Final Report

Use of information and communication technologies

Technical report

Non-binding guidance documents on urban logistics
N° 1/6

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Table of Contents

Glossary and definitions

ALICE:	Alliance for Logistics Innovation through Collaboration in Europe
AVL:	Automatic Vehicle Location
B2C:	Business To Consumer
BESTUFS:	Best Urban Freight Measures
CCTV:	Closed-Circuit Television
C-ITS:	Cooperative Intelligent Transport systems
CIVITAS:	City Vitality Sustainability: Cleaner and better transport in cities
C-LIEGE:	Clean Last Mile Transport and Logistics Management for Smart and Efficient Local Governments in Europe
CO_2:	Carbon Dioxide
CO-GISTICS:	Cooperative Logistics for Sustainable Mobility of Goods
DTLF:	Digital Transport and Logistics Forum
EC:	European Commission
EU:	European Union
ERTRAC:	European Road Transport Research Advisory Council
GNSS:	Global Navigation Satellite System
HGV:	Heavy Goods Vehicle
ICT:	Information and Communication Technology
IT:	Information Technology
ITS:	Intelligent Transport systems
KPI's:	Key Performance Indicators
LP:	Logistics profile
NBGDs:	Non-Binding Guidance Documents
NOx:	Nitrogen Oxide
PM:	Particulate Matter
PPP:	Public–Private Partnership
RTIINS:	Real Time Information of Infrastructure Network Status
SUGAR:	Sustainable Urban Good Logistics Achieved by Regional and Local Policies
TURBLOG:	Transferability of Urban Logistics Concepts and Practices from a World Wide Perspective
UFT:	Urban Freight Transport
UL:	Urban Logistics
V2I:	Vehicle to Infrastructure Communication
V2V:	Vehicle to Vehicle Communication

Executive Summary

This report is one of a series of six, prepared within the scope of the Study on Urban Mobility - Preparation of EU guidance on Urban Logistics (MOVE/C1/2014-370) commissioned by the European Commission (EC). The NBGDs aim to help stakeholders understand the challenges produced by logistics activities in an urban context, and to identify the most suitable measures and actions to overcome these challenges.

This report presents technical information used as a support to the preparation of the EU Non-Binding Guidance Document (also one in a series of six) on *information provision of route guidance for urban freight logistics vehicles, data sharing and use of Information and Communication Technologies (ICT)*.

The issues and challenges accruing from urban freight logistics operations, which notably freight distribution, are known and well-discussed in literature, namely: aggravation of traffic conditions, conflicts with other vehicles and pedestrians, complexity of urban freight logistics and freight transport patterns, stakeholders' low interest in cooperation, enforcement of regulations and legislation, or sub-optimal utilisation of vehicles. The concept of Logistics profile is proposed as an easy-to-use tool to find homogeneous areas in urban freight logistics terms. The added value of this concept is that, after identifying areas with similar profiles, a given solution could be deployed. The characterisation of the Logistics profile is based on three factors, these being: stakeholders' needs, urban area features and characteristics of the freight. A total of six LPs are presented.

A total of thirteen ICT measures were identified and grouped in six broad groups are proposed, as follows:

- Vehicle Support Equipment – refers to on-board technology that can help drivers take better and informed decisions. Two measures were identified:
  1. Navigation Software & Location Equipment;
  2. Communication Vehicle to Vehicle & Vehicle to Infrastructure.
- Operations Management – refers to measures that can process large quantities of information and be used by stakeholders to improve their urban freight logistics processes and operations. Two measures were identified:
  3. Real Time Logistics Monitoring;
  4. Fleet Management.
- Information and Dissemination – refers to measures that can act as vectors for the dissemination of information among people and stakeholders. Two measures were identified:
  5. Data sharing;
  6. Real Time Information about the Transport System.
- Decision Support and Enforcement – refers to measures that can process large quantities of information and support public authorities to make decisions and become more effective. Two measures were identified:
  7. Access Restrictions and Control;
  8. Real Time Monitoring Logistics Operations.
- Infrastructure Technology – refers to measures that are deployed in the transport infrastructure and can be used to interact with traffic and pedestrians. Three measures were identified:
  9. Automated Adjustment of Traffic Rules;
  10. Traffic signs;
  11. Payment & Collection Systems.

- Sharing Economy and e-Business Services – refers to measures that support the emergence of sustainable services and markets. Two measures were identified:
    12. Shared economy platforms;
    13. Collaborative platforms.

The identification of the ICT measures was supported on a comprehensive review of relevant technical and scientific documents, complemented with a stakeholders' survey. A step-wise approach is suggested for the purpose of helping public stakeholders choosing the suitable ICT measures, according to the specific concerns.

- Step 1 – Delimiting the Area of Intervention
- Step 2 – Characterisation of LP
- Step 3 – Selection of ICT Measures: LPs and economical dimension
- Step 4 – Definition of Performance Variables and Metrics
- Step 5 – Implementation of ICT Measures and Drive Results

The presentation is complemented with a set of easy-to-follow tables. A set of examples and case studies, including web links, is also presented, so that readers can understand the advantages and limitations of every measure.

Chapter 1 Introduction

1.1 Study Description

1.1.1 Objective

Recent social and economic dynamics, such as urbanisation, ageing and individualization, or increasing relevancy of sustainable development have transformed the way goods are transported and distributed within and across urban regions. Policymaking is of paramount relevance to ensure that social and economic objectives are met. Bearing in mind the complexity of the issues involved and the diverse interests of various stakeholders, well-designed consultation and participation processes are required. This is particularly accurate with the case of urban regions, since it involves many different parties with diverging and often conflicting interests who have to share the same urban space.

An efficient urban freight logistics system is essential for sustainable development in urban areas. Urban logistics is now facing many difficult challenges due to:

- Increasing urbanisation;
- Increasing demand for frequent and just-in-time deliveries in urban areas, including at consumers' homes; new urban supply chains;
- Increasing competition for the use of limited urban infrastructure;
- Increasing complexity of the multidisciplinary issues both encountered and caused by urban goods transport.

Policy-making for urban freight logistics is particularly complex and difficult due to the following features:

- Conflicting and diverse requirements of a wide range of participants;
- Complex and diverse operations of urban goods transport and the various issues caused therefrom;
- Lack of expertise from urban practitioners.

An efficient urban freight logistics system might increase the liveability of cities. Additionally, effective and efficient transport not only affects local and regional productivity rates, but also has an impact on the quality of life of citizens[1]. Indeed, poor urban freight logistics is one reason for decreasing urban liveability (due to the vehicle's emissions, noise pollution or increased collision risk). Therefore, an efficient urban freight logistics system is vital in promoting economic growth while mitigating external effects[2].

As mentioned above, this technical report aims to provide technical information to support the writing of a non-binding guidance document on the topic *Information provision of route guidance for urban freight logistics vehicles, data sharing and use of ICT*. A brief discussion on the broad uses of ICT and the specific cases of information provision of route guidance – i.e. journey planners – and data sharing[1] will follow.

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[1] Data sharing refers to the ability of seamlessly exchanging the same data resources with multiple users (i.e. machines or humans). Data sharing requires the definition of common communication protocols.

Logistics chains consist of multiple up and downstream flows, namely: physical flow (movement of goods), information flow (between stakeholders), financial flow (payments and other fees) or contractual flows (responsibility). The information flow is of paramount importance. It aligns and streamlines the agents into a coordinated chain. Information brings visibility to the logistics chains (e.g. location of goods, inventory, invoicing, etc.). It allows agents to take proactive actions and to optimise the resources along the logistics chain. By way of example, the information about the delay in the delivery of a spare part (worth a few hundred euros) can allow stakeholders' agents to activate avoiding actions in order to avoid the slowdown or even closure of a machine or factory. The importance of information is so high, that it is becoming as relevant as the goods themselves.

Over the last few decades, significant technological advancements have taken place, impacting all societies and economies across the globe. Nowadays, technology is ubiquitous, being present in every aspect of social life and interactions and being the lubricant of markets.

Technological advancement and the advent of ICT, such as: mobile communications, machine to machine communications or even machine to human communications, were greatly beneficial to both logistics and freight transport sectors. Nowadays, the main logistics companies, notably the so-called integrators (e.g. TNT, FedEx, UPS, Chronopost), rank amongst the most technological companies (e.g. UPS has its own dedicated satellite), all of them operating state of the art information and communication systems.

Technological advancement resulted in decreasing production costs, while increasing computational power meant that any company could resort to increasingly sophisticated technology. In parallel, we witnessed a progressive miniaturisation of technology. The consequence was the emergence of handheld devices with increasing capabilities. Nowadays, any person can use a small device to conduct complex tasks remotely. Again the impact on the logistics and freight transport sector was tremendous due to the fragmentation of the business (many vehicles and multiple warehouses handling hundreds or thousands of small packages moving across different locations).

One of the most common utilisations of ICT is on the provision of information of route guidance – that is, journey planners. A set of technological advancements converged to enable the production of inexpensive and small sized equipment. Firstly, the availability to the civil use of Global Navigation Satellite Systems (constellation of satellites) enables the calculation in real time, remotely and with sufficient accuracy, of the geographical coordinates of an object anywhere on the globe. Secondly, growing capabilities of computers supported the development of fast and reliable pathfinder's algorithms. Thirdly, growing storage capacity allowed the storage of maps and route information. Nowadays, journey planners are valuable tools for urban freight logistics activities. They allow drivers to find the most adequate route. Real traffic conditions can even be considered, guiding drivers through the fastest routes. The advantages are numerous: higher efficiency of services, improved quality of services, lower levels of consumption, lower emissions and lower costs.

Advancement in ICT resulted in increased capacity to monitor, retrieve and transmit information, often in real time, which coupled with an ever availability of data storage space, lead to storage of a growing amount of up-to-date data. Such a trend eventually leads to the coining of the Big Data[2] jargon. Big Data is also a growing reality in many of the largest logistics

[2] Big Data is commonly used to denote the availability of vast amounts of information that require sophisticated computational algorithms to navigate through and obtain valid and useful intelligence.

and freight transport companies, since they are often responsible for handling and transporting thousands of individual packages across regions and continents. Not only logistics or freight transport companies have to deal with Big Data issues, public authorities are nowadays able to retrieve traffic information at the city or metropolitan level. They can track and trace in real time freight and paths of freight vehicles and operations. The amount of information is ever growing. The analysis of the information can provide valuable evidence to the study of patterns and behaviours in urban freight logistics activities and, hence, support the identification of actions to improve them. Above all, it is important to realise that each player only has access to a portion of data (each private stakeholder to its own activities, and public agencies only to visible operations). Thus, each one has an imperfect and local view of urban freight logistics. If we envisage getting a global picture of urban freight logistics, then Data Sharing is the path to follow. Even if only partially, Data Sharing amongst stakeholders can result in substantial gains of efficiency, since each one can obtain access to information (that otherwise is out of reach). Additional information can be used to optimise operations or to release unexploited opportunities. Yet, Data Sharing is often difficult to achieve. Each stakeholder (rightly) perceives that its own information is a valuable source of competitive advantage. Necessarily, by revealing information, that source would dry out. This is where public authorities can play an important role in promoting the share of information by stakeholders and to ensure a level playing field in which all grant, and have, access to the information in the same conditions.

The ICT landscape of urban freight logistics stakeholders is rather heterogeneous. Large logistics and transport companies tend to deploy sophisticated ICT systems to organise and manage their distribution networks. These include companies such as DHL, Chronopost or TNT. The same happens with big retailers and other companies. A typical example is the company Inditex, that own brands such as Zara or H&M. Inditex monitors on real time sales worldwide. The objective is to early detect consumption trends and adjust their supply chains accordingly. Commonly, these companies have developed their own tailored technological solutions. Conversely, smaller companies tend to resort to simpler technological solutions, often relying on paper based systems. They may own proprietary systems, resort to off-the-shelf solutions, or none (e.g., using own mobile phones). Typical cases are local retailers (e.g., a restaurant), that use their own mobile phone to contact local suppliers and organise deliveries. In some case, the local retailer can use its own vehicles to pick up the goods at origin. So, while larger stakeholders already perceived the benefits of ICT; the smaller are still lagging behind. The reasons for such gap are several: (i) unawareness or unconsciousness about the benefits, (ii) lack of knowledge on how to deploy or (iii) insufficient financial capacity. Regardless the case, efforts have to be made to bring these stakeholders up. Logistics firms report that in the long term both information services can complement and support each other – notably real time travel and traffic information about disturbances could have a significant impact on the operation of logistics firms.

Over the last couple of decades, the EC has been actively working on the development and deployment of ICT at EU level. One of the first research projects was DRIVE Project, which resulted in the design of a framework for ICT applications and services connected with road transport, including their interfaces with other transport modes. The framework was an attempt to begin harmonising deployment and operational use of ICT throughout Europe where possible. Since then, many other projects and initiatives were undertaken.

The EC has proposed 16 initiatives set out in the Digital Single Market strategy (adopted in May 2015). It is built on three pillars: (i) better access for consumers and businesses to digital goods and services across Europe; (ii) creating the right conditions and a level playing field for digital networks and innovative services to flourish; (iii) maximising the growth potential of the digital economy. A flagship initiative related thereto is the ITS Directive.

In 2008, the EC established, an Action Plan for the Deployment of ITS in Europe[4]. The Action Plan defined a total of 24 actions, grouped in six priority areas. It supported the development of the relevant Directive 2010/40/EU on the framework for the deployment of Intelligent Transport Systems (ITS) in the field of road transport and for interfaces with other modes of transport[5]. The Directive establishes a framework in support of the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the Union. The ITS Directive establishes a set of guiding principles. It begins with the definition of the key priority ITS areas:

- Optimal use of road, traffic and travel data,
- Continuity of traffic and freight management ITS services,
- ITS road safety and security applications,
- Linking the vehicle with transport infrastructure.

In parallel, it establishes the key priority actions, as being:

- the provision of EU-wide multimodal travel information services;
- the provision of EU-wide real-time traffic information services;
- data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users;
- the harmonised provision for an interoperable EU-wide eCall;
- the provision of information services for safe and secure parking places for trucks and commercial vehicles;
- the provision of reservation services for safe and secure parking places for trucks and commercial vehicles.

Most important, the Directive set the principles for specification and deployment of ITS:

- Be effective – make a tangible contribution towards solving the key challenges affecting road transportation in Europe (e.g. reducing congestion, lowering of emissions, improving energy efficiency, attaining higher levels of safety and security including vulnerable road users);
- Be cost-efficient – optimise the ratio of costs in relation to output with regard to meeting objectives;
- Be proportionate – provide, where appropriate, for different levels of achievable service quality and deployment, taking into account the local, regional, national and European specificities;
- Support continuity of services – ensure seamless services across the Union, in particular on the trans-European network, and where possible at its external borders, when ITS services are deployed. Continuity of services should be ensured at a level adapted to the characteristics of the transport networks linking countries with countries, and where appropriate, regions with regions and cities with rural areas;
- Deliver interoperability – ensure that systems and the underlying business processes have the capacity to exchange data and to share information and knowledge to enable effective ITS service delivery;
- Support backward compatibility – ensure, where appropriate, the capability for ITS systems to work with existing systems that share a common purpose, without hindering the development of new technologies;
- Respect existing national infrastructure and network characteristics – take into account the inherent differences in the transport network characteristics, in particular in the sizes of the traffic volumes and in road weather conditions;
- Promote equality of access – do not impede or discriminate against access to ITS applications and services by vulnerable road users;
- Support maturity – demonstrate, after appropriate risk assessment, the robustness of innovative ITS systems, through a sufficient level of technical development and operational exploitation;

- Deliver quality of timing and positioning – use of satellite-based infrastructures, or any technology providing equivalent levels of precision for the purposes of ITS applications and services that require global, continuous, accurate and guaranteed timing and positioning services;
- Facilitate inter-modality – take into account the coordination of various modes of transport, where appropriate, when deploying ITS;
- Respect coherence – take into account existing Union rules, policies and activities which are relevant in the field of ITS, in particular in the field of standardisation.

