Senator

Smart network operator platform enabling shared, integrated and more sustainable urban freight logistics

D6.3 Business Environment Analysis: Technical and Market Regulatory Recommendations Report 3

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3PLs	Third Party Logistics Operators
AI	Artificial Intelligence
BEV	Battery Electric Vehicle
CBA	Cost Benefit Analysis
CFC	Customer Fulfilment Centre
DSM	Digital Single Market
EDC	European Distribution Centre
eFTI	Electronic Freight Transport Information
EU	European Union
GDP	Gross Domestic Product
GDPR	General Data Protection Regulations
GHG	Greenhouse Gas Emissions
GVW	Gross Vehicle Weight
HGVs	Heavy Goods Vehicles
ICT	Information and Communication Technologies
IP	Internet Protocol
ITS	Intelligent Transport Systems
LEZ	Low Emission Zone
LGVs	Light Goods Vehicles
LTN	Low Traffic Neighbourhood
MGVs	Medium sized Goods Vehicles
NBGDs	Non-Binding Guidance Documents
NCA	National Competition Authority
NDC	National Distribution Centre
ONS	Office of National Statistics (UK)
RDC	Regional Distribution Centre

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Executive Summary

1 Introduction

The **objective of this report** is to set out the policy, technological and market-based context within which the SENATOR platform is being developed and therefore highlights some recommendations for how it should be developed.

RECOMMENDATIONS	
Recommendation 1.1	As urban logistics is a derived demand and a cost of production of the goods being transported, SENATOR should focus on minimising the costs of the transport operators.
Recommendation 1.2	As different stakeholders have different goals in relation to urban logistics, the SENATOR should support the public sector in its role in finding the correct balance between 'economic' and 'environmental' objectives for a particular urban area.

2 EU Policy Review and Competition Law

EU policy has sought to encourage city authorities to seek a balance between economic and environmental objectives in relation to urban logistics, recognising that efficient urban logistics is essential for the economy and the quality of life in cities. It also emphasises that logistics is a largely neglected area of urban transport policy and planning. The EU has mainly focused on providing guidance for, and best practice on, urban logistics rather than introducing legislation.

There is significant emphasis in a European Commission Communication called The New EU Urban Mobility Framework (December 2021) on urban logistics within the context of the overall subject of urban mobility. The Communication recognises that urban logistics is essential to the functioning of urban economies, while also aiming to completely decarbonise urban freight deliveries and collections by 2030. The more explicit inclusion of urban mobility - and urban logistics – into the TEN-T that is set out in the Communication should help to improve the integration of longer distance freight movements with first and last mile collections and deliveries via multi-modal distribution parks on the edge of urban areas and increase accessibility to EU funding for necessary infrastructure.

Provisional agreement on a new TEN-T Regulation has been reached, which would make the development of Sustainable Urban Mobility Plans (SUMPS) a requirement for urban nodes on the TEN-T. These SUMPs would need to include provision for urban freight and logistics, in an integrated approach with passenger transport.

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The EU has also been developing measures to ensure that vehicle manufacturers offer a higher proportion of zero emission vehicles to the market and that Member States will develop en route refuelling and recharging infrastructure for zero emission vehicles.

In relation to **competition law**, SENATOR should be in a position to provide a neutral 'third party' approach to the effective receipt and dissemination of information between the actors in the urban logistics supply chains. However, it will be extremely important in the design of the SENATOR tool to ensure that no 'strategic information' exchange is possible between competitors or non-competitors whether this is by design or default. A further way in which SENATOR can mitigate any risk of distorting the market by restricting participants is to allow open access and participation by market players irrespective of their size. Finally, it is necessary to ensure as much transparency in the SENATOR system as possible, without compromising the rules of information exchange and confidentiality.

RECOMMENDATIONS	
Recommendation 2.1	SENATOR should take full account in its design of the potential for the use of alternative (zero carbon) modes such as cycle logistics and also, where feasible, less carbon-intensive modes such as rail and inland waterways.
Recommendation 2.2	The SENATOR platform should take into account the overall requirements of Sustainable Urban Logistics Plans (SULPs) based on zero-emission vehicles and solutions, while allowing for flexibility to cater for the specific needs of individual urban areas.
Recommendation 2.3	The SENATOR platform should, wherever possible, improve the integration of longer distance freight movements with urban logistics via multi-modal distribution parks on the edge of urban areas.
Recommendation 2.4	The SENATOR platform should be designed to reflect the requirements of GDPR and the rules about processing of personal data to protect the integrity and confidentiality of any personal data that is kept.
Recommendation 2.5	SENATOR should be designed to facilitate collaboration between operators to minimise carbon emissions, while also maintaining a high degree of commercial confidentiality and not reducing competition.

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3 Urban Logistics – Market Structure

The urban logistics sector in Europe should be regarded as being **highly competitive and operationally very efficient**. It generally operates in the private sector and on purely commercial terms; although some national postal operators are state owned, they operate on commercial terms as, in effect, private enterprises.

Diesel powered road transport is currently the dominant mode, although the actual final deliveries into receivers' premises are also undertaken by other means, such as cargo bikes and on foot etc., and some cites have been experimenting with more sustainable solutions such as using fleets of electric vans, trains/trams and barges.

There are three main types of commercial organisation involved in urban logistics, namely:

- **Shippers** – the organisations which physically despatch goods into urban areas as a result of demand from its population.
- **Logistics operators** – the commercial organisations which physically convey goods into urban areas on behalf of shippers.
- **End-users or consumers** – the ultimate end-users or purchasers of the goods that are delivered into urban areas.

Within urban logistics, the public sector's role can be divided into two broad areas:

- The provision and management of highway infrastructure (including the kerbside) and other freight-related infrastructure such as parcel lockers; and
- Undertaking economic, safety and environmental regulation.

However, it could be argued that a further objective of public policy in urban areas in relation to urban logistics should be to encourage efficient logistics which will benefit the economy of the urban areas which are being served. Often efficiency and sustainability can be achieved simultaneously and the objective of public policy should be to seek 'win-win' solutions that optimise overall economic benefits (while taking into account economic externalities) rather than just seeking to minimise the 'nuisance' caused by urban logistics through regulation.

RECOMMENDATIONS	
Recommendation 3.1	SENATOR should be designed to minimise the costs for. and facilitate the operations of, private sector logistics operators, while also reflecting the legitimate regulatory concerns of the public sector, particularly in terms of emissions.

4 Key Demand Drivers

Overall drivers of demand for consumer goods in Europe have been driven by increasing **urbanisation of the population** and the increasing **importance of the services sector** rather

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than manufacturing, which affects the mix of goods which are distributed into and out of urban areas.

Another important demand driver over the last 20 years is the growth of retail goods sold via **e-commerce** platforms at the expense of sales via traditional 'bricks and mortar' outlets. This trend has been hastened by the impact of lockdowns due to the Covid-19 pandemic. The implication of this trend for urban logistics is that demand is being met by the use of smaller HGVs and LGVs to fulfil deliveries on a multi-trip basis rather than larger deliveries to retail outlets by HGVs. The rise of e-commerce suggests increasing trip rates into urban areas by freight vehicles.

Other key trends are:

- The rise of **convenience retail**, where many households have abandoned the traditional weekly trip to the supermarket/hypermarket for groceries and replaced it with an e-commerce order of some staple non-perishable items, supplemented by daily or every other day visits to convenience ('metro') type grocery stores for fresh and perishable groceries.
- The rise of **on-demand services**, whether purchasing digital services (e.g. streaming of music), through to the delivery of takeaway food through the use of digital applications.

RECOMMENDATIONS	
Recommendation 4.1	SENATOR should be designed to fully incorporate the use of mobile technology and the internet used by end consumers and logistics providers to make and receive orders, including integration with external digital market places (used by local as well as larger businesses) and receive and carry out deliveries in urban areas.
Recommendation 4.2	SENATOR should cater for a wide range of goods deliveries in urban areas, but there should be a particular emphasis on e-commerce deliveries of parcels due to the high levels of growth that are being seen in this sector in Europe as consumers move away from traditional 'bricks and mortar' retail.

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5 Urban Logistics – Business Models

There are three broad types of business models for urban logistics:

- The **classic logistics model** where goods are delivered in larger vehicles to 'bricks and mortar' retail outlets via a network of National and Regional Distribution Centres (NDCs and RDCS);
- **'E-commerce 1'** where goods are delivered from large RDCs direct to consumers (e.g. Amazon) often using a dedicated fleet of delivery vehicles (e.g. Amazon);
- **'E-commerce 2'** where goods are delivered from a single national Customer Fulfilment Centre to consumers, usually using parcel operators and via their cross-docking facilities located on the outskirts of urban areas.

The large 'bricks and mortar' retail chains are generally able to despatch fully laden using standard 13.6 metre semi-trailers as part of articulated HGV combinations when delivering into urban areas. Likewise, many other distributors (e.g. food or beverage wholesalers) are also able to assemble sufficient cargo so they can despatch fully laden vehicles into urban areas (albeit generally on a 'milk round' basis, so that they are making multiple deliveries and leaving their depot fully laden but returning empty). Consolidation within this sector over the past decade has also aided this process.

In the e-commerce sector, the common practice of contracting specialist 3PLs (including parcel couriers) means that goods delivered into urban areas from multiple shippers (often competitors) will end up being consolidated and ultimately delivered by common logistics operators using shared transport capacity.

In each case the goods vehicles entering urban areas are, predominantly, already running fully laden (or approaching fully laden) on the initial inbound flow. Furthermore, it means the number of vehicle movements into urban areas is significantly reduced. Overall, cargo consolidation into urban areas is already happening, driven by market mechanisms rather than regulation.

RECOMMENDATIONS	
Recommendation 5.1	SENATOR should be designed to cater for all 'last mile' logistics operations within an urban area and therefore be agnostic between the different logistics model used by shippers and their logistics providers.
Recommendation 5.2	SENATOR should be designed to cater for the concept of consolidation and therefore the transfer of goods, perhaps between logistics providers, prior to the 'last mile' delivery. Although consolidation tends to add cost to supply chains, the SENATOR platform should seek to add value by enhancing coordination between different logistics providers

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and reduce costs, while also maximising the confidentiality of data flows.

6 Emerging Issues and Associated Policy/Market-Based Measures

The key issue in relation to urban logistics is the need to **minimise the environmental impact of urban deliveries** and public policy therefore seeks to both minimise the impact of urban logistics and enhance the wider urban environment, while at the same time acknowledging that goods still need to be efficiently delivered to ensure that urban areas remain economically competitive and attractive places to live or work (from a commercial perspective).

The key long-term objective currently with respect to minimising the environmental impact of urban logistics is the **replacement of diesel and petrol powered freight vehicles** by other forms of propulsion (principally battery electric vehicles) and the greater use of **non-road modes** where feasible such as cargo-bikes, so called 'portering' (where cargo is handled over to delivery staff at designated drop-off points for delivery on-foot, aided where appropriate by carry-bags, sack-trucks or battery-electric powered trollies) and, in some more limited cases, rail and barge.

The other main area where the environmental impact of urban logistics can be mitigated is through the application of **highway management powers**. These powers assume the use of diesel or petrol powered road freight vehicles, but the type and time of day they can operate is restricted through:

- Weight and length restrictions
- Time restrictions
- Restricting or banning vehicles which generate the highest levels of gaseous and particulate pollutants.

A large number of urban areas in Europe have introduced **road charging schemes** either to reduce road congestion (congestion charges) or to improve air quality (Low Emission Zones). London, for example, has a Congestion Charge which requires most vehicles entering a central zone to pay £15 per day. It also has a Low Emission Zone for HGVs, which requires HGVs which are not Euro VI class to pay a punitive daily charge of at least £100 and £300 for most polluting older vehicles.

Urban consolidation centres are where multiple freight operators (3PLs and own account operators) initially deliver goods into a warehouse type facility located on the urban fringe. However, where their use has been voluntary, take-up to date has been very limited because additional handling adds cost to the supply chain, large-retail chains are already receiving deliveries in full loads and 3PLs (such as parcel couriers) are already in effect consolidating cargo from multiple shippers into shared transport capacity. As a result, freight vehicles are already running fully laden (or approaching fully-laden) on the initial inbound flow into urban areas. Further large-scale take-up of urban consolidation centres is therefore unlikely,

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except where special/specific circumstances have been demonstrated and necessitate some form of consolidation.

RECOMMENDATIONS	
Recommendation 6.1	SENATOR should be designed to monitor environmental emissions as Key Performance Indicators, with a particular focus on carbon emissions but also on other emissions that affect air quality such as particulates. To avoid excessive complexity, these KPIs could be based on average emissions per kilometre travelled in an urban setting for the relevant mode and vehicle.
Recommendation 6.2	SENATOR should be designed to cater for modes of transport that can realistically provide a more sustainable alternative to diesel and petrol-powered road vehicles and to be essentially agnostic between them, while reflecting reasonable generic values for their actual financial costs and environmental emissions.
Recommendation 6.3	SENATOR should be designed to accommodate the impact of other regulatory measures (such as road pricing) that could be introduced by city authorities, which are likely to either restrict the use of certain modes and vehicle types or increase their costs or require deliveries to be made by specified logistics operators.

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1 Introduction

1.1 Objective of Report

The **objective of this report** is to set out the policy, technological and market-based context within which the SENATOR platform is being developed and therefore highlights some recommendations for how it should be developed.

This report is the second deliverable from **Task 6.1 Technical and market-regulatory recommendations for integrated flexibility services and considers the business environment** within which the SENATOR products and services would be provided, considering both policy/regulatory and market-based issues. It is an update of D6.2, which was delivered in May 2022.

The **policy/regulatory issues** considered are:
- EU urban logistics and technology policy to ensure that the tools and services developed during the project are in line with these policies;
- EU anti-trust and competition law to ensure that any horizontal and vertical collaboration between commercial players is in line with EU law in this area; and
- Ensuring that vertical and horizontal collaboration is in line with EU data protection and privacy law.

The **market-based assessment** of the business environment considers:
- Societal trends;
- Technological drivers;
- Demand drivers; and
- Emerging business models in relation to urban logistics.

In addition, a new section on **technological issues** has been added, which focuses on:
- Digital technologies that are emerging; and
- Alternative fuel technologies for urban logistics.

Specific recommendations for the project are provided in tables at the end of each chapter.

1.2 Working Definitions

Urban logistics may be defined as the movement of goods, equipment and waste into, out, within or through an urban area[1]. It is a broader definition than 'urban freight transport' as it includes the movement of vehicles related to the provision of services (i.e. including the

[1] COMMISSION STAFF WORKING DOCUMENT A call to action on urban logistics, European Commission 2013

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transport of equipment and tools required for servicing activities, such as maintenance and repairs) rather than just the movement of goods and waste.

Urban freight transport is the subset of urban logistics that relates only to the movement of goods and waste.

However, the SENATOR project is focused on the movement of goods and waste rather than servicing activities and so the scope of the project is essentially closer to that of urban freight transport.

In economics**, demand** is the quantity of a good or service that consumers are willing and able to buy at a given price in a given time period. The level of demand for particular goods and services is influenced by a number of factors, including necessity, quality, convenience, purchasers income and tastes/fashions. **Supply**, on the other hand, refers to the total amount of a specific good or service that producers are able and willing to make available to consumers. Urban logistics (and by extension urban freight transport) is a **derived demand** and should be seen as a cost of production; the demand for urban logistics is the result of demand for goods (which subsequently needs to be transported into an urban area from distant locations) rather than demand for urban logistics services in its own right.

Shippers refers to the organisations which physically despatch goods into urban areas as a result of demand from its population. The process of transporting goods into urban areas can be undertaken either directly by shippers (using their own transport fleet) or by specialist **logistics service providers** (freight transport operators) on behalf of shippers. **Supply** within urban logistics therefore generally refers to the amount of freight transport capacity that can be made available to shippers rather than the amount of goods available. The total supply of freight transport capacity will be defined by the number and size of HGVs, vans or cargo bikes etc. that operators can make available to shippers.

1.3 Generic Stakeholder Analysis

Stakeholder framework for urban logistics

Urban logistics involves the movement of vehicles in urban areas which generate economic externalities, such as environmental emissions, congestion and noise, the latter being a particular issue if deliveries are being made at night. These issues cause concern for residents in urban areas and for the city authorities that are responsible for environmental regulation and transport policy.

At the same time, however, residents want to have a wide range of goods available in the local shops, to visit bars and catering establishments and to receive e-commerce parcels at their homes or offices. They would also recognise that freight transport activity generates employment, as well as supporting city economies by providing an efficient low cost service.

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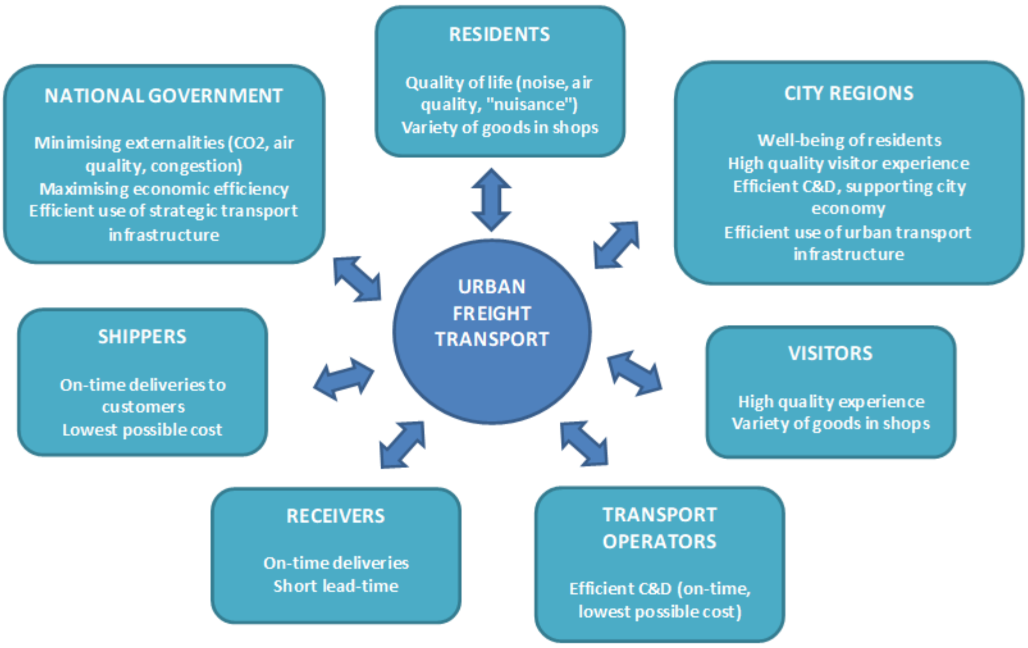
Taking these different perspectives into account, it is important that the regulatory/policy regime reflects the interests of local residents as well as the private and commercial interests of the private sector freight industry.

The different expectations of the various actors in relation to urban logistics can be described through stakeholder analysis, which categorises the different groups of people and organisations with an interest in the subject and highlights their different expectations.

The figure below shows the main stakeholder groups that are affected by freight transport in cities, with their main expectations. In very general terms, residents and visitors are seeking a high quality of life/experience, while transport operators and their customers (including local businesses in the urban areas) have a strong interest in achieving low cost, on-time deliveries.

Figure 1.1: Urban Freight Transport – Key Stakeholders



These different expectations can result in conflicts that need to be resolved through trade-offs between the private needs of the freight industry and its customers and public needs (improved air quality, lower congestion etc.) through the intervention in the market by city authorities. In economic terms, where the costs of private activities are not fully reflected in the user costs of the freight industry and their customers, there is market failure; the public sector therefore has a role in seeking to balance the needs of the private operators with the wider needs of society and the required balance may be different in different cities because there is no "one size fits all solution".

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The perspectives of national government are likely to be different from those of city authorities. While government at the national level is likely to be more concerned with impacts on the strategic transport infrastructure, the more strategic (and global) issue of greenhouse gas (GHG) emissions and the efficiency of the national economy, city authorities are likely to have a greater concern with the well-being of local residents and the functioning of the local economy. Having said that, national authorities are increasingly introducing policies to secure Net Zero that have an immediate impact on cities and urban logistics, such as the introduction of deadlines for the end of the sale of diesel and petrol-powered vans.

Stakeholder analysis: the case of Chester

One of the measures adopted by city/local authorities as they aim to balance the needs of their residents with those of transport operators is enforcing vehicle access regulations. These measures can take various forms such as a low/zero-emission zone, congestion charging, or a pedestrianised area. Depending on the regulation, vehicle access can be contingent on vehicle type, emissions class, payment of a fee or toll, or time of day. This is applied to limit congestion, increase safety, reduce noise pollution and improve air quality by reducing emissions from vehicles or to provide a more attractive vehicle-free environment for residents of, and visitors to, a town or city[2].

Chester is a heritage city in Cheshire in North West England, founded as a Roman fortress in AD75. Its centre serves as a destination for tourism supported by businesses in the leisure and hospitality industry, and a retail sector focused on small specialist shops and outlets with an e-commerce offering as well as larger retail chains. As such, the businesses often require low-volume, but frequent goods deliveries. This generates high trip rates into the city centre by both light goods vehicles (LGVs) and smaller heavy goods vehicles (HGVs).

The historic city centre has a long-standing access restriction for all motorised vehicles from 10:30am to 4:30pm, implemented to protect its heritage characteristics and the safety of pedestrians while they enjoy the city centre attractions.

To investigate the effect of pedestrianisation on urban freight activity, two surveys were carried out, as follows:

- A survey of business perceptions in the city centre;
- An observational commercial vehicle traffic survey.

The **survey of businesses** investigated the experience of businesses in the city centre with respect to the delivery/collection of freight and waste collection, both within and outside the pedestrianised area.

The majority of businesses surveyed operate in the non-food retail sector. Respondents also contained a representative selection of businesses in food retail and takeaways, as well as cafes and restaurants. Questions explored the nature and frequency of freight deliveries and

[2] Urban Vehicle Access Regulations - European Commission (europa.eu)

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issues that emerge for the businesses located in the city centre. Key insights are summarised below:

- Most freight deliveries were in the form of parcels and boxes, implying they are relatively lightweight and can be handled by a single person;
- Deliveries are generally made before the city centre is closed to vehicles with a peak from 09:00-10:30 (61% of businesses), but a reasonably high proportion remains that receives deliveries after this time;
- The majority of deliveries are by transport operators using a light goods vehicle ('white van'), while some are by specialist logistics companies using a mix of light and rigid heavy goods vehicles;
- Deliveries are likely to come mainly from Regional or National Distribution Centres, but also on occasions even from abroad;
- Most businesses did not report significant issues with deliveries. However, there remained businesses that experience late deliveries, suffered from the unreliability of deliveries, and the inconvenience of delivery times.

Only about a quarter of respondents had collections of non-food retail goods. Of those that had collections, key insights included:

- Most collections are carried out by parcel companies, specialist logistics companies, or Royal Mail;
- Collections are dispatched to outside the North West region and to the North West region beyond the immediate Chester area;
- Some referenced late collections, the infrequency of collection services, and the inconvenience of collection times as significant issues.

Businesses also pointed to temporary congestion in streets by the barriers of the pedestrianised zone if vehicles that are unaware of restrictions attempt to enter. Short-term congestion also occurs in narrow one-way streets when vans are loading or unloading. Overall, the survey indicates pedestrianisation causes no major issues, probably because logistics providers have adapted over many years to the existence of bans on deliveries and collections in the middle of the day in Chester city centre.

The observational traffic survey examined the movement of commercial vehicles through the city centre in the morning peak period for deliveries from 07.00 to 11.00. It quantified the number and type of vehicles used to move freight in the heritage city centre. Where possible, it also aimed to estimate their origin and purpose of visit based on the nature of the business advertised on the vehicle.

