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

Deliverable D1.3: Network data collection, current supply chain network efficiency and collaboration opportunities – Release 1

Dissemination level:

☒ Public ☐ Confidential, only for members of the consortium (including the Commission Services)

Version number: 1.0

Submission deadline: 31/10/2019

www.logistar-project.eu

DOCUMENT INFORMATION

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Document control

Version	Date	Comment
0.1	11/10/2019	First draft
0.2	16/10/2019	Updated with Deusto comments
0.3	22/10/2019	Updated with Chemical & LSP input
1.0	29/10/2019	Final version

Document approval

Version	Date	Partners
1.0	29/10/2019	All partners

LOGISTAR project has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement no. 769142.

BASIC PROJECT INFORMATION

Horizon 2020 programme

H2020 - Mobility for Growth- 5-2-2017. Innovative ICT solutions for future logistics operations

Grant Agreement No. 769142

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Executive Summary

There can be distinct benefits for those companies that adopt collaborative practices, but there are many reasons that companies offer for not embracing this approach. Therefore, companies need to be convinced of the benefits, not only through discussions, but they also need to be shown the opportunities within their own supply chain operations to convince them of the business case. The aim of this work element task is to examine the supply chains of a number of companies from different industrial sectors in order to identify those flows that are suitable for collaboration and that are economically and environmentally beneficial to each company. This will provide confidence, not only for stakeholders taking part in the LOGISTAR project, but also for other shippers who might be interested in taking part in the living lab use cases.

This report evaluates and discusses an initial set of results from the detailed analysis of freight transport flow data supplied by a number of companies in different industry sectors. These companies are a combination of stakeholder partners plus other companies who have all expressed an interest in the LOGISTAR project and are also interested in taking advantage of the opportunity to collaborate to achieve cost and environmental savings.

In total 12 companies have supplied data for this first strategic phase, including three FMCG manufacturers, six chemical companies, two logistics service provider and a pallet pooling supplier. The data covered various periods of time and included order delivery information such as origin and destination locations, loads and delivery sequences, dates and times of despatch and completion, delivery windows, and quantities in various units. In addition, company facilities were identified, and the types of vehicles used. Generic vehicle costs were used to obtain a base case.

Excel, complete with add ins and specially written macros, has been used to undertake the initial validation and analysis of the data and this has been followed with the use of sophisticated modelling software such as Tableau and Llamasoft to assess the collaborative opportunities for reducing empty running and improving vehicle fill.

The base analyses have examined the load and delivery sizes, the daily, weekly and monthly demand profiles, regional densities and in the case of FMCG, pareto of customer demand, delivery windows and delivery to time. A network design model was used to identify a base case from which to compare the various collaborative strategies. All results were presented to the various companies to ensure they were satisfied with the outcomes so that the next stage involving modelling the empty running flows and small order customers could be examined for cost and environmental savings through collaborative arrangements.

For the FMCG sector, the backhauling of 53 previously empty flows were cost effectively matched at the strategic level. The outcomes indicate potential savings in cost, distance, time and CO_2 of 43% on these 53 flows, with an impact of reducing the original 25.4% of empty kilometres to 22.5%, an 11.2% improvement. For co-loading the vehicle capacity utilisation for customer orders of 18 pallet footprints or less is 62%. Modelling of these flows indicates a 12.5% improvement to 70% could be obtained at the strategic level.

It should be noted that these are the theoretical maximum benefits for the flows examined, which it may not be possible to realise in practice. Once the LOGISTAR system analyses the live real time networks of the companies, these savings will vary.

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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 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

1.1. Background

Logistics is the backbone of society and companies appear to be operating their supply chains very efficiently within the constraints of their own operation. However, there is clearly a problem with transport efficiency in Europe because EU statistics show that vehicles are filled on average to only 57% of their weight capacity, and 27% of vehicles are running empty. This results in an overall efficiency factor of 43%. If it were possible to increase this efficiency factor to 70% it would result in a saving of over €160 billion (World Economic Forum, 2009, Cruijssen, 2012). In addition, the EU's aim is to reduce dependence on imported oil, cut carbon emissions by 60% by 2050 and move 30% of road-based freight on to alternative modes of transport by 2030 (EU Transport White Paper, 2011). In order to achieve these aims significant changes are needed in supply chain operations.

Optimizing truck movements through collaboration routinely achieves cost savings and efficiency gains of between 6% and 10% according to Transport Intelligence (Graham, 2011). From the many surveys undertaken (EFT, 2010; Palmer et al, 2012; Gartner, 2012; ECR/McKinsey, 2012; Aberdeen, 2013) it is clear that collaboration is currently playing, or going to have to play, a key role in companies thinking and operations. There is a consensus of opinion from many companies that certain collaborative approaches would increase vehicle asset utilization and therefore achieve cost efficiency, whilst also reducing the environmental impact caused by logistics activities (Hingley et al. 2011). Practical demonstrations and pilot studies of new value chains and business strategies between major companies/shippers produced real world logistic cost reductions of 10-20%, and carbon footprint reductions of 20-30% (CO3, 2014). In the FMCG manufacturing sector, benefits such as enhanced customer service and better on shelf availability from more frequent deliveries were seen, together with lower inventory at customer distribution centres, and this was achieved with lower transport costs, better truck utilisation and lower carbon footprint (Surtees, 2013).

However, collaboration is not suitable for all companies. Those with rapidly changing or growing businesses are more likely to have fluctuating volumes and flows, plus potential changes to supply chain networks. Collaboration is most suited to established businesses with fairly constant and predictable movements and volumes. In the FMCG sector there are many common customers for the established manufacturers making it ideally suited to collaboration. Indeed, vertical collaboration, where retailers and manufacturers work together such as in vendor managed inventory, has been a feature of this sector since the mid 1990's. There are many other sectors like this such as automotive, electrical, chemicals and construction.

Using collaborative partners with a compatible mix of products, transport and delivery areas, enables higher capacity utilisation and reduced empty running to be achieved on road freight, with the added benefit of improvements to the sustainability through reduced emissions and congestion (Palmer & McKinnon, 2011). However, the generation of higher volumes from collaborative flows may provide opportunities for the use of alternative higher capacity road based vehicles and rail freight options which also have the ability to reduce costs and emissions (OECD, 2011; Bina et al, 2014; SteadieSeifi et al, 2014).

In the EU, competition law has often inhibited the adoption of collaborative practices since in many instances companies suitable for a collaborative partnership can be competitors. The legal aspects of collaboration were examined in the EU sponsored project Collaborative Concepts for Co-modality (CO3) (Biermasz & Louws, 2014). The outcome was a framework around which companies could legally overcome the limitations of competition law relating to collaboration by ensuring that any efficiency gains are shared with customers, and that the way the potential partners implement the collaborative arrangements should be transparent to avoid the accusation of them being a cartel.

1.2. Work Element

One of the work elements in the first work package within the LOGISTAR project is to undertake a strategic assessment of the collaboration opportunities for a range of shippers and transport service providers to identify efficiencies that reduce empty running and maximise vehicle fill. The focus of this work will be on the stakeholder partners within the consortium, but there are a number of other shippers who have provided, or will provide, data to supplement the work to obtain a detailed understanding of collaborative opportunities and savings. This group is made up of significant European shippers and LSPs, who have already started to make the mental shift necessary having shown a willingness to support the concept of collaboration.

There are numerous examples of projects arguing the case for horizontal collaboration and there are distinct benefits for those companies that adopt this approach as can be seen from various examples across Europe. However, although companies need to be convinced of the benefits through discussions, fundamentally they also need to be shown the opportunities within their own supply chain operations to convince them of the business case. The aim of this work package task is therefore to examine the supply chains of a number of companies from different industrial sectors in order to identify those flows that are suitable for collaboration and that are economically and environmentally beneficial to each company. This will provide confidence, not only for each stakeholder taking part in the LOGISTAR project, but also for other shippers who might be interested in taking part in the living lab use cases. The specific objectives are:

- To assess the degree to which distribution centre locations for each of the companies taking part are currently optimised with respect to factory/supply and customer/shop locations;
- To estimate the cost / energy / CO_2 benefits of reassigning customers/suppliers within the existing and an optimised network of DCs;
- To boost horizontal and vertical collaboration among those companies taking part, focusing on full truck load (FTL) backhaul opportunities, consolidation of less than truckload (LTL) deliveries, supply chain collaboration and synchromodal opportunities.

Four industry domains are to be considered in this strategic analysis. These represent significant supply chain operations with opportunities for collaboration. They are:

- FMCG: This sector has shown considerable interest in collaboration with many examples across Europe. Vertical collaboration between suppliers and their customers, in the form of vendor managed inventory, has been a feature of this sector since the mid 1990's and the UK institute of Grocery Distribution has been actively promoting horizontal collaboration. Letters of support for the LOGISTAR project have been received from a number of FMCG manufacturers and retailers. Two of the LOGISTAR consortium partners are Nestlé and pladis who plan to work together to realise transport and logistics synergies in their retail distribution network in the UK.
- Chemicals: Similar to FMCG, the chemicals sector has also shown interest in collaboration with many companies attending the CLICCS (Collaborative Logistics Information Community for the Chemical Sector) workshops, and EPCA, the European Petrochemical Association also encouraging collaboration through reports such as *A Paradigm Shift : Supply Chain Collaboration and Competition in and between Europe's Chemical Clusters*. Letters of support for the LOGISTAR project have also been received from many chemical companies.
- Logistics service providers: Initially, some LSP's saw collaboration as a threat to their business with shippers having more control over their transport operation. Now, however, many LSP's are embracing collaboration, seeing it as an opportunity to attract customers with new innovations to achieve lower costs. Codognotto, one of the LOGISTAR partners will work with a number of shippers and rail terminals in Italy to bundle freight flows and realise smart solutions for synchromodal shift. Other LSP's sent letters of support for the LOGISTAR project and one non-consortium member has shared data for the strategic analysis.
- Ports and terminals: These organisations play an essential part in enabling collaboration to happen through consolidation of customer transport. Understanding their role is key to successful collaborations with synchromodality an important element of this. Interporto Verona as a consortium partner, will play an active role in supporting the Codognotto operation.

During the development of the functional requirements for the LOGISTAR system, 21 companies were interviewed. Some of these were willing to provide data for this strategic analysis and were questioned about their supply chain operation, company culture and attitudes to collaboration, and where they think it might fit within their supply chain operation. These were helpful in developing an understanding of the issues or barriers that might be occurring from the strategic results.

2. Methodology

2.1. Approach

It is recognised that to achieve a step-change in transport efficiency larger and more complex collaborative initiatives are required by pooling the transport demands of numerous companies. To quantify the economic and environmental benefits of this higher level of collaboration it is necessary to collect, on a consistent basis, large amounts of transport data from companies wishing to participate in the initiative.

