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

Deliverable D1.1: Market research: interviews, user needs & functional requirements analysis

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TABLE OF CONTENTS

Executive Summary	5
1. Introduction	6
2. Outcomes from the interviews	7
2.1. Current supply chain networks	8
2.2. Current transport operations and management systems	10
3. Proposed functional requirements	12
4. Conclusions	21
List of abbreviations and acronyms	23
Appendix 1: The questionnaire	24
A. General Information	24
B. Physical Assets and Data	24
C. Operations	26
D. Systems Supporting the Supply Chain Operation	27
Appendix 2: Outline set of functional requirements	30
Appendix 3: Data required for functional requirements	33
Appendix 4: Suggested parameters required in company and open datasets	36

LIST OF FIGURES

Figure 1: List of 21 companies interviewed	7
Figure 2: Outline schematic of proposed system	21

Executive Summary

This deliverable discusses the outcomes from 21 company interviews conducted over a period of four months between August and November 2018, and from these a list of functional requirements has been developed for the LOGISTAR system.

The companies interviewed come from a number of industry sectors and cover manufacturing, retail and logistics services. All manufacturing and retail companies interviewed use third party carriers, though the retailers and two of the manufacturers in the FMCG sector also have their own vehicles. All the logistics service providers have an own vehicle fleet but will supplement them with third party carriers. The predominant vehicle used by all companies is an articulated vehicle carrying palletised goods. Rail is only used in limited cases.

The manufacturing and retail companies all receive orders requiring a specific delivery date with the FMCG companies being more exacting with many orders requiring a specific time. The transport operation is supported by a range of transport management systems with the load planning function often carried out manually. Those companies that use computerised vehicle routing and scheduling do so in a tactical manner which means a high level of approximation is carried out with limited ability to change anything at the last minute. On road monitoring is also limited for companies that subcontract their loads to third party carriers.

The functions required for the LOGISTAR system cover the prediction of orders and travel time using historic data and external public and open source data. These will be used in the global optimisation element which will produce a range of routes to maximise vehicle fill and minimise the empty running of vehicles, taking advantage of any synchromodal rail opportunity. Routes involving collaborative partners will go through a negotiation process involving automatic plan generation software. A planning dashboard will display routes and schedules over a five-day period with the option of exporting selected ones to a company TMS. Companies will plan final routes and schedules as in their current operation and for a given day these will be uploaded from the company TMS to LOGISTAR for monitoring vehicles while they are on the road or rail. An execution dashboard will display real time information on the status of vehicles plus the latest KPI's enabling company planners to act at the earliest opportunity.

1. Introduction

The main aim of the LOGISTAR project is to allow effective planning and optimising of transport operations in the supply chain by taking advantage of vertical and horizontal collaboration among different sectors and companies and using increasingly real time data gathered from the interconnected environment such as Internet of things (IoT) devices, smartphones, on-board units and open data. To achieve this, a real-time decision support and visualisation tool of freight transport will be developed using advanced algorithms, big data analytics and artificial intelligence which will deliver key information and services to the various agents involved in the supply chain such as freight transport operators and their clients.

This aim will be achieved by:

- Identifying logistics related open data sources and harmonize this data together with the other closed sources (i.e. IoT devices and company data)
- Increasing the accuracy planning of logistics operations by applying artificial intelligence techniques for timing predictions and learning preferences of logistics chain participants
- Ensuring a seamless flow of the operations in the supply chain making use of machine learning techniques for identifying potential disrupting events and taking relevant actions to modify any required reconfigurations
- Making the best use of the available resources and provide the best possibilities for horizontal collaboration among logistics agents applying optimisation techniques to route planning and scheduling in freight transport networks
- Allowing negotiation among different agents involved in the supply chain taking into account any constraints arising in real-time, making use of distributed constraint satisfaction techniques

The first work package within the LOGISTAR project is required to undertake an assessment of current supply chain operations, inefficiencies and user needs, and from this to define a set of functionalities for the LOGISTAR system. This deliverable discusses the outcomes and conclusions from the interviews of 21 individual companies from a range of industry sectors in five different countries. They represented retailers, manufacturers, logistics service providers and a rail freight terminal operator, and they used a variety of transport modes. A semi structured questionnaire was used (see Appendix 1) based around the supply chain network, transport operations and the systems used to support the transport operation. From these outcomes a set of functional requirements have been defined for the LOGISTAR system. These requirements are intended to capture the behaviour of the system. They are described in a non-technical language so that they can be readily understood by a general audience.

The LOGISTAR system will complement existing company software such as transport management systems, interfacing with them to provide functionality that supports them by addressing weaknesses so that optimum transport operations are achievable.

The main outcomes and conclusions from the interviews are described in the next section of the report. These have been used to define the set of functional requirements which is in section 3 of this report.

2. Outcomes from the interviews

The table below shows the companies interviewed and categorised by three industry sectors plus a general sector referred to as Other. The companies highlighted in yellow are partners in the LOGISTAR consortium. The first three of these sectors, plus Zailog, were chosen because they represented companies operating in the areas of the three use cases to be performed in the LOGISTAR project.

<u>FMCG</u>	<u>Chemicals</u>	<u>LSP</u>	<u>Other</u>
Nestle	Huntsman	Ahlers	Zailog
Pladis	Celanese	Codognotto	Chep
Kelloggs	Vynova	NFT	Toyota
Mars	Du Pont	Turners of Soham	
Kimberly Clark	Corbion		
Asda	BP Chemicals		
Procter & Gamble			
Tesco			

Figure 1: List of 21 companies interviewed

Eight of the companies were in the fast-moving consumer goods (FMCG) sector, 6 of them being manufacturers and 2 retailers. All these companies were chosen because they had either previously been, or are currently involved, in collaborations, or have expressed a keen interest in the concept of collaboration. In the chemicals sector six companies were interviewed, and in the logistics service provider (LSP) sector four companies involved in supplying transport to shippers. The last category included the automotive manufacturer Toyota who collect car parts from various manufacturers across Europe to supply the car assembly plants. This category also includes Chep who rent pallets to a wide range of companies across Europe. The final company in this sector was Zailog who are part of Consorzio Zai, the landlords and operators of Interporto Verona, the rail freight terminal. This wide-ranging sample of companies has helped to provide a solid plan of what the LOGISTAR system should look like.

A semi structured questionnaire, shown in Appendix 1, was used to understand the supply chain networks used by these companies plus the transport operations and supporting computer systems.

The outcomes from these discussions identified not only how the current supply chain operations are conducted, but also identified weaknesses in the current systems. During the interviews it was important to ensure there was a consistency in terminology. In many cases different words were used by different companies which essentially meant the same thing. Thus, the words carrier, haulier, logistics service provider, 3rd party logistics (3PL) and 4th party logistics (4PL) were used which all imply externally provided transport to move goods. In many of the companies interviewed, constant themes that emerged from the discussions were echoed in a recent Mercedes-Benz Business Barometer survey¹, which showed that delivery drivers are losing more than one hour of their working day as a result of congestion. This survey of 2,000 truck owners and operators also found that congestion is a major barrier to growth. The top five transport related growth barriers were:

¹ <https://vans.mercedes-benz.co.uk/i/vans/home/fleet/van-insights>, September 2018

- Rising fuel costs 57% of responders
- Congestion 31% of responders
- Vehicle Expenditure 29% of responders
- Driver shortages 21% of responders
- Meeting increasing customer demand 16% of responders

There are considerable pressures on the supply chain operation to be as efficient as possible by achieving the desired service levels at minimum cost, whilst at the same time being aware of the environmental impacts. The focus of these interviews has been with companies that deliver ambient, non-hazardous, palletised goods. All companies interviewed transport goods by road and some complement this with rail, but it is a very small element of the customer delivery supply chain compared to the inward supply element where rail transport features more significantly. However, for all companies spoken to, they have less control over the inbound goods than outbound to customers. Inbound goods are typically received as a result of a production plan aimed at satisfying customer demand. Customer delivered goods are more complex in their operation with companies, particularly in the FMCG sector, having to satisfy tight delivery time windows.

The companies interviewed operate a range of different road transport categories. These include

- an owned transport fleet such as that operated by the FMCG retailers, plus Nestle and Pladis.
- a dedicated contracted carrier who would manage the supply chain on behalf of a company and provide vehicles dedicated to a company operation or would provide the main tractor units and drivers but tow company owned trailers.
- a non-dedicated contracted carrier who might use different vehicles each day for transporting a company's goods and who might be used because of their regional expertise, or for specific routes. This carrier's trailers might contain only a single company's goods (single user), or there might be goods from several companies on a trailer (shared user).
- Ad-hoc or spot hire carriers for unexpected, awkward or urgent flows undertaken on a one-off basis.

All four categories of transport are typically used in the FMCG and LSP sectors. Companies in the chemicals sector tend to use non-dedicated contract carriers only.

