can be arranged by looking at specific combinations of participants, with certain configurations yielding to a higher network performance than others. Therefore, a synchromodal and collaborative strategy will result in performance improvements only if properly deployed and coordinated. Between the improvements, enhanced reliability should be defined in a network setting. A definition that can be used to operationalize the concept, rather than statically assessing its value on a specific network configuration, is missing in the literature. This measure for reliability should be defined in such a way to respect composition structures of transport networks and, at the same time, being valuable for stakeholders. Moreover, following this definition, we aim at understanding the inherent relations between reliability and the other network performance measures, i.e., costs and emissions. Establishing the price of reliability in terms of quantifiable measures comes down to determining the cost of increasing network reliability to a certain extent. In this direction, several studies have investigated synchromodal planning and execution methods from the point of view of a unique central planner (B. Van Riessen 2013; Bart van Riessen, Negenborn, and Dekker 2015; Behdani et al. 2014). We plan to extend those works, especially because we explicitly consider coalitions of stakeholders, but also because of our focus on reliability and on different levels of information sharing.

In the second direction, collaborative agreements, instead, assume a central role in establishing the gap. Indeed, they occupy a relevant position in the collaborative planning of synchromodal transport as the development of a synchromodal transport network involves multiple suppliers of transport and handling services. Different transport service providers may not have aligned interests because of their different positions in the transport network, different performance of their services, or specific dependencies of their operations to particular timing of information provision. For instance, stacking operations can be optimized when advance information on the container flow through the terminal is given, while carriers might defer taking decision on container routing - and the resulting information sharing – to wait for revelation of further information. In this example, if the carrier's
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decision is going to affect the terminal operator, as the latter can or cannot be on the chosen route, a clear misalignment of incentives in information sharing is found. To our knowledge, this effect has not been studied so far as operational planning problems have predominantly been studied for network operators that act as single decision makers. For the studies where different operators act cooperatively in planning transportation, full integration of the planning process has to be assumed (Krajewksa et al. 2007; Agarwal and Ergun 2010). We plan to start our research from those works by extending and modifying the models proposed there, so that the effect of information sharing on operational planning is explicitly captured. Moreover, by reversing the previous research process, i.e., going from given targets of network performance measures to the collaborative agreements, we will determine the value of operational information sharing between stakeholders. Those results will clarify how to construct collaborative agreements that can effectively enable synchronomodal planning and execution.

To summarize, we underlined a two-fold research gap. In a first direction, there is a clear gap in the academic knowledge on the effect of diverse information sharing levels, heterogeneity in cooperating parties and different coordinated planning levels on synchronomodal network performances, in particular reliability of transportation. In the second direction, knowledge is missing on the impact of benefit sharing concepts and incentive alignment mechanisms on the performance of a synchronomodal network.

4.1 Research scoping

This section describes the scope of the academic research we will carry out, as well as, the domain of the applications considered in this EGLS.

Logistics and transport are the two wide domains this research belongs to. More specifically, the focus is on collaborative logistics, both horizontal and vertical cooperation, and container transport as we will consider multiple organizations cooperating in an hinterland container transport network. Studying hinterland networks is bringing this research away from the specific problems of maritime systems. Moreover, the empty container repositioning problem will not be considered. Operational planning is going to be the prominent focus of this study, therefore, excluding the tactical and strategic planning.

The cooperative aspect of this research belongs to the domain of game theory, in general, and cooperative game theory, more specifically. Solution concepts for cooperative games will be considered, as well. We will not study pricing models unless those might become relevant as effective coordinating mechanism under a collaborative agreement.

In both of the research gap directions that were presented in the previous section, the concept of value of information was clearly underlined. Therefore, assessing the value of information is another domain of this research.

When coming to the applications of this research, the domains of container transport and urban distribution are included. Indeed, while container transport can be seen as transport of standardized cargo units, urban transport can be tackled similarly as a special case of a transport setting where a variety of units is used.

4.2 What academic research is required?

This section presents the methodologies that we are going to consider to address each of the two directions of the research gap. In general, our methodological approach is a combination of optimization models and cooperative game theory applications. This research will make use of stochastic dynamic network flow models to initiate the investigation on the definition of reliability. Those models are a compromise between detailing operational planning to its full complexity and putting into the model abstract concepts of resource synchronization. Indeed, a network flow model

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is not considering operations in their full details but presents transport resources in an aggregated manner. This will allow for a simplified representation of transportation, thus, facilitating the evaluation of reliability and of concepts of synchronization of resources. Stochastic parameters will be used in the combinatorial models in order to capture uncertainty. The value of different levels of information sharing will be addressed by a scenario-based analysis that fixes variability of certain parameters of the combinatorial models and a comparison of those results.

Different solution concepts from cooperative game theory (the Shapley value, the core, etc.) will be used to represent different benefit sharing mechanisms. On the same issue, we might consider specific non-cooperative game models to capture the self-interested behaviour of multiple organizations. Those models will be linked to the combinatorial models reported above.