In this first phase of the strategic assessment, three companies in the FMCG sector (two of whom are stakeholder partners), six companies in the chemicals sector, a logistics service provider and a pallet pooling company, have supplied detailed flow data for analysis.

Various computer software models were used in the analysis ranging from a network design model interfaced to backhauling and co-loading software, a bundling, backhauling, and roundtrip tool (BBART), Llamasoft and Tableau, plus the functionalities, add ins and macro features provided in an Excel spreadsheet.

The data provided by the companies included all freight transport flows in a given period of time. For the FMCG sector, detailed data on each journey undertaken was provided. This included sequenced routes each day showing collections and deliveries, and covered flows between depots and customers, inter depot movements, and supplier collections under the company’s direct control (i.e. paid for by the company). Any collections by customers from company depots were excluded. Each of the origin and destination locations were specified using postcodes. Also shown was whether the journey was undertaken by an own vehicle or carrier and the quantities moved. The volumes were generally provided in weight and pallet quantities, but also in footprint units because some pallets are double stacked. Booking and delivery dates were given plus any delivery windows. All the companies used articulated vehicles with different sizes of semi-trailers. These trailers were typically capable of loading up to 26 pallet footprints but some were smaller taking 24 pallet footprints and some were longer semi-trailers capable of taking up to 30 pallet footprints. Because two of the companies examined in the FMCG sector are LOGISTAR partners, a more detailed analysis was undertaken. For the three companies examined, in order to establish a sound basis for cost comparison, Freight Transport Association (FTA) generic vehicle cost tables were used to apply fixed and variable costs, plus operational parameters, to the various vehicle types used by the companies (FTA, 2018).

From food packaging to pharmaceuticals, the chemical industry plays a dominant role in today’s national and global economies. Developing and sustaining a local chemical industry, able to compete on a global scale, has both economic and political importance as the chemical industry supplies the full spectrum of Europe’s manufacturing industry with intermediate products. In Europe many companies are located in clusters such as Tarragona, Antwerp/Rotterdam and Rhine-Ruhr. If companies can agree, this provides an opportunity for collaboration and supply chain benefits. A chemical cluster, like other industrial clusters, is characterized by a high concentration of manufacturing companies and service providers operating in the chemical business. But the cluster population consists also of associations and public or private organizations such as port and terminal authorities. Interviews with chemical companies as part of the functional specification has identified many drivers, as well as blockers, which impact the opportunity for collaboration. As part of the

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strategic analysis, six companies provided data to assess backhaul opportunities and bundling of smaller orders. These were Eastman, Chemours, Corbion, Procter & Gamble, Lubrizol, BP Chemicals.

Some were located in the Benelux area and Germany, others near Barcelona. The Spanish companies tended to deliver in Southern Europe whilst the Northern European companies distribute goods throughout Western Europe. The following data elements for the most recent full calendar year were requested from, and supplied by, the companies:

- Origin address = city, postcode, country (*)
- Destination address = city, postcode, country (*)
- Customer ship-to name (*)
- Customer sold-to name
- Order reference
- Transport mode(s) (*)
- Vehicle or unit type (tautliner, container, reefer,…)
- Transport date (*)
- Delivery time windows
- Product type (general cargo or ADR)
- Shipment size (pallets, load metres and/or kgs) (*)
- Shipment cost (can often also be deduced from contractual price matrices)
- Name of transport company or haulier

Fields marked with (*) were the minimum needed to analyse a network. Other fields were optional. These companies all used LSP's for their transport movements.

Logistics service providers have a key role to play in supporting the concept of collaboration. They attempt to optimise their transport operations by combining customer orders where possible in order to not only maximise their profit, but also to achieve the contractual requirements of their customers. Ahlers as well as another logistics company were analysed in this first phase of work, but for commercial sensitivity reasons the second one cannot be named at this stage. The data collected from these companies were the same as those for the chemical companies.

In this first release of the strategic analysis work element no data has been received from any ports and terminal operators and so have not been included in any results.

The flow data obtained from all these companies has been analysed and 'sense checked' to ensure it is consistent and appropriate for the task. This was to ensure that the data provided was valid and did not produce any unexpected results. The data was analysed using spreadsheet functionality and a range of relevant modelling tools to produce a base case for each of the individual participating companies. Anomalies in historic company data is inevitable and can often be explained by the companies. For instance, deliveries might start on one date and be delivered the following day, even though the distances involved may only represent a few hours drive. This can be explained by carriers, requiring an efficient flow, collecting the goods and keeping them overnight in their facility before delivering them the next day. Other anomalies that often occur are incorrect postcodes which means geocoding a location is difficult. Past experience has shown that, typically, up to 20% of locations may have issues. However, the location data received from companies has been fairly reliable, with realistic compromises made. Quantities can also often be an issue, with volumes

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possibly exceeding a vehicles capacity or zero, or the quantity units being incompatible, or multiple deliveries to the same location at the same date and time. Again, in many instances, companies can explain these anomalies. Some data are simply wrong and have to be ignored from the analyses. Instances, such as delivery dates and times occurring before the loads have been despatched were detected.

Discussions took place with each of these companies to ensure the accuracy of the data used and to ensure outcomes were satisfactory. After analyses and modelling and all the base cases agreed could the task of assessing the collaborative options begin.

The data was then combined to identify collaboration opportunities by examining a number of strategies which are split into two sections. The first covers company specific options and the second was related to various forms of collaborations.

2.2. Company Specific Strategies

It is essential to start with this set of strategies for three reasons. Firstly, they highlight any inefficiencies within a company's supply chain and may provide suggestions to the company to remedy. This would not only reduce their cost but would often reduce their environmental impact as well. Also, any suggestions would be more likely to be accepted and actioned if it is within a company's own supply chain. Secondly, it gives a measure of the level of inefficiencies, or not as the case may be, of supply chain operations in Europe based on a sample of companies. Thirdly, the results of these strategies are the "reward" for companies providing us with data. It has been found that companies are far more willing to provide data if they know that their supply chain operation will be analysed. The company specific strategies considered were:

1. Optimisation of the existing supply chain network – using centre of gravity techniques there may be cost and environmental savings by moving distribution centres or reassigning customers or suppliers to more cost optimised company facilities.
2. Use of alternative larger or smaller more fuel-efficient vehicles – there are significant fuel savings that can be achieved by using the right type of vehicle kitted out with the most fuel efficient aerodynamic equipment and tyres, and ensuring drivers understand the implication of their driving technique. These will vary depending on whether vehicles are used for long haul, urban or regional movements. This strategy will be duplicated in the collaborative assessment as well, since there are likely to be larger quantities available to be delivered when considering more than one company.

2.3. Collaborative Strategies

There are many types of collaborations that could take place including backhauling and various forms of consolidation of part loads. The strategies considered are:

1. Backhaul opportunities - reducing empty running by ensuring a vehicle can collect cost efficient return loads within service level and transport operation constraints
2. Co-loading of small deliveries - the combination of part loads originating from depots located near to each other and destined for the same, or nearby, customer locations.

3. Consolidation of small deliveries - the combination of part loads belonging to different companies but originating from the same, multi-user, depot and destined for the same, or nearby, customer locations.
4. Use of regional consolidation centres - channeling part-loads through a consolidation centre in each region whose location would be optimized with respect to inbound and outbound part load flows and enabling full load movements between regions.
5. Optimisation of urban freight and use of urban consolidation centres – to receive consolidated part loads from depots or regional consolidation centres some distance from cities and to make freight movement within cities more efficient.
6. Multi modal opportunities - being able to achieve critical mass for train movements has been one of the main reasons for not using rail. With the volume from a number of European companies the use of modes of transport other than road will be examined.
7. Consideration of logistics clusters – co-locating of company depots in a cluster to enable consolidation of all flows and enabling full load movements between clusters.

Based on outcomes from previous country-based studies, this approach should produce results showing significant cost and environmental benefits from collaboration opportunities.

In order to maximise the success of a collaboration it is essential to understand not only the cost and environmental benefits but also the issues of why there is a need to collaborate, with which companies it would be best to collaborate, which activities are most suited to collaboration and what are the key elements of collaboration.

Although some of the collaborative strategies represent what might be called “blue sky” thinking, these highlight any opportunities for companies and quantifies the potential benefits. They also represent steps on the roadmap towards a physical internet. If the most realistic and practical options were taken by companies, the benefits would be considerable, possibly up to 20% saving on cost and CO_2 emissions (Palmer & McKinnon, 2011). There would also be societal benefits from a reduction in the external cost of transport in terms of the number of accidents, congestion, air quality, noise and infrastructure.

The key is to have a sequence of practical interventions which are socially acceptable and economically attractive, and which drive down emissions. Although this work element has examined logistical activities, and alternative types of transport, additional benefits can be obtained from engineering aspects by optimising features such as aerodynamics and driving style.

3. Base Data Analyses

The purpose of these analyses is fourfold:

1. To validate the data and 'sense check' to ensure they show expected norms
2. To gain an understanding of the transport operations
3. To identify any commercial opportunities such as changing the locations of distribution centres or addition of regional transhipment centres
4. To identify any inefficiencies or anomalies

Because of commercial sensitivity, all data and results presented in this report have been aggregated and anonymised.

3.1. FMCG sector

In the course of task 1.1 Specification of business needs and functional specification, eight FMCG shippers and two logistics service providers focussing on the FMCG sector were interviewed about their supply chain operations and their attitudes to collaboration. FMCG consists of products that can be both ambient, chilled, frozen and fresh, perishable and non-perishable. Tight constraints on backloading and collaboration are imposed on companies with specialized vehicles or products with specific handling characteristics. Variable sized pallets, for instance, pose a problem for companies and their potential collaborators. This can be related to the different type of handling units such as cases, roll cages and stacks used by the companies. For example, companies with 1.5 metre height pallets cannot easily optimise vehicle utilisation when collaborating with companies using 1.9 metre height pallets. A similar case was found in a study by A.T. Kearney (1997) where variable sized pallets and roll cages were adopted by the FMCG companies. This created inefficiencies in the utilisation of vehicle cube. At present, according to data provided, companies only collect data related to the carrying capacity of a vehicle commonly recorded in tonnes or pallets. They are not collecting data based on volume that could improve vehicle fill.

