Towards a Shared European Logistics Intelligent Information Space

D2.4 Simulation environment and investigation of new models for LLs
(final version)

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Executive Summary

SELIS WP2 aims at the research and development of new business innovation models for Living Labs, which at the same time are driving and enabled by the SELIS infrastructure, i.e. the community nodes and networks. This deliverable is the final version of the report on the development and implementation of SELIS simulation environments linked to the individual objectives of SELIS Living Labs. It is based on the interim version of this deliverable, D2.3 Simulation environment and investigation of new models for LLs.

Computer based simulation has traditionally played an important role in research and development of many natural systems. Supply chain simulation has various benefits, such as helping to understand the overall supply chain processes and characteristics by providing graphical output and animations. The main goal of the here presented activities was the development and implementation of simulation environments in the context of SELIS European Green Logistics Strategies (EGLS). The term Simulation Environment was coined to describe an individual set of tools, data sources and workflows that is suitable to implement a particular simulation study and is assembled in order to execute possibly many recurrent simulation runs over an arbitrary period of time. Accordingly, there are a number of such environments within SELIS, each closely linked to the individual objectives of SELIS Living Labs. These environments are used to demonstrate the benefits and impacts of various SELIS solutions that are influenced by the EGLSs and designed to establish the shared logistics information space. In the Living Lab context, simulation can be useful to validate and configure new SELIS solutions before they will be deployed in a real operational environment. From the perspective of the SELIS Community Nodes and networks (SCN), the simulation process helps to validate the quality and performance of the services provided by the SCN under more realistic conditions compared to the ad hoc testing with just a small fraction of potential users during a short period of time.

Three Living Labs have been selected for the initial developments of conceptual simulation models and the further implementation of simulation environment prototypes and business scenarios that are linked to the respective EGLS:

- LL2 – Port of Rotterdam centered synchromodal logistics (PoR)
- LL5 – SELIS Node for rail, truck, and terminal collaboration (Adria Kombi)
- LL8 – Shipper driven continuous investment in green logistics (SONAE)

The simulation environment that has been prepared for LL2 can be used for both LL uses cases. The first use case scenario was designed to investigate the inland reliability toolbox, which is linked to EGLS1 (Collaborative Planning and Synchromodality). The second use case mainly focuses on the introduction of fixed barge scheduling schemes, to improve hinterland reliability of cargo flows, which is also linked to collaborative synchromodal planning (EGLS1) and EGLS 3 (Supply chain Visibility & CAPA). LL5 is focused on supply chain visibility in conjunction with ETA prediction (EGLS 3). After the development of additional high-level conceptual simulation models, another simulation environment was prepared for LL8. This simulation environment was used to investigate additional use cases regarding the LL8 SCN decision support application, which is implementing a collaboration framework among SONAE and its suppliers to ensure near real-time visibility of stock levels and future product orders to prevent stock-outs and waste. This simulation study focuses on supply chain visibility (EGLS3) and Supply Chain Optimisation (EGLS6) with regard to collaborative inventory management.

The validation of the simulation models during the first stage, the design phase, was important to increase the credibility and overall acceptance of the observed and analysed process flows as well as any assumptions made, concerning the organizational workflow and operating philosophy. During the validation phase, a common understanding of the necessary and sufficient level of abstraction could be successfully established among the simulation team and domain experts form the Living Labs. In the next step, additional and realistic input data was collected and integrated for all existing simulation prototype scenarios being fully aligned with the Living Lab scope and target range in terms of geography and users. In addition to advancing the existing development, the conceptual simulation models for other Living Labs were further transformed into programmed models in order to facilitate experiments and impact assessment through individual “what-if” simulation scenarios. The respective activities are described in detail in this deliverable.
The benefits and results from the simulation studies that have been demonstrated can be summarized as follows:

**LL2**
- Visualize transport flows on a geographic map
- Analyse the lead times and deep-sea terminal calls of barges (KPIs) for particular hinterland routes and corridors
- Validate feasibility of alternative barge schedules
- Analyse and forecast delays caused by different waiting times due to congestion

Ultimately, the simulation modelling and the experiments have shown that gains in lead times and reliability, from adopting alternative schedules, are significant. Effectively, the decision for more aligned schedules comes down to a trade-off between service reliability and flexibility of customers.

**LL5**
- Compare live (on route) trains with timetables
- Analyse ETA prediction accuracy
- Validate feasibility and quality of re-planning strategies

The implementation and application of the simulation model supported the investigation of thresholds for acceptable ETA quality of trains and scheduling alternatives in order to simulate the planning – execution – re-planning cycle. The scenario was deemed useful to get better insight into the influence of ETA quality as a leading indicator on possible asset utilisation. The results were considered extremely helpful to calibrate prescriptive analytics for re-planning.

**LL8**
- Visualize demand variations in terms of sales and sales forecasts
- Visualize and analyse the stock levels with time-charts to capture dynamics
- Evaluate the impacts of sales forecast accuracy
- Evaluate and estimate safety stock boundaries to reduce wastage and stock-outs
- Evaluate different order-split policies also considering environmental factors like fleet type and distances to suppliers with respect to stock-level variations and agreed lead times
- Experiment and validate feasibility of alternative strategies and parameters to model production capabilities of suppliers

The simulation modelling and the experiments have shown how improvements of the forecast accuracy affect the stock levels and stock-outs that indicate possible lost sales. These results were also applied to different inventory management strategies to gain more insight into the use and effectiveness of the collaborative inventory management strategy and its sensitivity to order-split policies in a many-to-many retailer and supplier environment.