In a first moment of this research, we plan to use stylized models to provide clear insights into the different roles. By stylized models, we mean simple examples where the instance size of the combinatorial models is small. In a second moment, we might consider performing simulations as a way to properly address more involved network structure, or when obtaining closed solutions are not feasible anymore.

4.3 What applied research is required?

Applied research needs to demonstrate in what manner collaborative arrangements and information exchange should be enhanced in current transport systems. Although various levels of collaboration and information exchange between different heterogeneous players can be established, the question is what the outcome will be. One, therefore, needs to define and assess different performance dimensions of collaborative transportation networks composed out of heterogeneous players. This will allow the examination of trade-offs between different performance dimensions. Moreover, there is a need to increase the visibility and awareness of the different collaborative agreements and schemes on the overall performance of a transport.

The required collaboration and information exchange is closely related to the design of planning and execution of synchronmodal processes. Information exchange should provide decision makers with the required level of situational awareness to fully utilize the available resources and to meet actual demand. In order to deploy the various resources in an optimal way, there should be no frictions between the planning and execution by the different actors that hinder optimal system performance.

The applied research should take into account the feasible designs in the Living Lab environments. This investigation will provide insights into how the planning and execution processes should be designed to leverage the potential value of collaboration towards the realization of synchronmodal transport.

Next to organizational boundaries, also certain organizational procedures may not be defined away immediately. The same holds true for legal and institutional constraints. In general, a stakeholder analysis is required to map out the drivers and barriers of adoption of collaboration and synchronmodality.

4.4 What solutions will be developed?

This section illustrates different solutions that will be developed by addressing the research gap. Managerial insights will be presented first, followed by tools that will be developed as a result of prior investigations.

Although one can easily understand that cooperation in a transportation system is a way to produce benefits and create innovative solutions, one can also easily glimpse the higher level of complexity that is brought into play by collaboration. This simplified argument on the possible benefits and on
the complexity of cooperation motivates the need for providing practitioners with well-formulated and educated insights. Indeed, to extract value from collaborations it is important that organizations can easily understand and evaluate their position with respect to others in terms of collaborating opportunities, rather than competing advantages. The research aiming at filling the first gap described in Section 4 will accomplish this claim. Actually, understanding the value of different collaboration levels is directly aligned with this purpose. Moreover, establishing the value of information sharing in the collaborations will allow network operators to confidently share operational information and exchange those with other partners in a cooperation.

The investigation that will be carried out on the definition of reliability will provide insights on how to improve transport services and lever on reliability to further promote one’s position in the network. Studying the price of reliability will provide guidance on at what costs can one organization improve its reliability, or sell services with different reliability levels. In this analysis of reliability, the study of stochastic combinatorial models will be the predominant source of remarks.

In addition to managerial insights, new tools to plan and execute transport service in a cooperative environment will be needed. While providing insights gives guidance in evaluating the potential benefits of a collaboration, developing tools for operationalize this cooperation will be done to allow stakeholders to fully achieve the expected performance targets. Those tools will be developed from the synchromodal cooperative planning models. Indeed, our investigations will foresee and address real-world planning issues that would be otherwise hindering the value of cooperatively planning itself.

4.4.1 IT Solutions needed

From the above presentation of the research solution to be developed, it is possible to highlight IT solutions that should be implemented next. We first describe general features of the IT system and, then, connect the IT solution with the managerial insights and the tools that will be developed.

In general, the designed IT system should be flexible in terms of being able to connect a large number of players. Moreover, the entrance in and exit from the system should be easy both in terms of IT complexity and in terms of having minimal legal- and cost-related barriers. Such a system should also enhance visibility in the transport chain by allowing cooperating stakeholders to share operational information. Allowing visibility within a collaboration only is critical: stakeholders should trust the way the platform share their information.

Following the results from the investigation of the impact of different collaboration level on synchromodal transport, the system should reproduce a practically viable Collaborative Synchronmodal Planning Toolbox. From the analysis, it will be possible to assess what would be the characteristics of such a tool, therefore, guide an implementation that already incorporates those findings. This Toolbox will use information on the resources shared by the different organizations to allow network operators and carriers to plan synchromodal transport by having a clear view on the value of different performance measures of a possible plan.

Following the study on reliability, a Network Reliability Tool should be devised and implemented within the SELIS platform: using data related to schedules and the actual realization of transport, the system should be able to provide insights into the reliability of different transport services operating in the network. Such a tool will show how the reliability of an overall transport solution depends on that of the services involved. The implementation of this feature should follow the research results on the definition of reliability itself.

From this perspective, the Publish&Subscribe system can be used to notify carriers in real-time and use sensor data to automatically trigger notifications. We provide some examples of possible messages that can be shared:

a. if a service is delayed, notify the following service connected to the previous one;
b. if a terminal is congested, notify incoming barges;
   c. if a disruption occurs, notify all services using that leg of the network;
   d. if the planned arrival of a service is changed, notify the stakeholder at the arrival facility;
   e. if a service is not on the planned schedule and track, notify the service owner for reaction.