The companies also spoke about food safety and quality standards of products delivered to the customers. That makes compatibility of product types and potential contamination of products an issue for consolidation of loads. For example, a company mentioned that consolidating food products with other products such as washing powder affects the odour and causes possible contamination of their food products. The companies are legally obliged to use standard quality assurance systems at each step in the food supply chain to ensure the safety of food and to ensure that they meet strict quality standards imposed by regulatory bodies (Trienekens and Zuurbier, 2008). This includes the transport of food products where companies need to comply with certain hygiene standards during loading/unloading of vehicles. Therefore, the handling of food products and consolidation with other products becomes difficult especially between temperature controlled and ambient vehicles.

The findings from the interviews revealed that many manufacturers relied on 3PL's to optimise their backloads. A manufacturer with their own fleet stated that "*it is difficult to optimise any return deliveries below the Coventry area as it is more expensive and time consuming to find return loads in the South as depots are clustered in the Midlands*". A retailer who had difficulty in finding return loads from the South also provided a similar reason. This said, both organisations were open to the idea of collaboration opportunities with other companies or a 3PL for backhauling in that geographical region. The retailers were also looking for opportunities to reduce empty running on return journeys.

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Based on the interviews, there was a significant interest among all companies to collaborate with external organisations. Generally, they were involved in vertical collaboration with their suppliers. However, examples of horizontal collaboration among companies to consolidate loads and improve vehicle utilisation is still limited despite the Nestle/pladis collaboration still held as a classic success story. Developing internal and external collaboration requires massive cultural and organisational change and most of the time internal resistance in the firms prevents implementation of collaboration (Ireland and Bruce, 2000).

3.1.1. Review and validation of company base data

Although the focus of these analyses has been on the partner stakeholders of Nestle and pladis, a third FMCG company, Kellogg's has been included in the strategic evaluation to avoid the ability to disassemble any of the results.

2018	Number of flows	Number of drops	Footprint pallets dropped	Total cost	Cost per pallet dropped	Total distance (km)	No. of vehicles	Tonnes of CO2
Total	4,784	270,237	4,776,845	£80,959,556	£16.95	75,235,604	250	71,196

Table 1 Summary of movements for all three companies

A summary of the annual movements for all three companies is shown in Table 1. The 4,784 flows were all between origin and destination locations unique to each company. Two of the companies used a combination of own transport and carriers, and one used carriers only. The outsourcing arrangements meant that the companies were not aware of how many actual vehicles were involved in their operation in total. By using the network design model, an assessment could be made of the number of full-time equivalent vehicles likely to be required. At any time, on average, there would be about 250 vehicles on the road, but extra vehicles would be needed to cover peak periods and downtime for maintenance or repair. There were a total of 49 distribution centre and factory locations for these companies but many of them delivered only small volumes. The smaller facilities tended to be based at production sites serving one or two customers directly, or depots located in areas of low demand.

A Pareto analysis of the delivery locations for all companies showed that about 11% of customers accounted for 80% of the pallet footprints delivered indicating a great reliance on just a few key customers. These are likely to be the distribution centres of the main supermarket retailers.

Within the FMCG sector as a whole there is generally a typical seasonal peak towards the holidays of Christmas and Easter. However, some companies have a diverse range of products which can smooth out these peaks. For instance, water and ice cream are typically higher volumes in the summer periods. Certain products such as breakfast cereals and coffee do not show any marked seasonal peaks across the year unless there are specific sales promotions. All three company's deliver goods seven days a week with the profile shown in figure 1 below.

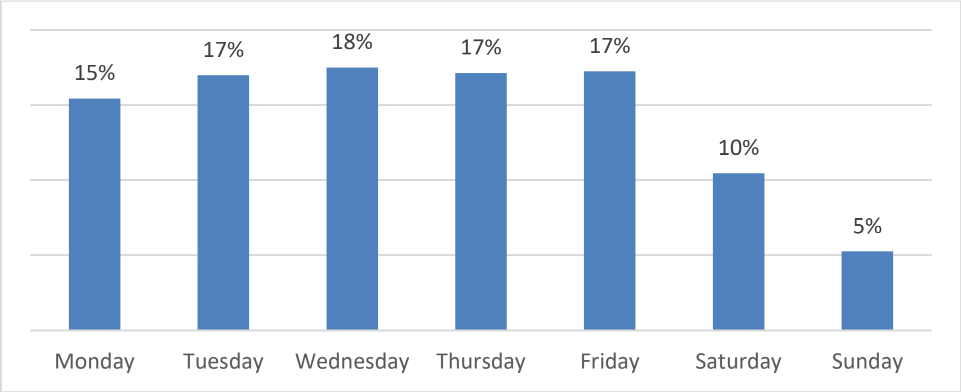

Figure 1 Percentage of pallet footprints delivered by day of the week

In terms of customer delivery size, figure 2 below shows that, on average for the three companies, over 50% are full truck loads reflecting the volumes being sent to major retailer's distribution centres. About a third are less than 16 pallets which would typically be combined with other deliveries into multi drop full truck loads. This is borne out by figure 3 below which shows that over 70% of loads are FTL and about 20% are LTL.

Vehicle capacity utilisation for the three companies, expressed as a percentage of the maximum pallet footprint of a standard length articulated trailer, is averaging 79% for customer deliveries, but is over 95% for factory to warehouse movements.

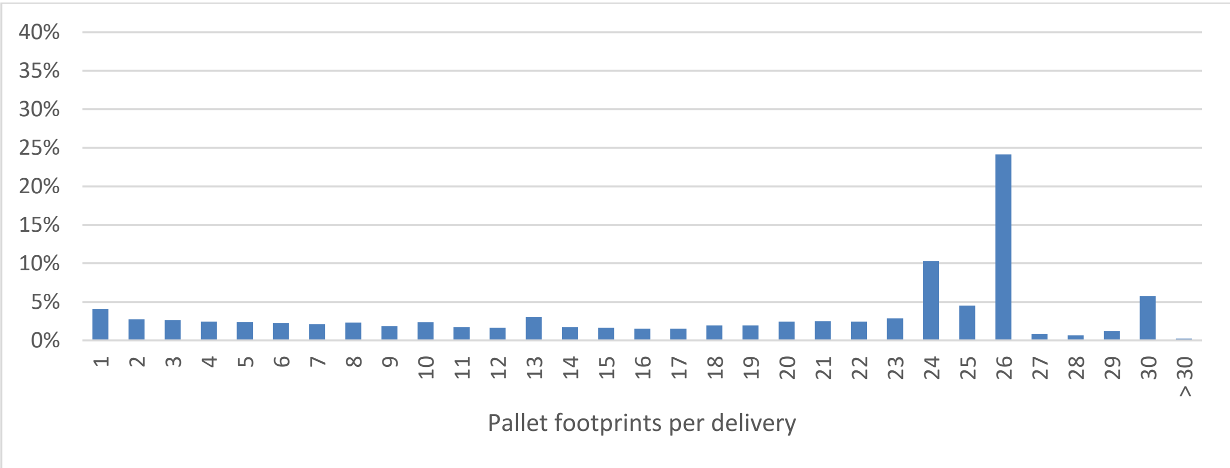

Figure 2 Percentage of customer deliveries made by drop size

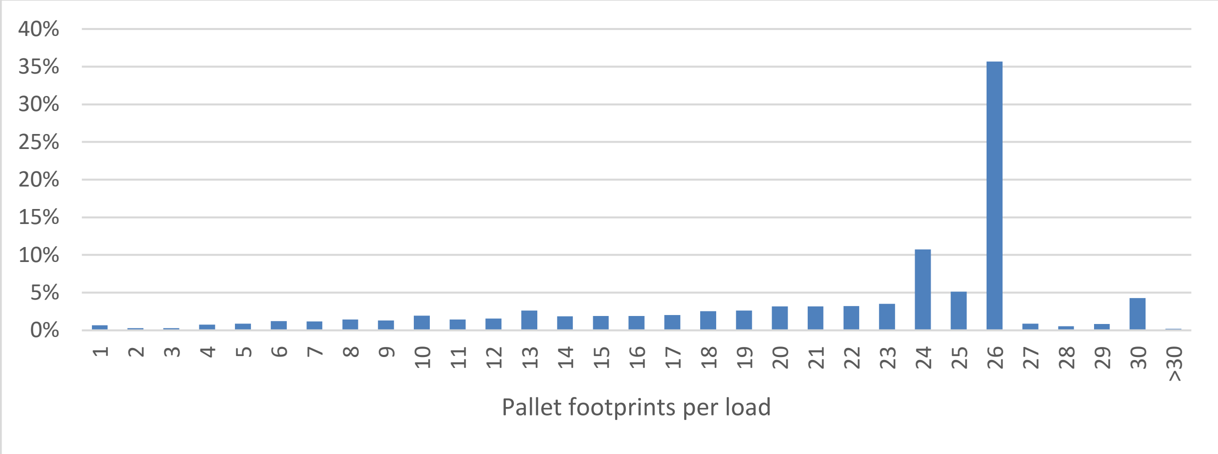

Figure 3 Percentage of vehicle loads by number of pallet footprints

Demand for FMCG comes from the population so the area density plot shown in figure 4 below is typical for most companies in this sector. The map shows the percentage of pallet footprints delivered into postcode areas. Retailer distribution centres, serviced by manufacturers, are typically located in areas designed to serve their stores cost effectively and the stores are located to serve the population. The high-density areas, shown in dark green, are predominantly in the central, most populous, locations of the UK

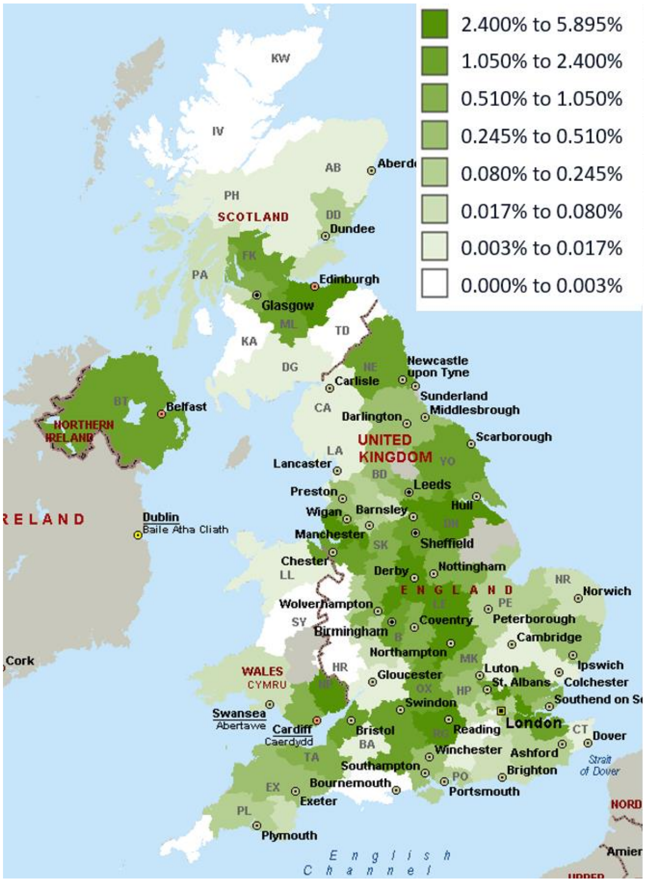

Figure 4 Regional demand profile showing the percentage of pallets delivered

The majority of deliveries made by the three companies had to meet customer delivery time windows as shown in figure 5 below. 38% of deliveries had a specific time to deliver, with 11% of deliveries allowing delivery any time within a 24 hour window.

