“Enhanced data management techniques for real time logistics planning and scheduling”

Deliverable D7.1 – Definition of Use Cases and Validation Plan

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Executive Summary

This report describes the following living labs or test projects in WP7 of the LOGISTAR project.

- In LL1, Nestlé and pladis will work together to realize transport and logistics synergies in their retail distribution network in the UK.
- In LL2, Zailog and Codognotto will work together with a number of shippers and rail terminals in Italy to bundle freight flows and realize smart solutions for synchromodal shift.
- LL3: DISCLAIMER *Due to internal decisions in Ahlers, the scope of Living Lab 3 is under re-definition. This section will be updated in an upcoming version of the report when the information becomes available.*

The consortium partners are confident that all living labs will offer adequate potential to test and report the impact of the LOGISTAR system in a real-time logistics environment, showing measurable impact on KPIs for efficiency (transport cost), effectiveness (service level) and sustainability (CO2, empty running, modal shift).

The 3 LLs will follow a similar methodology:

In a first phase, historical data will be collected to map and visualize the logistics networks and their freight flows. The as-is situation will be investigated in a strategic assessment. Data analytics will be used to calculate baseline efficiency, service level and sustainability KPIs.

After validation of the as-is baselines, a number of theoretical to-be scenarios will be developed to improve the asset utilization, empty running and intermodality of the network. The assumption to be tested is that through data-driven and real-time planning using the LOGISTAR system, it should be possible to improve trip combinations, reduce empty kilometres and carbon emissions, improve waiting times and productivity, enhance modal shift, etc.

The LOGISTAR system will then be configured to support this optimization in a controlled test environment, based on each test company's logistics targets and user requirements. To make testing possible, the pilot companies will temporarily open up their internal ICT systems to provide some real-time data streams to LOGISTAR for online analytics and decision support.

The planning teams of the living lab companies will then execute the suggestions of the LOGISTAR system in their daily operations and evaluate the KPI improvement results and user acceptance.

In support of this, each living lab will investigate the added value of IoT devices and related technology to increase the visibility of the network activities and freight flows that are in scope.

Great care will be taken in all living labs with regard to cybersecurity and personal data privacy.

1. Introduction

LOGISTAR ("Enhanced data management techniques for real time logistics planning and scheduling") is an EU research project funded by the European Commission under the Horizon 2020 programme, which was launched in June 2018. It will last for three years, until June 2021.

LOGISTAR is aimed at allowing effective planning and optimizing of transport operations in the supply chain by taking advantage of horizontal collaboration relying on the increasingly real-time data gathered from the interconnected environment.

For this, a real-time decision-making tool and a real-time visualization tool of freight transport will be developed, with the purpose of delivering information and services to the various agents involved in the logistic supply chain, i.e. freight transport operators, their clients, industries and other stakeholders such as warehouse or infrastructure managers (Figure 1).

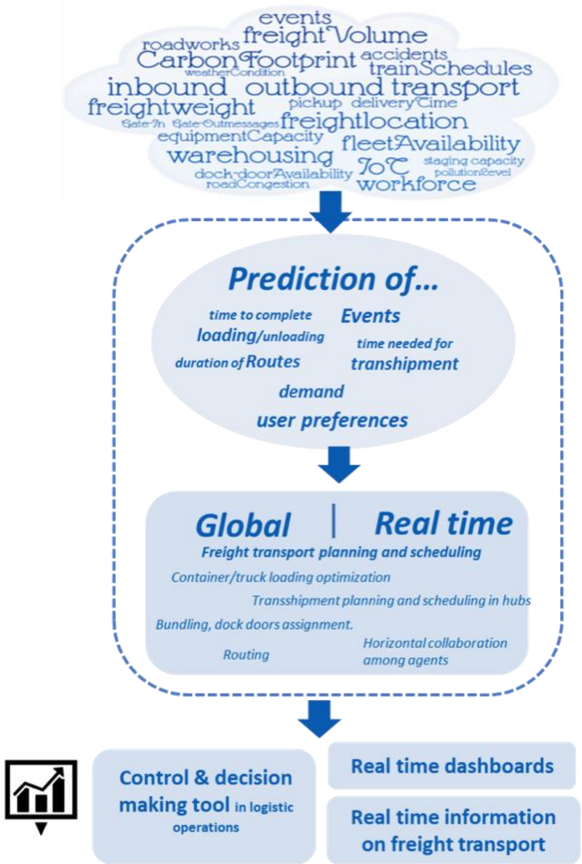

Figure 1 Structure of LOGISTAR

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LOGISTAR's objectives are:

- To increase by a minimum of 10% the load factors of freight vehicles derived from the optimization techniques applied to freight deliveries planning.
- To shorten by a minimum of 10% the delivery routes by applying planning of optimal routes relying on synchromodality, being continuously updated in case of disruption.
- To increase the reliability and efficiency of logistics services by predicting events and incidents affecting the supply chain and by providing alternative routes in real-time to these disruptions.
- To facilitate the management of logistic operations by providing real-time supply chain visibility through dashboards not only displaying information but also showing deviations, alerts or recommendations to take actions.
- To boost horizontal collaboration among logistics agents focusing on full truck load (FTL) backhaul opportunities, consolidation of less than truckload (LTL) deliveries, supply chain collaboration and synchromodal opportunities.
- To demonstrate that it is possible to increase the visibility of deliveries by using IoT sensors to monitor the goods shipped and by sharing the resulting data and information among logistics agents.
- To promote the sharing of open data in the logistics sector by promoting the benefits of collaboration and Big Data analytics across stakeholders.
- To enable new market opportunities on the logistic information services sector, by developing new business models focused on data and high value service delivery and exploring concepts such as "sharing" rather than "owning" transport assets. The policy and legal dimension will also be studied.

The project will be tested in 3 living labs or uses cases with different stakeholders of the logistic value chain, such as Logistic Service Providers, infrastructure managers and FMCG manufacturers. These 3 living labs are the following:

- LL1: FTL and LTL transport sharing in the UK (pladis/Nestlé)
- LL2: Synchromodal optimization in Italy (Codognotto/Zailog)
- LL3: DISCLAIMER *Due to internal decisions in Ahlers, the scope of Living Lab 3 is under re-definition. This section will be updated in an upcoming version of the report when the information becomes available.*

2. Living Lab 1: Backhauling and co-loading (Nestlé-pladis)

2.1. Introduction

A retail distribution network is typically a complex and very dynamic logistic environment. With many stakeholders involved and with very short lead times in place, the retail industry is facing challenges to ensure that its transportation flows are as efficient as possible. Future trends are likely to create extra complications. Consumer expectations are evolving together with the increasing e-commerce popularity, resulting in a huge focus on product on-shelf availability as well as in fragmented product flows. (Deloitte, 2019).

In addition to these challenges, although FMCG logistics managers try to be as efficient as possible within the constraints of their own operation, they often have to manage, plan, and operate their network with a lack of visibility and transparency and may operate with manual planning processes or fragmented ICT systems, which inevitably leads to inefficiencies in their supply chain networks. The results of this are typically lots of expensive transport kilometers, small drop sizes and underutilization of vehicle capacity.

Furthermore, optimization efforts to counter these inefficiencies are typically initiated from an individual company's perspective, where each of the different market players focusses efforts on their own supply chain. This approach has an impact on the overall efficiency of logistics operations in the industry. For some companies, individual improvement efforts by shippers may lead to suboptimalities in drop sizes, on shelf availability, inventory rotations and in conflicting delivery schedules. (Palmer, Saenz, Van Woensel, & Ballot, 2014).

Optimizing truck movements through collaboration routinely achieves cost savings and efficiency gains of between 6% and 10% (Palmer & McKinnon, 2011). As suppliers of big retail chains, consumer goods shippers often deliver their goods to a limited number of retail distribution customers, who are the same across all competitors. This means that there can be an overlap in the flows to and from these shared customers. Industry players could therefore combine loads to shared destinations, or fill empty return trips, in order to create logistics synergies exceeding individual improvements.

Several collaboration efforts have been successfully executed. In the UK, the most prominent example is the agreement between Nestlé, the world's largest food manufacturer and pladis, the largest biscuit and snack food manufacturer in the UK. Having started in 2009, they are continuing to share truck capacity through backhauling, which has resulted in the elimination of 280,000km of empty trailer journeys per year, saving 95,000 litres of fuel, reducing CO2 emissions by 250 tonnes, and reducing costs by £300,000 a year. (Mirzabeiki, Humphries, & Wilding, 2017).

Both companies are now looking to expand these collaboration efforts in the future by increasing the number transport lanes in scope. However, there is a lack of a global view of both operations, which will lead to missed opportunities of collaboration. This living lab will focus on showing how the information delivered by the decision-making tool developed in LOGISTAR can reduce empty running by filling empty return legs, and where possible co-loading to maximize vehicle fill and reduce total kilometres driven. In addition, the added value of IoT devices on their trucks for real-time tracking and tracing will be tested.

2.2. Stakeholders in LL1

Creating horizontal collaboration in a retail network is a complex undertaking with many different involved parties. The main stakeholders in this test case are Nestlé and pladis, with support from their hauliers and the technical LOGISTAR consortium partners:

2.2.1. Nestlé

Nestlé is a leading nutrition, health and wellness company. Nestlé is known for the numerous food brands in its portfolio, covering almost every food and beverage category. Some examples are: Nescafé, Perrier, Maggi, Nestea, etc. Nestlé has a worldwide turnover of 91,4 billion CHF. Nestlé UK is active in retail with over 2.000 brands. They have facilities in Bardon, Deeside, Melksham, Hams Hall, Narberth, Buxton and York. (Nestlé, 2018).

2.2.2. Pladis

Pladis is one of the fastest growing global snacking companies, based in Turkey, but with extensive operations in the UK, as a result of taking over United Biscuits in 2016.The expertise of their 17,000 global workforce spans 34 factories in 13 countries. Within two years pladis has become one of the fastest growing companies in the sector, with annual revenues in 2017 of £3.5 billion. They use their global footprint to grow their brands and products in new and innovative ways and they reach more than 4 billion people around the world. (pladis, 2018).