By vehicle type, most freight and servicing vehicles were LGVs (75.5%) followed by HGVs (18.0%). Waste collection vehicles made up 5.7% of vehicles, while bicycles used for food takeaway deliveries were the least prevalent (0.8%). This is reflective of the location, as LGVs and small HGVs are most suited for urban freight transport and servicing activities. Less than 1% of movements observed were by zero emission vehicles.

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The peak of movements was during the period 09.30-10.30, which is when 44% of total freight movements were recorded.

Research on the impact of time-restricted vehicle access highlights a change in transport operators' behaviour who have to adjust their deliveries to be carried out in a shorter timeframe. This could mean operating a larger number of smaller vehicles if multiple time-restricted locations have to be served simultaneously. Similarly, concentrating deliveries during the peak commuting period could exacerbate congestion, leading to more time-consuming and relatively inefficient deliveries.

In this case, however, as the pedestrianised zone is quite small and Chester, with its "closed" city centre during much of the working day is usual in the wider region, freight transport operators are probably able to shift delivery schedules so that deliveries within the pedestrianised zone are prioritised in the morning before access is restricted, and then other locations are served by the same vehicles later in the day; this allows the operators to maintain the same number of vehicles used and trips undertaken so that operational costs are not affected.

Various stakeholders' interests are involved when a regulation such as vehicle access restriction is applied. By implementing a pedestrianised city centre, the local authority is able to find a balance between the interests of the residents, visitors, transport operators and receivers of goods. Residents enjoy the safe and traffic-free access to shops and eateries during the day and an enhanced quality of life from reduced air pollution and noise. Receivers of goods in the city centre have on-time deliveries early in the working day and transport operators are able to schedule their deliveries and collections in the city without too much of an impact on their costs and wider regional operations. Benefits such as improved air quality, reduced noise, and safe access to the city centre are, similarly, enjoyed by tourists visiting the city, so that visitors' expectations of a high quality experience are also met.

Data from the two Urban Living Labs in Zaragoza and Dublin will be used to inform the next iteration of the Business Plan for SENATOR in Task 6.2.

1.4 Recommendations for the project

RECOMMENDATIONS	
Recommendation 1.1	As urban logistics is a derived demand and a cost of production of the goods being transported, SENATOR should focus on minimising the costs of the transport operators.
Recommendation 1.2	As different stakeholders have different goals in relation to urban logistics, the SENATOR should support the public sector in its role in finding the correct balance between 'economic' and 'environmental' objectives for a particular urban area.

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2 EU Policy Review and Competition Law

2.1 EU Transport Policy

2011 White Paper[3]

The 2011 White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" gave significant attention to urban transport and included the goal of **achieving essentially CO2 free city logistics in major urban centres by 2030.** Policy at this point was therefore focused on reducing GHG emissions from urban logistics, rather than other policy goals.

A Call to Action on Urban Logistics, 2013

Following the publication in 2012 of an independent study on urban freight transport[4], which included policy recommendations specifically on the sector, the Commission published in 2013 its Commission Staff Working Document entitled, "A call to action on urban logistics" alongside a Communication on the wider issue of urban mobility[5].

This document, which provided an estimate that urban freight produces approximately 6% of all transport GHG emissions, also highlighted the importance of the efficiency of 'last-' and 'first-mile' logistics on the urban economy and in the take-up of e-commerce across the EU.

It argued that, "The short distances, regular start stop, captive fleets and the large number of people exposed to the air and noise pollution provide an opportunity for urban logistics to make an early and significant contribution to optimising transport and foster the early and cost effective introduction of new types of operations, technologies and business models." It also suggested that, "Simple improvements in urban logistics such as better mode and vehicle selection, improved load factors, route optimisation and access to loading/unloading zones can be very cost effective and reduce the cost of goods and services."

The Working Document highlighted a number of issues in policy-making by cities in relation to urban logistics:

- Urban logistics is heavily neglected in city and transport planning.

[3] https://ec.europa.eu/transport/themes/european-strategies/white-paper-2011_en
[4] Urban Freight Transport, MDS Transmodal & ITL, 2012
[5] COM(2013) 913 final Together towards competitive and resource-efficient urban mobility

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- Cities do not have a long-term vision for urban logistics and it is not properly integrated into urban transport and economic development strategies.
- Without co-operation and understanding amongst stakeholders (when urban logistics is operated by and for the private sector, often without coordination with the city authorities) it is not possible to implement long term solutions to urban logistics problems.
- In almost all cities there is a lack of information and understanding of freight flows, which makes it difficult to improve operational efficiency and plan for the long term. There is also a lack of easily available and useful information available to urban transport operators about urban logistics policies, regulations and services in each city.

The Working Document states that, "City authorities, regions, logistics operators and businesses have a common interest to optimise city logistics – but far too often they operate in isolation and without the necessary co-operation and agreement. Through bringing together the local actors, as part of a Sustainable Urban Mobility planning, meaningful plans of action can be developed."

Recommended measures included:

- Managing demand through Delivery and Servicing Plans for large-scale sources of demand for urban logistics (e.g. hospital sites, large offices).
- Shifting mode from road to bike, boat or rail "for certain flows" (which are assumed to be niche markets where the geography of the city might favour some deliveries by barge in specific locations or strong regulatory measures that ban motor vehicles in large areas of a city and which would therefore support the use of cargo-bikes).
- Improving the efficiency of urban logistics through the greater use of ITS (e.g. to improve load factors, routing and allocation of loading bays etc.) within the context of longer (even international) logistics chains.
- Improving vehicles and fuels, given that the density and frequency of operations and actors makes urban areas a particularly attractive place for the roll out of alternative fuel infrastructure.

The Commission pointed out that the EU has funded the development of large volumes of best practice documentation[6] for city authorities, but it would be producing further guidance documents to provide cities with practical assistance on how to improve urban logistics performance.

The document concluded that, "Efficient urban logistics is essential for the economy and the quality of life in cities where most European citizens live but is largely neglected in urban

[6] Best Practice Factory for Freight Transport (BESTFACT) available at www.bestfact.net.

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transport policy and planning. Despite the general agreement on the problems, and in many cases the solutions, there is a broad lack of attention to urban logistics issues".

Study on Urban Logistics – The Integrated Perspective (2018)

In 2018 a consortium of experts developed the further guidance that was referenced in *A Call to Action on Urban Logistics* in the form of some Non-Binding Guidance Documents (NBGDs) for urban logistics[7]. The guidance was mainly designed for the public sector, supporting them in developing an integrated approach to the sector.

NBGD1 was on Use of Information and Communication Technologies and aims to assist policy makers by identifying current best practices for the use of ICT and is therefore particularly relevant to SENATOR. It offers an overview of 13 ICT solutions, grouped in six clusters. Some examples of solutions are communication from vehicle to vehicle and from vehicle to infrastructure, real time logistics monitoring, fleet management or collaborative platforms.

The other NBGDs are:

- NGBD2: Treatment of logistics activities in Urban Vehicle Access Regulation Schemes
- NGBD3: Engagement of stakeholders when implementing urban freight logistics policies
- NGBD4: Logistics schemes for E-commerce
- NGBD5: The use of Environmentally Friendly Freight Vehicles
- NGBD6: Indicators and data collection methods on urban freight distribution

The study concluded with the following general recommendations for the development of urban logistics policies by the public sector:

- Step 1 – Identifying the Urban Freight Logistics Issues: identification of the challenges to be addressed where a challenge is "a well-defined (in time and space) freight logistics activity that disturbs the normal development of the other urban users' activities." The issues (such as congestion and emissions) should be defined using stakeholder consultation and the collection of relevant data.
- Step 2 – Characterising the city's Logistics Profile (LP): the identification and isolation of homogeneous groups of logistics needs within the area of intervention, defined based on the following key aspects: (i) the urban characteristics of the area, (ii) the requirements of the logistics agents (i.e. type of delivery), and (iii) the characteristics of the products being transacted. An example is a business centre (a concentration

[7] https://ec.europa.eu/transport/themes/urban/studies_da

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of offices), with courier deliveries and collections, small-scale deliveries (e.g. stationery) and e-commerce deliveries to office workers.
- Step 3 – Selecting relevant solutions: The selection of the best solution based on the logistics profile, the nature and magnitude of the challenges and other contextual issues. Investments in policy must be compared against the expected benefits using some form of cost-benefit analysis (CBA) or multi-criteria analysis (MCA).
- Step 4 – Definition of Performance Variables, Data Collection and Metrics: Key performance indicators (KPIs), can monitor the most important aspects of the urban mobility system. They must be chosen on a case-by-case basis, related to the policy measure, and according to the SMART[8] approach. Data collection after implementation allows for an evaluation of the policy, and can allow for the policy to be adjusted at a later stage.
- Step 5 – Implementing policy solutions and achieving results: final implementation of the measures, while listening to and engaging with stakeholders to resolve the issues and formal evaluation of impacts.

The New EU Urban Mobility Framework (2021)

Introduction

In December 2021 the European Commission published a new Communication on its plans to take more decisive action on urban mobility to shift from the current approach based on traffic flows to an approach based on moving people and goods more sustainably. This is so that transport in urban areas can contribute to the EU's increasingly ambitious climate, environmental, digital, health and societal objectives.

Trans-European Transport Network (TEN-T)

The Commission argues in its Communication that cities are important elements of a well-functioning TEN-T Network. However, network bottlenecks, missing links and poor connections remain major challenges for integrating urban nodes (i.e. cities) into the network.

Urban freight transport is given some prominence in the Communication. Interconnectivity between long distance and 'first and last mile' connections for efficient freight transport is fundamental for the smooth functioning of the TEN-T and should be better reflected in urban and regional planning. For example, to support quicker and more efficient zero-emission logistics in urban nodes, a sufficient number of multimodal terminals and freight consolidation centres is needed.

The deployment of recharging and refuelling infrastructure for low- and zero-emission vehicles at these centres and logistics hubs is particularly important for delivery vehicles, so

[8] Specific, Measurable, Attainable, Reliable, Time-based

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that a switch can be made from long distance transport modes to zero emission vehicles for local deliveries and collections.

Alternative delivery solutions, such as cargo bikes and inland waterways should also be considered and better utilised in urban logistics, with automated deliveries and drones (unmanned aircraft) being increasingly used in the future where such modes are appropriate. To tackle these deficiencies for passenger and freight transport, the TEN-T Regulation needs to be strengthened to include urban mobility, which is essential for the overall good functioning of the network. At the same time, cities need to retain a sufficient level of flexibility in full respect of subsidiarity. Therefore, the proposed revision of the TEN-T Regulation provides for a reinforced approach to a larger number of urban nodes.

The Commission was proposing to revise the TEN-T Regulation, with the following requirements for urban nodes in relation to freight:

- The adoption of Sustainable Urban Mobility Plans (SUMPs);
- The collection and submission of urban mobility data;
- The development of multimodal freight terminals to ensure sustainable urban logistics is based on a comprehensive analysis at Member State level.

Monitoring progress

To understand the progress achieved and improve existing plans, comprehensive data has to be available. As local authorities take individual actions to achieve policy goals, it is becoming more evident that a common approach to monitoring and providing information is lacking. EU-wide standardised indicators would also make it easier for cities to share best practices. This common knowledge base could in turn allow them to pursue joined-up approaches at the European level to implement sustainable urban mobility plans.

Therefore, in order to increase the uptake of the indicators, the Commission will:
- by the end of 2022, improve and streamline the set of 19 sustainable urban mobility indicators already identified as well as the related benchmarking tool;
- in 2023, launch a programme support action under the Connecting Europe Facility to Member States for the collection of data for harmonised mobility indicators in order to monitor the progress achieved by TEN-T urban nodes towards sustainable urban mobility.

Zero-emission city freight logistics and last-mile delivery

The Communication accepts that urban logistics is essential to the functioning of urban economies, even more so during and following the COVID-19 pandemic which has resulted in an increase in e-commerce activity and home deliveries. Consumer e-commerce deliveries grew by 25% in 2020 due to the pandemic, and the increase in last-mile deliveries is likely to persist.

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Besides the proposed features on urban nodes in the revision of the TEN-T Regulation, the Communication argues that deployment of rapidly developing and sustainable solutions such as cargo bikes needs to be accelerated, using new distribution models, dynamic routing, and a better multimodal and connected use of urban rail and inland waterways. This would support optimisation of the use of vehicles and infrastructure and reduce the need for empty and unnecessary movements.

Freight should feature prominently in the sustainable urban mobility planning to accelerate their deployment. More effort is needed to ensure that the existing sustainable urban logistics plans (SULPs) are better embedded in the SUMP framework and further developed and implemented across the EU37. This will help to achieve the goal of zero-emission urban logistics by 2030.

Interventions should focus on the deployment of zero-emission solutions, technologies and vehicles for urban logistics.

Ensuring the engagement of public and private stakeholders is central to optimising urban logistics and last-mile delivery in economic, social and environmental terms. Collaboration between local authorities and private stakeholders, regular dialogues among all parties, networking and exchanges among cities' planners are key actions mentioned by both local authorities and private stakeholders to build knowledge on sustainable urban logistics management and planning. In addition, more work is necessary at EU level on assessing the need for more urban freight data collection and sharing.

Conclusion

There is significant emphasis in the Communication on urban logistics within the context of the overall subject of urban mobility. The Communication recognises that urban logistics is essential to the functioning of urban economies, while also aiming to completely decarbonise urban freight deliveries and collections by 2030.

The more explicit inclusion of urban mobility - and urban logistics – into the TEN-T should help to improve the integration of longer distance freight movements with first and last mile collections and deliveries via multi-modal distribution parks on the edge of urban areas and increase accessibility to EU funding for necessary infrastructure.

The EU has built on the Communication on urban logistics to implement more practical measures in the TEN-T Regulation and the 'Fit for 55' measures, which focus in particular on working to decarbonise transport chains within urban areas.

TEN-T Regulation (2023)

A provisional agreement was reached in December 2023 between the European Parliament and Council on a revised TEN-T. The revision will set mandatory targets including that all 430

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major cities will be required to develop Sustainable Urban Mobility Plans to enhance zero and low emission transport.

It also sets a target of developing safe and secure parking spaces along the core road network, at an average of every 150 km by 2040. Additionally, the number of multimodal transhipment terminals is to be developed in line with traffic flows and the sector's needs, with the target of shifting more freight onto sustainable modes and adopting more combinations such as rail-road to move freight.[9]

National Support Programmes for Sustainable Urban Mobility Planning (2023)

The Commission adopted in March 2023 a Recommendation on National Support Programmes for Sustainable Urban Mobility Planning[10] as a follow-up on the Urban Mobility Framework of 2021.

A decade prior to this Recommendation, the concept of SUMPs had been introduced as a framework for urban mobility planning and their adoption had been encouraged for use by local authorities, planners and stakeholders. Non-binding guidance and reference materials are made available by the Commission to support cities in preparing and implementing their SUMPs[11], which fall entirely within the responsibility of Member States and their cities. Their benefit is outlined in the Recommendation, which points to the emergency and resilience procedures prepared in existing SUMPs as playing a role in cities' resilience during the COVID-19 pandemic. Cities with a SUMP were able to efficiently adapt their mobility policies. A wider adoption of SUMPs is called for, as there remains uneven uptake across Member States in their adoption and alignment with the EU framework.

The Commission had previously recognised the need to update the SUMP concept to reflect new EU strategies and policy priorities. The Recommendation retained the original eight guiding principles:

1. Clear and measurable goals and objectives;
2. Long-term vision and a clear implementation plan;
3. Assessment of current and future performance;
4. Integrated development of all modes of transport while prioritising the most sustainable ones;
5. Integrated approach to passenger mobility and urban freight transport and logistics;
6. Participatory approach and coordination with other relevant initiatives;
7. Monitoring, review, reporting and quality assurance; and
8. Guidance and support at European level.

Updates are made within each principle where needed, which incorporate policy developments such as enhancing road safety and addressing climate change by supporting

[9] Provisional agreement on more sustainable and resilient trans-European transport network brings Europe closer together - European Commission (europa.eu)
[10] Publications Office (europa.eu)
[11] SUMP Guidelines and Decision Makers Summary - European Commission (europa.eu)

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zero-emission mobility. Member states are invited to inform the Commission of actions taken annually as a result of this Recommendation, starting in March 2024.

Within the European strategy for data, the Commission proposed addressing the fragmented nature of the transport and mobility data landscape by establishing a common European mobility data space (EMDS). The aim is to help public and private actors access and use relevant data in an easier way. This applies to urban logistics as it would enable access to freight and urban infrastructure data such as kerbside use, real-time traffic monitoring, and data on charging infrastructure. Phase 1 took 12 months up to the end of 2023 and began by mapping existing mobility and data ecosystems and forming an initial identification of common standards. Future phases will focus on creating data-space pilots built around traffic and urban mobility indicators.[12]

Sustainable urban mobility indicators are adopted to monitor the implementation of SUMPs, in addition to identifying strengths and weaknesses of mobility systems. The revised TEN-T Regulation includes data collection requirements in the following areas: greenhouse gas emissions, congestion, deaths and serious injuries caused by road crashes, modal share for all modes, access to mobility services, data on air and noise pollution in cities.[13]

Euro 7 Standards

In December 2023, a new emissions standards regulation was adopted covering cars, vans, and heavy-duty vehicles under one set of rules. This is set to come into force in 2025 for cars and vans, introducing stricter limits to the harmful pollutants produced by road vehicles. Heavier vehicles such as buses and trucks will have two additional years until 2027 to meet its requirements.

For cars and vans, Euro 6 previously had different exhaust emission limits based on fuel type, while Euro 7 applies the lowest Euro 6 limits to all new vehicles regardless of fuel type. It also introduces standards for brakes and tyres, which shed particulate matter as they are used. A new requirement extends the application of Euro 7 to electric vehicles as it will target the longevity of their batteries. [14] For vans, durability is set at 75% from start of life to five years or 100,000 km, and 67% up to eight years or 160,000km. [15] New digital methods are to be used for emissions monitoring through on-board sensors to simplify compliance over the lifetime of a vehicle.

Fit for 55: CO_2 emissions performance standards

[12] Explanatory Memorandum to COM(2023)751 - Creation of a common European mobility data space - EU monitor

[13] Sustainable urban mobility planning and monitoring - European Commission (europa.eu)

[14] Euro 7: Council and Parliament strike provisional deal on emissions limits for road vehicles - Consilium (europa.eu)

[15] Euro 7: Deal on new EU rules to reduce road transport emissions | News | European Parliament (europa.eu)

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In order to achieve the 'Fit for 55' target of reducing net greenhouse gas emissions by at least 55% by 2030, the European Council adopted stricter CO_2 emission performance standards for cars and vans.

From 2030 to 2034, it set a target of a 50% CO_2 emission reduction for vans compared to 2021 levels, and a 100% CO_2 emission reduction from 2035. Manufacturers must ensure the average CO_2 emissions from their newly registered vehicles do not exceed an annual emissions target, otherwise they must pay a premium of €95 per gram CO_2/km. [16]

Fit for 55: Alternative Fuels Infrastructure Regulation (AFIR)

Also part of the 'Fit for 55' package, the alternative fuels infrastructure regulation (AFIR) aims to ensure the development of a sufficient infrastructure network for recharging or refuelling vehicles running on alternative fuels.[17] On main roads, it specifies a target of at least 60km between recharging stations.

Smart Cities Marketplace 2023: Urban Freight Logistics Solution Booklet

The Smart Cities Marketplace is an initiative supported by the European Commission which brings together stakeholders with a common interest in climate-neutral smart city projects. Its policy recommendations place cities at the core of regulating services to be more efficient and sustainable, defining them as leaders who then shape regional and national policy. Defining medium and long-term strategies is emphasised in redesigning urban infrastructure.

Moreover, stakeholder engagement is identified as crucial to achieve wide consensus and deliver a lasting impact. This could further be enhanced in the field of city logistics with a city logistics manager or a freight quality partnership. The policy recommendations also touch on creating a favourable ecosystem for innovation by balancing actions between policy, technical, and logistical aspects. Finally, it is recommended that stakeholders' acceptance in addition to different groups' interests and problems are considered when implementing multiple types of measures such as market-based and regulatory measures.

2.2 EU Digital Policy

The European Commission's document **Digital Agenda for Europe (2014)**[18] set out the digital and technological priorities of the EU and sought to boost 'Europe's economy by

[16] 'Fit for 55': Council adopts regulation on CO2 emissions for new cars and vans - Consilium (europa.eu)
[17] Alternative fuel infrastructure: Provisional agreement for more recharging and refuelling stations across Europe - Consilium (europa.eu)
[18] https://op.europa.eu/en/publication-detail/-/publication/27a0545e-03bf-425f-8b09-7cef6f0870af

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delivering sustainable economic and social benefits from a digital single market'. It set out how the EU would look to support the deployment of high-quality, digital network infrastructure, and activities that turn digital research into successful European innovation stories.

In its **Digital Single Market Strategy (2015)**[19], the European Commission set out the concept of a digital single market (DSM), which allows individuals and businesses to seamlessly access and engage in online activities in an environment of fair competition. The DSM was adopted in May 2015, with the following pillars:

1. Access: better access for consumers and businesses to digital goods and services across Europe;
2. Environment: creating the right conditions and a level playing field for digital networks and innovative services to flourish;
3. Economy & Society: maximising the growth potential of the digital economy.

The DSM Strategy encouraged extracting the maximum growth potential from the digital economy, regarding digitisation as offering "unprecedented opportunities to other economic sectors, such as transport (e.g. intelligent transport systems)".

The strategy considers data as a catalyst for economic growth, innovation and digitisation across all economic sectors. A fragmented market is seen as being a barrier to providing sufficient scale for cloud computing. A lack of interoperable systems and data portability between services represents a barrier for the cross-border flow of data and the development of new services.
The theme of interoperability - effective communication between digital components like devices, networks or data repositories and better-connected supply chains – is key to the success of the strategy and therefore the adoption of standardisation was seen as helping to steer the development of new technologies and data driven services such as e-transport.

The Deployment of Intelligent Transport Systems (ITSs) in Europe (Directive 2010/40/EU)[20]

ITSs[21] are expected to contribute to creating a cleaner, safer and more efficient transport system across the EU. The Directive seeks to encourage the development of innovative transport technologies with the introduction of common EU standards and specifications, with a focus on road transport and how different ITSs communicate with other modes of

[19] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52015DC0192
[20] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32010L0040
[21] ITS are defined in the Directive as "systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management."

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transport. The directive calls for the optimal use of road traffic and travel data, continuity of traffic and freight management ITS services and linking vehicles with the transport infrastructure, i.e. equipping vehicles to allow for exchange of data or information.

European e-freight Capabilities for Co-modal Transport (2013), European Commission

The vision of e-freight project (funded by the EU) was to rely on co-modality and advanced technology to provide a competitive European surface freight transport system whilst promoting environmental sustainability. The e-freight project explored the potential for a paperless freight transport process where an electronic flow of information is linked to the physical flow of the goods. It was expected that this would lead to a future of "intelligent cargo", meaning that goods would be location-aware and connected to a range of information services allowing the automation of transport management processes.

The e-freight project was designed to inform other transport policy, specifically those concerned with ITS and freight transport. It developed from the Freight Transport Logistics Action Plan (2007) which encouraged working towards "a standard for information flows to ensure the integration and interoperability of modes at data level and provide open, robust data architecture primarily for business-to-business administration (B2A) flows". Other areas it wanted to explore included a standard data set to describe freight, including for regulatory requirements and the establishment of a Single Window (single access point) and 'one stop shopping' for administrative procedures in all modes.

The concept of the single window was introduced by the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) with the aim of enhancing the efficient exchange of information between trade and government. In the EU context, single windows have been developing for many years across two main areas; trade facilitation (e-Customs) and for transport (monitoring vehicle and cargo movements). Both of these single window concepts rely on businesses, port authorities and customs authorities reporting into the single window concept, with inputs from national authorities.

