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Final Report

Use of information and communication technologies

Non-binding guidance documents on urban logistics

N° 1/6

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Glossary and definitions

B2C:	Business To Consumer
CO_2:	Carbon Dioxide
DTLF:	Digital Transport and Logistics Forum
EC:	European Commission
EU:	European Union
GNSS:	Global Navigation Satellite System
ICT:	Information and Communication Technology
ITS:	Intelligent Transport System
NBGDs:	Non-Binding Guidance Documents
NOx:	Nitrogen Oxide
PM:	Particulate Matter
LP:	Logistic Profile
TURBLOG:	Transferability of Urban Logistics Concepts and Practices from a World Wide Perspective
UL:	Urban Logistics
US:	United States
V2I:	Vehicle to Infrastructure
V2V:	Vehicle To Vehicle

Chapter 1 Introduction

Non-Binding Guidance Documents

This document is one of a series of six Non-Binding Guidance Documents (NBGDs) prepared within the scope of the Study on Urban Mobility - Preparation of EU guidance on Urban Logistics (MOVE/C1/2014-370) as commissioned by the European Commission. The documents 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.

This non-binding guidance document (N° 1 out of 6) covers the issue of the use of information and communication technologies (ICT). It provides the user with the necessary knowledge and tools to identify and deploy ICT-related measures to mitigate and, ideally, solve issues arising from urban logistics activities[1].

ICT solutions for mitigating challenges in urban logistics

Emissions and road congestion have been ranked as the two most important challenges posed by freight transport and logistics in urban areas[2]. Additional issues for urban logistics are (i) the lack of parking areas for loading and unloading, (ii) lack of space for logistics facilities leading to relocation and concentration in suburban areas (logistics sprawl), (iii) regulatory procedures, (iv) noise, (v) poor liveability in urban areas, (vi) costs for logistics suppliers, (vii) poor enforcement of regulations, (viii) energy costs, and (ix) infrastructure wear and tear[3].

Over the last couple of decades, the European Commission has been actively working on the development and deployment of ICT at EU level. The Commission has proposed 16 initiatives set out in the Digital Single Market strategy (adopted in May 2015[1]). 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. More information on all the actions and progress can be retrieved via this website: https://ec.europa.eu/commission/priorities/digital-single-market

The flagship initiative related thereto is the well-known ITS Directive (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 transport[4]. 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 in particular calls for the interoperable access and exchange of travel and traffic data incl. the use of standards and data sharing mechanisms including National Access Points. 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) are close to adoption[2].

The European Commission 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 European Commission in respect of the preparation of standards in the field of Intelligent Transport Systems[3]. In May 2016, the CEN established a new Working Group (WG17) on Urban-ITS. The establishment of WG17 was

[1] COM(2015) 192 final
[2] The ITS Directive established six priority actions. Priority A is "EU-wide Multi-Modal Travel Information" and Priority B is "EU-wide Real-Time Traffic Information". Further information available at: http://bit.ly/1yjwMQM
[3] More information available at http://www.itsstandards.eu

accompanied with the publication of a pre-study aimed at identifying gaps and overlaps in ITS standards at urban level[5]. 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. Further development is expected in the coming months or years, as the works proceed.

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)[4]. 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 final initiative worth mentioning is the ETP-ALICE[6]. ETP-Alice is a platform of experts, academics and logistics companies. It aims to develop a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovation in Europe.

This NBGD aims to assist the policy maker by offering current best practices for the use of ICT. This non-binding guidance document (i) describes the major challenges choosing and implementing ICT solutions for managing the logistics sector within the urban context, (ii) offers various options to address these challenges, (iii) describes the advantages, disadvantages and impacts of these options, (iv) helps choose the optimal policy approach, and (v) offers guidance on the main implementation issues as well as some solutions to mitigate undesirable impacts of the scheme.

The goal of these Non-Binding Guidance Documents (NBGD) is to support local authorities who are planning to introduce ICT tools, by providing non-binding guidance. The guidance is primarily aimed to be used by public authorities such as municipalities or local agencies, responsible for the management of the traffic, transport and transport infrastructures within urban areas. Furthermore, logistics and freight transport operators with operations in cities may also benefit from this document. No background in logistics or freight transport is required to understand this document. More in-depth examples, references and practical guidance can be found in the fully referenced Technical Report on which this less technical NBGD is based.