2.3. Deployment of the LOGISTAR System in LL1

Based on previous investigation and site visits to Nestlé and pladis in the strategic analysis phase, and as described in the description of services document, the following LOGISTAR functionalities will be tested in LL1. The services are ranked in order of priority, as agreed between Nestlé and pladis:

1) **Horizontal collaboration**, i.e. maximize the vehicle capacity sharing between Nestlé and pladis through creation of mainly backhauling and if possible, also co-loading combinations with following goals:
    a. Reduction of (empty) miles: to all ship-to customers, but also for complicated destinations areas such as Scotland.
    b. Increase vehicle fill rate: maximize average number of pallets of payload per trailer or reduce cost per km or transport cost per delivery.

   This will be done through recombination of orders in real-time, using negotiation techniques. The first priority of LL1 will be the creation of FTL backhauls or roundtrips. Co-loading will be tested only after further investigation of legal liability aspects.
2) **Risk assessment**: analyze and predict causes of delivery rejection, based on insight into historical rejection codes and real-time IoT information.
3) **Forecasting and optimization of fleet capacity and driver workload**: calculation and planning of optimal number of trucks and drivers that will be need on daily basis to carry out the necessary deliveries, in order to reduce unproductive working hours and waiting times.
4) **Prediction of risk**: the tool could predict a percentage chance of rejection for a delivery, or indicate the customers, delivery periods or destination regions with the highest rejection risks

5) **Increase visibility of truck geolocations** after departure from their DC's or en route between customers, with real-time prediction of their ETA (assuming this can be integrated into Nestlé's transport system).
6) **Prediction of weather conditions and their impact on delivery service levels**: e.g. for maritime traffic to Ireland (if enough data can be collected for this).
7) **Prediction of delays and delay propagation**: proactive prediction instead of reacting to lateness of orders after the facts. This can be done by using the live tracking and geolocation information from the fleets of Nestlé and pladis (GPS trackers), which is currently not being used in an automated manner.
8) **Use of IoT data to track and visualize in real-time the condition of the goods**, in particular with regard to the prediction of temperature excursions (for chocolate products).
9) **Prediction of timings in the supply chain**: better predictions in terms or truck arrivals and delays, both for pick-up at production facilities (to keep production lines running) and delivery (to respect delivery time windows). These predictions will be based on IoT data in the first place, and by historical data in the second place.
10) **Prediction of orders**: which product will be delivered to which customers in which quantities and when. Rolling forecast for the next days and weeks, based on order data from the past 2-3 years which has been made available in the strategic analysis phase. N.B. this topic is not mandatory according to the DoA.

To prepare the living lab, Nestlé and pladis have supplied historical transport data for all their domestic flows in UK.

For Nestlé these flows cover all customer deliveries and interfacility flows from Bardon, Deeside, Melksham, Buxton, Hams Hall, Narberth and York as well as factory-warehouse movements.

Pladis have provided flow data between 7 manufacturing sites throughout UK who all supply the single DC in Ashby de la Zouch, with UK as well as international customers serviced from this facility. International deliveries will be out of scope for this use case. Pladis also operate as a logistics service provider for a number of companies. As well as Pladis customer deliveries from Ashby de la Zouch, the flow data also includes co-loading activities with Interserve's KP distribution centre at Ashby, plus collections and deliveries from various locations for other companies.

The pladis network has an own fleet of 60 tractor units, 140 drivers, 300 trailers (100 of which are longer semi-trailers), 6 shunt units and 7 choc tank trailers. These are complemented with day hire hauliers engaged on round trip journeys, as well as 3rd part hauliers. Also the Nestlé network makes use of own trucks, as well as outsourced carrier capacity.

For both companies, the majority of orders are full truck load (FTL) in a single (i.e. point to point) delivery or drop. An FTL can be considered as any load greater than 20 pallet footprints. The remaining deliveries are multi drop FTLs or LTL flows.

FTL flows will be assessed for backhauling opportunities, the other flows which are less than full truck load (LTL) will be assessed for co-loading, as well as subsequent backhauling.

For the logistics flows in scope, a detailed strategic validation is being conducted to evaluate the collaboration potential more in-depth. Within this strategic analysis, the lanes will be identified where synergy opportunities are most likely to occur and which can therefore result in significant cost savings and in empty kilometer reductions in UK. This analysis is currently being conducted based on historical data.

However, LOGISTAR will consider the entire supply chains of Nestle and pladis to identify collaboration opportunities which may vary on a daily basis. These collaborations will be presented in LOGISTAR to each company according to maximum cost saving potential. These collaborations will be compared to those identified in the strategic analysis to ensure valid opportunities have been generated.

After deployment of the LOGISTAR system, the identification of these collaborative lanes and their possible bundling opportunities will be presented in real-time to the Nestlé and pladis planning teams, who will then determine the feasibility of their execution within their daily operations.

Once shipments are planned and executed, the LOGISTAR service will also provide Nestlé and Pladis with real-time information about these deliveries. In order to achieve this, the LOGISTAR system will collect data regarding all UK orders and deliveries, the state of the transport fleet, as well as traffic incidents and other relevant data gathered from IoT devices.

2.4. Expected outcome of LL1

The LOGISTAR services tested in the Living Labs need to have a demonstrable impact on service to the client, cost reduction and reduction of empty miles.

They need to show this impact for at least a number of representative transport routes, distribution centers/hubs, transport resources (trucks, drivers) and relevant KPIs (fill rate, cost, CO2 emission…).

The use of the LOGISTAR platform in LL1 aims to improve logistic operations of both Nestlé and pladis on five different aspects. First, there will be a focus on empty running. With the LOGISTAR system providing opportunities to share capacity, it should be possible for both companies to reduce vehicles running empty kilometres.

Second, there is a focus on vehicle fill. It is not just a goal to reduce empty running, the LOGISTAR system should also increase the fill rate of existing vehicles. While empty running will mainly be decreased by finding backloads, the fill rate will also be increased by co-loading products of both Nestlé and pladis on the same truck.

Third, there is the cost of delivery. Currently Nestlé and pladis deliver their goods at a certain baseline cost. For their own fleet, this cost typically covers standing costs like insurance and depreciation of trucks and running costs like, fuel, maintenance and drivers. Third party costs are usually agreed based on a lane or volume and will include a profit element for the 3rd party company. The two companies should agree a mechanism of cross charging for collaborative routes. When Nestlé and pladis start combining their deliveries and trucks the total costs for both networks will decrease.

Fourth, there will be a focus on the timeliness of delivery arrivals. As explained, the LOGISTAR system will construct optimized routes that take into account both customer delivery windows and expected time of arrival requirements. With the tracking and tracing functionality on top of that, both pilot case companies should be able to complete more deliveries on time.

Finally, one of the goals of the test case is to also measure the number of deliveries that failed to arrive. This measurement is closely related to previous timeliness of arrivals. It happens that, when

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a delivery was made outside the expected time window, the customer may reject that delivery because it is too late or too early. The LOGISTAR system should help in decreasing the occurrence of such failed deliveries.

For the purpose of evaluating this use case, a number of KPIs are proposed that will measure each of the success factors described above. For each of these topics a proper set of KPIs will be defined which will initially be calculated based on the historical data provided by both Nestlé and Pladis. This will form a solid baseline for the evaluation of the LOGISTAR system. The presented KPIs are listed in Table 1. Both Nestlé and pladis should evaluate these KPIs separately and compare them with the KPIs defined in the baseline.

Focus area	**KPI**	**Expected Improvement**
Empty running	Actual empty miles/kilometres (km/mi.)	Underachievement [<-7%] Acceptable [-7%, -10%] Overachievement [>-10%]
Asset utilization	Vehicle fill rate (#pallets on the truck/#truck)	Underachievement [<7%] Acceptable [7%, 10%] Overachievement [>10%]
Transportation cost	Total transportation cost/cost per delivery (£/delivery)	Underachievement [<-7%] Acceptable [-7%, -10%] Overachievement [>-10%]
Delivery timeliness	Number of deliveries on time and in full (OTIF) (#orders on time/#orders)	Underachievement [<7%] Acceptable [7%, 10%] Overachievement [>10%]
Failed to arrive	Number of deliveries that were rejected (#orders rejected/#orders)	Underachievement [<-2%] Acceptable [-2%, -5%] Overachievement [>-5%]

Table 1 KPIs to monitor the LOGISTAR performance in LL1

Below a bit more detail is given about the success measurement and interpretation of the KPIs.

- Empty running:
  - Empty miles/kilometres (expected reduction of 7 to 10%)
  - The distance vehicles from Nestlé and pladis move completely empty will be calculated. Total aggregated reduction for both Nestlé and pladis will be measured, with expected reduction of a minimum of 10% over the actual operational procedure, in any case, none of them is expected to increase this KPI.

- Asset utilization:
  - Vehicle fill rate (expected increase of 7 à 10%)
  - Fill rate will be calculated as the ratio of the actual capacity used to the total capacity available in terms of number of pallet footprints/weight. Fill rate for single vehicle with multiple drops will be weighted averaged over time.

  - Asset utilization is also measured as available driver time compared to actual plan, not just trailer fill.

- Transportation cost:
  - Total transportation cost/cost per delivery (expected reduction of 7 à of 10%)
  - The definition of standard costs will be used for the measurement of this KPI, in particular, cost per km will be used. These costs can be sensitive to particular conditions (different truck types, driver experience...)

- Delivery timeliness:
  - Number of deliveries on time and in full (OTIF) (expected increase of 7 à 10%)
  - This KPI will be calculated as the number of deliveries OTIF divided by the total number of deliveries. In order to consider a delivery on time, time windows defined by the client will be used. In this case, every single client can have a different time window.

- Failed to arrive:
  - Number of deliveries that were rejected (expected reduction of 2 à 5%). In this case, rejected deliveries will be counted considering the delivery is done outside the agreed time window.