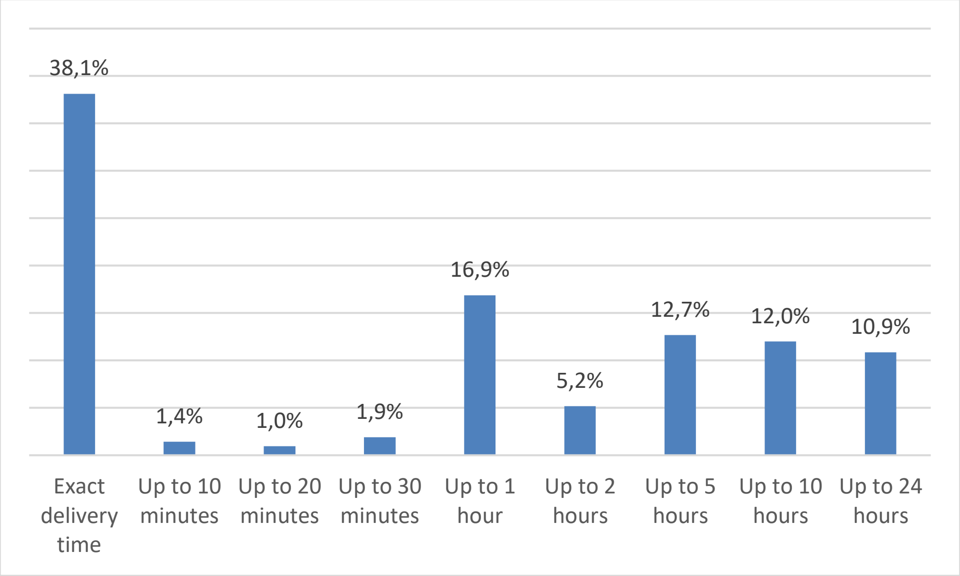

Figure 5 Percentage of deliveries to meet a given time window

An analysis of delivery time accuracy is shown in figure 5 below. It can be seen that over half of all deliveries made by the three companies met the delivery window criteria, with nearly 30% arriving early and just over 17% arriving later than planned. Over 7% of the deliveries were in excess of 2 hours late, with 1.1% of these arriving more than 20 hours later.

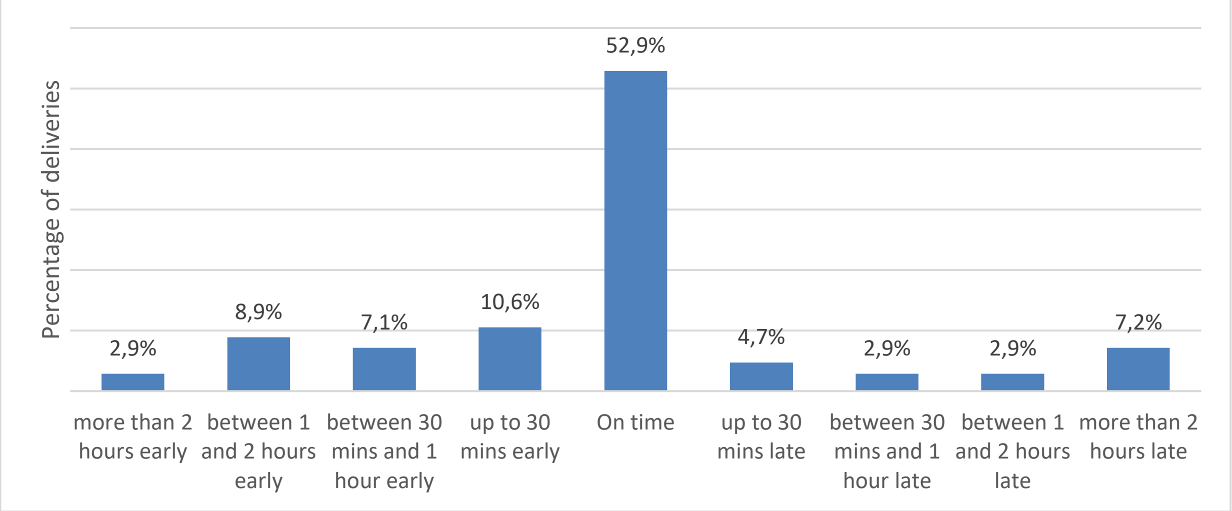

Figure 6 Delivery time accuracy

In order to ensure these outcomes and analyses corresponded with what is known and expected within the individual companies, these results were presented to each company to ensure they were valid and suitable for the collaborative assessment. During these discussions, factors behind any anomalies and changes to the data were explored.

3.2. Chemicals Sector

For the strategic analysis in the chemicals sector, flow data was collected from 6 chemical shippers as well as from 1 Logistics Service Provider (Ahlers).

The transport flows were visualized and mapped before being analysed for synergy potential. Distances and transport routes were derived from Tableau and Llamasoft software supported by a Google Maps API. In order to calculate transport costs, this was connected with contractual price matrices some of which were generic (based on previous market tenders) and some of which were provided the companies. Although delivery time windows were requested, in the chemicals sector this wasn't an issue and delivery on a specified day was all that was needed. Only packaged, palletised goods were examined for the companies under analysis. Dangerous goods were left out of scope for the analysis.

3.2.1. Review and validation of company base data

Seasonality was examined to identify peaks and troughs in the year. The variations were dependent on the type of chemicals supplied such as one company that provided chlorine saw peaks in the summer months when swimming pools were most used. Another who supplied PVC material used in the manufacture of windows saw interruptions in the case of bad weather when construction was slowed, or fluctuations in GDP which meant the level of construction such as house building varied.

The entire European distribution network was examined for each company, and the trade lanes with the highest frequencies and volumes were identified on the basis that these would have the greatest opportunity for collaboration. Most chemical companies transport a mix of FTL and LTL shipments. For the investigated chemical companies in the Barcelona area, being a regional area for distribution, typically 90% of all orders were LTL, making them a prime co-loading opportunity.

3.3. Logistics service providers

3.3.1. Review and validation of company base data

For investigation of the chemicals LSP sector, outbound flow data for the full calendar year 2017 was analysed from the European Distribution Center of LOGISTAR partner Ahlers. This EDC, which has been sold off in the meantime, was a hub for storage and distribution of chemical products at the time of the study.

Figure 7 Ahlers Chemicals EDC in the Port of Ghent Belgium

This LSP distribution network, covering multiple chemical shippers such as Eastman, was investigated for outbound co-loading and synchronization opportunities.

The datasets which were received directly from chemical shippers elsewhere in Europe focused on LTL co-loading as well as FTL backhauling potential.

For one of the companies mostly full truck load movements were investigated in order to find backhauling opportunities. For the other shipper networks, mostly LTL and co-loading (bundling) were considered.

One of the chemical shippers that provided data for the investigation of FTL roundtrip potential in the European transport network was a manufacturer of paint and specialty chemical products with administrative headquarters and a physical distribution hub nearby the Port of Antwerp, Belgium.

It operates around 100 structural LTL and FTL transport lanes across Europe with outsourced capacity. The majority of its distribution happens through LTL shipments with various groupage providers. A small portion of its distribution, especially intercompany deliveries and shipments to large key customers, happens with outsourced FTL transport.

Another group of chemical shippers provided LTL distribution data focusing on their logistics operations in the Barcelona, Spain region.

The supply chain management teams of all of the investigated companies had a structural interest in horizontal collaboration and freight flow bundling to improve logistics costs, service levels and transport sustainability.

3.4. Ports and terminals

At the present time data is not available to assess the strategic possibilities in this section. Analysis of this type of operation will take place in the second phase of this work element.

LOGISTAR project has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement no. 769142.

4. Analysis of Collaborative Initiatives

At an operational level, the companies in the interviews recognised that collaboration can bring long-term benefits that can drive increased cost-savings and greater efficiency of vehicles. However, companies potentially need to collaborate with their competitors in order to gain full benefits from collaboration. This creates a barrier to the implementation of full collaboration.

Seven collaborative initiatives will be considered using the combined data from the various companies supplying data. For this first stage of the 1.3 work element, two initiatives are described below. The results only cover the transportation of the goods. No allowance has been made for facility-related costs and the costs associated with CO_2 emissions. The baseline figures for 2018, against which all comparisons are made, are shown in Table 1. The assumptions made about load sizes are that a full load is be any single movement between an origin and destination that represents more than 80% of the capacity of the vehicle used for that movement, typically more than 20 pallets. Similarly, a part load has been assumed to be any single movement that represents less than 60% of the capacity of the vehicle used for that movement, typically 16 pallets.

4.1. FMCG sector

4.1.1. Backhaul opportunities

The flow data supplied by the companies showed the delivery sequences against vehicle loads or shipments. Using this information, it was possible to derive empty legs in any route. In some instances, legs were clearly identified as being empty. For all empty leg flows returning to a company facility, whether it is a distribution centre or factory, the inference is that there must have been a filled vehicle load going in the opposite direction, from the company facility. Because the backhaul model being used is a strategic tool, only empty legs that occurred in excess of 52 times a year were input to the model. The reasoning behind this being that there was a greater chance of matching loads if there were at least one per week on average. Based on research by Cundill & Hull (1997) and McKinnon & Ge (2006) an assumption was made that the maximum offset distance (that is the extra distance travelled by a vehicle in going to collect a backhaul load plus the distance between the destination of that backhauled load and the vehicle's original starting location) would be 100km, or half of the outbound distance, whichever was the lower value. Cost analysis revealed that there were a number of instances in which the total cost of backhauled loads with an offset distance between 60km and 100km exceeded the cost of two separate journeys with empty backhauls. These were excluded from the results. In some cases, the time taken to perform a backhaul slightly exceeded a driver shift of 10 hours requiring a second day to complete the journey and a step-increase in operating cost. Any matched movements that were less than 2 hours over a shift time were excluded. Finally, any outbound journeys of less than 15km were also rejected. The software prioritised backhauling within a single company's logistics system were possible. It also ensured that the vehicles used were always compatible with the goods being moved.