The ITS Directive calls for a set of standards at several levels, such as: i) static and dynamic datasets structures, ii) communication protocols, iii) timings, iv) availability and accessibility, or v) facilitation of exchange of data.

Since the publication of the action plan, in 2008, and the ITS directive, in 2010, important developments have already been achieved.

In the specific domain of ITS for urban areas, the EC established in 2010 the Expert Group on ITS for urban areas. The Group worked for 24 months on three areas: multimodal information, smart ticketing, and traffic management and urban freight logistics. In what concerns, the latter, the Expert Group concluded that standardisation activities at European Union level were required[6]. In the context of urban logistics, the specifications of priority action 'b' (EU-wide real time traffic information) and the specifications of priority action 'a' (EU-wide multimodal travel information services) have been adopted. These specifications will provide the necessary requirements to make travel and traffic information services accurate and available across borders. They establish the specifications necessary to ensure the accessibility, exchange and update of standardised travel and traffic data. The provision of comprehensive, accurate and reliable travel and traffic information services will be beneficial for freight operations in an urban area with improved access to relevant incident and travel planning information to optimise freight operations. The EC is currently preparing a delegated regulation on Cooperative-Intelligent Transport Systems.

In 2015, the EC established The Digital Transport and Logistics Forum (DTLF) (Decision C(2015)2259). The DTLF is a consultative platform for the coordination and cooperation between stakeholders in a multimodal and cross-sectorial perspective. This expert group provides expertise and user requirements for the further digitalisation of transport and logistics, and the possible preparation and implementation of EU legislation. However, it does not take any binding decisions, but should formulate opinions or recommendations and support the Commission in formulating a roadmap and strategy. Key working areas of the DTLF include: electronic transport documents (e.g.: acceptance of electronic transport documents, harmonisation of data elements and for the establishment of multimodal e-transport documents, or digitalisation of transport documents) and optimisation of cargo flows along transport corridors (e.g.: business cases of better exchange of data across different IT systems, identify bottlenecks and to propose measures to overcome the identified barriers). The works of the latter working area are focussed on: data ownership, quality, protection and sharing; standards and interoperability, and business models and governance[3].

The EC has been diligently working, with other institutions, notably with the CEN – European Committee for Standardization, to implement such standards. In this sense, the CEN Committee CEN/TC 278 was established to advise the EC in respect of the preparation of standards in the field of Intelligent Transport Systems[4]. In what concerns the urban dimension, the works

[3] More information is available at: http://bit.ly/1E1kopw and http://bit.ly/2p9p21N.
[4] More information available at http://www.itsstandards.eu/

started in 2015. Already in February 2016, the European Commission required CEN and other standardisation organisations to develop standards to implement the ITS Directive at urban level. As a consequence, CEN established in May 2016, a new Working Group (WG17) on Urban-ITS. The establishment of WG17 was accompanied with the publication of a pre-study aimed at identifying gaps and overlaps in ITS standards at urban level[7]. In what concerns urban freight logistics, the report identified it as "the least mature and least organised/more diverse" of the various urban-related subject areas. The study then suggests standards in several areas, being: emissions monitoring, low emission zones data and applications, standardised emissions data, and geo-fencing data and applications. It concludes by stating that, at this stage, urban freight logistics is "not well enough developed to make firm proposals". Further development in the coming months or years, as the works proceed.

Another initiative is the C-ITS platform – Platform for the Deployment of Cooperative Intelligent Transport Systems in the EU. C-ITS are systems that allow effective data exchange through wireless technologies so that vehicles can connect with each other, with the road infrastructure and with other road users[5]. A last initiative worth mentioning is the ETP-ALICE[6]. ETP-Alice is a platform of experts, academicians and logistics companies. It aims at developing a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovation in Europe.

ICT supports the implementation of ITS, by enabling the monitoring, storage and communication between devices and systems. In April 2016, the EC adopted a communication setting up ICT standardisation priorities[8], as follows: 5G communications, cloud computing, the internet of things, (big) data technologies and cybersecurity. The definition of common ICT standards is expected to bring benefits at several dimensions, including: eHealth, smart energy, intelligent transport systems and connected and automated vehicles, including trains, advanced manufacturing, smart homes and cities and smart farming.

As of 2013, the EC is publishing the Rolling Plan for ICT Standardisation[7]. The Rolling Plan identifies the relevant EU Policy priorities where standardisation, standard or ICT specification should play a determinant role in the implementation. In what concerns urban freight logistics, the 2016 Rolling Plan proposes the following ICT standardisation action[9]:

- European standardisation deliverables on reference data models, common data dictionaries and metadata structure across the three domains and specific European standards (Action 13):
  - Multimodal information services: new mobility services, alternative fuels infrastructure,
  - Traffic management: static/dynamic road data, traffic and traffic control data, weather data and traffic prioritisation and access regulations,
  - Urban logistics: intelligent parking for light vehicles/commercial vehicles/trucks and loading bays information and reservation services for special freight vehicles and logistics sectors.

The standardisation and the implementation of common ICT standards is of paramount importance to the accomplishment of the goals and objective of the 2010 ITS Directive. Thus far relevant milestones have been reached, including the EU-wide eCall system. In what concerns the urban context, there are three main initiatives on-going: i) multimodal information services, ii) traffic management and iii) urban freight logistics. In the specific case of urban freight logistics, the various available reports unanimously acknowledge that this is the domain that requires more efforts and works. By way of example, no common rules for building static or

[5] More information is available at http://ec.europa.eu/transport/themes/its/index_en.htm.
[6] More information available at: http://www.etp-logistics.eu/.
[7] More information available at: https://ec.europa.eu/digital-single-market/en/rolling-plan-ict-standardisation

dynamic datasets are defined. By the same token, rules for the interoperability of logistics stakeholders' systems have not been defined.

The current situation is somewhat understandable. Logistics is an activity conducted by private stakeholders. Each one exhibits unique properties and have different technological developments. Moreover, many resort to proprietary information systems, which may have limited connectivity and interoperability features. Moreover, data privacy is a major concern of any logistics stakeholder. Hence, the willingness to evolve towards interoperable systems of data sharing is inherently low, if not, of resistance.

The recent efforts and initiatives to establish common standards and implement ITS are changing the status quo, but time is required to mobilise stakeholders and adapt systems and equipment.

1.1.2 Approach

This technical report is the first of a series of six, prepared within the scope of the Study on Urban Mobility - Preparation of EU Guidance Documents on Urban Logistics (MOVE/C1/2014-370) commissioned by the EC. The study's Technical reports aim to help stakeholders understand the challenges brought about by logistics activities in an urban context, and identify the most suitable measures and actions to overcome these challenges. The technical report is the theoretical and research basis for the related Non-Binding Guidance Documents (NBGD 1).

This report (N° 1) covers *information provision of route guidance for urban freight logistics vehicles, data sharing and use of ICT*. It provides specific information on the most important measures to achieve more efficient and sustainable urban freight logistics operations.

The primary target group in this technical report is public authorities, such as municipalities or local agencies, responsible for the management of the traffic, transport and transport infrastructures within urban regions. Furthermore, logistics and freight transport operators with city operations may benefit from this report.

1.2 Listing ICT measures

Based on a review of projects' deliverables, reports and literature on urban freight logistics on the topic of this technical report, and on the results of the stakeholders' survey conducted, it was possible to identify a set of key measures and actions that, either deployed in isolation or together, can improve urban freight logistics activities.

A total of thirteen ICT measures were identified and grouped in six broad groups, as follows:

- **Vehicle Support Equipment** – refers to on-board technology that can help drivers take better and informed decisions. Two measures were identified:
  - Measure 1: Navigation Software & Location Equipment;
  - Measure 2: Communication Vehicle to Vehicle (V2V) & Vehicle to Infrastructure (V2I).
- **Operations Management** – refers to measures that can process large quantities of information and be used by stakeholders to improve their urban freight logistics processes and operations. Two measures were identified:
  - Measure 3: Real Time Logistics Monitoring;
  - Measure 4: Fleet Management.

- **Information and Dissemination** – refers to measures that can act as vectors for the dissemination of information among people and stakeholders. Two measures were identified:
  - Measure 5: Data Sharing;
  - Measure 6: Real Time Information about the Transport System.
- **Decision Support and Enforcement** – refers to measures that can process large quantities of information and support public authorities to make decisions and become more effective. Two measures were identified:
  - Measure 7: Access Restrictions and Control;
  - Measure 8: Real Time Monitoring of Logistics Operations.
- **Infrastructure Technology** – refers to measures that are deployed in the transport infrastructure and can be used to interact with traffic and pedestrians. Three measures were identified:
  - Measure 9: Automated Adjustment of Traffic Rules;
  - Measure 10: Traffic signals;
  - Measure 11: Payment & Collection Systems.
- **Sharing Economy and e-Business Services** – refers to measures that support the emergence of sustainable services and markets. Two measures were identified:
  - Measure 12: Shared Economy Platforms;
  - Measure 13: Collaborative Platforms.

1.3 Structure of the Technical Report

The document is structured into seven chapters. The first chapter is dedicated to the overall presentation of the study and of the topic. In Chapter 2, the concept of LP is described. LP will provide the information to characterise the contextual properties of urban activities. In the following chapter, Chapter 3, the key agents with interest in urban freight logistics activities are presented along with their needs. Chapter 4 discusses the main urban freight logistics challenges that can be addressed by ICT. This is relevant to frame the scope of action. Chapter 5 describes a stepwise approach for the selection of ICT measures. Chapter 6 provides the characterisation of the thirteen measures mentioned above. These measures are clustered in a set of six thematic groups. Each measure is then characterised according to a set of elements, including: description, relevant agents, LPs or examples. Finally, Chapter 7 concludes the report with a brief recap of the key ideas and elements.

Chapter 2 The concept of Logistics Profile

The concept of Logistics profile (LP) was initially developed by Macário[10] (Figure 1). It is based on the hypothesis that it is possible to identify, for some well-defined areas inside a city, reasonably homogenous groups of logistics needs, based on three key points: i) the urban characteristics of the area, ii) the requirements of the logistics agents (i.e. the requirements concerning the type of delivery), and iii) the characteristics of the products being transacted. The LP of a given urban area is thus defined by the interaction of these three key aspects.

Figure 1 Logistics profile

Source: adapted from Macário[10]

Furthermore, according to Macário[11] in the areas of the city in which LPs can be defined, it is possible to adjust urban freight logistics services which will optimise the consumption of the involved public and private resources such as space and vehicles, according to the needs of the different market segments. The definition of the LP can therefore be summarised as a homogeneous group with similar logistical needs[10]. Several variables are used to qualify the LPs.

For the definition of LPs, it is firstly necessary to identify the characteristics that will define the city area features, the products' characteristics and the delivery profile in the first phase. For the characterisation of the city area, it is necessary to identify the features that can represent any possible constraints, but also give a picture of the actual state of affairs in terms of logistics conditions, such as commercial density and homogeneity, logistics accessibility, or if there are any restrictions being applied. The product characteristics are the ones that can determine the type of vehicle to be used or if there are any restrictions, such as easiness of handling or special conditions; and finally, the agents' needs or delivery profiles (for example, frequency and urgency of delivery).

Second, for the classification of the LPs, it is necessary to set a scale, in order to quantify (or qualify) each of the features identified. Based on this classification, conditions are met to identify and characterise the LPs. These LPs should be as comprehensive as possible, so, there are some features considered crucial for the definition of the type of profile, while others can be left undefined. It is, however, very important to compare all profiles, so as to ensure that they are independent from one another.

The purpose of the definition of LPs is to identify what are the features that best suit the conditions to the definition of the logistics profile. For each of these features a scale was set, as described in the following sub-chapters.

Table 1 presents the classification options for features. For the identification of the LP, four measurable main city area 'features' were considered: commercial density, homogeneity, logistics accessibility (based on the existence of measures implemented considering logistics needs and on the traffic congestion), and if there is any kind of restrictions to the deliveries applied (for example time windows for deliveries).

Table 1 City Area Features (source: TURBLOG[12])

	Features	Classification		
1	**Commercial Density**	**Low** >30% Commercial face to residencies/services/ industry	**Medium** 30% to 70% Commercial face to residencies/services/ industry	**High** >70% Commercial face to residencies/services/ industry
2	**Homogeneity**	**Low** Several types of services and products	**Medium** Mix residential areas with offices and commercial stores	**High** Cluster of one type of service or similar products
3	**Logistics Accessibility**	**Bad** Bad level of access between the shop and parking (e.g. no loading bays). High level of traffic congestion	**Reasonable** Specific measures considering logistics needs (e.g. loading bays non-exclusive) Reasonable (high on peak hours)	**Good** Transport network suited for logistics needs (e.g. exclusive loading bays) Low traffic
4	**Restrictions Applied**	**Yes** Off peak deliveries, quantity, nature of the products Type of vehicle authorized (size, emissions, etc.)	**No**	
+	**Orography**	**Hilly**	**Between hilly and flat shared**	**Flat**

The products' characteristics have a major influence on how the deliveries are made, especially considering the easiness of handling and the conditions in which the product must be delivered (for example, type of packaging, temperature needs, fragile products, and so on), so they are closely connected to the deliveries profile. The next chapters present the classification for the features considering the products' characteristics.

Table 2 Products' characteristics and features (source: TURBLOG[12])

	Characteristics	Classification		
1	**Easiness of handling** Size Weight Holding conditions	**Difficult** Large (wheelbarrow) Heavy Packages (off-size, off-shape, …)	**Reasonable** Medium (>1 person to carry one unit) Packages (standard dimensions)	**Easy** Small (< 1 person to carry) Light volumes (letter, documents, …)
2	**Special Conditions**	**Special Needs** Valuable products, frozen products, etc.,	**Might have special needs** Open packages, food handled at ambient temperature, chilled,	**No Special needs**
3	**Fragility & Perishability**	Fragile Perishable	etc. Not perishable	

For the delivery profiles, it is important to know the demands of the client in terms of urgency of delivery. This will determine the frequency of the deliveries, and, together with the amounts to be delivered (number of units per shop, number of shops, etc.), explain how the deliveries are made.