2.5. Size of the testing

In order to properly measure the performance of the LOGISTAR system in LL1, the following guidelines will be taken into account:

- Measurement of the baseline KPIs: using historical information, the actual performance of the network will be calculated and expressed in a number of relevant KPIs. This is currently already ongoing in the strategic assessment phase. LOGISTAR should be able to do a continuous calculation of the evolution of this baseline. It is important that the baseline KPIs can be drilled down to the level of transport lanes, ship-to customers, warehouse, etc. so that they are comparable for the parts of the network which will be operationally involved in the testing phase (e.g. specific DC-customer lanes).
- Measurement of the actual KPIs versus the baseline: actual values of the involved KPIs will be calculated by the LOGISTAR system, for a period not shorter than 30 (= 3 x 10) working days.
- The system will be tested for a period not shorter than 10 working days. These days will be selected in order to assure the coverage of different logistics situations and events. If possible, the test should be longer than 10 days to account for the high seasonality of the Nestlé and pladis businesses. It will probably be necessary to test the LOGISTAR system in a number of 10-day iterations, in order to finetune the system and take into account test user feedback. If the overall timeline of the project allows it, we aim to have a minimum of three 10-day test cycles.
- The minimum number of warehouses or physical hubs involved in the testing will be 4 (2 for Nestlé and 2 for pladis)
- During these days, a selection of no less than 25 deliveries per warehouse will be introduced in the LOGISTAR system, in order to calculate an optimized plan.
  - Deliveries should cover different geographical areas, as well as be focused in an area in which both companies have deliveries to be served.
  - Deliveries selected must require at least the movement of 10 trucks per warehouse.

    - Deliveries have to allow the possibility for multiple-drop planning. That is, it is important to avoid (as far as possible), that the selected deliveries involve only full trucks but also LTLs, in order to maximize the probability of collaboration.
    - The planning performance provided by LOGISTAR will be compared in terms of following KPIs:
        - Empty running
        - Asset utilization
        - Transportation cost
        - Delivery timeliness and failed to arrive will be estimated in this stage, assuming travel time and client behaviour predictions.
- The optimized plan will be powered by the negotiation module, in order to provide both companies with a set of alternatives.
- In a first stage, optimized and manually (following usual operational practices of the companies) planned deliveries will be put on trial in simulation for measuring delivery timeliness and failed to arrive KPIs under special situations and delays, and in order to measure re-optimization capabilities of LOGISTAR:
    - Client rejects a delivery which is on route.
    - Important delay occurs in a route.
- For operational testing, the companies will select the plan to execute (manual or optimized, in order to not interfere with their operations), and LOGISTAR will monitor the state of the operations. In case of real events or incidents occur, or in case the prediction module comes up with an expected important disruption, the re-optimization module will provide new alternatives to the companies.
    - During the stage in which the plan is running, performance of prediction system will be tested in terms of capabilities of advancing real incidents.
    - In the same way, capabilities of LOGISTAR to provide alternatives will be evaluated.

With regard to the use of IoT for real-time visualization and detection of delays and unforeseen events, pladis already has a GPS location system in their own trucks which is linked with their Microlise delivery execution system. It is expected that it will not be needed to deploy any additional IoT devices in pladis trucks if LOGISTAR can have to access to the existing Microlise location data in order to enable real-time visualization and detection of delays or unforeseen events.

Nestlé also have tracking devices on their own trailers and trucks, but the resulting data is not currently available to the transport planners through an integrated TMS or other software environment. Vehicle locations and delays are today communicated manually by the drivers. If the data from the current trackers cannot be captured in LOGISTAR, it would be beneficial to deploy extra tracking devices on the Nestlé trucks to enable the necessary real-time visibility, monitoring and ETA calculations in the test phase. If needed to test the necessary LOGISTAR functionality, these extra IoT devices need to be installed before test phase.

A remark needs to be made here that Nestlé's own fleet covers only a very limited portion of its total movements. Nestlé uses various third-party hauliers to manage the rest, and there is not a consistent tracking solution across all service providers. Adding bespoke trackers into all trailers is unlikely to be workable in the long term in view of the size of the industry.

3. Living Lab 2: Synchromodality (Zailog-Codognotto)

3.1. Introduction

The market context in the inland terminal of Verona Quadrante Europa and, at large, in the North of Italy is characterised by a growing popularity of the intermodal transport option.

In the last decade, rail freight transport in Europe has been stable, but the combined transport component has grown considerably, reaching a total weight of 21.6%. Rail accounts for 17.4% of the total goods transported on the continent, while road dominates with 76.4%.

In Italy the train accounts for 15%, while standard road haulage is still the first option. A Report published by the German BSL Transportation Consultants GmbH on behalf of UIC (Union Internationale des Chemins de Fer) shows that Italy is among the few in Europe where the combined quota is over 45% compared to the total freight transport by rail. The study underlines that a large part of the combined trades has its fulcrum in seaports, highlighting the excellent growth potential of ports such as Trieste and Genoa. Within this general market context framework, the freight village of Verona handled in 2018 the following flows:

Intermodal traffic	Total 2018
INTERMODAL TRAINS	13,536
N. UTI	427476
N. TEU equivalent	765 182 *
N. Tonn	7,918,560 **
Other railway traffic	**Total 2018**
Traditional (Tonn)	187 395 °
New Cars (Tonn)	19,926 °°
Total trains (n °)	2,340
Total rail traffic	**Total 2018**
Trains worked (n °)	15,911

* UTI / TEU transformation coefficient: 1.79 (Source: 2012 UIR Report)
** TONN / Intermodal Train transformation coefficient: 585
° TONN / WAGON coefficient: 4.3
°° TONN / WAGON coefficient: 13.00

Table 2 Verona rail freight traffic

However, rail transport today still faces many challenges. The limited integration of rail and road data sources leads to incomplete optimization of intermodal flows, making it difficult to avoid empty running and unnecessary idling stops.

The following issues of different nature are examples of what can be improved in rail transport in Europe:

- difficulties related to long-term and daily transport planning due to variations in volumes and the overall duration of the procurement contracts that limit the generation and use of economies of scale;
- large number of transport combinations and assets to be considered leading to fragmentation and difficulties in having a clear, real-time overview and an updated dashboard of the situation ongoing on a daily basis;

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- still limited integration along the value chain of the logistic process with a set of IT systems (e.g. EMSW, ERP, TMS, FMS, WMS and ERTMS), with the systems not communicating and not interconnected

Furthermore, the rail and intermodal market today does not offer good solutions to support predictive planning decisions. The main weak point is the difficulty to establish a transparent track & trace system that can support the transport planning in an integrated way. This condition negatively affects logistics operators as well as rail terminal operators.

Due to such complexities, road transport can appear more competitive than intermodal transport, being easier to control and faster in reaction.

Zailog and Codognotto Group consider the improvement of the IT integration along the logistics chain and the secure sharing of real-time transport and planning data as key enabling factors for improving rail transport. Better data visibility can for example ensure that the containers, trailers and flatbeds in an intermodal network move around with minimal empty kms and idle time, which is crucial for the profitability and sustainability of rail transport. It will enable to move more freight units off the road and onto rail capacity with minimal re-planning cost and time loss (i.e. synchromodality), which will have beneficial effects on costs and carbon emissions.

This challenge will be the focus of LL2. This living lab will focus both on the real-time optimization of the train handling process in the Verona Quadrante Europa terminal and on the improvement of the related truck fleet operations of Codognotto.

The living lab will also provide Codognotto with a planning and decision support system for the multimodal end to end routes through several intermodal terminals (Verona and others).

In LL2, Codognotto and Verona Freight Village will develop a new system to collect and leverage intermodal location data, i.e. seamlessly collect and process data related to the location of loading units in the context of a transport mission performed with the use of different transport modalities, with one or more modal shifts. Supported by IoT, LL2 will try to solve the operational problems caused by the lack of visibility along the rail supply chain. The generated data will be used to feed the LOGISTAR decision support tool to recommend the best route combinations of road and rail in different countries in real time.

It should be noted that the scope of LL2 changed a bit since the start of LOGISTAR in 2018. The current market shows a volume decline in the Verona Freight Village which is the main rail hub of Codognotto Group. This pushed the partners to enlarge the scope of analysis, involving also logistics nodes outside Verona, such as Pordenone, Meolo, Orbassano, Piacenza and Novara in the Northern part of Italy. It may also be needed to involve other forwarding agents or intermodal transport operators such as KombiVerkehr, who is the main MTO (Multimodal Transport Operator) operating in Verona and on the Brenner axis.

The expanded analysis will provide to the LOGISTAR project new potential stakeholders, a higher volume of flow data and potentially also a better scalable solution for creating intermodal flows.

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3.2. Stakeholders in LL2

Rail transport is more complex than road transport. To clarify the living lab, here below are listed the relevant actors and stakeholders in the intermodal chain:

- The transport companies or forwarding agents (like Codognotto) that haul the goods of their customers from point A to point B;
- The terminal manager, whose objective it is to handle the loading units of the shippers;
- The railway undertaking who carries physically the freight from terminal A to terminal B (and vice versa);
- The shunting company that tows the wagons from the railway station to the terminals (and vice versa);
- The railway infrastructure manager that is the owner of the railway network and especially of the railway paths;
- The M.T.O. (Multimodal Transport Operator) that is a broker able to arrange the entire intermodal trip. It is a sort of travel agency selling full packages to the shippers that can avoid contacting all the players of the chain to move their loading units on the intermodal route selected.

Sometimes some transport companies have such a huge volume of freight traffic that they can decide to buy all the slots on the train. In this way the M.T.O. gives them a commercial discount. A fully loaded train with the loading units of one shipper is called a “Company Train” or “Block Train”.