To ->	Nestle		pladis		Kellogg		Total	
From	No of flows	Cost saving over two way	No of flows	Cost saving over two way	No of flows	Cost saving over two way	No of flows	Cost saving over two way
Nestle	21	£745,010	0	£0	0	£0	21	£745,010
pladis	10	£260,854	20	£798,876	2	£47,507	32	£1,107,237
Total	**31**	**£1,005,864**	**20**	**£798,876**	**2**	**£47,507**	**53**	**£1,852,247**

Table 2 Results of backhauling model

These results shown in table 2 are the maximum that might be possible in one year based on the 2018 historic data provided. They show that it might be possible to combine 21 flows within Nestle and 20 flows within pladis each saving about a quarter of a million pound per year. There are 10 flows that could be matched if Nestle and pladis collaborate and 2 flows if pladis and Kellogg collaborate, although this latter saving may prove too small to justify the action. With the manual load planning that takes place in Nestle and pladis the within company matched flows might easily be missed. The backhauling model looks at the cost comparison of an empty return leg or a backhaul, but manual planners would not have that information easily available to them, but with an automated live, real time, system such as LOGISTAR these matches would be presented to the planners and the savings achieved.

The data received from the three companies indicated that empty running was 25.4% of all kilometres travelled. This compares with UK statistics indicating that kilometres run empty by articulated vehicles is 28.2% (DfT, 2018). In Europe, Eurostat figures do not break down the percentage empty running by vehicle type but indicate that nationally, for 28 EU countries, empty running for road freight transport, as a percentage of all kilometres travelled, is 23.1%. Clearly, the three companies are achieving a slightly better than average empty running percentage for UK vehicles. The results from the backhaul modelling suggest 53 matches which have the potential to reduce empty running from 25.4% to 22.5%, an 11.2% improvement.

These results are based on a strategic assessment. A sample tactical examination of specific matched flows and the dates on which they occurred, indicated that some of these flows occurred on the same date, but not necessarily at a convenient time. If operational systems could be so arranged these matches could be achieved in practice. Discussion with the companies indicated that timing of some of these matched flows was critical to meet customer deliveries which may also inhibit the opportunity of matching return loads. Consequently, once operational constraints are taken into account, the actual potential for cutting cost, distance, time and CO_2 for the empty legs considered in this analysis could be lower. However, the focus of this strategy has been on the historical empty legs and there may be efficiencies from changing what are currently single company round trips into collaborative round trips. Also, when the LOGISTAR system is operating in real time, there may be backhaul opportunities in those empty legs that have not been considered in this backhaul analysis, i.e. those that occurred on less than 52 occasions per year.

When these strategic savings are compared with the current two way operation of the matched flows it shows about 43% reduction in cost, distance, time and CO_2. When comparing these savings with the two way operation of all empty leg flows, a reduction of about 8% in cost, distance, time and CO_2 is seen. These results echo those in similar studies such as the two Starfish projects.

4.1.2. Co-loading opportunities

Clustering and centre of gravity analyses were used to identify the optimum number of clusters within the UK for LTL customer deliveries. The deliveries for all loads less than 60% of a full truck load, i.e. 16 pallets or less were extracted from the data supplied by the three companies and input to the co-loading model. Because the co-loading model is strategic, any deliveries for which there were less than 52 deliveries per year were ignored on the basis that there was the likelihood of a better match if deliveries occurred at least once per week. The co-loading model created a cluster for any delivery locations that were within 5km of each other. A total of 35 clusters were identified with between 2 and 5 delivery points in each as shown in figure 7 below.

Figure 8 Cluster delivery location density

Using these 35 clusters, the model produced costs for each cluster depending on how far the co-loading depots were apart, and how long the vehicle spent loading at the second depot. Not all 35 clusters showed cost savings. Figure 8 below shows the number of clusters with savings and the cost depending on whether the distance between co-loading depots is 15km, 30km or 50km, and whether the loading time is 1 hour, 1.5 hours, or 2hours.

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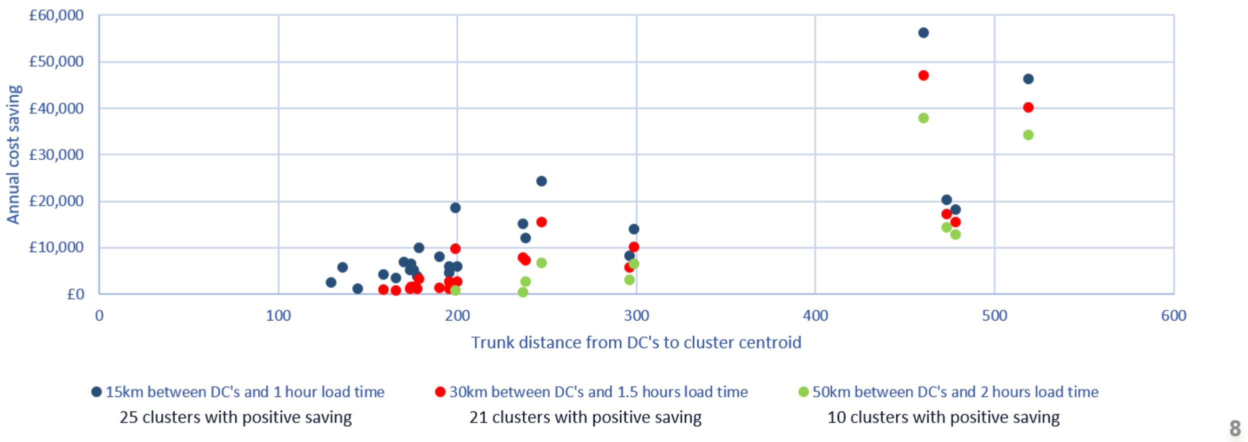


Figure 9 Effect of variable distance and load time for co-loading

The total potential cost savings for co-loading varied from £313,000 for the 15km distance and 1 hour load time to £119,000 saving from 50km distance and 2 hour load time. These represent a cost saving of between 15% and 6% of the cost of serving these clusters separately. There is a significant reduction in kilometres travelled of over 40% but there is a time penalty in having to load at the second depot. The reduction in kilometres would come with the added benefit of lower fuel usage and consequently lower external social transport costs including lower CO_2 emissions.

Examining specifically the opportunity for co-loading savings between the pladis distribution centre at Ashby de la Zouch and the Nestle distribution centre at Bardon produced a density map as shown in figure 9. As can be seen, the greatest savings can be made by co-loading at Ashby and Bardon and then delivering to customers in Scotland, with slightly less savings achievable for clusters in the Southern part or North East of England.

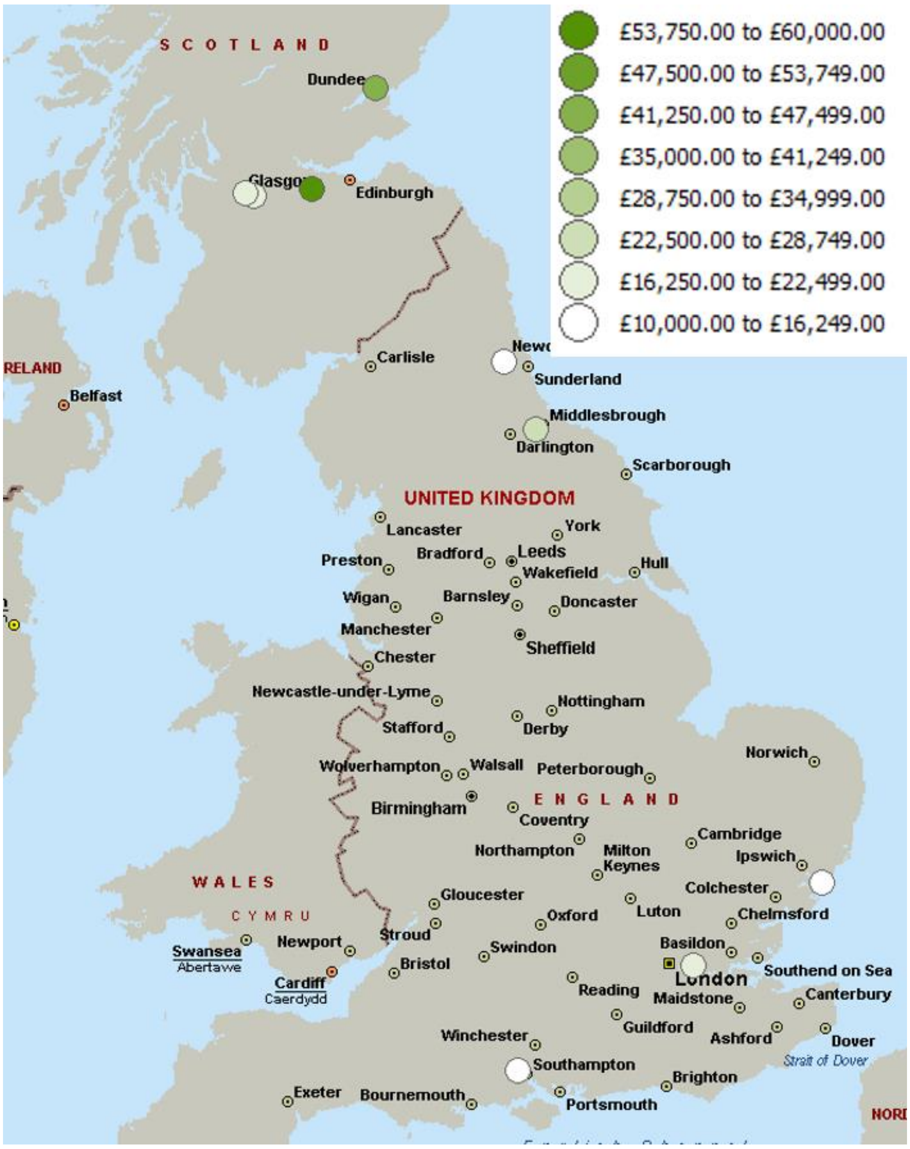


Figure 10 Cluster cost savings from co-loading at Ashby & Bardon

Although the overall average vehicle capacity utilisation is 79% for customer deliveries, loads for smaller orders (less than 18 pallets per delivery), only achieve a 62% vehicle capacity utilisation. Analysis of the results from the co-loading model indicate that 70% is achievable at the strategic level, representing a 12.5% improvement, if loads could be combined.

4.2. Chemicals sector

4.2.1. Backhaul opportunities

Two of the companies examined found an opportunity to backhaul loads between Belgium and Germany.

The first company is a manufacturer of titanium dioxide and specialty paint chemicals that ships FTLs from its distribution center near the Port of Antwerp to a large customer in Germany. The other shipper has a manufacturing site near the destination region and ships FTLs in opposite direction to customers in Belgium.