[4] More information is available at: http://bit.ly/1E1kopw and http://bit.ly/2p9p21N
[5] More information is available at: http://bit.ly/1n3FzMb
[6] More information available at: http://www.etp-logistics.eu

Chapter 2 Challenges for city policy makers in applying ICT solutions

This section describes the main challenges resulting from urban logistics activities, paying particular attention to those that can be solved, or at least, mitigated by ICT-related measures [6].

Figure 1 Key Challenges of Urban Freight Logistics

1. Complexity of the Urban Freight Logistics System

A distinguishing feature of urban freight logistics is the presence of a large ecosystem of stakeholders, namely: producers, logistics & freight transport operators, retailers, citizens or public authorities. Each stakeholder has specific perspectives, strategies or modus operandi, which are not necessary compatible. By way of example, logistics & freight transport operators would like to freely choose their delivery hours; while citizens and public authorities prefer to concentrate deliveries off-peak. A second distinguishing feature is the diversity of urban freight logistics chains, in terms of the type of goods (e.g., food vs. non-food delivery), location (e.g., office vs. home deliveries) and nature (e.g., express services). Again, each chain has specific features which must be taken into consideration. By way of example, express service is often based on time window deliveries, which may be heavily disturbed if control access regulations limit access to certain hours of the day. A third aspect is related to the issues generated by urban freight logistics, which contribute to traffic congestion, the degradation of transport infrastructure and greenhouse gas emissions. These penalties however, are borne by Society and not by the responsible stakeholder. Ensuring that each stakeholder pays the full societal costs of its activities is difficult.

2. Low Interest in Cooperating

Urban freight logistics stakeholders typically demonstrate a very low willingness to cooperate. Logistics is a highly competitive sector, and bearing in mind that cooperation entails sharing information and resources, stakeholders' interest is understandably reduced. They fear losing their competitive edge. Also, some business segments are characterised by secrecy or at least

by some reservations to shared delivery of their products with others, for fear of damage to their goods or of losing control over overall service quality.

3. Excessive Demand for Road Transport Services

Urban freight logistics operations are primarily 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 polluting. The outcomes are congestion and worsening traffic fluidity (for example: a double-parked truck creates a bottleneck in the road), and growing conflicts with other vehicles and pedestrians (in case of parking on sidewalks).

4. Handling Operations

These refer to the movement of goods between the vehicle and the delivery point (e.g., house, restaurant, office, etc.). They are often done in unlawful conditions, such as by parking vehicles outside designated loading bays, on street, on bus lanes, on cycling paths or on sidewalks. This results in conflict with other users of the public space (e.g. with pedestrians in case of parking on the sidewalk). The causes 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 often occupied by cars). Many of the deliveries are completed in a very short period of time (less than three minutes). Then, there is a higher propensity for illegal behaviour (for example, double parking of the vehicle).

5. Insufficient Enforcement of Regulations

Adequate enforcement is the key to ensure that law and regulations are complied with. Yet, enforcement of urban freight logistics activities is generally weak. Available enforcement resources tend to be scarce, and urban freight logistics do not rank higher in priorities. 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 unmarked vehicles. Identification of such vehicles is difficult. Thirdly, the available public space is often scarce and there are simply no available parking spaces.

6. Sub-optimal utilisation of vehicles or road space and inefficiency of processes

A final challenge 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), or inappropriate driving or handling behaviour (e.g. leaving the vehicle idling during stops). Indeed, a significant share of vehicles is run with reduced load factors. Several causes 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.

It is not only urban freight logistics that offers relevant challenges. Implementing ICT tools is also a challenge. The main challenges for implementing ICT to improve the functioning of the logistics sector in an urban context are threefold[7], [8]:

1. Owing to the accelerated rate of technological development, there is a **high rate of obsolescence**. That is, in a matter of just months or a few years, the existing technology is no longer useful. New software releases are often not compatible with the older versions and even may require new types of hardware. Companies are then required to regularly invest in maintenance and acquisition of the latest versions and equipment.

2. **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 undesirable access continues. In addition, remote repositories of data, typically designated as Cloud Services, may also be accessed by undesirable parties.
3. **Communication and information interoperability** is often an issue with ICT systems. Companies implement their own systems and solutions. These systems follow specific communication protocols which are not necessarily compatible with others.