3.2.1. Verona Quadrante Europa

After the Second World War, there was a need to restart the agriculture and the industrial sector in the city of Verona. For this reason, the municipality, the chamber of commerce and the province of Verona created a public body, Consorzio ZAI. In 1970, Consorzio ZAI created the freight village of Verona Quadrante Europa. The area where it was developed is very close to the city but outside the centre. In this way, the flow of business vehicles (like trucks) does not cause traffic jams on the city roads. The location of the freight village was strategically chosen at the intersection of the North-South and West-East transport axis, and at the crossing point of the respective Brennero and Serenissima railways and motorways. At the beginning of its activity, the first important building created inside the Verona Quadrante Europa area was the customs. In fact, in those years, there were the European borders and the goods coming especially from Germany had to stop in these offices to carry out the customs declarations. Then, the first terminal (ex CEMAT terminal) which is currently equipped with yellow gantry cranes was built. Then, Consorzio ZAI converted the existing railway tracks of the ex “Magazzini Generali” into a new terminal (called “Interterminal”) for combined transport. Quadrante Servizi, a subsidiary company of Consorzio ZAI, manages this terminal.

Lastly, in 2010, the Quadrante Europa Terminal Gate (QETG) was realized, thanks to a joint venture (50% each) of Consorzio ZAI and RFI. It is a last generation terminal that has the same capacity and performance of the terminal managed by Terminali Italia (first and second modules) using the half of the space. Terminali Italia is the terminal manager of QETG. The node of Verona Quadrante Europa handled about 20 tons of goods by road and 8 tons of goods by rail in 2018.

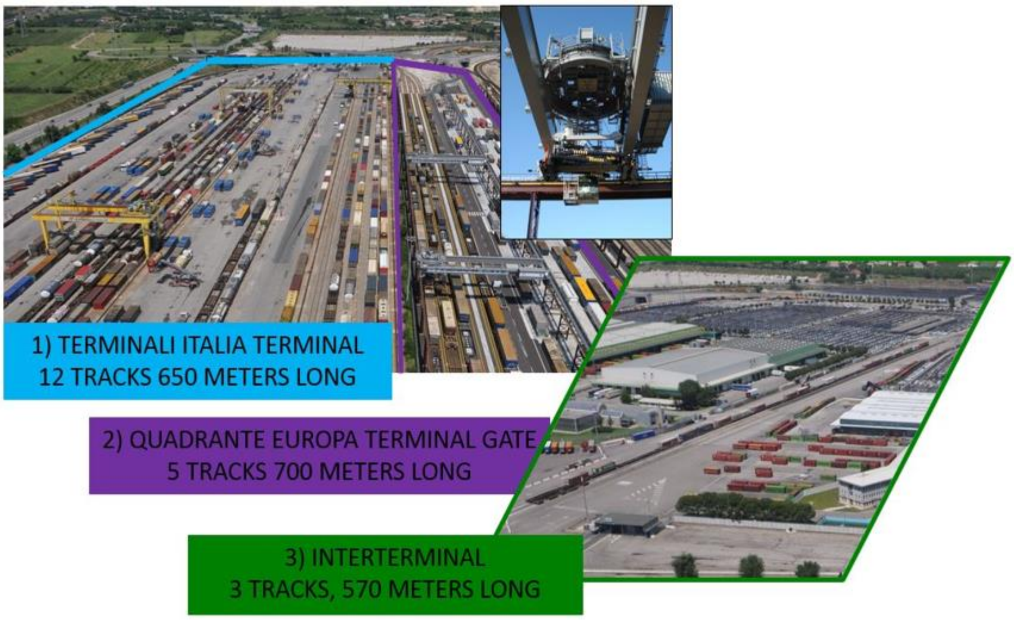

Figure 2 Verona Freight Village Terminals

The following picture gives an overview of Verona's railway network in 2019:

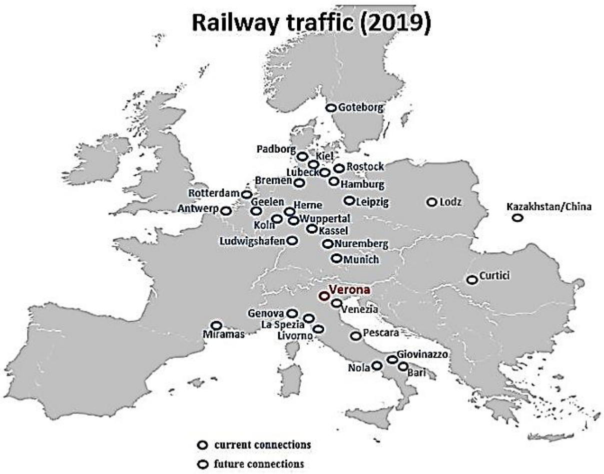

Figure 3 Verona's railway network

The freight village of Verona handled in 2018 almost 16.000 trains, of which

- about 13,500 were intermodal trains;
- about 2,500 were trains used to carry cars, spare parts or other goods (called conventional trains).

The Verona Quadrante Europa rail-road terminal is connected with the majority of the Italian and European ports and to the most important inland terminals in Europe. It also has a railway connection to China via Hamburg. The loading units managed in Verona are mainly trailers but also an important number of swap bodies are handled. Containers occupy only a lower share of the market (5%), but

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the planned investments aim to increase this number. Trailers are one of the reasons why the freight village of Verona Quadrante Europa is steadily growing its business activity since players like Codognotto are investing a lot in this type of loading units. The increase in the use of trailers is due to their wheels that make it easier to switch from road to rail and back.

Verona Quadrante Europa develops its traffic especially on the Brenner axis. Usually, the entire intermodal trip is organized by an M.T.O. (Multimodal Transport Operator) that coordinates all the players involved in the chain. Roughly, the 70% of the Verona freight village market is absorbed by Germany that is an interesting market for Codognotto Group.

3.2.2. Codognotto Group

The Codognotto Group is a logistics and transport company operating in over twenty countries with fifty offices. The Group has been established in 1946 in Salgareda (Province of Treviso – IT) and deals with integrated logistics and transport through the use of all modes:

- Full Truck Load (FTL);
- Groupage (LTL);
- Air and Ocean since 2009;
- Contract Logistics;
- Custom services and consultancy.

Codognotto serves every year more than 5.000 customers across Europe and Middle East, establishing commercial and operational relations with more than 5.000 contracted suppliers.

The Group positions itself as a driver of innovation. For example, the company has been involved so far in 11 EU funded projects on R&I (e.g. Horizon 2020, Connecting Europe Facility), mostly dedicated to digitalisation and IT development to improve the operational standards in the transport and logistic sector. Codognotto also puts strong focus on sustainability through alternative fuels, fleet renovation, eco driving training and modal shift.

The Codognotto Group schedules and organises every year an average of ca. 275.000 shipments. In the first 4 months (January ’19 – April ’19), the company managed:

- road transports (FTL and LTL or groupage), 54,036;
- intermodal transports:
  - rail: 10,753;
  - shortsea: 3,961.

Transports are managed both across Europe and outside the European Union (Belarus, Russian Federation and EAE).

Road traffic remains the core business of Codognotto but in the last years it has also increased its number of intermodal services, mostly via the Verona Terminal. Living Lab 2 will make maximal use of the Verona intermodal network and connected terminals in a “synchromodal” philosophy:

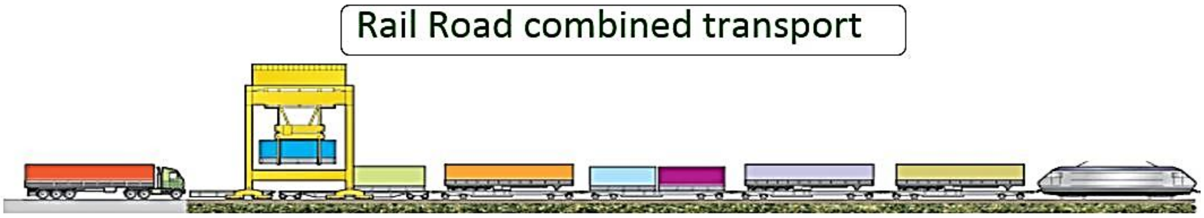

Figure 4 Zailog and Codognotto's "synchromodal" train

Figure 5 Codognotto Group intermodal offer on EU market

Figure 6 Codognotto facilities and equipment

For this purpose, Codognotto Group operates an intermodal transport control tower which is located in the Italian intermodal hub of Piacenza, with a direct linkage with the Group HQ located in Salgareda (Province of Treviso). The standard set up for the intermodal flows performed is the collection by road haulage in the first mile of the transport and the subsequent delivery at the sea or inland intermodal terminal to manage the modal shift. The last mile is performed by road haulage with own fleet or subcontractors until the final delivery point scheduled in the transport order. The

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longest stretch in between the first and the last mile is performed along the railway lines linked to the Verona Quadrante Europa freight village.

Through its control tower, Codognotto manages directly several intermodal flows across EU countries. In particular, it operates as Multimodal Transport Operator (MTO) for a flow Italy – Poland, from the hub of Piacenza in Northern Italy to the one in Gliwice in Silesia (Southern Poland). Thanks to this intermodal connection, every year about 5.000 trucks are shifted from road to rail in Central Europe. The Codognotto Group also exploits the services offered by the logistics hub of Verona Quadrante Europa to offer its customers an intermodal flow to and from Germany and Northern Europe. At present, the Codognotto Group manages only spot transports and no regular daily or weekly flows to Germany via Verona, due to the very dynamic nature of the intermodal market

3.3. Deployment of the LOGISTAR System in LL2

Codognotto has the ambition to increase its intermodal volumes through the development of a better capability to control, track, trace and consequently better manage the rail transports. This is needed in order to optimize and reduce the empty km performed, along with the idle time at intermodal terminals during the modal shifting operations.

In the view of the company, this achievement will require the further digitalization of main transport corridors and the implementation of an effective track & tracing system for loading units of any kind. Having such an integrated solution in place will dramatically improve the sustainability, operational routines and administrative routines of rail transport, with a concrete economic and social benefit.

The focus of LL2 is to test in real market conditions the concept of synchromodality flows by building a real-time decision support system around the intermodal transport chains of Verona Freight Village and Codognotto Group.

