URBAN LOGISTICS AS AN ON-DEMAND SERVICE

IMPACT ASSESSMENT FRAMEWORK

ULaaDS D5.1: Framework, methodology and KPI identification

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Abstract

ULaaDS sets out to offer a new approach to system innovation in urban logistics. Its vision is to develop sustainable and liveable cities through re-localisation of logistics activities and re-configuration of freight flows at different scales. Specifically, ULaaDS will use a combination of innovative technology solutions (vehicles, equipment and infrastructure), new schemes for horizontal collaboration (driven by the sharing economy) and policy measures and interventions as catalysers of a systemic change in urban and peri-urban service infrastructure. This aims to support cities in the path of integrating sustainable and cooperative logistics systems into their sustainable urban mobility plans (SUMPs). ULaaDS will deliver a novel framework to support urban logistics planning aligning industry, market and government needs, following an intensive multi-stakeholder collaboration process. This will create favourable conditions for the private sector to adopt sustainable principles for urban logistics, while enhancing cities' adaptive capacity to respond to rapidly changing needs. The project findings will be translated into open decision support tools and guidelines.

A consortium led by three municipalities (pilot cities) committed to zero emissions city logistics (Bremen, Mechelen, Groningen) has joined forces with logistics stakeholders, both established and newcomers, as well as leading academic institutions in EU to accelerate the deployment of novel, feasible, shared and ZE solutions addressing major upcoming challenges generated by the rising on-demand economy in future urban logistics. Since large-scale replication and transferability of results is one of the cornerstones of the project, ULaaDS also involves four satellite cities (Rome, Edinburgh, Alba Iulia and Bergen) which will also apply the novel toolkit created in ULaaDS, as well as the overall project methodology to co-create additional ULaaDS solutions relevant to their cities as well as outlines for potential research trials. ULaaDS is a project part of ETP ALICE Liaison program.

Keywords

Impact assessment, impact evaluation, Key Performance Indicator, objective, methodology

Executive summary

ULaaDS will be conducting research trials for zero-emission, shared and crowdsourced on-demand delivery of goods to customers and businesses in the lighthouse cities of Bremen, Mechelen and Groningen. Schemes to be tested are containerised last-mile delivery, platforms for on-demand city logistics, platform for integrated management of urban logistics, hubs for dual goods and passenger flows (MobiHubs) and shared vehicles (CargoHitching).

This deliverable presents the framework for the impact assessment of the ULaaDS trials. The framework identifies areas of impact, objectives and indicators for the trials. The deliverable is a result of the 1st iteration of the framework, which took place in the first six months of the ULaaDS project (September 2020 - February 2021). The framework will be further developed and validated in the 2nd iteration, which is planned to start in March 2021 and to be completed after completing the trial planning, which is due in November 2021.

The ULaaDS impact assessment framework builds on existing knowledge and expertise in the field obtained through literature review, studying documentation from other EU projects and by leveraging the ULaaDS partners' expertise.

The methodology for the impact assessment framework is largely based on the bottom up 7-stage approach from the TRIANGULUM project. Key elements in this approach is the extensive cooperation with city stakeholders, and co-production of both the framework and the impact assessment indicators. The TRIANGULUM methodology is used in combination with the STRAIGHTSOL approach to assure stakeholder objectives are fully considered, as well as the SUCCESS approach to ensure the quality and relevance of the indicators.

The methodology of the ULaaDS impact assessment is based on the principles of topical application, multi-criteria, multi-actor views, co-production and an iterative process, and comparability. This framework identifies areas of impact, objectives and indicators for the trials. These have been determined by mining the ULaaDS project description, consulting ULaaDS partners and reviewing literature and project documentation.

The trials will have societal impacts, i.e. impacts on issues of concern for the city, the local community, the citizens and society at large. The trials will also have business model impacts, i.e. impacts which the new business models has on the competitive value for the logistics service providers and their customers. The areas of impact to be assessed in ULaaDS are: environment, land-use, traffic conditions, logistics efficiency, economic impacts, user experience and acceptance and awareness. Objectives for the area *environment* include reduced greenhouse gas (GHG) emissions, reduced air pollution, reduced noise pollution and increased service accessibility. For *land-use* and *traffic conditions* the objectives are more efficient use of existing public space, reduced congestion and improved traffic safety. In addition, increased utilisation of load capacity of vehicles, increased speed of delivery and more efficient use of vehicle fleets are objectives for *logistics efficiency*. The areas *economic impacts* and *user experience and acceptance* include the objectives of economically sustainable business models, as well as same or better level of service as existing schemes and increased acceptance. Finally, increased awareness of sustainable delivery solutions is an objective for the impact area of *awareness*.

Preliminary Key Performance Indicators (KPIs) are defined for each objective, and for each KPI there is a set of support indicators. The support indicators will help understand and interpret the outcome of the KPIs.

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1. Introduction

The purpose of this deliverable is to present a framework and comprehensive methodology to identify and assess impacts of the ULaaDS research trials in the lighthouse cities Bremen, Mechelen and Groningen. The framework is meant to be used for assessing how well the trials perform, as well as assessing various effects, and for impact calculations and comparability among the trials.

This deliverable is meant to be used by the ULaaDS partners, especially the ones involved in data collection and assessment connected to the trials. The lighthouse cities and the logistics stakeholders developing and implementing the trials are central to the impact assessment framework. Another target group is the satellite cities Rome, Edinburgh, Alba Iulia and Bergen. In addition, the deliverable could be useful for interested parties and uses outside of the ULaaDS project.

The framework identifies and defines impact areas and objectives for the ULaaDS trials, as well as preliminary Key Performance Indicators (KPIs) for each impact area (cf. chapter 4). The first assessment of data availability has been conducted. Data collection methodology is addressed in chapter 4.4.

This deliverable has received input from, and will provide input to, other work packages, tasks and deliverables in ULaaDS, as described in chapter 3. This deliverable is the result of the 1st iteration of the impact assessment framework. The framework will be further tested, developed and validated in the 2nd iteration. The two iterations are described in more detail in chapter 3.2.