After identifying the match, on the suggestion of both companies, the strategic analysis was focussed on this high volume FTL tradelane between Antwerp, Belgium and Stuttgart, Germany. This tradelane has a relatively high logistics cost due to the high number of 3rd party trucks being used and the lack of backhaul volumes in the network of the chemical shipper.

On average, the first chemical company ships 420 FTLs each year from Antwerp to Stuttgart region, which in most cases need to come back empty. The other company in the Stuttgart region with compatible transport requirements (i.e. packaged, palletized goods) has a structural transport flow from Stuttgart to Antwerp of ca. 688 FTLs per year. This creates the potential for a “perfect roundtrip” whereby each truck from the chemical company can bring back a payload from the other company after making only a small detour.

The figure below illustrates the collaboration potential for the chemical shipper (A13) and the other company (S16).

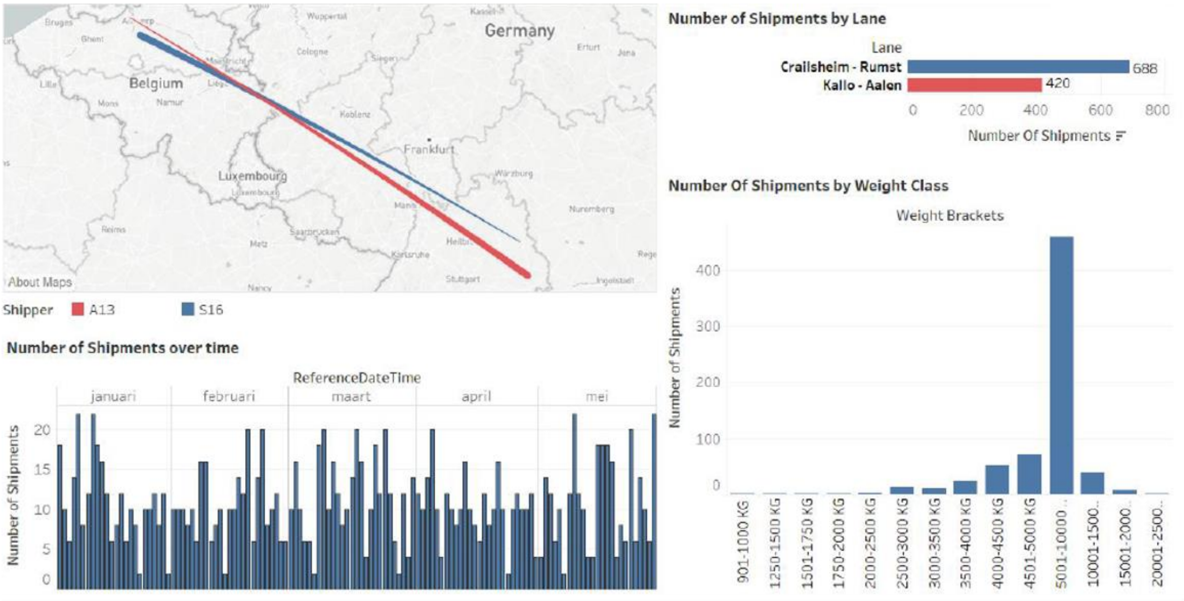


Figure 11 Roundtrip potential for the two companies identified

In order to calculate the potential financial savings, a market survey was carried out with 9 LSPs to evaluate the cost of one-way versus frequent roundtrip FTL transport. The most attractive LSP offering enabled a theoretical saving of 8,9% on the roundtrip transport cost for the 2 shippers as well as a significant reduction in empty kilometres.

Even taking into account that this theoretical collaboration savings can never be totally achieved in practice, the improvement potential of FTL backhauling is clearly demonstrated.

This business case at the same time illustrates the added value of a “trustee” or neutral matchmaking mechanism in horizontal collaboration, to help shippers identify compatible transport flows.

The strategic assessment of this case indicated that an important hurdle to take in the creation of FTL roundtrips will be the limited willingness of carriers to support such collaboration. More than one carrier gave as feedback that this way of working disrupts their traditional groupage business model and necessitates the implementation of “hypercare” real-time planning procedures in their dispatching centre.

4.2.2. Consolidation of loads

To investigate the potential of LTL transport bundling and chemical logistics clustering, six chemical shippers in Europe were interviewed and provided a sample of their European transport data. This included all shippers manufacture packaged, palletized chemical goods which can make use of the same transport vehicles.

Based on the interviews, a potential improvement project was identified to increase the fill rates of LTL distribution of chemical products out of the Barcelona, Spain region. All investigated shippers appeared to have frequent outbound flows to the same industrial destination regions in Spain as well as in some surrounding countries. The figure below illustrates this concept (each colour represents a different shipper – one of the six shippers showed no overlap in Spain):

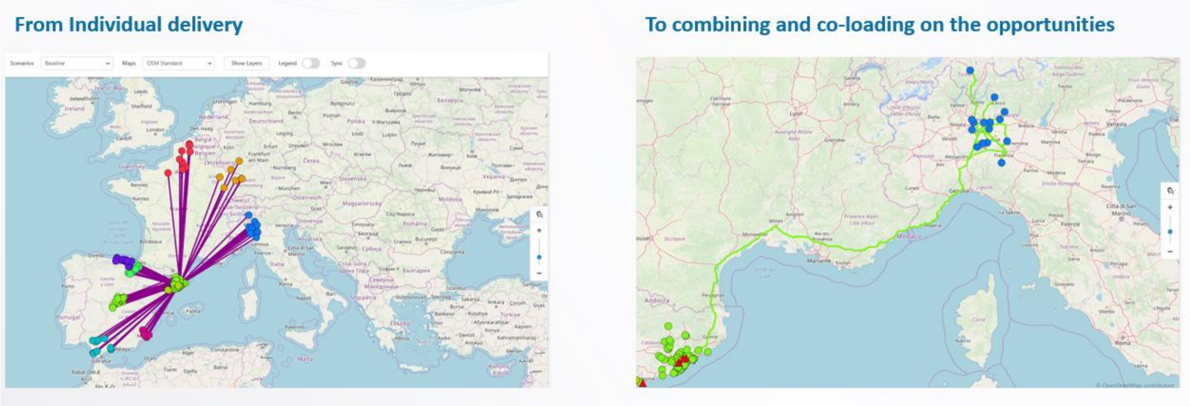


Figure 12 Regional analysis for Barcelona based chemical companies

The investigated collaboration concept assumes that the chemical shippers would cross-dock their LTL shipments in one of their hubs, or that they would make use of a 3PL consolidation hub nearby. To increase the synergy potential and truck fill rate, also the effect of synchronization was calculated for the outbound flows.

More than 50 high level opportunities for LTL co-loading in the Barcelona region were identified overall, with more than 20 opportunities having sufficiently profitable expected business cases to justify further analysis. For each of those cases, a detailed flow modelling and cost calculation was made with specialized software, as is illustrated in the figures below.

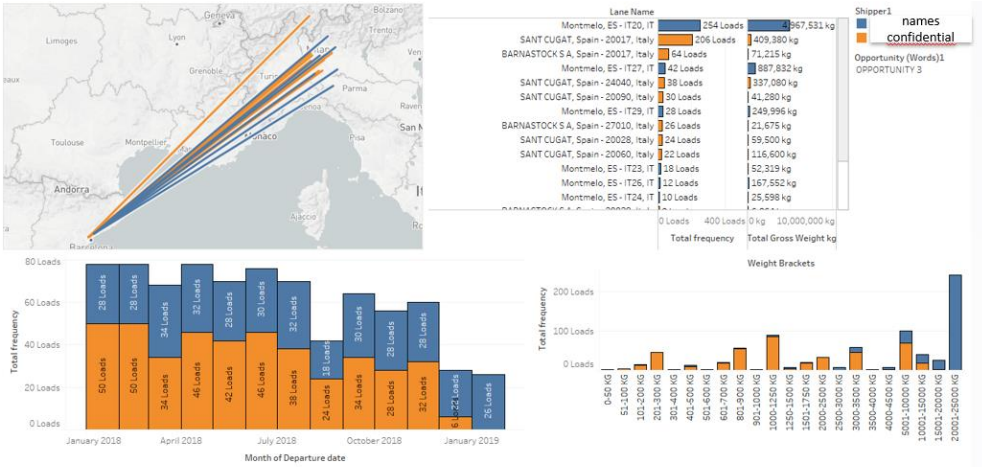
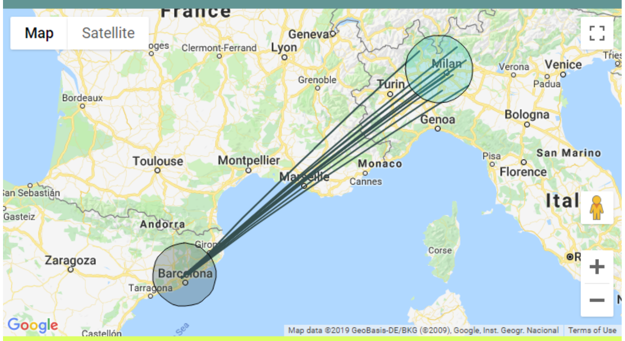


Figure 13 Analysis of chemicals LTL bundling in Barcelona region

Opportunity	# lanes	Dist. (km)	Volume	Vol. km	Shared distance (%)	Shared volume (%)	Shared vol. km (%)	Closed volume (%)	Closed vol. km (%)
1	11	1011.01	3437.11	2726872.5	96.82%	98.31%	99.97%	0%	0%



Origin /	Destination	Lane volume	Lane dist. (km)	Lane vol. km	Origin latitude	Origin longitude	Destination latitude	Destination longitude	Company ID (shipment)
1	2	57.68	707.03	40781.57	41.5411	2.1588	45.5365	8.9894	Lubrizol (50)
1	2	0.24	707.62	169.83	41.5411	2.1588	45.4057	9.1328	Lubrizol (219)
1	2	83.78	732.05	61330.76	41.5478	2.2547	45.2295	9.7722	Corbion (42)
1	2	443.92	680.07	301897.29	41.5478	2.2547	45.1347	9.0721	Corbion (11)
1	2	15.09	732.27	11049.99	41.4738	2.0955	45.4334	9.352	Lubrizol (97)
1	2	2483.77	715.41	1776908.7	41.5478	2.2547	45.5325	9.2304	Corbion (1)
1	2	203.39	715.93	145612.89	41.4738	2.0955	45.5365	8.9894	Lubrizol (24)
1	2	68.9	740.25	51003.14	41.4738	2.0955	45.5383	9.3728	Lubrizol (46)
1	2	12.8	757.52	9696.27	41.5478	2.2547	45.7112	9.7131	Corbion (104)
1	2	41.38	692.11	28639.38	41.5478	2.2547	45.869	8.4589	Corbion (59)
1	2	26.16	758.45	19840.97	41.5478	2.2547	45.9488	9.4774	Corbion (74)

Figure 14 Developing the collaborative business case

The potential cost savings were calculated based on LTL tariffs for a recent European tender for chemical road transport. Also, the costs for extra stops were taken into account to cover the necessary loading/unloading time of the truck.