At the beginning of the project, it was the intention to involve Interterminal in Verona as testing ground for LL2 because it manages the trains from/to Wuppertal which was the selected railway corridor for the implementation of LOGISTAR. After a recent feasibility analysis, Zailog and Codognotto concluded that there are not enough free slots on the trains from/to Wuppertal. Therefore, they decided to carry out the LL2 testing phase primarily on the Köln and Antwerp destinations which are managed in the Terminali Italia area.

Besides the Verona Quadrante Europa rail node and its transport connections, also other intermodal corridors with Codognotto flows will be in scope. In order to maximize the opportunities and the size of the dataset to be analysed in LOGISTAR, Codognotto Group will continuously investigate the intermodal flows touching other nodes such as Pordenone, Meolo, Orbassano, Piacenza and Novara.

Since the base volume of data from Verona may be too low, the following intermodal flows from Codognotto will be considered as potential extra volumes:

- Novara – Zeebrugge – Vice versa;
- Meolo – Lione – Vice versa;
- Piacenza – Gliwice – Vice versa.

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The main problem for a forwarder such as Codognotto is defining the rail destinations in spite of the volatility of the market. A steady freight flow is necessary to collect the high volume of data necessary to deploy the LOGISTAR system and to make significant predictions.

However, being irregular spot flows, the loading units travelling along the intermodal corridor available from Verona Quadrante Europa Freight Village will change constantly. Despite the will to define in advance the ideal route on which to develop the second living lab, the continuous fluctuations of the market make it impossible. Therefore, only an analysis of the market conditions produced a few weeks before the beginning of the Living Lab can show which is the best route to test the LOGISTAR system.

A detailed definition of the route(s) to be tested will be provided beforehand by Zailog and Codognotto to the technical partners so they can test their system functionalities and software components. If such information about the final route(s) is not available in time for the system development, Zailog and Codognotto will provide representative historical data or dummy data.

Zailog is in contact with several road operators and terminal managers in the region to continuously collect quantitative and qualitative data on new freight flows that could be converted to intermodal. At the same time, Codognotto plans to use and exploit other railway nodes as from the beginning of the living lab. Therefore, they decided to proceed in this way:

- Zailog will provide expertise to Codognotto in order to overcome the volume volatility that affects the railway sector. In addition, Zailog will support Codognotto in the identification of the suitable routes, MTOs and relevant railway undertakings in order to create a strong chain, enhancing the cooperation and maximizing the final outputs. Lastly, it will be possible to involve other players such as shippers/forwarders (if they are willing to sign an agreement to put an IoT device on their loading units) operating to/from Verona, to extend the impact of the testing phase, gathering as much data as possible in order to grow the available flow database;
- Codognotto will consider stable flows on the mentioned rail nodes. The most relevant flow considered will be Novara – Zeebrugge since the equipment used in the flow are semitrailers for which the accuracy of track and tracing is better while swap bodies and containers present more difficulties due to the lack of signal from the inside of the box. Furthermore, a switch to the Pordenone freight village will be considered instead of starting from Novara. This will also be part of the LOGISTAR test.

The adoption of this strategy will allow to have a sufficiently large volume of data to enable the LOGISTAR system testing in LL2. However, some months after the beginning of the Living Lab, there will be additional physical tests in Verona using the destinations identified or new ones, according to the Codognotto market status. It is important to highlight that during the first months both Zailog and Codognotto will provide all the expertise necessary and the data available in order to measure the impact of the LOGISTAR solution on their operative systems.

The living lab partners have already started to collect the necessary historical freight movement data in Verona and elsewhere that will be used to support the planning and predictive analytics modules of the LOGISTAR system.

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After investigating the reasons for delays and inefficiencies in rail transport, Zailog and Codognotto concluded that the majority of problems come from the railway side since there is not visibility of the freight after it has been loaded on the train.

Currently, the railway undertakings and the railway infrastructure manager of each country on which the train is travelling know the position of the train, but this is normally only communicated to the transport companies in a reactive way, in case of peculiar problems and only "on demand". Therefore, the IoT devices placed on the loading units will provide valuable information both to the terminal managers and to the transport companies, enhancing the efficiency of the entire intermodal chain.

Therefore, the first action to carry out in this Living Lab will be to create a track and tracing system able to provide the real-time position of the goods. At the start of the operational phase, Codognotto will equip its loading units with IoT devices in order to collect real-time information about the movement of the goods, modal shift and geolocation of the train.

After some months of its implementation, Zailog and Codognotto expect that this system will produce enough information to create a database that will be used by the LOGISTAR smart algorithms to make predictions.

In addition to the terminal data and the IoT track and trace information, Codognotto will also share data from its TMS with LOGISTAR via a data connector (API). This combined data will enable to create real-time information on the train's movements, supporting synchromodality and advanced tool for business analytics. Such visibility is at the moment lacking in the rail industry.

Working in this way, it will be possible to create a database describing which are the rail routes with frequent delays. Therefore, two services will be implemented:

- The real-time information of freight transport will be given to the terminal manager, so he will be able to know in advance if the train is stopped on the railway line.
- The control and decision-making tool in logistics operations will be provided to Codognotto, along with the real-time overview of where all loads are geolocated. As such, Codognotto can check in every moment the movements of the trains on which the goods are traveling and reorganize the entire trip if there will be delays, or exploiting the knowledge acquired to plan a modal shift.

This will allow, along with the data on frequent delays:

1) an optimization of the transport planning in the mid/long-term and a more accurate and effective recovery plan;
2) an easy management day-by-day of the transport, with the possibility to foresee and operate punctual and systematic corrective measures.

The terminal managers will provide data about the scheduling of the trains such as their origin or destination, the planned time of arrival or departure, the name of the MTO, of the railway undertaking and of the forwarder and the average delay on a specific route. All such information can be processed by the LOGISTAR system to make predictions and to enhance the overall efficiency of the synchromodal process.

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For the rail terminal managers themselves, it is important to reduce the number of crane lifts, the number of loading units left in the buffer area and the queues outside the terminal gates. This can be made possible using a predictive system able to help the terminal manager in the coupling of the road and rail traffic, producing an overall optimization of the intermodal chain. The LOGISTAR system will be essential to achieve these objectives because the terminal operator can know in advance which trains stopped on the railway line (e.g. on the Brenner axis) and which is the expected delay for them. This will be possible thanks to combination of the Track and Trace and the predictive system deployed in LOGISTAR that will provide both an overview of the conditions of freight trains and an estimate about the difference between the scheduled and the actual time of arrival.

3.4. ICT landscape and data sources

The transport missions performed by Codognotto Group are managed by a combination of highly customised IT systems to support the operational department in their daily activities.

The transport management system (SGA) and the warehouse management system (click reply), allow the scheduling and subsequent management of transport orders inserted in the system.

The intermodal transport dataset provided by Codognotto to the LOGISTAR technical partners is the result of an extrapolation from these IT systems. The data have been validated by the Group controlling and business intelligence department. Furthermore, the dataset will be adapted to the format and requirements coming from technical partners of the consortium.

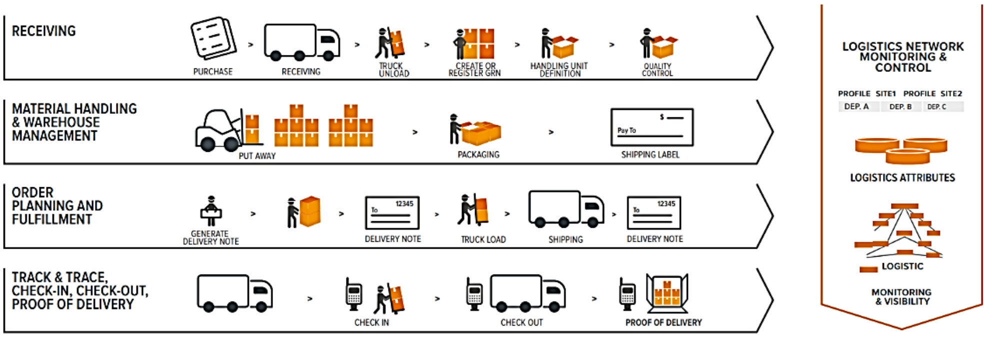

Figure 7 Workflow example

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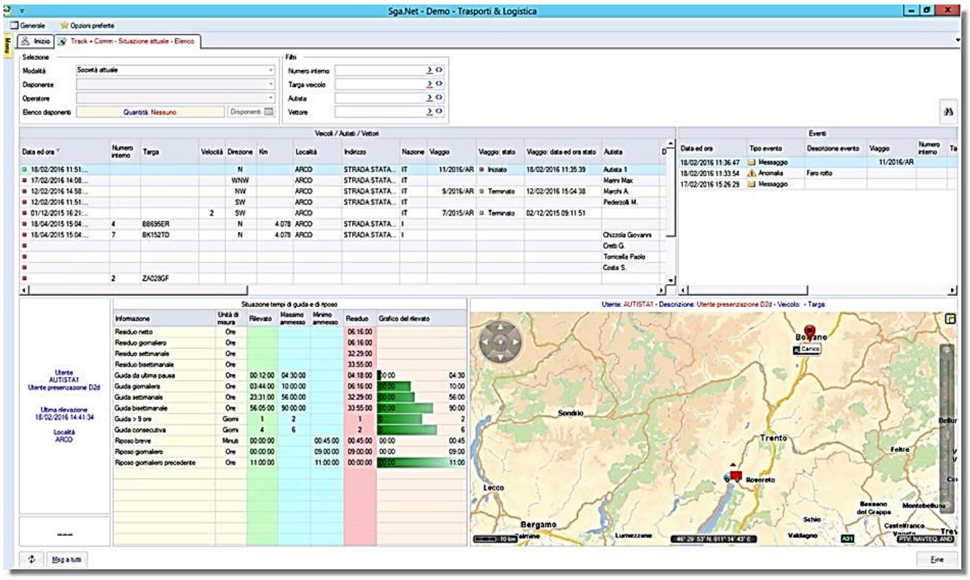

Figure 8 TMS example

In addition, the management systems of the terminals of the Verona freight village can provide data about the scheduling and the actual timings of the managed trains. These systems are connected to the RFI (the Italian railway infrastructure manager) portal but unfortunately this system shows only the trains travelling on the Italian railway network. In addition, these systems are not well connected to the customer's ones, making real-time management of train delays difficult.