2.1. Current supply chain networks

All manufacturing and retail companies interviewed operate stocked distribution centres and do not tend to tranship or cross dock through stockless hubs. The exception to this are the FMCG retailers who operate primary consolidation centres (PCC) for smaller suppliers who deliver their goods into a PCC for consolidation so that only full vehicle loads (FTL's) are sent to the main stocked distribution centres (DC's). This minimises the number of trucks arriving at what are generally very congested DC's.

Articulated trucks are the dominant vehicle type used in the interviewed companies. Bulk tankers are used in the chemicals sector for transporting liquids and powders, though there are a significant number of articulated vehicles with standard box trailers that are used for palletised goods such as bags and drums. It is proposed that the LOGISTAR system should focus on ambient palletised goods as there would be issues with bulk tanker cleaning which would limit backhaul and co-loading

opportunities. In the FMCG sector palletised boxed goods are the norm but there are a range of different trailer types used. Some will be box trailers with either barn door or roller shutter opening at the rear, and there may be a tail lift. Some trailers will be curtain sided, often referred to as tautliners, which have the ability to be side loaded. There is also a trial of a longer semi-trailer taking place in the UK which is being used by some of the FMCG companies interviewed. This type of trailer which is up to 2m longer than the traditional trailer allows for 13% more pallets to be loaded, though the legal weight limits are still applied. Nestle and Pladis both load double height pallets into these and other types of trailers. A further trailer type used is a tall trailer with smaller wheels, referred to as a double deck, which permits up to twice as many pallets on two levels within the trailer. Finally, some trailers may have chill facilities, referred to as a reefer trailer, which can maintain products at various refrigerated temperatures. Compatibility of product and trailer have to be essential features of any LOGISTAR system. Generally, there is no problem with product compatibility within the individual sectors in the use cases, though checks will need to be made when the companies involved in the chemicals use case become clearer.

Some companies will have stand-trailers at their DC's, whereby trailers are left to be loaded or unloaded without the need for a tractor and driver. A slave tug in the DC's yard is used to move these trailers into position. This makes it a cheaper operation for the transport operators because a tractor and driver can pick up a loaded trailer or drop off a trailer to be unloaded more quickly.

The companies all use a transport management system (TMS) to manage orders, but the functionality varies depending on the type of transport being used. These TMS's can be based locally or centrally. Many of the multi-national FMCG companies have systems and planners based in eastern Europe for managing the entire European operation. In the case of Asda, the system is based in the US because of the Walmart ownership.

In the vast majority of cases, orders are delivered from a company's DC, with carriers coming in to the DC to collect those orders at a pre-booked time and then delivering to their target region. Some customers will send in vehicles to collect orders from a DC. In some instances goods are co-loaded, with part filled trucks leaving one DC, travelling to a second DC to add orders to the truck, before delivering to customers.

The chemical companies use rail for moving bulk product across Europe but there is limited use of rail for palletised goods. The short distances in the UK make rail a less cost-effective option than road for the FMCG sector, though a few of these companies do use a central England to Scotland rail link. The main reasons for not using rail include products not compatible with rail such as height of pallets, service levels can't be met or too expensive. Rail usage is often on the initiative of the contracted carrier rather than the shipper.

The volumes delivered obviously fluctuate throughout the year. Seasonality in parts of the FMCG sector are significant, particularly the Christmas peak. In the chemicals sector volumes can fluctuate based on various factors. For instance, one company that manufactures chlorine finds that volumes increase when the weather is hot, which means more people using swimming pools. Another is a manufacturer of chemicals that go to make PVC windows. In good economic conditions more houses are built which requires more windows and thus this particular chemical.

All the companies interviewed try and ensure the vehicles are used as efficiently as possible. Own vehicle operators and dedicated contracted carriers try and ensure trucks are loaded at all times with backloads where possible. However, this is within the constraints of their own operation which can

limit backhauling opportunities. Companies that use non-dedicated carriers all say they pay a one-way journey which suggests the onus is then on the carrier to find a backload. However, the likelihood is that a company will pay more than a one-way cost because pricing of trucks isn't necessarily transparent. For supermarket retailers, after delivering to stores many of the return loads are filled with empty roll pallets, packaging and food waste. Some companies mentioned that backhauling is not done in some instances because vehicles may not return to base in time for the next route.

In the FMCG sector the majority of loads are full truck loads (FTL). About half of these are single company orders, the rest are a mixture of orders for more than one customer. For the chemicals use case, which will be focussed on co-loading, it is likely that trucks will be loaded as efficiently as possible for multi company delivery.

2.2. Current transport operations and management systems

Orders are received by companies in a variety of ways. These can be by electronic data interchange (EDI), email, telephone or surprisingly, even by fax. Some of these orders are based on vendor managed inventory which means a company has visibility of a customer's stock and will replenish to achieve a certain stock level requirement at the customer. All companies interviewed have an enterprise resource planning (ERP) system which receives and processes orders to be delivered. When orders arrive they are checked that the products ordered are valid and the quantities required are available in stock. The financial status of the customer ordering is checked and that any required delivery date and time is achievable. Orders held on an ERP system may have the customers name and address but in some companies a code is used linked to the customer master file. The ERP system will generally add a code or name to indicate the source of the goods, typically a DC or manufacturing site, that will deliver to the customer. It will also convert the quantities ordered into weight and, sometimes, cube, plus warehouse picking units and transport footprint. A transport footprint may be a double stacked pallet which some companies operate. In this instance a stackability system ensures only the most appropriate pallets of goods are placed on top of other pallets, so that damage does not occur. In the FMCG sector a delivery date and specific delivery time is usually requested, but the chemicals sector tend to have greater flexibility as to when an order is to be delivered.

Orders are generally transferred from the ERP system to a TMS for arranging the delivery of the ordered goods but the features in these systems vary depending on the type of transport used to deliver goods. For companies that operate their own fleet or have a dedicated contracted carrier, the transport planning element of the TMS system is used to build loads, route and schedule vehicles. On despatch either the TMS, or a separate but connected system, handles the execution of the delivery. The TMS also handles proof of delivery and management of any issues arising from the delivery. Logistics service providers in Europe are legally required to complete a CMR document which is similar to the proof of delivery.

For companies that use non-dedicated contracted carriers, orders are typically offered to the carriers by email, or via a company portal using TMS's such as Transporeon or Transwide. These systems only display orders for the approved carriers to select. The TMS may specify a latest time for these orders to be collected from a DC. Carriers may then book a time slot at the DC to collect the ordered goods. The carrier will generally decide on the routing and scheduling of the vehicles, so the booked time slot for collecting the goods is often connected to whether a carrier vehicle is in the vicinity of the DC. If a DC is able to pick the goods at the carriers requested time, but it is maybe too early to

deliver, a carrier may temporarily hold the loaded trailer at their own local DC before it is sent to the customer. Some non-dedicated carriers will share loads with other customers to make efficient use of their transport. These carriers will generally communicate by EDI, telephone and email, with the company contracting them. Some carriers will also communicate directly with the company's customers, particularly if there is a problem with the delivery. For companies using non-dedicated carriers it is difficult to monitor what the carrier's transport is doing. In many instances, companies will only know that goods have been successfully delivered when a proof of delivery (POD) is received, and this may occur several days after the actual delivery. Some carriers will have in-cab technology but generally a company won't know the location of the trucks. The exception to this is Toyota where carriers collect manufactured car parts across Europe and bring them to Toyota's assembly plants. These trucks only carry Toyota product and there is a portal through which Toyota can see exactly where each truck is located. They are not permitted to see any driver performance characteristics. For other companies, there may be GDPR issues if their non-dedicated carriers combine other company products on a vehicle (shared user).

Although many TMS systems support computerised routing and scheduling (VRS), for many of the companies interviewed that operate their own vehicle fleet, the load planning is manual. There are several reasons for this but the most dominant one is that manual planners are more efficient at using trucks. This is because there is no flexibility in the parameters used by the VRS systems. A manual load planner can see the big picture and adapt these same parameters to exceed certain bounds if necessary (and legal) so that the minimum number of trucks are used. There was also a comment that it takes too long to set up and manage the parameters in these computerised systems. Those that use VRS do so in a tactical manner. That is, they use the system to route and schedule orders the day before delivery using standard road speed characteristics but have to manually adjust the plans on the day of delivery to reflect any delays that may have occurred either at the DC prior to setting off or on the road. Companies will typically only plan one day at a time.

When the load planners have scheduled the vehicles, the warehouse system is informed so that pick and despatch times can be planned. The TMS system may also add an estimate of arrival time at customers.

Some companies have systems that assess the ability of products to be stacked one on top of the other to ensure damage doesn't occur when transporting the goods. They also have systems to ensure that the weight of loads are spread evenly across the bed of the trailer.

When trucks are despatched a few of systems in the companies interviewed have the ability to monitor goods on the road in real time via tablets in the cab, though some have locational devices attached to tractors and trailers so their location can be monitored when they are separated. Delays on the road may occur but these are usually resolved with a phone call to a customer and being offered a reallocated delivery time slot. In very occasional instances deliveries are refused and need to be returned to the DC. For many companies delivery execution can be a 24/7 operation.