Table 3 Agents' features and delivery profiles (source: TURBLOG[12])

	Features	Classification		
1	**Urgency of Deliveries**	**Immediate**	**During the day**	**Next day**
2	**Frequency of Deliveries**	**Low** Several a week	**Medium** Daily	**High** Several per day
3	**Routes:** **A) fixed origin/unknown destination** **B) unknown origin/destination** **C) fixed origin/ destination**	**How many routes?**	**Number of Stops**	
4	**Planned Deliveries**	**Route defined at the moment**	**Pre-established route**	
5	**Special Delivery Schedule**	**After hours deliveries**	**Morning (8-10 a.m.)**	**No special Schedule**

The EU co-funded research project TURLOG [5] identified a total of six main LPs (A to F), as follows (Table 4):

- Profile A: cluster of shops specialized in one specific type of service/product (e.g. a neighbourhood that is known for furniture stores, craft or art pieces, technological poles);
- Profile B: hotels, restaurants, small grocery stores, small neighbourhood markets;
- Profile C: business Centre (courier, small deliveries, B2C);
- Profile D: large commercial stores (retail, shopping centres, distribution warehouses);
- Profile E: residential areas with local trade;
- Profile F: e-commerce, mainly residential areas but it can appear in any location.

Table 4 presents the main characteristics of every profile which is a profile based on the three characteristics and their features.

Table 4 Characteristics for profiles (source: TURBLOG[12])

	Profile A	Profile B	Profile C	Profile D	Profile E	Profile F
City Area Features						
1.Commercial density	High	Low/Medium/ High	High	High	Low/Medium	Irrelevant
2. Homogeneity	High	Low/Medium/ High	Low	Low	Low/Medium	Low/Medium/ high
3. Logistics accessibility	Good/ reasonable	Bad/Reasonable/ Good	Reasonable/Bad	Good	Reasonable/Bad	Bad/Reasonable/ Good
4. Restriction applied?	Yes/no	Yes/No	Yes	No	Yes	Yes/No
Product Characteristics						
1. Easiness of handling	Easy/Reasonable /Difficult	Easy/Reasonable /Difficult	Easy	Easy/reasonable /Difficult	Easy/reasonable /Difficult	Easy/Reasonable
2. Special conditions	No special /special needs	Special needs	No special needs	Might have special needs	Might have special needs	No special conditions
3.1. Fragility 3.2 Perishability	No special needs Not perishable	Fragile Perishable	No special needs Not perishable	No special needs Not perishable	No special needs Not perishable	No special needs Not perishable
Agent Profile/Deliveries Profile						
1. Urgency deliveries	Irrelevant/ Relevant/Urgent	Urgent	Relevant/Urgent	Relevant	Irrelevant/ Relevant/Urgent	Relevant/Urgent
2. Frequency deliveries	Low/Medium/ High	High	High	Medium/High	Low/Medium	Low/Medium/ High
3. Amounts to be delivered	Few/Several/ Many	Several	Few/Several	Many	Few/Several/ Many	Few/Several/ Many
4. Planned deliveries	No defined routine/Defined routine	Defined routine	No defined routine/Defined routine	Defined routine	No defined routine	No defined routine

Chapter 3 Identification of Needs of Agents

One of the most distinguishing features of urban freight logistics systems is the existence of a large ecosystem of agents (Figure 2). Agents do not necessarily have aligned strategies or business models, which eventually leads to tension and conflicts within the system. Such conflicts are the source of many issues and challenges. ICT measures may contribute to bridge their differences. Bellow follows a brief presentation of each agent, and respective interest or uses of ICT measures (Table 5).

Figure 2 Ecosystem of agents in urban freight logistics

- **Producers and Shippers** are responsible for the goods. Their responsibility may also include other operations, such as bundling and packing; although such services are increasingly being outsourced, such as third party logistics (3PL) and fourth party logistics (4PL).

  These stakeholders may run a proprietary fleet of vehicles. In these cases, they also assume the role of transport companies. This type of transport, commonly designated as own account transport, may account to up to 30% of urban deliveries[13], [14] and, even, go as high as 50%[15].

  ICT is being used to support different functions, such as:

  - *Ordering and Production Management* – ICT is used to establish direct (either automated or manual) communication between producers and other agents of the supply chain (namely wholesalers, retailers or consumers.). Orders can be automatically triggered or manually sent. Advantages of ICT include an enhanced responsiveness, since variations in demand are readily identified allowing producers to quickly respond.
  - *Invoicing and billing* – ICT is increasingly used to support invoicing, billing and related tasks. These tasks entail a set of repetitive actions, which are prone to be conducted by machines. Also, producers commonly establish many different contracts with specific payment timings, rates and other rules. As such, the amount of information necessary to

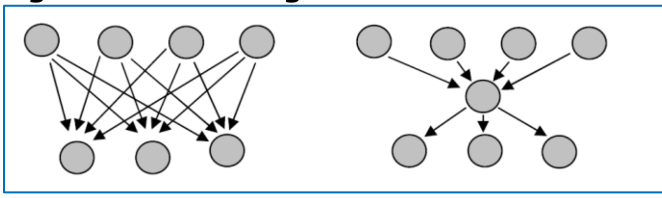
handle and process is substantial. ICT is suitable to manage all flow of documents and ensure all actions are correctly performed.
- *Quality control of the supply chain (e.g. cold chains)* – ICT can monitor the production and movement of goods along the supply chain. This is important to ensure the quality of the goods. For example, in the food segment, some products must be transported at controlled temperatures (e.g. frozen food). Sensors can be implemented on the food to continuously monitor the temperature. If the temperature goes beyond a predefined range, alerts are triggered.

Table 5 Main Uses of ICT

Stakeholders	Main uses of ICT
Producers	Ordering and Production Management, Invoicing and Billing, Quality Control of the Supply Chain.
Wholesalers	Inventory Management, Order Management, Invoicing and Billing, Quality Control.
Freight Transport and Logistics Operators	Monitoring Vehicle Location and Routing, Loading Vehicles Optimisation, Fleet Optimisation, Invoicing and Billing.
Receivers	Order Management, Track and Trace of Goods, Inventory Control, Invoicing and Billing.
Urban Area Residents & Users	Order Management, Track and Trace, Information.
Public Authorities	Dissemination & Information, Enforcement, Planning and Decision Making.

- **Wholesalers** are middlemen between Producers and Receivers (Figure 3). Typically, they buy large quantities of products in bulk, from different producers, and re-sell them, arranged in lots, to the retailers. Often they own (or manage) warehouses in the outskirts of cities. Wholesaler activity can promote the rationalisation of the number of vehicles and transport kilometres, since they promote the concentration of flow in a reduced number of locations.

Figure 3 Positioning of Wholesalers



The main functions of ICT include:

- *Inventory Management* – ICT is used to control inventory. ICT can monitor stock levels and other variables (e.g. validity dates), and trigger messages in case of need. Based on current demand (orders) and supply, and on past data, complex algorithms have been developed to estimate the future demand of stock;
- *Order Management* – ICT is used to manage all order processing (see Producers for further details);
- *Invoicing and Billing* - ICT is used to process invoicing and billing (see Producers for further details);
- *Quality Control* - ICT is used to monitor and ensure the quality of the service (see Producers for further details).

- **Freight Transport and Logistics Operators** are responsible for the physical movement of goods. Logistics operators provide additional services, such as invoicing and billing, warehousing, or inventory management. They may work in a similar fashion as the wholesalers, in the sense that they also collect and bundle the freight flows from different producers (or wholesalers), before making the distribution among retailers. As such Figure 3 is also valid in the context of logistics operators.

  Logistics operators tend to be the visible facet of urban freight logistics, as they run the vehicles (in most cases road transport vehicles).

  Their operations reflect the need to satisfy customers' demands (for example, opening hours of stores or designated time windows to make the deliveries), while optimising processes. The scope for change is thus limited. These stakeholders usually aim at minimising their costs by maximising the efficiency of their pick-up and delivery tours. There is a trade-off between a high level of service and the efficiency of freight vehicles loads.

  The market of freight transport companies is quite heterogeneous, ranging from small family-run companies, with a fleet of one or some vehicles, to large international companies, with a fleet of hundreds of vehicles, either owned or sub-contracted.

  These stakeholders have greatly benefited from the advancements in ICT:

- *Monitoring Vehicle Location and Routing* – ICT enables real time tracking of the fleet. The benefits are several, such as: security (e.g. detecting if vehicle is detoured), management of operations (e.g. detecting if vehicle is delayed), or planning of operations (e.g. allocation of vehicles according to the location and distance from origin point). By way of example, Express Companies (like Chronopost) monitor the fleet in real time. Whenever a new Order is made, the closest vehicle is called to attend the request;
- *Loading Vehicles Optimisation* – Loading vehicles is a complex task due to i) the diversity of shapes and volumes of the packages and ii) the different dimensions of freight vehicles. Although logistics operators often resort to pallets (to reduce the variety), optimising vehicles' capacity remains a challenge. ICT can be used to automatically retrieve

information about the goods and vehicles, supporting the development and utilisation of optimisation algorithms;
- *Fleet optimisation* – ICT can collect information about each and every vehicle, such as: location, routing, loading, overall functioning state (reporting damages or other issues), fuel levels, etc. This information can be used to support planning activities, ancillary operations (such as maintenance, if a malfunction is detected, spare parts can be provided in the next station for a quick repair) or optimising the fleet utilisation (e.g. the location of the vehicles can be used to optimise routings);
- *Invoicing and billing* - ICT is also used to process invoicing and billing (see Producers for further details).

- **Receivers (e.g. retailers, shopkeepers, offices, construction sites, etc**.) are the end point of the transport chain. In what concerns retailers, there is a wide diversity, ranging from small street shops to major commercial centres. Each one sells specific products and therefore has specific transport demands (e.g. frequency, quantities, type of vehicles, etc.). Smaller retailers often own, at least, one car or van. They negotiate with wholesalers and pick-up the goods at the wholesaler' warehouses using their own cars. Hence, they are directly involved in urban freight logistics services. A relevant aspect is that the vehicle is commonly used as a family vehicle, for leisure trips. Another common scheme is to buy the goods including delivery services. The transport price is included in the price of the goods.

  ICT has become relevant in the following tasks:

  - *Order Management* – Depending on the supply chain strategy (pull or push), order management follows different approaches. In the pull strategy, the retailer places the order on the supplier (upstream). In the case of the push strategy, the producer (or supply chain manager) defines the orders, without direct request from the retailer (downstream). Regardless of the situation, an efficient order management depends on the streamline of information both up and down streams;
  - *Track and Trace Goods* – Knowing the location of the goods, including an expectable time of arrival, might be valuable information for any retailer. It allows the management of inventory and sales;
  - *Inventory Control* – Similarly to wholesalers, retailers also have their own stocks (naturally at a reduced scale). Hence, the advantages discussed in the wholesalers also apply here;
  - *Invoicing and Billing* – ICT are also used to process invoicing and billing (see Producers for further details).

- **Urban Area Residents & Users** refer to the people who live or spend a substantial amount of time in the urban area (e.g. working, leisure, shopping, etc.). They expect proper living standards and quality of life. Inevitably, urban freight logistics services, such as emissions, smell, noise, vibrations, etc., are undesirable. Residents and city users may voice their discontentment towards urban freight logistics activities in different ways, such as sending letters to city halls, audiences with public representatives or even law suits. An important group is the vulnerable road users (cyclists and pedestrians). These users share the same infrastructure as freight transport vehicles. Due to their size and agility, vulnerable road users can pass unnoticed by truck drivers resulting in collisions. Passenger vehicles are (sometimes) hindered by double-parked trucks while loading and unloading at the kerbside or on the road. Another group to consider is the Visitors and Tourists. Although these spend shorter periods of time in the urban area, the exposure to the harms of urban freight logistics may nonetheless create a negative image.

  These stakeholders play another role as consumers and receivers of goods. In this role, they expect a high quality of service (e.g. on-time deliveries, real time tracking of their shipments, diversity of delivery options including deliveries at pick up points, flexibility of delivery, etc.). These stakeholders are key elements (and increasingly so) responsible for the dynamics of urban freight logistics.

A major trend concerning this type of stakeholders refers to home deliveries and e-commerce. People are increasingly resorting to internet-based commerce to acquire goods, ranging from groceries and other fast-consumption goods, to technology, books and even fashion. Commonly, goods are delivered to a designated location, e.g. home, office or drop off point. This trend is introducing prefund changes in the organisation and structure of urban freight logistics systems (i.e. new delivery schemes, different route planning or different vehicles) and the actual impacts are still unknown[8].

Uses of ICT include:

- *Order Management* – All e-commerce transactions are only possible due to ICT. This includes choosing the good (and quantity), delivery address, payment methods, invoicing, etc.;
- *Track and Trace of Order* – In addition to the actual transaction, ICT also allows customers to follow the dispatch of goods, from the point of origin to the point of destination. This increases the quality and reliability of the service.

- **Public Authorities** are responsible for ensuring the social, economic and sustainable development of urban regions. We may distinguish three levels of public authorities: the local government, the national government and the EC (e.g. setting EURO-standards for truck engines). Local authorities refer to the municipalities, regional and metropolitan agencies.

  Local authorities are mainly interested in reducing congestion and environmental nuisances as well as increasing safety. They face important challenges. On the one hand, they are urged to curb the negative impacts of urban freight logistics activities (e.g. congestion or greenhouse gases). Additionally, they must avoid jeopardizing the economic vitality of regions (of which freight transportation is of paramount relevance). These stakeholders define the urban freight logistics possibilities, that is, they define the rules (i.e. legislation, regulations, etc.).

  Bearing in mind that urban freight logistics are, from a geographical point of view, confined to the urban area, the role of national or European authorities (apart from setting up the baseline legislations on labour, safety and standards) is usually reduced. However, the interests (such as reducing congestion and externalities at a national or regional level) of national authorities affect many urban freight logistics operations as well as local authority policies.

  ICT plays an increasingly relevant role in supporting authorities' duties:

  - *Dissemination & Information* on the current traffic conditions and state of the transport network. Current mass dissemination of information (e.g. variable message panels) is only possible due to the existence of ICT;
  - *Enforcement* – ICT proved to be a relevant support to monitor freight transport activities and detect illegal activities. By way of example, ICT can automatically monitor the duration of loading/unloading operations; or they can identify illegal parking;
  - *Traffic Management* – ICT is increasingly used to control and manage of urban traffic. This can be achieved in different ways, such as traffic lights, lane allocation, etc. Bearing in mind that urban freight logistics operations are primarily conducted by road vehicles, this utilisation is of value.

[8] The reader interested in the topic of E-commerce is referred to the Technical Report No. 4, which precisely deals with this topic of e-commerce.

- *Planning and Decision Making* – ICT capabilities to collect and store data are being increasingly used to supply both decision-making and planning processes with valuable data and intelligence.

- **Other Stakeholders** – the above list does not exhaustively indicate the stakeholders with interests in urban freight logistics. Among these, we would like to highlight the so-called resource supply stakeholders[16], including: investors, infrastructure providers and managers (such as ports, airports, intermodal terminals, road networks), landowners and providers of vehicles or of information technologies (IT) support systems. These stakeholders may not be directly involved but their investments and innovations determine the possibilities for urban freight logistics to evolve. Hence, if necessary, they may be called to participate in the engagement initiatives.