Simulation modelling and experimenting has been applied to a range of applications and EGLS strategies. Traditional tools, like spreadsheets would have failed to manage a similar amount of data and level of detail for process models. Working with simulation environments, like in SELIS, will probably become more common to business stakeholders, as finding answers to “what-if” questions in a risk-free environment have clear benefits. However, designing and implementing appropriate simulation models typically requires at least some efforts. In addition to training and learning, which of course also comes with some positive aspects in general, data collection and preparation is sometimes a burden to companies with diverse and distributed or less integrated IT infrastructure. Therefore, a clear methodology and simulation approach has been presented that can also be applied to complement the development and introduction of new logistics software solutions as done in SELIS.
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<td>Third Party Logistics</td>
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<td>ABS</td>
<td>Agent-Based Simulation</td>
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<tr>
<td>AIS</td>
<td>Automatic Identification System</td>
</tr>
<tr>
<td>ATA</td>
<td>Actual Time of Arrival</td>
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<tr>
<td>CAPA</td>
<td>Corrective and Preventive Actions</td>
</tr>
<tr>
<td>DES</td>
<td>Discrete-Event Simulation</td>
</tr>
<tr>
<td>DSS</td>
<td>Decision Support System</td>
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<tr>
<td>EGLS</td>
<td>European Green Logistics Strategy</td>
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<tr>
<td>ELT</td>
<td>Expected Lead Time</td>
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<tr>
<td>ETA</td>
<td>Estimated Time of Arrival</td>
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<td>GHG</td>
<td>Green House Gases</td>
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<td>GIS</td>
<td>Geographic Information System</td>
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<td>IWW</td>
<td>Inland Waterway</td>
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<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
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<td>LSP</td>
<td>Logistic Service Provider</td>
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<td>OR</td>
<td>Operations Research</td>
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<td>SCM</td>
<td>Supply Chain Management</td>
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<td>SELIS Community Node</td>
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<td>Supply Chain Operations Reference</td>
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<tr>
<td>SKU</td>
<td>Stock Keeping Unit</td>
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<tr>
<td>TEU</td>
<td>Twenty-foot Equivalent Unit</td>
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<tr>
<td>TID</td>
<td>Target Inventory Days. Inventory days are the days the current stock level of one product is predicted to support the forecasted demand for this product</td>
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<tr>
<td>TMS</td>
<td>Transport Management System</td>
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<tr>
<td>TOS</td>
<td>Terminal Operating System</td>
</tr>
<tr>
<td>TRL</td>
<td>Technology Readiness Level</td>
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<tr>
<td>UML</td>
<td>Unified Modeling Language</td>
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<td>WMS</td>
<td>Web Map Service</td>
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<td>3PL</td>
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<td>ABS</td>
<td>Agent-Based Simulation</td>
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1 Introduction

This deliverable is the final version of the report on the development and implementation of simulation environments in the context of SELIS European Green Logistics Strategies (EGLS) linked to the individual objectives of SELIS Living Labs. It bases on the interim version of this deliverable, D2.3 Simulation environment and investigation of new models for LLs (SELIS, 2018). The EGLSs are used to drive the simulation models and scenarios that are presented in this report in order to determine the particular benefits for the Living Labs. Therefore, simulation environments are composed to support the visualisation of scenario-based experiments, impact assessment and future dissemination of SELIS innovations. As a result of the work with stakeholders from these Living Labs, outcomes from the implementation, tests and validation of the envisioned simulation scenarios are presented.

1.1 Addressing the SELIS Description of Action

The following table provides a definition of this deliverable and list of tasks to be accomplished by it.

Table 1: Deliverable’s adherence to SELIS objectives and Work Plan

<table>
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<td>T2.3 - Simulation environment and investigation of new models for LLs</td>
<td>2 Simulation in Logistics and Supply Chain Management</td>
<td>Chapter 2 briefly introduces the role of simulation, available simulation techniques and possible advantages for systems concerned with logistics and supply chain management. The introduction in this chapter summarizes the relevance of modelling and simulation to the individual EGLSs, LLs and SCN. A full description is included in D2.3.</td>
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<td>ST2.3.1 – Compose modelling environment toolset</td>
<td>2 Simulation in Logistics and Supply Chain Management</td>
<td>Chapter 2 introduces a common methodology and guidelines for creating LL and EGLS driven simulation models and discusses high-level architectural requirements for the simulation environments. Descriptions that are more detailed are included in D2.3.</td>
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<td>ST2.3.2 – Gather required data and link system to data sources</td>
<td>2 Simulation in Logistics and Supply Chain Management</td>
<td>Section 2.4 provides a common modelling template that aims at supporting LL and EGLS owners in the simulation design process.</td>
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<td>Chapter 2.5 documents potential data sources to gather various types of required data, to compile initial sets of master data as well as examples of information services that have been used to complete model data.</td>
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<td>Chapter 3 utilizes prototype simulation models as examples from LL use cases to provide an overview of the existing model specifications. The models specifications include refinements and consolidations that have been made after the first design phase if models had to be aligned to the LL use case developments and new requirements.</td>
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1.2 Document Structure

This document consists of the following chapters:

- **Chapter 1, Introduction**: This chapter contains a short introduction to this deliverable, followed by an overview, which shows the addressed SELIS GA tasks and subtasks with their related sections in this document. The description of the document’s structure concludes this chapter.

- **Chapter 2, Simulation in Logistics and Supply Chain Management**: This chapter provides a concise overview on how simulation models may be used to solve certain EGLS-centric problems and outlines the methodology of creating and validating a feasible simulation model. Finally, a brief overview of tools and potential sources of data that are relevant for transport and supply chain related simulation scenarios is given. A more detailed description can be found in the chapters 2, 3, and 4 of the interim version of this deliverable, D2.3 Simulation environment and investigation of new models for LLs.

- **Chapter 3, Simulation Environments and Business Scenarios for Stakeholders**: This section provides an overview of the model specifications, development and use of simulation environments. The models, which have been chosen as examples, focus on planning policies and performance characteristics.

- **Chapter 4, Simulation results**: The initial setup, implementation and use of simulation environments are presented in this chapter. After the high-level conceptual simulation models have been introduced in the previous chapter, the necessary refinements and consolidation work is explained, which in some cases led to different or more detailed implementations than initially planned. This chapter concludes with a compendium of SELIS enabled simulation case studies that successfully linked EGLS strategies to Living Lab based stakeholder communities and a teaching case concept for future dissemination and public use.

- **Chapter 5, Conclusions and next Steps**: The current results concerning the specification and validation of simulation models as well as the feedback from stakeholders are presented in this final chapter. Finally, an outlook on next steps and comments on possible adoption and uptake of the simulation work and lessons learned are provided.

- **Chapter 6, References**: This part contains a list of the references used in this document.

- **Annex I: Conceptual Simulation models (Phase 1)**: For the sake of completeness, the collection of conceptual simulation models, as developed during the first project period, is included in the annex of this report.

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2 GA Annex 1 (Part A) uses an inconsistent number scheme for subtasks 2.3.x. Despite 2.3.3 is omitted therein, it has been decided to use a continuous numbering in all deliverables and communications.
2 Simulation in Logistics and Supply Chain Management

As already described in SELIS D2.3 (2018), computer based simulation has traditionally played an important role in research and development of many natural systems. Simulation allows control over experimental conditions and allows reproducing the system’s behaviour regarding simulation results in a way that is difficult or impossible with a prototype or fielded system. Supply chain simulation has various benefits, such as helping to understand the overall supply chain processes and characteristics by providing graphical output and animations. Simulation models can capture system dynamics including probability distributions on input data and unexpected events. By ‘what-if’ simulation, users can test various alternatives before changing a plan and understand the impact of certain events and conditions and so the risk of changes in planning or in a control process could be minimized (Chang and Makatsoris, 2001).