A record that the goods have been delivered is by a confirmation key on the tablet or, as in the case of carriers, an electronic transmission from the carrier to the company once the vehicle has returned to base and confirmed a delivery has taken place. If problems occur with a delivery such as an incorrect product or quantity, or damage of some sort, it is usually resolved by the driver making a mobile phone call to the company office. In some instances goods may have to be returned to the DC, which may cause a problem with any subsequent backhaul load. POD's and CMR's are still mainly paper based. These may be sent back to the company by post or possibly scanned by a

carrier before being sent back to a company via an EDI link. In general, there are very few instances of problems, with companies claiming well in excess of 95% successful deliveries.

Orders are generally archived, and there is limited analysis undertaken.

There are a large number of key performance indicators (KPI's) used by the companies interviewed but the extent to which they are monitored varies. The most commonly mentioned was on time in full (OTIF). In other words, the right quantity of the right products were delivered at the right time. Empty running is also measured but there was concern about the definition. Most companies defined it as a completely empty return leg of a journey. Capacity utilisation was typically measured in terms of the number of pallets on a truck rather than cube or weight. The products despatched by the interviewed companies were generally cube constrained rather than weight. Driver performance and productivity were often mentioned, with discussions held with drivers to discuss these KPI's. Drivers in some companies were incentivised to optimise fuel consumption which was also a measured KPI. Third party carriers were assessed on arrival to time, load to time, failure to arrive and whether they have returned the POD confirmations. There were various cost based KPI's as well as CO₂ measurements. Time compression is important for many companies so waiting time and turnaround time at customers were also measured. The level of vehicle asset utilisation was a common KPI.

3. Proposed functional requirements

Having discussed current supply chain operations with a range of companies, together with weaknesses in the way they operate, a set of functional requirements have been developed for the LOGISTAR system. Although the description of work (DoW) specifies a range of mode transports, these requirements have focussed on rail and road which is appropriate for the three use cases. The fundamental methodology will be the same so that LOGISTAR can be extended to alternative transport modes in the future. An outline of these requirements are shown in Appendix 2, together with a classification of "essential" or "nice to have" against each use case. Also shown is an indication of frequency with which certain functions should be performed. The requirements are categorised as shown by a dark blue separator line. There are a number of general requirements listed in points 1 to 11 in Appendix 2, followed by a set of requirements linked to the various LOGISTAR work packages, or company operation. One of the columns headed WP which attempts to indicate into which work package each requirement might sit. The first eleven are some general requirements which could be considered as a way of developing the system. There is also a classification of company function for some requirements which shows that an action by company employees is required, but would involve the LOGISTAR system having some functionality in the way it is presented to the companies systems. As a clarification, where the term route is used, this means a journey involving one or more visits to locations to deliver or collect goods and ending either at the location at the start of the route or some other predefined destination.

The requirements listed are elaborated on below.

1. **The Logistar system should be designed to compliment (run in parallel with) existing TMS systems** It's important to be realistic and pragmatic about what can be achieved in the timeframe for developing the LOGISTAR system. It is a decision support tool and will therefore compliment, rather than replace, a TMS. Therefore, there has to be seamless interfaces between the various companies existing TMS's, IoT sensors deployed and the LOGISTAR

system. These will include the transfer of orders and other data as described in Appendix 3 from company systems to LOGISTAR, the option to export selected routes and schedules from LOGISTAR to company TMS's in a standard format, latest predicted travel times LOGISTAR to company TMS's, and final agreed routes and schedules for a given day from company TMS's to LOGISTAR for active on road/rail event management.

2. **Intelligent adjustments to master data rules such as turnaround time for delivering at customer premise** - Turnaround delivery time at customers premises can be a significant contribution to the total journey time. Accurate predictions of this time could be very important. This also applies to turnaround time at distribution centres.
3. **Comparison of separate company operations compared with collaboration – to identify savings made, intelligent reporting** - The DoW states that the aim of LOGISTAR is to shorten delivery routes by 10% and improve vehicle load factors by 10%. In order to measure the benefit, it would be useful for LOGISTAR to produce separate company route plans in the first instance and compare these against route plans produced with collaboration permitted. These comparisons could be in the form of cost or kms and CO₂ saved, and vehicle fill (capacity utilisation). This approach would also help identify those combined flows that show the greatest saving which could be the focus of subsequent LOGISTAR planning.
4. **Routing & scheduling should ensure loads are single company where possible & backhaul preferred over co-loading/consolidation** - Many companies have shown reluctance to collaborate and they would all prefer to keep vehicle routing and scheduling within the constraints of their own operation. However, collaboration has been shown to be beneficial in many ways. Therefore, the LOGISTAR system should try and keep all deliveries and backhauling within company where possible and collaborate with external companies where it can be shown to be beneficial in terms of cost and kms saved.
5. **Overarching principle is that the total of all loads should be cost minimised** - In addition to point 4 above, the aim of LOGISTAR planning should be to ensure that the planned and real time routes can be achieved at the lowest cost for the required service levels. The cost of a vehicle is made up of a driver, a fixed vehicle cost such as depreciation, finance charge, licences and taxes, and a variable cost made up of fuel, maintenance, tyres and oil. Typically, this is split into one third driver cost, one third fixed cost and one third variable cost. The first two are time related and the variable cost is distance related. Invariably, in routing and scheduling systems, travel time is based on the quickest route since fixed cost and drivers cost represent two thirds of the total. The alternative is usually the shortest route. However, for this system to minimise the costs the cheapest route between two locations should be used by ensuring the time and distance are costed.
6. **Mechanism for cross charging of collaborative partners** - Where routes involve collaborative partners, a cross charging mechanism should be in place. This can be external to LOGISTAR, but the companies involved should have contractual arrangements and processes to allow for this. For instance, when company A's vehicles are used for company B's orders, company A will need to send an invoice to company B, and vice versa. However, the costs of such activity should be considered within LOGISTAR so that a recommendation as to which companies vehicles should handle which other companies orders can be made to company load planners. This feature could potentially be part of the negotiation functionality within WP5.

7. **Multiple day planning for all current and predicted orders** - All orders will be input to the LOGISTAR system, covering a five day period. If only a selection of orders are considered it is likely the LOGISTAR system will produce a sub optimal solution. However, there should be a means of identifying any orders for which collaboration with another company is not permitted. Having said this, the use case involving Codognotto & Zailog would only require specific orders to be input to LOGISTAR, such as those requiring synchromodal movement from Italy to Northern Europe.
8. **LTL orders should be combined into FTL for offer to hauliers (depends on contract pricing)** - This requirement is fundamental to the LOGISTAR planning system. All LTL orders will be bundled together within individual, and, if appropriate, across collaborative, companies to create FTL multi drop loads. These will then be submitted to each company's planning team for approval. This will be particularly beneficial where carriers are used and their rates are on a reducing cost per pallet basis, for instance, which means that a full load can be cheaper than several LTL orders.
9. **Knowledge of stand trailer locations to help deal with imbalances between locations** - A number of companies operate stand trailers which are filled and unloaded without the tractor & driver being present. These trailers are moved around a DC's yard by a slave tug after loading or unloading. The number of stand trailers required and available can be out of balance, so knowledge of where these stand trailers are located would be a "nice to have" feature.
10. and 11. **Live visibility of hauliers performance at the time a journey is assigned to haulier and Allocation of loads to the "best, most suitable, haulier"** - Another "nice to have" feature would be for company planners to see, on a dashboard, KPI's for the different contracted carriers who might be asked to deliver a load. The companies would then be able to see how well a carrier is performing and select accordingly.
12. to 15. **Prediction of orders/loads for the next five days and Calculation of route matrix of road travel times and legs (& distances?) between all these order locations (& potential RFT locations with rail waiting & travel times for synchromodal operation), by time of day & day of week for current & predicted orders, taking into account weather/road conditions** - The prediction module will require a significant amount of data to analyse and produce the outputs required by WP4 and WP5. There will be two prediction elements. The first will take the known current orders, examine the historic ordering profile of customers and try to connect this with any external source factors, or other company database information, to predict the likely customer orders over the next five days. This will aid both warehouse and fleet planning operations by giving advanced notice of likely volumes and vehicle requirements. The second prediction element will use the locations of the current and predicted customer orders together with the known origin of the goods (typically a company DC) to assess point to point travel times based on historic travel time information, known current travel information, and any predicted events or travel disturbances from open source data, including weather conditions and traffic. This will be of particular importance to the synchromodal use case which should consider all these factors to enable a decision to be made on whether to move goods by rail or road. It is likely that companies will not keep accurate historic travel times so a database will need to be available within LOGISTAR to hold this information. It will be necessary to understand the rules for freight travel planning - motorways/weight restrictions/height restrictions, etc. These timings should reflect the time of day and day of the week, since identical travel times will be variable

depending on these factors. Any travel time predictions will reflect a series of roads to be taken between two locations. This information will need to be conveyed to drivers when they start their journey to ensure any planned routes can be achieved. To aid the predictions it would be useful to have as much company data as possible in case any parameter may be shown to have an influence. These predictions can be considered as digital twins whereby they will update and change as their physical counterparts in the real-world change. The prediction module will continuously learn and update itself from multiple sources, particularly for travel time which will come from on-vehicle IoT sensors, to virtually represent the expected near real-time status.

