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

Executive Summary

This report looks at the current state of the logistics sector and assesses the improvements that can be made in areas such as digitisation and, in particular, with the use of the LOGISTAR system. There are three relevant use cases in the LOGISTAR project involving load optimisation, synchromodality and travel time accuracy, and the report considers how each of these use cases can benefit the logistics sector.

The continuing and growing demand for goods will cause increases of freight transport movements. Road is the dominant mode of freight transport and there are significant environmental and external social costs associated with this form of transport. Supply chains are very complex with many influences, not least the fragmentation of orders caused by multi-channel retailing and customer demands, which causes inefficient loads to be transported. It has been shown in numerous studies that horizontal collaboration can achieve significant cost and environmental savings but there are still very few examples of this measure in practice. One reason for this is that horizontal collaborations are intrinsically more difficult to manage. It needs a high level of trust and transparency between collaborating partners.

There are two main factors driving inefficient road transport operations in Europe. Statistics show that vehicles are running empty for about 20% of kilometres travelled. Although there are some geographical imbalances and vehicle types for which it is difficult to obtain a return load, it is still feasible to reduce this figure by about 5%. Capacity utilisation is not currently measured in EU statistics, but historic figures show that this was about 60% by weight. Many products mean that vehicles are constrained by cubic capacity but, again, this figure is not measured. However, it is known that there are gaps in vehicle loads which have the potential to be filled and an increase to 70% capacity utilisation is quite feasible if the right vehicle was used to optimise the density of goods being moved.

In order to achieve this level of improvement in empty running and vehicle capacity a real time operational decision support system such as LOGISTAR is needed. The functionality has been specified after discussions with 22 major companies in the FMCG, chemicals, LSP and automotive market, amongst others. There are other software products on the market but not that have the unique features of the LOGISTAR system.

Three use cases have been trialled in the project and include load optimisation, synchromodality and travel time accuracy. This report considers the current situation in each of these areas and looks at the opportunities which LOGISTAR can exploit.

1. Introduction

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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 visualization 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 optimization 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 LOGISTAR project includes three use cases (referred to in the project as living labs) involving a number of stakeholder companies as follows:

Living lab 1 – The LOGISTAR system will demonstrate a proof of concept which, if successful, will enable two stakeholders, Nestle & pladis, to extend their current small-scale collaboration by identifying and enabling greater opportunities for backhauling and co-loading. These two partners are submitting a constant stream of order data to the LOGISTAR system so that any cost-effective backhauling or co-loading opportunities can be identified. Nestle & pladis will each have to agree to any collaborative routes, and these will be monitored in real time to measure the effectiveness of the journeys using KPI's, and to highlight any potential delays.

Living lab 2 –This living lab involves a stakeholder partner, Codognotto, a third-party logistics company, and Zailog who support the operations of the Verona rail freight terminal. It requires LOGISTAR to look at the movement of individual Codognotto FTL's and find the optimal routing from an origin (pick up location) to a destination (delivery location) by comparing options such as all road, or multi modal involving road, rail and water. The Verona rail freight terminal may be chosen but other terminals in the area would be considered. LOGISTAR will ensure the timings for multi modal options flow seamlessly together ensuring synchromodality. When this planned routing is accepted, LOGISTAR will then monitor the load via on board IoT devices to enable the load to be tracked and traced, and to alert various operators in the event of a disruption that causes a significant delay. The aim is to ensure that waiting time is kept to a minimum, and success will be measured by improvements in various KPI's.

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Living lab 3 – This is now a twofold living lab with data from a number of chemical companies being used to test the LOGISTAR system in a virtual environment, and a live testing to try and improve the travel turnround times at customers of Chep. The virtual environment is an invaluable method to ensure the system can cope with high volumes of order data and can produce satisfactory results within a reasonable period of time. It will test out the technical functions of the LOGISTAR system and components using virtual daily order flows from two chemical companies to assess backhauling and co-loading opportunities, and it may also be possible to simulate disruptive events such as road or rail blockages and congestion. The second part of LL3 now has a new stakeholder in Chep which can be considered as a successful recruit for user engagement. Chep is a unique company in that it has taken part in many EU research projects over the years and is one of the leading partners encouraging collaboration with a dedicated department providing added value to their customers. There is a significant problem with waiting times at various loading and unloading premises with up to 40% of shift time wasted. This living lab will use live vehicle tracking with a reliable prediction of the estimated time of arrival to manage and allocate slots dynamically.

This report considers the commercial opportunities of applying the LOGISTAR system in the three living lab key areas namely load optimisation, synchromodality and estimation of travel time.

2. Background

Freight demand generally depends on economic growth and international trade activity, together with other factors including population change, the importance of physical goods, transport costs, and the adoption of new technologies and retailing channels. Prior to Covid-19 and various trade conflicts, based on current patterns, global freight was expected to triple between 2015 and 2050, at an annual compound rate of 3.4% (ITF, 2019).

The demand for freight movements will therefore steadily increase with the growth of population and trade, although in the EU this growth wouldn't be consistent across all regions (European Commission, 2016) (ITF, 2018). In Europe the highest growth is expected to occur in EU13 where, on average, a strong correlation between GDP and freight growth has been observed (European Commission, 2016). There are variations in this correlation between countries, with the UK showing some decoupling due to the introduction of heavier vehicle weights in the early 2000's and longer semi-trailers.

In the EU, road freight is the dominant mode of transport and currently represents 76% of all freight movements (Sipotra, 2019). In order to achieve net zero carbon emissions by 2050, the amount of CO_2 emitted from trucks should be reduced by at least 55%, from 1990 levels, by 2030. To do this there is a push to use electric vehicles with a target level of renewable electricity of 32% by 2030. However, relying solely on electric trucks is not going to achieve the desired level of decarbonisation (EC, 2020).