Description of deliverable D5.1 in the Grant Agreement (2020):

D5.1: Framework, methodology and KPI identification

Deliver a framework and methodology to be used for impact calculations and comparability among the trials. Identify primary Key Performance Indicators (KPIs) including definitions and assessment of data availability and data collection methodology. Selection of impact area and indicators per area.

KRI and KPI. KRI is commonly understood as Key Result Indicator or Key Risk Indicator. Both the term KPI (Key Performance Indicator) and KRI are used in the WP5 description n the Grant Agreement. The two terms seem to be used interchangeably. Based on the understanding that the term KRI is used as a synonym for KPI in the Grant Agreement, this deliverable will be based on the use of the term and the concept of KPI.

2. Review and findings

The impact assessment framework in ULaaDS builds on existing knowledge and expertise in the field. This knowledge and expertise are obtained through literature review, studying documentation from other EU projects and by leveraging the ULaaDS partners' expertise. The aim of this knowledge acquisition is to gain a better understanding of the opportunities that lie in evaluating projects and explore existing evaluation frameworks to see how the ULaaDS assessment framework can be designed and what it should contain. The purpose is also to investigate which indicators have previously been used to assess the effects of urban logistics trials.

Evaluations are performed to measure the performance, learn for future projects and exchange experiences. Evaluation gives valuable input to decision makers as it helps to improve future planning, better target measures on specific groups and optimise allocation of resources (Dziekan et.al, 2013). Evaluation is important to understand the nature and extent of the impacts that the measure generates and the processes that are involved (Engels, Van Den Bergh and Breemersch, 2017). Regardless of the method chosen to evaluate a project it is essential to collect and analyse data before (baseline) and after implementation (ex-post). A central question to answer is: *What was the situation before the measure was implemented and what changes can be attributed to the measure? (*Dziekan et.al, 2013).

To be able to compare results and experiences and learn from each other across different European projects it is important to evaluate based on comparable indicators and measurement methods. This reinforces the importance of acquiring knowledge as part of the preparation of the ULaaDS impact assessment framework. Of course, also with a view to reusing previous experiences and acquired knowledge and to thus be better equipped to develop a well-functioning framework.

The type of data needed to review urban freight distribution depends on the specific situation, the current and future planning and policy framework, existing data collection methods and the availability of existing data. Prior to collecting the data, the purpose and description of how the data will be provided as input need to be clarified (van den Bossche et.al, 2017).

The literature review had a special focus on detecting relevant methodologies and frameworks, in addition to urban logistics indicators and important criteria in the selection of indicators.

2.1 Evaluation frameworks

The CIVITAS deliverable *Support Action Towards Evaluation, Learning, Local Innovation, Transfer & Excellence* is used as a guiding document in this deliverable. The CIVITAS deliverable provide a framework to be used in all CIVITAS demonstration cities aiming at achieving a coordinated and consistent set of results among CITIVAS projects. The CIVITAS deliverable focus on two main evaluation approaches: impact evaluation and process evaluation. Impact evaluation is *the assessment of the changes which are attributed to a specific measure or integrated package of measures*. A measure will have an impact at a specific scale which can be regional or more limited to a specific area of the city or restricted to a specific target group. The CIVITAS deliverable propose to collect context data of the general mobility situation in a city to be better equipped to interpret

the observed impact of the measures. The context parameters can also be used to evaluate the impact of the measures. The general concept of impact evaluation is as follows:

- Propose a set of indicators that describe the important characteristics of the situation
- Observe the value of these indicators before and after the implementation of the measure, while preventing other elements from influencing the indicators or removing the impact of the other elements before assessing the “after” situation,
- Compare before and after situation
- Draw conclusions about the impacts induced by the specific measure (Engels, Van Den Bergh and Breemersch, 2017).

To clearly understand the impact of measures it is important to understand the way measures can affect the mobility system. One way to structure the evaluation approach is to define different impact categories that can be affected by the measures. Five main impact categories are defined: society (people and the organization of society), transport system (performance of the mobility system), economy (effectiveness or benefits derived from a measure in relation to the costs), energy (consumption of energy), environment (pollution/nuisance and resource consumption) (Engels, Van Den Bergh and Breemersch, 2017).

The identification of evaluation indicators is a crucial element of the framework and the CIVITAS deliverable provide a list and descriptions of proposed impact indicators. The deliverable further acknowledges that this list should be regularly updated to consider new data opportunities, new societal trends and technological developments and recent policy objectives. There are often many indicator options for measuring an impact, it is important to select the right indicators based on predefined criteria (Engels, Van Den Bergh and Breemersch, 2017).

Indicators and data collection methods on urban freight distribution (van den Bossche et.al, 2017) is a guidance document commissioned by the European Commission. This report provides insights on common indicators on urban freight distribution and what data is needed for urban logistics policy-making. In addition, the report gives descriptions of the purpose of the suggested data and the best means of collection. The report focuses on indicators used to describe different impact factors, for instance: delivery profile (incorporates the timing, frequency, location, parcel size, shipper, etc. of the deliveries) and the transport profile (type of transport operator, the sector, the type of load, type of vehicle, load factor and bundling) (van den Bossche et.al, 2017).

2.1.1 Common performance indicators

Literature looking at frameworks for analysis of urban logistics, conclude there is a need for indicators exclusive for urban logistics activities (Wolpert and Reuter, 2012). Among those who use indicators in analyses of urban logistics, it has been observed that the methods for collecting data are not systematic, and different data sets can therefore often not be compared with each other. Data describing urban freight transport are often incompatible, which makes it difficult to compare observations between cities and activities at different times. One reason for these problems is that different countries have different definitions of «urban goods movements» and different cities and countries do not collect data on freight transport in cities on a regular basis (van den Bossche et.al

(2017). There is therefore a need to establish a set of common performance indicators for use in the study of urban logistics.