Chapter 3 Policy options for choosing ICT solutions for urban logistics issues

3.1 Six clusters of ICT Measures

Information and Communication Technologies (ICT) is a generic term that refers to any technology that, either standalone or as part of a large system, is able to capture, retrieve, store and communicate information to other technologies or people. ICT proved to be instrumental in the efficiency of many logistics and transport operators[9].

The so-called integrators, such as DHL, TNT, FedEx, UPS or Chronopost, rank amongst the most technology-developed companies; e.g. UPS has its own dedicated communication satellite.

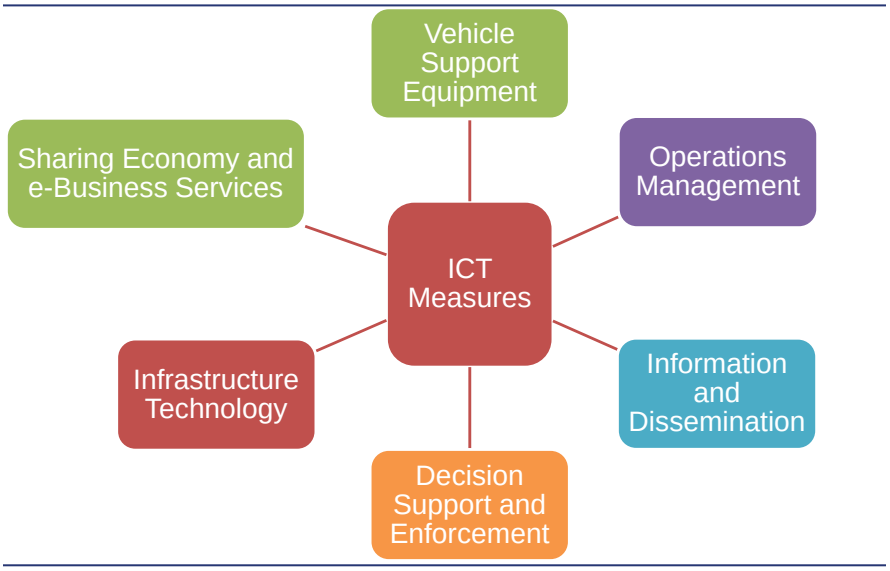
ICT generates efficiency gains and cost reductions. The provision of route guidance, commonly designated as journey planner, is a good example of an ICT solution, both for freight and people. The advantages are numerous, including finding optimal routes, assessing traffic conditions or identifying available loading/unloading bays.
Recent advances in ICT at the level of monitoring, transmission and storage open the door to better and more data, leading to improved control over urban logistics activities (e.g.: routes, vehicles, delivery times, etc.).

Public authorities are nowadays able to retrieve freight traffic information at city or metropolitan level. Logistics operators can track and trace, in real time, freight and patterns of freight vehicles and operations. Producers can monitor real time consumption patterns, anticipate new needs and react accordingly. Logistics operators can optimise their distribution network, and optimise fleets or loading plans. Public authorities can take decisions concerning regulations and other matters, in a more informed way. And consumers can follow the transport of their goods and have a good idea about their estimated arrival time.

This NBGD offers an overview of 13 ICT solutions. These solutions can, either individually or collectively with other measures and actions, actively contribute to mitigate the issues stemming from urban logistics.

The 13 ICT measures have been clustered into six domains, according to their nature and application (Illustrated in Figure 2).

Figure 2 Six Clusters of ICT Measures



- **ICT measures related to Vehicle Support Equipment**

  This cluster refers to the various ICT measures that follow on-board vehicles. These technologies have multiple applications depending on their nature. They can collect information about the location of the vehicles and goods, monitor the conditions of the vehicles (e.g.: tire pressure or motor consumption rates) or even autonomously send messages to or receive messages from other machines or people. The impacts are manifold, and include helping vehicle drivers make better and informed decisions, improving transport safety and improving management related operations. Practical examples include: the support to eco-drive, adaptive speed limiters and an enhanced "green driving" support system; collision avoidance systems that use lateral collision avoidance, intersection collision avoidance, vision enhancement for crash avoidance, safety readiness, pre-crash restraint deployment and automated vehicle operation. Two measures[7] are suggested in this cluster:

  - Measure 1: Navigation Software & Location Equipment;
  - Measure 2: Communication Vehicle to Vehicle & Vehicle to Infrastructure.