Digitalisation of Freight Transport Information[22]

In April 2020 the Council of the European Union adopted new rules in the form of a Regulation which has the objective of making it easier for freight transport companies to provide information to regulatory authorities in digital form. Following adoption by the European Parliament it was subsequently published in the Official Journal of the EU on 15 July 2020 and entered into force 20 days later.

[22] https://eur-lex.europa.eu/eli/reg/2020/1056/oj

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The new rules will create a uniform legal framework for the use of electronic freight transport information (eFTI[23]) in relation to regulatory requirements for all modes of transport. All relevant public authorities will be required to accept information provided electronically on certified platforms whenever companies choose to use such a format to provide information as proof of compliance with legislative requirements.

The regulatory authorities will be required by the Regulation to accept data in digital form from 30 months after the date of entry into force of the first of the delegated and implementing acts referred to in the Regulation and which will implement the Regulation at a more practical level.

The European Commission will also adopt implementing acts that lay down common procedures and detailed rules, including common technical specifications, for access by competent authorities to eFTI platforms, including procedures for the processing of regulatory information and for communication between competent authorities and the economic operators concerned in relation to that information.

In relation to SENATOR, the EU is seeking to increase the digitalisation of the regulatory aspects of data exchange between economic operators in the sector and the regulatory authorities. This Regulation, which it seems is likely to become European law, is the first step towards a fully digitised regulatory relationship between economic operators and mainly national regulatory authorities and therefore supports the future SENATOR tool where they facilitate digital exchange of information of a regulatory nature.

Overall, the Regulation is important in that provides a direction of travel for the digitalisation of the European logistics sector, within which the SENATOR tool can play a role in increasing the efficiency of the relationship between the city regulatory authorities and economic operators in the urban freight sector.

2.3 General Data Protection Regulation (GDPR)

Introduction

The SENATOR project aims to develop a smart network, supported on an ICT platform, for integrated logistics operation. This will be a dynamic tool that will enable optimisation for

[23] eFTI' means a set of data elements that are processed by electronic means for the purpose of exchanging regulatory information among the economic operators concerned and between the economic operators concerned and competent authorities.

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efficient urban logistics by connecting demand, the fleet of transport vehicles including different modes, intelligent route planning and the network and nodes of the urban infrastructure. .

The General Data Protection Regulation

The EU Charter of Fundamental Rights stipulates that EU citizens have the right to protection of their personal data. The EU brought in legislation to implement this; the data protection package adopted in May 2016 aims at making Europe fit for the digital age with the same data protection rights for people across the EU and regardless of where their data is processed. In its essence, this right guarantees that personal data should only, and always, be processed lawfully, fairly and in a transparent manner; be collected for specified purposes; be limited to what is necessary; be accurate; be stored for no longer than necessary; and be kept securely and confidentially.

Regulation (EU) 2016/679[24] on the protection of natural persons with regard to the processing of personal data and on the free movement of such data has been instigated to strengthen individuals' fundamental rights in the digital age and facilitate business by clarifying rules for companies and public bodies in the digital single market.

The regulation entered into force on 24 May 2016 and has applied since 25 May 2018. The GDPR is also incorporated into the EEA Agreement so that Iceland, Liechtenstein and Norway are subject to the same obligations and protections. The regulations were transposed into UK law (for UK domestic application) following the end of the Brexit transition period on 31 December 2020.

The GDPR applies to:

- A company or entity which processes personal data as part of the activities of one of its branches established in the EU, regardless of where the data is processed; or
- A company established outside the EU and is offering goods/services (paid or for free) or is monitoring the behaviour of individuals in the EU.

Application of the GDPR rules is related to the business or organisation scale. While SMEs that process personal data have to comply with the GDPR, if processing personal data is not a core part of the business and the activity does not create risks for individuals, then some obligations of the GDPR such as the appointment of a Data Protection Officer ('DPO') do not apply.

[24] https://eur-lex.europa.eu/eli/reg/2016/679/oj

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The type and amount of personal data a company or organisation may process depends on the reason for processing it (the legal reason used) and the intended use. The company or organisation must respect several key rules, including:

- Personal data must be processed in a lawful and transparent manner, ensuring fairness towards the individuals whose personal data is being processed ('lawfulness, fairness and transparency');
- There must be specific purposes for processing the data and the company or organisation must indicate those purposes to individuals when collecting their personal data. A company or organisation cannot simply collect personal data for undefined purposes ('purpose limitation');
- The company or organisation must collect and process only the personal data that is necessary to fulfil that purpose ('data minimisation');
- The company or organisation must ensure the personal data is accurate and up-to-date, having regard to the purposes for which it is processed, and correct it if not ('accuracy');
- The company or organisation cannot further use the personal data for other purposes that are not compatible with the original purpose;
- The company or organisation must ensure that personal data is stored for no longer than necessary for the purposes for which it was collected ('storage limitation'); and
- The company or organisation must install appropriate technical and organisational safeguards that ensure the security of the personal data, including protection against unauthorised or unlawful processing and against accidental loss, destruction or damage, using appropriate technology ('integrity and confidentiality').

GDPR and the United Kingdom after Brexit

EU GDPR rules have been incorporated into the UK Data Protection Act of 2018, which effectively forms UK GDPR. The UK data protection regime also contains the Privacy and Electronic Communications Regulations (PECR) which is derived from European law (the European Directive known as the ePrivacy Directive[25]). It sits alongside the GDPR and deals with issues such as data confidentiality, spam, and cookie usage. The EU is in the process of updating its current ePrivacy Directive to tackle the evolving dynamic technology environment.

The UK has been aiming since it left the EU to simplify its regulatory requirements, while maintaining high data protection standards. Amendments were proposed in the form of a UK Data Protection and Digital Information Bill which was initially introduced in July 2022, but was subsequently paused and revised into a "No. 2 Bill"[26]. The No. 2 Bill is subject to debate

[25] https://www.edps.europa.eu/data-protection/our-work/subjects/eprivacy-directive_en
[26] https://www.bdo.co.uk/en-gb/insights/advisory/risk-and-advisory-services/uk-data-protection-and-digital-information-bill-no2-what-is-changing-for-uk-organisations

and will need to pass through the House of Lords before it can be finalised[27]. Although similar to UK GDPR, it will introduce some key changes, including:

- Removing the list of circumstances requiring a data protection impact assessment, instead relying on guidance from the Information Commissioner's Office;
- Broadening the scope of "scientific research" to include commercial purposes;
- Introducing a data protection test to assess the adequacy of other countries' data protection for international data transfers;
- Replacing the role of a Data Protection Officer with a new position of a Senior Responsible Individual (SRI) who is mandated to be an member of senior management.

GDPR and Artificial Intelligence (AI)

The protection of personal data is a fundamental right in the EU. As such it applies also to processing of personal data through artificial intelligence and robotics. However, when the data used for AI are anonymised, then the requirements of the GDPR do not apply. GDPR has been designed to be technologically neutral and provides the framework for the development of an AI respectful of citizens. GDPR allows automated decision making where there is a justification either by a contract, explicit consent or a law, and provided that specific safeguards for the individuals concerned are applied, such as the right to receive meaningful information about the logic involved and the envisaged consequences of such processing on them.

In April 2019, the EU's *High-Level Expert Group on AI* presented its *Ethics Guidelines* for Trustworthy Artificial Intelligence[28]. According to the Guidelines, trustworthy AI should be:

- Lawful – respecting all applicable laws and regulations;
- Ethical – respecting ethical principles and values; and
- Robust – both from a technical perspective while taking into account its social environment

The Guidelines put forward a set of seven key requirements that AI systems should meet in order to be deemed trustworthy. A specific assessment list aims to help verify the application of each of the key requirements:

- Human agency and oversight: AI systems should empower human beings, allowing them to make informed decisions and fostering their fundamental rights;
- Technical Robustness and safety: AI systems need to be resilient and secure. They need to be safe, ensuring a fall back plan in case something goes wrong;

[27] https://secureprivacy.ai/blog/uk-data-protection-digital-information-bill-latest-updates-implications-future-impact
[28] https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

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- Privacy and data governance: besides ensuring full respect for privacy and data protection, adequate data governance mechanisms must also be ensured, taking into account the quality and integrity of the data, and ensuring legitimised access to data;
- Transparency: the data, system and AI business models should be transparent. Traceability mechanisms can help achieving this;
- Diversity, non-discrimination and fairness: Unfair bias must be avoided, as it could have multiple negative implications, from the marginalisation of vulnerable groups, to the exacerbation of prejudice and discrimination;
- Societal and environmental well-being: AI systems should benefit all human beings, including future generations. It must hence be ensured that they are sustainable and environmentally friendly; and
- Accountability: Mechanisms should be put in place to ensure responsibility and accountability for AI systems and their outcomes.

In March 2024, the European Union approved its Artificial Intelligence Act (AI Act), the first comprehensive and binding framework to regulate AI. It establishes obligations for AI based on a tier system of potential risk with four categories: unacceptable, high, limited, and minimal. It will be fully applicable 24 months after its entry into force with the exception of certain items such as those deemed to pose an unacceptable risk[29]. Those include:

- Biometric categorisation systems such as those based on facial images from the internet or CCTV footage to create facial recognition databases;
- Social scoring by public or private actors which could be based on social behaviour or personality characteristics.

The vast majority of AI systems are expected to be low risk, such as spam filters or content recommendation systems. High-risk uses concern critical infrastructure such as water or electrical networks, which will be subject to stricter requirements.

Personal Data Definition

Personal data is any information that relates to an identified or identifiable living individual.[30] Different discrete pieces of information which when put together can lead to the identification of a particular person also fall into the definition of 'personal data'. Only irreversible anonymisation of personal data can be no longer considered as personal data.

Examples of personal data are:

- A name and surname;
- A home address;
- An email address such as name.surname@company.com;

[29] https://www.europarl.europa.eu/doceo/document/TA-9-2024-0138_EN.pdf
[30] https://ec.europa.eu/info/law/law-topic/data-protection/reform/what-personal-data_en

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- An identification card number;
- Location data (for example the location data function on a mobile phone)[31];
- An Internet Protocol (IP) address;
- A cookie ID[1];
- The advertising identifier of your phone;
- Data held by a hospital or doctor, which could be a symbol that uniquely identifies a person.

Implications for SENATOR

There are two broad strands for compliance with GDPR in the context of the SENATOR project:

- Collection, processing and storage of personal data within the project team and during the living labs;
- Collection, processing and storage of personal data when the software has been designed and is in use.

For the former, compliance is covered by the contract and agreements within the consortium and with the EU and is not further discussed here.

More significantly, the development of the model and the reporting on any results from research during the trial cases in Dublin and Zaragoza need to take careful account of the potential for breaching the regulation. The key rules around processing of personal data that must be incorporated into the design of the software tool are the protection of the integrity and confidentiality of any personal data that is kept. In the context of SENATOR such data is likely to include some or all of the following but may also cover data characteristics not in the list:

- Name and address of originator or receiver of goods
- Email address of individuals within the businesses involved in the trial or the end product
- IP address of individuals involved with conducting the trial or using the end product
- Mobile phone location data
- Tracking information

Where possible personal data should be anonymised so that business locations can be used within the software tool but no individual person may be identified. It is likely that the

[31] Note that in some cases, there is a specific sectoral legislation regulating for instance the use of location data or the use of cookies – the ePrivacy Directive (Directive 2002/58/EC of the European Parliament and of the Council of 12 July 2002 (OJ L 201, 31.7.2002, p. 37) and Regulation (EC) No 2006/2004) of the European Parliament and of the Council of 27 October 2004 (OJ L 364, 9.12.2004, p. 1).

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transparency rule cannot be kept with respect to viewing personal data, whether one's own or that of others, but it can be adhered to through contractual arrangements with any individuals involved in part of the research or using the end product.

Case study: lessons learned on GDPR from the Zaragoza Urban Living Lab

The Zaragoza Urban Living provides an example of the issues related to personal data under GDPR. Anonymized data, based on agreements between Correos and Correos Express, were used to allow the sharing of data on shipments but this data was not shared in the SENATOR platform. This whole issue of personal data was a major problem for the ULL and the origin of many delays.

In practice in the ULLs the minimum data necessary to allow two or more companies to share (or merge) their distribution networks includes the name and address and telephone number of the person receiving a delivery. This requires a preliminary agreement among the parties (the companies themselves and their customers, and data protection policies) and the implementation of the platform must involve the development of commercial and data transfer agreements, as well as adequately informing customers who might receive the shipment from a different operator than the one they contracted.

Additionally, whenever vehicle or employee data is to be collected and monitored, special attention should be paid to the applicable law and to whether an informed consent signed by the affected personnel should be collected.

As well as the GDPR as set out in EU legislation, particular attention needs to be paid to how it is interested in each Member State. The evolution and implementation of the Spanish and European legislation on Data Protection and digital rights and security of the information of the consumers directly affected the data sharing needed for the Spanish pilots. In order to share the information, it was necessary to comply with that legislation, as well as with each company's data protection policy and the agreements signed with their customers. This implied anonymizing the information under the following premises:

- No address data, shipping code or recipient's name can be shared under any circumstances.
- No data that can identify Correos operational personnel can be shared under any circumstances.
- Delivery address information may not be shared by street and number because a recipient is considered potentially identifiable.
- Delivery coordinates may only be shared with a geo-position error of at least 5 metres to ensure anonymization of the information.

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- The delivery code may be shared but must be anonymized by deleting two digits of the delivery code.
- The geo-positioning of the routes (vehicles and PDAs) can be shared in such a way that the Correos staff working in the delivery operation is never identified, and with a sufficient error to guarantee the anonymity of the information, that is, to collect the geo-positioning information from the PDAs in an interval of no less than 3 minutes. In order to collect and use this information, it was necessary that all the delivery personnel in Zaragoza signed an informed consent, increasing the bureaucratic tasks and delaying the collection of information for the project.

Compliance with these restrictions has greatly complicated the necessary technological developments to be carried out in Correos (leading the Zaragoza Urban Living Lab and one of the two transport operators that wanted to share data), as well as the need to have the information for the shipments (predictive development of shipments) before going out for delivery, a development that was not available in the company and that has been carried out exclusively for the project.

2.4 Competition Law

Introduction

The SENATOR project seek to develop an information tool that will enable more efficient and integrated urban logistics operations. To do this it is likely to harness a representation of the physical infrastructure of the urban area and enable the transport supply to meet the transport demand while taking account of the dynamic nature of traffic and network usage over different times of the day. This could have implications for competition between transport operators or the owners of freight and therefore it is important to mitigate any consequential, whether inadvertent or not, anti-competitive behaviour.

Competition encourages companies to offer consumers goods and services at the most favourable terms. It encourages efficiency and innovation and reduces prices. To be effective, competition requires companies to act independently of each other, but subject to the competitive pressure exerted by the others.

European Competition Law is developed from two central rules set out in Articles 101 and 102 of the *Treaty on the Functioning of the European Union*.[32]

Article 101 of the Treaty prohibits agreements between two or more independent market operators which restrict competition. This provision covers both horizontal agreements

[32] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A12012E%2FTXT

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(between actual or potential competitors operating at the same level of the supply chain) and vertical agreements (between firms operating at different levels, i.e. an agreement between a manufacturer and its distributor). Only limited exceptions are provided for in the general prohibition. The most flagrant example of illegal conduct infringing Article 101 is the creation of a cartel between competitors, which may involve price-fixing and/or market sharing.

Article 102 of the Treaty prohibits firms that hold a dominant position in a given market to abuse that position, for example by charging unfair prices, by limiting production, or by refusing to innovate to the prejudice of consumers.

Commercial Cooperation

An agreement will only be caught by Article 101 if it affects trade between Member States and restricts or distorts competition to a significant degree, which is not always easy to define. In order to determine whether a commercial agreement falls foul of Article 101(1) it is necessary to identify the affected markets in all respects, that is by product and by geography. The Commission provides guidance on how it would arrive at a market definition[33] for competition law purposes, noting that every individual case is examined on its own merits and through consulting with the parties, customers and competitors. There is also a guidance notice – the De Minimis notice[34], which proceeds on the basis that agreements between actual or potential competitors are more likely to pose a threat to competition than agreements between non-competitors. So, therefore, the Commission allows agreements between large companies that are non-competitors if the parties have a market share of no more than 15%, of course, assuming that the agreement does not have the object of preventing, distorting or restricting competition within the internal market. Where competitors are entering into an agreement the threshold is 10% with the same proviso with respect to not having the object of preventing, distorting or restricting competition. SMEs[35] are not normally capable of affecting trade between Member States and will not normally merit investigation.

Assessment of the scale of impact of any agreements has to take into account whether any trade flows between Member States are appreciably affected and, if not, then any competition issues should be a matter for the relevant National Competition Authority (NCA); and which markets may be affected together with the parties' strengths in those markets. An agreement will not be relevant within Article 101 if the weak market position of the parties means that there is no appreciable effect on market behaviour or on the opportunities available to third parties (customers, competitors and suppliers).

[33] The Commission's Market Definition notice (OJ 1997 C372/3, 9.12.1997)
[34] De Minimus Notice (OJ 2014 C291/1, 30.8.2014)
[35] Small and medium-sized enterprises with fewer than 250 employees and annual turnover not exceeding €50m or assets not exceeding €43m)

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In the context of SENATOR it is likely that the NCA will be the governing authority given that urban areas are likely to be contained discretely within one Member State. NCAs are empowered to apply Articles 101 and 102 of the Treaty fully, to ensure that competition is not distorted or restricted. National courts may also apply these provisions to protect the individual rights conferred on citizens by the Treaty.

Illegal Contacts and Agreements Between Companies

Anti-competitive contacts between companies which, irrespective of their form, may distort the normal play of competitive forces are prohibited. Such contacts can take many forms and do not require the formal acceptance by the companies involved through an agreement. Even informal arrangements among business representatives can be considered illegal.

Cartel behaviour in the form of price fixing, sharing markets or customer allocation, limiting production or output, whether through bid rigging or otherwise, qualifies as 'hardcore' restrictions of competition as they are most likely to restrict competition. These hardcore infringements are vigorously pursued by the Commission and can result in companies being heavily fined.

Private exchanges between competing companies of individualised information concerning their intended future prices or quantities can also amount to a hardcore infringement. More generally all exchanges of confidential, strategic information between competitors can give rise to competition concerns. Such information would include anything reducing strategic uncertainty in the market, for example relating to production costs, customer lists, turnover, sales, capacities, qualities, marketing plans, etc. This includes unilateral disclosure of strategic information by one company via mail, email, phone calls or meetings to its competitor(s).

Agreements between companies at different levels of the supply chain, typically distribution agreements between suppliers and re-sellers, which aim at fixing prices or artificially partitioning the internal market, are also illegal. For instance, a supplier may not oblige its distributors to refuse to sell goods to customers residing outside of a given territory. In addition, it may not impose on its distributors a resale price for a given product.

It is important to keep in mind that agreements between competitors and companies at different levels of the supply chain can also have anti-competitive effects even if they do not contain any of the above-mentioned hardcore restrictions. For example, the agreement might have a negative impact on one of the parameters of competition, namely price, output, innovation, or the quality or variety of goods and services. It is possibly the latter may be relevant to SENATOR. Ideally SENATOR should lead to improved quality of services but it

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may equip companies unequally and thereby distort the market eventually leading to poorer quality of service through companies cherry-picking better routes/services etc.

Abuse of a Dominant Position

If companies have a large proportion of the business in a particular market, they are likely to hold a dominant position in that market. Such companies have a special responsibility not to engage in behaviour which is considered abusive. They should not act in a way that prevents competitors from competing effectively or drives them out of the market.

Examples of abusive conduct on the part of dominant companies are: charging unreasonably high prices which may exploit customers; charging unrealistically low prices which may be used to drive competitors out of the market; unjustified discrimination between customers; and forcing unjustified trading conditions on trading partners.

Vertical Block Exemption Regulation & new Vertical Guidelines

On 10 May 2022 the European Commission adopted the new Vertical Block Exemption Regulation (‘VBER') accompanied by the new Vertical Guidelines, following an evaluation and review of the 2010 rules. The revised rules provide businesses with more up-to-date rules and guidance and, in particular, are designed to help them assess the compatibility of their supply and distribution agreements with EU competition rules in a business environment reshaped by the growth of e-commerce and online sales. The revised VBER and Vertical Guidelines enter into force on 1 June 2022.

The VBER exempts from the prohibition in Article 101(1) of the Treaty on the Functioning of the European Union (‘TFEU') agreements between companies that are active at different levels of the production or distribution chain, subject to conditions. The rules thus provide for a safe harbour where certain agreements are block exempted.

The main changes to the previous rules focus on adjusting the safe harbour to ensure that it is neither too generous nor too narrow. In particular, the new rules:

- Narrow the scope of the safe harbour as regards: (i) dual distribution, that is, where a supplier sells its goods or services through independent distributors but also directly to end customers, and (ii) parity obligations, that is, obligations which require a seller to offer the same or better conditions to its counter-party as those offered on third-party sales channels, such as other platforms, and/or on the seller's direct sales channels, like its website. This means that certain aspects of dual distribution and certain types of parity obligations will no longer be exempted under the new VBER but must instead be assessed individually under Article 101.

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- Enlarge the scope of the safe harbour as regards: (i) certain restrictions of a buyer's ability to actively approach individual customers, i.e. active sales, and (ii) certain practices relating to online sales, namely the ability to charge the same distributor different wholesale prices for products to be sold online and offline and the ability to impose different criteria for online and offline sales in selective distribution systems. These restrictions are now exempted under the new VBER, provided all other conditions for the exemption are met.

The revised VBER rules have also been clarified and simplified, to make them more accessible to those who use them in their day-to-day business. In particular, the VBER rules have been updated as regards the assessment of online restrictions, vertical agreements in the platform economy and agreements that pursue sustainability objectives, among other areas. In addition, the guidelines provide detailed guidance on a number of topics, such as selective and exclusive distribution and agency agreements.

Mitigation of Risks

SENATOR should be in a position to provide a neutral 'third party' approach to the effective receipt and dissemination of information between the actors in the urban logistics supply chains. For example, freight transport providers cannot actively inform each other of their total supply capacity in detail (i.e. size and location of their fleets) as this would be regarded as anti-competitive. However, a software tool could display any free/available capacity which is not allocated to any particular shipper. Likewise, shippers cannot share their demand characteristics (forward sales data) with other shippers (again this is regarded as anti-competitive), but they could do so via the software to freight transport operators. Visual representations of the movement of freight in the urban area, probably allocated to physical infrastructure, should not have detailed characteristics attached that would identify individual companies.

It is extremely important in the design of the SENATOR tool to ensure that no 'strategic information' exchange is possible between competitors or non-competitors whether this is by design or default. It is no defence to plead that any strategic information exchange that occurs because of the use of SENATOR was not meant to happen. The Commission will not be sympathetic to this argument so the tool must be designed in such a way as to prevent this occurring.

A further way in which SENATOR can mitigate any risk of distorting the market by restricting participants is to allow open access and participation by market players irrespective of their size. Any agglomeration that could lead to market dominance has to be avoided whether unforeseen or not.

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Finally, it is necessary to ensure as much transparency in the SENATOR system as possible without compromising the rules of information exchange and confidentiality.

Competition law is notorious for being open to interpretation and dependent on the definitions of addressable market and market size and so on. It would be prudent to ensure that legal opinion is sought on the competition law aspects in advance of launching a commercial product.

2.5 EU Postal Service Directives – Case Study: the UK Market

Up until the mid-1980s, the *Royal Mail*[36] had a near total monopoly on the distribution and delivery of letters and parcels in the UK. The main exception was a parcel operation owned and run by the former national railway operator (namely British Rail), called *Red Star Parcels*, where consignments were moved on passenger train services between stations (though the initial despatch and final collection had to be undertaken in person at stations)[37].