This chapter provides a brief introduction into the area of simulation in the logistics and supply chain management context, respective tools, and methodologies. Further details can be found in the chapters 2, 3, and 4 of the interim version of this deliverable, D2.3 Simulation environment and investigation of new models for LLs.

The purpose of simulation within the SELIS project is to facilitate the investigation of new models, strategies and objectives for the various SELIS Living Labs. A set of strategies that are meant to be implemented in the Living Labs are jointly developed in close cooperation between different organisations focusing on both recent academic findings and requirements that have been expressed by practitioners from the Living Labs. By definition, a strategy is a set of actions that are meant to be pursued to achieve goals established by a company or organization. Therefore, the main scope of the strategies - structured as EGLS\textsuperscript{2} - is to act as a guidance to follow in order to achieve the main targets defined in SELIS Living Labs. A detailed description of these strategies can be found in SELIS deliverable D2.1 (2017). Simulation can help to verify and investigate the impacts of these EGLSs in an either abstract or simplified environment or in a more practical setup if applied directly by a Living Lab. In the Living Lab context, simulation can be useful to validate and configure new SELIS solutions before they will be deployed in a real operational environment (see Figure 1).

Figure 1: Simulation relevance to EGLSs and Living Labs

The term Simulation Environment was coined to describe an individual set of tools, data sources and workflows that is suitable to implement a particular simulation study and is assembled in order to execute possibly many recurrent simulation runs over an arbitrary period. The SELIS Living Labs will demonstrate the benefits and impacts of various SELIS solutions that are designed to establish the shared logistics information space. The Living Labs consist of various use cases which address particular challenges within the context of

\textsuperscript{2} European Green Logistics Strategy (EGLS)
their business models, e.g. the deployment of synchromodal services (LL2) or the efficient utilisation and scheduling of rail cars (LL5) and barges (LL4) in the hinterland as well as the inventory optimisation for fresh products in a collaborative inventory management environment for suppliers and retailers (LL8). Accordingly, there will be a number of Simulation Environments within SELIS. A summary of the SELIS EGLSs and related functionality together with potential applications of simulation environments can be found in chapter 2.1 of D2.3.

2.1 SELIS Simulation Environments

In this chapter, we give a short overview of the SELIS Living Labs and respective Use Cases, which were selected as a SELIS Simulation Environment. Descriptions that are more detailed can be found in chapter 2.2 of D2.3. Table 2 below shows selected Living Labs along with the responsible technology partner.

Table 2: Living Labs and Simulation Technology Partners

<table>
<thead>
<tr>
<th>Selected Living Lab for Simulation</th>
<th>Responsible Technology Partner</th>
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<tr>
<td>LL2 (Port of Rotterdam)</td>
<td>ISL</td>
</tr>
<tr>
<td>LL5 (Adria Kombi)</td>
<td>EBOS</td>
</tr>
<tr>
<td>LL8 (SONAE)</td>
<td>ISL (CLMS)</td>
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For the first phase of the simulation, “functional” prototype applications for each selected LL are currently used. The development and implemented functionalities of these applications along with the integration with the SCN are described in detail in SELIS deliverable D5.3 (SELIS, 2017b).

2.1.1 LL2 – Port of Rotterdam centered synchromodal logistics (PoR)

**Example from Use Case 1:** An example model for this use case is envisioned for EGLS1 (see D2.1). Reliability, the central theme of this use case, is one out of three most important criteria for shippers and freight forwarders in selecting supply chain partners and routing alternatives. A pre-development simulation should help to understand how different reliability indicators of inland transport could be used by various stakeholders like shippers, port authorities or terminal operators. In order to investigate potential impacts, simulation scenarios can be carried out to gain theoretical insights with regard to decision making in a synchromodal transport system.

**Example from Use Case 2:** The specific problem addressed by this example is related to the first use case as it also combines visibility and coordination of alternative barge schedules. Simulation modelling allows for a comparison of different schedule policies regarding the use of transport modes and voyage execution time. Essentially, an analysis should consider and compare two different sets of barge schedules: the existing routine schedules that are based on a short regular recurrence scheme and the second scheme that is more adaptive to medium term demand patterns.

2.1.2 LL5 – SELIS Node for rail, truck, and terminal collaboration (Adria Kombi)

**Example from Use Case 1:** In this case possible delays of rail transport services caused by deviations and irregularities are investigated. A prediction model will be applied to estimate the time of arrival at the next terminal and finally at the destination (rail terminal). A pre-development simulation could be useful to find the most effective strategy to optimize the prediction of the ETA.
Example from Use Case 2: In the case of delays of wagon-sets used for rail hinterland transport services, a prediction model will be applied to estimate delays, as also mentioned in use case 1. By improving the tracking capabilities, the forecasting of delays and timely availability of wagon-sets can be improved.

2.1.3 LL8 – Shipper driven continuous investment in green logistics (SONAE)

Example from Use Case 1: This use case relates to supply chain visibility and aims at sharing information to increase collaboration among the key actors improving the decision process and optimizing the joint planning of logistics operations in the food retail market.

2.1.4 Relevance to SELIS Community Nodes and Networks

As already described in D2.3, the simulation process helps to validate the quality and performance of the services provided by the SELIS Community Nodes and networks (SCN) under more realistic conditions compared to the ad hoc testing with just a small fraction of potential users during a short period of time. The SCN collects historical data and real-time (or near real-time) data from legacy systems and different information sources, combines them and, by utilising big data analytics, performs calculations (e.g. ETA predictions, CO₂ reductions, KPI forecasts) along with planning and optimisation suggestions. Since simulation experiments can be performed with application prototypes, the SCN services can be used in the same way. The simulation approach will be used to assess the performance of SCN services and algorithms in terms of accuracy of results and applicability.

2.2 Simulation methodology

In this chapter, a methodology of creating and validating a feasible simulation model is outlined. In order to achieve a valid and feasible simulation model a certain set of steps should be followed, which start with the formulation of the problem. Simulation analysts can choose from various but only slightly different methodologies like explained by Law (2015) and Ülgen (2006). The following diagram (Figure 2) illustrates these ten steps for a complete simulation study, from which the first seven steps are the most relevant regarding the actual design of the simulation model. A more detailed description of the ten steps is provided in chapter 3.1 of D2.3.
2.3 Definition of Tools and Models

In the following, we give a brief overview of simulation tools and models used with SELIS. A more detailed description can be found in chapter 3.2 of D2.3.

**Living Lab-Oriented Simulation Tools**

Of vital importance is the difference between general-purpose simulation tools versus their domain specific counterparts. A general-purpose tool offers a maximum concerning flexibility and fields of application, whereas a domain specific system may have its advantages in easier access and finer granularity regarding the configuration of predefined process modules. In order to facilitate the implementation and study of Living Lab- and EGLS-oriented simulation scenarios, it is important to identify common requirements and functional components for the simulation environments.