Furthermore, in support of these 2030 and 2050 targets, the EU has made it clear that it is also imperative for goods to move from carbon intensive modes such as road freight to cleaner modes such as rail and water. However, there is an issue with this because operating these cleaner modes requires a larger scale of operation and it is not always possible for individual companies to easily switch to these alternative modes. Increased economies of scale can be achieved by means of horizontal collaboration between companies, being either logistics service providers or shippers, so this can accumulate enough transport volume to fill a train, ship or barge, thereby reducing cost and decreasing total emissions of the transport industry in Europe. The World Economic Forum (2009) advocated that smaller companies should collaborate with each other by consolidating flows so that a modal shift becomes a more cost effective and economically viable measure. Indeed, where logistics service providers operate on behalf of several companies, they are already facilitating collaborative services.

Therefore, combined with freight growth, other technologies and measures are going to be needed to achieve the required level of decarbonisation by 2030, to stand any chance of achieving net zero GHG emissions by 2050. The LOGISTAR system is one such technology that can contribute to this aim.

Supply chains have become very complex. Customers demanding more frequent deliveries of smaller quantities to keep their stock levels to a minimum, multi-channel retailing and home deliveries which also fragments the supply chain, and reverse logistics, are just three examples causing supply chain complexity. There is pressure to become ever more competitive, so companies are now looking beyond the boundaries of their own organisations and even beyond their own supply chain. The result of this is that supply chains that traditionally were virtually separate, are now starting to overlap, for example by jointly using transport capacities, warehouses, collaborative planning and forecasting, etc.

Companies will also typically have drivers that include minimising supply chain costs, maximising service levels and activities to ensure sustainability. Companies are generally managing their supply chains efficiently, but despite this, road freight is inefficient. The average empty running for 28 European countries is 20% of kilometres (Eurostat, 2020)[1], and capacity utilisation, by weight, averaging about 60%. Some companies have shown that collaboration has made significant improvements to their supply chain operation. Vertical collaboration in which customers and suppliers work together has been around since the mid 1990's, but it is horizontal collaboration that can achieve major bottom-line improvements. This has been around since early 2000's but has yet to show significant take up. Despite the cost and service improvement opportunities, there are still very few horizontal collaboration projects in practice. The reason for this is that horizontal collaborations are intrinsically more difficult to manage than vertical collaborations since they lack the usual authoritative power of one of the parties in the value chain. For instance, getting customers to change their replenishment cycles and inbound scheduling can be difficult, particularly when they occupy a dominant position in the supply chain and are more concerned about the efficiency and convenience of their internal processes. Issues such as trust, mutual understanding, long term visions giving and taking etc. are keywords for horizontal collaboration and are quite fragile by nature. Even projects with very positive business case will fail if they are not founded on a strong enough level of trust among the partners or if it is not managed completely correctly.

3. Business improvement & LOGISTAR functionality

[1] This European database shows the UK at 19%, but UK statistics state that empty running for HGV's is 29%

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There are two main factors driving inefficient road transport operations in Europe, and these are empty running and low levels of vehicle loading. In the case of empty running, inevitably there will be imbalances in the levels of geographic trade, plus there will be vehicles for which it would be difficult to get a back load, such as car transporters, liquid tankers and cement mixers, for instance. However, with clever technologies some of these trucks could be converted to give the ability of return loads. Perhaps because of increasing awareness of the environmental and cost impact of trucks running without a load, European statistics show that for the first time, empty running was below 20% at 19.9% of vehicle kilometres in the latest set of data (Beguerie, 2019). In the case of low load factors, this is mainly due to the complexities of ordering as a result of customers wanting to keep inventory costs down and therefore ordering more frequent deliveries of smaller quantities, plus just in time policies which have a similar impact. European statistics show that vehicle loading factors, by weight, have changed slightly over the last 10 years, with an improvement shown in Britain of about 5% between 2008 and 2019 to a fill rate of 61% (Department for Transport, 2020). This figure disregards the cubic capacity of a vehicle which may well be filled to a higher level for volume constrained products. Unfortunately, the cubic capacities of vehicle loads are not measured in any European country. Together empty running and low loading factor produce an overall efficiency score for European road transport of around 45% (Cruijssen, 2012).

In 2018, EU statistics show that trucks in EU28 covered 178 million kilometres of which just under 20% (36 million km) were empty. It will not be possible to eliminate empty running completely because of trade imbalances which means, for individual companies, internal coordination has limitations, but also there are various vehicle types for which return legs would be difficult. Therefore, 73% of the total kilometres travelled (130 million km) are estimated to be in industrial sectors that used types of vehicles capable of return loads. It is not possible to breakdown the empty running between sectors but if it is assumed that all journeys in those sectors operating vehicle types for which a return journey is possible, then 11.6 million km, or 10% of journeys were empty. Allowing for trade imbalances, if this could be halved to 5%, it would save almost 6 million empty kilometres. This represents about 6 thousand tonnes of CO_2 saved, plus savings in the other external costs of transport such as pollution, accidents, noise and infrastructure. An EU handbook on transport externalities suggests that there is a potential saving of €3 billion per year from this reduced empty running.

There are over 6 million trucks on the road in Europe. Although capacity utilisation isn’t currently measured, historic EU statistics show that the average load, by weight was 60%. The main issue with this is that many products are volume constrained which means that vehicles may well be filled to a high cubic capacity, but unfortunately this factor isn’t measured. However, it is known that there are gaps in vehicle loads which have the potential to be filled. If the average load by weight could be increased to 70% then this would effectively take almost 1 million trucks off the road.

Within the European Technology Platform ALICE one of the five themes is called Global Supply Network and Collaboration. This theme has established that external collaboration is a concern, particularly for larger companies, because of competition law in the case of competitors, but there are many other reasons put forward by companies for not wanting to collaborate. For instance:

- Collaboration is a minor part of the supply chain operation and is likely to save only a small amount of cost so doesn’t warrant the effort required to make it work

- Concern about any company with whom they would be collaborating. Competition is still the norm, and collaboration requires trust and transparency among the collaborating companies.
- Many shippers use LSPs and fear that any lanes taken from their operation for collaboration may incur a net higher cost from the LSPs. A number of shippers interviewed indicated that their LSPs could be contacted on their behalf but the LSPs showed a great deal of unwillingness to participate, obviously fearing that their business would be negatively affected.