16. to 24. **Routes & schedules will be produced for next five days using the matrices supplied by the prediction module, taking into account any intermodal options available, and regulations associated with drivers hours. and Optimise vehicle fill & backloading taking into account timing & offset distances to collect/deliver backhaul. Co-loading should be considered taking into account cost and timing. Ability to have multiple collect and deliver in the same route. Vehicle routes should not have to start and end at the same location. Sequencing of multi drop routes should consider backhaul opportunities. FTL loads should also take into account return load opportunities and have the option of steps/legs as in “pony express”, i.e. a system of relays via DC locations (drop and swap), ensuring timescales are met. Flexible routing to either return vehicle at end of route to origin or another location.** - These current and predicted orders, together with travel times, will be sent to the WP4 (Global optimisation module). Traditional LTL multi drop routes have been produced, often by computerised vehicle routing and scheduling systems, in petal shapes, i.e. vehicles set off from a depot and travel to various delivery points in a defined area and return to the depot empty after the last delivery. Similarly, FTL vehicles would set off from a depot to deliver to a single destination and possibly return to the depot empty. In order to achieve the desired 10% improvement in vehicle fill and 10% reduction in kms travelled, the LOGISTAR system should examine all the LTL and FTL orders, and route and schedule them so that empty running is minimised, and vehicle capacity is maximised. The aim is therefore to avoid missed opportunities to pick up additional loads for little increase in time or distance. Thus, the timings of FTL and LTL loads setting off from an origin, within the constraints of delivery time windows and drivers hours regulations, should coincide with goods to be returned from the vicinity of the destination or final delivery, to the vicinity of the origin, minimising the cost of such a route, and ensuring that the overall cost of all FTL and LTL journeys is also minimised. In particular, the sequencing of multi drop routes must take into account the possibility of a collection at or near the final delivery to bring goods back (backhaul) to the vicinity of the origin, again ensuring all costs are minimised. It would be useful if any routing algorithms used were able to take into account rush hour periods and attempt to avoid these whilst still achieving the desired delivery windows. This would improve truck efficiency and go some way to relieving congestion. The routing algorithms should also look at the possibility of switching loads between days, if possible, to see if more cost-effective loads could be obtained. This will be flagged up to company load planners to show the transport efficiency opportunity, and so they can action any changes with the affected customers.
25. **Routes with multiple orders/collections should be checked for product and vehicle compatibility** - It's essential that any backhaul matching uses vehicles compatible with the goods being moved. Similarly, where there are multi drop routes, the LOGISTAR system should check that they contain compatible orders and ability to stack one pallet on top of another. A database of goods, vehicle and stackability compatibility will be required.

26. Routes will be allocated to schedules which minimise the number of vehicles being used

- The LOGISTAR system will produce routes for all the orders and will allocate them to schedules of vehicles/carriers. These will be presented to the individual company load planners, as suggestions for them to use in their own TMS operation. Where a backhaul is involved, the company involved in the outward (fronthaul) movement will be used for the backhaul flow.

27. Ability to synchronise with rail if goods are compatible, timetables fit and cost is OK. -

Although sea, air and waterway have to be considered, the focus of the initial system development should be on rail movement, particularly for the Zailog & Codognotto use case, but also to include the option of using rail in the other use cases. Rail timetables should be built in to the LOGISTAR system and considered when serving customers. The system should compare the costs and timings of delivering directly by road, with a road-rail-road alternative, minimising any waiting time at the rail freight terminals. Synchromodality is the best possible combination of transport modes, selected dynamically for each incoming order, based on aspects like costs, duration, reliability, and sustainability, taking into account the smooth real time transition between modes. The LSP can have contracts with multiple carriers that have one or more modalities available to transport the goods. Synchromodality needs the ability to switch in real-time between transport modes tailored to available resources.

28. to 32. These routes and schedules will be visually presented to company load planners and Various activities within a company -

Each company would have its own automatic plan generating software (an 'agent'), within the LOGISTAR system, for routes involving collaborating companies. These routes should be passed to software agents representing the individual companies, which may then automatically accept, reject or modify them. The software should be able to rearrange the orders onto alternative routes if they feel a better solution can be produced. These alternative routes will be supported by the latest known route timings from the prediction module. The individual company software agents will allocate these routes into schedules. These alternative routes and schedules will then be sent back to the software agents of all the other companies involved, which again can accept them or propose modifications. This exchange of proposals will continue until finally a single plan is found that all involved companies can agree with. All of this will happen automatically but there will always remain the possibility for humans to intervene, and under all circumstances the final plan should always be verified by at least a human in each involved company. Any LOGISTAR routes involving collaborating company order(s) will show the minimum detail necessary for the load planners to accept or reject. All the final LOGISTAR planned routes and schedules should be presented to the individual company load planners with an with the opportunity of selected ones to be exported into a company's TMS in a standard format. It is unlikely that all the LOGISTAR routes and schedules will be exported so these will be supplemented with routes produced manually by company load planners on their TMS and these should be supported by the latest known route timings from the prediction module. External factors such as extreme weather conditions or strikes may prohibit certain orders from being delivered on the day required. In these circumstances company load planners should be informed so that revised delivery dates can be submitted to the LOGISTAR system for re-planning. The company load planners will allocate all routes to own vehicles and carriers according to current TMS practice. Where orders are to be offered to carriers such as in the chemicals sector, the current practice will be maintained. For dedicated carriers it will be important to discuss and identify how vehicles can be tracked in real-time. An example of this might be the Toyota model who are only able to see carrier locations, through a portal, but not driver performance.

33. to 34. **Revised routes and schedules (with transport allocation) in the company TMS will be passed to Logistar for updating and Final routes and schedules will be passed from the company TMS to the company's delivery execution system** - Company load planners will transfer final routes produced in the company's TMS together with the schedules and allocated vehicles to their delivery execution system, and to the LOGISTAR system so that on road/rail monitoring can take place. This will need to be done before a defined deadline (eg X hours prior to planned departure time). The revised cost, kms and CO₂ for these final routes will be compared with the original LOGISTAR routes & schedules, and used for reporting of potential and actual savings in kms, etc. Many of the companies interviewed use satnavs in their vehicles which provides up to date traffic information. However, depending on individual company requirements, the recommended roads to be used to meet the predicted travel times may need to be conveyed to drivers through some technology such as a smartphone or on-board unit so that the routing calculations can be achieved
35. **Real time route monitoring and changes made if efficiencies develop, or transport (truck/rail) is going to be late to prepare for knock on impact** - The LOGISTAR real time information freight service (WP6) will monitor the land-based activity of all modes of transport by interfacing to the IoT system of sensors on the various transports. These sensors will monitor current real time conditions of each vehicles GPS location. The delivery execution module will compare the predicted timings and activities against the actual timings and activities. An event will be triggered periodically, (e.g. every 15 minutes), informing company dashboards of the status of vehicles. An event can be considered as a state change which is expected or unexpected. In the case of the former this could be the expected and actual location of a vehicle matching, whereas the latter could be a delay caused by various unpredicted incidents such as accident, or congestion, for instance. The event management process should reflect situation awareness so that vehicle locational information is provided and can be combined with anticipation of what is happening in the vicinity of the vehicle, and what may happen subsequently on the journey. Any deviation from the roads suggested by the predicted travel time function should trigger an event to ensure routes are being followed. The system should compare the current vehicle location with the expected planned location. Where an event is triggered which indicates a delay of some sort, LOGISTAR should assess the expected length of the delay and consider rescheduling with new timings when the delay reaches a certain threshold (e.g. 30 minutes), there is a high risk of failing a pick-up/delivery, or when a major event occurs (e.g. vehicle break down, train cancellation, etc.). Types of events could be classified into:
- Minor < 30 minutes
 - Intermediate < 90 minutes
 - Major >90 minutes
 - Impossible to deliver

Any unexpected delay can then be acted on at the earliest opportunity. Where is discovered a delay that reaches a certain threshold (e.g. 30 minutes), vehicle locational information should be provided more frequently, say every 5 minutes (sensor battery life should be considered here), and a re-scheduling analysis undertaken with the latest known route timings. For synchromodal operations, if a significant train delay is known or predicted to be in excess of 12 hours, the rescheduling may consider unloading any trailer at the next available train terminal and continuing by an alternative train route or by road, providing the timings and cost are

acceptable. When a vehicle is back on schedule the event trigger can be reset to every 15 minutes. This could be considered as complex event processing (CEP) because it combines data from several sources to provide real-time decision support from analysis that may infer events causing delays.