- **ICT measures related to Operations Management**

  This cluster refers to ICT solutions that can aid 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 solutions are fleet management systems such as vehicle telematics, video messaging signs and others that can be linked to traffic management systems and/or to freight transport management systems. Impacts can be expected in the reduction of congestion, optimal use of parking spaces and loading/unloading areas, and the improved functioning of consolidation centres. Two measures are suggested in this cluster:

  - Measure 3: Real Time Logistics Monitoring;
  - Measure 4: Fleet Management.

- **ICT measures related to Information and Dissemination**

  This cluster refers to ICT solutions that can collect data related to urban logistics activities, such as route, speed, traffic conditions or occupancy of loading and unloading bays. These data can be processed and then distributed to other actors. By way of example, information on the availability of loading/unloading bay areas can be made available in variable message panel displays.
  These data can then be made available to different urban logistics actors. Impacts can be expected in higher efficiency of logistical chains, better understanding of the issues, better dimensioning of policies, increased impact of policies or improved support for and acceptance of urban logistics policies. Two measures are suggested in this cluster:

  - Measure 5: Data Sharing;
  - Measure 6: Real Time Information about the Transport System.

- **ICT measures related to Decision Support and Enforcement**

  This cluster refers to ICT solutions that can process large quantities of information and can help public authorities to take decisions and become more effective. In addition, these ICT solutions can help authorities to improve the control and management of freight operations through enhanced monitoring and enforcement. Examples of utilisation include access regulation[8] of freight vehicles in certain city areas, or regulation of loading operations by installing bollards or plate-reading cameras. Two measures are suggested in this cluster:

  - Measure 7: Access Restrictions and Control;

[7] A more detailed description of each of these and other measures can be found in the Technical Report that lies at the basis of this NBGD.
[8] The interested reader on access regulation is referred to NBGD 2 and the respective Technical Report.

- Measure 8: Real Time Monitoring of Logistics Operations.

- **ICT measures related to Infrastructure Technology**

  This cluster refers to ICT solutions embedded on or in the transport infrastructure. Such solutions are able to change transport infrastructures' characteristics in order to increase the safety and efficiency of freight operations. Examples include the dynamic allocation of dedicated lanes and lane prioritizing, or the dynamic adjustment of traffic signals by the use of variable message signs and sign posting freight routes. Another example is Dynamic electronic toll collection for freight vehicles. Three measures are suggested in this cluster:

  - Measure 9: Automated Adjustment of Traffic Rules;
  - Measure 10: Traffic signals;
  - Measure 11: Payment & Collection Systems.

- **ICT measures related to the Sharing Economy and e-Business Services**

  This cluster refers to ICT that can support e-business, sharing economy services and web platforms. Businesses supported by this ICT include freight-sharing services like van-sharing services and/or car-sharing services dedicated to goods transport. An emerging business model is related to instant home-delivery companies. These companies deliver catered food or groceries, or any other retail products. Examples include companies like Instacart or Postmates (in the US). There is a fee associated with these services. Other examples include cooperative web-based platforms that use virtual distribution centres, freight partnership schemes and driver support. Three measures are suggested in this cluster:

  - Measure 12: Shared Economy Platforms;
  - Measure 13: Collaborative Platforms.

3.3. Main impacts on urban logistics of implementing these ICT solutions

The main impacts of the introduction of ICT solutions that can be expected are the following:

- Gain more insight into the complexity of urban logistics activities, **enabling better suited policies** to mitigate the ensuing issues;
- Providing better insights into the expected benefits of improvements will create **more interest and support for cooperation** of all stakeholders;
- **Reduce the demand for road transport services** by offering more efficient transport solutions
- **Increase the efficiency of the freight handling** (loading/unloading operations) operations;
- **Better enforcement** of freight transport regulations;
- **More efficient use of freight vehicles** and reduction of the inefficiency of logistics processes.

Together these impacts of ICT solutions will lead to better realisation of the overall objectives of the urban freight policies, reduce congestion and emissions, whilst ensuring optimal economic and social benefits for the urban area concerned.