In the mid-1980s, a key policy of the then Conservative Government was the introduction of more market competition into the wider economy (and away from state-owned monopoly providers). As part of this policy, it was decided to open up the parcels market to competition in the Business-to-Business (B2B) and Business-to-Consumer (B2C) sectors. The wider Royal Mail Group, albeit still state owned, was subsequently split into three operating divisions in 1986 to reflect the new market structure:

- Royal Mail letters – monopoly position retained;
- Royal Mail parcels – monopoly for Consumer-to-Consumer (C2C) retained, but subject to full competition in the B2B and B2C sectors;
- The Post Office – the fixed retail outlet network for the letter and parcel divisions, while also providing other Government services.

A number of new entrants were subsequently attracted into the market to complete with Royal Mail parcels, mainly the large international courier operations e.g. TNT, DHL, UPS etc... In 1990, Royal Mail parcels was rebranded as *Parcelforce*. It was proposed in 1992 to

[36] The Royal Mail, the historic national postal operator in the UK, can trace its roots back to 1516 as the King's personal postal service. It was the first public postal operator in the world to offer a universal delivery service for a fixed fee by means of a pre-paid stamp – the 'penny black' – in 1840.
[37] Red Star Parcels was purchased by *Lynx Express* in the late 1990s, which was itself acquired by *UPS* in 2005 (and subsequently rebranded as *UPS*). It ceased using passenger rail services in 2001, with all consignments moving by road or air.

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separate Parcelforce away from Royal Mail and subsequently sell it to the private sector, albeit this was eventually postponed due to political difficulties.

EU Postal Services Directives

The first Postal Services Directive *(97/67/EC)* established a regulatory framework for European postal services. In line with the principle of subsidiarity and acknowledging the differences in the postal markets of EU countries, the Directive gave flexibility to EU member countries in terms of how the various provisions were implemented. Two subsequent Directives (2002/39/EC and 2008/6/EC) have introduced various technical amendments and updates, albeit the original principles of the first Directive are retained.

The key aim of the Directives was to open up postal services (and by extension the delivery of individual parcel consignments) to full market competition in accordance with the internal market (the EU Single Market). Parcels are defined as consignments not exceeding 20kg. Effectively, the consequence of the Directives is that any operator is now able to set-up and operate a postal service within the EU. However, to prevent so called 'cherry picking', whereby operators would only focus their services on lucrative high-demand markets (e.g. in urban areas or e-commerce) at the expense of areas of low demand or difficult to serve, the Directive introduced the concept of the '*Universal Service Obligation*' (USO). The USO requires that letters and parcels must be delivered to every home and business address 5 days a week across the EU.

Each Member State is required to designate one or more 'universal service providers' that are obliged to deliver the USO. Where multiple providers are designated, these can be split between different market segments (e.g. letter or parcels) or geographic areas. Member States must periodically review the appointment of their universal service providers (and by extension can designate new providers), though the period of designation must be long enough to allow a sufficient return on investments. In the UK, the *Royal Mail* is the single universal service provider. Likewise, *AnPost* and *Correos* are the designated operators in Ireland and Spain respectively.

Where the USO cannot be provided by the designated operator(s) at a profit (i.e. it entails a 'net cost'), it can effectively be subsidised by a Member State through:

- Procuring the services by means of a competition under public procurement rules; and
- Compensating operators from public funds or via a 'levy' on all postal service providers (i.e. those operating on purely commercial terms and outside the USO) and users.

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Importantly, Member States *"cannot grant or maintain in-force exclusive or special rights for the provision of postal services"*. The Directives require the establishment of an independent regulator to oversee the market alongside the performance of the universal service providers (in terms of service quality and efficiency). In the UK, the Directives have been transposed into domestic law via various pieces of primary legislation, most recently the Postal Act 2011.

The Directives also define the rules under which competing (but non universal service provider) postal operators are able to access the 'last mile' delivery networks of the universal service providers. Access to such networks must be under transparent, proportional and non-discriminatory conditions. A set of tariffs (which shall be cost orientated to ensure efficiency) must be published. While these can be at a uniform (per-item) rate, operators can negotiate their own individual agreements.

Between 2002 and 2006, the provisions of the first two Postal Services Directives were implemented in the UK, as the market for letter and parcel services was fully opened to full-scale competition. In 2002, the USO for parcels was transferred away from Parcelforce to Royal Mail letters (by this time simply branded *Royal Mail*). From this date onwards, Parcelforce has competed on fully commercial terms, specialising in B2B and B2C express and tracked parcel services (i.e. without the USO). Royal Mail also began 'last mile' deliveries of letters and parcels for its competitors. *Postcom* was established to be the sector regulator. It was subsequently abolished in 2011 and its responsibilities transferred to the *Office of Communications (Ofcom)*, hitherto the media regulator in the UK. The third Postal Services Directive was transposed into domestic UK law via the Postal Act 2011. The Act also transferred the Royal Mail Group to the private sector, which was undertaken in 2013 by means of an Initial Public Offering (IPO). Its shares are currently traded on the London Stock Exchange. It continues to operate in two broad areas:

- Royal Mail – the UK's designated Universal Service Provider for letters and parcels; and
- Parcelforce – commercial arm focused on B2B and B2C express/tracked parcels (no USO).

The Post Office remains as a separate Government owned retailer, albeit it acts as the Royal Mail's sales agent for parcels and letters along with supplying other Government services. The USO has also been maintained without any need for Government subsidy or levies on other operators. The graphs below illustrate recent trends in the UK parcels market as

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described, in terms of the volumes of parcels handled and the revenue per parcel handled since Financial Year (FY) 2013-14. Also shown (in the Table following) is the current estimated market share by operator. The volume data covers returns made by all the main parcel operators to regulator Ofcom, including Royal Mail (USO and Parcelforce), DHL, UPS, DPD and Amazon.

Note the step-change in parcel volumes between FY 2019-20 and FY 2020-21. This reflects the rapid growth in e-commerce (as reported in Section 4.2) over the same period of time, primarily due to the Covid-19 pandemic and the closure of non-essential retail outlets. Discounting FY 2020-21 due to its exceptionality, growth between FY 2013-14 and FY 2019-20 was 61%. Similar trends were also recorded by *AnPost* in the same reporting period. However, it is also important to note that the revenue earned per parcel handled has fallen over the same time period.

The table following shows that, after nearly 40 years of full market competition in the B2B and B2C sectors and 20 years for C2C, Royal Mail still remains the largest operator in the parcels sector (by volume) with a market share of around 34%. This is, in part, due to customer loyalty to the historic Royal Mail 'brand' (by consumers rather than commercial companies) combined with relatively easy access to their parcel services via the extensive Post Office retail network (which is likely to have created a degree of inertia on the part of consumers).

Conversely, full market competition has generated an open and highly competitive environment for parcel services. The established operator (Royal Mail) now only has around one-third of the market, despite its history, brand loyalty and the extensive retail network of the Post Office. Competing operators have now established themselves in the market, primarily focused on the B2B and B2C sectors (and C2B for returns). This is most likely reflected in the declining revenue per parcel handled data, suggesting that there is significant competition between operators based around price in order to win/retain business in what is a volume intensive and growing market (particularly from the e-commerce sector – see Section 4.2). It also means operators have had to drive through efficiencies to compensate, including investment in further automation and ensuring delivery vehicles leave depots fully loaded and asset utilisation is maximised.

The key conclusions to draw from above are therefore:

- Full market competition has generated an open and highly competitive environment for parcel services, resulting in significant market choice in terms of the range of services offered, improved quality of service and lower costs to end-users. It has also necessitated efficient working practices in order to remain competitive and

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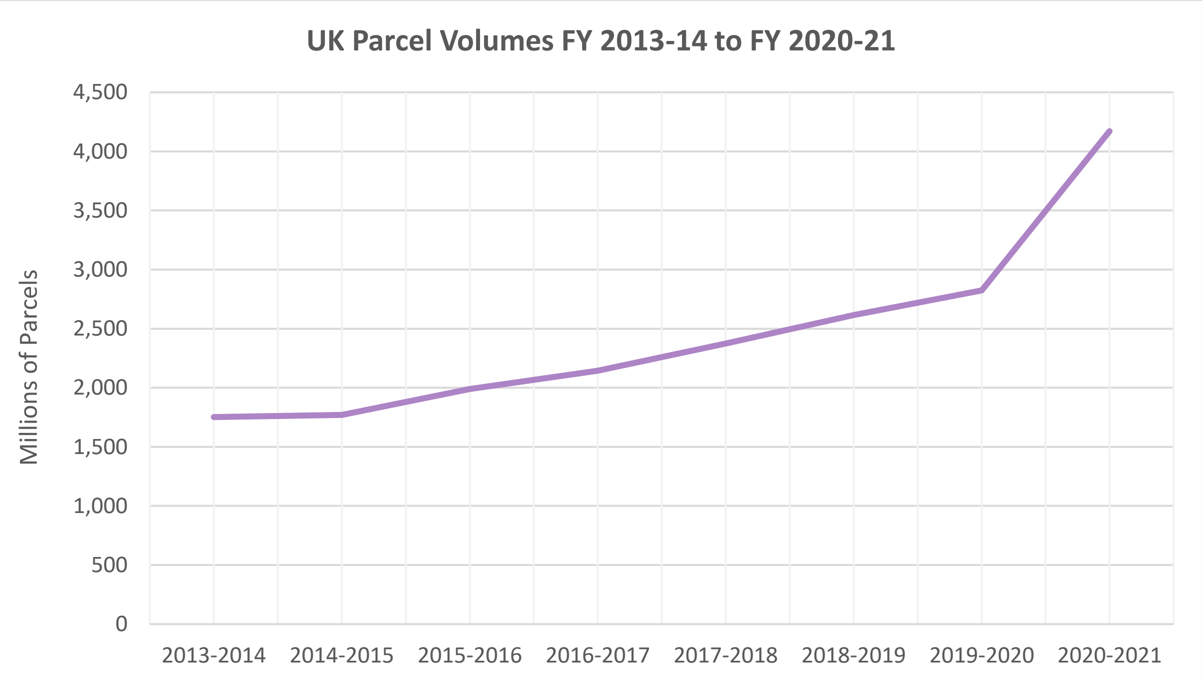
retain/win business. As described in Section 4.2, this partly explains the growth of e-commerce (ability to access commercially competitive delivery services);

- A USO has been maintained at the same time as the introduction of full market competition; and
- Future urban delivery policies and technologies will need to recognise and accommodate the provisions of the Postal Services Directives. In particular there is need to maintain a fully open and competitive market for parcel delivery services alongside the inability to specify/grant special privileges or rights to certain operators.

Figure 2.1:



Source: Ofcom (all main operators including Royal Mail and Amazon)

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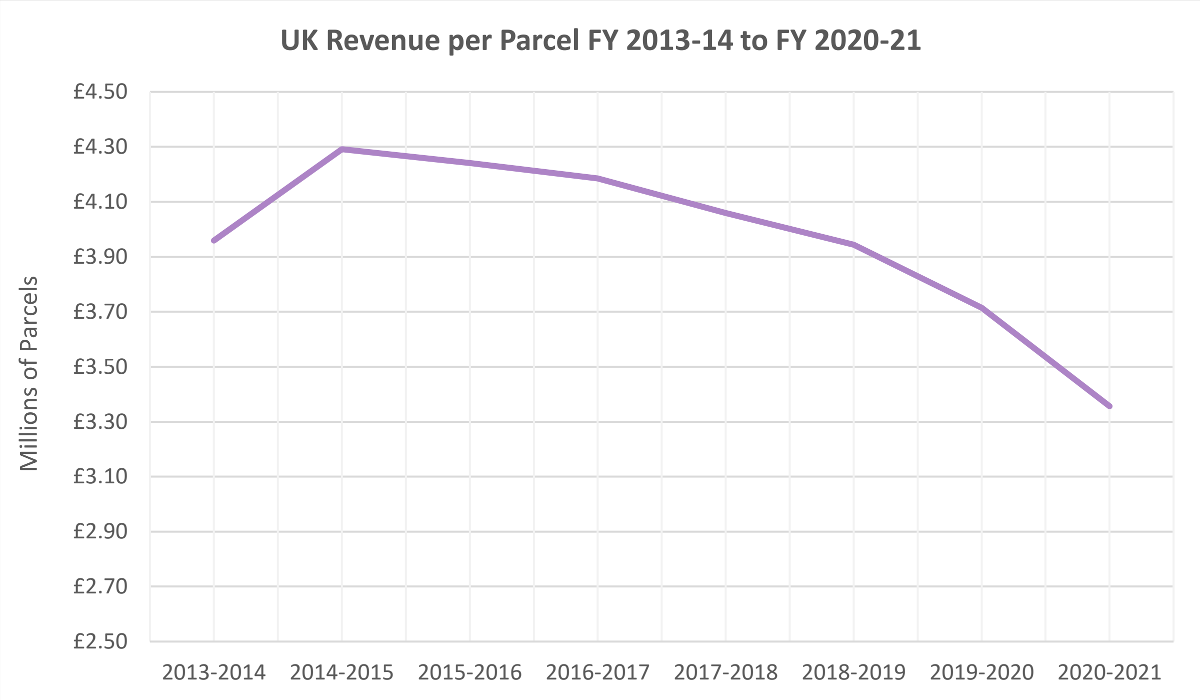
Figure 2.2



Source: Ofcom (all main operators including Royal Mail and Amazon) plus MDST calculations

Table 2.1: UK Parcels – Market Share by Operator

Operator	Market Share
Royal Mail (inc Parcelforce)	34%
Amazon	15%
Hermes	12%
DHL	8%
UPS	7%
Yodel	5%
DPD	5%
TNT (inc FedEx)	3%
UK Mail	2%
Others	9%

Source: Ofcom

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Recommendations for the project

RECOMMENDATIONS	
Recommendation 2.1	SENATOR should to take full account in its design of the potential for the use of alternative (zero carbon) modes such as cycle logistics and also, where feasible, less carbon-intensive modes such as rail and inland waterways.
Recommendation 2.2	The SENATOR platform should take into account the overall requirements of Sustainable Urban Logistics Plans (SULPs) based on zero-emission vehicles and solutions, while allowing for flexibility to cater for the specific needs of individual urban areas.
Recommendation 2.3	The SENATOR platform should, wherever possible, improve the integration of longer distance freight movements with urban logistics via multi-modal distribution parks on the edge of urban areas.
Recommendation 2.4	The SENATOR platform should be designed to reflect the requirements of GDPR and the rules about processing of personal data to protect the integrity and confidentiality of any personal data that is kept.
Recommendation 2.5	SENATOR should be designed to facilitate collaboration between operators to minimise carbon emissions (including using zero emission vehicles and, where appropriate, active modes of transport), while also maintaining a high degree of commercial confidentiality and not reducing competition.

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3 Technological context

This section of the deliverable provides a review of the technological developments which SENATOR has needed to take into account when developing its solution. This includes both digital and vehicle technology.

1) Internet of Things (IoT) Integration:

Real-time Tracking Enhancement:

Real-time tracking has emerged as a critical component in the optimization of logistics operations, providing unprecedented visibility and control over the movement of goods throughout the supply chain. With the advent of advanced technologies such as GPS, RFID, and IoT, real-time tracking has evolved from a mere tracking tool to a sophisticated system capable of enhancing operational efficiency, improving customer service, and mitigating risks [1]. One significant enhancement in real-time tracking is the integration of GPS technology, which enables precise location tracking of vehicles and shipments in transit. This integration allows logistics managers to monitor the exact whereabouts of assets at any given moment, facilitating accurate delivery estimations and proactive intervention in case of delays or disruptions. Furthermore, RFID technology has revolutionized real-time tracking by enabling automatic identification and tracking of individual items or containers as they move through the supply chain [2]. By attaching RFID tags to products or pallets, logistics operators can capture real-time data on inventory levels, shipment status, and asset utilization, streamlining warehouse operations and reducing the risk of stockouts or overstocking.

Moreover, the integration of IoT devices has further enhanced real-time tracking capabilities by enabling seamless communication and data exchange between interconnected devices and systems [3]. IoT-enabled sensors can provide real-time information on environmental conditions such as temperature, humidity, and shock, ensuring the integrity and quality of sensitive goods during transportation. Additionally, IoT devices can detect anomalies or deviations from predefined parameters, triggering immediate alerts and corrective actions to prevent potential damages or losses. Another significant advancement in real-time tracking is the development of advanced analytics and visualization tools that harness the vast amount of tracking data generated by logistics operations [4]. These tools leverage machine learning algorithms and predictive analytics to derive actionable insights from real-time tracking data, enabling logistics managers to optimize routes, allocate resources efficiently, and make informed decisions in real-time.

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Real-time tracking enhancements facilitated by IoT integration have indeed revolutionized various industries, particularly in logistics and supply chain management. UPS, for example, has implemented IoT technology in its logistics operations to optimize routing, minimize delivery times, and enhance package tracking. By integrating GPS and RFID technologies, UPS can monitor the movement of packages in real-time, ensuring timely deliveries and improving overall efficiency.

Integrating innovative technologies such as Internet of Things (IoT), artificial intelligence (AI), and blockchain into the SENATOR project can further enhance the efficiency and sustainability of urban logistics operations. These technologies can enable real-time tracking, optimize route planning, and facilitate transparent and secure transactions, thereby contributing to the development of a comprehensive and future-ready urban logistics model.

Monitoring for Efficiency and Data Collection for Optimization:

Monitoring for efficiency in urban logistics has become increasingly crucial as cities grapple with congestion, environmental concerns, and the need for seamless transportation of goods. Advanced monitoring systems leverage a variety of technologies such as GPS, telematics, and IoT sensors to track vehicles, shipments, and inventory in real-time [5]. Through the integration of various data collection methods such as GPS tracking, RFID tagging, and sensor networks, logistics companies can gather a wealth of information about their supply chain processes in real-time [2]. By continuously monitoring key performance indicators (KPIs) such as delivery times, fuel consumption, and vehicle utilization rates, logistics operators can identify inefficiencies and bottlenecks in their operations. This real-time visibility allows for proactive decision-making, enabling managers to optimize routes, adjust schedules, and allocate resources more effectively. Additionally, monitoring systems enable the implementation of predictive maintenance strategies, where sensors detect early signs of equipment failure, minimizing downtime and reducing maintenance costs. Furthermore, monitoring technologies facilitate compliance with regulatory requirements, such as emissions standards and road safety regulations, by providing accurate data and audit trails. Data collection for optimization plays a pivotal role in enhancing the efficiency and effectiveness of urban logistics operations. This data encompasses a wide range of metrics including vehicle location, speed, temperature, and cargo status. By harnessing this comprehensive dataset, logistics managers can gain valuable insights into their operations, identifying areas for improvement and optimization. For instance, analysis of route data can reveal traffic patterns and congestion hotspots, enabling planners to optimize delivery routes and schedules to minimize delays and improve customer satisfaction. Moreover, data on vehicle performance and fuel consumption can inform decisions regarding fleet management and maintenance schedules, leading to cost savings and environmental benefits and data collection facilitates continuous monitoring of inventory levels and demand patterns, enabling proactive replenishment strategies and reducing the risk of stockouts or overstocking. Overall, by leveraging data collection for

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optimization, urban logistics companies can enhance operational efficiency, reduce costs, and better meet the dynamic demands of modern supply chains.

For SENATOR incorporating advanced monitoring technologies like GPS, telematics, blockchain and IoT sensors could provide valuable insights into logistics operations. These technologies enable real-time tracking of vehicles, shipments (including temperature-controlled shipments), and inventory, allowing for proactive decision-making, optimization of routes, and resource allocation to improve efficiency and reduce environmental impact.

Blockchain technology and temperature traceability has been integrated into the ICT Platform for the Zaragoza Urban Living Lab to test the feasibility of using the technology to achieve a more efficient and sustainable urban delivery system, including for temperature-controlled goods. The integration of blockchain technology into the platform development focused on providing thorough tracking and immutable traceability of shipments and the delivery process. Through this technology, information regarding the shipment's status at each stage, from receipt to package delivery, was continuously and immutably recorded. This ensured information integrity, as blockchain technology prevents any attempt at manipulation and it offered a comprehensive record of real-time package location tracking and the ability to review the movement history. The use of blockchain technology also improved the reliability of the delivery process by enabling more efficient coordination of shared resources, such as the fleet and delivery routes, between operators without compromising competitiveness, quality or control over the process by each company.

Another notable aspect of integrating blockchain technology into SENATOR was its application in cold chain traceability. To ensure proper management of products from local markets, the delivery fleet was equipped with integrated sensors that sent information to the blockchain network, allowing continuous monitoring of product temperature from market collection to final consumer delivery. This approach ensured the secure tracking of cold chain logistics, meeting stringent standards, and making it easier for consumers to access these products through home delivery services.

2) Big Data Analytics for Traffic Optimization:

Traffic Flow Optimization:

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Utilizing big data analytics for traffic flow optimization involves analysing vast amounts of traffic data collected from various sources, such as GPS devices, traffic cameras, and mobile applications [8]. By leveraging advanced analytics techniques, such as machine learning algorithms and predictive modelling, urban logistics stakeholders can gain insights into traffic patterns and trends. These insights enable them to identify bottlenecks, predict congestion, and optimize delivery routes in real-time. For example, by analysing historical traffic data and combining it with real-time information, logistics companies can dynamically adjust delivery routes to avoid congested areas, reducing delivery times and fuel consumption [9]. Additionally, traffic flow optimization strategies can be integrated with intelligent traffic management systems to implement dynamic traffic signal control and lane management, further enhancing overall logistics efficiency in urban areas.

Traffic flow optimization relies on a collaborative effort between urban logistics stakeholders and highway network managers, typically city authorities in urban areas, to effectively manage traffic flows and ensure efficient transportation of goods. The highway network manager plays a crucial role in providing data collected from various sources, such as traffic cameras, sensors embedded in roads, and mobile applications, to feed into the traffic flow optimization process. This data includes real-time traffic conditions, congestion hotspots, and historical traffic patterns, which are essential for identifying bottlenecks and predicting traffic flow disruptions. Furthermore, the highway network manager is responsible for managing traffic signals and implementing dynamic traffic signal control strategies. By coordinating traffic signals based on real-time traffic conditions and optimizing lane management, the highway network manager can help alleviate congestion and improve traffic flow efficiency, creating smoother pathways for logistics vehicles. Additionally, the integration of intelligent traffic management systems allows for the implementation of adaptive traffic control measures, dynamically adjusting traffic signal timings and lane configurations to accommodate varying traffic volumes and patterns.

For SENATOR, integrating advanced technology solutions like IoT sensors, GPS tracking, and data analytics platforms can enhance the effectiveness of the urban logistics model. Leveraging these technologies can provide real-time visibility into transportation networks, optimize route planning, and improve resource allocation, thereby contributing to the sustainability goals of urban logistics operations.

Congestion Reduction Strategies:

Big data analytics provides valuable insights for implementing congestion reduction strategies in urban logistics. By analyzing traffic data, such as vehicle speeds, traffic volumes, and congestion levels, city authorities can identify key factors contributing to congestion and develop targeted interventions [10]. These interventions may include implementing congestion pricing schemes, optimizing delivery time windows to avoid peak traffic hours,

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and incentivizing off-peak deliveries. This necessitates collaboration among logistics companies, recipients of goods, and city authorities to ensure effective implementation and address the complex interplay between freight and passenger flows.

To enhance the effectiveness of SENATOR's urban logistics model for sustainability, integrating advanced technology solutions like IoT sensors, real-time tracking systems, and predictive analytics can optimize transportation routes, minimize emissions, and improve overall efficiency. SENATOR has included the monitoring vehicles in real-time and a visualization of the "traffic density" with aggregated data which will be available for the city authorities in the two ULLs.

Efficiency Improvements through Data-Driven Decision-Making:

Big data analytics enables data-driven decision-making in urban logistics, leading to efficiency improvements across the supply chain. By analysing historical and real-time traffic data, logistics planners can make informed decisions regarding vehicle routing, fleet management, and warehouse operations. For example, predictive analytics models can forecast future traffic conditions and demand patterns, allowing logistics companies to optimize inventory levels and allocate resources more efficiently. Additionally, by integrating big data analytics with other technologies, such as IoT sensors, logistics stakeholders can further enhance operational efficiency and responsiveness. Overall, leveraging big data analytics for traffic optimization empowers urban logistics stakeholders to adapt to dynamic environments, minimize costs, and deliver superior customer experiences [12].