Codognotto and Zailog will collect and integrate the data required by the Living Lab. They will also use the expertise of the technical partners to carry on an already ongoing mapping process of the IT gaps of the infrastructure in operation.

Zailog and Codognotto will document this data collection to take into account data security requirements. This aspect has been addressed at consortium level with a confidentiality agreement among the project partners. The same goes for the technical integration aspects of IoT hardware and software applications that will be part of the project scope.

3.5. Expected outcome of LL2

Zailog and Codognotto will verify and test in LOGISTAR a feasible solution to optimize in real-time the internal operations and performance of the multimodal network with a specific focus on setting up a continuous track & tracing system of the loading units, with measurable impact on efficiency, service level and sustainability KPIs.

Codognotto and Zailog are working closely together with the market and with the technical consortium partners to create a comprehensive operational dataset that will support the development of a LOGISTAR system that addresses the needs of synchromodal stakeholders. Once established and operational, this living lab will represent the testbed where the various functionalities of LOGISTAR system will be tested with real stakeholders. These functionalities are:

- the **predictions** that can be carried out through the data provided both by the rail operators involved and by the IoT devices. These predictions will be focused mainly on the timings of the

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loads in the supply chain, the risks, the delays, the orders, the events, the accidents, the prediction of rejections of deliveries from the clients;

- the **optimization of the handling in the terminal** and of the management of the routes. The terminal managers will have visibility over the real-time information and delay predictions from the LOGISTAR system, which may help them to do internal capacity planning or reorganize the shifts of the workers. Accordingly, data concerning the trains' status, delays and disruptions on the lines served will be accessible by the terminal operator offering visibility of the transport's situation. The loading/unloading scheduling and the management of the storing surface of the buffering area will be positively affected by the optimization process.
  For instance, if three trains were expected between 10 am and 1 pm but they are stopped on the railway line, the shift of the morning can be cancelled for some workers and at the same time it is possible to manage the train arrived in time. In this way, the terminal manager can call the forwarder to warn about the early arrival of its freight. Therefore, he will send some trucks to the terminal and the loading units will be loaded directly on them, preventing to be placed on the yard and in the buffer area for a long time. On the other hand, the forwarder can avoid the queues outside the terminal gates since it will have access to the fast lane. The lapse of time saved can be used to carry out other trips. It is important to remember that currently data about the loading units travelling on the railway line are not available so they will be essential for the improvement of the entire intermodal chain (both rail and road side). At large, the progressive optimization of the whole process and of the communications between the different actors involved will therefore allow a reduction in working times and an increase in general productivity, with positive impacts on the reduction of the linked environmental and social negative externalities. This is because the unnecessary operations will be reduced and the traffic inside the terminal and in the areas adjacent to the freight village will be made smoother;
- the **re-routing of the trips**, changing the scheduling every time a logistics event occurs;
- the **real-time tracking and tracing** of the goods, including ETA calculation.

The evaluation will be produced using KPIs able to detect the benefits produced (if any). Zailog and Codognotto think that the involvement of other rail nodes and shippers will not be a negative aspect because more stakeholders involved means the achievement of a more comprehensive perspectives and an extension of the impact of the living lab itself. More information on the KPIs is given below.

KPIs

Road and rail transport are very different logistics operations. For this reason, it is better to establish a separate set of KPIs for rail in this living lab.

These can be suggested from the long-term experience of the terminal managers that need to make an evaluation about the performance of the terminal. The most important indicator is the terminal efficiency. It is measured considering the number of train pairs handled in one operative track per day. A train pair means that the measure starts from the arrival of the train on the railway station's tracks to its departure from the same tracks so after the entire unloading and loading phases. The calculation must be carried out taking into account the operative tracks and the opening hours of the terminal.

For instance, in the smaller terminal of the Verona freight village (called Interterminal) the average terminal efficiency for 2018 was 2,2 daily train pairs, with peaks of 2,5 daily train pairs in February,

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March and July. The calculation was done considering 303 working days (opening 19 hours per day) and two operative tracks. It is a good result compared to the performance of the competitors, but it is important to highlight that a small terminal has more flexibility than a bigger one. Therefore, a good management can exploit this feature to get better performance.

Another important indicator is the turnover rate of the train. It is quite similar to the terminal efficiency but in this case are measured the number of hours necessary to handle a train (from its arrival at the station to its departure) per operative track. Interterminal scored an average of 8.63 hours to handle one train per track with an opening of 19 hours per day.

Consequently, a number of KPIs in LL2 will be related to the internal efficiency of the rail terminal operations. A predictive system like LOGISTAR can produce real-time forecasts about the real status of the trains on the line. With this information (which is currently missing), the terminal manager can re-organize the personnel shifts, the loading/unloading procedures, the use of the equipment and the management of the available buffer surface. This will result in a reduction of corrective measures and a smoother loading/unloading.

For example, the terminal manager will be able to decide if it is better to handle other trains already arrived since the previous trains on the scheduling list are blocked on the line. This operation permits to exploit better the tracks of the terminal, avoiding occupying some of them to wait for these trains. In fact, without this information in real time, the terminal manager has to follow the scheduling list and cannot manage other trains that should arrive after the blocked trains. This system based on the priority given by the scheduling list sometimes blocks the entire terminal.

Moreover, this will impact the road haulage, as trucks will be directly loaded avoiding buffering or the organisation of the buffering area will make possible to reduce the loading time itself.

Terminal efficiency is measured considering the number of train pairs handled in one operative track per day. A train pair means that the measure starts from the arrival of the train on the railway station’s tracks to its departure from the same tracks so after the entire unloading and loading phases. The calculation must be carried out taking into account the operative tracks and the opening hours of the terminal.

For instance, in the smaller terminal of the Verona freight village (called Interterminal) the average terminal efficiency for 2018 was 2,2 daily train pairs, with peaks of 2,5 daily train pairs in February, March and July. The calculation was done considering 303 working days (opening 19 hours per day) and two operative tracks. It is a good result compared to the performance of the competitors, but it is important to highlight that a small terminal has more flexibility than a bigger one. Therefore, a good management can exploit this feature to get better performance.

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One more KPI is the average timing to carry out a gantry lift. It measures the number of seconds necessary to load or unload a loading unit on the train. This indicator is less used then the other two described before, but it provides an idea about the efficiency of the operator and of the exploitation of the machinery.

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Lastly, another good terminal indicator is the number of useless shunting operations. In fact, if the terminal is congested because it is not well managed, the trains arrived at the station must be moved to the marshalling yard, waiting their turn to be handled. The shunting of the internal locomotive to move the train on the marshalling yard and then inside the terminal when it is its turn implicates an extra cost to add to the final price for the customer.

From the forwarder perspective, the KPIs will be the reduction of the transit time using intermodal flows. Taking as example, the flow Novara-Zeebrugge where Codognotto is already collecting some data for LOGISTAR analysis; the transit time for road is A-D while for train it is A-F. Potentially the transit time could be A-E but no operator is willing to guarantee this. The main reason is the lack of accurate prediction systems.

Another KPI will be the cost reduction that will be taken as baseline for the road transport. Since, nowadays rail costs are about 10% higher, it will have to be comparable to the road one. The coverage of the track and trace system will also be evaluated, as well as the capacity to provide a transparent freight flow monitoring system to a test shipper.

To summarize, following KPIs will be monitored in LL2:

- **Modal shift:** percentage of deliveries that will be switched from road to rail. The KPI will be assessed considering the average number of trucks loads performing the flows under review at the beginning of the LL2 implementation and the same number during the LL2 and at its end.
  - Overachievement: >20% trucks shifted;
  - Acceptable: 10%<x<20% trucks shifted;
  - Underachievement: <10% trucks shifted;

- **Train delays:** train departures delay over the planned time horizon. The KPI will be assessed considering the average delay on the flows under review at the beginning of the LL2 implementation and the same data during the LL2 and at its end.
  - Overachievement: ≥ 60 minutes reduction;
  - Acceptable: 20 ≤x≤ 60 minutes reduction;
  - Underachievement: ≤ 20 minutes reduction;

- **Waiting time:** time spent by the delivery from gate in to gate out. The KPI will be assessed considering the average turnaround time spent at the beginning of the LL2 implementation and the same data during the LL2 and at its end.
  - Overachievement: ≥ 30 minutes reduction;
  - Acceptable: 10 ≤x≤ 30 minutes reduction;
  - underachievement: ≤ 10 minutes reduction;

- **Train loading factor:** ratio between the potential capacity of the train and the occupied capacity. The KPI will be assessed considering the average occupied capacity at the beginning of the LL2 implementation and the same data during the LL2 and at its end.
  - Overachievement: ≥ 90% occupied capacity;
  - Acceptable: 70% ≤x≤ 90% occupied capacity;
  - Underachievement: ≤ 70 % occupied capacity;

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- **Door-to-Door Transport time:** ratio between the actual “door” of the shipper to the “door” of the consignee transport time and the time required for a similar transport exploiting LOGISTAR solution.
  - Overachievement: ≥ 1 of transit time reduction;
  - Acceptable: 0.5 ≤x≤ 1 of transit time reduction;
  - underachievement: ≤ 0.5 day of transit time reduction.

- **Cost reduction:** the cost of the rail transport in comparison to the previous road transport. This KPI will be successful if it is lower or <10% expensive for rail than for road.

In addition, the potential increase in the number of trains managed per day/week by the Interport terminals will results in an increased and attractiveness for the market of the intermodal transport. Accordingly, this will allow an increase in the transport missions managed intermodally and a reduction of road mileage for medium-long range transport mission. The shift will result in **a reduction of typical pollutant emissions** (such as NO_x or CO_2) **related to road haulage**.