The next section develops a step-by-step approach for choosing the best fitted ICT solution for dealing with urban logistics challenges.

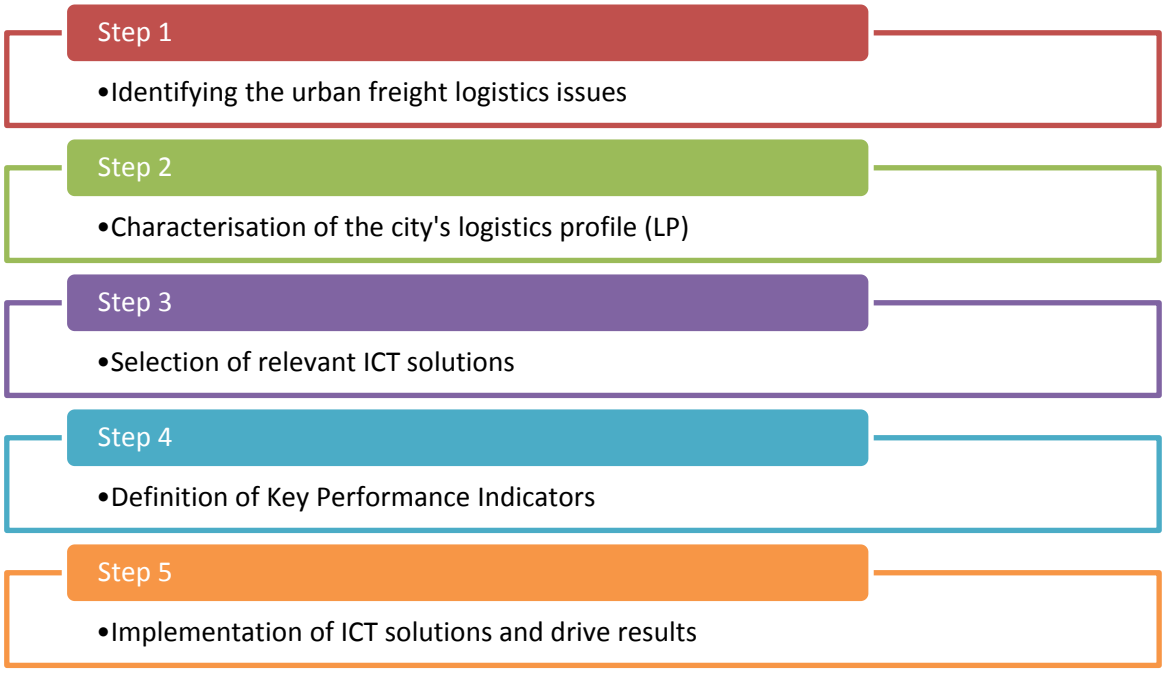
3.4 Choosing the best fitted ICT solutions

The selection of the most appropriate ICT solution depends on the identification of the drivers and nature of the issues and challenges, expected objectives, physical properties of the city and even the nature of the logistics and 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 impact studies. Just because an ICT measure was successful in city A does not guarantee that it will be successful in city B.

The suggested approach consists of five steps as portrayed in Figure 3, and explained from page 14 onwards.

Figure 3 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

This step begins with the identification of the challenges to be addressed. 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:

- A double parked freight vehicle parked disturbs the traffic flow;
- a freight vehicles parked on the sidewalk preventing the normal pedestrian flow;
- moving freight in between vehicles and store may conflict with crossing vehicles or pedestrians; or
- 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 issues of that challenge are felt. The typical case is

either a street or borough (e.g., historic district). If impacts spread to adjacent streets, they should also be included in the area of intervention.

The identification of the issue can be achieved in different ways, such as direct observation of urban logistics operations, feedback from citizens, or meetings with stakeholders[10]. 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 are of particular interest. Chapter 6 of the Technical Report Document provides detailed information on the usefulness of ICT in identifying 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.

In addition to challenges, efforts should be made to identify their causes. The isolation of the cause of an issue is relevant because often different causes require different solutions.

The vehicles that deliver fresh food to retail stores as well as the vehicles that deliver urgent documents may both induce congestion. Yet, the underlying logistics chains follow very different principles and must be addressed separately. Two different ICT solutions are likely to be required.