**Simulation Execution Platform**

A Simulation Execution Platform typically consists of a client application with a graphical user interface with editors to configure scenario specific inputs and outputs and controls to execute, pause and stop a simulation run.
Real-Time and Spatial Visualisation

Geographic Information systems (GIS) have been widely used to visualize location-related data and GIS-based visualisation is an essential requirement in many logistics applications. The integration of GIS and visualisation provides a realistic presentation of spatial data. Animation is an important tool in the simulation process and is utilized during model verification and validation.

Modelling of Reusable Components

If substantial efforts for modelling of a new SELIS artefact have been made, e.g. data models, dashboard component, optimisation algorithm, decision support rules, etc., these results should be reused in the respective simulation environment as far as possible. Hence, the simulation execution platform must support and facilitate the integration of external components, either by using the code libraries directly or possibly via remote APIs.

2.4 Modelling Templates

As already described in D2.3, the documentation of the design phase should be supported by the use of structured modelling templates, which simplifies the recapitulation of changes made to the model in earlier iterations and helps the developer of the implementation to meet all requirements defined in the modelling stage. In accordance with the suggested simulation methodology and guidelines, the model design also includes an experimental design, which provides a description of the experiments to be conducted with the simulation environment to produce the required information at reasonable time and costs. For the sake of completeness, Table 3 shows the structured Conceptual Simulation Model Template which was used in SELIS and which was introduced in chapter 3.3 of D2.3.
Table 3: Conceptual Simulation Model Template

<table>
<thead>
<tr>
<th>Simulation Model</th>
<th>(high-level conceptual model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short name</td>
<td></td>
</tr>
<tr>
<td>Model Owner</td>
<td>e.g. a Stakeholder from a LL or EGLS owner</td>
</tr>
<tr>
<td>Domain (application area)</td>
<td>[Intermodal Transport]</td>
</tr>
<tr>
<td>System/EGLS</td>
<td>[Collaborative Planning and Synchromodality (EGLS1)]</td>
</tr>
<tr>
<td>Objective</td>
<td>[Investigate the impact of information sharing on operational planning of synchromodal transport solutions in terms of reliability and cost efficiency as well as emissions (KPIs) of transport.]</td>
</tr>
<tr>
<td>Strategy</td>
<td>e.g. comparison, evaluation, optimisation, prediction, ranking and selection, sensitivity analysis, etc.</td>
</tr>
</tbody>
</table>

**Problem Statement (Overview)**

A detailed overview from the perspective of the user, providing an accurate, unambiguous and complete description of the objective.

**Input Description**

A technical description of the model input, including scenarios, data and object types, attributes, random variable characterizations, files, and databases. UML diagrams for structural modelling can be used.

**Problem Domain and Components (Scope)**

Describes the domain elements that make up the model. These components represent problem domain specific entities like actors and decision makers, environment as well as behavioural aspects (functional description of the model. The description is intended to explain what exactly the model represents. UML diagrams for structural and behavioural modelling can be used.

**Experiments (What-if Scenarios)**

A description of the experiments to be conducted with the simulation model. An experiment can be designed to compare different sets of input data or alternative strategies or algorithms.

**Output Description**

Desired output data including a description of data types and format for further use.

**Presentation of Results**

e.g. time series, graphs and charts, images, descriptive statistics, etc.

**Validation and Acceptance Criteria**

A list of conditions that have a significant influence on the credibility of the simulation results. It should be mentioned whether the model is limited to certain specific assumptions.
2.5 Tools for Data Gathering, Data Sourcing and Cleansing

This chapter provides a brief overview of tools and potential sources of data that are relevant for transport and supply chain related simulation scenarios. Common data sets and standardized data models should allow users to efficiently model, visualize and simulate logistics operations. However, due to the practically unlimited range of individual requirements, a general-purpose solution or data library does not exist. Instead, each simulation study must define its own data requirements and scope, also in terms of a sufficient level of detail.

The following overview provides some potentially helpful sources, of which some have already been used for the implementation of the simulation environments for some SELIS use case scenarios. Due to the large number of available and potentially useful data sources and individual requirements per simulation study, an in-depth analysis is out of the scope of this report. A more detailed description can be found in chapter 4 of D2.3.

Transport Networks and Routes

Today, geographic information systems (GIS) and digital maps are a part of many software products and tools for the transport and logistics industry. Likewise, simulation software uses GIS-based mapping functions to create static or dynamic views on transport and logistics processes. In addition to the basic visualisation functions, geospatial data is also a valuable source of infrastructure data. Transport networks are based on infrastructure links (e.g. roads, rail tracks and inland waterways), transhipment links (e.g. terminals and hubs) and their corresponding elements of geographic map data are nodes and ways. In order to assign freight flows to feasible routes, a simulation environment should include a routable network representation that is aligned with its visualisation function, such that a valid and consistent presentation (animation) is possible.

Traffic Information Services

Traffic information is particularly useful to detect locations and times when specific conditions like congestion occurred. Information about current or historic traffic situations can be used to design more realistic model scenarios, or to investigate the impact of actual traffic conditions on the system of interest. Even though road traffic can have large impacts on daily transport performance, the use of real-time traffic data is not practicable within the Living Lab simulation scenarios, because of the longer time horizon and different scope of problems of interest. Whenever traffic conditions are taken into account, general assumptions about local and temporal variations are considered sufficient.

Weather Data Providers

The climate data for simulation scenarios could be derived from the ERA-Interim climate reanalysis provided by the European Centre for Medium-Range Weather Forecasts (ECMWF\(^3\)). ERA-Interim is a global data set describing the recent history of the atmosphere, land surface, and oceans, containing climate data from January 1979 to present. Datasets can be downloaded from the ECMWF homepage via a web interface and the ECMWF WebAPI.

Enterprise Data Sources, WMS, TMS, TOS, etc.

The simulation models and scenario specific data usually differ from case to case. In that way, it is important to check what kind of data is actually useful and available for the particular model, as well as the geographic and temporal scope of the data. For example, in order to understand and capture realistic transport demands as an input of the simulation study, historical data can be collected from existing systems, operational databases or surveys and statistics. A statistical analysis of operational data is necessary to understand the characteristics of transports, like volumes per origin/destination pair but also time constraints and seasonal fluctuations.

\(^3\) www.ecmwf.int
3 Simulation Environments and Business Scenarios for Stakeholders

[This section is deemed confidential.]
4 Simulation results

The initial setup, implementation and use of simulation environments are presented in this chapter. After the high-level conceptual simulation models have been introduced in the previous chapter, in some cases refinements and consolidation work has led to more detailed implementations of these models.