From the literature one finds several ways to group indicators. A common method is to group the indicators according to which elements are affected (Steenbergen et.al, 2013). Allen and Browne, (2008) have the same approach and have grouped indicators according to a framework adapted to different services and activities and what data is needed to carry out evaluations and analyses of these.

The final report on *Indicators and data collection methods on urban freight distribution* written by van den Bossche et.al (2017) on behalf of the European Commission determines the common indicators needed in an urban freight context and data collection methods to collect these indicators. The report states that stakeholders are often unaware of the usefulness of the urban logistics indicators they commonly use. Thus, there is a need to collect and analyse data in a more focused way, and then use results to affect policy and decision-making. Further, the report points out that few authors in recent literature has made the link between urban freight collection methods and indicators. Rai Buldeo et.al (2018) point out that indicators are a good tool for quantifying freight transport in cities in a way that provides the opportunity to obtain objective information, monitor services and compare developments over time. The indicators can be integrated into project-specific analyses and assessments and are also often used for benchmarking (Rai Buldeo et.al, 2018).

Indicators are a valuable tool for cities and urban areas to review their mobility system. Cities and urban areas continue to develop Sustainable Urban Mobility Plans (SUMPs) and work towards EU policy goals. Indicators can be used to document this progress to ensure that such achievements become visible. The European Commission has developed Sustainable Urban Mobility Indicators for this purpose (European Commission, 2021).

According to Dziekan et.al (2013) three basic requirements have to be taken into account when defining indicators. The indicators must (1) clearly reflect the performance or impact of the measure, (2) they must match the objectives, and (3) be capable of reliable assessment using the experimental tools and measurement methods. Development of indicators is a continuous process, partly because the challenges associated with urban logistics change over time, the expertise and the requirements for analyses increase. A step towards establishing commonly accepted indicators is therefore a step towards getting better tools for analyses of activities in urban logistics (Dziekan et.al, 2013).

2.2 Other EU projects

Documentation from various EU projects, such as STRAIGHTSOL, TRIANGULUM, SUCCESS, NOVELOG and CITYLAB, has been studied. The purpose was to explore different evaluation methodologies to gather knowledge for the development of the ULaaDS assessment framework. Several of these projects, which are evaluating trials within a similar topic as ULaaDS (last mile, urban logistics, on-demand), also have information relevant for identifying and defining KPIs.

2.2.1 STRAIGHTSOL

STRAIGHTSOL (Strategies and measures for smarter urban freight solutions) demonstrated new solutions for smart and sustainable urban-interurban transhipment and last mile distribution. Based on the demonstrations and their assessment, the project provided policy recommendations, deployment strategies and real practice benchmarks. The STRAIGHTSOL evaluation framework includes three stages: description and assessment, evaluation and recommendations and lessons learned. These stages are fed by initial input. Due to the complex interaction between the many actors in the urban transport, the most essential input was a list of stakeholders and their respective objectives. Stakeholder support is significant for the potential success of a solution (Johansen et al 2014).

In order to be able to properly evaluate the different options, STRAIGHTSOL developed a set of indicators which is used to both characterize the current situation and the alternatives. These indicators are categorized according to four impact areas: economy, environment, society, and transport (Balm and Quak, 2012). STRAIGHTSOL is concerned with defining the right set of indicators through understanding stakeholder needs and their objectives (Balm and Quak, 2012). The procedure is illustrated in Figure 1.

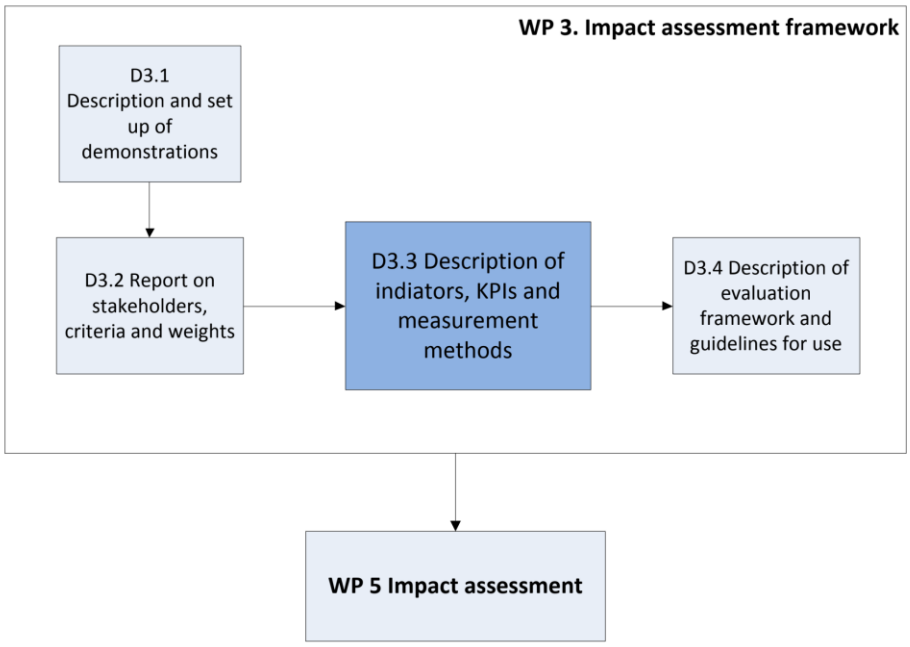

Figure 1: Relations between impact assessment related deliverables in STRAIGHTSOL

STRAIGHTSOL stated the selection of indicators should be closely associated with assessing the present state (3.1) and the stakeholders involved and their objectives (3.2). The input from stakeholders included allocation of weights to different criteria. The selection phase of KPIs were also conducted based on input from other consortium partners. The following definition of KPI was used “Key Performance Indicators are quantifiable and clearly defined measurements, that reflect the core goals and targets of the intended measure based on the stakeholders’ perspectives”.