36. and 37. Information to be displayed on company dashboard:

- a. Planned versus actual travel/delivery time, expected arrival time, etc.;
- b. Status of transport (location plus loading, travelling, break, unloading, and unexpected situations such as stationary for longer than, say, five minutes or off planned route);
- c. List of target and current KPI's;
- d. Event responses & incident prediction probability;
- e. Relevant open source information on likely weather/congestion/incidents
- f. Alerts & recommendations
- g. and Company informed of any suggested route changes with option to intervene.

As well as automatically re-assessing the vehicle routes and schedules, this option may be triggered manually by the company load planners as a result of information displayed on the dashboard. The dashboard should display high level information in each of the categories specified but should have the ability to drill down as necessary to gain further insight. When re-scheduling has taken place, the company load planners should be informed of all changes to live routes and schedules. For collaborative routes, information should be displayed on all collaborating company dashboards, with an indication that the vehicle concerned has multi company products on board. A negotiation should take place within the re-optimisation module (WP5) to agree the re-scheduling options. For the synchromodal use case it would be useful to display rail freight terminal status such as:

- a. waiting for a shunter to bring train in to terminal
- b. waiting for a reach stacker/crane to load/unload
- c. waiting in buffer zone
- d. train delayed waiting for late arriving trailer, etc.

38. Real time route timings will be passed to WP3 to update the historic route time database

- When routes have been completed the actual timings should update the historic route timings used by the prediction module.

39. and 40. IOT sensor to detect when trailer doors are opened/closed and Visibility of haulier trucks in real time (only for single user or co-loaded users - will be issues with regulations if shared user) - Although nice to have these could be part of the displayed dashboard information

In a single company environment, many of these requirements are available from the latest commercial TMS software, but the innovative aspect of LOGISTAR is to combine them all into a cloud- based system that works in a multi-company collaborative environment. There are many commercial vehicle routing and scheduling software packages available and it may be worth assessing these with a view to integrating one within the LOGISTAR system. However, if possible, the software should have the following features:

- to route with the ability to maximise backhauling opportunities
- to consider synchromodal road and rail options

- to have multiple collection and delivery in a single route
- to be able to co-load from more than one distribution centre prior to delivery
- to have the option of a route not ending at the starting point
- to consider multi day planning with a view to moving loads across days, if permissible, to produce more efficient and cost effective routes
- to recognise collaborative routes
- to accept an external route time matrix
-

plus the following features which are often standard in most commercial VRS software

- to take into account delivery time windows
- to allocate routes to vehicles and drivers that maximise use of vehicle and driver assets
- takes into account legal requirements such as drivers breaks and driving hours
- to allow for turnaround time at distribution centres and customer premises

Appendix 3 follows on from Appendix 2 with the same set of functional requirements. It indicates whether each functional requirement is an input, a process or an output. It also shows the source, specifying whether data is provided by the companies or external systems, or generated by the LOGISTAR system, and the type of data used by the requirements.

The main data required from companies for the prediction module in LOGISTAR are the current orders and historic orders to form a view of orders over the next five days, plus data from external public sources such as weather, traffic, political and economic, etc. and historic routings to enable vehicle route timings to be predicted.

To enable vehicles to be routed the global optimization module of LOGISTAR additional data will be required from company sources including information about the current own vehicle fleet and carriers used by companies, information about the own fleet drivers such as working hours to ensure legal requirements are met, and information about the facilities such as distribution centres and manufacturing including the location, opening times and booking slot allocations. Another essential dataset will be information about compatibility of ordered products and vehicles to ensure the appropriate vehicle and trailer is used for all orders. This is particularly relevant where collaborations occur.

To ensure that the transport planning module enables synchromodality, information about current rail timetables will be required including departure and arrival times by date. Knowledge of times to perform various activities at rail freight terminals would also be useful to ensure the timely arrival and departure of road-based vehicles at the terminals. Appendix 4 lists the possible parameters required in each of the datasets to enable the LOGISTAR system to function effectively.

The schematic in Figure 2 provides a high level, non-technical overview of the proposed LOGISTAR system. It does not show how the system should be designed, structured or set up technically. It should be seen from a logistics perspective of flows between the various functions.

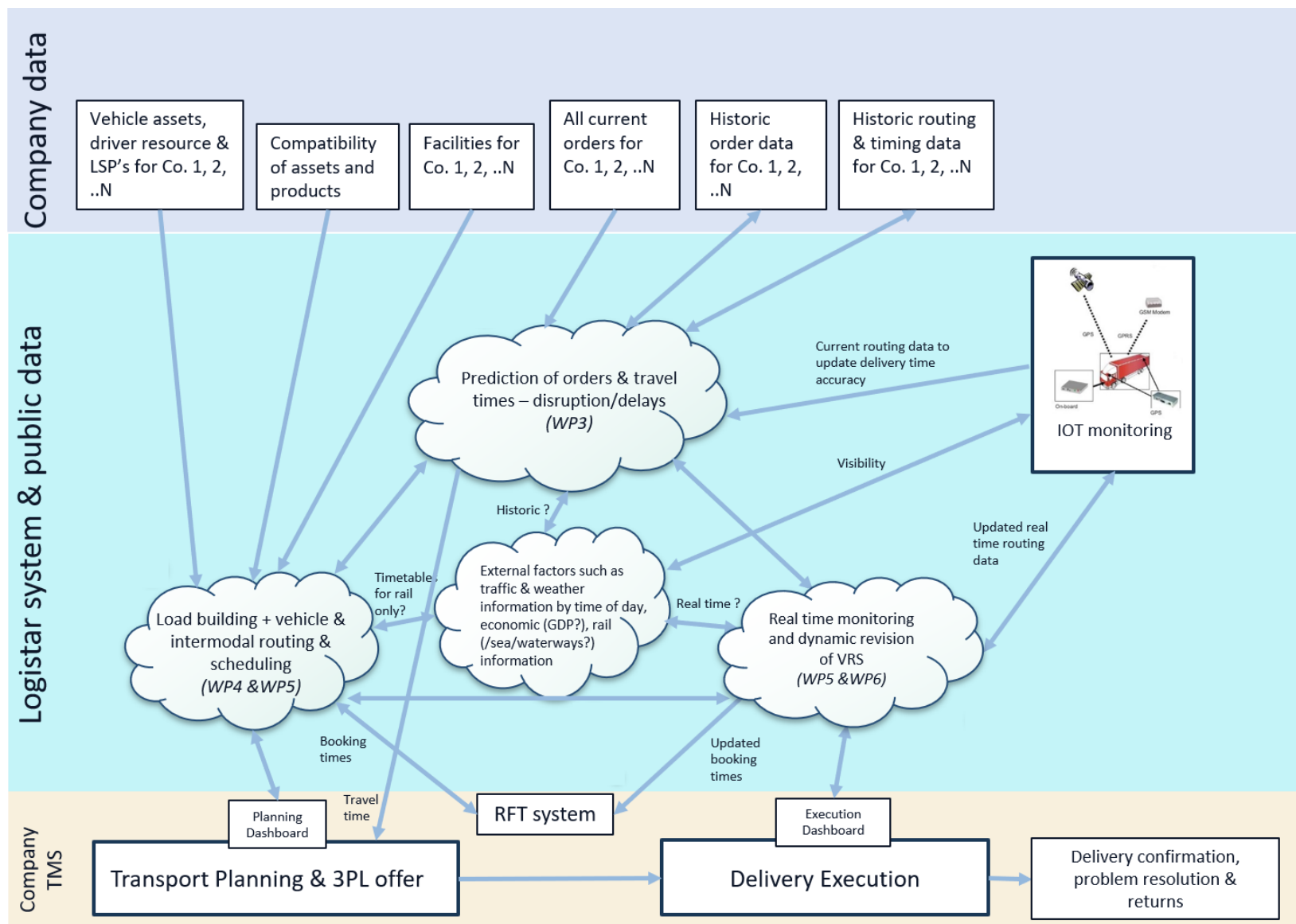


Figure 2: Outline schematic of proposed system

It is split into three horizontal sections. The top section shows the datasets required from companies, although as stated earlier, it is unlikely that the full information about historic route timings will be available. The middle section shows the connections between the various modules within the proposed LOGISTAR system, the external public data and, in the bottom section, the various systems operated by companies.

4. Conclusions

This deliverable has discussed the outcomes from 21 company interviews conducted over a period of four months between August and November 2018, and from these a list of functional requirements has been developed for the LOGISTAR system.

The companies interviewed come from a number of industry sectors and cover manufacturing, retail and logistics services. These companies operate in very different ways, even those within the same industry sector. Service is of paramount importance for the FMCG sector with cost a secondary issue. Although service is important in the chemicals sector, cost is an equal factor. The outcomes from these interview discussions have produced a large number of potential functional requirements for the LOGISTAR system but have been scaled back to produce, a more pragmatic and practical solution that can be developed within the project time available.

All the manufacturing and retail companies interviewed use third party carriers, though the retailers and two of the manufacturers in the FMCG sector also have their own vehicles. The carriers operating for the FMCG companies can be on a dedicated contract for the company supply chain or on a non-dedicated basis meaning any of the vehicles used by a carrier can be used for a company on a day to day basis. This latter option is common to the chemical companies. All the logistics service providers have an own vehicle fleet but will supplement them with third party carriers as required. The predominant vehicle used by all companies is an articulated vehicle carrying palletised goods with rail being a very small element of the supply chain operation.