The course of logistics activities depends on the interaction between the abovementioned stakeholders. On the one hand, authorities affect planning procedures by establishing rules and limits on the utilisation of the public transport network. On the other hand, they may also collect mass data on traffic dynamics, which are a valuable source for more efficient and reliable planning of the transport network. In this matter, there is an increasing interest of private stakeholders on urban-related information, such as Google Maps, Here and Bing Maps. These companies have begun providing proprietary traffic-related information, in real time.

Bearing in mind that private stakeholders seek profit maximisation, a desire for reduction in transportation costs is therefore implicit as well as an increase in the amount of sales, while keeping in mind that their customers expect it to be economic and reliable. Similarly, the prime objective of producers can also be stated as a growth in profit, implying a reduction of the total cost of their operations. These costs consist of opportunity, manufacturing or purchasing and logistics costs (which encompass inventory, transportation and information processing costs)[17]. As for residents, with the prime goal of living in a good environment, it is necessary to reduce the negative impact that comes with traffic, which mainly relates to truck emissions. In order to fully understand the dynamics of logistics in urban areas, it is then necessary to comprehend how these stakeholders interact, their degrees of understanding and their dependence upon each other.

A key characteristic of urban freight logistics is the intertwined web of relationships between stakeholders, in which the behaviour of one may lead to a cascade influencing the entire ecosystem. By way of example, if freight transport operators do not comply with deliver time windows, their clients may charge a penalty for delay. Simultaneously, trucks performing deliveries release emissions which, when brought to a limit, generate complaints from residents to city administrators who intervene through the introduction of access restrictions, time frames, noise and emissions related regulations, etc. These regulations go back to affecting freight carriers who are forced to revisit their delivery schedule[18]. As seen up to this point, the state of logistics in a certain urban area is the result of initiatives from both private and public entities, along with their interactions and coexistence of interests. Since private entities have set their main goals on the optimization of deliveries and reduction in costs, the enforcement of social, economic and environmental standards regarding the field of city logistics falls under the attention of public entities who are then in charge of safeguarding those interests[19].

Among the stakeholders, authorities play a fundamental role in the urban freight All in all, logistics activities in an urban context are sources of concerns and challenges that jeopardise the social, economic and sustainable development of the urban region. Figure 6 groups the main challenges, which are then explained briefly. ICT can contribute to overcome some of those challenges.

Table 6 suggests ICT measures that could positively contribute to overcome each of the selected challenges. Both the challenges and the contributions of ICT are briefly reviewed. Among the stakeholders, authorities play a fundamental role in the urban logistics system, as they aim to ensure high living standards in the social, economic and environmental fields of each city. Consequently, the responsibility to initiate, motivate and coordinate urban freight logistics measures lies with these stakeholders[20]. However, as already discussed, the task at hand is not easy, since economic objectives do not always go hand-in-hand with social and environmental objectives. Yet, authorities face considerable limitations. Urban logistics activities are essentially of a private nature, which reduces the scope of intervention of public operators. Indeed, the little influence of local governments on the basic drivers of freight flows can be seen as the main problem these entities deal with regarding their intervention on the field of urban freight logistics. Urban logistics is often just a small portion (last mile) of longer supply chains.

Also, the impact of the measures is limited to the scope of influence of local authorities, which is the urban region. Indeed, because of the interdependencies within a chain, policies to address a problem created by one part of the chain affect other links. For example, the control of delivery hours affects upstream operations of warehouses and downstream operations of receivers. Essentially, "the complexity and flexibility of supply chains make the outcomes of policy interventions uncertain"[21]. Hence, the capacity of local authorities to shape those supply chains is relatively reduced. Authorities' intervention is nonetheless essential in order to regulate freight activity within urban areas, where environmental and operating standards and goals are set and have to be met and guidelines and rules are needed. What is relevant is to ensure the effectiveness of measures. So that they contribute to achieve the envisaged objective with the minimal impact in private stakeholders' operations and upstream supply chain.

Chapter 4 Description of the Challenges and Issues to be addressed

Urban logistics activities are known sources of conflict [22]–[24]. These are originated in different factors. Foremost, agents have different strategies and objectives, which are not aligned. This factor was already discussed in Chapter 3. Secondly, urban freight logistics have to share public space with other activities, such as pedestrian, private or public transport, and leisure. The mix of different uses leads to conflicts and issues. Thirdly, many EU urban areas have consolidated city centres which were not originally designed to cope with urban freight logistics activities. Nowadays, there is the need to adapt, which eventually results in inefficient measures.

Figure 4 Main challenges of urban freight logistics

All in all, logistics activities in an urban context are sources of concerns and challenges that jeopardise the social, economic and sustainable development of the urban region. Figure 6 groups the main challenges, which are then explained briefly. ICT can contribute to overcome some of those challenges.

Table 6 suggests ICT measures that could positively contribute to overcome each of the selected challenges. Both the challenges and the contributions of ICT are briefly reviewed.

Table 6 Linking ICT measures with urban freight logistics challenges

Urban Logistics Key Challenges	ICT group	ICT measures
Complexity of the urban freight logistics system	Information and Dissemination	Data sharing, Real time information of transport systems.
Low interest in cooperating	Information and Dissemination.	Data sharing, Real time information of transport systems.
Excessive Demand for Road Transport Services	All measures can positively contribute towards these challenges both from the private and public stakeholders.	

Handling Operations	Information and Dissemination.	Real time information of transport systems.
Insufficient Enforcement of Regulations	Decision Support & Enforcement	Access Restrictions, Monitoring of Logistics Operations.
Sub-optimal Utilisation of Vehicles or Road Space and Inefficiency of Processes	All measures can positively contribute towards these challenges both from the private and public stakeholders.	

- **Complexity of the Urban Freight Logistics System**

  As often mentioned, an important challenge lies in the complexity of the urban freight logistics activity. Firstly, the multitude of urban freight logistics segments that may coexist (e.g. independent retailers, chain retailers, food deliveries, home deliveries, express services, etc.). Each segment has its own specific properties (in terms of vehicles, delivery windows, transport conditions, etc.) which reduce the scope for joint or merging operations. Secondly, the large diversity of stakeholders with different perspectives, goals and strategies. There is eminently a division between private stakeholders (profit driven) and public stakeholders (envisaging the social, sustainable and economic development). Although not necessarily incompatible, the perspectives are substantially different, requiring efforts and willingness to be bridged. Thirdly, the urban freight logistics sector generates externalities. Urban logistics activities contribute to traffic congestion, the degradation of transport infrastructure or the emissions of greenhouse gases. Yet, such costs are borne by the Society and not by the responsible. The internationalisation of such externalities is likely to result in opposition by private stakeholders.

  New communication means, such as video- or audio-conference can be used to promote dialogue and establish privileged communication channels between selected stakeholders. Often important barriers, such as distance or schedules, are mitigated. In addition, ICT can be used to promote transparency of the urban freight logistics system. They characterise stakeholders' activities, operations (e.g., the needs, requirements or limitations) or respective interactions; which can be used to identify common and friction points or gaps. ICT Groups considered in this Technical Report helpful to overcome this challenge include (Table 6):

  - Information and Dissemination ICT Group can help on the characterisation of the freight transport and logistics operators' activity patterns (e.g., routes, fleet, timings, etc.). This will help assess their actual role on the degradation of the urban (transport) system conditions. Furthermore, these tools can help on the identification of the interactions between stakeholders (e.g., drop-off location). An important step to disentangle the web of connections among stakeholders, and to understand the gaps and common aspects.

- **Low interest in Cooperating**

  The inherent lack of propensity of private stakeholders to cooperate is another challenge. Logistics and freight transports are highly competitive sectors. Bearing in mind that cooperation entails sharing information and resources, companies' interest is naturally reduced. They fear losing any competitive hedge they may have against their competitors. Also, some business segments are characterised by secrecy or at least some reservations (e.g. often restaurants have exclusive producers and products). Such segments will deny sharing their exclusive products with other products, for fear of damage to the goods or access to suppliers from their competitors (restaurants).

As discussed in the previous challenge, ICT tools can promote visibility about the urban freight logistics system. Visibility is necessary to build trust, which is turn is an essential condition to promote cooperation. Furthermore, ICT can be used to anonymously exchange selected data between stakeholders. Hence, the risk of confidential data ending up at the hands of competitors is minimised. So, each stakeholder will have full access on real time to its services and partial access to other services. ICT Groups considered in this Technical Report helpful to overcome this challenge include (Table 6):

- Information and Dissemination ICT Group works as described in the previous challenge. It can promote transparency about the operations and interactions of stakeholders. Hence, it can establish a network of tailored communication, ensuring that only the right information is transmitted between stakeholders.
- Sharing Economy and e-Business Services ICT Group is changing the urban mobility systems landscape, by generating economic value of activities that thus far have had no (or low) value (e.g., spare capacity in private vehicles' trunk). This ICT group is bringing together suppliers and consumers in an open and transparent way, in which the system's reliability and trust is built by the users (through reviews and peer-evaluation). These new possibilities are modifying the mentality and cultural beliefs of those stakeholders with higher resistance to cooperation and change.

- **Excessive Demand for Road Transport Services**

A third challenge that can be addressed by ICT concerns the demand for road transport infrastructure. Indeed, the vast majority of urban freight logistics operations are undertaken by road vehicles (two-wheelers, cars, vans and small trucks). These vehicles compete with private and public transport vehicles for the scarce transport infrastructure. Added to this, trucks are slower, consume more space, are noisier and more pollutant. The outcomes are congestion and worsening traffic fluidity (for example: a double parked truck creates a bottleneck in the traffic capacity of the road), and growing conflicts with other vehicles and pedestrians (in case of parking on sidewalks).

All ICT Groups can positively contribute to work against the excessive demand of road-based urban freight logistics services, as follows:

- Vehicle Support Equipment ICT Group can assist road vehicle drivers choosing optimal routes avoiding congested areas.
- Operations Management ICT Group can help logistics and freight transport operators optimising vehicles' loading, according to the geometry of the goods, drop off sequence and other variables. Another useful application of this ICT group is on the optimisation of these stakeholders' distribution network (e.g., routes and drop off locations).
- Information and Dissemination ICT Group works as described above. It may help stakeholders grasping an enhanced view and understanding about the urban freight logistics system (e.g., namely: congestion patters, routes and fleet, or parking availability. Also of relevancy, this ICT Group will generate large quantities of valuable data. If properly worked through advanced mathematical algorithms, it may be used to recognise non-trivial behavioural patterns and trends (e.g., propagation of congestion across the road network).
- Decision Support & Enforcement ICT Group will support authorities and other public stakeholders controlling the type and amount of vehicles that circulate on the urban transport network. Of importance, this ICT Group will also help monitoring urban freight logistics operations.
- Infrastructure ICT Group can be used by authorities and other public stakeholders to dynamically change the conditions of the transport infrastructure and, in this way, to influence the behaviour of users (e.g., changing times of green light). In parallel, this

ICT Group can be used to help stakeholders get an up-to-date view about the dynamic utilisation of the transport network, including utilisation of parking bays. An enhanced view about the real time utilisation of the transport network and early spot of trends (e.g., congestion) help stakeholders to responds accordingly. By way of example, access rules can be adapted in function of road vehicles demand, or information about utilisation of loading/unloading parking bays can be known.

- Shared Economy & e-Commerce ICT Group will contribute to the rationalisation of the urban freight logistics system. This may occur in different ways, such as i) by giving an economic value to unutilised road transport capacity (e.g., private vehicles' available space), or ii) by giving the possibility of other stakeholders entering into the logistics business (e.g., bicycle riders). In both cases, the outcome is a decrease for the need for road vehicles.

- **Handling Operations**

Handling operations is a key challenge of urban freight logistics operations. Handling operations are often done outside designated loading bays in illegal conditions (e.g. second lane, bus lanes, on sidewalks or in illegal parking places). Whatever the situation, the outcome is also a conflict with other uses of the public space (e.g. with pedestrians in case of parking on the sidewalk). The roots are diverse, but include the lack of suitable parking places (indeed, parking places for freight vehicles are scarce, often located in secondary roads away from shops, and when available can be occupied by private vehicles). Also, many deliveries are done in a very short period of time (less than three minutes). In these cases, there is a higher propensity to illegal actions (for example, parking the vehicle in double lane). The time of the illegal act is short and the probability to be caught by public authorities is low.

As mentioned in the previous challenge, ICT tools are being widely used to support traffic management, including parking and handling operations. In what concerns parking, ICT tools can be used to monitor parking times, to detect illegal parking (e.g., private vehicles on loading/unloading parking bays) or to grant access of vehicles to access control areas. ICT Groups considered in this Technical Report helpful to overcome this challenge include (Table 6):

- Information and Dissemination ICT Group will bring visibility about the handling operations. Authorities and other public stakeholders will have enhanced understanding about the dynamics of the urban freight logistics system (e.g., parking on double lane, or temporal concentrations).
- Decision Support and Enforcement ICT Group will assist authorities and other public stakeholders monitoring the handling operations the effective utilisation of the loading/unloading parking bays. If necessary, this ICT Group can be used to deploy local regulations (e.g., identify transgressors).

- **Insufficient Enforcement of Regulations**

An adequate enforcement is the key to ensure that law and regulations are complied with. Yet, enforcement of urban freight logistics activities is often weak or neglected. Available resources of the police forces (or other authorities) tend to be scarce and other priorities jump in.. Also, monitoring urban freight logistics activities is a difficult task. Firstly, as stated above, many deliveries are fast. Spotting them would require permanent surveillance of every street, which is impracticable. Secondly, many urban freight logistics activities are done with small and uncharacterised vehicles. Identification of such vehicles is difficult. Thirdly, the available public space is often scarce and there are simply no available parking spaces. Yet, urban freight logistics activities must occur, otherwise, local commerce goes bankrupt. In these situations, overlooking regulations may be a deliberate decision.

ICT tools have proved valuable in helping authorities enforcing regulations. The ability to continuously record information, without human intervention, allows for the coverage of vast areas. This is important due to the discrete nature of urban freight logistics activities. ICT tolls have been used in different ways: i) to monitor vehicles access, ii) to monitor parking times, iii) to monitor parking bays utilisation, particularly by unlawful private vehicles, or iv) to detect illegal parking of freight vehicles outside designated areas. ICT Groups considered in this Technical Report helpful to overcome this challenge include (Table 6):

- Information and Dissemination ICT Group will assist authorities and other public stakeholders monitoring urban freight logistics operations (e.g., utilisation of freight parking bays).
- Decision Support and Enforcement ICT Group, will help stakeholders to take appropriate measures to improve the urban freight logistics system. Most importantly, it will help stakeholders ensuring their effective deployment of regulations. By way of example, a violation to the time permit can be automatically detected and a fine (or other penalisation) can be issued to the respective logistics or freight transport company operator.