One of the biggest issues is the reluctance to share sensitive cost information. Collaboration needs a safe space for sharing, where mutual trust exists. Collaboration has been sporadic over many years and there are many other barriers that have been quoted as the main reasons for not collaborating. These include:

- Own organisation culture/internal politics
- Lack of trust
- Hard to find partners
- Managerial inertia
- Costly in terms of time and effort
- Technical incompatibility
- Poor knowledge of internal flows
- Fear of losing competitive advantage
- Increased complexity of operation
- Lack of cross network visibility
- People's capability and skills
- Fear of the unknown
- Free-riding
- Service expectations
- Competition law
- Gain sharing
- Dependency on external support
- Difficult to distinguish own company in group

Overcoming these barriers will enable more companies to collaborate and improve load optimisation. ALICE has also established that internal collaboration is happening in the larger companies, with control towers to manage the loads to ensure efficiencies are maximised. It has been suggested that because there is a need to drastically reduce GHG emissions, the need to collaborate will grow because the cost of electric trucks is higher than conventional fossil fuelled trucks which means they are likely to be used intensively to maximise the asset. This could be the reason to share capacity and increase load factors. There is currently a significant shortage of drivers in the UK and to lesser extent throughout the rest of Europe. This will invariably cause wages to increase as companies compete for diminishing resource. This will also create the impetus for more collaboration.

Logistics service providers and platforms have a greater potential to consolidate goods, reduce empty kilometres and realise better use of assets, as they are more open, flexible and easier to scale. However, LSPs and platforms are given very low managerial capacity by shippers which reduces the potential benefits.

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In cities there is a greater need to collaborate because of pressures for city councils to reduce pollution and congestion, so there are more developments in urban logistics than long haul. In addition, it has been noticed in ALICE meetings that shippers are not giving LSP's the freedom to combine loads and share capacity with other shippers. However, the recent growth of e-commerce has possibly improved this position, as multiple on-line retailers are effectively now consigning cargo to a relatively small number of parcel couriers . Perhaps a new generation of digitally educated supply chain managers that are more used to sharing and combining is needed, rather than existing managers who are educated in hard competition. Interviews and questionnaires have discovered that those companies that do collaborate have generally needed individuals that have certain characteristics. These are:

- Many years logistics experience
- Sound knowledge of operations
- Are pragmatic and prepared to share and take small risks
- Don't get hung up on details
- Dedicated specialists with no other responsibilities
- Very active in external bodies – work with industry, benchmark, share best practice
- Open minded, flexible and willing to think "out of the box"
- See logistics as non competitive
- Are computer literate
- Are totally supported by senior managers/directors

A business case for collaboration will only be positive if enough synergy exists within a group of collaborating companies. Synergy can be defined as compatibility in terms of the type of products, the type of vehicle and trailer, the regions being served, plus the difference between the total stand alone cost and the total cost of the collaboration. A business case development phase is needed to develop a qualitative plan into a quantitative project proposal. This is typically done by applying various operations research techniques. Dependent on the type of collaboration project, for example Strategic Network Design problems, Vehicle Routing problems, Collaborative Fleet scheduling problems, Inventory optimization, etc. can be formulated and solved by software tools available on the market. Such an analysis can then result in statements like the one in Frisk et al. (2010): "The result of the analysis shows that there is a lot of money to save, up to 14.2% of the transport cost. The transport cost for these companies is about 60 million Euros and the potential saving relates to more than 8 million Euros. Additionally, the environmental effects of better co-operation between the companies are very positive with about a 20% reduction of emissions from the trucks."

As stated in the business plan D8.7, the target market for the LOGISTAR system are those shipper companies, and logistics service providers, operating their own fleets of vehicles. It will also be appropriate for use in industrial sectors that transport goods typically moved on standard flatbed or box trailers. As an example, the food and beverage sector, which represents a significant part of all kilometres travelled would benefit from LOGISTAR.

During the LOGISTAR project there have been many non-stakeholder partner companies willing to help in terms of providing data and interview time, so horizontal collaboration is of interest to many people. Various collaborative strategic analysis projects involving many companies have shown

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positive benefit, but the question has always been asked “How can we achieve these savings in practice?”.

LOGISTAR is the answer to this question. The functionality of the system has been specified after discussions with 22 leading shipper and logistics service providers from a range of industry sectors, but mainly in the same sectors as the living labs, i.e. FMCG, chemicals, LSPs and terminals.

Although LOGISTAR is a real time system, it is not an operational system. It has been designed as a decision support tool that supports a company’s TMS. It is inevitable that after three years other freight transport software will have been developed along similar lines. However, commercial software is sometimes sold on what it’s claimed to do, rather than what it actually does. There is software available that overlaps LOGISTAR to some extent, such as Lanehub (freight exchange), MixMove (splitting collaborative orders to maximise vehicle fill, no mention of backhaul), Semicab (freight exchange), Shippeo (on road monitoring), Microlise (single company planning and on road monitoring) and Timocom (freight exchange), Vinturas (on road visibility platform). These software products look extremely useful but the transparency of the real content of these systems is often clouded because of commercial sensitivities. They are often a black box, so any innovative algorithms are presented in a superficial way, without knowing their true effectiveness. Some of these software products contain the individual components that are in LOGISTAR, but not in the context of a collaborative system. The innovative part of LOGISTAR is the unique algorithms of these components and the way they are put together into a system that handles freight transport collaboration. Individual companies will plan their transport as efficiently as they can, but it will be within the constraints of their own operation. LOGISTAR doesn’t just receive orders from companies which can’t be planned efficiently. That would make LOGISTAR a freight exchange system of which there are many products available. LOGISTAR plans all orders from the collaborating companies.

Vehicle routing has been around for several decades. There are many commercial packages available, and generally work very efficiently, but rather than conventionally minimising travel time or cost, the route planning in LOGISTAR is based on some innovative algorithms that uses a technique to minimise empty running and maximise vehicle fill, which in turn should minimise cost. The route planning algorithm takes all orders from the collaborating companies on a daily basis so that there is flexibility to have different collaborations. LOGISTAR doesn’t rely on regular, fixed flows unlike some systems. In other systems, when there is a suggested collaboration, it is not known if a collaborative multi drop load is cheaper than individual companies doing those deliveries themselves. Common sense suggests a collaborative load is better, but it needs to be shown to be better. LOGISTAR produces a set of routes as though the individual companies were delivering their own loads, and then puts everything together so that it is clear what the cost and KPI benefits of any collaborations are. All this is based on minimising empty running and maximising vehicle fill within a collaborative environment which also considers synchromodal options. The route planning is supported by AI/machine learning algorithms that produces accurate travel and turnaround times taking into account historic data and open-source data (although that is limited at the moment). There is also a preference learning element that registers the manual load planners’ actions so they can be used to improve the subsequent routes produced by LOGISTAR.