STRAIGHTSOL further listed four criteria the indicators should meet: 1) relevant for achieving a stakeholder's objective, 2) measurable during the evaluation process, 3) generically and clearly defined (i.e. reliable) and 4) influenced by the intended measure (i.e. interdependence). STRAIGHTSOL acknowledged that not all indicators would be relevant for all measures and that new indicators could be defined when needed for the assessment. For instance, more detailed, specific or local level indicators. Deliverable 3.3 also list data needs, data collection and measurement methods and provided tables with descriptions of each indicators in addition to context and relevance of the indicator.

2.2.2 TRIANGULUM

TRIANGULUM (Triangulum: The Three Point Project / Demonstrate. Disseminate. Replicate) is a lighthouse project set to demonstrate, disseminate and replicate solutions and frameworks for the future of urban development. The Lighthouse Cities Eindhoven (NL), Stavanger (NO) and Manchester (UK) have tested cross-sectoral smart city solutions and worked as test-beds for new business models, technologies, and strategies of citizen engagement. The goal was to reduce energy use and carbon emissions, enhance quality of life and stimulate economic development (Evans et al 2017).

Deliverable 2.1 *Common Monitoring and Impact Assessment Framework* (2017) describe the development of a framework for monitoring and evaluation to assess the impacts of the demonstration projects. The Impact Assessment Methodology was developed to support replication in the follower cities of Prague, Sabadell and Leipzig. The methodology was based on a bottom-up approach in cooperation with city stakeholders and the impact assessment framework and indicators are co-produced by different task groups in the project.

TRIANGULUM adapted a seven stage methodology (see Figure 2) for developing indicators and calculated impacts (Evans et al 2017):

1. Review of existing literature and frameworks
2. Identify and document expected outcomes
3. Co-produce and document impacts, indicators and datasets
4. Align and verify impacts, indicators and metrics
5. Prepare for impact calculation
6. Store data to be used in impact calculation
7. Calculate impacts

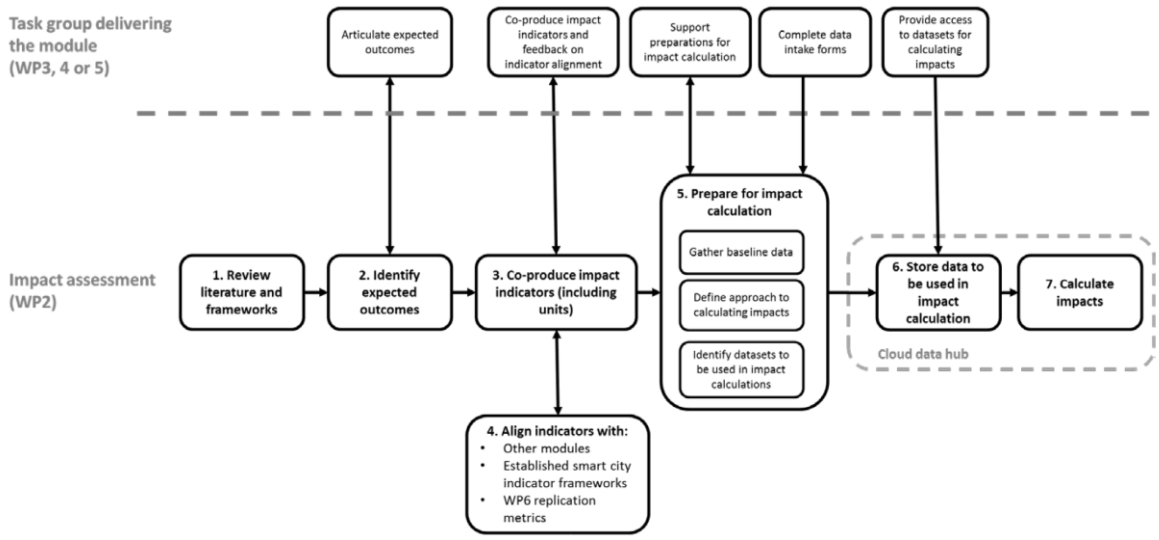

Figure 2. TRIANGULUM Seven-Stage Methodology for Developing Indicators and Calculating Impact

Each of the seven steps (except step 1) entails involvement and input from other work packages in the TRIANGULUM project.

TRIANGULUM used a two-stage review of the expected impacts to ensure comparison between cities. In the first stage the original expected impacts were cross referenced with the lead cities and the project as a whole. It was investigated whether they had: not indicated a use of the metric, implied the use of the metric, had obligated to use the metric, or that the metric was not applicable to the city and/or project. In the second stage, the impact mapping table was presented to the lead cities to validate whether the interpretations were correct. It also provided an opportunity for cities to update their commitments since the submission of the proposal and in view of the other cities' obligations. This resulted in numerous alterations to both preferred metrics and their respective commitments (Evans, et. al., 2017).

2.2.3 SUCCESS

SUCCESS (Sustainable Urban Consolidation CentrES for construction) aimed to explore, find and test green and efficient solutions regarding various issues in Construction Supply Chain and material freight logistics in urban areas. The different solutions were tested in Valencia, Paris, Verona and Luxembourg City (Success, 2020).

SUCCESS defined KPIs to answer to the project's objectives and the methods and tools to collect the data required to compute the KPIs (Ferrero, et al, 2015). This was the first step of the evaluation process to quantify the potential impact in terms of cost efficiency and negative externalities of a Construction Consolidation Centre and other improvement measures (To-Be) against the current situation (As-Is). As part of the KPI identification method a pre-selected list of KPIs were proposed based on literature review and project partners' experience from other relevant projects. A common

set of KPIs were established for the four case studies. Each indicator was reviewed by the project partners using the following criteria (Ferrero, et al, 2015):

- Is the indicator understandable?
- Is the indicator relevant?
- Is the data available?
- Is there any other relevant indicator which is missing?

The feedback from the SUCCESS partners was analysed and the initial list of indicators was shortened, reducing the number of KPIs to less than half. Each of the KPIs were in turn defined with the associated data collection method and unit (Ferrero, et al, 2015).