- **Sub-optimal Utilisation of Vehicles or Road Space and Inefficiency of Processes**

A final challenge that ICT can contribute to overcome relates to the sub-optimal utilisation of vehicles. It refers to situations that reduce the efficiency of vehicles, such as inappropriate loading (i.e. circulating half empty), difficult traffic conditions (e.g. congestion or absence of parking spots forcing the driver to move around streets) and inappropriate driving or handling behaviour (e.g. leaving the vehicle idling during stops). Indeed, the vast majority of vehicles run with reduced load factors. Several roots can be pointed out, including inefficient planning operations, access restriction measures that force companies to use multiple vehicles and poor traffic conditions that reduce speed and force the utilisation of multiple vehicles. The sub-optimal utilisation of vehicles can also be the consequence of the business model. Indeed, in the case of express delivery services, some companies keep vehicles running in the city waiting for customers' calls. Another factor for the sub-optimal utilisation of vehicles lies with traffic conditions. Congestion and heavy traffic lead to frequent accelerations and decelerations, resulting in higher consumption of fuel and rapid deterioration of vehicles (e.g. brakes, tires, etc.). Finally, drivers often do not switch off engines during handling operations. The reasons are several: negligence, short periods of time (perceived as no need to switch off engine) or controlled temperature vehicles requiring a permanent source of energy. Regardless of the case, the outcome is inefficiency, exacerbated consumption of fuel and increase in costs.

All ICT Groups can positively contribute to work against the sub-optimal utilisation of the available resources, as follows:

- Vehicle Support Equipment-related ICT Group can help vehicle drivers choosing optimal routes avoiding congested areas. Routes can be dynamically updated, according to real time information on traffic conditions.
- Operations Management Group can help logistics managers optimising vehicles loading (hence, contributing to reducing the fleet size), based on optimisation algorithms.
- Information and Dissemination-related ICT Group can help logistics managers build an enhanced understanding about the urban transport system. Through (big) data analysis tools, traffic patterns, customers' requirements or infrastructure capacity can be predicted. Logistics managers can feed this information into their distribution networks planner.
- Decision Support & Enforcement-related ICT Group can help authorities and other public stakeholders to take informed decisions on how to organise the urban transport

system. This may include control access rules (e.g., vehicles, time windows) or location of freight parking bays.

- Infrastructure-related ICT Groups can help in several ways. Foremost, it can deliver up-to-date utilisation patterns of the transport infrastructure, including freight parking bays or congested zones. Secondly, it can modify the properties of the transport infrastructure and, hence, directly influence the traffic dynamics (e.g., green lights timings or changing road lanes properties). Thirdly, it can be used to interact with the drivers and other users (e.g., disseminate information, collect tolls, etc.).
- Shared Economy & e-Commerce-related ICT Group is contributing to an increased efficiency of the available transport resources. Examples were already provided in previous challenges.

Chapter 5 Choosing ICT measures for Urban Logistics Challenges

This document offers a step-by-step approach to help readers selecting the most promising ICT measures to tackle urban freight logistics challenges. As it will be discussed below, the selection of the most appropriate ICT measure depends on the identification of the drivers and nature of the issues and challenges, expected objectives, properties of the city or even the nature of the logistics and freight transport chains. Urban regions often present distinguishing and unique features and ICT measures must be chosen accordingly. The transfer of ICT measures between cities should as such be subjected to ex-ante studies. Success in one city is not a guarantee of success in another. The suggested approach is presented in the following figure.

Figure 6 Proposed five-step approach to select the best fitted ICT solution for mitigating the urban logistics challenges

Step 1

- Identifying the urban freight logistics issues

Step 2

- Characterisation of the city's logistics profile (LP)

Step 3

- Selection of relevant ICT solutions

Step 4

- Definition of Key Performance Indicators

Step 5

- Implementation of ICT solutions and drive results

Step 1 – Identifying the Urban Freight Logistics Issue

This first Step aims at identifying the urban freight logistics challenge and respective geographical area of intervention. A challenge is a well-defined in time and space freight logistics activity that disturbs the normal development of the other urban users' activities. Examples include i) a freight vehicle parked on second lane that disturbs the regular flow of traffic; ii) a freight vehicles parked on the side walk preventing the normal pedestrian flow, iii) moving freight in between vehicles and store may conflict with crossing vehicles or pedestrians, or iv) the excessive demand of freight vehicles on a short time window to a specific location or city. The cases are numerous and rather heterogeneous. Some of the issues may impact a specific area on a street, whereas others may impact the whole urban area. Along with the identification of the urban freight logistics issues, it is relevant to identify the area of intervention. The area of intervention is the area in which the problem of that challenge is felt. The typical case is either a street or a borough (e.g., historic district). If impacts spread to adjacent streets, they should also be included in the area of intervention.

ICT are increasingly valuable to spot urban freight logistics issues. In this sense, the Information and Dissemination Group, the Decision Support and Enforcement Group or the Infrastructure Technology Group is of particular interest. Chapter 3 provides detailed information on the usefulness of ICT to identify urban freight logistics challenges. By way of example, ICT tools (e.g., radar) can automatically monitor and collect data about the urban transport network (e.g., traffic) or urban freight logistics operations (e.g., loading/unloading, locations, timings, etc.). Big data analysis tools and advanced mathematical algorithms can then work over collected data. Enhanced information about the patterns and dynamics of urban freight logistics, such as congested areas, residual traffic or unlawful activities, can be spotted.

Yet, ICT may not be enough to conveniently characterise an urban freight logistics problem. Those facets with no visible manifestation cannot be tracked down by an ICT tool. Issues may be linked with logistics operators' processes, tied with difficulties of communication among stakeholders, or related with particularities of the built environment. It is recommended to complement the utilisation of ICT, with other methods, namely: stakeholder engagement or observation. Stakeholder engagement is a valuable approach to collect data and information about urban freight logistics operations directly from the involved or relevant stakeholders[9]. Observation consists on the collection of data through participation of involvement on the operations.

Step 2 – Characterisation of the Logistics profiles

The second Step aims at the characterisation of the urban freight logistics problem. We recommend to make use of the concept of Logistics profile (LP). A LP is a homogeneous group of logistics needs. An urban freight logistics problem may have more than one LP, depending on the level of complexity and area of intervention. The advantage of LP is the ability to isolate the constitutive parts of the problem.

The concept of LP is described in detail in Chapter 2. In short, the LP (Figure 1) refers to a well-defined and specific set of logistics properties, according to three key dimensions:

1. The urban characteristics of the area (Table 1): commercial density, homogeneity, logistics accessibility (based on the existence of measures implemented considering logistics needs and on the traffic congestion), and whether there is any kind of restrictions to the deliveries applied (for example time windows).
2. The characteristics of the products (Table 2): easiness of handling and special conditions.
3. The requirements of the logistics agents (i.e. the requirements concerning the type of delivery) (Table 3): the urgency and frequency of the deliveries, and the routing scheme.

Previous research has already typified six LPs. They are are likely to exist in a given city:

- Profile A: cluster of shops specialized in one specific type of service/product (e.g. a neighbourhood that is known for furniture stores, craft or art pieces, technological poles).
- Profile B: hotels, restaurants, small grocery stores, small neighbourhood markets;
- Profile C: business Centre (courier, small deliveries, B2C);
- Profile D: large commercial stores (retail, shopping centres, distribution warehouses);
- Profile E: residential areas with local trade;
- Profile F: e-commerce, mainly residential areas but it can appear in any location.

[9] The reader interested on this topic is referred to the Non-Binding Guidance Document on Stakeholder Engagement. (i.e. NBGD 3: Engagement of stakeholders when implementing urban freight transport policies).

Table 4 lists the main characteristics of the six typical LP. This however does not replace the need to conduct a proper assessment of the relevant LP.

Step 3 – Selection of ICT Measures

This Step corresponds to the selection of the ICT tools. Overall, each problem requires a dedicated study. A distinctive feature of urban freight logistics issues is their uniqueness. Let us consider one example: the problem of illegal parking (double lane) can have many different reasons (e.g., no parking available, parking bays wrongly located, insufficient enforcement, etc.). Even when a problem has a similar origin, it will likely be differently addressed in a large city (e.g., Paris) than in a smaller city (e.g., Genoa). Moreover, the solution will also differ in function of the perpetrator: a large retailer (e.g., Zara) works differently than a local retailer (e.g., restaurant). The selection should be done based on ex-ante analyses considering the properties of the urban freight logistics problem, the properties of the ICT measures and the LPs of the area of intervention. The expectable costs and benefits should be assessed and compared against the available budget. In addition, stakeholder engagement initiatives could be undertaken to ensure the acceptability by stakeholders.

An important aspect to the success of an ICT initiative is the interoperability of data, and static and dynamic datasets between stakeholders. Bearing in mind the amount of private stakeholders and diversity of information systems, this measure is of utmost importance. Fulfilment of ISO/CEN standards is relevant to promote interoperability of information systems[10].

The selection of ICT can also be supported on benchmarking exercises. The study of ICT solutions to overcome similar urban freight logistics issues can be a valuable source of information and recommendations. Forums and platforms, such as the DTLF or the ETP-Alice, publish valuable suggestions and recommendations, on different topics. Since these initiatives include professionals, academicians and/or companies, they are knowledgeable on the topic and the outputs are valuable.

Previous studies[25] supported the development of Table 6, Table 7 and Table 8:

- Table 6 identifies the ICT Groups/Tools most suitable to mitigate each type of challenge/problem, already discussed in Chapter 4.
- Table 7 provides information about the preferable ICT Group/Tools per type of LP.
- Table 8 attempts to identify the suitable ICT Group/Tools per type of stakeholder. More than one stakeholder may benefit from the ICT measure.

Yet, typically, there is one that is in charge for the implementation and management (marked with an X). Hence, the successful deployment of an ICT measure depends on this stakeholder's agreement.

The stakeholders are classified as follows:

A. Producers and Shippers
B. Wholesalers
C. Freight Transport and Logistics Operators
D. Receivers
E. Urban Area Residents & Users

[10] More information available at: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=54706&published=on or https://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID,FSP_LANG_ID:6259,25&cs=10F7E154C4B7D33D5711C5A7BE30FF13A

F. Public Authorities

It is important to emphasise the need to consider each problem as individual. Moreover, the actual contribution of a given ICT will depend on several factors, including the LP, the nature of the challenges and other contextual properties.

Table 7 ICT Applications vs. Logistics profile

ICT Domains	ICT Action	Logistics profile					
		A	B	C	D	E	F
Vehicle Support Equipment	Navigation Software & Location Equipment		✓			✓	
	Communication Vehicle to Vehicle & Vehicle to Infrastructure	✓	✓	✓	✓	✓	
Operations Management	Real Time Logistics Monitoring	✓	✓	✓	✓	✓	✓
	Fleet Management	✓		✓	✓		
Information & Dissemination	Data Sharing	✓	✓	✓	✓	✓	✓
	Real Time Information about the Transport System	✓	✓	✓	✓	✓	
Decision Support & Enforcement	Access Restrictions and Control	✓	✓			✓	✓
	Real Time Monitoring of Logistics Operations	✓	✓	✓	✓	✓	✓
Infrastructure	Automated Adjustment of Traffic Rules	✓	✓	✓	✓		✓
	Traffic signals	✓	✓	✓	✓		✓
	Payment & Collection Systems	✓	✓	✓	✓	✓	✓
Sharing Economy and & e-Business Services	Shared Economy Platforms	✓	✓	✓	✓	✓	✓
	Collaborative Platforms	✓	✓	✓	✓	✓	✓

Table 8 Promoting Agent of ICT measure and spill over effects

ICT Domains	ICT Action	Stakeholders					
		A	B	C	D	E	F
Vehicle Support Equipment	Navigation Software & Location Equipment			X	X		
	Communication Vehicle to Vehicle & Vehicle to Infrastructure	✓	✓	X	✓		X
Operations Management	Real Time Logistics Monitoring	✓	✓	X	✓		
	Fleet Management		✓	X	✓		
Information & Dissemination	Data Sharing	X	✓	X	✓	✓	X
	Real Time Information about the Transport System	X	✓	X	✓	✓	X
Decision Support & Enforcement	Access Restrictions and Control			✓			X
	Real Time Monitoring of Logistics Operations			✓			X
Infrastructure	Automated Adjustment of Traffic Rules		✓	✓			X
	Traffic signals			✓			X
	Payment & Collection Systems			✓			X
Sharing Economy and & e-Business Services	Shared Economy Platforms	X	✓	X	X		✓
	Collaborative Platforms	✓	✓	✓	✓	✓	X

Step 4 – Definition of Performance Variables and Metrics

The impacts accruing from the implementation of an ICT should be assessed. The purpose of Step 4 is to establish a reference framework made of relevant performance variables. The performance variables should be chosen according the i) urban freight logistics problem, ii) specific needs of each stakeholders and iii) the objectives of the intervention. The monitoring efforts should begin as soon as possible, ideally even before the deployment of the ICT. The purpose is to develop a referential situation (base case) against which the impacts of ICT could be assessed. In parallel, benchmark analyses (against cases in other urban areas) could be elaborated. In this situation, similar performance variables should be chosen.

Diverse EU co-funded research projects have elaborated lists of performance indicators. The web-portal TRIP – Transport Research & Innovation Portal[11] offers a comprehensive list of relevant projects indicators and references. The EU co-funded research project STRAIGHTSOL[26] suggests a total of thirty indicators organised in four impact areas, as follows:

1. **Economical and Financial Impact Area** concerns the estimation of the effectiveness or benefits derived from an ICT measure in relation to the costs associated with its development. This includes (operational) costs and revenues, and investments.
    - 1.1. *Costs per delivered item* are the average costs paid by the shipper for the transportation of a good or service unit.
    - 1.2. *Costs per received item* are the average costs (directly or indirectly) paid by the receiver for the transportation of a good or service unit.
    - 1.3. *Operating benefits* are the operating revenues minus the operating costs.
    - 1.4. *Return on investments* is the ratio of money gained or lost on an investment relative to the amount of money invested.
    - 1.5. *Enforcement costs* are the amount of money spent by the local authority to enforce other parties to comply with changes in the transport system.

2. **Environmental Impact Area** concerns the estimation of the environmentally-related impacts, such as emissions or noise.
    - 2.1. *Air pollutants* concern the healthiness and safety of the atmosphere, which can be described by the level of pollutants in the air.
        - *2.1.1. Carbon Dioxide (Co2)*
        - *2.1.2. Sulphur dioxide (SO2),*
        - *2.1.3. Nitrogen dioxide (NO 2)*
        - *2.1.4. Particulate matter (PM2.5 and PM10).*
    - 2.2. *Noise level* resulting from the logistics and transport operations, such as handling goods (e.g., open/close door, moving carts about) or vehicles' engines.
        - 2.2.1. Actual noise level is described as the outdoor sound level caused by human activities, including transport.
        - 2.2.2. *Noise perception* is people's perception on the noise level caused by transport activities.

3. **Societal Impact Area** concerns the assessment of the social acceptability and compliance of an ICT measure. These may in turn have further effects on factors such as business opportunities and the quality of life in general.

[11] Available at: http://www.transport-research.info/

3.1. *Producers and Shipper's attitude towards environmental impact* is the degree to which the shipper of goods is concerned with the environmental impact of the activities required for the shipment of goods.
3.2. *Freight Transport and Logistics Operators* attitude towards environmental impact is the degree to which the logistics service provider is concerned with the environmental impact of their transport activities.
3.3. *Receiver's attitude towards environmental impact* is the degree to which the receiver of goods is concerned with the environmental impact of the activities required for the delivery of goods.
3.4. *Employee satisfaction* is used to describe whether employees are happy and contented and fulfilling their desires and needs at work.
3.5. *Attractiveness of urban environment* describes how people perceive their surrounding environment, in terms of visual attractiveness and physical nuisance.
3.6. *Space occupancy* refers to the amount of space that is dedicated to logistics activities such as loading, unloading and handling.
3.7. *Business climate* indicates how state, regional and local policies, relationships and local communities support business development.
3.8. *Easiness of compliance* refers to the degree to which people easily act in accordance with the relevant authority and their requirements.
3.9. *Acceptance level* is the degree to which people are satisfied with the existence and/or use of the ICT measure.