Service levels for FMCG companies are paramount and orders will generally be received with a specific date and a rigid time to deliver, which if late may become a refused delivery. Chemical companies generally only have a delivery date with a flexible delivery time. The transport operation is always supported by a range of commercial or in-house developed transport management systems with the load planning function often carried out manually. Those companies that use computerised vehicle routing and scheduling do so in a tactical manner which means a high level of approximation is carried out with limited ability to change anything at the last minute. Loads or orders for carriers are offered in a variety of ways from portals to email and telephone. For chemical companies, on road monitoring is limited for subcontracted loads to third party carriers, with confirmation of order unknown for some days until a proof of delivery or CMR is returned. This is also true of those FMCG companies that subcontract their supply chain, with only some of those companies that operate their own fleet able to check immediately that goods have been delivered.

The functions required for the LOGISTAR system cover the prediction of orders and travel time using historic data and external public and open source data. These will be used in the global optimisation element which will produce a range of routes to maximise vehicle fill and minimise the empty running of vehicles, taking advantage of any synchromodal rail opportunity. Routes involving collaborative

partners will go through a negotiation process involving automatic plan generation software. A planning dashboard will display routes and schedules over a five day period with the opportunity for companies to export selected ones to company TMS's in a standard format. Companies may supplement these selected routes and schedules with options using their own company TMS. The final routes and schedules for a given day will then be uploaded from the company TMS to LOGISTAR for on road/rail event management. An execution dashboard will display real time information on the status of vehicles and the latest KPI's.

List of abbreviations and acronyms

3PL	Third party logistics company
4PL	Fourth party logistics company
CMR	Convention Relative au Contrat de Transport International de Marchandises par la Route
DC	Distribution centre
DoW	Description of work
EDI	Electronic data interchange
ERP	Enterprise resource system
FMCG	Fast moving consumer goods
FTL	Full truck load
KPI	Key performance indicators
LSP	Logistics service provider
LTL	Less than full truck load
NDC	National distribution centre
PCC	Primary consolidation centre
POD	Proof of delivery
RDC	Regional distribution centre
TMS	Transport management system
VRS	Computerised vehicle routing and scheduling system

Appendix 1: The questionnaire

This questionnaire has been designed so that a vision of an outline system can be developed. This can then be adapted and changed to reflect additional requirements as they emerge. All interviews will take between 2 and 3 hours and will be recorded.

A. General Information

1. Company:
2. Industry Sector:
3. Products or services of the company:
4. Countries of operation:
5. For LSP's and terminal operators – how many customers use your facilities
6. Size of the company (this location and worldwide, € and employees):
7. Contact name:
8. Function of the person being interviewed:

B. Physical Assets and Data

The aim of these questions is to establish the type of supply chain network being used and its effect on the company operations.

1. Please describe the type of facilities that you have – stockholding, cross dock, transshipment, EDC, RDC, etc. - locations
 - 1.1. Are these facilities owned or 3rd party operated?
 - 1.2. What are the operating hours of these facilities?
 - 1.3. For LSP's – are they dedicated or shared user facilities
 - 1.4. What sort of products pass through these facilities?
 - 1.5. What is the regional coverage of these facilities?
2. Please describe the type of road vehicles you operate – number, type (artic/rigid/etc.), trailer/box description, size
 - 2.1. What is the ratio of own to 3PL operations?
 - 2.2. How many vehicles are on the road each day – owned & 3PL
 - 2.3. What sort of distances do they travel – do drivers have overnights – what %
 - 2.4. Would your vehicles be able to deliver goods from other companies – collaboration requirement (In UK a standard national licence is required for carrying goods other than your own)
3. Do you use any other type of transport mode? – please specify

- 3.1. What type of operation/products/regions are they used for?
- 3.2. How frequently are they used?
- 3.3. Are they combined with other transport modes – which ones
- 3.4. Do you consider environmental issues in intermodal configurations?
4. What type of products do you sell?
 - 4.1. Are they manufactured within the company or purchased – from where
 - 4.2. What is the typical seasonality profile of these products?
 - 4.3. What are the storage and handling characteristics of these products – pallet, roll cage, chill, high value, hazardous, contamination issue, stackability, etc.
 - 4.4. What are the typical dimensions and weight of goods on the storage mode?

Information and historic data is requested for the following & would you share this data under an NDA:

Products ordered

Product code
Order number
Quantity
etc.

Product profile

Product code
Ambient/chill/frozen/hazardous
Dimensions
Weight
Stackability
Contamination data
etc.

Order data

Order number
Facility picking order or Supply location
Date & time order placed
Date & time order ready for despatch
Date & time required for delivery
Delivery window
Latest despatch date & time
Delivery location of order or Facility location
Special delivery requests
Predicted delivery time at destination
Problem delivery reasons
etc.

Facilities data

Location
Vehicle access constraints
Opening hours
etc.

Vehicle data

Tractor Id
Trailer Id
Vehicle departed from location
Date/time of departure
Current location
Date/time expected at destination
Order id's on vehicle
etc.

Tractor data

Tractor id
etc.

Trailer data

Trailer id
Carrying capacity in weight & dimensions/pallets
Curtain sided or barn door
Tail lift
etc.

Other transport modes

Rail
Short sea
Inland waterway
Pipeline
etc.

C. Operations

The questions in this section will assess the key operational factors to be considered in the LOGISTAR system and to assess the suitability of the organisation's operations in relation to collaboration.

1. What is the profile of ordering?
 - a. Typical order to despatch time
 - b. What are your service levels % - on time, in full, etc?
2. How do you decide which facility should pick an order?
3. What are the loading processes at the facilities and how long does it take?
4. How do you plan the allocation of deliveries: dates of departure, means of transport, how frequently do you update this planning, what variables do you consider?
5. For LSP's – do you pool orders from different customers to make up full vehicle loads
6. What proportion of orders are FTL/LTL, owned/subcontracted?
7. For FTL what proportion are backhauled (owned/subcontracted) and how is this managed?
8. For LTL do you attempt to maximise vehicle fill and how is consolidation achieved?
9. What are your thoughts about multi modal transport for elements of your supply chain?
10. Do you use time windows for delivery – are they a specific time or a range, flexible (if so, how flexible see 11.) or fixed, is there an indicator on the order
11. What tolerance do you have around expected delivery times at final destination?
12. Do you manage reverse logistics; i.e. end-of-life products, faulty products, packaging....?
13. Do you use any devices for tracking the goods and the delivery vehicles? Trucks position, position of deliveries, status of goods (in case of food temperature, humidity etc.)
14. What status updates do you get while the products are in transit? What status updates would you like to get?
15. What recourse actions are available while products are in transit? (e.g. can you change the destination of a truck? Can you change the next leg of a journey for a product?)
16. Do late deliveries incur financial penalties? If not, how important is reputation/trust damage?
17. How do you prevent and deal with problems/disruptions arising in your supply chain operation?
18. What status alerts, or predictions of future status, would cause you to take a recourse action? (e.g. the product is not now expected to be ready for dispatch until 4pm; road travel between A and B is expected to be delayed by 30 minutes; there is a 60% chance that the product will be more than 24 hours late reaching its final destination; all customs clearance at that port is expected to take 1 hour longer than usual; the ship containing your products is expected to be 12 hours late reaching the port; there is a 75% chance of a railway

workers strike in France on Thursday and Friday, delaying all shipments by up to 48 hours; there is an extreme weather front crossing the Atlantic which will cause cancellation of all flights west of Germany)

- a. What problems do you currently experience during transport planning or during transport? (e.g. such as road closures, strikes, delays of subsequent transport, floodwater, storm ..)
 - b. Are you able to rank such obstacles in the different categories?
 - c. In what percentage of all transports do such disturbances occur?
 - d. What are the main impacts of such obstacles?
 - e. How do you act/react to minimize negative impacts when such events arise and what effort do have to put in based on these actions?
 - f. Can you imagine if there are likely to be other obstacles in the future and if so, what would those be and how should a platform like LOGISTAR react to it?
 - g. How do you identify delays, or events that will affect a delivery?
19. Are there specific event types in the UK/European logistics networks that you know or believe have a significant effect on shipping success?
20. Do you use a system for registering the entrance or departure of a delivery?
21. Do you measure empty running? If Yes what is the percentage? How is the measurement calculated?
22. Do you measure vehicle fill? If Yes what is the percentage? How is the measurement calculated?
23. What other KPI's do you measure?