There is a second part to LOGISTAR which is to monitor the goods on the road using IoT devices. This is fairly common in a few available commercial systems, but with LOGISTAR it is the combination of functional components. The LOGISTAR system is constantly checking to see if there are any significant delays which may require a replanning of the loads.

This is all combined with synchromodality (and again, there are existing systems that include real time intermodal planning), but as mentioned previously, it is the combination with all the other elements of LOGISTAR that make this system innovative.

It's also important to note that the LOGISTAR system has been tested on some very big European companies in the living labs. In summary, the unique combination of LOGISTAR features includes:

- Every functionality in one cloud-based system, eliminates silo systems
- Uses AI to produce accurate travel times
- Takes into account open source data
- Optimises by planning all loads (and re-plan loads) in real time across multiple operators
- Will produce daily variable collaborations
- Cost and KPI comparison of individual company and collaborative routes
- Incorporates the Shapley Value calculation for apportioning values to collaborating partners
- Event prediction
- Built-In replanning in response to events
- Preference learning techniques to produce personalized solution for customers/stakeholders
- AI-predictive function, allowing potential interventions to be 'forecast' and consequently loads to be re-planned in response.
- Negotiation techniques for route acceptance amongst collaborating companies
- Dashboard information displays for planners to monitor and take action
- Synchromodal component, incorporating rail, sea and road modes
- Pan-European in its operation

Whether these unique features and the positive attitudes of companies that have helped throughout the project can be turned into a greater number of collaborations is the big question. Collaborative initiatives tend to work better when they start small, and where a common methodology is being used.

4. Use case opportunities

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Commercial sensitivities means that it's not always possible to understand exactly how companies supply chains are operating, and what systems are being used. However, there are a number of case study examples, particularly in the area of collaboration.

At a plenary session of IPIC 2021, Professor Alan McKinnon asked Pietro D'Arpa, Vice President, Supply Chain Europe: Logistics and End to End Strategic Planning at Procter & Gamble, what would be the one main thing that would benefit the environment by 2030, he responded with two things. One was to reduce empty running and empty space in vehicles, and the second was to move goods from road to less carbon intensive modes such as rail or water. These are two of the key attributes of the LOGISTAR system. In the following section these and the need for more accurate estimates of travel time, which is integral with load optimisation and synchromodality, are discussed.

4.1. Load optimisation

Profit margins are shrinking, especially in the transport-intensive commodity producing sectors, which means efficient logistics management can be a decisive factor for a company's success, since competition will take place on the basis of costs, service and timeliness. Margins for logistics operations have gradually reduced from 4% to 1.5% (LogisticsUK, 2021) with logistics being seen as a commodity itself for moving a vehicle load to a destination. Productivity improvements and innovation are the main ways for these companies to improve margins.

As mentioned in the previous chapter, utilisation of road vehicles in terms of empty running and vehicle capacity mean that there are inefficiencies in their operation. The main reason for this is that companies trade off higher vehicle costs against the costs of lower inventory and storage. It has been suggested that transport providers feel that it is the shipper's logistics activities that prevent better asset utilisation (quoted in McKinnon, 2018). Equally, various departments such as sales and marketing, and manufacturing tend to have a more important role in the strategic direction of companies than logistics operations. Despite this, individual companies will always try and operate their freight transport as efficiently as they can.

In the future, if the external costs of transport are internalised, which would increase the cost of freight transport, then the trade-offs to enable improved load optimisation, are likely to encourage more companies to focus on and improve their asset utilisation. Consequently, business models of the future would be more likely to include collaboration, and therefore better load optimisation.

Key factors driving operational inefficiency in the road freight transport industry are the high proportion of empty running (i.e. when vehicles return to their depots unloaded after having made a delivery) and low load factors (i.e. the weight and volume capacity of the vehicles is poorly used even when goods are carried). Empty running is a consequence of geographical trade imbalances and a lack of scale at companies moving the goods. Low load factors are mainly due to order fragmentation at shipper's premises following just in time production and working capital reduction policies, plus goods requiring specialist trucks.

With a higher focus on costs, customers have been more demanding when it comes to deliveries. Companies define specific days and tight time windows for when deliveries are allowed, households are now used to next day delivery for certain goods, or even one hour or less delivery slots for FMCG goods. This has an impact on vehicle utilisation which is why collaboration has become more important. Transport collaboration is the main way to improve load efficiency, with on the road examples and strategic studies showing benefits (CO3 project, 2014) (Surtees, 2013) (Palmer, 2016).

Realistically, it should be possible to improve load optimisation by reducing current levels of empty running by about 5% through collaborative planning. Similarly, strategic studies have shown that collaboration would also improve vehicle capacity utilisation by about 10%. There is a much-quoted statistic that suggests that the combined effect of these measures can improve transport efficiency from its current level of about 45% to 70%, saving EU companies €160 billion per year (World Economic Forum, 2009) (Cruijssen, 2012) (ALICE 2014).

Load optimisation can be achieved with various collaborative options such as:

- Co loading
- Consolidation
- Regional or urban consolidation centres
- Logistics clusters

Co-loading is the combination of part loads originating from depots located near to each other and destined for the same, or nearby, customer locations. If the co-loaded goods are destined for the same customer, then this approach obviously saves the customer from having to handle an extra vehicle. It also reduces the transportation cost of the goods by improving vehicle fill and saving distance travelled. However, the cost benefits are dependent on how far apart the co-loaded depots are, and the location of customers being serviced.