2.2.4NOVELOG

NOVELOG (New Cooperative Business Models and Guidance for Sustainable City Logistics) focused on the enabling of knowledge and understanding of freight distribution and service trips by providing guidance for implementing effective and sustainable policies and measures (NOVELOG, 2020). One of the objectives in NOVELOG was to develop an evaluation framework for city logistics measures, which would assess the complexity of UFT systems, through selected performance indicators, divergent stakeholders' interests, conflicting business models and operations.

The NOVELOG assessment framework is structured as a multi stakeholder multi-criteria decision making framework. Additionally, the evaluation framework develops four separate modules to support its objectives and facilitate the assessment process (Nathanail, et al 2016): 1) Impact assessment, 2) Social cost benefit, 3) Transferability and adaptability, and 4) Risk analysis. Behavioural modelling is also integrated to support the modules in the qualitative data collection (indicators and weights) and measuring the potentiality of behavioural change. The impact assessment module assesses traffic, environmental and safety performance of proposed smart urban logistics measures, based on existing methodologies. The "diamond" in Figure 3 reflects the four modules and behavioural modelling. The life cycle sustainability steps are taken into consideration in each of the modules and the behavioural modelling. In step 1 *Identification of urban logistics components* the logistics scene is set. The logistics components include key influencing factors, measures, logistics scenarios, and urban freight and service trips activities. Step 2 *Process mapping-life cycle inventory* the processes appearing in each of the defined measures are described analytically under each of the four stages of the lifecycle sustainability assessment. Step 3 *Disaggregation of sustainability disciplines and applicability enablers* includes the disaggregation of the impact areas. In this step, the relevant criteria are indicated, and respective key performance indicators are defined for each criterion. The KPIs are further described and justified according to the data needed for their estimation, their units and their stakeholder category. Step 4: *Data interpretation* refers to data interpretation and relies on the estimation of the Logistics Sustainability Index (LSI). The Logistics Sustainability Index (LSI) is a model aimed at providing insights into the general sustainability performance of a company's logistic activities. To raise awareness and to encourage companies to develop an effective sustainability policy. Including areas of impact such as energy consumption, emissions, noise, safety, use of space and infrastructure, use of raw materials, waste and packaging. The LSI provides a set of relevant quantitative and qualitative criteria and indicators (Nathanail et al 2016).

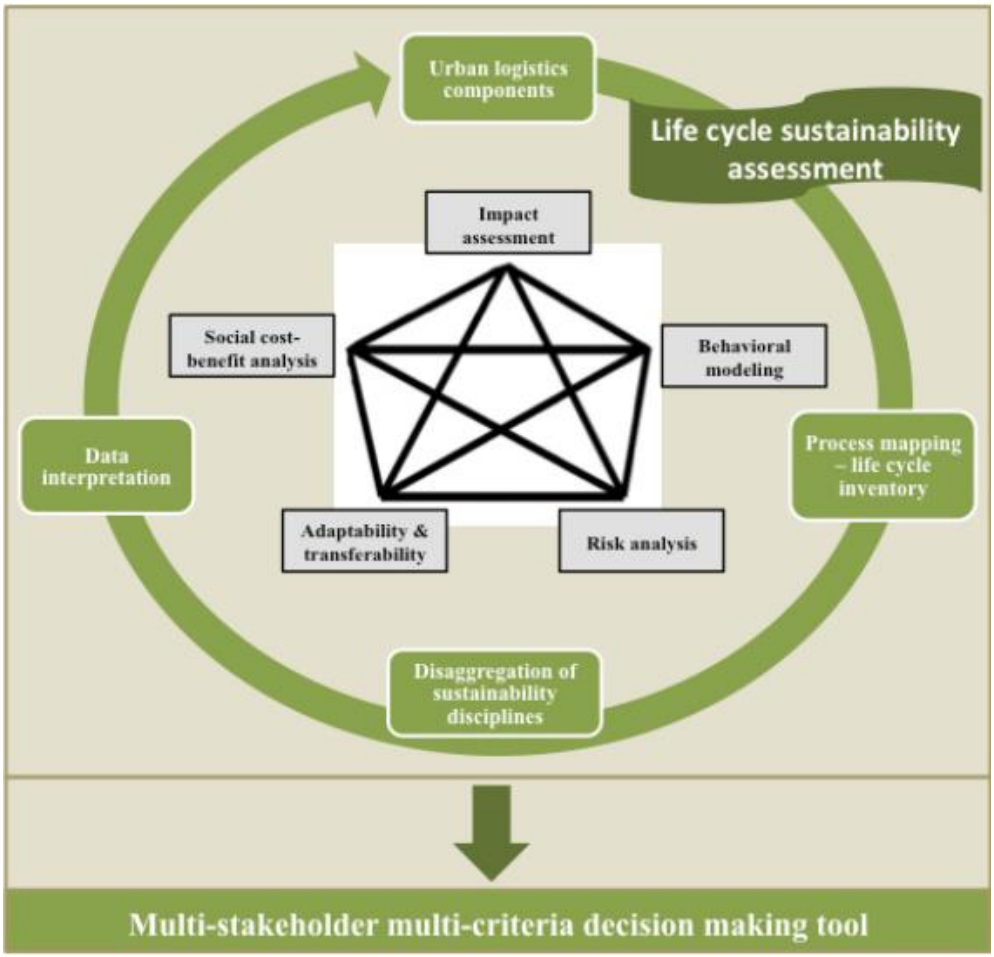

Figure 3: Structure of the NOVELOG evaluation framework

The NOVELOG evaluation framework addresses seven impact areas; (1) Economy and energy; (2) Environment; (3) Transport and mobility, and (4) Society; (5) Policy and measure maturity, (6) Social acceptance, and (7) User uptake. Within each area of impact there are 2-5 criteria, and each criterion has a set of indicators. NOVELOG differentiates between composite KPIs and individual KPIs. There are criteria for GHG emissions, noise pollution, level of service, safety and security, transport system and UFT vehicles. NOVELOG also uses criteria for costs and income related to the business models of the services being evaluated, e.g. income generated and creation, operating and maintenance cost (Nathanail, et al 2016).