D. Systems Supporting the Supply Chain Operation

This section will highlight how technological advanced the company is and to what extent it uses systems to support the business:

TMS Software	Purchase date		Frequency of use				Explanation
	Always	Regularly	Sometimes	Rarely	Never	Not available	
Transport planning (load building, freight capacity, freight cost)							
Transport optimisation							
Vehicle/trailer/container/driver resource management							
Measurement							
Carrier Management - booking, contract							
Port & terminals operations - ...							
Risk Management							
International Logistics Management							
Parcel Shipping							
Benchmarking							
KPI Reporting (time, quantity, distance, fuel, driver, ...)							
Real Time Tracking - vehicle and freight location (telematics)							
Fuel management							
Strategic analysis							
Procurement							
Freight payment							
Freight claims							
Proof of delivery							
Compliance, safety & security							
Routing & scheduling optimisation							
Vehicle identity							
Goods monitoring, condition, status							
Environmental performance							
Driver behaviour monitoring							
Driver communication							
Yard management							
Traffic information - expected delays							
Predicted arrival & departure times							
Time slot management							
Interfaces to ERP systems							

1. Do these systems fully support your supply chain?
2. What analyses do you receive from these systems?
3. What actions do you take from these analyses?
4. What additional functionality would you like to see and in which of your systems?
5. Are there any weaknesses in the current systems you would like to see strengthened?
6. How do your systems communicate with each other, which ones, how and what protocols are used?
7. What aspect/proportion of transport operations are covered by your transport management system?
8. How frequently are orders transferred from the ERP system to the TMS and what time period do the orders cover (number of days?)

Appendix 2: Outline set of functional requirements

ID	WP	Main requirement	Sub requirement	Use case 1 - FMCG Nestle & Pladis		Use case 2 - Chemicals Ahlers		Use case 3 - Sychromodality Codognotto & Zailog		Frequency
				Essential	Nice to have	Essential	Nice to have	Essential	Nice to have	
1	General	The Logistar system should be designed to compliment (run in parallel with) existing TMS systems		✓		✓		✓		
2	General	Intelligent adjustments to master data rules such as turnaround time for delivering at customer premises			✓		✓		✓	
3	General	Comparison of separate company operations compared with collaboration – to identify savings made, intelligent reporting		✓		✓				
4	General	Routing & scheduling should ensure loads are single company where possible & backhaul preferred over co-loading/consolidation		✓		✓				
5	General	Overarching principle is that the total of all loads should be cost minimised		✓		✓		✓		
6	General	Mechanism for cross charging of collaborative partners		✓		✓				
7	General	Multiple day planning for all current and predicted orders	Certain orders may be excluded for consideration in collaborative routes	✓		✓		✓		
8	General	LTL orders should be combined into FTL for offer to hauliers (depends on contract pricing)		✓		✓				
9	General	Knowledge of stand trailer locations to help deal with imbalances between locations			✓				✓	
10	General	Live visibility of hauliers performance at the time a journey is assigned to haulier			✓		✓		✓	
11	General	Allocation of loads to the “best, most suitable, haulier”			✓		✓		✓	
12	WP3	All current & historic orders, historic travel timings and relevant public/open source data will be input to prediction module		✓		✓			✓	Daily
13	WP3	Prediction of orders/loads for the next five days	All current & predicted orders for next 5 days will be passed to transport planning module (TPM)	✓		✓		✓		Daily
14			These predicted flows will be sent through the TPM to the transport planning system for acceptance/modification & returned to TPM	✓		✓		✓		Daily
15	WP3	Calculation of route matrix of road travel times and legs (& distances?) between all these order locations (& potential RFT locations with rail waiting & travel times for sychromodal operation), by time of day & day of week for current & predicted orders, taking into account weather/road conditions	Travel timings sent to transport planning module (TPM) for Logistar to route & schedule, and, as an option, will also be sent directly to company TMS to support the manual load planning process	✓		✓		✓		On demand

ID	WP	Main requirement	Sub requirement	Use case 1 - FMCG Nestle & Pladis		Use case 2 - Chemicals Ahlers		Use case 3 - Synchromodality Codognotto & Zailog		Frequency
				Essential	Nice to have	Essential	Nice to have	Essential	Nice to have	
16	WP4	Routes & schedules will be produced for next five days using the matrices supplied by the prediction module, taking into account any intermodal options available, and regulations associated with drivers hours.		✓		✓		✓		Daily
17	WP4	Optimise vehicle fill & backloading taking into account timing & offset distances to collect/deliver backhaul. Co-loading should be considered taking into account cost and timing. Ability to have multiple collect and deliver in the same route. Vehicle routes should not have to start and end at the same location. Sequencing of multi drop routes should consider backhaul opportunities. FTL loads should also take into account return load opportunities and have the option of steps/legs as in "pony express", i.e. a system of relays via DC locations (drop and swap), ensuring timescales are met. Flexible routing to either return vehicle at end of route to origin or another location.	Collect (C) -> Deliver (D) (DTDVRPTW ¹) traditional collect FTL from DC and deliver, return empty	✓		✓				Daily
18			C->D->D->D (DTDVRPTW ¹) traditional collect from DC and multi drop route, return empty	✓		✓				Daily
19			C->D->C->D (DTDVRPTW ¹) traditional collect FTL from DC and deliver, followed by collect & deliver backhaul	✓			✓	✓		Daily
20			C->D->C->D->C->D (DTDVRPTWPD ¹ or DTDVRPTWDPB ¹) multiple collect & deliver on a single route, ideally with backhaul	✓			✓			Daily
21			C->C->D co-load from 2 or more DC's for a single FTL delivery		✓	✓				Daily
22			C->C->D->D co-load from 2 or more DC's for a multi drop route		✓	✓				Daily
23			C->C->D->C->D co-load from 2 or more DC's for a single FTL delivery, with collect & deliver backhaul		✓	✓				Daily
24			C->C->D->D->C->D co-load from 2 or more DC's for a multi drop route, with collect & deliver backhaul		✓	✓				Daily
25	WP4	Routes with multiple orders/collections should be checked for product and vehicle compatibility		✓		✓		✓		Daily
26	WP4	Routes will be allocated to schedules which minimise the number of vehicles being used	Where possible carrier loads will be scheduled in the same way	✓		✓		✓		Daily
27	WP4	Ability to synchronise with rail if goods are compatible, timetables fit and cost is OK.		✓		✓		✓		Daily
28	WP4 & WP5	These routes and schedules will be visually presented to company load planners	Where there are collaborations these will have been subject to automated negotiation algorithms and the outcomes will be highlighted for each company to accept or reject	✓		✓		✓		Daily

ID	WP	Main requirement	Sub requirement	Use case 1 - FMCG Nestle & Pladis		Use case 2 - Chemicals Ahlers		Use case 3 - Synchromodality Codognotto & Zailog		Frequency
				Essential	Nice to have	Essential	Nice to have	Essential	Nice to have	
29	Company function	The routes and schedules should be displayed on the Logistar system with the option for the load planner to select specific routes or groups of routes to be exported to the company's TMS	Company load planners would supplement those routes with manually produced routes for orders not exported from Logistar using the latest predicted time information from WP3	✓		✓		✓		Daily
30	Company function	Companies would allocate schedules to own fleet & carriers as current practice		✓		✓			✓	Daily
31	Company function	For collaborative loads, load planners will accept/reject routes		✓		✓		✓		Daily
32	Company function	All orders for 3PL delivery will be offered to carriers as current practice. This is particularly relevant to the chemicals sector		✓		✓		✓		Daily
33	Company function	Revised routes and schedules (with transport allocation) in the company TMS will be passed to Logistar for updating		✓		✓		✓		Daily
34	Company function	Final routes and schedules will be passed from the company TMS to the company's delivery execution system		✓		✓		✓		Start of day
35	WP5	Real time route monitoring and changes made if efficiencies develop, or transport (truck/rail) is going to be late to prepare for knock on impact	This may be due to delayed departure from warehouse, congestion on route, accident, etc. which will be flagged by IoT GPS	✓		✓		✓		Real time
36	WP3 & WP6 & Company function	Information to be displayed on company dashboard: 1. Planned versus actual travel/delivery time, expected arrival time, etc.; 2. Status of transport (location plus loading, travelling, break, unloading, and unexpected situations such as stationary for longer than, say, five minutes or off planned route); 3. List of target and current KPI's; 4. Event responses & incident prediction probability; 5. Relevant open source information on likely weather/congestion/incidents 6. Alerts & recommendations	This will appear on each companies systems and allow the transport planners to react and modify journeys as appropriate	✓		✓		✓		Real time
37	Company function	Company informed of any suggested route changes with option to intervene.	Any delays displayed via dashboard to allow them to contact customer if required.	✓		✓		✓		Real time
38	WP5 & WP3	Real time route timings will be passed to WP3 to update the historic route time database		✓		✓		✓		Real time
39	WP6	IOT sensor to detect when trailer doors are opened/closed			✓		✓		✓	Real time
40	WP6	Visibility of haulier trucks in real time (only for single user or co-loaded users - will be issues with regulations if shared user)			✓		✓		✓	Real time