SENATOR could include leveraging advanced technologies such as IoT sensors, data analytics, and AI algorithms to develop a comprehensive urban logistic model. By harnessing these technologies, SENATOR can enhance the efficiency, sustainability, and resilience of urban logistics operations. Additionally, integrating emerging technologies like blockchain for transparent and secure data sharing for optimized transportation routes, can further advance the effectiveness of SENATOR's proposed model.

3) Digital Twins in Logistics Planning

Simulation Capabilities of Digital Twins:

Digital twins in logistics planning offer powerful simulation capabilities that enable stakeholders to replicate and model real-world logistics processes in urban environments. By creating a digital replica of physical assets, such as vehicles, warehouses and transportation networks, logistics planners can simulate various scenarios and assess the

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impact of different strategies on overall performance. For example, digital twins can simulate the interactions between different components of the logistics ecosystem, such as vehicles, infrastructure, and workforce, enabling comprehensive analysis and optimization of logistics operations. By running simulations in virtual environments, logistics stakeholders can test different scenarios, evaluate the effectiveness of proposed solutions, and make informed decisions to enhance efficiency and resilience in urban logistics [13].

City authorities can also utilize a digital twin, effectively a sophisticated freight transport model, to enhance urban logistics planning and management. A digital twin replicates the real-world urban environment virtually, allowing authorities to simulate various scenarios and assess their impact on the logistics network and operations. With a digital twin, city authorities can evaluate the effectiveness of different policy interventions, such as road pricing or infrastructure changes, before implementing them in the real world. By running simulations in this virtual environment, authorities can make informed decisions to optimize traffic flow, reduce congestion, minimize emissions, and enhance overall logistics efficiency. This proactive approach enables city authorities to address urban logistics challenges effectively, leading to more sustainable and resilient cities.

Optimization Capabilities of Digital Twins:

Digital twins enable optimization of logistics processes in urban environments by leveraging simulation data to identify opportunities for improvement and implement targeted interventions. Through continuous monitoring and analysis of real-time data, digital twins can dynamically adjust logistics operations to respond to changing conditions and demands. For example, digital twins can optimize delivery routes based on traffic conditions, weather forecasts, and customer preferences, minimizing delivery times and fuel consumption. Additionally, digital twins can optimize inventory management by forecasting demand, identifying surplus or shortage situations, and recommending inventory replenishment strategies. Moreover, digital twins can support workforce optimization by simulating different staffing scenarios, scheduling shifts based on demand fluctuations, and allocating resources efficiently. By harnessing the optimization capabilities of digital twins, logistics stakeholders can streamline operations, reduce costs, and improve customer satisfaction in urban logistics environments [14].

For SENATOR, leveraging the optimization capabilities of digital twins can greatly enhance its urban logistic model. Integrating advanced technologies like machine learning algorithms and predictive analytics into the digital twin framework can enable more precise optimization of logistics processes, leading to improved efficiency, cost savings, and sustainability outcomes.

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4) Green Technologies in Urban Logistics

Small Electric Heavy Goods Vehicles (HGVs) in Urban Logistics:

Small electric HGVs offer a promising solution for urban logistics, particularly in densely populated areas where space is limited and emissions regulations are stringent. These vehicles are designed to navigate narrow streets and congested urban areas with ease, making them well-suited for last-mile delivery operations. By replacing traditional diesel-powered HGVs with electric counterparts, logistics companies can significantly reduce carbon dioxide emissions, air pollution and noise levels in urban environments. Moreover, advances in battery technology are likely to be able to extend the range and payload capacity of small electric HGVs, allowing them to more closely match the range, payloads and costs of diesel HGVs operating on urban delivery routes while minimizing environmental impacts. With lower operating costs and zero tailpipe emissions, small electric HGVs will increasingly represent both a sustainable and commercially attractive alternative to conventional freight vehicles for urban logistics providers [15].

In addition to their environmental benefits, small electric HGVs can leverage cutting-edge vehicle charging technology to optimize their efficiency and effectiveness in urban logistics. These vehicles will increasingly be able to utilize rapid charging systems, which allow for quick replenishment of their battery power during short breaks in delivery routes. Furthermore, advances in charging infrastructure, such as megawatt chargers, will enable rapid and high-capacity charging, minimizing downtime and maximizing operational uptime for logistics companies which will more closely match the operational characteristics of diesel HGVs. By integrating state-of-the-art charging technology into their fleets, urban logistics providers can ensure seamless and uninterrupted delivery operations while further reducing their carbon footprint.

Electric Light Goods Vehicles (LGVs) for Urban Deliveries:

Although they are more expensive than their diesel counterparts, electric LGVs are likely to play an increasingly important role in sustainable urban logistics by offering efficient and environmentally friendly solutions for parcel and package deliveries. These compact vehicles are well-suited for navigating narrow streets and congested urban areas, making them ideal for last-mile delivery operations where small HGVs cannot operate. Electric LGVs produce zero tailpipe emissions, contributing to improved air quality and reduced carbon footprint in urban environments. With advancements in battery technology and charging infrastructure, electric LGVs can achieve longer ranges and faster charging times. Logistics companies are increasingly investing in electric LGVs to meet sustainability goals and comply with emissions regulations in urban areas. By transitioning to electric LGVs, urban logistics providers can

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reduce environmental impact, and meet the growing demand for sustainable delivery solutions [16].

Transitioning to electric LGVs (Light Goods Vehicles) offers several advantages compared to diesel LGVs: 1- Electric LGVs typically have lower maintenance costs due to fewer moving parts and simpler drivetrains compared to diesel vehicles. They also benefit from regenerative braking systems, which help recover energy during deceleration, improving overall efficiency. 2- Electric LGVs produce zero tailpipe emissions during operation, reducing air pollution and greenhouse gas emissions compared to diesel counterparts. This is especially crucial in densely populated urban areas where air quality is a significant concern. 3- While the upfront cost of electric LGVs tend to be higher than diesel vehicles at present, they often have lower operating costs over their lifetime. Electric vehicles have lower fuel costs since electricity is typically cheaper than diesel fuel and maintenance costs may also be lower because there are fewer mechanical moving parts. 4- Electric LGVs are much quieter than diesel vehicles, reducing noise pollution in urban environments. This can be particularly beneficial for nighttime deliveries or deliveries in noise-sensitive areas where diesel engine noise may be disruptive (although there is also a requirement to adopt quiet loading and unloading practices when the vehicles are stationary to ensure low noise deliveries and collections in urban areas). 5- Transitioning to electric LGVs can be aligned with the growing demand for sustainable transportation solutions. Many consumers and businesses prioritize environmentally friendly practices, making electric delivery fleets an attractive option for logistics providers looking to meet sustainability goals and consumer preferences.

Cargo Bikes for Sustainable Last-Mile Deliveries:

Cargo bikes offer a sustainable solution for last-mile deliveries in urban areas, particularly for small parcels and lightweight goods, but lack the economies of scale available from the use of LGVs or larger vehicles. These human-powered or electric-assisted vehicles can manoeuvre through congested city streets and narrow alleys and make use of dedicated cycle lanes, providing environmentally friendly delivery options. Cargo bikes produce zero emissions and generate minimal noise pollution, making them ideal for urban logistics operations in residential neighbourhoods and city centres where there may be bans on the use of motorised vehicles at certain times of the day. With innovative cargo designs and modular configurations, cargo bikes can accommodate various types of cargo, including parcels, groceries, and food deliveries. Logistics companies are increasingly incorporating cargo bikes into their delivery fleets in congested cities to reduce reliance on traditional vehicles and minimize traffic congestion in urban areas [17].

5) Predictive Analytics for Demand Forecasting

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Predictive analytics plays a crucial role in demand forecasting for urban logistics, offering insights into future demand patterns and enabling efficient inventory management. They are important in two particular ways – anticipating demand patterns and optimising inventory management:

i) Anticipating Demand Patterns:

Predictive analytics leverages historical data, market trends, and other relevant variables to forecast future demand accurately. In urban logistics, this involves analysing factors such as population density, economic indicators, seasonal variations, and consumer behaviour to predict demand for goods and services. By identifying patterns and trends in past consumption data, predictive analytics algorithms can extrapolate future demand scenarios, allowing logistics companies to anticipate fluctuations and plan accordingly. For example, during peak shopping seasons or special events like holidays, predictive analytics can help logistics planners anticipate spikes in demand for certain products or services, enabling them to adjust inventory levels, transportation schedules, and warehouse operations accordingly. Additionally, predictive models can factor in external factors such as weather conditions or traffic patterns that may impact demand, further enhancing the accuracy of forecasts [18].

Amazon, for example, has revolutionized demand forecasting using machine learning (ML). By automating through ML, Amazon predicts future demand for millions of products globally in seconds.

Implementing advanced predictive analytics technologies, such as machine learning algorithms and artificial intelligence systems, can empower SENATOR to anticipate demand patterns accurately in urban logistics. By leveraging real-time data from various sources, including IoT sensors, GPS tracking devices, and market databases, SENATOR can develop robust predictive models that account for complex factors influencing demand fluctuations.

ii) Optimizing Inventory Management:

Effective demand forecasting through predictive analytics enables urban logistics stakeholders to optimize inventory management practices. By accurately predicting future demand, companies can maintain optimal inventory levels, reducing the risk of stockouts or excess inventory. This helps minimize storage costs, improve cash flow, and enhance overall operational efficiency. Moreover, predictive analytics can support dynamic inventory replenishment strategies, triggering automatic orders or adjustments based on forecasted demand patterns. For example, sophisticated inventory management systems can automatically reorder products when inventory levels fall below predefined thresholds, ensuring that goods are always available to meet customer demand. Additionally, predictive analytics can facilitate just-in-time inventory management practices, where inventory is

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restocked as needed, minimizing holding costs and maximizing inventory turnover. Overall, leveraging predictive analytics for demand forecasting enables urban logistics companies to streamline inventory management processes, reduce costs, and enhance customer satisfaction by ensuring product availability [19].

Integrating advanced inventory management technologies, such as RFID tagging, barcode scanning systems, and cloud-based inventory platforms, can enhance SENATOR's ability to optimize inventory management in urban logistics. By leveraging real-time data capture and analysis capabilities, SENATOR can improve inventory visibility, accuracy, and control throughout the supply chain.

6) Collaborative Robotics (cobots) in Warehousing:

Enhancing Efficiency with Collaborative Robotics:
Collaborative robots, or cobots, are revolutionizing warehouse operations (such as fulfilment centres for e-commerce parcels) by working alongside human workers to streamline tasks and improve efficiency. These robots are designed to assist warehouse employees with repetitive or physically demanding tasks, such as picking, packing, and sorting items. By automating these labour-intensive processes, cobots can significantly increase productivity and throughput in warehouses. For example, cobots equipped with advanced vision systems can quickly locate and retrieve items from storage shelves, reducing the time and effort required for manual picking tasks. Additionally, cobots can collaborate with human workers in tasks that require precision and dexterity, such as assembling products or handling delicate items. This collaborative approach to robotics enables warehouses to achieve higher levels of efficiency while also ensuring the safety and well-being of their employees [20].

The fully automated warehouse is a facility where all operations, from goods receiving to order processing and dispatch, are carried out using automated logistics solutions. These warehouses minimize operator intervention, relying on robotics, conveyors, and smart software to handle tasks efficiently. Full automation may be required to minimise the operational costs and maximise the operational efficiency of urban consolidation centres to make them more likely to be economically viable.

7) Digital Platforms for Freight Matching:

Efficiency in Freight Matching:
Digital platforms for freight matching can, in theory, revolutionize the traditional process of connecting shippers with carriers by leveraging technology. These platforms utilize algorithms and data analytics to match freight shipments with available carriers based on

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various parameters such as load size, destination, and delivery timeframe. By automating the matching process, digital platforms significantly can reduce the time and effort required to find suitable carriers, resulting in faster and more efficient freight logistics. This efficiency can, in theory, reduce idle time for carriers, optimize route planning, and improved overall supply chain performance [22].

Indeed, the concept of digital platforms for freight matching relies heavily on the willingness of private sector operators to share their data, which may pose challenges due to concerns about competition and data privacy. In practice, some companies may be hesitant to disclose sensitive information about their operations, limiting the effectiveness of such platforms.

Commercial Challenges and Adoption Barriers:
Despite the theoretical advantages offered by digital freight matching platforms, there are several commercial challenges and adoption barriers that hinder their widespread application. One major challenge is the fragmentation of the logistics industry, with numerous stakeholders operating on different systems and platforms. This fragmentation makes it difficult to achieve interoperability and standardization across the industry, leading to inefficiencies and compatibility issues. Additionally, there may be resistance to change from traditional stakeholders who are accustomed to manual processes and established relationships [24].

The data privacy and security concerns pose significant challenges, as digital platforms require access to sensitive information such as shipment details and carrier profiles. Ensuring the confidentiality and integrity of this data is crucial to building trust and encouraging adoption among stakeholders. Moreover, regulatory compliance and legal considerations, such as antitrust regulations and liability issues, add complexity to the adoption of digital freight matching platforms. Overcoming these challenges will require collaboration between industry players, regulatory bodies, and technology providers to develop standards, address privacy concerns, and promote adoption across the logistics ecosystem.

8) Digitalization of Regulatory Compliance

Automated Compliance Monitoring Systems:

Digitalization of regulatory compliance in urban logistics involves the implementation of automated systems to monitor and manage adherence to regulatory requirements. These systems leverage technology such as IoT sensors, RFID tags, and GPS tracking to collect real-time data on various aspects of logistics operations, including vehicle emissions, driver hours-of-service, and cargo documentation. By continuously monitoring compliance metrics

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and generating alerts for potential violations, these systems help logistics companies proactively identify and address non-compliance issues, reducing the risk of penalties and fines [25].

The automated compliance monitoring systems facilitate record-keeping and reporting tasks by centralizing data collection and storage in digital formats. This streamlines the compliance documentation process, making it easier for logistics companies to maintain accurate records and demonstrate regulatory compliance during audits or inspections. Additionally, advanced analytics capabilities enable these systems to analyse compliance data trends and identify areas for process improvement, helping logistics companies optimize their operations while ensuring regulatory compliance.

Electronic Documentation and Reporting:

Another aspect of digitalization of regulatory compliance in urban logistics is the adoption of electronic documentation and reporting tools. Traditionally, logistics companies relied on paper-based processes for managing compliance-related documents, such as shipping manifests, customs declarations, and driver logs. However, the transition to electronic documentation offers numerous benefits, including improved data accuracy, reduced paperwork burdens, and enhanced data accessibility [26].

Electronic documentation systems allow logistics companies to digitize and store compliance-related documents in centralized databases, accessible from anywhere with an internet connection. This facilitates efficient document management, retrieval, and sharing, enabling seamless collaboration between stakeholders involved in logistics operations. Moreover, electronic reporting tools automate the generation and submission of compliance reports to regulatory authorities, reducing the time and effort required for manual reporting tasks [27].

By embracing digital solutions for regulatory compliance management, urban logistics companies can streamline their operations, reduce administrative overhead, and ensure adherence to regulatory requirements. However, it is essential to address data security and privacy concerns associated with digital systems and ensure interoperability with existing regulatory frameworks to maximize the benefits of digitalization in urban logistics compliance.

For SENATOR, exploring technologies such as electronic data interchange (EDI) and cloud-based document management systems could streamline electronic documentation and reporting processes in urban logistics. EDI enables the electronic exchange of standardized documents between trading partners, facilitating seamless data transmission and integration across supply chain networks. Cloud-based document management systems

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provide a centralized platform for storing, accessing, and sharing compliance-related documents securely over the internet, offering scalability and flexibility for urban logistics operations. Integrating these technologies into SENATOR's framework can improve efficiency, accuracy, and compliance in managing regulatory documentation.

9) **Real-time Environmental Monitoring:**

Sensor-Based Environmental Monitoring Systems:

Real-time environmental monitoring in urban logistics involves the deployment of sensor-based systems to track and manage not only the environmental impact of logistics operations, but also the impact on other road users. These systems utilize a variety of sensors, including air quality monitors, noise sensors, and particulate matter detectors, to continuously collect data on environmental parameters. By leveraging IoT technology, these sensors can transmit data in real-time to a centralized platform for analysis and decision-making. This real-time monitoring allows logistics stakeholders and city authorities to identify environmental hotspots, assess pollution levels, and take proactive measures to mitigate negative impacts on air quality, noise pollution, and other environmental factors [28].

Recently, FedEx launched FedEx Sustainability Insights, a tool that harnesses scan data from their global logistics network. This tool enhances customer access to emissions information, allowing better tracking and understanding of environmental impact.

Sensor-based environmental monitoring systems represent a crucial aspect of urban logistics, offering real-time insights into environmental conditions and their impact on logistics operations. By integrating advanced sensor technologies with IoT platforms, SENATOR can harness real-time data to optimize logistics processes, minimize environmental footprint, and ensure sustainable urban development.

Data Analytics for Environmental Impact Assessment:

Data analytics plays a crucial role in real-time environmental monitoring by enabling stakeholders to analyse and interpret the vast amounts of data collected by sensor-based systems. Advanced analytics techniques, such as machine learning algorithms and predictive modelling, can help identify trends, patterns, and correlations in environmental data. By analysing historical data and real-time observations, logistics stakeholders can assess the environmental impact of their operations, identify areas for improvement, and optimize resource allocation to minimize negative effects on the environment. Additionally,

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data analytics can support predictive maintenance strategies to ensure the continuous operation of environmental monitoring systems [29].

Data analytics technologies are fundamental for SENATOR's environmental impact assessment objectives. By leveraging advanced analytics techniques such as machine learning and predictive modelling, SENATOR can extract actionable insights from sensor data to optimize logistics operations, reduce environmental footprint, and promote sustainable urban development.

Integration with Sustainability Initiatives:

Real-time environmental monitoring is closely linked to sustainability initiatives in urban logistics, as it enables stakeholders to track progress towards environmental goals and compliance with regulations. By integrating environmental monitoring data with sustainability metrics and key performance indicators (KPIs), logistics companies can measure their environmental performance, benchmark against industry standards, and identify opportunities for improvement. Moreover, real-time environmental monitoring can support transparency and accountability in sustainability reporting, allowing stakeholders to communicate their environmental efforts to customers, investors, and regulatory authorities. By embracing real-time environmental monitoring as part of their sustainability strategy, logistics stakeholders can demonstrate their commitment to environmental stewardship and contribute to the development of sustainable urban logistics ecosystems [30].

SENATOR can leverage advanced technology solutions, such as IoT sensors, data analytics, and cloud computing, to integrate real-time environmental monitoring into its sustainability initiatives. By harnessing these technologies, SENATOR can collect and analyze environmental data in real-time, allowing for proactive decision-making and optimization of logistics operations to minimize environmental impact and enhance sustainability.

10) Smart Contracts in Logistics Transactions:

Automation of Transaction Processes:

Smart contracts offer a revolutionary approach to automating and securing transactions in the logistics supply chain. By leveraging blockchain technology, smart contracts enable parties to create self-executing agreements that automatically enforce the terms and conditions of a contract without the need for intermediaries. Blockchain technology enables the enforcement of contracts through the use of smart contracts, which are self-executing agreements written in code. These smart contracts are stored and executed on a blockchain network, which is a decentralized and immutable ledger. When parties enter into a smart

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contract, the terms and conditions are encoded into the contract's code. Once predefined conditions are met, such as the delivery of goods or completion of a service, the smart contract automatically executes the agreed-upon actions, such as releasing payment or transferring ownership of assets. Because smart contracts are executed on a blockchain, they operate in an environment where transactions are transparent, tamper-proof, and irreversible, ensuring that the terms of the contract are enforced without the need for intermediaries or centralized authority. Therefore, blockchain technology provides a secure and efficient mechanism for enforcing contracts through smart contracts.

In the context of logistics transactions, smart contracts can streamline various processes, such as order placement, shipment tracking, and payment settlement. For example, a smart contract can be programmed to trigger the release of payment to a carrier upon successful delivery of goods, eliminating the need for manual verification and invoicing. This automation not only reduces administrative overhead but also minimizes the risk of disputes and delays in transaction processing [31].

Exploring the integration of blockchain technology and smart contracts could enhance transaction processes within urban logistics, offering automated and secure mechanisms for managing contracts, payments, and transactions in real-time. See above under “Monitoring for Efficiency and Data Collection for Optimization” for more information on how blockchain was tested within SENATOR in the Zaragoza Urban Living Lab.

Enhanced Security and Transparency:

Smart contracts enhance security and transparency in logistics transactions by providing tamper-proof and immutable records of all contractual activities. Each transaction recorded on the blockchain is cryptographically secured, ensuring that it cannot be altered or deleted once added to the ledger. This transparent and auditable system reduces the risk of fraud, errors, and unauthorized modifications, thereby fostering trust among parties involved in logistics transactions. Moreover, smart contracts can include predefined rules and conditions that govern the execution of transactions, ensuring that all parties adhere to agreed-upon terms. This level of transparency and automation reduces the need for intermediaries, such as banks and escrow agents, streamlining the transaction process and reducing associated costs. Overall, smart contracts offer a secure, efficient, and transparent mechanism for conducting logistics transactions, paving the way for greater innovation and collaboration in the logistics supply chain [32, 33].

To leverage the benefits of smart contracts in logistics transactions, SENATOR could explore the development and implementation of blockchain-based platforms tailored specifically for the logistics industry. These platforms could utilize advanced cryptographic techniques and

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decentralized architectures to ensure the security, integrity, and transparency of transactional data.

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4 Urban Logistics – Market Structure

4.1 Introduction

Logistics is the commercial activity covering the transport of goods between the point of production and the point of consumption together with any associated functions such as storage, order processing and product handling. It is also called **distribution or supply chain management** (the terms are inter-changeable). Logistics considers the end-to-end supply chain to be an integrated system, with the different physical functions being managed as inter-connected rather than separate activities.

In the context of the SENATOR project, **urban logistics**, therefore, generally refers to when part of the supply chain passes into or through an urban area, typically the end point of consumption. However, it also concerns the return of unwanted goods to suppliers (so called reverse logistics) and the extraction of waste for recycling or disposal[38].

4.2 Market Structure

The urban logistics sector in Europe is regarded as being highly competitive and operationally very efficient. It generally operates in the private sector and on purely commercial terms i.e. for profit, albeit some national postal operators are state owned (though they operate on commercial terms as private enterprises). The public sector provides urban highway infrastructure and undertakes economic, safety and environmental regulation, while some niche operations have also received subsidies or preferential treatment on sustainability grounds.

Diesel powered road transport is currently the dominant mode, though the actual final deliveries into receivers' premises are also undertaken by other means (e.g. cargo bikes, on foot etc..) and some cites have been experimenting with more sustainable solutions (e.g. use of electric vans, trains/trams and barges).

[38] As noted in Section 1 above, the European Commission includes servicing activities in urban areas as being part of urban logistics. However, for the purposes of the SENATOR project the scope of urban logistics is limited to the movement of goods and waste.

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In economic terms, urban logistics is a derived demand[39]. It results from demand within an urban area for finished goods or materials which are produced at locations significantly distant from the immediate urban hinterland. Within Europe, urban areas are increasingly affluent and focused on the service sector; they have become places where goods are primarily consumed rather than produced. For consumer cargoes the point of production has shifted, in many cases, to Eastern Europe or the Far East. The need to move goods into urban areas from distant origins has therefore increased in importance over the past 50 years (and likewise the extraction of unwanted goods and waste, which is often over-looked).