The generic LTL price function that was used to calculate the beneficial effects of LTL co-loading is shown in the following figure:

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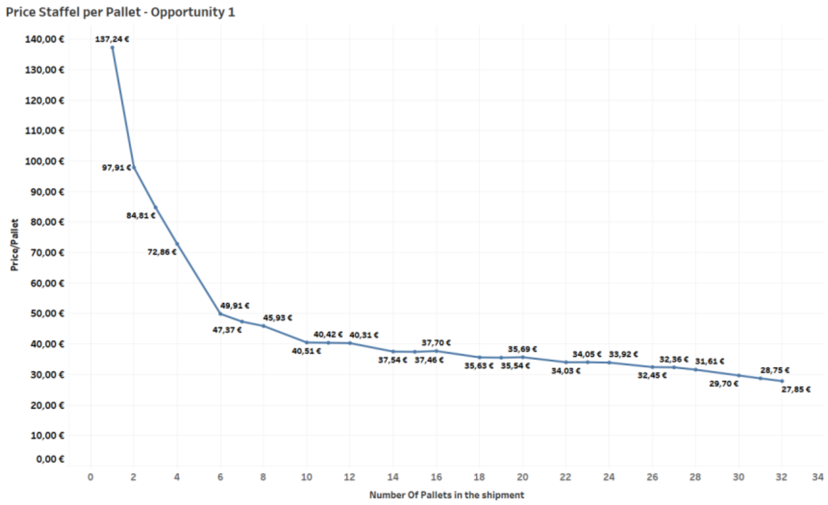


Figure 15 Generic LTL tariff

With regard to savings potential of LTL bundling and logistics clustering around a shared cross-dock, the following theoretical KPI impact was demonstrated and validated for this chemical community:

- Transport costs savings between 2.35% and 11.9%
- Route utilization improvements of typically 10% to 20%, with one lane showing improvements up to 30%
- Typically, a double-digit reduction in the total kilometres driven, with one collaborative LTL lane showing a km reduction of 35.6%

Even taking into account that a theoretical collaboration savings can never be totally achieved in practice, the improvement potential of LTL co-loading is clearly demonstrated.

The strategic assessment of this case indicated that an important hurdle to take in the creation of LTL co-loading communities will be the limited willingness of shippers' ICT departments to support such collaboration. More than one chemical shipper gave as feedback that this way of working puts an unforeseen burden on the workload of their ICT department, because new systems and interfaces need to be set to support the real-time exchange of data.

4.3. Logistics service providers

4.3.1. Consolidation of loads

At the start of the LOGISTAR project in June 2018, Ahlers investigated the bundling potential of the outbound flows of its own European Distribution Center for chemical products in the Port of Ghent, Belgium. In order to do this, all international outbound flows were mapped for the previous full calendar year:

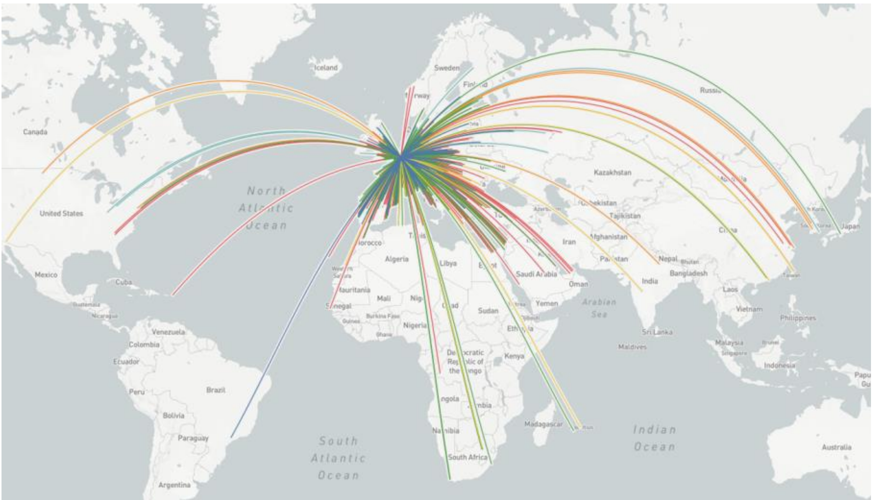


Figure 16 Ahlers Chemical EDC Global outbound flows

Out of this volume, the European LTL flows from different shippers were filtered which had at least a bi-weekly frequency. These were expected to have the highest consolidation potential:

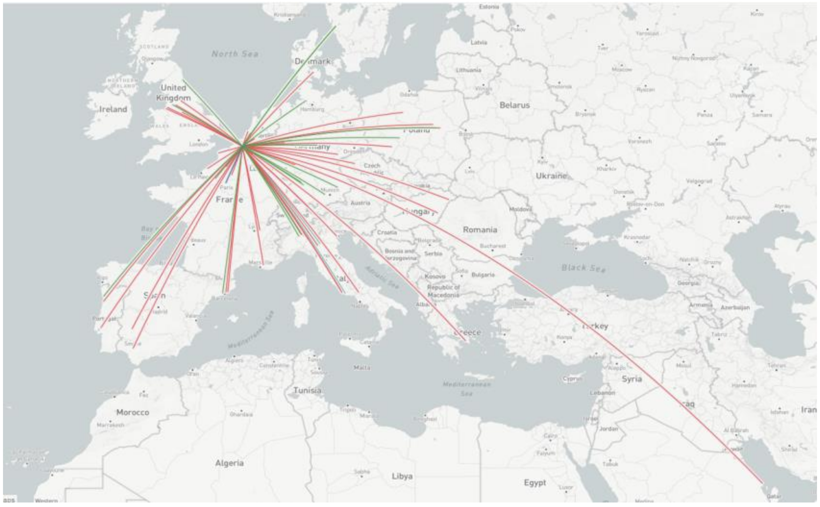
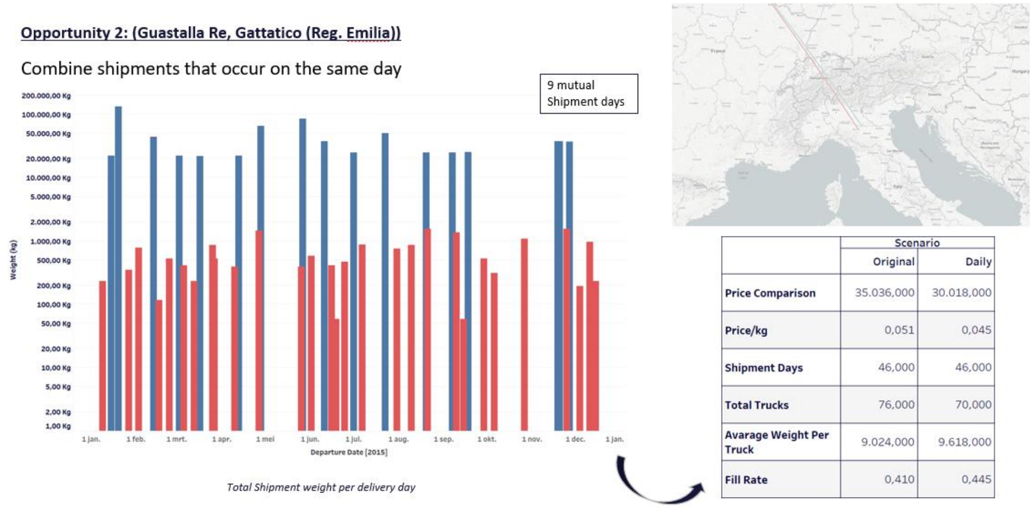


Figure 17 Ahlers Chemical EDC High frequency outbound flows

From this selection, in a next step of the strategic analysis, the LTL transport corridors were retained where different chemical shippers in the EDC had “overlapping” transport movements. For a number of these lanes, the opportunity for LTL consolidation and synchronization was calculated. An example of this high level calculation for overlapping flows to destinations in Italy is shown below:



	Scenario	
	Original	Daily
Price Comparison	35.036,000	30.018,000
Price/kg	0,051	0,045
Shipment Days	46,000	46,000
Total Trucks	76,000	70,000
Avarage Weight Per Truck	9.024,000	9.618,000
Fill Rate	0,410	0,445

Figure 18 Calculating the business case for co-loading

The strategic analysis indicated that there existed significant potential for LTL flow bundling among the chemical shippers in the EDC, on condition that they would be willing to show some flexibility in their outbound shipment dates. This would in turn result in higher vehicle fill rates, less empty kilometres, lower transport costs and reduced carbon emissions.

It was initially the intention to implement and test a number of such horizontal collaboration cases together with the chemical shippers that made use of the Ghent EDC, with operational support from the LOGISTAR decision support system. However, this use case was abandoned in October 2018 when the Board of Management of Ahlers unexpectedly decided to sell the EDC and move out of the chemicals business.

4.3.2. Roundtrip potential in an asset-based LSP network

In order to investigate the optimization potential of asset-based transport networks, an analysis of a leading European provider of FTL intermodal logistics and shortsea solutions was undertaken

The company operates a fleet of +300 own road trailers, 3,800 pallet wide high cube 45 ft. containers and 1,200 Huckepack intermodal trailers. It organizes ca. 185,000 FTL truck or container transport movements across Europe on annual basis for a variety of customers such as Fast Moving Consumer Goods, Chemicals, Steel, Paper, Food and Beverages, etc.

Most of these transports have an intermodal component in the sense that they make use of shortsea or rail connections, but also of pre- and on-carriage via road to pick up or deliver the goods at the customer’s doorstep or at the terminal.

In a first step of the strategic analysis, sample data was collected for the period January till June 2018, covering ca. 90,000 full load shipments on 8,583 transport trajectories across 15 countries. The volume of the collected information comprised 124,000 rows of data in flat file format.