4. **Transport Impact Area** concerns the assessment of the performance of the urban transport system. Emphasis is on understanding how much the ICT measure contributes to more efficient, safe and reliable freight transport.

The transport impact area is divided in three sub-categories:

4.1. Quality of service: relates to the quality and reliability of the (freight) transport service,
   4.1.1. *Punctuality of pick-ups* is described as the degree to which pick-ups take place at the appointed time.
   4.1.2. *Punctuality of deliveries* is described as the degree to which deliveries take place at the appointed time.
   4.1.3. *Accuracy of pick-up* is described as the degree to which the pick-up includes the appointed quantity of goods in the correct form. This means that no errors or damages are encountered by the shipper.
   4.1.4. *Accuracy of delivery* is described as the degree to which the deliveries include the appointed quantity of goods in the correct form. This means that no errors or damages are encountered by the receiver.
   4.1.5. *Supply chain visibility* is defined as the traceability of goods in transit from the sender to the receiver. This includes the availability of accurate and real time information.
   4.1.6. *Suitability of service* is described as the degree to which the customer favours the time and location of the transport activities, based on its own daily activities.

4.2. Transport system: includes number of movements and congestion level
   4.2.1. *Average vehicle speed* is described by the distance (km) travelled in a certain time period (hour).
   4.2.2. *Accessibility* refers to the ease of reaching goods, services, activities and destinations.
   4.2.3. *Network use* is described by the actual and potential traffic flow of a network.

4.3. Safety and security: includes traffic safety and the security of goods.
- 4.3.1. *Crime* refers to the number of goods that get stolen or deliberately damaged while being carried or stored between shipper and receiver.
- 4.3.2. *Security perception* is the feeling people have on the security of their goods while being carried or stored between shipper and receiver. The indicator focuses on the perceived and/or experienced likelihood of thefts.
- 4.3.3. *Traffic safety* is described by the number of traffic accidents, injuries and deaths.
- 4.3.4. *Safety perception* is the feeling people have on their safety when they participate in traffic. The indicator focuses on the perceived likelihood of traffic accidents and injuries.

The following table (Table 9) indicates the relevant stakeholders for each performance variable. The stakeholders are classified as follows:

A. Producers and Shippers
B. Wholesalers
C. Freight Transport and Logistics Operators
D. Receivers
E. Urban Area Residents & Users
F. Public Authorities

Table 9 Relevant Stakeholder per Performance Indicator

Impact Area	Performance Variable	Stakeholders					
		A	B	C	D	E	F
1. Economy & Finance	1.1 Costs per delivered item	✓	✓				
	1.2 Costs per received item		✓		✓		
	1.3 Operating benefits			✓			
	1.4 Return on investment	✓	✓	✓	✓		✓
	1.5 Enforcement costs						✓
2. Environment	2.1 Air Quality					✓	✓
	2.2 Noise					✓	✓
3. Society	3.1 Producer & Shipper's attitude towards environmental impact	✓	✓				
	3.2 Freight Transport & Logistics Operators' attitude towards environmental impact			✓			
	3.3 Receivers' attitude towards environmental impact		✓		✓		
	3.4 Employee satisfaction	✓	✓	✓	✓		

Impact Area	Performance Variable	Stakeholders					
		A	B	C	D	E	F
	3.5 Attractiveness of urban environment				✓	✓	✓
	3.6 Space Occupancy				✓	✓	✓
	3.7 Business Climate						✓
	3.8 Easiness of compliance					✓	✓
	3.9 Acceptance Level					✓	✓
3.1 Transport – Quality of Service	3.1.1 Punctuality of pick-ups	✓	✓	✓	✓		
	3.1.2 Accuracy of pick-ups	✓	✓	✓	✓		
	3.1.3 Supply chain visibility	✓	✓	✓	✓		
	3.1.4 Punctuality of deliveries	✓	✓	✓	✓		
	3.1.5 Accuracy of deliveries	✓	✓	✓	✓		
	3.1.6 Suitability of service		✓	✓	✓		
3.2 Transport – Transport System	3.2.1 Average vehicle speed			✓			✓
	3.2.2 Accessibility perception			✓	✓	✓	✓
	3.2.3 Network Use						✓
3.3 Transport – Security & Safety	3.3.1 Crime	✓	✓	✓	✓	✓	✓
	3.3.2 Security perception	✓	✓	✓	✓	✓	✓
	3.3.3 Traffic safety			✓		✓	✓
	3.3.4 Safety Perception					✓	✓

Step 5 – Implementation of ICT measures and Drive Results

Finally, ICT measures should be deployed and the associated elements that are part of the urban mobility system should be monitored. This is the purpose of Step 5 to ensure that the ICT measures are duly implemented and to monitor the impacts. This will ensure that a possible misalignment could easily be identified and corrective measures could be deployed.

A minimum amount of information is necessary to allow proper monitoring of the implementation strategy, which is to some extent related with the variables chosen in Step 4. Operational monitoring entails the following features:

1. Definition of data to be collected to achieve the required outputs, results, impacts and indicators.
2. Methods used to quantify the data or estimates generated by e.g. surveys must be specified (sample, panel data, data-bases, monitoring mechanisms, etc.) as well as authorities or bodies responsible for their collection.
3. Definition of operational links with the evaluation activities (ex-ante, mid-term and ex-post).
4. Definition of programme-specific indicators, to allocate the performance at mid-term if possible.

Chapter 6 Description of the ICT Measures

The 1990s were marked by the increasing importance of Information and Communication Tools (ICT) for freight transport[27]. Progressive sophistication of technology (i.e. higher quantities of enhanced-quality information being exchanged within reduced periods of time), coupled with a steady decrease in prices resulted in a widespread adoption of ICT. A growing number of added-value services (e.g. track and trace) were introduced in the market. Gradually, many transport companies evolved from pure transport providers (i.e. selling transport of freight between locations) towards complete service providers (i.e. selling transit times or time definitive delivery). The so-called *Integrators* (e.g. FedEx, UPS and DHL) are good examples of such transport service provider companies[28].

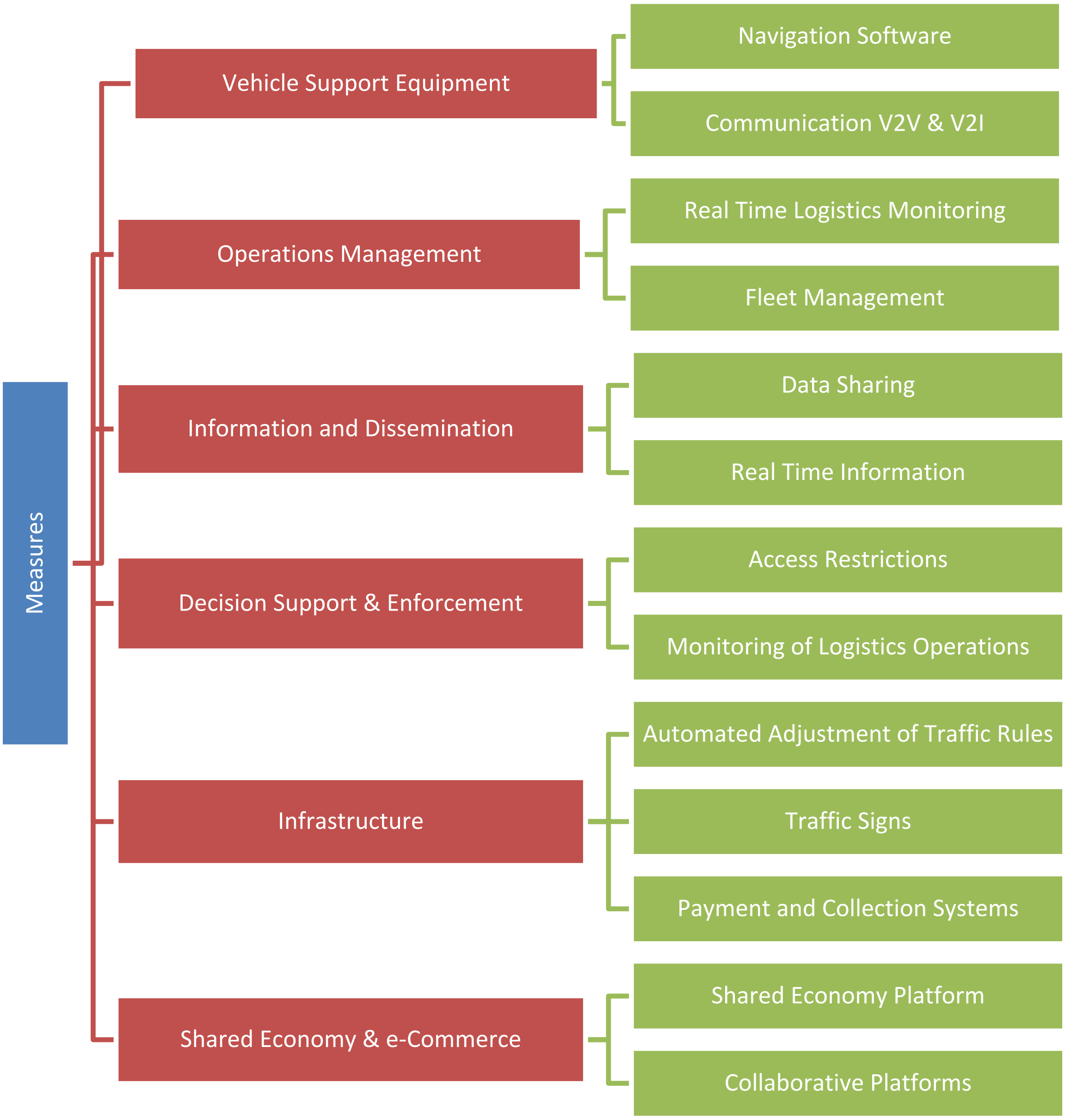
In this new paradigm, the physical movement of freight is just one of the components of the transport service and not necessarily the most important one. Within the context of logistics and transport, four main areas of utilisation of ICT have been identified[29], [30], as follows:

- **Transportation management applications** related to decision support tools in transportation planning, optimisation and execution. Typical functionalities include routing and scheduling, shipment tracking and tracing, or freight payment and auditing[31].
- **Supply chain execution** applications related to the management and automation of information exchange and real-time management during the actual execution of a distribution schedule[32].
- **Field force automation** applications support the integration between remote workforce and corporate business processes.
- **Fleet and freight management** applications are related to the organisation and planning of logistics operations. They are essentially reporting tools concerning vehicle travel times, service times, delivery points visited or other parameters (e.g. load temperature). A key functionality is the real-time monitoring which can be used to efficiently manage a fleet of vehicles during the execution of logistics activities.

Figure 5 lists the groups and respective ICT measures, in a total of thirteen. A brief characterisation of each group and measures follows. Since each urban context is unique as well as the group of agents, it is not plausible to conduct generalisations regarding the benefits. Additionally, the full description of the ICT measures lies outside the scope of this report. The reader is referred to the "Further Reading" chapter.

- **Vehicle Support Equipment** - This group refers to ICT measures which are installed on-board vehicles. They monitor both the vehicles and the freight. Various type of information is collected (e.g. speed, fuel consumption, temperature, etc.), which can then be transmitted to a server for posterior processing. Additionally, information can be used on real-time to help drivers choose better options, in terms of routing or driving conditions, such as eco-driving, collision avoidance or, even, automated vehicle operation. Since these ICT measures are to be implemented on vehicles, the main promoters are the agents directly in charge of vehicle operations, that is, logistics and transport operators.

Figure 5 List of ICT measures



Specific measures in this group include:

- ***Measure 1: Navigation Software and Location Equipment*** is navigational software with storage on server of GNSS files and location of equipment, as well as traffic monitoring and control measures. It helps to find efficient paths or parking facilities that can lead to reduced delays and planning issues, thus minimizing congestion costs.

  By way of example, the city of Utrecht in the Netherlands applied a measure called "clean route planning for freight traffic" focused on defining a method to guide, in real-time, freight traffic along routes that are less congested, based on air quality measurement. As a solution, a route navigation software was designed to calculate the most appropriate itinerary for a specific freight vehicle. The objectives are to reduce the emissions due to freight transport on the city level, reduce and avoid road congestion, and decrease fuel consumption.

Further information about this initiative is available at: http://www.civitas.eu/content/clean-route-planning-freight-transport

Figure 6 Deployment a clean route navigation in Utrecht, The Netherlands

- ***Measure 2: Communication Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I)*** is useful to optimise existing infrastructure reducing traffic congestions and improving road safety. They foster the coordinated management of road and public transport networks and ease the implementation of urban freight logistics and access restriction schemes.

  In many respects today's vehicles are already connected devices. However, in the very near future they will also interact directly with each other and with the road infrastructure. This interaction is the domain of Cooperative Intelligent Transport Systems (C-ITS), which will allow road users and traffic managers to share information and use it to coordinate their actions. This cooperative element – enabled by digital connectivity between vehicles and between vehicles and transport infrastructure – is expected to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation. C-ITS are also highly suited for urban freight.

Further information of C-ITS can be found here: https://ec.europa.eu/transport/themes/its/c-its_en

- **Operations Management -** This group refers to ICT measures related to the planning and monitoring of freight operations. These measures include: the planning of distribution schemes through consolidation centres, merchandise pick-up points, central buffer zones, virtual logistics platforms and proximity areas. Other measures that can be identified in this domain are fleet management systems such as vehicle telematics (on board units), video messaging signs, and others that can be linked to traffic management systems and/or to freight transport management systems. The main responsibility for the deployment of these measures lies with the agents in charge of the logistics operations.

Primarily, these are the logistics operators. This group includes two relevant measures to improve urban freight logistics:

- ***Measure 3: Real Time Logistics Monitoring*** requires several ICT measures such as Automatic Vehicle Location (AVL) or Automatic Vehicle Monitoring (AVM) systems. They collect various type of information, such as location or freight transport conditions. The advantages include enhanced expedition of deliveries and operational efficiency, decreased operational costs or improved incident response. Generally, they use a common architecture which includes a control centre, an on-board system and a communication network which allows a real time logistics monitoring, track and trace (monitoring), vehicles' load, routing and scheduling planning.

  In Malmö, a private courier company installed GNSS equipment in every vehicle in the fleet, in a total of 20, along with handheld devices for more efficient communication between the dispatch centre and the vehicles. The aim was for fewer vehicles to carry out more tasks, thus reducing fuel consumption and pollution. Specific targets included: reduction in emissions of greenhouse gases, particulates and other pollutants; reduction of fleet; less paperwork through the development of digital media; and a greater degree of control at the dispatch centre. The measure was a great success: average driven distances were lowered and coordination improved considerable. Additionally, the total number of tasks per day increased by around 3 percent.