Key Commercial Players

The key commercial players in the urban logistics sector can be divided into three broad categories:

1. Shippers – the organisations which physically despatch goods into urban areas as a result of demand from its population. They include:

- The major retail chains who operate 'bricks and mortar' outlets e.g. M&S, H&M, Carrefour etc..
- Suppliers of goods to smaller independent retailers e.g. wholesalers;
- Suppliers of food and beverages to catering and leisure facilities such as bars, cafes and restaurants;
- Producers and suppliers of goods which are used to service, maintain and develop the urban infrastructure e.g. building materials, plumbers spare parts etc.; and
- E-commerce retailers delivering goods direct to consumers.

2. Logistics operators – the commercial organisations which physically convey goods into urban areas on behalf of shippers. In some cases, a logistics operator can be a subsidiary division of a shipper, operating its own in-house transport equipment in order to deliver goods to the next stage in the supply chain, such as a retail outlet or cafe. This is particularly the case with smaller specialist suppliers, such as those serving the catering industry with fresh food produce or local builders merchants.

However, it is now common practice for shippers to out-source much of their transport and other logistics functions to specialist service providers on a *'hire and reward'* basis (a process also known as vertical collaboration). The principal reason for out-sourcing these requirements is that it generates economic efficiencies. Specialist operators are able to run goods vehicles more efficiently, in particular through their ability to combine shipments and collect backloads so that vehicles run fully-laden most of the time. They can also inject a

[39] In other words the demand for urban logistics is the result of demand for the goods being transported rather than demand for urban logistics services in its own right.

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degree of innovation into supply chains where there are long-standing but outdated operating practices. The competition to win/retain business also generates competitive rates and higher service quality.

Urban logistics operators fall into three broad categories:

- *Road hauliers* – operators who principally transport cargo using HGVs from one location to another at the direction of their customers;
- *Third party logistics operators (3PLs)* – in addition to road freight transport operations, 3PLs provide shippers with comprehensive packages of supply chain management services. These services include warehouse or distribution centre operations, inventory management, order fulfilment (order receipt, processing, packaging, despatch etc..) and reverse logistics (order returns from end-users and waste packaging). Generally, the larger the 3PL the more extensive the package of services they are able to provide to clients. Examples include DHL Supply Chain, XPO Logistics and Kuehne & Nagel; and
- *Parcel couriers, including the national postal operators* – these are essentially 3PLs that specialise in the delivery of mail and small/medium size packages up to 20kg. In particular, they specialise in the distribution of large volumes of small/medium sized individual consignments from one origin (e.g. a shipper's distribution centre) to multiple end-user destinations (e.g. residential properties) via shared-user distribution networks (i.e. conveying consignments for multiple shippers). Examples include the national postal operators that have Universal Service Obligations (AnPost, Royal Mail and Correos) and international parcel couriers such as FedEx, DHL and Evri (formerly Hermes).

Road transport is the dominant mode and a range of vehicle sizes are utilised:

- Full size HGVs (from 7.5 tonnes gvw up to 40/44 tonnes gvw) – for long distance flows and/or where large volumes are being transported in a single move to one destination (e.g. to a hypermarket or city centre department store). This includes articulated HGVs and rigid HGVs (both solo and hauling draw-bar trailers);
- Medium sized goods vehicles (MGVs, 3.5 tonnes to 7.5 tonnes gvw) – for single or multiple-drop delivery operations to retail and service sector outlets throughout urban areas; and
- Light goods vehicles (LGVs or 'vans' up to 3.5 tonnes) – often used for final deliveries or parcels and other small consignments to residential properties or smaller service sector outlets throughout urban areas.

Public policy, particularly at a local/city level, is now encouraging the use of more sustainable transport modes in urban settings other than diesel powered road freight vehicles. This is

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principally since such vehicles generate greenhouse gases, given that the 'Euro' emissions standards have significantly reduced both gaseous (e.g. NOx) and particulate matter pollution from tailpipes. This issue is addressed in Section 6 below. While not directly used for urban deliveries, a number of 3PLs use rail freight for some of their longer-distance flows (almost always to terminals on the edge of an urban area for transfer to road vehicles for final delivery into the urban area). Air freight is utilised by the parcel couriers for express international deliveries (likewise to airports that are located to serve urban areas where goods are transferred to road vehicles for final delivery).

3. End-users or consumers – the ultimate end-users or purchasers of the goods that are delivered into urban areas. In locational terms, it is typically also the end of the supply chain where goods are ultimately purchased and/or consumed, and includes traditional 'bricks and mortar' retail outlets (chain stores and smaller independents), leisure facilities such as bars, cafes and restaurants and increasingly direct to residential properties.

As noted, it is demand from the urban population that generates the flow of goods into the urban area. The nature of that demand will dictate the type of goods that will flow and the means of delivery. Recent trends include the growth of goods sold via e-commerce at the expense of those sold through traditional bricks and mortar outlets; this implies greater use of LGVs rather than HGVs or MGVs for urban deliveries. Groceries are also increasingly being sold through smaller city-centre convenience 'supermarkets', so that the 'little and often' shop is replacing the one-off weekly trip to the hypermarket.

4.3 The Role of the Public Sector

Within urban logistics, the public sector's role can be divided into two broad areas:

- The provision and management of highway infrastructure (including the kerbside); and
- Undertaking economic, safety and environmental regulation.

A key role for the public sector is the provision, maintenance and management of an urban area's highway infrastructure, including any kerbside facilities where goods vehicles park to unload cargo. Most highway infrastructure is directly funded from general Government revenues (i.e. taxation), though in some countries motorways and other strategic routes have been financed through public-private concession arrangements, with capital and maintenance costs recovered via tolls collected on entry/exit. Urban highways have traditionally been 'free' at the point of use, including orbital and transit motorways. A recent development has seen a number of cities implementing highway charging regimes on all/part of their road networks, with the aim of reducing congestion and pollution, e.g. the London Congestion Charge and Low Emission Zone (see Section 6).

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Highway authorities, whether at the national, regional or local level, also have road traffic management powers within urban areas covering the setting of speed limits, imposing vehicle weight and length restrictions, setting time windows for access to urban roads and restricting or banning the most polluting vehicles. This is covered in more detail in Section 6.

With respect to economic regulation, Section 2 above has described how competition law seeks to maintain fair market competition between rival companies and regulate behaviour which is 'anti-competitive', such as cartels and monopolies. It also regulates how organisations which are nominally 'competitors' are able to collaborate in order to generate economic efficiencies or other wider public benefits.

The safety and environmental regulation of road freight vehicle operators is broadly defined at national Government level, albeit laws are often derived from EU Directives/Regulations, while their implementation, enforcement and monitoring are undertaken by public bodies at the regional or local level e.g. regional administrations or city authorities. Regulations include:

- Operator licencing – operators of goods vehicles will require some form of operating licence. The process for administering will vary between countries, though the key aim is to ensure that goods vehicles are maintained in a road worthy condition and operated safely;
- Driver licencing – the process of awarding licences to drivers of road vehicles (and suspending/revoking where relevant). These are derived from EU Directives, albeit administered at the national level;
- Construction and Use regulations – stipulate how road vehicles should, in the first instance, be constructed by manufacturers, and subsequently maintained in a road-worthy condition. They are derived from EU Directives, albeit they are enforced at the national level. Includes the various 'Euro' emission standards for internal combustion engines; and
- The EU Drivers Hours Regulations – limits the amount of time which drivers are allowed to operate vehicles alongside stipulating mandatory break and rest periods (drivers of most goods vehicles over 3.5 tonnes gross vehicle weight). LGV drivers may be regulated by separate domestic laws and, in any case, the Working Time Directive applies.

The key factor linking the shippers and logistics operators is that they are both commercial organisations; their various activities are undertaken in return for monetary rewards, with the objective of generating profits and returns for investors. The public sector's role is to facilitate these commercial activities (through the provision of the necessary infrastructure)

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and to ensure they are undertaken in a safe and environmentally sustainable manner. This can be a fine balancing act. The provision of inadequate infrastructure combined with 'over regulation' in terms of strict vehicle weight, length and time restrictions will reduce the commercial players ability to operate profitably. On the other hand, a lack of regulation can result in significant environmental impacts, thereby damaging the wider attractiveness of the city as a place to live, work and for leisure activities.

It could also be argued that a further objective of public policy in urban areas in relation to logistics should be to encourage efficient logistics, which will subsequently benefit the wider economy of the urban areas which are being served. Often efficiency and sustainability can be achieved simultaneously[40], and the objective of public policy should be to seek 'win-win' solutions that optimise overall economic benefits (while taking into account economic externalities) rather than just seeking to minimise the 'nuisance' caused by urban logistics through regulation.

Recommendations for the project

RECOMMENDATIONS	
Recommendation 3.1	SENATOR should be designed to minimise the costs for. and facilitate the operations of, private sector logistics operators, while also reflecting the legitimate regulatory concerns of the public sector, particularly in terms of emissions.

[40] For example, when routing of road freight vehicles is optimised it both increases the operational efficiency (reducing fuel and vehicle fixed costs and allowing on-time deliveries and collections) and reduces emissions and road congestion.

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5 Key Demand Drivers

5.1 Urban Living and Service Sector Growth

Within the urban logistics sector, the two key demand drivers over the past 3-4 decades have been a combination of the following:

- The growth in the population that lives in urban areas; and
- The increasing importance of the service economy.

For the EU as a whole plus a number of selected countries, the table below shows the percentage of the population living in urban areas, from 1970 to 2019.

Table 4.1: Percentage of Population Living in Urban Areas (1970 to 2022)

	1970	1980	1990	2000	2010	2019	2020	2022
EU	64	68	69	71	73	75	75	75
Selected								
Netherlands	62	65	69	77	87	92	92	93
UK	77	79	78	79	81	84	85	84
Spain	66	73	75	76	78	81	81	81
France	71	73	74	76	78	81	81	82
Germany	72	73	73	75	77	77	77	78
Ireland	51	55	57	59	62	63	64	64

Source: World Bank

For the EU as a whole, the proportion of the population living in urban areas has increased from 64% in 1970 to 75% by 2022. There is therefore a clear trend since 1970 towards higher proportions of the population being urbanised. The Netherlands currently has the highest level of urbanisation, with 93% of the population living in an urban area (up from 62% in 1970). The UK, Germany, France and Spain are all more urbanised than the EU as a whole total. Ireland is currently less urbanised than the EU as a whole, albeit still conforming to the trend towards a higher percentage of urban living since 1970. The identified trend is a combination of natural 'organic' growth plus migration from rural areas.

For the EU as a whole plus a number of selected countries, the table below shows service sector value added as a percentage of total GDP, from 1990 to 2020.

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Table 4.2: Service Sector Value Added – Percentage of GDP (1990-2022)

	1990	2000	2010	2020	2022
EU	59	61	65	66	65
Selected					
UK	68	66	71	73	72
Netherlands	62	66	68	70	69
France	62	66	71	71	71
Spain	60	59	66	68	68
Germany	56	61	62	63	63
Ireland	56	55	67	55	53

Source: Worldbank

For the EU, service sector value added made up 65% of GDP in 2022, growing from 59% in 1990. In the UK, the service sector currently represents around 72% of the overall economy. The Netherlands, France and Spain record similar levels of service sector activity. Germany currently records service sector activity below that of the EU as a whole, demonstrating the continued importance of the manufacturing sector in that country. Ireland's service sector grew significantly during the 'Celtic Tiger' years, but fell back following the financial crash of 2008-09. Overall, the general trend across the EU is towards a higher proportion of GDP being generated by the service sector, reflecting the re-location of certain manufacturing processes to the Far East.

The combined effect of the above has been larger populations and a growing demand for goods within urban areas, much of which is produced at locations significantly distant from the immediate urban hinterland. Consequently, the need to move goods into urban areas from distant origins has therefore increased in importance over the past 50 years. However, the nature of that demand and the delivery methods used to satisfy it are also changing. These are explored further below.

5.2 E-Commerce

Another important demand driver is the recent significant growth of retail goods sold via E-commerce platforms at the expense of goods sold via traditional 'bricks and mortar' outlets. Three sets of data can demonstrate this trend. Firstly, the table below, derived from *Eurostat*, shows the percentage of adult individuals making at least one e-commerce purchase within a three month period, from 2010 to 20 (last year of data availability). The results are shown from the EU as a whole plus a number of selected countries.

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Table 4.3: Percentage of Individuals Making One E-Commerce Purchase in Three Months

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EU	31	33	35	38	41	43	45	48	50	53	54
Selected											
UK	60	64	64	71	72	75	78	78	77	80	83
Germany	48	54	55	60	61	64	64	66	68	71	75
Netherlands	52	53	52	55	59	59	63	68	70	70	77
Ireland	28	34	35	37	43	44	41	44	52	59	64
France	40	40	42	44	49	49	52	54	55	58	66
Spain	17	19	22	23	28	32	35	40	43	47	54

Source: Eurostat

For the EU as a whole, 54% of individuals made at least one e-commerce purchase in a three month period during 2020, increasing from 31% in 2010. The largest e-commerce retail market (using this measure) in 2020 was the UK, with 83% of individuals making at least one e-commerce purchase within a three month period. Denmark, Germany and the Netherlands all recorded figures above 70%. In contrast, only 54% of individuals in Spain made at least one e-commerce purchase within three months, albeit this had grown sharply from 17% in 2010.

In 2022 Eurostat reported that 75% of people in the EU had bought or ordered goods or services for private use, with e-commerce sales boosted by the Covid-19 pandemic when people were not able to visit "bricks and mortar" retail outlets during lockdowns. The highest shares of internet users who bought or ordered goods or services over the internet in 2022 were recorded in the Netherlands (92%), Denmark (90%) and Ireland (89%).

The second data set, focusing on the UK, tracks the value of e-commerce sales as a percentage of total retail sales since 2007. This is shown in the graph below (source: UK Office of National Statistics).

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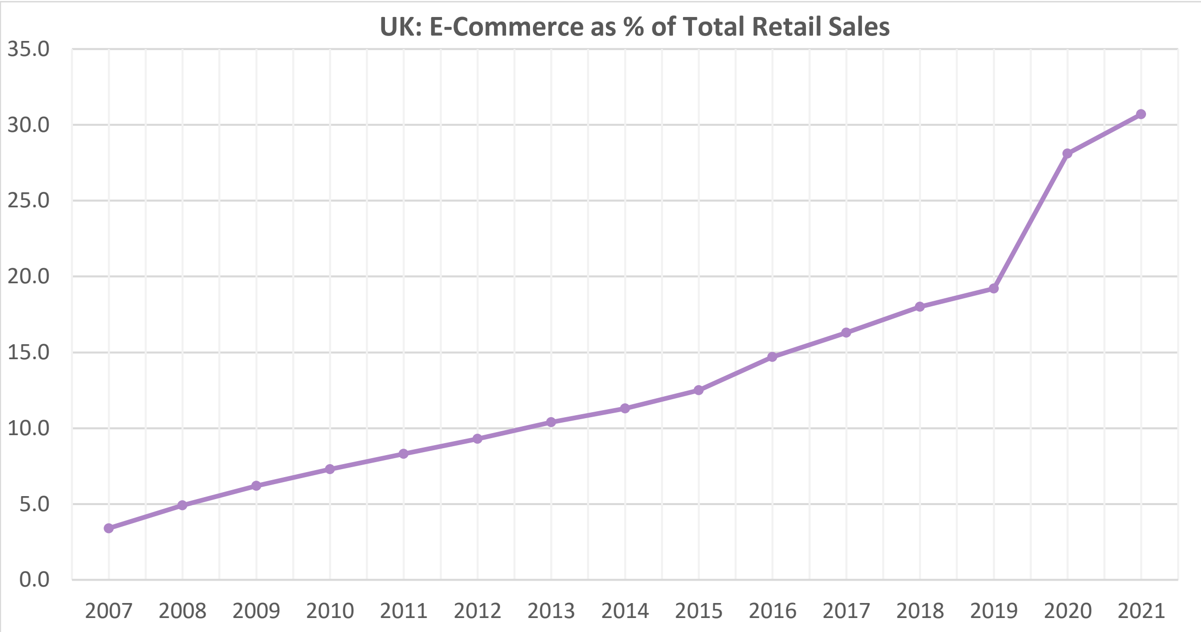
Figure 4.1: E-Commerce Retail Sales as Percentage of Total Retail Sales (by Value)



Source: UK ONS.

Around 30.7% of all retail sales in 2021 were undertaken via e-commerce (and then fell back to 26.6% in both 2022 and 2023 after the end of the Covid-19 lockdowns); they were below 4% in 2007.

Finally, the table below shows the volumes of parcels and packets handled in Ireland by *AnPost* between 2009 and 2019.

Table 4.4: AnPost Parcels and Packets Handled 2009-2019

	Millions										
Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Parcels and Packets	25	22	23	24	26	25	23	23	27	29	36

Source: AnPost

The data in the table covers all parcels (up to 2kg) and packets (up to 20kg) handled annually by AnPost. E-commerce relies heavily on parcel couriers to fulfil orders, and the recent trends identified in the previous datasets are also reflected in the table above; it shows a 44% increase in parcel and packet volumes handled by AnPost between 2009 and 2019.

This very significant growth, as demonstrated by the three datasets, can be explained by a combination of factors, including:

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- Technological developments – the development of smart phones and tablets alongside fast broadband and data provision services means many consumer products can be purchased within a few 'clicks';
- The opening up of parcel and courier services in the EU to full market competition (see Section 2.4) – an open and highly competitive environment for parcel services - has attracted new entrants alongside the incumbent national operators, and the competition has subsequently generated a range of efficient postal services which e-commerce retails have taken advantage of when fulfilling their customer orders. It is almost certainly the case that those countries recording the highest e-commerce sales (Table 2.4) were the ones with the greatest level of parcel service competition;
- Related to the above, retailers and their logistics providers have developed distribution/fulfilment centres which allow goods to be stored, picked and packed efficiently;
- The ability of the e-commerce retailers to competitively price goods, undercutting traditional 'bricks and mortar' retailers. This has arisen through a combination of bulk buying (from China/Far East), efficient storage and relatively cheap delivery services (see above bullets) and no requirement to operate a labour intensive outlet network in city/town centres which attract high rents and business rates/taxes; and
- Convenience – avoiding the need to travel into congested urban centres or retail parks (maximising leisure time).

The recent Covid-19 pandemic, and the subsequent forced lock-down of non-essential retail outlets, has resulted in a significant further step-change in the volume of e-commerce trade between 2019 and 2020. In the UK, for example, items such as clothing and electricals were only available to purchase on-line between mid-March and June, during November 2020 and the early months of 2021. ONS data for the UK suggests that e-commerce sales peaked at 33% of all retail sales in May 2020, though this declined slightly once retail outlets were able to trade under conditions similar to that before the lock-down. However, the long-term lasting impact of Covid-19 from a logistics perspective is that these trends are likely to continue, though it appears the 2020-2021 trend is broadly in-line with that recorded up to 2019..

The implication of this trend for urban logistics is important. Larger 'bricks and mortar' retail outlets would generally be served by full-size and fully-loaded HGVs (undertaking a single delivery then re-position back to the distribution centre). Vehicle unloading also generally takes place in dedicated areas away from the public highway network. In contrast E-commerce, as will be described in Section 5, is very much reliant on smaller MGVs and LGVs to fulfil deliveries on a multi-trip basis, many of which will be passing into residential areas

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and delivering from the public highway. The rise of e-commerce suggests increasing trip rates into urban areas by freight vehicles.

5.3 Convenience Retail

Linked to the rise of e-commerce is the issue of convenience retail. This has manifested itself in a number of areas. Firstly, many households have abandoned the traditional weekly trip to the supermarket/hypermarket for groceries, and instead it has been replaced with a combination of:

- An e-commerce order, say every 2-3 weeks, consisting of bulk quantities of staple (non-perishable) items, either delivered to home or collected by car ('click and collect' or e-drive etc..); and
- Supplemented by daily or every other day visits to convenience ('metro') type grocery stores for fresh and perishable groceries, either during lunch breaks or while commuting home from the office. This is the so called 'little and often' concept.

This trend has generated a rise in the number of convenience grocery stores in town and city centres e.g. Tesco Metro, Sainsburys Local, Carrefour City, Spar etc.. Deliveries often take place in smaller sized but fully loaded HGVs (e.g. rigid HGVs up to 18 tonnes) and often from parking/unloading areas on the public highway network. Again this suggests increasing trip rates into urban areas by freight vehicles.

5.4 On-demand Services

E-commerce retail has, until fairly recently, been divided into three broad categories:

- Digital fulfilment – instead of receiving a physical commodity, items such as films, music, books and event/travel tickets which can be purchased via an e-commerce platform and then immediately downloaded (delivered) for consumption (on a device or printed at home);
- Click and collect – the process of reserving goods via an e-commerce platform for physical collection in person at a traditional 'bricks and mortar' retail outlet; and
- Physical delivery – purchasing goods via an e-commerce platform with the order fulfilled by means of a physical delivery of the ordered items to a residential or commercial property.

Digital fulfilment is immediate, while in many cases click and collect minimum lead times are determined by how quickly a consumer can travel to the collection point store. Physical deliveries have, to date, had minimum delivery times of at least one day (e.g. order by 20:00 for next day delivery etc.). Most e-commerce retailers now offer graduated lead-times based

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on price, with next day express deliveries attracting a premium payment over a standard delivery of 3-5 days from order.

A more recent development concerns so called ‘on-demand’ e-commerce (sometimes referred to as ‘instant gratification’), where orders placed via an e-commerce platform are fulfilled fairly quickly after the order being placed (sometimes in under an hour, but certainly on the same day). To date, ‘on-demand’ e-commerce has been focused on the delivery of take-away food via on-line platforms such as *Deliveroo*, *Uber Eats* and *Just-Eat*. In each case the platform digitally passes a food order (and payment) to a local take-away outlet (which may be an independent outlet or part of a wider chain such as KFC) and then arranges delivery to the consumer’s residential property via one of its on-the-ground delivery agents (adding an arrangement/delivery fee to the food order cost as its commission.

The on-the-ground delivery agents are generally self-employed and are responsible for providing their own transport, with payment normally on a per-item delivered basis. In the case of Deliveroo and Just-Eat, transport is often a cargo-bike or moped. Uber Eats utilises its existing network of private hire vehicles.

More recently, the ‘on-demand’ concept has also been extended to deliveries of groceries. *Amazon* has launched its ‘*Amazon Fresh*’ service, which aims to deliver grocery items on a same day basis directly to consumer’s homes. In Europe, it is currently available in major urban areas. Likewise, a number of the existing on-line grocery retailers in Great Britain (including Sainsburys and Waitrose) also now offer same-day delivery options, albeit at a premium price and limited to a certain number of items. Given the lead times involved, these services are only available within large cities. Sainsbury’s has also trialled the use of cargo-bikes with its same day offer. Tesco has recently launched ‘whoosh’, which aims to delivery essential items, in some cases within 20 minutes. However, one of the early ‘app’ based players, *Getir*, has decided to exit the European market due to lower than expected take-up.

Recommendations for the project

RECOMMENDATIONS	
Recommendation 4.1	SENATOR should be designed to fully incorporate the use of mobile technology and the internet used by end consumers and logistics providers to make and receive orders and receive and carry out deliveries in urban areas.
Recommendation 4.2	SENATOR should cater for a wide range of goods deliveries in urban areas, but there should be a particular emphasis on e-commerce deliveries of parcels due to the high levels of growth that are being seen in this sector in Europe as

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	consumers move away from traditional 'bricks and mortar' retail.

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6 Urban Logistics Business Models

6.1 Introduction

The key aim of this section is to set out the main logistics business models that have been adopted by the market in the urban logistics sector. They each concern the physical delivery of goods into the urban environment for consumption, though unwanted cargo and waste/recycling materials can also be conveyed on the reverse flows. It should be noted that they are 'models' of logistics supply chain; they provide a simplified description of reality in order to assist in explaining how companies organise the movement of goods from producers/suppliers to the end-user. These models are not intended to be a perfect 'fit' with an individual organisation's actual supply chain, though examples of companies which have broadly adopted each model are given. It may be the case that an individual company's supply chain could be an amalgam of two or more models, or they may have adopted more than one model for different parts of their businesses.