The above-mentioned reduction can be only esteemed as the typology of road vehicles substituted (e.g. EURO V, EURO VI, …, LNG, Diesel, Hybrid, CNG, …), their operative status, the length in terms of mileage of the road transport mission shifted to rail make impossible to have a precise calculation.

3.6. Size of the testing

In order to properly measure the performance of the LOGISTAR system for LL2, the following guidelines are proposed:

- Measurement of the baseline for the KPIs: using historical information, averaged values of the involved KPIs will be calculated, using a period not shorter than 30 working days.
- The system will be tested for a period not shorter than 10 working days. These days will be selected in order to assure the coverage of representative logistics situations and events.
- During the selected days, the demand of deliveries to be planned must be higher than 20.
  - The demand must require at least the planning of 10 trucks.
  - The demand must match possibility for the use of rail transport.
  - The number of deliveries requiring train must be higher than 10.

- In a first stage, manually planned and optimized (following actual operative standards of the company) deliveries will be put on trial in simulation for measuring delays, waiting time, loading factor and modal shift potential. A number of alternative transport plans will be simulated.
- For the operational stage, the company will select the plan to execute, and LOGISTAR will monitor the state of the operations. In case a real event or incident occurs, or if the prediction module expects an important disruption, the re-optimization module will provide alternatives to the companies.
- During the stage in which the operational plan is running, the performance of the prediction system will be tested in terms of capabilities of predicting real incidents.

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4. Living Lab 3

Disclaimer: Due to internal decisions in Ahlers, the scope of Living Lab 3 is under re-definition. This section will be updated in an upcoming version of the report when the information becomes available.

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5. Risk Management

In each use case, the living lab companies will work closely together with the LOGISTAR technical partners to identify and prevent risks, barriers and obstacles that may hinder the system implementation.The most important risk factors and how to address them, are:

- Data sources and availability: real-time operational data from the living lab companies will have to come from a variety of technical sources and internal legacy systems. These sources have yet to be identified by the technicians of LOGISTAR. The test companies will facilitate this by organizing workshops to document the legacy system landscape. Also the possible impact of ongoing changes in this landscape (e.g. new TMS or SAP upgrade) will be monitored.
- Data quality: the ongoing strategic evaluation of each living lab indicates that the quality of the collected data is often not perfect, which is normal in logistics environments. The living lab companies will identify and address structural causes of data errors before streaming any live data to the LOGISTAR system.
- Lack of data standards: the living lab partners have different ICT landscapes and data sharing may be hindered by the lack of common standards, e.g. for transport master data or geolocations. The technical partners of LOGISTAR (WP2) will provide technical tools to harmonize the format of necessary data that needs to be shared across different actors in the logistics chain.
- Staff availability: the LOGISTAR technical partners will need active support from the end users of each living lab company, e.g. from the planners, dispatching teams or ICT staff. As these stakeholders have a daily operational focus, LOGISTAR may not be their top priority. This is addressed by making sure that each living lab company supports the project implementation on senior management level and frees up necessary staff when needed.
- ICT integration and interoperability: the ICT landscape of each living lab company consists of a mix of self-developed legacy systems and systems from outside vendors (e.g. TMS), whereas LOGISTAR works with state-of-the-art cloud components. Each living lab company will proactively facilitate the contact between their ICT department and the technicians of LOGISTAR, to make sure that systems interoperability becomes no showstopper.
- Data security and protection: all data exchange in LOGISTAR is covered by an NDA. In addition, the ICT departments of the living lab companies will have the opportunity to audit or test the cybersecurity of the LOGISTAR system before streaming any real-time data.
- User acceptance and operational change management: the dispatching teams of the living lab companies will need to change some of their operational planning processes in order to execute the improvement suggestions produced by the LOGISTAR system. The living lab companies will make sure to organize the necessary LOGISTAR communications and trainings and to provide sufficient management support to empower these employees to change their way of working during the test period.
- Sudden changes in freight flows or network volumes: these are quite normal in logistics environments and can occur at any moment. To prevent that they hinder the LOGISTAR system testing, each test company will make sure to involve a sufficiently high number of flows or trade lanes in the scope of their living lab.
- Unexpected changes in logistics resources: the living labs may be subject to external parameters that the partners cannot control (e.g. fuel prices, road taxes, driver shortages, demand peaks,…). Such potential risks are already being identified from in the strategic analysis phase, e.g. based on historical data.

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6. Cybersecurity and data privacy

The LOGISTAR living labs will make intensive use of logistics data, both from historical and real-time sources. This data can have high commercial value because it pertains to freight volumes, customer and carrier names and addresses, transport routes, delivery frequencies and costs.Moreover, the European Commission has provided guidelines on how to collaborate on transport and in these guidelines it is specifically highlighted that with regards to competition law, it is strictly forbidden to share certain sensitive information, such as supplier pricing agreements, with competitors (Biermasz, 2014).

Because of this, there are a couple of things to consider when implementing the LOGISTAR system in the use cases. The issue of data privacy is a crucial topic in this case. With companies sharing crucial information, the data needs to be used and shared with extra care. The LOGISTAR system and the whole LOGISTAR consortium will have to take the role of neutral trustee, i.e. the orchestrator that plays the role of intermediary in collaboration efforts. It should be assured that the partners in the collaborative community get to see only the information that they are allowed to see, conforming with EU competition law. Therefore, the technology and smart dashboards developed in the LOGISTAR system should also respect these competition law requirements.

Therefore, the living lab companies and technical partners will take great care to protect the confidentiality of this data and to prevent that the data becomes visible to any party that does not have a need to see it.

The LOGISTAR technical partners are already building an ICT infrastructure with a very high degree of security. The test companies will be allowed to have the system setup audited by their ICT departments, before going live and streaming any real-time data. It is not expected that there will be a need to process any individual, personal data in the living labs. In case there may exist a risk that certain data can be linked to individual persons (e.g. IoT data related to truck driver locations), this data will be anonymized upfront by the LOGISTAR system.

Each living lab partner is aware of the European GDPR regulation and will take appropriate measures to carry out the preparation and testing of the LOGISTAR system in conformity with this legislation. In case of doubt, the living lab companies will request advice from their legal counsels.

In general, ensuring compliance with ethical aspects and rules in LOGISTAR is key for a successful implementation of the project. Deliverable 10.4 aims at detailing how LOGISTAR has appointed an ethics mentor as an external advisor on ethics issues. The deliverable contains the background of the appointed person and a description of his roles and duties.

In the course of the project, the Ethics Adviser will support the Project Consortium regarding the ethical questions that are relevant. Especially, the Ethics Adviser will:

- assure the correct handling of sensitive data;
- ensure that appropriate EU standards are met, with an additional role to play in research carried out outside Europe to ensure that it complies with EU standards;
- suggest future continuation or early stopping of each research project in case warnings with regards to ethical risks are not taken into account by the consortium;
- confirm that the ethical standards and guidelines of Horizon 2020 are being rigorously applied by all beneficiaries and partner organizations.

7. Timing of the living labs

The execution of the living labs will be split into four different phases, taking into account the deadlines of the relevant deliverables of the other technical partners within LOGISTAR. The first phase starts with the collection of historical data from all test companies. Second, a thorough analysis will be conducted on this historical data in order to understand the current logistic networks of both companies and to validate the volumes, processes and KPIs. Once the historical data has been collected and validated, it will also be shared with the consortium partners responsible for the development of the LOGISTAR system. They can then use this data to set up and test the LOGISTAR system's technical components for each particular use case. Furthermore, an ICT connection will need to be established between the LOGISTAR system and the systems of the pilot companies. Last but not least, the go live of the use case will need to be planned, where operations and new processes involving the LOGISTAR system will be evaluated.

The Grant Agreement prescribes the following milestones and deadlines for WP7:

- M2 - M12: **Study and definition of the use cases (Task 7.1)**
  - Detailed definition of the functionalities of LOGISTAR to be tested in each living lab.
  - Define scope of living lab: goods to be monitored, warehouses involved, hubs, number of trucks, routes, staff involved…
    - Indications about the size of the cases to be tested in the living lab in terms of data to be captured (type, amount), demand (number of deliveries) to be planned… must be provided in order to technological WPs are able to properly size their solutions
  - Definition of the IoT that need to be deployed for real time monitoring of goods and vehicles
    - Type and number of devices to be deployed defined, as well as strategy for deployment (when, how…) must be defined.
  - The key indicators are identified
    - Which are the KPIs and how are they going to be measured in the Living lab?
      - In the case of collaboration, the reduction of time/cost/… is going to be calculated separately or not? How are they going to be calculated the current values of the KPIs (baseline)? Which levels of improvements are expected? Below which levels we consider LOGISTAR is underachieving or overachieving the metrics?
- M13 – M33: **Setting up of the living labs (Task 7.2**)
  - Deploy the needed sensing devices (IoT)
    - IoT devices in place: During the living lab, IoT devices must be operative, no later than M17 of the LL devices must be in site and ready to be tracked.
  - Create data access points
    - Data access point: deliveries to be planned (size, time window…), resources to be used (trucks…), open data (road state, incidences…), position of the trucks/goods…
    - Data must be accessible before the living lab.
    - First version of data access points required by technological partners (WP3, 4 and5) Access points not directly required by WP3, 4, and 5 must be accessible during the living lab. These Access points could be those related with visualization of KPIs and information to present in the dashboards, such as the positioning of the vehicles.
    - Historical data must be provided in advance for WP3 and samples of data to WP4 and 5.

  - A final version of the subsystems will be released in M26 for its final testing and validation, assuring the optimal results for system integration.
  - Starting in M22, a first release of the overall system will be deployed (WP6), getting a first release of the overall system (D6.2). Upgraded versions will be released until the final version of the overall system will be deployed in M33 (D6.2 final release).