  More information can be retrieved via: http://www.civitas.eu/content/satellite-based-traffic-management

- ***Measure 4: Fleet Management*** are ICT measures that provide assistance to achieve the best utilisation of the fleet. This may include actions such as the allocation of vehicles to services, refuelling options, maintenance schedules and loading capacity maximisation. ICT measures may include vehicle telematics (on board units), video messaging signs and more that can be linked to traffic management systems and/or to freight transport management systems.
  An interesting example of coordination of deliveries occurred in the City of Gothenburg, Sweden, in the segment of consumer companies of office materials. An agreement between a wholesaler and 17 retailers was established. The wholesaler was able to optimise distribution resulting in a better management of the required fleet to serve all of these locations. The initiative showed a decrease of transport frequency by 30% to 80% with a mean of 41%. This means that out of 101.5 transports per month to the target companies, 42 have disappeared as a result of the measure.

  Further information available at:

  http://www.civitas.eu/content/consumer-driven-goods-management-mobility-centre-base

- **Information and Dissemination** - this group refers to ICT measures related to the collection of information about logistics operations and the dissemination with other agents. Information can be collected through one of the abovementioned ICT technologies. The dissemination depends on a set of previously agreed standards and codes, so that relevant information can be automatically exchanged. In this sense, the EC is actively working in the domains of data collection and data sharing[12]. Bearing in mind that urban freight logistics includes many agents, exchange of information is key in promoting efficiency. By way of example, knowing the utilisation of parking spaces, can help logistics and transport companies better plan their routes

This type of ICT measure is being promoted by big players, such as Google. Information management is their core business. They often provide the information for free, earning money from selling individual information or through advertisements. In addition, governmental bodies may also promote such type of ICT measures, in which information may be made available for free or through a specific fee.

This group includes two relevant measures to improve urban freight logistics, data sharing and real time information:

- ***Measure 5: Data Sharing*** includes transport data apps (road traffic data, including managing parking spots through sensors), cost efficient data collection (collection, preparation and sending statistic information to relevant statistical authorities) and the exchange of information between agents and other parties. Another measure that can be used in this domain is the RTIINS systems (real time information on infrastructure network status) that informs on the condition of the infrastructure (e.g. icy roads) and weather conditions.

  By way of example, X-Road is a data exchange platform. It ensures the secure, transparent and automatic communication of data between databases of public agencies (e.g., security forces, health system, municipalities) of the Republic of Estonia. Within the project several X-Road interfaces for databases were developed on various platforms (Java, PHP), as well the X-Road Mini InfoSystem-Portal (MISP). In collaboration with the company Cybernetica AS Aktors, X-Road has been successfully exported to Azerbaijan.

  Further information available at: https://e-estonia.com/component/x-road/

- ***Measure 6: Real Time Information about the Transport System*** this is a particular and popular type of ICT measures focussed on the collection and sharing of data related to traffic conditions. Information about congestion levels is being used on route planning. Additionally, information about the conditions of the infrastructure can also be collected. This may include the existence of road blockage, pavement in bad conditions, non-working traffic lights, etc. Understandably, traffic conditions depend on the conditions of infrastructure conditions. As a consequence, there are several ICT measures that provide both types of information.

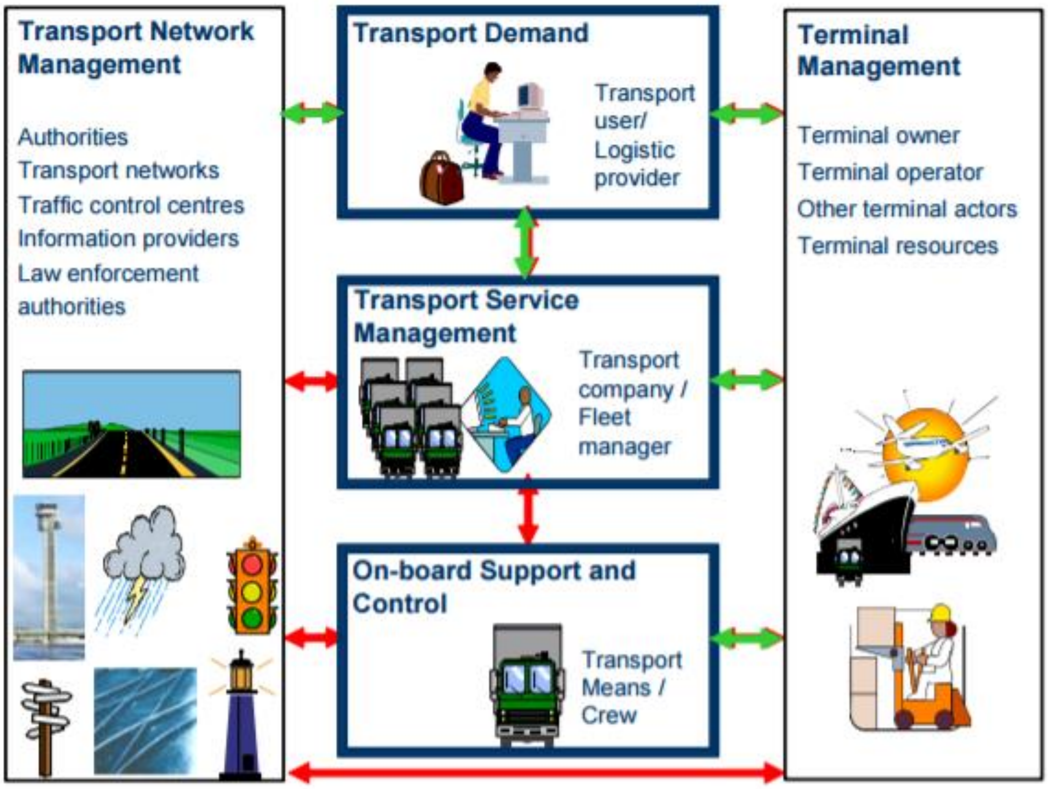
  By way of example, the Norwegian Ministry of Transport and Communications took the initiative to the establishment of ARKTRANS together with the national transport authorities for sea, road, rail and air. This partitioning allows ARKTRANS to simplify the transport sector (Figure 7), which is actually comprehensive and encompasses a large number of actors and activities. Transport users book transport services from transport companies. Fleet managers manage their fleet and follow up the specific transport operations performed by the transport means and their crew. The fleet managers also

[12] More information in Chapter 1.

have to provide the transport users with relevant information about the status of the transport operation (delays, etc.). Before and during the transport operations the transport infrastructure comprised by the transport network and the terminals have to be consulted. Information about traffic conditions is received; or booking of services (customs, loading/unloading, etc.) is done.

Further information available at: http://freightwise.tec-hh.net/Deliverable_D14_1_Component_model_and_config_guidelines.pdf

Figure 7 Architecture of ICT measure



- **Decision Support and Enforcement** - this group refers to ICT measures related to the control and management of freight operation through enforcement and decision support measures. As discussed in Chapter 4, a key problem of urban freight logistics activities is the illegal activity of many loading/unloading activities (e.g. double parking, parking on the sidewalk, or parking on non-authorised locations). Monitoring urban freight logistics activities is an essential step of enforcement. Yet, there are many challenges to it, such as the granularity of the activity or the very short duration of some operations (under 1 minute). Such conditions require permanent and comprehensive surveillance. This is difficult to achieve by use of human resources. ICT measures can provide a valuable help in this domain. By way of example, they can conduct automated surveillance of zones or provide differentiated access to some zones. This type of ICT measure is implemented by (local) authorities, or other mobility agencies, within their responsibility of controlling and monitoring passenger and freight mobility.

  This group includes two relevant measures to improve urban freight logistics:

- ***Measure 7: Access Restrictions and Control***[13] physically alter the road network as a result of reconfiguring streets and accesses, including the creation of pedestrian zones, or controlling access through the installation of bollards or by plate-reading cameras/CCTV. This is commonly used to ensure that only designated vehicles enter specific areas (e.g. historic zones).

Figure 8 Control Access ICT in the city of Burgos

Let us take the Spanish city of Burgos as an example. With the purpose of limiting the negative impacts of urban freight logistics, the municipality has implemented access control measures. Even so several issues remained. Firstly, despite the access control measures, the city centre and some pedestrian areas were permanently occupied by large delivery vehicles. Citizens were worried about these vehicles and troubled by the pollution and noise they caused. Another problem was pinpointed in the zones surrounding the restricted areas where vehicles parked illegally to deliver freight off timetable.

For these reasons, additional areas around the initial were designated for unloading, and a new scheme for distribution in the pedestrian areas was prepared. This was resulting in the use of new clean, silent and slow vehicles that reduced pollution and noise, and a new logistics centre for freight to serve the respective area.

Further information available at:

http://www.civitas.eu/sites/default/files/civitas20caravel20final20project20report20en.pdf

- ***Measure 8: Monitoring of Loading and Unloading Parking Places*** are ICT measures that monitor, commonly in real time, the utilisation of designated parking placed. Illegal utilisation (e.g. illegal duration or non-authorised vehicles) is immediately detected and actions are triggered. This may include image recording or warning of on-street officer. In some cities, such as the city of London, this type of system is linked to reservation systems, which enable transport operators to book a specific place for a time period.

An example is the vehicle parking reservation systems, which makes it possible for drivers to reserve curbside parking space. The program requires stakeholder coordination, as well as strict enforcement. In Toyota City, Japan, a pilot test allowed truckers to reserve parking spaces using cell phones. The parking area was remotely monitored using

[13] The interested reader on access control is referred to the respective Technical Report and Non-Binding Guidance Document.

cameras. The pilot was deemed a success because it led to a 56% reduction of parked vehicles on the street for loading/unloading.

Further information is available at: https://coe-sufs.org/wordpress/ncfrp33/psi/parking_area_management/

Infrastructure – this group refers to ICT measures that change the properties of the transport infrastructure with the purpose to maximise its efficiency. These ICT measures can be embedded in the infrastructure (e.g. detectors) or installed on the infrastructure (e.g. traffic lights, various message signs). Regardless the type, the point is that they influence the traffic behaviour and patterns. By way of example, they may change the lanes, retrain access of certain types of vehicles, or change the timing of traffic lights. The objective is to promote efficiency of the transport infrastructure.

This type of ICT measures is implemented by the (local) authorities, or other mobility agencies, within their responsibility of controlling and monitoring passenger and freight mobility.
This group includes three relevant measures to improve urban freight logistics:

- ***Measure 9: Automated Adjustment of Traffic Rules*** consists of the ability to change the direction or use (e.g. bus lane or freight lane) of the road lanes. By changing the use of the road lane, transport operations may be influenced. This solution assesses how road space can be best used, while integrating urban freight logistics operations with other uses such as public transport and general traffic. At the level of the vehicles and at public transport interchanges working on how to open bus lanes to other vehicles and minimizing impacts on public transport operations. These initiatives promote the use of available road capacity by allocating restricted lane right-of-way to trucks, buses, and occasionally high-occupancy vehicles.

  The lane usage can be allocated to different users using time windows, shared among designated users all day, or restricted to special use for certain users. Restrictions can be by vehicle type, or they can allow mixed traffic during the restriction interval. Cities that have deployed this type of ICT include:

  - Barcelona, Spain – multifunctional lanes in its commercial centre;
  - Gothenburg, Sweden – clean vehicles are allowed to use public transport lanes,
  - Bristol, United Kingdom – consolidation vehicles are allowed to use bus lanes,
  - New York, United States – truck lane restricted to right lane,
  - Georgia, United States – ban on through-trucks on interstate inside the perimeter freeway.

Further information is available at: https://coe-sufs.org/wordpress/ncfrp33/psi/traffic-management/rmul/

- ***Measure 10: Traffic signs*** include the ability to change any traffic sign according to the traffic conditions (e.g. weight restrictions, time window for loading and unloading operations, etc.). Traffic signs can be replaced by digital displays that change information according to current conditions. Among the approaches used to assist truck drivers are signs that provide information about speed limit, access restrictions, loading zones and other regulations. Another type of initiative focuses on the coordination of traffic signals. The Variable Message Signs are commonly used to inform drivers about traffic conditions (e.g., accidents, congested, weather conditions, etc.).

Further information is available here: http://cogistics.eu/

Figure 9 Example of Variable Message Signs

- ***Measure 11: Payment and Collection Systems*** can be used to charge for the utilisation of the infrastructure. This may include the access to a specific urban area, to use a road link or to access a parking place. The actual payment depends on the user and specific regulations. This solution is a typical example of a Vehicle to Infrastructure communication system. A typical example are the road tolls. At EU level some cities have implemented road pricing or congestion charging principles, including the city of London, United Kingdom, or Stockholm and Gothenburg, Sweden. The collection of the fees may be done through ICT.

- **Sharing Economy and e-Commerce Services** - this group refers to ICT measures that enable the establishment of cooperative or distributive urban freight logistics systems and support the delivery of e-business services. Sharing economy is an emergent trend and concept in many domains of economy and society. It loosely denotes to an economic and social system that enables collective access to something (e.g. goods, services, data, etc.). Distinguishing aspects of sharing economy include: 1) providers are not necessarily dedicated companies or professionals, 2) network properties of the system, in which more people means more business opportunities, and 3) the business opportunity (i.e. link between producer and consumer) is created through a technological platform (that shares information).

  According to Robin Chase "The shared economy is based on three miracles: the ability to leverage spare capacity, the exponential effect of shared learning and the omnipresence of resources"[33]. Examples of sharing economy in the domain of transportation include UBER, BlaBlaCar, Zipcar or Lyft. The emergence of this new economy was only possible due to the development of ICT, notably, smartphones, wireless mobile communication and Internet. E-Commerce is the generic term used to designate on-line sales, through a web portal. E-Commerce is one of the six topics prepared within the scope of the Study on Urban Mobility. The interested reader is referred to this topic.

The emergence of e-Commerce was only possible due to ICT, which established a direct communication between seller, consumer and logistics operator.

- ***Measure 12: Shared Economy Platforms*** for supporting urban freight logistics services, including freight-sharing services like the van-sharing service and/or car-sharing service dedicated to the transport of goods. This type of measure is commonly promoted by private operators.

  As an example, in Genoa, a van sharing initiative was introduced with car sharing service especially dedicated to goods distribution. The van sharing service works as a traditional car sharing system. The aim of the initiative was to incentivise retailers and other receivers to abandon the use of their private vehicles when restocking their shops, and instead to share vehicles when the use of professional transport is not possible. The first results were positive with an increase of 19% in the number of rides, 46% in kilometres covered and 69% in hours.

Further information is available at:
http://www.civitas.eu/sites/default/files/civitas20caravel20final20project20report20en.pdf

Figure 10 Van sharing in Genoa, Italy

- ***Measure 13: Collaborative Platforms*** for promoting the exchange and share of information between agents. A measure to alleviate urban freight logistics challenges is the establishment of a community of users (e.g. freight partnerships). In such a community, agents share their challenges and present their points of view. The purpose is to bridge the differences through dialogue and understanding. Agents work on the differences and common points, aiming to identify feasible actions.
  Commonly, this is done through physical meetings, which are costly and cumbersome. ICT may be used to promote exchange of information in a simple and efficient way.