4.1 Refinements and Consolidations of Models

[This section is deemed confidential.]

4.2 Simulation Results and Usage Principles

[This section is deemed confidential.]

4.3 Adaptation Guidelines and Dissemination

Simulation studies, as those described in this report, allow theoretical concepts and strategies to come to life in a virtual and safe environment. In contrast to trial-and-error approaches, which may cause undesired disruptions, or analytical solutions, which use static formulas to model a system, the dynamic nature of the presented simulation models facilitates understanding and learning of new and innovative ideas, regardless of business or industry. The purpose of simulation within the SELIS project is to facilitate the investigation of new models, strategies and objectives for the various SELIS Living Labs. By definition, a SELIS EGLS is a set of actions that are meant to be pursued to achieve goals established by a company or organization. Therefore, the main scope of the strategies is to act as a guidance to follow in order to achieve the main targets defined in SELIS Living Labs. Simulation can help to verify and investigate the impacts of these EGLSs in an either abstract or simplified environment or in a more practical setup if applied directly within a Living Lab. In the Living Lab context, simulation can be useful to validate and configure new SELIS solutions before they will be deployed in a real operational environment.

The following sections comprise community adaptation guidelines for EGLSs that have been verified and assessed through various simulation experiments in the context of the SELIS LLs. These guidelines are based on exemplary case studies; each dealing with different EGLSs the same time, since certain individual strategies are merely enabling others, as Supply Chain Visibility & CAPA (EGLS 3) is an enabling strategic capability for e.g. Collaborative Planning and Synchronomodality (EGLS 1) and Supply Chain Optimisation (EGLS 6). The case study descriptions provide universal objectives and outcomes so that users form the same community or a similar domain can easily grasp the possible benefits of simulation and understand the general procedure to adopt the model within their region or business domain.

Prior to the introduction of simulation case studies, particular emphasis should be placed on the role of the data for simulation purposes. Each simulation model contains various elements or components that represent objects or activities in the application domain, such as a vehicle, a plant or a production process. In order to represent and especially to combine these elements correctly within a simulation model, it is often helpful to represent existing operational objects along with their real-world state as detailed as necessary and possible. If a simulation model consists of digital counterparts from a real-world system or business, data collection and data preparation will be more natural, straightforward and efficient. Moreover, the information, e.g. the speed of a vehicle, a temperature, or terminal locations, may be often easily collected from domain experts or exiting IT-systems, e.g. warehouse management, ERP, GIS systems or even sensors like IoT (Internet of Things) components. With individual data from an actual business environment, the simulation model becomes a useful tool for forecasting and experimenting with new or improved strategies. It is also recommended to collect data not just once before the model will be implemented. The data collection process should be prepared for timely and recurrent execution in order to enable updates easily and frequently if the real-world systems evolve or additional scenarios are emerging.
4.3.1 Case Study: Collaborative Synchronodal Planning and Reliability of Inland Waterway Transport (IWT)

Cargo owners and shippers often perceive intermodal transport planning as less reliable than trucking. Thus, it is less often used than technically possible. Port authorities, deep-sea terminals and barge operators struggle with unpredictable waiting and handling times for inland connections of barges. This situation is mainly caused by congestion and delays due to missing information and increasingly complex coordination of deep-sea vessels with large call-sizes and barges that visit multiple terminals in a port in sequence and with rather small call-sizes.

The SELIS project focuses on the development of an Inland Reliability Tool, build upon the SELIS Community Node, and the respective communication infrastructure. The solution was aimed at supporting optimal decision making for intermodal (or possibly synchronodal) hinterland transport services and improved perception and usage of hinterland connections with reliable performance indicators.

Improving the inland operator decision-making processes and planning of hinterland transport requires enhanced visibility and access to relevant data and the measurement of the performance of the different alternatives and how these fit customers’ requirements.

In a pre-development analysis, the actual status and performance of selected inland transport services has been carried out. Using statistical data analytics, the stakeholders came up with a set of measured performance indicators based on data from terminals, barge operators and clients. The underlying dataset included operational data from terminals, barge schedules and booking data. The evaluated KPIs focus on lead times and the duration of transport and transhipment processes. Based on the collected data, a detailed simulation model could be built that allows users to set-up a digital counterpart of the current situation. The model was designed to simulate main participants of the inland transport scenario:

- **Clients** with their individual transport demands including information about the timing, the transport volumes and origin and destination terminals.
- **Barge operators** are represented by their barges with individual load capacities and schedules
- **Terminals** with handling characteristics
- **Planning process** that is responsible for allocating containers from booking to barge schedules based on available schedules and capacities.

Some additional information has been used during model building and calibration:

- Locations of terminals and warehouses
- Inland waterway network (navigable rivers and canals)
- Truck routes between warehouses and terminals (distances, speed)
- Time series of booking data (volumes)
- Expert knowledge of inland and barge transport service sector

The objective of the simulation study was to validate the impact of different inland schedule schemes on various performance metrics to facilitate the understanding, verification and validation of the scheduling decisions and compare new solutions with the existing real-world situation.

The tested new schedules comprise a special scheme that is inspired by inland transport corridors and a second approach rearranges schedules in order to reduce deep-sea terminal calls per journey but increases roundtrip frequencies to handle the same or possibly more bookings than today with the same amount of resources.
All simulation data was based on the Port of Rotterdam and a selected number of inland terminals. However, the simulation model itself – without data – is completely generic. Only the scenario specific data made the model unique and practically useful for the stakeholders.

This case study represents an example of how different EGLS can be combined to achieve a common objective. Supply Chain Visibility & CAPA (EGLS3), as a very generic enabling strategic capability, embraces a variety of measures, methods and ideas to take appropriate responsive or pro-active actions in transport systems. This case study has shown how visibility on detailed inland performance metrics, like lead times and reliability, can be improved in order to inspire and motivate better transport solutions as preventive measures to counteract negative developments and inefficiencies in conjunction with waiting times and congestion. Collaborative Planning and Synchromodal Transport (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 analysed solutions in this study allow for a combined view on collaborative networks of IWT service providers and transport performance indicators for (not only) synchromodal transport decision making.

Outcome

The simulation model has been implemented in a general-purpose programming language with use of a dedicated framework that includes many features that are needed to build and run a simulation model. An agent-based discrete-event simulation method was chosen to allow greater modelling and programming flexibility and emphasizing the roles and interactions between actors. This simulation environment was used to

- Visualize transport flows on a geographic map
- Analyse the lead times and deep-sea terminal calls of barges (KPIs) for particular hinterland routes and corridors
- Validate feasibility of alternative barge schedules
- Analyse and forecast delays caused by different waiting times due to congestion

Ultimately, the simulation modelling and the experiments have shown that improvements in lead times and reliability, from adopting alternative schedules, are significant. Essentially the decision for more aligned schedules comes down to a trade-off between service reliability and flexibility of customers.
However, the positive environmental impact should play an additional role. As the simulations have also shown, the reduction of sailing time inside the port area could free some capacity and have a positive impact in terms of additional roundtrips and reduced congestion in the port. Moreover, the increased frequencies of services can be used to shift more transport units from road to inland waterway.