Step 2 – Characterisation of the city's Logistics profile (LP)

The second step entails the identification and isolation of homogeneous groups of logistics needs within the area of intervention. We call such homogeneous group a Logistics Profile (LP). 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 LP of a given urban area is defined by the interaction of three key aspects (Figure 4): 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. In addition, it is necessary to set a scale, in order to quantify (or qualify) each of the features identified[9]. Based on this classification, conditions are met to identify and characterise the LPs.

[9] The Technical Report provides additional resources to support the identification and characterisation of the LPs.

Figure 4 Logistics Profile

Source: adapted from Macário[11]

Previous research[11] has identified six Logistics Profiles, which 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 known for furniture stores, craft or art pieces, technological pole);
- 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 in residential areas.

The existence of these profiles locally should of course be confirmed via case studies. These profiles can then be combined with **product characteristics** (ease of handling, specific conditions) and with **agents and deliveries' properties** (urgency, frequency, amounts, planned/unplanned). The combined positioning of the city in these three domains then offers guidance as to which ICT solution will be most effective.

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 considerably. In addition, 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

In Stockholm, the access for delivery of goods is restricted in the residential 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 were consolidated at this warehouse. Twice per day a truck delivered the consolidated goods to the construction site. To avoid traffic jams at 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. More information can be retrieved via: http://www.civitas.eu/content/optimising-freight-deliveries-construction-sites

Colruyt and Delhaize are Belgian food retailers. In Brussels, the companies face average delays of over 33% during peak traffic hours. They decided to initiate night deliveries in five designated areas. Most Colruyt and Delhaize shops in Brussels currently have an environmental permit allowing them to load and unload between 7am and either 7pm, 8pm, 9pm or 10pm. There were several objectives: fewer trucks on the road during the peak hours and reduced traffic congestion, increased traffic safety in city centres because trucks are less often confronted with vulnerable road users; and fewer emissions because trucks are not stuck in traffic. The delivery routine was carried out between 8pm and 10pm using 'silent' trucks and equipment. Results were positive and evidenced: a viable business case that can balance the cost reductions (time gains, fuel gains, etc.) and the increases in costs (labour costs, investment costs, etc.); reduction of CO_2, NOx and PM_{10} emissions of around 20%, 40% and 40% respectively. More information can be retrieved via: http://www.straightsol.eu

Step 3 – Selection of relevant ICT Solutions

The actual contribution depends on the logistics profile, the nature of the challenges and other contextual properties. The implementation of an ICT solution may require significant investment. In this context, open data and open source platforms are quite promising, due to lower costs (e.g., no fees and no royalties). Investments must be compared against the expected benefits and, obviously, the available budget. Several tools can be deployed, such as cost-benefit analysis, multicriteria analysis or even simulation. It is also important to understand how each ICT solution impacts on the different decision levels and on the stakeholders (agents) at that level[12]. The final choices should have sufficient support from the urban logistics actors, which commonly entails round tables and similar discussion fora[10].

[10] The interested reader on stakeholder engagement is referred to NBGD 3 and the respective Technical Report.

Looking elsewhere for similar initiatives and learning from past experiences can reveal implementation and acceptability difficulties, and can also disclose hidden disadvantages or advantages. Forums and platforms, such as the DTLF or the European Technology Platform 'ALICE' can provide valuable information.

Legislation and regulations at different governmental levels also play an important role in the choice process, as they may determine specifications and requirements on both technology (e.g., standards, specifications) and data utilisation (e.g., security, or access). Note that ICT data on urban logistics may concern persons and/or companies, which are subject to specific legislation on security and privacy. Relevant legislation on this matter includes the ITS Directive (Directive 2010/40/EU) and the legislation on protection of personal data[11], which includes the Directive 2016/680 and the Regulation 2016/679. Therefore, the decision making process should also incorporate all requirements related to the training of qualified human resources, adequate technological infrastructure (e.g., secured servers), etc.

Table 1 on the next page indicates which issues are likely to be mitigated by each ICT measure. The numbers in Table 1 coincide with those listed below. This way, a first selection can be made of the ICT domain and ICT solution best fitted to tackle the identified six issues. For example: To tackle issues 4 "Handling (loading/unloading operations) operations" one can opt for solutions like "Communication V2V & V2I", "Distribution schemes (planning)" or "Real time simulation & modelling".