The NOVELOG evaluation incorporates a multiple weighting scheme for shared decision-making. This takes into account the participation, viewpoint and contribution of the stakeholders (Nathanail et al. 2016).

2.2.5 CITYLAB

CITYLAB (City Logistics in Living Laboratories) used the cities of Amsterdam, Brussels, London, Oslo, Paris, Rome and Southampton as 'living laboratories' where public and private freight transport measures were evaluated, adapted and improved in a cyclical way. The aim was to improve the understanding of the impacts freight and service trips had on urban areas (European Commission / CITYLAB, 2020).

CITYLAB used before and after assessments for a range of indicators that are collected for each measure to allow comparison. These indicators are structured into four fields of evaluation, in which adoption and impact are two of them. 'Adoption' detects to what extent stakeholders who did not initiate the solution are willing to pay for the solution or to change their behaviour in order to perpetuate the solution. 'Impact' assesses and quantifies the changes that can be attributed to implementing the new urban freight transport measure and concerns changes in the well-being of all stakeholders (Verlinde and Kin, 2015). CITYLAB includes impact indicators for economy (costs, revenues, return on investment and customer satisfaction) and transport (vehicle speed, freight kilometres).

2.3 Key implications and findings

The TRIANGULUM framework monitored and evaluated city solutions to assess the impacts of the demonstration projects. The methodology used a bottom-up approach in cooperation with city stakeholders in which the impact assessment framework and indicators are co-produced by different task groups in the project. This approach makes sure that indicators are tailored to the modules and districts and are relevant and usable to the partners involved. This approach is in line with the views and goals of ULaaDS of achieving a clear and shared understanding among project partners regarding what KPIs to include in the impact assessment framework. Each of the seven steps (except step 1) entails involvement and input from other work packages in the TRIANGULUM project. This emphasizes the focus on cooperation in the preparation of the assessment framework. Several of the elements and the procedure of this methodology is in accordance with - and transferable to - ULaaDS.

STRAIGHTSOL categorized the indicators according to impact area to allow a more efficient evaluation process. This is in line with the approach of ULaaDS that will evaluate on the basis of several different areas of impacts within two main categories (defined and described in Chapter 4). The areas of impacts in ULaaDS have similarities to the ones of STRAIGHTSOL and STRAIGHTSOL thus provide information relevant for identifying and defining KPIs in ULaaDS. The indicators in STRAIGHTSOL are therefore used to validate and supplement the indicators in ULaaDS within the relevant areas of impact.

Due to the complex interaction between the many actors in urban freight, an essential input in STRAIGHTSOL is a list of stakeholders and their respective objectives. Stakeholder support is significant for the potential success of a solution (Balm and Quak, 2012). Input from stakeholders is a key input for the ULaaDS assessment framework also. A similar source of input will be available through the ULaaDS stakeholder mapping and local fora (this link is elaborated further in Chapter 3).

The STRAIGHTSOL criteria for selection of KPIs is, together with the SUCCESS approach, a good basis for the same selection procedure in ULaaDS. ULaaDS will strive to ensure relevance and collectability of KPIs and data amongst stakeholders. Having the indicators reviewed by the project partners using a set of criteria leads to a broad consensus about the choice of KPIs. In addition, it makes sure the proposed KPIs are manageable and make sense for the ULaaDS partners.

SUCCESS established a common set of KPIs for all their case studies, and proposed a pre-selected list of KPIs which was reviewed by the project partners. Inspired by SUCCESS a similar review process will be carried out in the identification, definition and selection of KPIs in ULaaDS. This will be performed in both the 1st and 2nd iteration of the framework by cities, logistics operators and other ULaaDS partners. A preliminary list of KPIs – common for all the ULaaDS trials - is proposed in this deliverable, based on literature review and project partners' experience. The review criteria used in SUCCESS form the basis for the review of preliminary KPIs in ULaaDS. The list used in SUCCESS was: 1) Is the indicator understandable?, 2) Is the indicator relevant?, 3) Is the data available? And 4) Is there any other relevant indicator which is missing?

Several of the topics addressed in the NOVELOG assessment framework – i.e. traffic, environment and safety performance - are also found in the ULaaDS Grant Agreement. For the identification of indicators NOVELOG provides valuable input to the ULaaDS assessment framework within the impact areas GHG emissions, noise pollution, level of service, safety and security, transport system, UFT vehicles and business model. The relevant indicators from NOVELOG will be used to validate and supplement the indicators in ULaaDS.

Some of the indicators relevant for the ULaaDS impact assessment match the sustainable urban mobility indicators developed by the European Commission (European Commission, 2021). This assessment framework will build on that and facilitate the integration of ULaaDS results in SUMPs / SULPs (which will be the focus of WP6).

NOVELOG relies on the estimation of the Logistics Sustainability Index (LSI) regarding data interpretation, taking into account the participation, viewpoint and contribution of the stakeholders. This can be relevant for the choice of methods for data analysis and evaluation to be used in ULaaDS. Relevant methods and information from the Logistics Sustainability Index (LSI) will be extracted and incorporated in the evaluation methods to be used in the ULaaDS impact assessment.

The main assessment method used in CITYLAB was before-and-after assessments. This will also be the case in the ULaaDS impact assessment. CITYLAB includes impact indicators for economy and transport, both areas of impact which are also found in ULaaDS. The indicators in CITYLAB will be used to validate and supplement the indicators in ULaaDS within relevant areas of impact.

The purpose of the CIVITAS deliverable *Support Action Towards Evaluation, Learning, Local Innovation, Transfer & Excellence* is to define impact categories to structure the evaluation approach. ULaaDS will define indicators and evaluate impacts within a set of impact areas (societal and economic). The ULaaDS impact areas have similarities to the CIVITAS impact categories. The CIVITAS indicator list and description of impact evaluation process therefor provide valuable guidance for the ULaaDS assessment framework. The CIVITAS deliverable notes that there exist many indicator options for measuring an impact and propose to select the right indicators based on predefined criteria (Engels, Van Den Bergh and Breemersch, 2017). The detection and defining of

indicators in ULaaDS will be a collaboration process including a large part of the ULaaDS partners. The selection of indicators will be defined based on a set of criteria, in which availability of data is important. Investigating existing and available data in cooperation with the trial cities and companies in ULaaDS will be a significant part of the preparation of the assessment framework and affect the choice of indicators.