6.2 The Classic Logistics Model

This is the classic (pre E-commerce) logistics model that has been adopted by the large 'bricks and mortar' retail chains alongside supply chains serving smaller independent retailers and the leisure sector, such as bars, cafes and restaurants. Flow-diagram 1 in the Appendix provides a visual description of this model.

National Distribution Centre (NDC) – a large warehouse which acts as an inventory holding point for both imported and domestically sourced goods, before re-distribution to subsequent stages in the supply chain. They are normally associated with goods which have long lead times, such as those imported from the Far East, or where stock is held well ahead of anticipated market demand (such as seasonal items). Due to this, dwell times can be lengthy (1-3 months). They are normally operated by manufacturers (or their import agents) and retail chains. As the name suggests, they would serve one country from the same facility (though many NDCs in Great Britain also serve Ireland).
European Distribution Centre (EDC) – essentially performing the same function as a NDC but serving two or more European countries from the same site.
Regional Distribution Centre (RDC) – a large warehouse which receives, consolidates and then re-distributes goods to end-destinations. Inbound goods can be from NDCs/EDCs or direct from suppliers (particularly for perishable cargoes). They would normally have a regional hinterland i.e. serving a region rather than a whole country. Goods which pass through RDCs are normally the result of orders placed by end-users or fast moving product lines. Therefore, while some storage functions may be undertaken, in many cases RDCs are used to consolidate and then re-despatch goods. Dwell times are consequently usually fairly short (from a few hours to 2-3 weeks).

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In this model, a NDC/EDC receives inbound deliveries of cargo from suppliers (by road, rail when located close to a terminal or by ship if located in a port). When required, goods will then be transported (mainly in HGVs but also intermodal rail freight services for longer distance flows) to a series of RDCs, which are normally located close to major urban conurbations. Likewise, each RDC will also receive inbound goods direct from multiple suppliers. Goods received at the RDC, either via the NDC/EDC or direct from suppliers, will then be consolidated before onward delivery to end-destinations within urban areas, such as a 'bricks and mortar' retail outlets, cafés, bars etc.. The RDCs could be large multiple facilities serving a single retailer's chain of outlets, or individual supplier/wholesaler warehouses serving a range of customers in the immediate urban hinterland.

In the case of the large 'bricks and mortar' retail chains, the whole NDC/EDC-RDC-store supply chain is normally under the control of a single retailer, albeit the different logistics functions will in many cases be out-sourced to 3PLs. Flows along the supply chain will generally be in full size HGVs (or equivalent-size intermodal units), and on a single-drop basis (i.e. a HGV from a RDC will deliver to a single retail outlet). Goods vehicles entering urban conurbations will therefore generally run fully-laden on the inbound flow, with the outbound movements often conveying waste and empty handling equipment such as pallets and roll-cages.

In other cases, such as suppliers of goods to smaller independent retailers or leisure/catering facilities, the different parts of the supply chain will generally be owned and under the control of separate organisations (i.e. each is a customer of the previous stage in the supply chain). For a food and beverage wholesaler, for example, they would be purchasing goods direct from multiple suppliers (their factories or NDCs/EDCs) before consolidating and then onward selling those goods to individual catering outlets within the adjacent urban hinterland.

While flows into the RDCs will again generally be in full size HGVs (or equivalent-size intermodal units), final deliveries to urban area end-destinations are more likely to be on a multi-drop basis using MGVs and LGVs (sometimes called 'milk-round' deliveries, where the freight vehicle will depart from the RDC loaded with consignments for multiple end-users, only returning to the RDC once it has visited all delivery locations). However, this means that goods vehicles initially entering urban conurbations will generally be fully laden and they will slowly empty out during their delivery rotation. Again, in many cases the process of handling and transporting goods can be out-sourced to 3PLs, though smaller specialist suppliers, such as those serving catering industry with fresh food produce, are continuing to operate their transport requirements in-house.

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Two recent variants of this model now accommodate e-commerce offers, namely 'click and collect' and 'delivery from store'. '*Click and collect*' (sometimes referred to as 'e-drive' or 'drive and collect') is where consumers are able to reserve stock in a store via an e-commerce platform (i.e. via a website or smart-phone app) for subsequent collection in-person. Collection of goods can be made 'on-foot' (e.g. a person who commutes to work by public transport and will collect the goods en-route to/from work) or using their own private car. The advantage of click and collect is threefold:

- It has allowed the retailers to distribute e-commerce orders via their established logistics networks – no extra vehicles to the road network as the goods are on the same HGVs serving the store;
- Rejected orders can be fed back into the retailer's inventory immediately and be available for re-sale (rather than having to return goods via a parcel or mail network, which could potentially take up to a month); and
- It also allows 'up-selling'; while a customer is in-store to collect an on-line 'click and collect' order, they may be tempted to make additional purchases.

'*Delivery from store*' allows individual consumers to purchase retail goods via an e-commerce platform, with the goods subsequently picked from a store's inventory and delivered direct to their homes, normally undertaken using LGVs or MGVs on a multi-drop basis. This to date has been focused on the grocery sector, though other retailers have offered similar services. By serving from store, it allows the retailers to distribute e-commerce orders via their established logistics networks. Unlike click and collect, this sales platform has resulted in additional freight vehicle trips into urban areas.

For both 'click and collect' and 'delivery from store', the e-commerce offer has essentially formed an 'add-on' to the retailer's existing 'bricks and mortar' store network. The new e-commerce models, described below, have essentially done away with the traditional physical retail outlet and are instead based around fixed logistics facilities (generally located outside urban areas) and freight transport, some of which operates into urban areas.

6.3 E-Commerce Model 1

This is one of the new e-commerce based logistics models that has emerged over the past few decades. Flow-diagram 2 in the report Appendix provides a visual description of this model. As an example, the retailer *Amazon* broadly follows this model in Great Britain.

In this model, a series of RDCs are located close to major urban conurbations. Each RDC receives inbound deliveries of cargo from the e-commerce retailer's multiple suppliers (by road or potentially rail if located at a rail-served site); the e-commerce retailer is therefore responsible for holding sufficient inventory at each RDC in anticipation of demand so that

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customer orders can be fulfilled in a timely manner. The retailer's multiple suppliers are now located both throughout Europe and further afield (predominantly in the Far East).

On-line orders placed by end-users via the retailer's e-commerce platforms are then picked, appropriately packed and labelled at the RDC, before being loaded onto freight vehicles for delivery to end-destinations, principally residential properties in the adjacent urban area but also commercial/office buildings. This is normally undertaken on a multi-drop basis and, in most cases, deliveries are undertaken by fleets of LGVs or MGVs, depending on the product being handled. Individual consumers can often nominate their place of work to receive deliveries rather than their homes.

Deliveries from the RDCs may be undertaken via the retailer's in-house LGV/MGV fleet. However, the retailer will often out-source (contract out) this part of the operation to specialist 3PLs, in many cases the main multi-national parcel couriers (e.g. FedEx, DPD, DHL etc.). Delivery vehicles will therefore, in many cases, contain shipments from multiple e-commerce retailers. In the case of Amazon in the UK, these deliveries are increasingly being handled by self-employed 'driver and van' operators (the driver is responsible for providing the LGV and is paid per item delivered). Likewise, the operation of the RDCs (covering the inbound receipt of goods from suppliers, inventory management, picking/packaging and loading to LGVs/MGVs for final delivery) may be undertaken in-house by the retailer or again out-sourced to a specialist 3PL.

In the case of some on-line only retailers, such as Amazon, the company will often be located (headquartered) in another country to where customer orders are placed, with the order fulfilment then undertaken on behalf of the retailer in the country of delivery. For example, orders placed with Amazon in the UK for UK delivery are actually made with Amazon's European parent company based in Luxembourg, with a UK-based subsidiary company being responsible for the order fulfilment in the UK on behalf of Amazon in Luxembourg. In addition to fulfilling orders for their own products, some on-line retailers will undertake order fulfilment on-behalf of other e-commerce retailers.

6.4 E-Commerce Model 2

This is the second of the new e-commerce based logistics models that has emerged over the past few decades. Flow-diagram 3 in the report Appendix provides a visual description of this model. On-line retailers Ocado, Next and ASOS in Great Britain broadly follow this model.

The retailer will operate a single or series of Customer Fulfilment Centres (CFCs) which receive and then store cargo from the retailer's multiple suppliers (generally by road or rail). The CFC could serve either a whole country or more than one country (effectively a NDC or

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EDC) or multiple regions within one country (i.e. larger hinterland than a classic RDC). Again, suppliers are often located overseas and the inbound movement to the CFC will take place via a port.

Order fulfilment initially begins at the CFC, where on-line orders received by the retailer via their e-commerce platforms are picked, appropriately packed and labelled before being loaded onto freight vehicles for trunking to a series of regional 'cross-dock' facilities located close to major urban conurbations. A cross-docking facility is superficially similar to a warehouse but is designed solely for transferring cargo directly between freight vehicles i.e. no storage or fulfilment functions. In this case, the trunking operation, which may be over fairly long distances, will generally be undertaken in full-size HGVs but also by intermodal rail freight services over longer distance flows. At the cross-docking facility, the consignments are off-loaded from the trunking freight vehicles and re-loaded onto other freight vehicles (normally MGVs/LGVs, as per e-commerce Model 1 above) for delivery to residential/commercial properties in the adjacent urban hinterland on a multi-drop (milk-round) basis.

In many cases, particularly for lighter/small individual consignments such as clothing, the process of delivering cargo to residential/commercial properties from the CFCs is often undertaken by the main parcel couriers (e.g. FedEx, DHL, Yodel, DPD etc..) via their shared-user trunking and delivery networks i.e. vehicles conveying consignments for more than one shipper. This is illustrated in Flow-diagram 4 in the report Appendix. The contracted parcel courier will collect goods from multiple e-commerce retailer CFCs before consolidating them at a central shared-user hub. Following sorting, the goods will then be loaded onto freight vehicles for trunking to a series of regional 'cross-dock' facilities located close to major urban conurbations. At the cross-docking facility, the consignments are off-loaded from the trunking freight vehicles and re-loaded onto other freight vehicles (normally MGVs/LGVs) for delivery to residential/commercial properties in the adjacent urban hinterland. The trunking and final delivery operations will therefore be undertaken using freight vehicles containing shipments from multiple retailers (which will often be direct competitors).

6.5 E-Commerce Model 3

A more recent trend is the emergence of Far-Eastern based e-commerce retailers who are serving the European market direct from the Far East (instead of European-based distribution facilities as described in Models 1 and 2 above). They key feature of these retailers, such as *Shein* and *Temu*, is that they sell extremely low cost products, with a particular focus on so called 'fast fashion' items. These are effectively copies of high-end (designer) clothing and footwear, but which have been assembled using low cost labour and poor quality materials.

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Goods are stored in the Far East, with individual order consignments shipped direct to consumers in Europe using spare capacity on express air freight flights or dedicated air freighter services when it becomes available (and paying reduced air rates as a result). When orders for goods from the likes of Temu are placed via their websites, the ‘estimated delivery’ window is often given as 5-8 days (lead time not specific). There is consequently an expectation that goods will not be shipped immediately, the benefit being that it will eventually be shipped but at a lower rate. Once in Europe, the individual consignments are then distributed via the shared-user trunking and delivery networks of the main postal operators or parcel couriers for undertaking final delivery to consumers. This commercial model relies on there being spare air freight capacity available at discounted rates.

6.6 Consolidation and Use of 3PLs

The large ‘bricks and mortar’ retail chains are generally able to despatch fully laden vehicles using standard 13.6 metre semi-trailers when delivering into urban areas. Likewise, many other distributors (e.g. food or beverage wholesalers) are also able to assemble sufficient cargo so that they can despatch fully laden vehicles into urban areas (albeit generally on a milk round basis). Consolidation within this sector over the past decade has also aided this process. Many beverage suppliers are now the distribution arm of the major brewers and drinks producers, while catering suppliers have consolidated into large national/multi-national suppliers (e.g. Brakes). As a result, vehicle trips into urban areas are minimised and those running will depart depots reasonably well laden most of the time.

The e-commerce sector has the potential to generate significant numbers of poorly laden MGV/LGV movements into urban areas. However, the common practice of contracting specialist 3PLs (including parcel couriers), as described, means that goods delivered into urban conurbations from multiple shippers (often competitors) will end up being consolidated and ultimately delivered by common logistics operators using shared transport capacity. This is because a single specialist 3PL (such as a parcel courier) will have multiple e-commerce clients, and they will actively seek to combine shipments from them in order to maximise vehicle fill and reduce/eliminate empty running. In practice, therefore, 3PLs are facilitating the consolidation of cargo from various e-commerce shippers that do not directly set out to collaborate with each other (including both competitors and complementary companies).

A consequential benefit of this position is that goods vehicles entering urban conurbations are, predominantly, already running fully-laden (or approaching fully-laden) on the initial inbound flow. Further, it means the number of vehicle movements into urban areas is significantly reduced. Overall, cargo consolidation into urban areas is already happening, albeit it has been driven by market mechanisms rather than regulation.

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Recommendations for the project

RECOMMENDATIONS	
Recommendation 5.1	SENATOR should be designed to cater for all 'last mile' logistics operations within an urban area and therefore be agnostic between the different logistics model used by shippers and their logistics providers.
Recommendation 5.2	SENATOR should be designed to cater for the concept of consolidation and therefore the transfer of goods, perhaps between logistics providers, prior to the 'last mile' delivery. Although consolidation tends to add cost to supply chains, the SENATOR platform should seek to add value by enhancing coordination between different logistics providers and reduce costs, while also maximising the confidentiality of data flows.

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7 Emerging Issues and Associated Policy & Market-Based Measures

7.1 Minimising the Environmental Impact of Urban Deliveries

The issue

Urban areas should be pleasant places to live, work and visit for leisure purposes. Historic cities should be able to 'show off' their heritage features to tourists (generally considered to be a source of income). They should be attractive places for businesses to locate, as they are generators of both direct and indirect employment. The decline of traditional manufacturing and the growth of the service economy (including a shift towards e-commerce retail, as described in Section 4) means that many cities are having to 're-invent' themselves as places where people (particularly environmentally conscious young adults) will want to live and enjoy their leisure time. However, delivering goods into urban areas causes environmental impacts. These impacts, which generally derive from the use of various sizes of road freight vehicles (as described the dominant mode), include:

- Visual intrusion, particularly where goods vehicles access narrow roads, historic streets and residential areas within urban conurbations (as roads not originally designed for large goods vehicles);
- Noise pollution – running of diesel engines and reefer generators;
- Emissions of greenhouse gases and gaseous/particulate pollution;
- Damage to the road infrastructure and urban fabric in general (including heritage buildings and infrastructure); and
- Congestion and interactions with pedestrians (which can result in accidents).

Public policy therefore seeks to both minimise the impact of urban logistics (including protecting historic fabric) and enhance the wider urban environment, while at the same time acknowledging that goods still need to be efficiently delivered to ensure that urban areas remain economically competitive and attractive places to live or work from commercial perspective. Balancing these two policy objectives can lead to some difficult choices.

The key long-term objective currently with respect to minimising the environmental impact of urban logistics is the replacement of diesel and petrol powered freight vehicles. This is due to two key reasons:

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- The need to improve air quality in urban areas. Emissions of NOx and particulate matter from diesel powered road vehicles are a key contributor to poor air quality; and
- Longer-term commitments under the Paris Climate Change treaty to reduce emissions of greenhouse gases (GHG). Road transport is one of the key contributors to global GHG emissions (e.g. 27% of current UK GHG emissions is from domestic transport).

This objective has two broad elements, namely the replacement of diesel/petrol engines with other forms of propulsion and the greater use of non-road modes where feasible.

Alternative fuels for LGVs

With respect to the first element, for smaller road freight vehicles (i.e. LGVs) battery-electric vehicles (BEVs) are emerging as the viable zero emission alternative to petrol or diesel powered vans. While uptake is currently slow, a greater choice of BEVs is likely to emerge over the coming years (between 2.5 and 4.25 gross vehicle weight). While purchase costs are currently higher than petrol/diesel vans, these should be outweighed by lower operating costs (fuel and maintenance). The range of BEVs is also improving and the price differential should also start to fall. This is particularly important for e-commerce trade, as LGVs are the principal means of delivering directly to residential and commercial properties.

Given a range of 150-200km on a single charge and the location of RDCs/cross-dock facilities serving most urban areas, battery-electric LGVs should be able to round-trip on a single charge, with re-charging taking place overnight (at the RDCs/cross-dock facilities). It is unlikely that significant charging infrastructure provision will be required in urban locations. The requirement for charging infrastructure is therefore likely to come from the need to recharge large fleets of LGVs simultaneously at a single edge of urban area depot location and from the same local grid connection.

Alternative fuels for HGVs

Decarbonising HGVs, however, is likely to be more challenging, though three options are emerging as potential alternatives (involving propulsion by means of electric motors):

- E-highways – similar to electrified railways, overhead live contact wires supported by catenary and masts provide power to the HGV (via a pantograph on the roof). It is likely that only long distance strategic highways could ever be wired and certainly not in the centre of historic cities. Additional power sources would therefore be required for trips away from the wires, such as an on-board battery (re-charged when under the wires);

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- Battery electric – similar to BEV LGVs, albeit the range will not be as long when compared with diesel powered HGVs; as the energy density of batteries increases and their costs fall due to mass production, it may be that battery electric HGVs are the most promising option. This solution is likely to require charging infrastructure provision in urban locations so that top-up charges can be undertaken during deliveries (while the primary overnight charge is at the HGV depots); and
- Hydrogen fuel cells – like diesel HGVs, they would have an extended range (when compared with battery electric HGVs) and rapid refuelling (either at roadside stations or at depots). The key issue is the method by which the hydrogen is produced as the electrolysis method currently requires a significant electric current and is therefore only sustainable when generated from renewables. Furthermore, fuel cell vehicles are currently estimated to have an efficiency of around 22%, compared to around 33% for diesel vehicles and 70% for battery electric vehicles).

Non-road modes

A number of non-road modes are also being trialled in a number of cities. **Cargo bikes** are specially designed bicycles with either pannier boxes attached to the front end or capable of hauling purpose-built trailers. They are designed for conveying small/medium parcel type shipments up to a total weight of 50-100kg depending on size (though in most cases they would 'cube-out' before reaching that limit). They are ideal for delivering cargo into historic city centres with narrow streets (where road traffic is difficult or impossible to accommodate), in areas with significant pedestrianisation or where the heritage urban fabric needs to be preserved.

For obvious reasons, cargo bikes cannot operate over distances longer than a few kilometres. Operationally, therefore, they need to operate from suitable locations on the edge of the urban centre, where they can receive pre-sorted cargo from road freight vehicles (LGVs/MGVs operating from RDCs or cross-dock facilities, as per the e-commerce logistics models). This can include car park type hard-standing areas on retail/industrial estates, ideally with some form of cover to protect from inclement weather. Alternatively, they can operate from a small 'warehouse' or 'lock-up' type buildings, again located on the edge of the urban centre and fed by road freight vehicles.

The other main draw-back is the size of consignments that can be handled. While suitable for small/medium size parcels sold via e-commerce platforms, they cannot handle bulky items or large volumes, such as those that a typical retail outlet or catering establishment would receive in a single delivery. Finally, their use inserts an additional handling and transport leg into the supply chain, and consequently adds extra costs over and above completing the delivery by LGV/MGV (which, as described, is required to serve the cargo

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bike). Their use currently has therefore been restricted to delivering into urban areas unsuitable for LGVs/MGVs or circumventing any time window restrictions (see below).

A similar solution is that of **'portering'.** This is where a freight vehicle (such as a LGV or MGV) would hand over multiple consignments (pre-sorted) to delivery staff at designated drop-off points, either close to the urban centre (which could be pedestrianised or have narrow streets) or a low traffic residential neighbourhood (see below). Deliveries are then completed on-foot using a variety of equipment such as carry-bags, sack-trucks or battery-electric powered trollies (also called *e-walkers*). The on-foot delivery element would typically be up to 500m in distance, but potentially longer for smaller items (such as mail or small parcels).

Portering requires dedicated loading bays (drop-off points) alongside the urban highway network (so that traffic flow is not impeded) where freight vehicles can park and discharge cargo securely. The provision of appropriate 'pavement infrastructure' at strategic locations is therefore key to this delivery process. Fast re-charging points for battery-electric MGVs could also be installed. The main advantage of portering over cargo bikes is that larger bulky items can be delivered into areas unsuitable for freight vehicles or during time restrictions. Beer kegs and cases of wine, for example, can be delivered using battery-electric powered trollies.

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Mini Case Study – Dublin

In association with parcel operator UPS, Dublin is trialling a 'portering' solution using e-walkers and quad cycles to enable city centre deliveries that don't contribute to local emissions or congestion. The pilot is funded by Dublin City Council, Enterprise Ireland and Belfast City Council and the system was developed as part of a Small Business Innovation Research (SBIR) challenge, which sought new approaches to optimising deliveries.

Design and manufacturing consultancy Fernhay has developed the containers, bikes and e-walkers for UPS to trial. Containers can be pre-loaded with consignments at distribution centres before being transferred to e-walkers at the road-side. The vehicles will enable workers to deliver goods such as groceries, medicine and parcels. UPS has managed to remove five diesel vehicles from the road, reducing carbon emissions by up to 45 percent.

Using **trains** to deliver e-commerce parcels traffics directly into city centres has been mooted, using redundant passenger rolling stock that have been re-purposed to convey cargo. Trains would operate from distant (rail-served) warehouses into platforms at city centre stations, where goods could be discharged onto cargo-bikes or battery-electric vans for final delivery to residential or commercial properties close by. *Orion High Speed Logistics* (part of the Rail Operations Group) have proposed a trial service from the London Gateway logistics park on the Thames Estuary into a main line London terminus station, using re-purposed passenger train sets. The main draw-back of this concept is that many city centre stations do not have spare platform capacity during the day-time (and take at least an hour to fully discharge) or appropriate facilities/space where cargo can be transferred to LGVs or bikes securely. In any case, most cross-dock facilities handling e-commerce are now within battery-electric LGV range of city centres given recent improvements in battery energy density. The provision of rail-served cross-dock facilities or RDCs on the edge of urban areas (which receive goods from rail-served NDCs/CFCs and from where deliveries can then be completed using battery-electric LGVs) are more likely to be both commercially and logistically viable.

The Dutch city of Utrecht uses **canal barges** to delivery cargo (mainly food and beverage supplies) and extract waste from commercial establishments located on or close to the historic canal which passes through the central area. Cargo is initially delivered by road freight vehicles to a wharf on the edge of the urban area and is subsequently loaded onto the barges and shipped into the city centre. Use of the barge is encouraged through the imposition of strict time and weight restrictions placed on road freight vehicle movements in the city centre (whereas the barge can operate 24/7). While this solution is commercially viable and successful, it is a niche opportunity and only applicable to cities with appropriate canal or riverside infrastructure.