There are a number of instances where companies have joined together to operate out of the same distribution centre. In the FMCG sector, this type of consolidation has been shown to reduce costs, improve service levels, have shorter replenishment cycles which reduces customer's inventory, maintain or improve truck capacity utilisation and reduce empty running. There are numerous case studies which show this including four manufacturers operating out of a single distribution centre operated by FM Logistic in Orleans, France, and another seven manufacturers operating out of a single distribution centre, also operated by FM Logistic, north of Paris. The main retailers are serviced from these distribution centres using collaborative transport coordinated by trustee organisations.

In a supply chain network, regional consolidation centres (RCC's) can be used to receive full truck loads of multi drop orders (i.e. LTL quantities) from various sources such as a central distribution centre or other regional consolidation centres. These goods are then consolidated and cross docked onto vehicles destined for final customer delivery. Regional consolidation centres can sometimes be used to store faster moving FMCG products. Because customer delivery costs are usually higher than supply costs, particularly if customer deliveries are LTL, regional consolidation centres are usually located in the vicinity of customers, in order to reduce the transportation cost of final delivery. However, there is also the opportunity for RCCs to act as primary consolidation centres and receive loads from suppliers, for backloading to company distribution centres. Although RCCs are best suited to LTL there may be opportunities for FTL loads to be routed via RCCs if there are backloads. In this situation trailer swapping would be appropriate rather than unloading goods. Using the principle of the Physical Internet which is aimed at the universal interconnection of logistics networks through consolidation, the RCC concept could enable more efficient movement of goods between centres by taking advantage of backhauling opportunities

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The purpose of an urban consolidation centre is to reduce the number of vehicles operating in an urban area thereby reducing the impact of congestion and making vehicles with multi drop routes operate more efficiently. The urban consolidation centre concept is based on modifying the supply chain of deliveries into a city, with all its inherent problems of congestion, noise, etc, from a single company delivering part loads direct to one or more customers, to sending the goods into an UCC, typically located at the boundary of an urban area, where the goods are merged with goods from other companies, and then despatched on appropriate common vehicles serving those companies' customers. However, urban consolidation centres have not been shown to be viable without additional value-added activities, as they have only tended to work successfully through compulsion or subsidy. Studies have shown that improved vehicle load factors of between 15% and 100% could be achieved, plus fewer vehicle trips and kilometres travelled (Allen et al, 2012) (van Rooijen and Quak, 2010) (Leonardi et al, 2014).

Whereas regional consolidation centres are situated at the centre of high demand areas, logistics clusters are situated at the centre of a large number of supply locations. A logistics cluster is a single site on which many industrial and distribution facilities in a region are co-located within a few kilometres of each other. Combined loads from these facilities would be trunked between all clusters, with local collection and delivery of part-loads within each region. This option is similar to the Physical Internet concept of hubs. It allows for trucks, or even trains when the volume is available, to be backloaded between clusters as well as maximizing the use of vehicle capacity by consolidating the loads within clusters.

Although all these strategies aim to improve vehicle efficiency, they are physical adjustments to supply chain networks which, when complemented with the LOGISTAR system, would achieve considerable vehicle efficiencies with cost and environmental savings.

Load optimisation isn't just about reducing empty running and maximising vehicle fill. It is also about making sure the right size of vehicle is used and possibly adjusting the timing of deliveries to ensure a maximum load. This latter option can suggest negotiating with customers so that they receive a load at a time convenient to ensure maximum vehicle fill, or it can also be rescheduling deliveries to off peak periods when there is less traffic congestion on the road.

Given that continued road freight growth is expected, maintaining current regulations on weights and dimensions would, all other things being equal, be expected to result in an increase in the number of goods vehicle movements and a relative increase in pollution, accidents and traffic levels arising from those movements. However, the nature of goods transported has changed and a larger proportion of loads shipped are now constrained by the available volume or deck area rather than the available payload weight. Higher capacity vehicles (HCVs), sometimes referred to as mega trucks, could be used for regular flows of low-density products on primary distribution in sectors such as fast-moving consumer goods. Effectively, if either two FTL loads or a LTL and a FTL shipment are travelling in the same direction, then these can be combined into one long haul on a vehicle with a bigger capacity. It has been estimated that between 5% and 10% of the tonne-kms currently carried by articulated vehicles could potentially be transferred to HCVs of 60 tonnes or more (vehicles offering an increase in both available volume and payload).

Rescheduling of deliveries and bundling by synchronising loads to maximise vehicle fill are also important ways to improve vehicle efficiency. Depending on order lead times and delivery windows, if deliveries could be delayed or released early, in order that they can be combined with other orders

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more efficiently to create full loads on appropriately sized vehicles, then capacity utilisation would be improved. However, depending on the sector and type of flow, this isn't always possible. In certain sectors such as FMCG, some shippers will have to submit to customers' demands for delivery dates and time windows.

4.2. Synchromodality

Synchromodality is a concept that has emerged as the freight and logistics sector, particularly unitised traffic (containers, trailers) has evolved. It is aimed at delivering efficient, reliable, cost competitive, flexible and sustainable movements along supply chains involving numerous parties focusing on co-ordination and co-operation. It potentially involves all surface modes of transport in supporting the flow of cargo. It involves synchronised and visible operations under the control of one key player, normally a 4PL, within single or multiple supply chains. It can also apply to internal arrangements within one corporate shipper as a stand-alone variant involving numerous network options and modes of transport to support commercial operations. To function effectively, it requires real time cargo traceability, technical, operational and commercial condition monitoring, compatible IT systems and interoperability between them, data analysis all designed to enhance decision making and minimise sub-optimal performance.

The synchromodal concept is underpinned by a network of data and compatible information technology which can support the whole "Command, Control & Communications" (C3) requirement to sustain it. This is needed for informed and intelligent planning, implementation, and response to disruption. The concept operates in real time and aims to improve flexibility through cooperation between the involved parties, and improved use of resources including technical and personnel capabilities. To be successful, however, requires coordination, cooperation and collaboration within a sector or sectors which can be intensely competitive and protective of commercial positions particularly pricing offers.