The case study proper of urban transport would require similar solutions. A system with the previous requirements will then allow for dynamic planning and routing with the following extras required by EGLS2:

1. Integration of the external data (weather data and traffic events) from the publish and subscribe platform
   2. Real-time monitoring of the different events allows proactive action according to a set of predefined operational rules; for example:
      a. If there is an expected delay of less than 10 minutes for a specific customer, do nothing;
      b. If there is an expected delay of 10 to 30 minutes, notify the customer by e-mail;
      c. If there is an expected delay of more than 30 minutes, notify the planning department in order to see if it is possible to reroute the vehicle
5 Framework

In this section, we introduce a framework to position the research that is going to be developed within EGLS1. The framework of EGLS1 is depicted in Figure 5. As stated earlier, EGLS1 is an operational collaborative strategy which determines how logistics resources are synchronized in an optimal way to achieve certain transport performance targets, in particular costs, emissions, and reliability. The research focuses on the question of how to use transport network visibility (by information sharing) and collaboration in such a way that transport network performance (in terms of reliability, costs, and emissions) is improved.

![Figure 5 Framework of EGLS1](image)

5.1 Help position the research questions

We now describe how the framework as depicted in Figure 6 helps us to position the various research questions. We start with the four questions that relate to the impact of the level of collaboration on synchromodal transport performance. The first research question relates transport network visibility and collaboration as enablers to transport network performance. To answer the question, the performance measures need to be known (second question) and planning and execution procedures need to be designed (third question).

1. What is the impact of the level of collaboration, and in particular the level of information sharing, on reliability and efficiency of synchromodal transport processes?

The second research question conveys that the notion of network reliability needs closer attention, as it is difficult to define.

2. How does one define reliability of synchromodal transport processes?

The third research question focus on the design of the planning and execution procedures to arrive at optimal performance.

3. How are planning and execution processes designed to capture the potential value of collaboration and information sharing?

The fourth question addresses the fact that the network performance has multiple dimensions that need to be balanced.
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4. In the trade-off between reliability and efficiency, what is the “price of reliability” for synchronodal systems?

The framework also helps to position the research questions about the impact of collaborative agreements on synchronodal transport performance. Here the emphasis is on the relationships between stakeholders and how they respond to incentives. These research questions do not touch upon the design of such incentive systems; this is left to EGLS2. The research question should address the impact of the incentivized collaborative behavior on the network performance. This is indeed the point of the first research question.

1. What is the impact of the various collaborative agreements between stakeholders on synchronodal transport performance?

The level of collaboration is addressed here in more detail and may range between all stakeholders being autonomous decision makers and all stakeholders acting collectively as a single decision maker. When comparing the performance impacts of these collaborative settings, one assesses the “price of anarchy”, i.e., the performance loss as decisions are not made in a fully coordinated way.

2. What is the price of anarchy?

While making such comparisons, certain incentive schemes among stakeholders may be more effective than others. While seeking the most effective collaborative agreements, the third research question is addressed.

3. Which collaborative agreements add the most value?

The collaborative agreements may not fall in place naturally. Required collaboration may redistribute benefits in an uneven way. Therefore, it may be required to realign incentives in such a way that all stakeholders are willing to take appropriate action and support synchronodal planning and execution.

4. What operational issues require incentive alignments from the collaborative agreements?

The answers to the questions above will further support the development (the first set of research questions) and adoption (the second set of research questions) of the collaborative platform. The two sets of questions form the research agenda of EGLS1.

5.2 Help positioning the foreseen innovation

The research developed following the research agenda will lead to innovative business cases in the domain of synchronodal transport. When these research questions have been answered, and when the associated solution directions have been shared with stakeholders in the Living labs and with the Technology Providers, who help build the collaborative platform, decision makers are able to:

1. Determine the various levels of information exchange and collaborative agreements, and the benefits in terms of enhanced network performance;
2. Decide which level of collaboration and information sharing among the incumbent stakeholders fits best with the associated performance levels, while taking into account less quantifiable drivers and barriers for the adoption of the collaborative platform;
3. New entrants to the collaborative platform can be assessed on their value add.

5.3 Connect the functionalities with the research needs

The IT functionalities required by this EGLS are also object of the research study carried out within the EGLS itself. For instance, the realization of an inland reliability tool will require a rigorous investigation on proper definition of reliability in terms of measurable quantities. In the research
question section, several issues related to the definition of the network performances were raised. Similarly, coordinating the operational planning will be investigated so that the best practices only will be implemented in the IT system itself. The aim is to develop functionalities whose characteristics have passed an educated scrutiny test and proved their consistency with the final aim of the SELIS project. In particular, understanding the impact of the collaborative agreements on the joint operational planning will clarify the value of different information sharing schemes. This research findings will impact directly the adoption rate of the IT system developed as it will be clear for the various parties how to extract benefits from joining it.
6 Bibliography


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