As a consequence, it is important to take in mind that for the simulation only a number of the actual participants (barge operators, terminals and clients) have been used with e.g. data assumptions on the demand side of the clients. The positive outcomes like the increased roundtrip frequency could therefore be interesting for all participants. In principle, this will mean a higher loading factor (number of TEU) and this could have a positive impact on barge transport, on the modal split of the terminals, and, furthermore reduce emissions per transported TEU.

As the simulation model has been implemented and applied to a preselected number of participants, the positive outcome is likely to be scalable and applicable to other regions and hinterland routes. The simulation environment can assist and support decision makers in further investigations.

Future users of this simulation model just need to provide the collected and prepared input data so that it can be used within the model for their individual simulation studies.

4.3.2 Case Study: Supply Chain Visibility & ETA Prediction for rail freight service collaboration

Several variables associated with the journey of a train can affect the time of arrival. In the case of possible delays of rail transport services, because of deviations and irregularities, a prediction model can be applied in order to estimate the time of arrival at the next terminal and moreover at the final destination (terminal). Deviations from planned train schedules can either result in spare times when trains are in queue in a station or, in case of serious delays because of incidents like a malfunction or bad weather conditions, result in cancellations or additional delays of following services. The quality of predictions is limiting the optimisation options.

A simulation could be useful to find the most effective strategy to optimize the prediction of the Estimated Time of Arrival (ETA). In this case, a practicable output of a simulation study is the difference between the ETA and Actual Time of Arrival (ATA). Visibility and tracking information (e.g., trains or wagons can be equipped with position sensors to report their current position) have been utilised for the ETA calculation method, so that the general availability or frequencies of position updates will likely affect the ETA accuracy. In order to investigate ETA prediction quality, the simulation model includes schedules of trains, wagons and probability and length of delays in order to simulate ATA and ETA predictions that are calculated during the various simulation runs.

The pre-development simulation study focused on the better prediction of the ETA that is applied in case of deviations. In this scenario, the output of the simulation was aimed at improving supply chain visibility by the positioning of the train in a map along with an early-stage ETA presentation. In this simulation scenario, the model took into consideration the transport network, parameters and constraints along with deviations in order to simulate inputs to the ETA calculation and visibility cycle.

Moreover, in the case of delays of wagon-sets used for rail hinterland transport services, the prediction model has been applied in a further step to estimate delays. By improving the tracking capabilities, the forecasting of delays and timely availability of wagon-sets were improved.

The simulation gave emphasis on the re-planning strategy that has been applied in case of deviations. Re-planning has been done either in a more cautious way, thus minimizing the risk of taking wrong decisions or with a more reckless or optimistic strategy. In this scenario, the output of the simulation focused on asset utilisation KPIs as the main objective of the re-planning activity within the overall scenario. The planning decisions for changing the schedule of a wagon-set or using an additional wagon-set in order to adhere to the original schedule were based on carefully developed rules. As an example, the absolute estimated delay time and the confidence interval of the estimated ETA could be used to guide decisions and hence a numeric threshold (ETA quality) can be defined to trigger those decisions, e.g. to schedule a wagon-set for an additional round-trip.
Outcome

In this simulation scenario, the model also included the thresholds for acceptable ETA quality and scheduling alternatives in order to simulate the planning – execution – re-planning cycle. The scenario was deemed useful to get better insight into the influence of ETA quality as a leading indicator on asset utilisation as the lagging indicator. The results would help to calibrate prescriptive analytics for re-planning.

While the simulation of the re-planning strategy evolved over the time, the simulation model was able to predict more accurate and improved ETA results. This quantified the impact on the visibility of the moving trains along with the better planning of those that were delayed, along with their better scheduling by utilising of the available wagon-sets. This ETA prediction evolution along with the effect on the evaluation of the rescheduling suggestions are presented in the below two KPI diagrams (Figure 4 and Figure 5).

![Accurate ETA Predictions - Yearly Comparison](image)

**Figure 4 - ETA Predictions**

![Rescheduling Suggestions Evaluation](image)

**Figure 5 - Rescheduling Suggestions**

4.3.3 Case Study: Collaborative Inventory Management

The collaborative inventory management constitutes a strategy that entails visibility and collaboration among different players. The default concept connects both a supplier with many retailers and each retailer
with its many suppliers. For the scope of this case study, this can be seen as a follow up on the current way of working, where the one-to-many and the many-to-one collaborative set-ups are combined and applied to a global ecosystem.

Collaboration and information sharing seem to be ingrained in many dimensions of the SELIS project, so these concepts are also integrated with the inventory management optimization as described more detailed in SELIS EGLS6. The SELIS project focuses on the development of an Inventory Management Toolbox, which is a union of three subsystems of planning, forecasting and replenishment. This toolbox allows the supplier and retailer to have a fundamental collaboration in different states of inventory management from planning to delivery execution. The tool takes advantage of collaborative planning and visibility in order to increase performance of ordering procedure in both sides. The optimization toolbox has been designed based on the CPFR (collaborative planning, forecasting and replenishment) model.

Supply Chain Visibility & CAPA (EGLS3), as a generic enabling strategic capability, embraces a variety of measures, methods and ideas to take appropriate responsive or pro-active actions in transport and logistics. Supply chain visibility aims at sharing information to increase collaboration among the key actors improving the decision process and optimizing the joint planning of logistics operations in the food retail market. Collaborative Inventory Management (EGLS6) by suppliers and retailers is an integral part of this case study. As described in detail in SELIS D2.1, collaborative inventory management has many dimensions raising a variety of research questions that are practically relevant for the implementation of the intended SELIS solutions.

The most interesting goals are to investigate and understand the impact of the sales and order forecast accuracy as well as the value of visibility and information sharing on the supply chain performance from the perspective of a single retailer.

Traditionally, a particularly interesting question for a retailer is how many items it should have in inventory for the next order periods. A simulation study has been seen as very useful to assess the performance incurred with particular order or replenishment policies and hence helps to decide what policy should be implemented.

Sales forecasting by suppliers and retailers is an important strategy to improve production and inventory planning in order to reduce stock levels, waste and stock-outs and to increase the retailer’s service level that is typically measured by various KPIs of which OTIF (On Time In Full deliveries) and lost sales, measured by out-of-stock frequency, are important in this simulation study. The main purpose of the simulation is to investigate the impact of accuracy and visibility of the sales and order forecasts on the supply chain performance.