- M18 – M36: **Testing and evaluation (Task 7.3)**
  - M18-M21:
    - Testing the first release of WP2, 3, 4 and 5
    - For M18 a first release of functionalities of WP2, 3, 4 and 5 must be operative within the real environment. In order to achieve this, it is important that the data each one of the modules is going to receive as input is stablished
      - WP2 must have the identified data sources in order to get information to present to the rest of the technical WPs.
      - WP3 must receive historical data received previously in order to build prediction models. To receive actual data during the living lab, in order to be able to generate new predictions and testing the (initial) accuracy of the systems.
      - WP4 and WP5 have to receive sample of real data in order to validate their subsystems. During the living lab, they must be able of getting data about the current orders to be planned (WP4), as well as of the execution of the planned operations, in order to evaluate negotiation re-planning strategies. A selection of routes provided by LOGISTAR must be executed in order to measure performance in terms of KPIs.
  - M22-M26
    - Final versions of software modules (WP2, 3, 4 and 5) produced with all the functionalities and under evaluation, and first release of the overall system (WP6).
    - Using evaluation in previous stage, software modules able to work independently must be provided by WP3, 4 and 5. In order to do so, a data capture and distribution (WP2) module must be operative and the feed of data to technical modules must be stable and continuous. All the modules must be able to perform all their functionalities.
  - M27-M32
    - Final version of the overall system (WP6). Modules have corrected detected issues and bugs in previous phase.
  - M33-M35
    - Final version of the integration of the whole system for its testing.
- M27 - M36: **Results assessment (Task 7.4)**
    - M33 – M36 – Final testing: Everything must be fully operative at this point and data collection in order to evaluate KPI performance must be performed.

The GANTT chart below gives an overview of the different phases in each Living Lab and their timing:

Proposed timing of LL1:

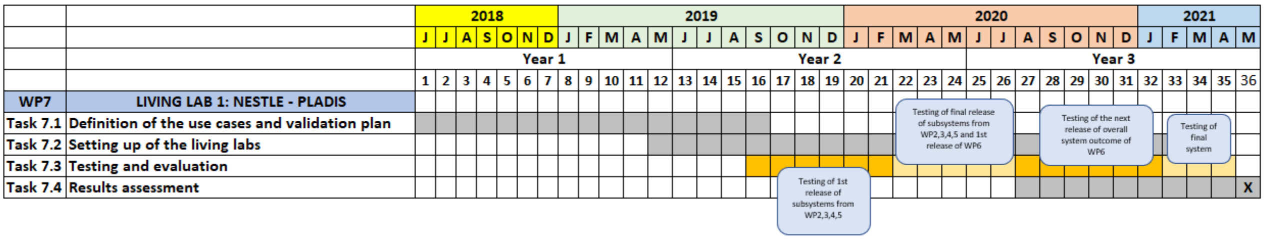

Figure 9 Timeline of LL1

Proposed timing of LL2:

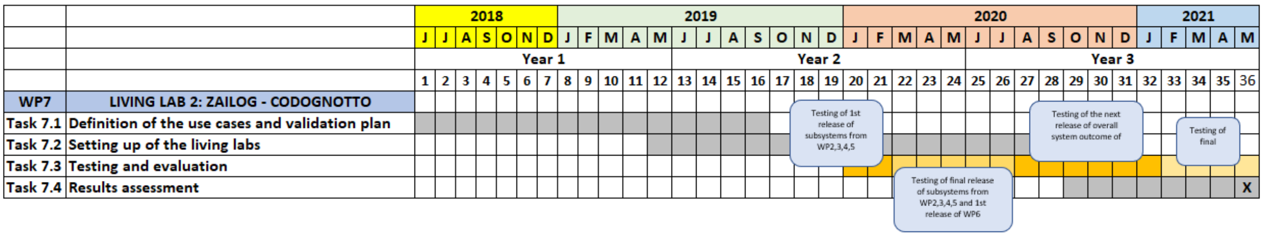

Figure 10 Timeline of LL2

Proposed timing of LL3:

DISCLAIMER *Due to internal decisions in Ahlers, the scope of Living Lab 3 is under re-definition. This section will be updated in an upcoming version of the report when the information becomes available.*

7.1. Definition of the use cases & validation plan

The historical data collection phase will serve as the basis for the next phases and will as well be used for testing the LOGISTAR platform's algorithms and the platform in general. In a first step, it will be used to get a solid view on the characteristics of the current network operations and on the current KPIs the LOGISTAR system aims to improve.

This phase is currently already ongoing and some of the living lab companies have already shared logistics datasets with the technical partners. It is expected to complete this phase in the coming months. The goal is to have analyzed all historical flow data collected from all test companies as soon as possible.

This phase will be the basis for KPI measurement within the use case. In this step it is important to get a view on the current performance of each logistics network. A thorough view on the current logistics network and its efficiency will be the starting point to calculate potential improvements achieved by using the LOGISTAR platform. Having a clear view on the current situation will also allow the consortium partners to align their understanding of the living lab companies' operations. Additionally, it will allow the consortium to validate the data together with the use case companies.

The data analysis will also be an input for deliverable 1.3 and 1.4 Network data collection, current supply chain network efficiency and collaboration opportunities – Release 1 and 2. The aim is therefore to finish this phase together with the deliverable in Month 17.

The due dates have been defined as the absolute deadlines for the different phases and hence the timing of this living lab. However, it is recommended to execute each of these phases as soon as possible.

7.2. Setting up of the living labs

The historical data collected will also help the developers and other technical partners to develop, test and finetune their algorithms and other software components. It will allow them to understand what data is to be expected in terms of data quality and quantity and in terms of data formats. Furthermore, historical data will be used to test some optimization modules and other LOGISTAR functionalities.

The end of the system testing phase will run together with the software development deliverables in the different work packages. Most of these lie in Month 26 of the LOGISTAR project. Therefore, the end of this phase is planned accordingly.

An important aspect of the LOGISTAR system is that it will give recommendations to the companies involved in the use case in real-time. This means that connections and interfaces will need to be established between the LOGISTAR platform and the operational systems of all living lab companies involved. This interface establishment is expected to become complex and will require special attention, as it will involve cooperation of ICT teams from the respective living lab companies. Also, legal and security aspects of data sharing will need to be handled.

The end of the ICT interface establishment is planned together with deliverable 2.4 Data acquisition and extraction layer of the LOGISTAR platform in Month 20. However, it is important to note that this is a vital phase in the use case project and any delay will also cause a delay in the next phases in

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the project. We therefore recommend to follow up thoroughly and to treat this project phase with extra care.

7.3. Testing and evaluation

As soon as the LOGISTAR system capabilities have been developed and the ICT interfaces have been established, the system can be put to use at the living lab companies. During this go live phase, the recommendations of the system will be executed by the planning teams of the use case companies. This will happen under strictly controlled circumstances and it will need “hypercare”, i.e. extra attention to avoid potential risks and disruptions in the daily business operations. Foreseeable risks will need to be mapped out beforehand. During the testing, KPI measurement and collection will be highly important as this will form the basis to evaluate the outcome of the use case.

This go live is planned to start as soon as all testing and interfacing is finished. For now, it is planned together with the delivery of deliverable 6.5: Software quality assurance and testing of the LOGISTAR platform in Month 33. However, as stated, the earlier the go live can be planned the more performance data can be collected in each use case and hence, on the potential improvements of the KPIs that are defined earlier in this document.

7.4. Results assessment

The results of each living lab will be investigated by means of the KPIs and compared to the as-is baseline in the historical data. Furthermore, learnings and conclusions of each use case will be presented to the consortium.

This phase is the final step in each living lab and is expected to be delivered together with deliverable 7.5: Testing results evaluation in the Living Labs.

After approval by all stakeholders, the use case results will be disseminated through seminars, publications and social media.

8. Conclusions

This document describes the three living labs which will be implemented to test the LOGISTAR system between 2019-2021.

In LL1, Nestlé and pladis will work together to realize transport and logistics synergies in their retail distribution networks in the UK.

In LL2, Zailog and Codognotto will work together with a number of shippers and rail terminals in Italy to bundle freight flows and realize smart solutions for synchromodal shift.

Due to the dynamic nature of the logistics market, a number of scope changes had to be applied between the initially foreseen use cases and the ones described in this document. However, the consortium partners are confident that the living labs proposed in this document will offer adequate potential to test and report the impact of the LOGISTAR system in a real-time logistics environment, showing measurable impact on KPIs for efficiency (cost), effectiveness (service level) and sustainability (CO2, empty running, modal shift).

All use cases will follow a similar methodology. They will start with a strategic analysis of historical data to identify the freight flows with the highest optimization potential and their baseline KPIs. Then, scenarios will be identified for optimization of the relevant KPIs. In the meantime, the technical partners will develop the LOGISTAR system according to the requirements of each living lab and its users. The ICT landscapes of the test companies will be mapped in order to build connectors with the LOGISTAR system. Then, after the necessary security checks, a real-time data stream will be established between the living lab companies and LOGISTAR. The use cases will go live under controlled circumstances and during the testing, the planning teams of the test companies will try to execute the improvement suggestions of the LOGISTAR system. In a final stage, the impact of these improvement actions on the chosen KPIs as well as user acceptance will be evaluated.

Last but not least, the LOGISTAR system will also allow for better IoT tracking and tracing, which will be tested in the living labs to provide real time status and ETA updates on the collaborative shipments.

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List of abbreviations and acronyms

4PL	4th Party Logistics Provider
API	Application Programming Interface
BBART	Bundling, BAckhauling and Roundtrip Tool
EDC	European Distribution Center
ETA	Estimated Time of Arrival
FMCG	Fast Moving Consumer Goods
FTE	Full Time Equivalent
FTL	Full Truck Load
GDPR	General Data Protection Regulation
ICT	Information and Communication Technology
IoT	Internet of Things
KPI	Key Performance Indicator
LL	Living Lab
LTL	Less than full Truck Load
MTO	Multimodal Transport Operator
NDA	Non-Disclosure Agreement
OTIF	On Time In Full
TMS	Transport Management System
R&I	Research and Innovation
WMS	Warehouse Management System
FMS	Fleet Management System

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