Legend: Meaning of numbers 1 to 6 of issues in Table 1 on the next page:

1.	Complexity of the Urban Freight Logistics System;
2.	Low interest in Cooperating;
3.	Excessive Demand for Road Transport Services;
4.	Handling Operations;
5.	Insufficient Enforcement of Regulations;
6.	Sub-optimal use of vehicles or road space and inefficiency of processes.

[11] More information available at: http://ec.europa.eu/justice/data-protection

Table 1 ICT solutions for most important type of issues

ICT Domains	ICT type of solution	Issues					
		1	2	3	4	5	6
Vehicle Support Equipment	Navigation software & location equipment			✓			✓
	Communication V2V & V2I			✓			✓
Operations Management	Real time logistics monitoring;			✓			✓
	Fleet management (planning)			✓			✓
Information & Dissemination	Data sharing, including big-data	✓	✓	✓		✓	✓
	Real time information of transport system	✓	✓	✓	✓	✓	✓
Decision Support & Enforcement	Access restrictions and control			✓	✓	✓	✓
	Real time monitoring			✓	✓	✓	✓
Infrastructure	Dynamic allocation of road lanes & Traffic rules			✓			✓
	Traffic signals			✓			✓
	Payment & collection systems			✓			✓
Sharing Economy and & e-Business Services	Shared economy platforms		✓	✓			✓
	Collaborative platforms		✓	✓			✓

Step 4 – Definition of Performance Variables and Metrics

Key performance indicators can monitor the most important aspects of the urban mobility system[13]. They must be chosen on a case-by-case basis and accordingly with the SMART approach. An indicator is SMART when it is:

- **Specific** – to be detailed and as specific as possible;
- **Measurable** – to be quantifiable;
- **Attainable** – to be realistic and possible to achieve;
- **Realistic** – to be attainable in the existent working environment; and
- **Time-related** – to have a time horizon.

Indicators often used to map impact of ICT measures in urban logistics are:

- **Transport Operations Impacts** aimed at understanding how much the ICT measure contributes to a more efficient, safe and reliable urban transport system. Examples of performance variables include punctuality of pick-ups, punctuality of deliveries, accuracy of pick-ups, duration of loading/unloading operations, number of daily deliveries, vehicle-kilometres, vehicle load factors, queuing times, stop times, average speeds, trip lengths, and number of deliveries.

- **Societal Impacts** concern the assessment of the social acceptability and compliance of an ICT measure. Examples of performance variables include: stakeholders' attitudes towards environmental impact, attractiveness of urban environment, space occupancy, and ease of compliance.
- **Environmental Impacts** concern the estimation of the environmentally-related impacts, such as emissions or noise. Example of performance variables include: noise levels, air pollutants.
- **Economical and Financial Impact** concerns the estimation of the effectiveness or benefits derived from an ICT measure in relation to the costs associated with its development. Examples of performance variables include costs per delivered item, costs per received item, average costs, operating benefits, return on investments and enforcement costs.

Step 5 – Implementation of ICT Solutions and drive Results

Finally, ICT solutions should be deployed and the associated elements that are part of the urban mobility system should be monitored[14]. This will ensure that eventual misalignment can easily be identified and corrective measures can be deployed.

A minimum amount of information is necessary to allow proper monitoring of the implementation strategy. Operational monitoring entails the following features:

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

Table 2 summarizes which ICT measures can be best applied given the specific logistics profile of the area, the necessary stakeholders' involvement, and the decision levels (strategic, tactical, operational) that are supported by the ICT application.

Legend Table 2 on next page:

Logistics profiles:

- Profile A concerns clusters specialized shops in one specific type of service/product;
- Profile B are hotels, restaurants, small grocery stores, small neighbourhood markets;
- Profile C refers Business Centre;
- Profile D are large commercial stores;
- Profile E concerns residential areas with local trade;
- Profile F e-commerce, mainly residential areas.