In a pre-development analysis for the simulation study, the actual status and performance of selected retailers and suppliers in the food retail market has been carried out. Using historical and actual operational data of a small set of products (SKU = stock keeping units), a statistical analysis provided initial performance metrics that could be further used for comparisons with outcomes of simulation runs for different strategies and system parametrisations. The model was designed to simulate main participants of the inventory management scenario:

- **Suppliers** with individual subsets of SKUs, retailer relationships and production plans and order lead times
- **Retailers** with individual subsets of SKUs, supplier relationships, sales forecasts and supplier ratings

Additional decision variables and system parameter variations are used for detailed investigation:

- Order split policy (e.g. equal, first come first served, weighting factors)
- Inventory policy (Min-Max with safety stock or periodically)
- Sales forecast accuracy (mean error and bias)
- Collaboration strategy (no-sharing vs. forecast data sharing)

The Objective of the simulation study was to investigate and understand the possible impact of these strategies and model parameters on the various performance metrics like

- Stock-outs per ordered SKU: frequency and quantity delivered vs. original order
• OTIF (On-Time In Full): measured as % orders that are delivered in full or on-time
• Min, max and average supplier stock level
• Min, max and average retailer stock level
• Safety sock estimation

Ideally, the average stock level and safety stock should be as low as possible as both have an impact on inventory holding costs and lost sales. They can also be seen as main leading indications for possible stock-outs and lost sales, but also for wastage since fresh products (food and vegetables) usually have a short shelf life. Dynamic simulation modelling offers an effective instrument to forecast inventories and evaluate multi-level interdependencies in a many-to-many retailer–supplier network. Collaborative Inventory Management means that retailers and suppliers collaborate in terms of inventory management, which allows dealing with greater flexibility in demand, forecast sales and order replenishment as well as to optimize promotion events.

Outcome

The simulation model has been implemented in a general-purpose programming language with use of a dedicated framework that includes many features that are needed to build and run a simulation model. This simulation environment was designed and implemented to

• Visualize demand variations in terms of sales and sales forecasts
• Visualize and analyse the stock levels with time-charts to capture dynamics
• Evaluate the impacts of sales forecast accuracy
• Evaluate and estimate safety stock boundaries to reduce wastage and stock-outs
• Evaluate different order-split policies also considering environmental factors like fleet type and distances to suppliers with respect to stock-level variations and agreed lead times
• Experiment and validate feasibility of alternative strategies and parameters to model the production capabilities of suppliers

Ultimately, the simulation modelling and the experiments have shown how improvements of the forecast accuracy affect the stock levels and stock-outs that indicate possible lost sales. These results were also applied to different inventory management strategies to gain more insight into the use and effectiveness of the collaborative inventory management strategy and its sensitivity to order-split policies in a many-to-many retailer and supplier environment.

4.3.4 Teaching Cases

In the SELIS project, a number of logistics communities have started to implement digital platforms, based on SELIS Community Nodes, of which functionalities help to boost logistics performance, notably costs, reliability, utilization of resources, and carbon footprint. Obviously, it does not suffice to introduce such a platform to create higher levels of visibility by data sharing and offer opportunities to plan and execute in a collaborative way. The logistics communities may need to review their mode of operations fundamentally, and consider the impact of digital platform adoption for various stakeholder roles in their community. Such adaptation guidelines require dissemination of the underlying principles, as proposed by the EGLSs⁴, through practical case studies. The EGLS propose strategies or strategic capabilities that help logistics communities to take advantage of digital platform functionalities; for details, see D2.1 and D2.2 (SELIS, 2017a) of this project.

In this section, we will focus on a number of case studies to exemplify the above. In the final phase of the SELIS project, these case studies will be further developed and disseminated in the form of teaching cases and serious games. It is the specific purpose of these instruments to not only demonstrate and disseminate the potential of deploying digital platform functionalities as specified, but also to explain and explore the position of stakeholders towards platform adoption in face of the associated transformation of the business community.

⁴ The EGLSs have been summarized in a public deliverable (see forthcoming SELIS EGLS Compendium at http://www.selisproject.eu/Publications).
Teaching Case: Visibility & Reliability in the Port of Rotterdam

In the summer of 2017, large delays in barge handling at the deep-sea terminals were reported; this problem even received personal attention by the Minister of Infrastructure and Water Management. Affected parties considered moving their containers flows to truck instead (“reverse modal shift”), whilst the focus had been on creating a modal shift towards more sustainable modes of transport. The level of information visibility in these processes was very low and therefore operators were not able to differentiate between terminals based on data. Together with hinterland actors, the deep-sea terminal was looking for ways on how to enhance data visibility and to promote the modal shift.

The study was part of the European SELIS Project. The SELIS project aimed at developing a shared European intelligent information space that would serve as a platform for collaboration on different aspects of economic activity among different actors, private and/or public, within and between supply chains. The Learning Objectives of the teaching case include:

- Describe and analyze the disruption caused by digital technologies in the shipping industry;
- Discuss reliability and how this definition can be different for different parties within the supply chain;
- Identify problems different stakeholder in a supply chain might have towards sharing information and discuss solutions to overcome these barriers;
- Explain concepts such as intermodality, synchromodality and a-modal booking.
- Explain the purpose of a modal shift and think of measures to stimulate a modal shift;
- Illustrate how the availability and use of data and analytics can add value for different stakeholders within a supply chain;
- Develop a (mockup) dashboard, which provides indicators that will enhance visibility and transparency in the hinterland transport between deep sea and shipper’s origin location.

In this manner, the teaching case addresses the aforementioned aspects well. The teaching case is suitable for undergraduate or graduate courses in supply chain management, operations management or business information management. The case can also be used in workshops or stand-alone modules focused on intermodal transport, synchromodality, business intelligence systems and port logistics. This teaching case predominantly disseminates elements of “Collaborative Planning and Synchromodality” (EGLS1).

This teaching case has already been developed and as already been tested in a classroom environment with MSc students from a business school/school of economics.