  In Stockholm, the access for delivery of goods is restricted in the house district of Hammarby Sjöstad. As a consequence of a recent housing expansion, the construction site would receive over 400 uncoordinated deliveries per day, or roughly 700 tons of construction material per day during peak periods. Aiming to reduce the number of individual delivery trips into the area through co-transportation, a support logistics centre was implemented. The logistics centre provided coordinated transportation of goods, temporary storage, and smart traffic guidance. Quantities of material below four pallets are consolidated at this warehouse. Twice per day a truck delivered the consolidated goods at the construction site. In order to avoid traffic jams on the site, deliveries not passing though the logistics centre were centrally coordinated. The logistics centre reduced the number of small direct deliveries by 80 percent during peak periods.

Further information is available at:

http://www.civitas.eu/content/optimising-freight-deliveries-construction-sites

Chapter 7 Conclusions

ICT is nowadays at the backbone of many logistics and freight transport companies. Indeed, the capacity to monitor operations, and retrieve, share and process information lies at the core of the competitiveness of many agents. The technological development of recent decades resulted in the proliferation of ICT equipment and low prices. As a consequence, nowadays, there is a vast amount of ICT measures that can be used to improve the efficiency and sustainability of urban freight logistics services.

In order to better understand how to deploy ICT, the report discusses a set of aspects, including the urban freight logistics system: stakeholders, challenges and influence of context (through the concept of LP). Among these, it is important to recap that the challenges that potentially need to be addressed when dealing with ICT include:

1. Complexity of urban freight logistics activities;
2. Low interest in cooperation;
3. Excessive demand for road transport services;
4. Handling (loading/unloading) operations;
5. Insufficient enforcement of regulations;
6. Sub-optimal use of vehicles and inefficiency of processes.

Based on a thorough search of available literature, a total of thirteen ICT measures were identified:

- *Vehicle Support Equipment*: Navigation software & location equipment, Communication Vehicle to Vehicle & Vehicle to Infrastructure;
- *Operations Management*: Real time logistics monitoring, Fleet management (planning);
- *Information and Dissemination*: Data sharing, including Big-Data, Real time information of transport system;
- *Decision Support and Enforcement*: Access restrictions and control, Real time monitoring logistics operations;
- *Infrastructure Technology:* Dynamic allocation of road lanes & Traffic rules, Traffic signs, Payment & collection system;
- *Sharing Economy and e-Business Services:* Shared economy platform, Collaborative platforms.

In order to help public stakeholder identifying ICT measures a step-wise approach is proposed:

- Step 1 – Delimiting the Area of Intervention
- Step 2 – Characterisation of LP
- Step 3 – Selection of ICT Measures: LPs and economical dimension
- Step 4 – Definition of Performance Variables and Metrics
- Step 5 – Implementation of ICT Measures and Drive Results

Based on the technical works, a set of recommendations for the implementation of ICT measures was elaborated.

Conclusion 1: Investigate the urban freight logistics issue thoroughly

Each urban freight logistics issue is a unique combination of different aspects such as stakeholders, location or products. Use the concept of Logistics profile to duly characterise the issue. The concept of Logistics Profile will provide guidance on the relevant variables and will also enable comparability with other cases.

Analysis of the concern might entail various forms of qualitative and quantitative data collection techniques. ICT are increasingly valuable to spot urban freight logistics issues. In this sense, the Information and Dissemination Group, the Decision Support and Enforcement Group or the Infrastructure Technology Group is of particular interest. Other techniques may be used, including:

- Gathering objective field data: emissions, numbers of vehicles (types, time patterns) and congestion data.
- In-depth interviews.
- Focus groups. The advantage of using focus groups is to obtain information from individuals affected by the issue or who are close to the solution.. Best practice can be taken from the airline industry
- Ex ante behavioural surveys. Whilst the previous two techniques are qualitative in nature, behavioural surveys tend to produce quantitative estimates of how the scheme considered for implementation would be affected by a given policy or program.

Conclusion 2: Listen to and engage stakeholders in order to resolve the issues

A distinguishing feature of urban freight logistics is the ecosystem of relevant stakeholders: producers, wholesalers, logistics & freight transport operators, receivers, citizens or public authorities. Each has unique features, perspectives, objectives or strategies. The success of any measure largely depends on their engagement. Stakeholders are in a privileged position to identify and help characterising the issue. They can also give inputs on the most suitable ICT measures. And, naturally, they will have to deploy and use it.

For all of this, it is vital to engage and listen to the key stakeholders. Effective engagement of stakeholders (e.g. residents, local retailers and regional logistics operators) brings multiple benefits, such as:

- Lead to common confirmation (or adjustment) of the issue to be resolved, or mitigated, by a policy intervention;
- Will provide the public and private sector with a full understanding of the constraints and expectations of the various stakeholders;
- Will enable the policy maker to chart implementation paths that have a better chance of succeeding.

Both public and private sector representatives need to feel that their points of views are being heard and taken into account.

Additionally, analysing other cities and cases is beneficial to understand the difficulties, advantages and disadvantages. Associations, Platforms and Forums gather knowledgeable people and companies. Their recommendations are thus valuable. Examples include the Digital Transport and Logistics Forum or the European Transport Platform ALICE.

Conclusion 3: Promote and ensure the interoperability of ICT measures by e.g. implementing the ITS Directive

Information interoperability remains the Achilles heel of ICT. Many urban freight logistics stakeholders use proprietary information systems with limited or none communication capabilities. This strongly limits the creation of synergies.

Promoting and ensuring interoperability is fundamental. We suggest following the guidelines and recommendations laid down within the ITS Directive.

Conclusion 4: Be aware and mitigate the hidden challenges of ICT

Despite the potential advantages of ICT, technology is subject to a **high rate of obsolescence**. That is, in a matter of months or few years, the existing technology may be no longer proper to use. This should be considered in the financial analysis, technical specification and contracts. Otherwise, there is the risk of coming to a halt.

Another important aspect concerns **information security**. Any information transmitted over a network such as the Internet or wireless can be captured by any other entity. Despite all available security measures, the risk of undesired access continues to exist. Particular care should be taken to transmit anonymous and encrypted data. Moreover, ICT systems should be kept up to date to ensure that the latest security measures are in place. Again this will influence the financial analysis technical specifications and contracts.

Conclusion 5: **Evaluate and adjust** (if necessary)

As the ICT solutions directly or indirectly will have measurable impacts on emissions and congestion it is important to organise evaluations of the schemes. The evaluation compares the data retrieved in step 1, where the problems are mapped and examined, with the current congestion and emission levels.

ICT tools have been progressively transforming societies and economies worldwide. They have generated efficiency gains and cost reductions in many business segments. Nowadays, all actors of the urban logistics ecosystem – producers, consumers, logistics operators and public authorities – can make use of ICT tools to monitor, collect, transfer and store data. Additionally, data can be analysed so that information and intelligence can be derived. Unfortunately, a long way lies ahead as ICT benefits are still seldom explored. Despite the advantages of ICT, there are also noteworthy disadvantages such as i) security issues, related with the storage and transmission of information, ii) difficulties of interoperability, which the EC has been working to mitigate, or iii) the acquisition and maintenance costs, since the rapid pace of technological development results in the rapid obsolescence of equipment.

References

[1] D. Albalate and G. Bel, "Factors explaining urban transport systems in large European cities: A cross-sectional approach," Barcelona, Spain, IREA Working Papers 200905, 2009.

[2] R. Gevaers, E. Van de Voorde, and T. Vanelslander, "Cost Modelling and Simulation of Last-mile Characteristics in an Innovative B2C Supply Chain Environment with Implications on Urban Areas and Cities," *Procedia - Soc. Behav. Sci.*, vol. 125, pp. 398–411, Mar. 2014.

[3] G. Horton, M. Biedka, C. Chif, C. de Stasio, C. Doll, L. Meija-Dorantes, H. Bruhova-Foltynova, Z. Sperat, R. Jordova, D. Bárta, A. Polydoropoulou, and I. Skinner, "Research Theme Analysis Report - Cooperative Intelligent Transport Systems," Brussels, Belgium, 2016.

[4] European Commission, "COM(2008) 886 final - Action Plan for the Deployment of Intelligent Transport Systems in Europe," Brussels, Belgium, 2008.

[5] European Parliament and Council, *Directive 2010/40/EU on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transpor*. 2010, p. 13.

[6] Urban ITS expert group, "Potential neds for standardisation of urban ITS," Brussels, Belgium, 2013.

[7] CEN/TC/278, "Pre-study Urban ITS - Standards and actions necessary to enable urban infrastructure coordination to support Urban-ITS," Brussels, Belgium, 2016.

[8] European Commission, "COM(2016) 176 final - ICT Standardisation Priorities for the Digital Single Market," Brussels, Belgium, 2016.

[9] European Commission, "Rolling Plan for ICT Standardisation," Brussels, Belgium, 2016.

[10] R. Macario, L. Filipe, V. Reis, and P. Martins, "Elements for a Master Plan in Urban Logistics," in *Proceedings of City Logistics*, 2007.

[11] R. Macário, "Modeling for Public Policies Inducement of Urban Freight Business Development," in *Freight Transport Modelling*, M. Ben-Akiva and E. Van de Voorde, Eds. Emerald Group Publishing Limited, 2013, pp. 405–432.

[12] TURBLOG, "Deliverable 2 - Business Concepts and Models for urban logistics," 2011.

[13] F. Russo and A. Comi, "City Characteristics and Urban Goods Movements: A Way to Environmental Transportation System in a Sustainable City," *Procedia - Soc. Behav. Sci.*, vol. 39, pp. 61–73, 2012.

[14] R. Macario, "Innovation policy as a driver for the development of urban freight logistics," Leipzig, Germany, 2012.

[15] L. Dablanc, "Commercial Goods Transport in Paris, France," Case study prepared for Global Report on Human Settlements 2013, 2013.

[16] MDS Transmodal Limited, "DG MOVE European Commission: Study on Urban Freight Transport," 2012.

[17] J. F. Ehmke, S. Meisel, and D. C. Mattfeld, "Floating car based travel times for city logistics," *Transp. Res. Part C Emerg. Technol.*, vol. 21, no. 1, pp. 338–352, Apr. 2012.

[18] E. Taniguchi and D. Tamagawa, "Evaluating city logistics measures considering the behavior of several stakeholders," *J. East. Asia Soc. Transp. Stud.*, vol. 6, pp. 3062–3076, Jan. 2005.

[19] C. Gomes, "Optimisation model for determining the optimal location of a consolidation centre: case study of Glasgow," Instituto Superior Técnico, University of Lisbon, 2015.

[20] M. Kiba-Janiak and K. Cheba, "How Local Authorities are Engaged in Implementation of Projects Related to Passenger and Freight Transport in Order to Reduce Environmental Degradation in the City," *Procedia - Soc. Behav. Sci.*, vol. 151, pp. 127–141, Oct. 2014.

[21] Transportation Research Board, *City Logistics Research - A Transatlantic Perspective: Summary of the First EU-U.S. Transportation Research Symposium*. Washington DC, United States, 2013.

[22] K. Zografos and A. Regan, "Current Challenges for Intermodal Freight Transport and

Logistics in Europe and the United States," *Transp. Res. Rec. J. Transp. Res. Board*, vol. 1873, pp. 70–78, Jan. 2004.

[23] J. H. R. van Duin, H. Quak, and J. Muñuzuri, "New challenges for urban consolidation centres: A case study in The Hague," *Procedia - Soc. Behav. Sci.*, vol. 2, no. 3, pp. 6177–6188, 2010.

[24] L. Dablanc, "Goods transport in large European cities: Difficult to organize, difficult to modernize," *Transp. Res. Part A Policy Pract.*, vol. 41, no. 3, pp. 280–285, Mar. 2007.

[25] TIS.PT, NEA, UNIVLeeds, S. Inovamais, BHTRANS, PTL-UNI, and TIS.BR, "TURBLOG-Deliverable 1. A worldwide overview on urban logistics interventions and data collection techniques," Lisboa, Portugal, 2010.

[26] S. Balm and H. Quak, "Deliverable D3.3 - Description of indicators, KPIs and measurement methods," 2012.

[27] D. Banister and D. Stead, "Impact of information and communications technology on transport," *Transp. Rev.*, vol. 24, no. 5, pp. 611–632, Sep. 2004.

[28] W.-J. Zondag, "Competing for Air Cargo – a Qualitative Analysis of Competition in the Air Cargo Industry," Free University of Amsterdam, 2006.

[29] G. Marchet, A. Perego, and S. Perotti, "An exploratory study of ICT adoption in the Italian freight transportation industry," *Int. J. Phys. Distrib. Logist. Manag.*, vol. 39, no. 9, pp. 785–812, Oct. 2009.

[30] A. Perego, S. Perotti, and R. Mangiaracina, "ICT for logistics and freight transportation: a literature review and research agenda," *Int. J. Phys. Distrib. Logist. Manag.*, vol. 41, no. 5, pp. 457–483, Jun. 2011.

[31] S. J. Mason, P. Mauricio Ribera, J. A. Farris, and R. G. Kirk, "Integrating the warehousing and transportation functions of the supply chain," *Transp. Res. Part E Logist. Transp. Rev.*, vol. 39, no. 2, pp. 141–159, Mar. 2003.

[32] G. M. Giaglis, I. Minis, A. Tatarakis, and V. Zeimpekis, "Minimizing logistics risk through real-time vehicle routing and mobile technologies," *Int. J. Phys. Distrib. Logist. Manag.*, vol. 34, no. 9, pp. 749–764, Oct. 2004.

[33] R. Chase, "What the rise of the sharing economy means for transport," 2015.

Further reading

- BESTUFS. *BEST Urban Freight Measures*. Available at: http://www.bestufs.net/download/BESTUFS_I/deliverables/BESTUFS_I_Results_Deliverable4.pdf

- CIVITAS. *Policy recommendations for EU sustainable mobility concepts based on CIVITAS experience*. Available at: http://civitas.eu/sites/default/files/civitas-policy-recommendations_0.pdf.

- CIVITAS. *Urban logistics: Access restriction and control - Lessons learned from CIVITAS PLUS*. Available at http://www.civitas.eu/content/urban-freight-logistics-access-restriction-and-control-lessons-learned-civitas-plus

- CIVITAS. *Policy recommendations for EU sustainable mobility concepts based on CIVITAS experience*. Available at: http://civitas.eu/sites/default/files/civitas-policy-recommendations_0.pdf

- DG MOVE. *EC: Study on Urban Freight Transport - FINAL REPORT*. Available at: http://ec.europa.eu/transport/themes/urban/studies/doc/2012-04-urban-freight-transport.pdf

- ELTIS Portal. *The urban mobility observatory: Enlarged goods distribution scheme in Genoa/Italy*. Available at: http://www.eltis.org/

- EC. *COM(2013) 913 final - Together towards competitive and resource-efficient urban mobility*. Available at: http://ec.europa.eu/transport/themes/urban/doc/ump/com%282013%29913_en.pdf.

- FREIGHTWISE. *Management Framework for Intelligent Intermodal Transport*. Available at http://freightwise.tec-hh.net/Deliverable_D14_1_Component_model_and_config_guidelines.pdf

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