It could be argued that cargo already moves through complex transits and supply chains using orthodox methods involving numerous parties (Shippers, forwarders, hauliers & train operators, warehouse and storage operators, shipping lines, ports, terminals, and official agencies). This typically uses linear messages and data movements which, for example in the case of delay or disruption, can then trigger further delay through the unsynchronised trickle down of information to other players rather than immediate information network pooling. Resolving these types of situations using conventional methods and structures needs a lot of manual interventions with the risk of delay and consequent loss of credible, timely and cost-effective resolutions.

Transport operators, forwarders, and logistics service providers (LSPs) can and do operate without synchromodality. The use of manually intensive efforts to manage supply chain activities can imply errors, late responses to constantly changing circumstances and situations and adds to the vulnerability of operations if key personnel are not fully informed of cargo status and intentions. This position can arguably also apply to the whole cargo tendering and contracting process which is increasingly focusing on digital solutions.

The compelling advantage of synchromodality, where it is applicable, is the enhanced level of coordination and control using technology and communications systems to advise all parties of the position of cargo moving through a supply chain network together with its technical, operational and commercial condition. The control of the transit would typically be under the control of a 4PL able to manage and intervene as necessary based on a network of data, data analysis and information. This is of great value in the event of disruptions and delays within and between individual modes of transport, changes of cargo movement sequencing and priorities and is aimed at restoring stability with minimum cost and delay. Synchromodality can assume an overview of all modal options in the planning and operational phase and react and respond to changes in plans and intentions at minimum cost, again involving all relevant modes. This does imply that transport service providers are able to react and respond to rapidly changing scenarios. Some may be better able to do so (road compared to rail). Resolving disruption events either as individual or multiple events is a key benefit of synchromodality.

In terms of an evolving concept synchromodality has emerged via inter-modality, co-modality and other concepts all focused on the movement of (largely) unitised cargo. The focus was primarily on cost reduction, reduced emissions derived from a changed modal split, reduced road transport involvement and smarter use of resources. Synchromodality could also have the ability to ensure containers and trailers are in the right place to maximise equipment utilisation.

Synchromodality is a new paradigm governing the movement of cargo. It covers all aspects of supply chain activities (raw materials, product design, packaging, handling, and hazard notification) plus the operational and commercial aspects involving service suppliers and the cargo parties involved. The adoption of synchromodality implies the elevation (or surrender) of the management and direction of a supply chain to a 4PL, for instance, within a defined group of players leaving the decision criteria to the 4PL to secure commercial benefits. As a concept it can be applied to a defined network of routes, terminals and relevant modes identified to support the cargo moving through the supply chain. It can also be used in “open” applications where origins and destinations are more dynamic and intermittent. Control of the cargo under synchromodality and the liability for its safe movement is a key issue as this can and does vary at stages through a supply chain. This includes any official requirements for customs, cargo safety, hazardous cargo, inspections etc. and needs to be recognised under synchromodal conditions.

The stakeholders in evolving synchromodal governed supply chains effectively operate as previously using their capabilities, capacity and expertise for specific functions, but the overarching C3 coordinating position would typically be assumed by a 4PL. 3PLs may be recognised under this designation or maintain the more traditional freight forwarder responsibilities with a mix of capabilities. The shippers’ and receivers’ expectations need to be factored into the design and operation of a synchromodal supply chain. The 4PL can act as a super-integrator in the management and operation of a synchromodal model and should be able to maintain total control of traffic in the system. It also implies an interventionist position based on real time data, analysis and information to resolve any identified or emergent issues which could compromise cargo flowing efficiently and effectively within the network. If something happened enroute the 4PL would have to step in to correct it without necessarily communicating with any of the shippers whose goods are on that mode of transport. The adoption of synchromodality implies the identification of benefits to the shipper/receiver through cost savings, improved equipment utilization and reduced empty running. Modal shift and wider environmental impacts could also flow from the adoption of the synchromodal model.

Identifying critical success factors flowing from the adoption of synchromodality is essential as it could and does imply the functional recasting of individual organizations and the relationships between them. There is a need to demonstrate quantifiable operational and commercial benefits to these parties by moving from individually controlled and managed supply chains and networks, and this may be difficult to achieve. Critical to the success of synchromodality is the availability and use of enabling technologies to support C3 actions. Without this and the ability to maintain open continuous contact with all the relevant parties within the synchromodal structure there are risks of sub-optimal use of resources.

Synchromodality can support demand driven supply chains which increasingly focus on consistent and unfailing reliability, through transit security, service availability and contact on a 24/7 basis. The availability of real time information on cargo in transit across a supply chain allows reaction and response to individual and multiple internal and external changes and the evaluation of recovery measures before implementation. It facilitates a managed coordinated response of the involved stakeholders and stability of supply chains.

In terms of implementation of synchromodality as a concept, and the recognition of its potential and value to the parties involved, it has to deliver tangible and measurable benefits. It can also contribute to wider issues (carbon emissions reduction, modal shift) although identifying these in detail may be more difficult. For the key players, the adoption of synchromodality suggests investment in systems and equipment able to communicate quickly, easily and in a recognised format across a supply chain on a continuous basis or when an anomaly is identified requiring notification to the relevant parties. This applies across the interests of a wider supply chain. Moving to a synchromodal model and exploiting the new paradigm does raise legacy issues in terms of cooperation and collaboration between differing and potentially competing players. They have to evaluate whether the claimed benefits of the synchromodal model will outweigh any dilution of competitive strengths and net incremental business will flow in terms of volume and revenue.

The claimed strengths and benefits of synchromodality centre on the widespread use of data analytics, and information in real time across a new or existing supply chain which may involve cross border and international flows and facilitate a reaction and response to unplanned disruptions or delays. It allows for re-planning and re-prioritising cargo flows and related activities by making all relevant parties aware of issues and intentions. It is aimed at minimising sub-optimal positions leading to unnecessary costs being incurred including delays and missed delivery windows. This can involve a change of routing, a change of mode and re-scheduling but all the involved parties in the supply chain are made aware of intentions and can re-plan their involvement. The C3 capability supported by compatible IT systems, data analytics and communications is key to the success of the concept.

Synchromodality is intended to secure cost reduction, maintain visibility of transactions, reduce emissions and secure modal shift particularly to more carbon friendly modes. Asset productivity increases should be achieved with the minimisation of empty equipment moves.