The guidance document from the European Commission provides a comprehensive summary of possible indicators that may be used in data analysis to make urban logistics decisions. These indicators are used for inspiration in detecting and defining KPIs and support indicators in ULaaDS.

To sum up, the impact assessment framework of ULaaDS is inspired by several EU-projects in different ways. The methodology leading towards the final impact assessment framework itself is largely based on the 7-stage approach from TRIANGULUM. This methodology is used in combination with STRAIGHTSOL to assure stakeholder objectives are fully considered and the SUCCESS approach to ensure avoiding unwanted mismatch of what is desired and what data can actually be gathered. In addition, the indicators in NOVELOG, CITYLAB and STRAIGHTSOL will be used to validate and supplement the indicators in ULaaDS within relevant areas of impact.

3. Impact assessment methodology

The ULaaDS impact assessment methodology aims to make a framework for identifying, evaluating and comparing impacts of on-demand services tested in the ULaaDS trials. The methodology is used to define relevant KPIs and quantifiable units to measure the impact and performance of the trials.

3.1 Guiding principles

The ULaaDS impact assessment methodology is based on the following principles:

- **Topical application.** Integration of the methodological approach with the topical application of shared, connected and on-demand urban logistics (GA 2020).
- **Multi-criteria.** Given the complexity of the expected impacts of the deployment of shared, connected, on-demand urban freight transport, the impact assessment requires an evaluation based on a set of different criteria and from different perspectives (GA 2020).
- **Multi-actor views.** The different points of view from various stakeholders will be brought together in a multi-actor view (GA 2020). The methodology adopts a bottom-up approach. It is the involved cities and companies which will define and select the KPIs to be used. KPIs must be relevant for these stakeholders, and data must be available and within their means to get access to.
- **Co-production and iterative process.**
- **Comparability.** Be able to compare the performance of the ULaaDS trials with each other, as well with other trials outside the ULaaDS project.

3.2 Iterations

The work towards a final version of the impact assessment framework will consist of two iterations. The **1st iteration**, which constitutes this deliverable (D5.1), is conducted prior to the final definition and description of the ULaaDS trials. The first iteration is based on input from relevant literature and other EU projects, in addition to experience and expertise of the ULaaDS partners. KPIs have been preliminary validated and adjusted in cooperation with the lighthouse cities and other ULaaDS partners. The 1st iteration has produced the preliminary impact assessment framework which is presented in this deliverable.

In the **2nd iteration**, which is initiated close to the scheduled trial implementations, the pre-defined KPIs and units of measurement from the 1st iteration will be aligned and tailored further to the ULaaDS trials. The adjustments will be included in an updated version of the impact assessment framework. In addition, the 2nd iteration will include a description of the evaluation methods to be used for the assessment of the trial impacts.

ULaaDS strive to achieve a cooperative approach among the project partners in defining KPIs. In the development of the framework proposed KPIs were discussed and validated both by project partners responsible for defining the data collection methods and for collecting and providing data. This cooperation will continue in the 2nd iteration of the framework.

3.3 The impact assessment framework process

The following tasks have been carried out in the 1st iteration of developing the ULaaDS impact assessment framework:

1. Searched for and gathered information about impact assessment frameworks and KPI identification in existing literature and other EU projects
2. Discussed proposed approach to identify objectives, KPIs and scope of the assessment framework with other ULaaDS partners and received feedback for improvement
3. Identified a set of preliminary KPIs based on the accumulated knowledge from literature review, other EU projects and the expertise of the ULaaDS partners
4. Validated the preliminary KPIs through meetings and workshop (WP4) with ULaaDS partners, including Lighthouse city representatives and companies.
5. Suggested support indicators and units of measurement for the defined KPIs
6. Completed the 1st iteration of the impact assessment framework

ULaaDS strive to achieve a horizontal communication flow to make sure there is a clear and shared understanding among project partners regarding (1) what is to be evaluated, (2) what data is to be collected to perform the desired evaluation, and (3) how this data should be collected and in what format. The identification of KPIs is developed based on a bottom-up approach in which the lighthouse cities and relevant stakeholders are encouraged to contribute and validate. The process towards the preliminary set of KPIs in the 1st iteration and the planned further work of the 2nd iteration is shown in the ULaaDS impact assessment process Figure 4.