Appendix 3: Data required for functional requirements

ID	WP	Main requirement	Sub requirement	Logistar - Input / Output / Process	Data requirements - externally provided to Logistar										Logistar generated data			
					Current orders	Historic orders	Historic route timings	Vehicle	Driver	Facilities	Product & vehicle compatibility	Rail time tables	Other public/open source data	Predicted orders /loads	Predicted route timings	Routes & schedules	Even	
1	General	The Logistar system should be designed to compliment (run in parallel with) existing TMS systems																
2	General	Intelligent adjustments to master data rules such as turnaround time for delivering at customer premises																
3	General	Comparison of separate company operations compared with collaboration – to identify savings made, intelligent reporting																
4	General	Routing & scheduling should ensure loads are single company where possible & backhaul preferred over co-loading/consolidation																
5	General	Overarching principle is that the total of all loads should be cost minimised																
6	General	Mechanism for cross charging of collaborative partners																
7	General	Multiple day planning for all current and predicted orders	Certain orders may be excluded for consideration in collaborative routes															
8	General	LTL orders should be combined into FTL for offer to hauliers (depends on contract pricing)																
9	General	Knowledge of stand trailer locations to help deal with imbalances between locations																
10	General	Live visibility of hauliers performance at the time a journey is assigned to haulier																
11	General	Allocation of loads to the "best, most suitable, haulier"																
12	WP3	All current & historic orders, historic travel timings and relevant public/open source data will be input to prediction module		Input	✓	✓	✓						✓					
13	WP3	Prediction of orders/loads for the next five days	All current & predicted orders for next 5 days will be passed to transport planning module (TPM)	Process	✓	✓									✓			
14			These predicted flows will be sent through the TPM to the transport planning system for acceptance/modification & returned to TPM	Process	✓	✓										✓		
15	WP3	Calculation of route matrix of road travel times and legs (& distances?) between all these order locations (& potential RFT locations with rail waiting & travel times for synchromodal operation), by time of day & day of week for current & predicted orders, taking into account weather/road conditions	Travel timings sent to transport planning module (TPM) for Logistar to route & schedule, and, as an option, will also be sent directly to company TMS to support the manual load planning process	Process			✓						✓		✓			

ID	WP	Main requirement	Sub requirement	Logistar - Input / Output / Process	Data requirements - externally provided to Logistar										Logistar generated data			
					Current orders	Historic orders	Historic route timings	Vehicle	Driver	Facilities	Product & vehicle compatibility	Rail time tables	Other public/open source data	Predicted orders /loads	Predicted route timings	Routes & schedules	Event	
16	WP4	Routes & schedules will be produced for next five days using the matrices supplied by the prediction module, taking into account any intermodal options available, and regulations associated with drivers hours.		Input & Process	✓			✓	✓	✓	✓	✓		✓	✓			
17	WP4	Optimise vehicle fill & backloading taking into account timing & offset distances to collect/deliver backhaul. Co-loading should be considered taking into account cost and timing. Ability to have multiple collect and deliver in the same route. Vehicle routes should not have to start and end at the same location. Sequencing of multi drop routes should consider backhaul opportunities. FTL loads should also take into account return load opportunities and have the option of steps/legs as in "pony express", i.e. a system of relays via DC locations (drop and swap), ensuring timescales are met. Flexible routing to either return vehicle at end of route to origin or another location.	Collect (C) -> Deliver (D) (DTDVRPTW ¹) traditional collect FTL from DC and deliver, return empty	Process														
18			C->D->D->D (DTDVRPTW ¹) traditional collect from DC and multi drop route, return empty	Process														
19			C->D->C->D (DTDVRPTW ¹) traditional collect FTL from DC and deliver, followed by collect & deliver backhaul	Process														
20			C->D->C->D->C->D (DTDVRPTWPD ¹ or DTDVRPTWDPB ¹) multiple collect & deliver on a single route, ideally with backhaul	Process														
21			C->C->D co-load from 2 or more DC's for a single FTL delivery	Process														
22			C->C->D->D->D co-load from 2 or more DC's for a multi drop route	Process														
23			C->C->D->C->D co-load from 2 or more DC's for a single FTL delivery, with collect & deliver backhaul	Process														
24			C->C->D->D->D->C->D co-load from 2 or more DC's for a multi drop route, with collect & deliver backhaul	Process														
25	WP4	Routes with multiple orders/collections should be checked for product and vehicle compatibility		Process														
26	WP4	Routes will be allocated to schedules which minimise the number of vehicles being used	Where possible carrier loads will be scheduled in the same way	Process														
27	WP4	Ability to synchronise with rail if goods are compatible, timetables fit and cost is OK.		Process														
28	WP4 & WP5	These routes and schedules will be visually presented to company load planners	Where there are collaborations these will have been subject to automated negotiation algorithms and the outcomes will be highlighted for each company to accept or reject	Output												✓		

ID	WP	Main requirement	Sub requirement	Logistar - Input / Output / Process	Data requirements - externally provided to Logistar										Logistar generated data			
					Current orders	Historic orders	Historic route timings	Vehicle	Driver	Facilities	Product & vehicle compatibility	Rail time tables	Other public/open source data	Predicted orders /loads	Predicted route timings	Routes & schedules	Events	
29	Company function	The routes and schedules should be displayed on the Logistar system with the option for the load planner to select specific routes or groups of routes to be exported to the company's TMS	Company load planners would supplement those routes with manually produced routes for orders not exported from Logistar using the latest predicted time information from WP3	Input & Process												✓		
30	Company function	Companies would allocate schedules to own fleet & carriers as current practice		Input & Process												✓		
31	Company function	For collaborative loads, load planners will accept/reject routes		Process & Output												✓		
32	Company function	All orders for 3PL delivery will be offered to carriers as current practice. This is particularly relevant to the chemicals sector		Process														
33	Company function	Revised routes and schedules (with transport allocation) in the company TMS will be passed to Logistar for updating		Output		✓										✓		
34	Company function	Final routes and schedules will be passed from the company TMS to the company's delivery execution system		Output												✓		
35	WP5	Real time route monitoring and changes made if efficiencies develop, or transport (truck/rail) is going to be late to prepare for knock on impact	This may be due to delayed departure from warehouse, congestion on route, accident, etc. which will be flagged by IoT GPS	Process														
36	WP3 & WP6 & Company function	Information to be displayed on company dashboard: 1. Planned versus actual travel/delivery time, expected arrival time, etc.; 2. Status of transport (location plus loading, travelling, break, unloading, and unexpected situations such as stationary for longer than, say, five minutes or off planned route); 3. List of target and current KPI's; 4. Event responses & incident prediction probability; 5. Relevant open source information on likely weather/congestion/incidents 6. Alerts & recommendations	This will appear on each companies systems and allow the transport planners to react and modify journeys as appropriate	Process & Output	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
37	Company function	Company informed of any suggested route changes with option to intervene.	Any delays displayed via dashboard to allow them to contact customer if required.	Input & Process												✓		
38	WP5 & WP3	Real time route timings will be passed to WP3 to update the historic route time database		Process & Output								✓		✓				
39	WP6	IOT sensor to detect when trailer doors are opened/closed		Process														
40	WP6	Visibility of haulier trucks in real time (only for single user or co-loaded users - will be issues with regulations if shared user)		Process														

Appendix 4: Suggested parameters required in company and open datasets

Data Type	Data	Data Type	Data	Data Type	Data
Order Data	Order Number Facility picking order (this could be Facility code) Date & time order placed Date & time order ready for despatch Date & time required for delivery Customer code or delivery location of order Quantity of transportation units in order Special delivery requests Tractor allocated to order (when scheduled) Trailer allocated to order (when scheduled) Driver allocated to order (when scheduled)	Historic route times	Tractor ID (with link to tractor description) Trailer ID (with link to trailer description) Driver ID (perhaps driver name if possible) Vehicle departed from location Date & time of expected/actual departure Destination location Date & time expected/arrived at destination List of order IDs on vehicle (to connect with a. above) Truck and trailer ID Driver ID (perhaps driver name if possible)	Facilities	Facility code Addresses Opening hours Vehicle access (restrictions) Typical loading/unloading times
Customer data	Customer Code Location of customer Vehicle access constraints Opening Hours Typical delivery turnaround/drop times	Vehicle data	Tractor ID Trailer ID Costs per hour Costs per km	Rail timetables	Train & schedules by departure and arrival locations Capacity Rail operator Real time information Train costs
Historic orders	Order ID Facility Picking Order Date & time order placed Date & time order ready for despatch Date & time required for delivery Customer code or delivery location of order Quantity ordered in transport units Special delivery requests Delivery accuracy (OTIF?) Failed delivery reason	Tractor data	Tractor ID Tractor type Tractor description Current location of tractor	Rail freight terminal	Terminal location Truck buffer capacity Time to load/unload trailer/container Truck waiting times Terminal costs
		Trailer data	Trailer ID Trailer type Trailer description Current location of trailer	Carrier data	Carrier ID/name Tractor & trailer types used Allocated delivery regions or lanes Carrier performance attributes Carrier costs?
		Driver data	Driver ID Driver name? Current status of driver Time already worked / allowed to work Current schedule	Public/open data	Weather Traffic Events of interest (to be specified) News articles (relevant) Pollution levels / location Economic Political