To work effectively it requires complete “buy in” by the various players on some sort of agreed performance related contracted basis and a resilient C3 system. This is a potential weakness and assumes competence, connectivity, and compliance amongst the various players to make the system work. This implies an initial higher level of complexity than more traditional or existing manual methods, 24/7 involvement, support and a surrender of control of the overall supply chain direction to a 4PL. The determination of payback after opting to move to synchromodality is not easily identified. In the event of a major failure, under synchromodal rules it is essential to identify

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weaknesses and attribute responsibility, and this may deter participation. If a new company starts to transport goods through a synchromodal channel it is necessary to ensure that it can interact efficiently with the other companies operating in that channel.

The wider acceptance and recognition of synchromodality as a working and workable concept, able to deliver real gains, is a potential threat to wider adoption. The loss of control may be a concern to transport and logistics operators particularly in relation to pricing and costs. Given the highly competitive nature of the sector this may be a real constraint. The fundamental requirement within synchromodality for comprehensive communications and IT systems across all involved parties in real time could also be seen as a threat given the implied costs, complications, and risk of failure.

To become an integral part of the freight and logistics world the synchromodal concept has to deliver real results in the form of cost savings, revenue and volume gains on a sustained basis. To practitioners within the sector its presence may not be as visible as the proponents of the concept and structure suggest. In terms of business applications, the synchromodal concept lends itself to applications where one lead shipper/manufacturer is supplying to multiple destinations over a multi-product range of commodities with varying shelf life and replenishment requirements. Effectively the shipper/manufacturer passes control to the 4PL to manage the flow of commodities through the supply chain with the involvement of the requisite service providers including forwarders/3PLs and transport service providers. The lead shipper would anticipate cost reductions by effectively outsourcing the whole supply chain control position, but this would need to be governed by defined roles, scope of involvement and contractual positions being in place and monitored. For open systems, the position appears to be more complex and involve a dynamic mix of players and supply chains which may vary markedly in terms of traffic activity, routing requirements etc. Constructing, operating, managing, and marketing an open synchromodal option could be seriously constrained.

In summary synchromodality offers some advantages to some shipper/receivers and cargo interests. It is a sophisticated construct and may not be applicable to some traffic and commodity flows. These would need to operate under more established and orthodox rules and relationships. Synchromodality holds out the prospect of integrated and informed logistics and freight operations but is not a panacea. It is part of an evolving set of models and processes and should be seen in that light.

4.3. Travel time accuracy

Travel time accuracy is important for all forms of transport and in particular for synchromodality. To ensure waiting time and delays of any sort are minimised it’s important to know the exact timings of the various freight modes. Over the last five years, rail freight trains in the UK have, on average, been delayed by 10 minutes for every 100 kilometres travelled (ORR, 2021). Based on the distance travelled by freight trains in Europe, this means that more than half are likely to be delayed by more than one hour. The reliability of the rail freight sector has therefore been more scrutinised, especially when compared to other modalities where delays are far less excessive.

However, road is the dominant form of freight transport and there are increasing numbers of software products trying to accurately predict travel time. Historically, vehicle route planning (VRP) software used a digitised road map which consisted of a series of nodes and links. The nodes represented points on a map which had coordinates and could typically be a road junction of some form, or a change in the type of road. The links were the connections between the nodes and had associated with them, amongst other things, a distance and a road category for which a typical speed was defined. With these parameters a travel time for the link could be established. The same road category speeds could be different if it was a rush hour period or a congested city, for instance. A shortest path algorithm would then be used to find the shortest distance or quickest time between two nodes which could be a distribution centre or a customer. This approach produced an adequate approximation but lacked many of the operational issues that trucks came across on a daily basis. For instance, the speed, and hence travel time, on a particular stretch of road could vary constantly by time of day and by day of the week. In addition, predicted short term congestion such as road works could not be taken into account. Too little attention has been given to the effects of congestion on the variability of transit times and the wider consequences for logistical efficiency and performance. Traffic congestion impairs the reliability of travel times. Increasing congestion has had an effect on road speeds, gradually reducing them over time. Most congestion is regular and predictable. It can be comfortably accommodated by building extra slack into delivery schedules, usually involving the commitment of extra resource in vehicles and drivers. One supermarket retailer said that they had previously sent trucks to serve London stores starting from a distribution centre at 5.30am, but now they were having to start at 5am. Congestion was therefore being anticipated for a given route. Something traditional VRP software could not handle. However, when traffic congestion lengthens the average transit time, the quantity of inventory in the transport system increases (ITF, 2014).

Road infrastructures are not keeping pace with increasing traffic which means congestion will only get worse. Traffic congestion occurs throughout the day but particularly in the morning and evening peak times of 7am to 9am and 4pm to 7pm respectively. About 80% of all freight movements occur during the day (Palmer & Piecyk, 2010). Freight transport operators may be able to absorb predictable congestion-related delays and revise their delivery schedules to accommodate longer transit times. In practice, however, congestion also causes variability in journey times from day to day, reducing the reliability of transport operation. Vehicles could be re-routed, but this would incur extra distance, fuel consumption and carbon emissions. One option would be to postpone travel to off-peak times which would enable transport operators to use their vehicles more efficiently by taking advantage of free-flow traffic conditions. The benefits of rescheduling road freight transport operations are usually considered in the context of urban distribution. Deliveries, especially in urban areas, can be subject to several different types of time restrictions such as night-time restrictions imposed by local authorities at the point of delivery, access time restrictions in pedestrianised areas, area-wide loading and unloading time restrictions on the kerbside or delivery time restrictions imposed by the receiving unit. Research indicates that cost and CO_2 savings of between 1.6% and 5.1% could be achieved by rescheduling deliveries to off peak periods and in particular to night-time deliveries (Palmer & Piecyk, 2010).

A survey suggested that congestion contributed to a third of delays. Other journey delays occur due to problems at collection and delivery points such as queueing at distribution centres, vehicle breakdowns and staff absences (McKinnon et al, 2009). This survey looked at 55,820 journey legs across a number of industry sectors, and showed that 26% of these legs were subject to a delay and 35% of these delays (i.e. 9% of the total) were attributed mainly to traffic congestion. The table below summarises the findings.