Other potential teaching cases, which may include serious games, based on the EGLSs and LL Use Cases include:

- **Digital platform for booking capacity on barges: Booking.com for the port?** Based on the observation that barges are not fully utilized, that barge schedules are not synchronized toward better utilization, and that empty slots on barges are not matched with demand effectively, there are quite a few opportunities that could justify the introduction of a booking platform functionalities for barges in the port. In fact, such booking platforms have already started to emerge, and this has been studied in one of the use cases in the SELIS project. A teaching case could reflect on these benefits, but also on the roles of stakeholders who may either applaud or discourage the introduction of such a platform. It would also be a good demonstrator of how the introduction of technologies will not only help enhance the performance of a logistics community, but also enable a transformation of it. Here elements of “Collaborative Planning and Synchromodality” (EGLS1) could be disseminated;

- **Digital platform for adaptive control of rail freight: Toward more reliable services.** The journey of a freight train that crosses borders and thereby the jurisdiction of railway undertakings, not only faces disruptions of all sorts, but also a governance model which may be quite complex. A digital platform may support collaborative arrangements to support the data acquisition and logic to arrive at prognostics functionalities that help to estimate the arrival times of trains at intermediate and final terminals, and the re-planning of the train voyage as soon as disruptions occur. The teaching case could reflect on the
roles of various stakeholders to enable such enhanced prognostics and planning. The teaching case could elaborate on the impact of quality of information (ETA) on planning and execution performance (reliability). It may also reflect on the kind of interventions required (rescheduling or even cancelling rail services) on the tightly governed rail network, and the relationship between the governance on the rail network and the digital platform. Here elements of “Supply Chain Visibility & CAPA” (EGLS3) could be disseminated;

- **Collaborative inventory management: Toward a multi-sided digital platform.** A digital platform can support collaborative planning, forecasting, and replenishment between multiple suppliers and retailers. The digital platform connects multiple types of organizations that are either competitors (horizontal collaboration) or suppliers and buyers (vertical relationships). Data sharing will enable platform functionalities such as visibility and collaborative planning and forecasting, but at the same time is very sensitive by the nature of the interorganizational relationships. The teaching case could reflect on the benefits of collaborative planning, forecasting and replenishment. It could contrast the many-to-many situation with the one-to-many situations (one suppliers, many retailers and many suppliers, one retailer). In particular, the rationing of inventory, strategic behaviour with regard to reporting sales forecasts are interesting behavioural patterns for which a digital platform may develop moderating governance measures that go beyond the beneficial functionalities offered. The teaching case could disseminate elements of the “Collaborative Inventory Management” (EGLS6);

- **Digital Platforms for environmental performance.** Most probably not the main feature of a digital platform, but as a bonus feature, the estimation of carbon footprint based on operational data could be used for carbon monitoring and reporting. Transportation and logistics are notoriously complex and carbon footprinting tends to be more difficult. The Smart Freight Centers’ GLEC framework provides a proper tool to do so. The SELIS project has provided a collection of insightful use cases to study the implementation of the GLEC framework. The teaching case at hand could reflect on the implementation of the GLEC framework in specific logistics communities and reflect on some of the methodological issues that are encountered. The teaching case could disseminate elements of the “Environmental Monitoring and Reporting” (EGLS5).
5 Conclusions and next Steps

This deliverable reported on the work in Task 2.3 of the SELIS project, which aimed at the investigation of new strategies and objectives for the various SELIS Living Labs and logistics communities. Different simulation environments have been developed and described to support visualisation of new strategies, running test scenarios and estimate impacts of the adoption of new strategies, model and tools. The simulation models and specifications are implemented in a way to facilitate experiments and analysis of desired output. Therefore, a set of tools, data sources and workflows must be assembled for each simulation study. The term Simulation Environment was coined to describe this toolset, which is also meant to be available for accompanying support of Living Labs and for SELIS solution designers. Simulation experiments can be repeated at any time with adjusted parameters and input data according to the current requirements of the individual use case from the Living Lab.

The validation of all simulation models was an important step to increase the credibility and overall acceptance of the observed and analysed process flows. Domain experts from various Living Labs have also discussed and agreed to several necessary abstractions and assumptions made, concerning the input data selection, organizational workflow and operating philosophy. During this first validation phase, a common understanding of the necessary and sufficient level of abstraction for effective and helpful simulation studies has been established.

The first simulation environment (Living Lab 2) has been designed and implemented to investigate synchromodal coordination and different aspects of transport reliability with regard to possible impacts and interrelations with visibility and relevant key performance indicators. The main strategies involved in this study are Collaborative Planning and Synchromodal Transport (EGLS1) and Supply Chain Visibility & CAPA (EGLS3). Since environmental emissions will be investigated as well, Carbon Accounting (EGLS5) will be consulted in the future for the utilization of the CO2 emissions accounting methodology. The evaluations of different barge schedule schemes allowed Living Lab participants to get detailed insights and understand performance differences. Further evaluation on improvements of the model may be possible with assistance from relevant EGLS groups.

The second simulation environment (Living Lab 5) was mainly focussing on ETA prediction methodology, which is an important functional task in EGLS3. Essentially, the final experiments have shown good results that have been used to improve the algorithms that drive the SCN based services and the predictive model used by Living Lab 5. The insights from the simulation environment results have been integrated and implemented within the end-user application. The results presented in this deliverable allow the end-users to get overall visibility on their cargo. The solution also provides to the operator a situational awareness on the entire supply chain, predicted delays and the option to re-schedule and change train planning at the appropriate terminal. The user interface also provides some interesting insights, mainly useful for the rail transport management, and focus primarily on the accuracy of ETA prediction, and the successful re-scheduling and how these can increase the utilisation of wagon-sets.

The process definition, initial input data collection and implementation of a third simulation environment (Living Lab 8) was successfully completed during the second period of the project. This simulation study builds directly on the intermediate results of the SCN based SELIS application and further develops and validates the strategy of Collaborative Inventory Management (EGLS6) in the many-to-many retailer and supplier community. The simulation environment has been used to better understand and quantify the impact of sales forecast errors and information sharing in a collaborative set-up.

However, due to the complexity of the investigated domains and the variety of facets of the SELIS EGLSs, the simulation environments can be further developed and adapted. Furthermore, variations of scenarios with different sets of input data and parameters are easier to implement than before, since at least the basic skills and learnings have been achieved. The post-development phase of the project can be used to collect additional data that can be used to fine-tune the strategies or compare them with alternative ones.

Simulation modelling and experimenting has been applied to a range of applications and EGLS strategies. Traditional tools, like spreadsheets would have failed to manage a similar amount of data and level of detail for process models. Working with simulation environments, like in SELIS, will probably become more
common to business stakeholders, as finding answers to “what-if” questions in a risk-free environment have clear benefits. However, designing and implementing appropriate simulation models typically requires at least some efforts. In addition to training and learning, which of course also comes with some positive aspects in general, data collection and preparation is sometimes a burden to companies with diverse and distributed or less integrated IT infrastructure. Therefore, a clear methodology and simulation approach has been presented that can also be applied to complement the development and introduction of new logistics software solutions as done in SELIS.
6 References


SELIS (2017a). SELIS D2.2 Community Perspectives.


Annex I: Conceptual Simulation models (Phase 1)

[This section is deemed confidential.]