Highway management

The other main area where the environmental impact of urban logistics can be mitigated is through the application of highway management powers. These powers assume the use of diesel or petrol powered road freight vehicles, but the type and time of day they can operate is restricted. In particular:

- Weight and length restrictions – the ability to limit the gross vehicle weight and/or length of goods vehicles when using certain parts of a city's road network. These are generally implemented on environmental grounds to protect the historic fabric of a city or when the road infrastructure cannot physically accommodate vehicles above a certain size/weight, for example banning HGVs over 7.5 tonnes from sensitive parts of a historic city thereby ensuring deliveries are undertaken in more appropriate LGVs;
- Time restrictions – the ability to limit the time of day goods vehicles are able to use certain parts of a city's road network. These are generally implemented for reasons of visual intrusion, noise and inter-action with pedestrians at certain times of the day, but also to remove freight vehicles during peak periods. Time restrictions are also linked to the *pedestrianisation* of urban centres. Pedestrianisation is the concept that certain streets or parts of a city should only accessible on foot or bikes, to create a more pleasant environment and/or protect historic urban fabric. However, any

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businesses located in a pedestrian area still need to receive goods. Time restrictions are implemented to ensure that freight vehicles can access at appropriate times; in Chester in North West England, for example, which has an attractive pedestrianised heritage city centre with retail outlets, deliveries are only allowed before 10.00 and after 16.00; and

- Restricting or banning vehicles which generate the highest levels of gaseous and particulate pollutants. A number of cities now operate so called 'clean air zones', where diesel vehicles below Euro 5/6 emission standards are either banned or have to pay significant 'entry' fees to use roads within urban areas (see Road Charging below also). Road vehicles in France have to display a pollution rating certificate ('CRIT-air'), with those displaying the highest rating banned from certain cities (e.g. Paris) when air quality falls below pre-determined levels.

Environmental mitigation measures have to date predominantly been introduced in relation to urban centres, particularly historic central areas. However, a recent concept is that of *low traffic neighbourhoods (LTNs)*. These are residential areas where access in road vehicles is reserved for the private residents only. Walking and cycling is encouraged, and the ability to drive through them (i.e. using the roads to connect between other parts of the city) is blocked either using physical obstructions (such as bollards) or time and weight restrictions. Likewise, deliveries of cargo into LTNs have to be undertaken by other means, such as using cargo-bikes or portering. The growth of e-commerce and the associated deliveries direct to residential properties means that a balance needs to be found between minimising vehicle movements and allowing freight to be delivered. Ideally, appropriate parking and loading bay infrastructure is provided on the edge of each LTN.

The use of these powers needs to be balanced with the continuing need to service the receivers of cargo. For example, cafes and bars in historic city centres still need to have regular deliveries of catering and beverage products. Highway management powers need to ensure these can still take place on a reasonably flexible basis, but at the same time protecting the urban fabric and providing a pleasant wider environment so that the centre can continue to attract visitors.

7.2 Road Charging

A number of urban areas have introduced road charging schemes, which are in addition to tolls chargeable on motorways and/or estuary crossings which have been built under concession arrangements. The purpose of urban road charging schemes is normally twofold:

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- To reduce road congestion – the imposition of fees to use all or part of an urban area's road network in order to dampen demand for vehicle travel at certain times of the day such as morning or evening peaks;
- To improve air quality (pollution control) – as part of so called Low Emission Zones, where the most polluting road vehicles are charged an 'entry fee' when using roads in all or part of an urban area. It is hoped the fee will reduce or eliminate the use of older polluting road vehicles thereby helping to improve air quality.

In most cases, road freight vehicles are included in the charging regimes. The most widely known road charging schemes are in London. The *London Congestion Charge* was originally introduced in 2003 and applies to a defined zone in the centre of the city. Road vehicles must pay the charge, currently £15, when entering the zone between 0700 and 2200 Monday to Friday (though vehicles can enter and leave the zone multiple times once the charge has been paid). There are a limited number of exemptions, including for battery-electric vehicles. Unless exempt, freight vehicles of all sizes have to pay the charge.

The *London Low Emission Zone (LEZ)* commenced operation in 2008. It now covers the whole of the Greater London metropolitan area (i.e. a larger area than for the congestion zone) and operates 24/7. A daily charge applies to all commercial vehicles powered by diesel engines, including buses, HGVs, MGVs and LGVs, when operating in Greater London; only those with newer less polluting engines are exempt from the charge. From March 2021, exempt vehicles will only be those with Euro VI engines; vehicles with Euro V diesel engines or below will be charged £300 per day.

Both the London Congestion Charge and the LEZ are fixed charges enforced by means of static cameras located at key locations. Brussels is planning to introduce a road charging scheme (called *SmartMove*) in 2022, with charges set based on time of day, distance travelled and size of engine. It will apply to delivery vehicles. As battery-electric vehicles become more popular, and consequently the amount raised from fuel taxes declines, it is likely that schemes such as SmartMove will become the norm.

The Polish city of Krakow trialled a scheme whereby freight vehicles were charged an entry fee when delivering into and nearby to the historic central cathedral square (mainly to cafes and bars). Goods vehicle operators (principally catering/beverage suppliers) were entitled to a number of free entries in each month, with fees then charged for additional trips. It was hoped that the scheme would encourage those located on/near the square to better plan their stock requirements and only order replacement goods when absolutely required (there was an understanding that many cafes and bars ordered small quantities of supplies daily rather than larger volumes less frequently). The scheme was never fully implemented.

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7.3 Urban Consolidation Centres

Urban consolidation centres are where multiple freight operators (3PLs and own account operators) initially deliver goods into a warehouse type facility located on the urban fringe. The goods are consolidated and then reloaded onto freight vehicles for the final delivery into the urban area. They have been promoted on the grounds that, in theory, they deliver the following benefits:

- Fewer road freight vehicle trips into city centres – they 'intercept' multiple part-loaded freight vehicles at the urban fringe, converting them into fewer but fully-laden vehicle trips into the city centre; and
- Given the short distances involved, this part of the delivery process could also be undertaken by battery-electric vehicles.

However, where their use has been voluntary take-up to date has been very limited. They have mainly been adopted where specific circumstances have necessitated consolidation or their use has been mandatory for special reasons. For example, London Heathrow Airport requires most goods to be security scanned at an off-site consolidation centre before delivery into the airside passenger terminals. Some cities have also tried to incentivise their use by allowing time restrictions to be circumvented when goods pass via a consolidation centre.

Take-up has been limited for three main reasons:

- The consequent additional handling and transport leg adds further costs into the end-end supply chain (compared with direct deliveries). The consolidation centre operator would naturally make a charge to the transport operator for the handling and subsequent re-distribution, which requires additional vehicles and staff. Most centres have not been able to run on fully commercial terms without some financial support from the public sector. In the case of Heathrow, the airport's security arrangements effectively fund the centre, which ultimately are recharged back to passengers via their airline tickets;
- Large retail outlets are already receiving a full-load on each delivery. Using a consolidation centre would mean that goods are discharged from one fully-laden HGV only to be reloaded onto a subsequent fully-laden HGV; and
- As noted above, the use of 3PLs (such as parcel couriers) has already had the effect of consolidating cargo from multiple-shippers into shared transport capacity. As a result, freight vehicles are already running fully-laden (or approaching fully-laden) on the initial inbound flow into urban areas.

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There is also a risk that enforced consolidation will result in a switch to last-mile deliveries by a higher number of smaller vehicles which would have a negative impact on road congestion.

Further large-scale take-up of urban consolidation centres is therefore unlikely, except where special/specific circumstances have been demonstrated and necessitate some form of consolidation.

7.4 Urban Franchises

Urban delivery franchises are a concept that has been mooted but not yet implemented. In basic terms, an urban delivery franchise is when a single logistics operator, following an open competition, wins the ‘rights’ to exclusively deliver cargo into parts of an urban area for a fixed period of time (e.g. 3 years). The franchise could be sector specific (e.g. e-commerce parcels) or covering all deliveries into a defined urban zone. Exemptions would apply to large shippers moving regular fully laden HGVs, such as to a large retail outlet.

They would operate in broadly the same manner as urban consolidation centres. All freight movements into the franchise zone (in the sectors covered) would initially be delivered into warehouse type facilities operated by the franchise holder (which could be multi-user and located both close to or distant from the franchised zone). The goods would then be consolidated and reloaded onto freight vehicles operated by the franchise holder for the final delivery into the urban area. In theory, as for urban consolidation centres, it would eliminate many partially laden freight vehicle trips into city centres, replacing them with fewer fully-laden movements.

The difference in this case is that their use would be mandatory; all cargo in the sectors concerned would have to be delivered by the franchise holder. Regular open competitions to win the franchise would keep costs to a minimum and ensure overall service quality as poor service reliability would result in the holder being excluded from subsequent bidding rounds. However, they would suffer the same draw-backs as the current voluntary consolidation centres; they would inject additional costs into the supply chain (which would ultimately feed through to consumers) and simply replace one fully-laden vehicle with another fully-laden vehicle (as consolidation through the use of 3PLs has already resulted in efficient running). Overall, they are unlikely to result in fewer freight vehicle trips but impose higher costs.

There may, nevertheless, be some niche operations where this model would provide benefits. The extraction of waste and recycling from commercial premises (which is generally subject to competition unlike residential waste collections by municipalities) can

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often result in multiple vehicle trips by different disposal organisations to adjoining properties. These could be eliminated through the use of a franchised collector.

Recommendations for the project

RECOMMENDATIONS	
Recommendation 6.1	SENATOR should be designed to monitor environmental emissions as Key Performance Indicators, with a particular focus on carbon emissions but also on other emissions that affect air quality such as particulates. To avoid excessive complexity, this could be based on average emissions per kilometre travelled in an urban setting for the relevant mode and vehicle. Mapping of this data, and other impacts such as noise, would be particularly valuable to help visualise results for city authorities.
Recommendation 6.2	SENATOR should be designed to cater for modes of transport that can realistically provide a more sustainable alternative to diesel and petrol-powered road vehicles and to be essentially agnostic between them, while reflecting reasonable generic values for their actual financial costs and environmental emissions.
Recommendation 6.3	SENATOR should be designed to accommodate the impact of other regulatory measures (such as road pricing) that could be introduced by city authorities, which are likely to either restrict the use of certain modes and vehicle types or increase their costs or require deliveries to be made by specified logistics operators.

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Appendix

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Figure A1: Flow-diagram 1 – The Classic Logistics Model

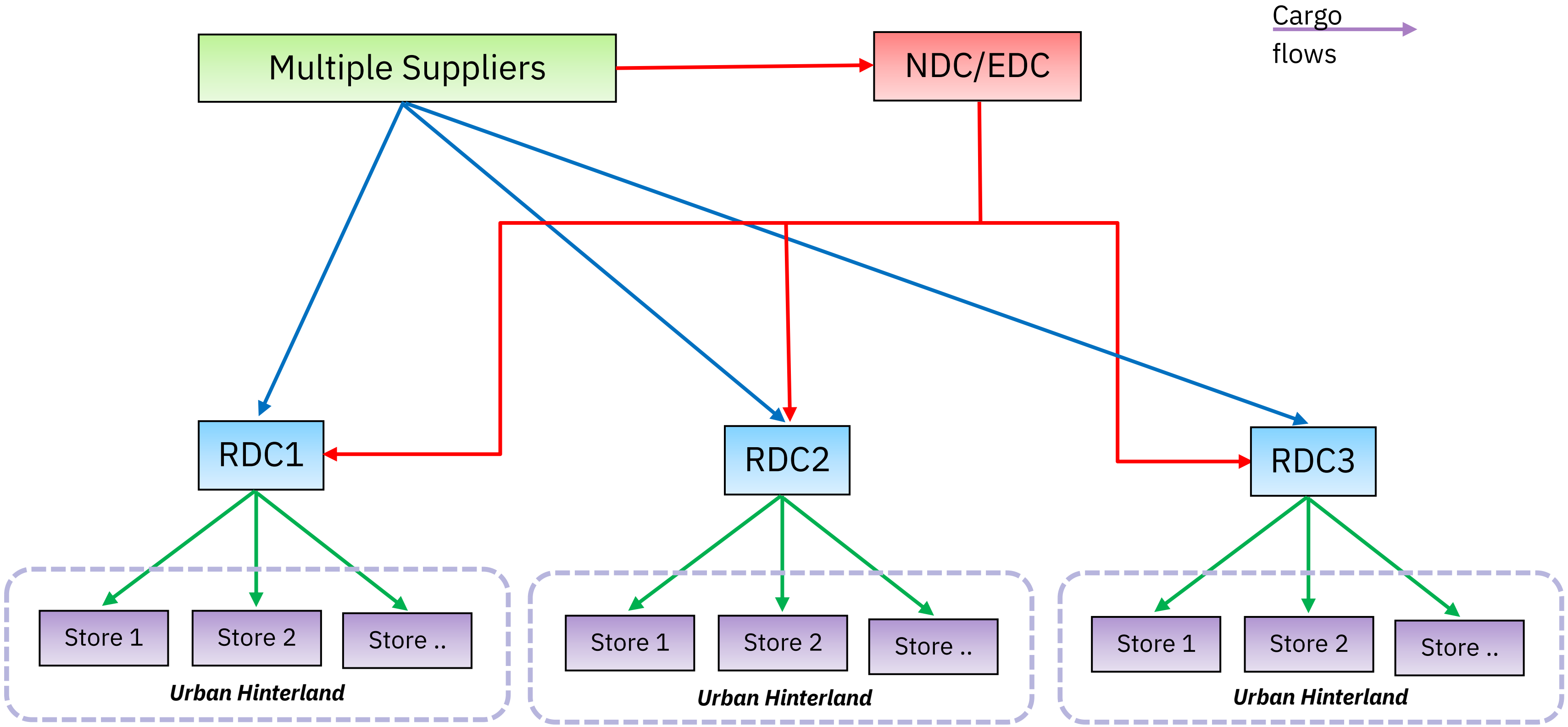

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Figure A2: Flow-diagram 2 – E-Commerce Model 1

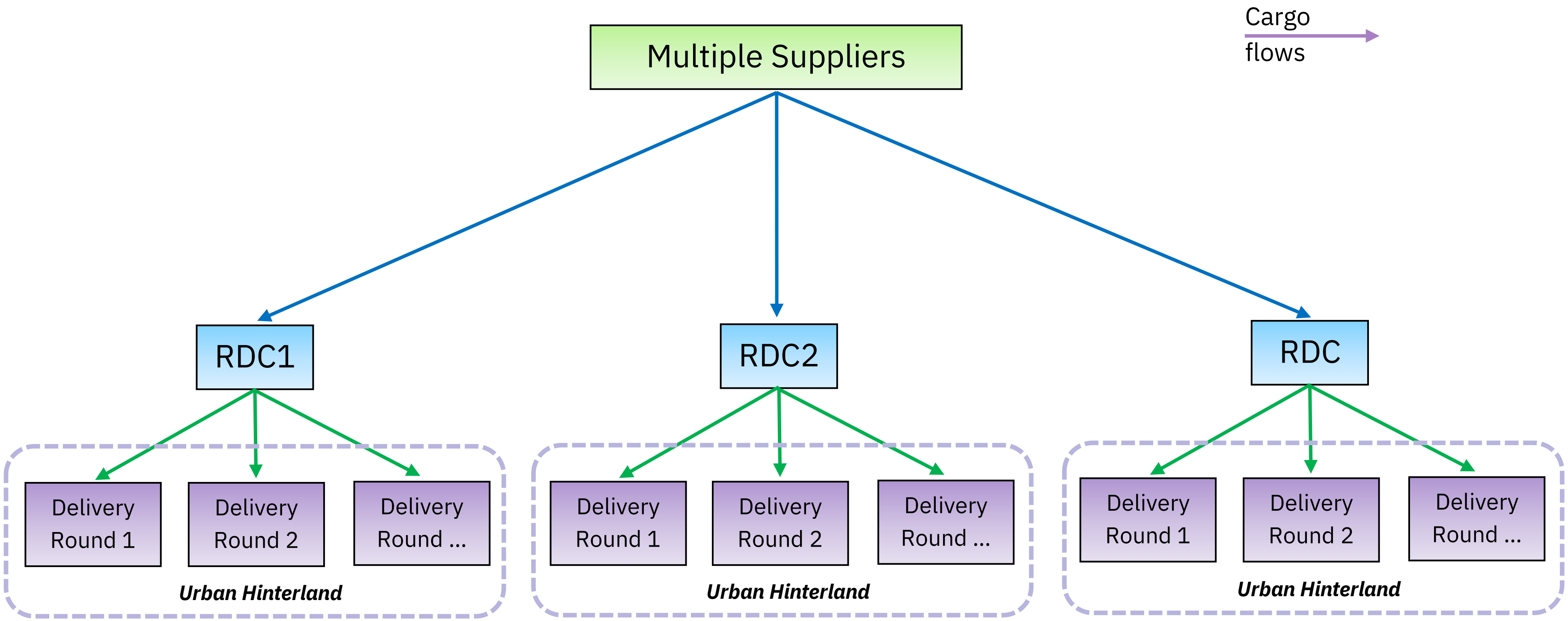

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Figure A3: Flow-diagram 3 – E-Commerce Model 2

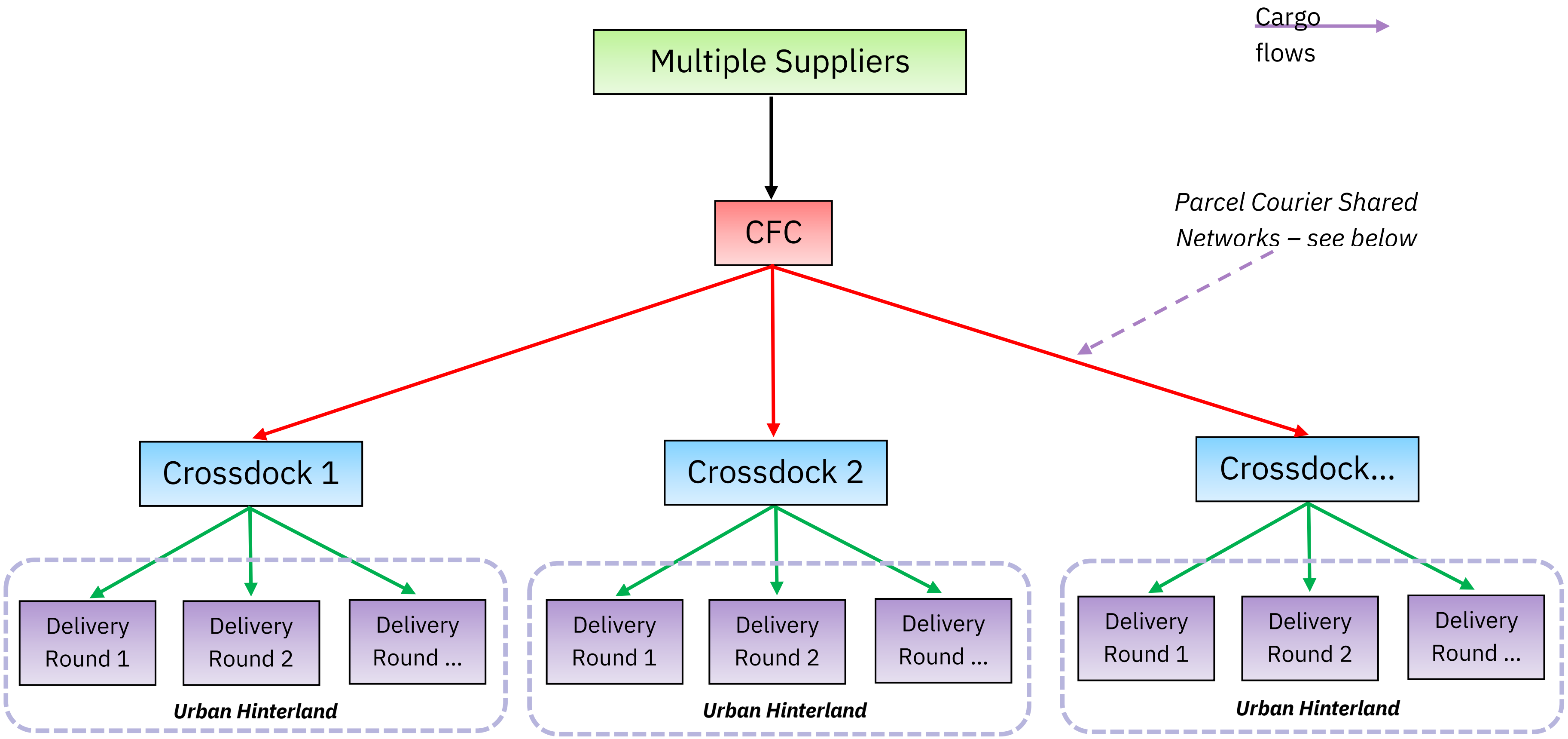

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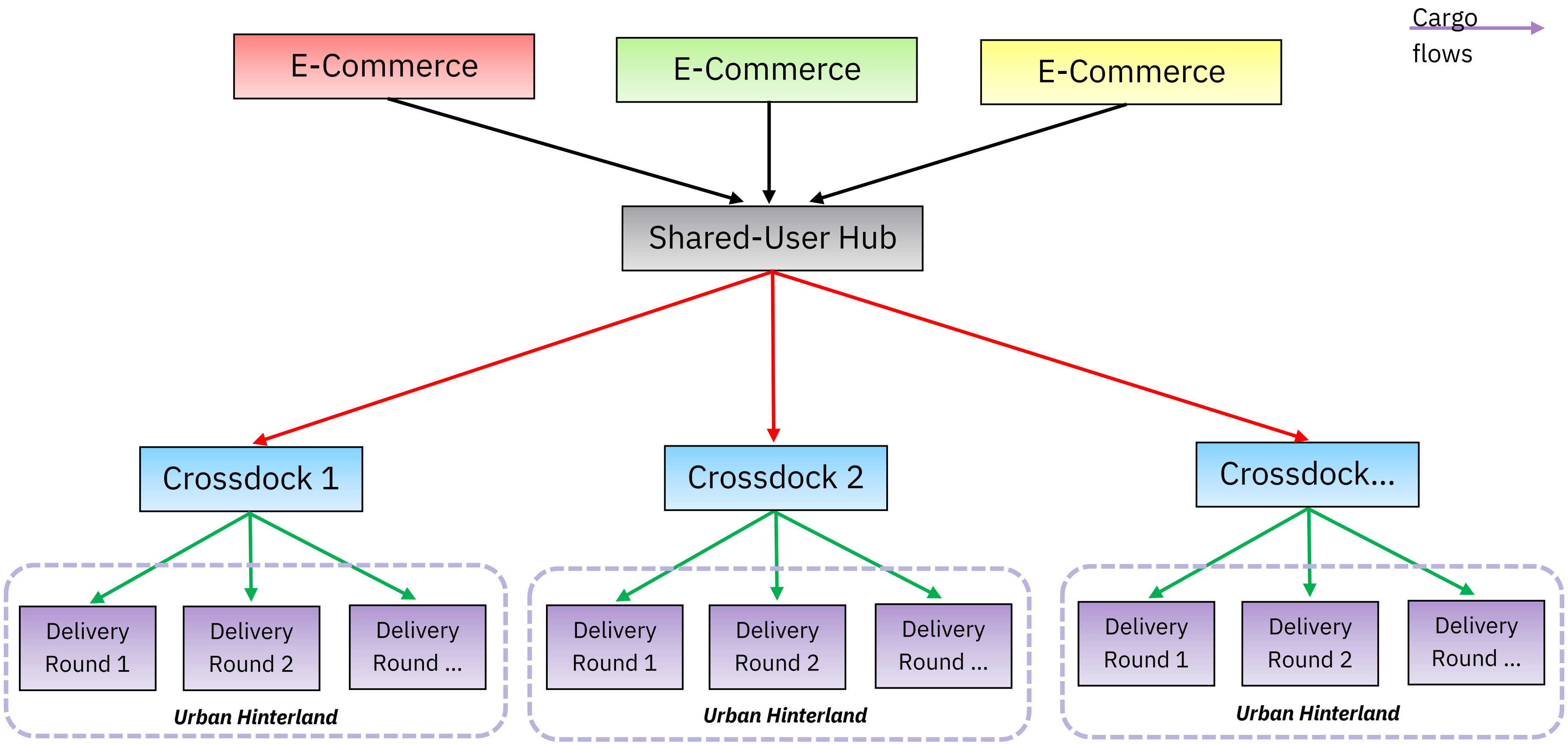
Figure A4: Flow-diagram 4 – Parcel Courier Shared Networks



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