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	Food	Drink	Pallet-load C&D	Pallet-load trunk	Non-food retailers	Automotive	Builder's Merchants
Traffic congestion	35%	21%	34%	31%	57%	10%	34%
Problem at delivery point	28%	26%	41%		17%	4%	37%
Problem at collection point	8%	6%	16%		6%	6%	
Own company action	24%	8%	8%	11%	26%	4%	20%
Lack of driver	4%	2%	1%	1%		5%	
Vehicle breakdown	1%	1%	0%		2%	4%	9%
Hub operation				57%			

Table 1: Percentage of journey legs delayed disaggregated by cause and sector (reproduced from McKinnon et al, 2009)

Surveys also show that companies are wanting to monitor the progress of orders on the road so that appropriate actions can be taken in the event of delays (Gartner, 2020) with one survey showing that 70 percent of consumers want the ability to track progress of shipments and 47 percent want an accurate delivery date estimate (Project44, 2020). There is rapid growth in real time visibility software, but it is very fragmented and the software may only cover some aspects of the supply chain operation. To be effective these software products need accurate prediction of not just travel and arrival times at customers premises, but also turnround times.

Companies will tend to prioritise outbound flows, and if a planner does not have confidence in travel time accuracy, they are unlikely to allow a backload as this may compromise subsequent outbound journeys. The concern is that any delays whether outbound or inbound may transmit the problem further down the supply chain, possibly resulting in stockouts and lost sales downstream. Also, if companies are constrained by the activities of upstream suppliers and downstream distributors and customers, particularly if there are specific customer requirements, then this may mean that scheduling will be tightly constrained, and shippers will be forced to make a large proportion of deliveries at peak times making them more likely to be seriously affected by congestion.

More recently a number of vehicle route planning and on the road monitoring software systems have started to use dynamic travel times using artificial intelligence. With increasing levels of data being collected from on road monitoring, this technique uses historical data and probabilities to find more accurate travel times, with machine learning to constantly refine and improve the accuracy of these measurements. These calculations come from vast numbers of GPS traces from satellite navigation systems. For any pair of junctions X and Y connected by a road segment, large datasets of travel times at different datetimes would be available. Based on that premise, for any requested journey, a route map can be populated with the appropriate timings, which can then be used to compute the timings for any proposed route.

Using AI to more accurately reflect these problems in travel time variability will mean assets such as trucks and drivers are used in the most optimal fashion and that customers can be sure of reliable deliveries. It will also help with scheduling of vehicles knowing that trucks will be in an expected location at the expected time. On the road, this approach is useful for proactively making adjustments to downstream supply chain activities in the event of any unexpected delays. For customers, knowing exactly when a shipment will arrive allows the unloading team at the customers premises to be ready and therefore be more efficient with their time. This, and having the ability to proactively notify customers of any changes, will also keep customers satisfied and loyal.

However, in order to get the maximum benefit of this AI methodology, it can only be useful to those companies that have a significant and clean historic database of routes with orders that have

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recorded actual loading and delivery times including any intermediate drop off or collection points. This should ideally include enroute real time GPS data. The reason for this is that obtaining accurate and precise travel and turnround times is dependent on including many variables in the AI calculation such as traffic, weather, order information, the driver's past activity and breaks, dwell time on site, etc.

5. Conclusions

This report has briefly looked at the current state of the logistics sector and considered the improvement potential when companies collaborate. It has shown that although empty running is currently about 20% it will not be possible to eliminate it. However, it may be feasible to reduce this level by about 5% through careful collaborative planning. In addition, although volumetric vehicle capacity utilisation isn't measured, by combining volume constrained and weight constrained products to create a balanced, densely packed vehicle it would be possible to improve vehicle fill capacity.

Various strategic analyses have shown that horizontal collaboration has the potential to not only reduce costs, but also to also have a significant reduction in kilometres travelled thereby reducing the external costs of transport. However, collaboration can be complex and time consuming which tends to inhibit companies. Of particular concern are the issues of trust and transparency. There are many other barriers to overcome and for collaboration to be successful it needs a certain type of company culture such as pragmatism and innovative thinking, but it also needs individuals of a certain character who are able to push through the barriers and drive collaboration forward. There may come a day when there isn't a choice and collaboration between transport operators will be the only way of operating supply chains. This is the aim of the Physical Internet (PI) which is being proposed by various groups around the world because freight transportation is crucial to society, and it is beset with inefficiencies. The purpose of the Physical Internet is to create an open global logistics system founded on physical, digital, and operational interconnectivity in order to improve how physical goods are transported, handled, stored, supplied and used across the world. Collaboration and coordination are key factors in achieving the PI aim. The PI concept may be achieved through government policies, consumer pressure, or competitors, such as disruptor companies like Amazon.

According to Gartner (2020a) sustainability will be a major focus for logistics companies in the 2020s and this will be achieved through digitised freight platforms, artificial intelligence, internet of things devices, real time transportation visibility and methods for improving existing capacity utilisation through collaboration with other shippers.

The LOGISTAR project is a contribution towards the views expressed by the companies surveyed in Gartner's vision, as well as the PI, by developing a system that enables companies to collaborate operationally. The three use cases that have been trialled include load optimisation, synchromodality and travel time accuracy. This report has considered the current situation in each of these areas and looked at the opportunities which LOGISTAR can exploit.

List of abbreviations and acronyms

3PL Third party logistics – a service company that has assets and resources to provide transport and/or warehousing operations

4PL Fourth party logistics – a service company that does not necessarily own assets and resources but organises freight transport operations on behalf of a company or groups of companies. A 4PL will use one or more 3PLs coordination services but does not execute any of the activities themselves.

ALICE Alliance for Logistics Innovation through Collaboration in Europe

C3 Command, Control & Communications

FTL Full truck load

GHG Greenhouse gas emissions

HCV Higher capacity vehicle

LTL Less than full truck load

LSP Logistics services provider

PI Physical internet

RCC Regional consolidation centre

UCC Urban consolidation centre

VRP Vehicle route planning

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