Economic agents:

1. Producers and Shippers
2. Wholesalers
3. Freight Transport and Logistics Operators
4. Receivers
5. Urban Area Residents & Users
6. Public Authorities

> Marked with an X is the promoting agent <

Table 2 Characterisation of the ICT Measures

ICT Domains	ICT Measures	Logistics profiles						Agents					
		A	B	C	D	E	F	1	2	3	4	5	6
Vehicle Support Equipment	Navigation software & location equipment		✓			✓				X	X		
	Communication V2V & V2I	✓	✓	✓	✓	✓		✓	✓	X	✓		X
Operations Management	Real time logistics monitoring	✓	✓	✓	✓	✓	✓	✓	✓	X	✓		
	Fleet management (planning)	✓		✓	✓				✓	X	✓		
Information & Dissemination	Data sharing, including big-data	✓	✓	✓	✓	✓	✓	X	✓	X	✓	✓	X
	Real time information of transport system (demand and supply)	✓	✓	✓	✓	✓		X	✓	X	✓	✓	X
Decision Support & Enforcement	Access restrictions and control	✓	✓			✓	✓			✓			X
	Real time monitoring	✓	✓	✓	✓	✓	✓			✓			X
Infrastructure	Dynamic allocation of road lanes & Traffic rules	✓	✓	✓	✓		✓		✓	✓			X
	Traffic signals	✓	✓	✓	✓		✓			✓			X
	Payment and collection systems	✓	✓	✓	✓	✓	✓			✓			X
Sharing Economy and & e-Business Services	Shared economy platform	✓	✓	✓	✓	✓	✓	X	✓	X	X		✓
	Collaborative platforms	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X

Chapter 4 Recommendations

Introducing ICT solutions in the area of urban freight transport can contribute to more effective transport policies and more efficient functioning of logistics chains. The impacts will lead to less congestion and emissions, whilst safeguarding the economic and social interests of the area concerned, as well as its surroundings.

Nowadays, all actors in the urban logistics ecosystem – producers, consumers, logistics operators and public authorities – can make use of ICT tools to collect, transfer and store data. These data can be analysed so that better public and business decisions are taken. However, there is a long road ahead, as ICT benefits are still seldom explored.

Based on all the success and fail factors as observed in examples from EU cities, we have identified 13 ICT solutions and grouped those in six ICT clusters. Based on the specific issues of a certain urban area, and its specific LP, we have developed a step by step approach to choosing the optimal set of ICT solutions.

The recommendations for cities considering the implementation of ICT solutions are as follows:

1. Investigate the urban freight logistics concerns thoroughly.
2. Listen to and engage stakeholders in order to resolve the issues[12].
3. Promote and ensure the interoperability of ICT measures by deploying the ITS Directive.
4. Be aware of and mitigate the hidden challenges of ICT.
5. Evaluate and consider adjustment if needed.

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

- Gathering objective field data: emissions, numbers of vehicles (types, time patterns), 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.

[12] The interested reader on stakeholder engagement is referred to NBGD 3 and respective Technical Report.

Recommendation 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 one has unique features, perspectives, objectives and/or strategies. The success of any measure largely depends on their engagement. Stakeholders are in a privileged position to help identify and characterise the issue. They can also give inputs on the most suitable ICT measures. And, naturally, they will have to deploy and use them.

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:

- It will lead to common confirmation (or adjustment) of the issue to be resolved, or mitigated, by a policy intervention.
- It will provide the public and private sector with a full understanding of the constraints and expectations of the various stakeholders.
- It 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, analysis of 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.

Recommendation 3: Promote and ensure the interoperability of ICT measures by deploying the ITS Directive

Information interoperability remains the Achilles heel of ICT. Many urban freight logistics stakeholders use proprietary information systems with limited or no communication capabilities. This strongly limits the creation of synergies.

Promoting and ensuring interoperability is fundamental. We suggest following the guidelines and recommendations laid down in the ITS Directive. The principles of the ITS Directive are the objective of standardisation. In this sense, the European Standardisation Committee (CEN) and the International Standardisation Organisation (ISO) have already published several standards and their work is ongoing.

Recommendation 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 a risk that the project may come to a standstill.

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 undesirable access continues to exist. Particular care should be taken to transmit anonymous and encrypted data. CEN and ISO standards have been published. 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.

Recommendation 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 evaluations compare the data retrieved in step 1, where the issues are mapped and examined, with 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 therefrom. Unfortunately, there is still a long way to go, 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, and iii) acquisition and maintenance costs, since the rapid pace of technological development results in the rapid obsolescence of equipment.

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