An analysis of the geographical transport lanes and the number of shipments on these lanes for the given period, as well as their seasonality, was performed:

Figure 19 High level analysis of asset-based LSP network

In a second step of the preliminary analysis, a specialised algorithm “BBART” was used to filter out the transport lanes with FTL backhauling or roundtrip potential. Also transport lanes where identified where “continuous moves” could be organized with a sufficiently high frequency to be profitable. This is illustrated in the figure below:

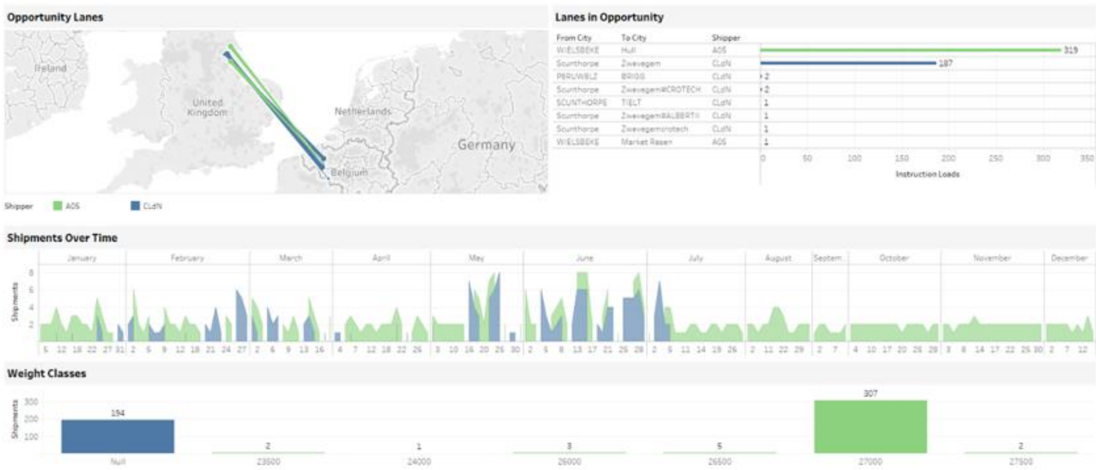


Figure 20 Identifying FTL roundtrip potential in asset-based LSP network

This preliminary investigation indicated that there exists significant opportunity to reduce empty kilometres and idle time of FTL transport assets in the European network.

This observation was validated on a much larger scale with historical data covering all European transport movements from the same logistics service provider during the period 2016 till 2018.

This new dataset contained 778,000 rows of full load transport data, 986,000 rows of vehicle distance data and ca. 50,000 unique origin, destination or hub locations in Europe.

In spite of significant data quality and accuracy challenges in this very large dataset, again a significant number of FTL backhauling and continuous move opportunities was detected by the algorithm.

A visual dashboard was constructed to analyse and calculate some of the most promising bunding opportunities, as is shown in the figure below:

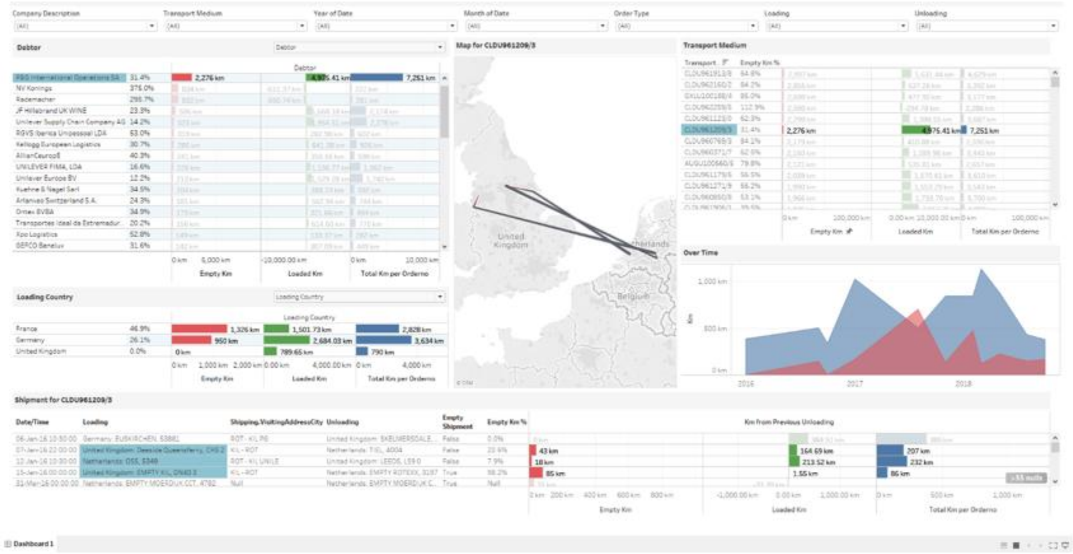


Figure 21 Visual display dashboard for identifying collaborative opportunities

This dashboard made it possible to identify a large number of opportunities to reduce empty kilometres in the LSP's own network and to shift freight from road to other transport modes.

The intention was to elaborate and implement a shortlist of these improvement "hotspots" using the LOGISTAR decision support system.

However, this use case was abandoned when the logistics service provider decided to withdraw from the LOGISTAR project following a management change.

The strategic assessment of this case indicated that an important hurdle to take in the optimization of large asset-based FTL networks will be the very high volume of data to process, as well as data quality and cleansing issues.

Also, it was demonstrated that collecting and analysing freight flow data for horizontal collaboration opportunities in large companies can take a long time. This poses the risk that the company loses interest after a while or that some changes in the management occur which reduce the support for the collaboration project.

5. Conclusions

The aim of this work element has been to examine the supply chains of a number of companies from different industrial sectors in order to identify and analyse those flows that are suitable for collaboration to show that they are economically and environmentally beneficial to each company. This will give confidence to each company by showing that savings are achievable and that, the LOGISTAR system, when implemented, can make those savings realisable.

Collaboration opportunities typically only apply to part of a company's supply chain. It is therefore important for companies to understand the impact of that element in the context of how it impacts the total supply chain. Modelling a company's supply chain network to identify cost effective collaboration opportunities is therefore vital to convince a company of the benefits, and ensure they take part in the operational aspects of the LOGISTAR project.

Between 2011 and 2014, the EU-funded CO3 project (Collaboration Concepts for Co-modality) set out to develop qualitative tools to encourage the implementation of logistics horizontal collaboration in Europe. From over 100 interviews with industry players, collaboration was seen as a major next step in supply chain optimisation to reduce costs and carbon emissions. The missing link, however, was seen to be a system, such as LOGISTAR, to make collaboration happen. However, in the first instance companies need to be convinced that savings can be made and this is being done through this strategic analysis.

The main deliverables in this work element have been analysed company data and quantified estimates of the potential reductions in cost, kilometres and CO_2 emissions, for two of the collaboration initiatives, including the metrics and measurements which could be used to assess the success of the LOGISTAR system. Semi-structured interviews also provided qualitative insights on the way companies organise their logistics operations.

This deliverable reports the results of a strategic assessment of the potential for saving cost and CO_2 emissions in the FMCG and chemicals sectors by applying two of seven collaborative transport initiatives. The analyses have shown that there are opportunities to improve operational efficiency and cut carbon emissions. The potential exists to backload over 164,000 full load movements in one month thereby reducing empty running of vehicles, saving over £3.3 million (9.3%) and 3,000 tonnes of CO_2 (10.4%). Out of the two collaborative options considered this would be the easiest to undertake. The co-loading option of combining part loads from nearby depots destined for common locations together with more efficient routing to nearby customers would provide the next easiest-to-implement option and save about 7% in cost and about 5% of CO_2.

The savings identified in the analyses represent the theoretical maximum, which it may not be possible to realise in practice. Once the LOGISTAR system analyses the live real time networks of the companies, the savings may be significantly lower. This may be due to factors such as the timing of deliveries, variability of load size and the incompatibility of company procedures and equipment. In addition, there may be cultural or competitive issues between companies which will need to be overcome. There are many real and perceived barriers to logistical collaboration including legal compliance, establishing an equitable system for allocating benefits, and defining the nature of the relationship. However, the results of this study should give the participating companies encouragement to agree collaborative strategies for sustainable logistics within the boundaries of the LOGISTAR system.

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The analysed data has aided the understanding of the supply chain operations of each of the companies, and the modelling of specific flows have shown that savings are achievable. For backhauling in excess of 40% of cost, kilometres and CO_2 can be saved in the matched flows, and the co-loading analyses have indicated a savings of between 6% and 15%, depending on the strategy. These are all in line with results produced by similar studies of the UK FMCG sector.

The outcomes from this work element can improve awareness of the economic and environmental benefits of collaboration. The results of this exercise, and lessons learnt in other collaboration projects such as CO3, will act as a catalyst to encourage companies to pilot selected initiatives and also to supply real time data to LOGISTAR's advanced decision support and visualisation tool.

5.1. Impact Assessment

Empirical studies have shown that collaboration studies such as this can reduce cost plus CO_2 emissions by on average around 15%. In some (road transport) cases there were proven savings of up to 40%. These savings are accomplished by, among others, a better matching of supply and demand, reduction of inter drop distances and increased load factors. The environment can be improved even more when collaboration is combined with modal shift. Successful collaborations should also yield more efficient transport processes including increased load factors, increased use of co-modal transport, with lower costs, lower usage of scarce resources and lower energy use. It should also lead to more effective use of human and physical resources, including reduction of capital cost.

This strategic analysis can provide benefits at several levels:

- Network overview – It allows businesses to identify opportunities within their own networks for efficiency improvements
- Collaboration opportunities – It identifies where backhaul and joint delivery opportunities exist between the participants
- System design – It will help to identify what the industries priorities should be and provide valuable input in terms of system requirements and real time data to the operational stages of the LOGISTAR project

5.2. Next steps

In the next phase of the strategic analysis work element, there will be:

- Analysing and incorporating flow data in a similar manner from a number of other non partner companies in the different industry domains, including stakeholders Codognotto and Zailog.
- An assessment of individual company efficiency and potential improvements
- Additional collaboration analyses in the form of
    - Consolidation of small deliveries - the combination of part loads belonging to different companies but originating from the same, multi-user, depot and destined for the same, or nearby, customer locations.
    - Use of regional consolidation centres - channeling part-loads through a consolidation centre in each region whose location would be optimized with respect to inbound and outbound part load flows and enabling full load movements between regions.

- Optimisation of urban freight and use of urban consolidation centres – to receive consolidated part loads from depots or regional consolidation centres some distance from cities and to make freight movement within cities more efficient.
- Multi modal opportunities - being able to achieve critical mass for train movements has been one of the main reasons for not using rail. With the volume from a number of European companies the use of modes of transport other than road will be examined.
- Consideration of logistics clusters – co-locating of company depots in a cluster to enable consolidation of all flows and enabling full load movements between clusters.

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List of abbreviations and acronyms

3PL	Third party logistics company
4PL	Fourth party logistics company
API	Application Programming Interface
BBART	Bundling, Backhauling and Roundtrip Tool
DC	Distribution centre
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

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