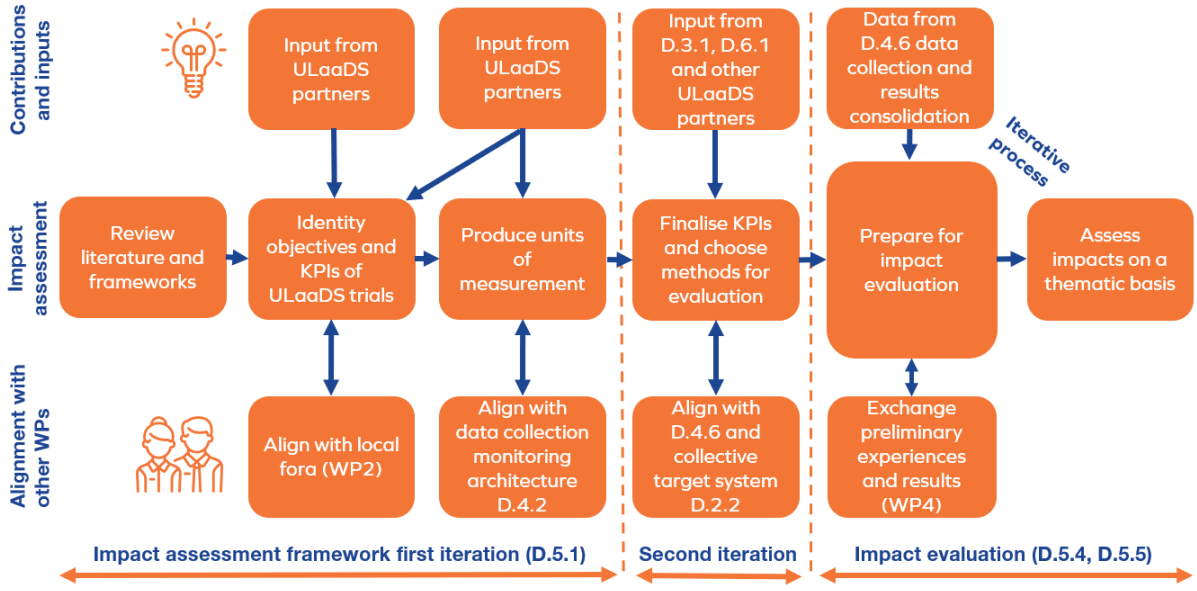

Figure 4: ULaaDS impact assessment process

The local fora on urban freight (WP2 / Task 2.2) will provide the environment to discuss and confirm the availability and sharing of KPIs and data. The local fora will be organized in each of the ULaaDS Lighthouse cities involving the local stakeholder ecosystem to understand their needs and requirements. The involvement of both private and public actors makes the local fora a valuable source of input to the impact assessment framework. In addition, the collective target system (D2.2) and Task 2.3 *Stakeholders' needs and requirements for ULaaDS use cases* might affect the choice of final KPIs. The final list of KPIs will be provided as a result of the 2nd iteration of the assessment framework. The target system will be defined to correlate the opinions and objectives of the important stakeholder groups. This system will allow the identification of priorities for implementation within each city. Stakeholder opinions and objectives naturally provide important input in the selection and prioritisation of KPIs in the 2nd iteration of the assessment framework.

In the design of the impact assessment framework dialog has also been made with WP3 (development of new business and operating models) and WP6 (SUMP / SULP assessment) to ensure their input and confirm that relevant KPIs needed for their activities are included. The work on *Benchmarking business / operating models and best practices* in D3.1 is especially useful in the development of KPIs related to the evaluation of economic impacts in Task 5.3. Some KPIs that were identified during the initial steps in developing the benchmark (D3.1) were already included in the first iteration of the impact assessment framework. When defining the final list of indicators in the 2nd iteration it will be useful to align the evaluation criteria for the assessment of other pilots (benchmarks) from D.3.1 with those for the ULaaDS trials. If ULaaDS use the same variables it makes it easier to understand success factors and enables the project to take corrective measures.

In the 2nd iteration it could also be useful to pay attention to some of the KPIs being discarded. For instance, if a KPI is discarded due to lack of data, it could still be a relevant KPI to use later, in other projects and circumstances. In such cases it might be helpful if ULaaDS stakeholders could share best practice and thus encourage each other to collect and analyse more data for better-informed decisions.

There is also an important link between WP4 and the assessment framework. In D4.2 *ULaaDS data collection & monitoring architecture* will provide data requirements for research trial execution and the methods that will be used for the continuous collection and registration of data assets. Therefore, there should be alignment with data requested through suggested KPIs and data collection methods used. WP4 will provide necessary input on both KPI identification in the 1st iteration and data evaluation methods presented in the 2nd iteration of the assessment. Data collection methods prepared in Deliverable 4.2 will build on the KPI identification in the assessment framework. The work on the assessment framework needs also to be aligned with the actual data collection activity in ULaaDS. Task 4.5 *Data collection, monitoring & results consolidation* will collect different datasets from the sites and other stakeholder engagement initiatives. All the collected data will be analysed and processed. This process will be combined with a constant monitoring of the progress achieved during research trials, based on common assessment framework of KPIs defined in this deliverable for impact assessment. This will thus be an iterative process between WP4 and WP5 (illustrated in Figure 4).

Dialog with other ULaaDS partners during the definition of KPIs and respective units of measure has been key. This has been done deliberately to:

- Ensure relevance of proposed KPIs,
- Detect omitted KPIs and/or units of measurement that should be included,
- Ensure availability and collectability of data (for the cities and logistics companies)
- Detect existing data (show stakeholder mapping result)
- Early stage information and management of expectations regarding required input for the impact evaluation

Involving project partners, and especially city representatives and companies, at an early stage in the development of the assessment framework broadens the scope of possibilities to detect existing and available information sources. For instance, available data that might be useful in the impact assessment and/or planned data collection activities that ULaaDS can benefit from and engage with. In addition, it gives the cities a heads up concerning what type of data and information will be requested in the course of the project. In connection with WP4, a workshop was arranged for ULaaDS partners with the aim to discuss KPIs and data availability.

On the one hand, the impact assessment framework ought to be flexible, as different cities and companies might have different datasets available and different data gathering possibilities. In turn, there might be changes in the implementation of the trials both concerning timeframes and content. On the other hand, the intention is to compare the performance of the trials across the cities. To achieve the latter, comparable KPIs and data is needed. Thus, there is a need to balance between evaluating the same KPIs, in the same manner, in the different cities (and trials), and tailoring the KPIs and data collection to each city.

An unfortunate development that ULaaDS aims to avoid, is a mismatch between the requested data and the data possible to collect. This reinforces the desire for a good communication flow in the project on the identification and collection methods of KPIs. One-way ULaaDS will strive to avoid this mismatch is by adapting the KPI identification methodology from the SUCCESS project. This methodology allows the project partners to review each proposed KPI based on a set of criteria (see chapter 4.3). The feedback from the project partners will be analysed and will result in an initial list of well-defined KPIs. This approach leads to a broad consensus on the choice of KPIs and ensures that the KPIs are manageable and relevant for the parties in the project.

4. Impact assessment framework

The impact assessment framework defines areas of impact, objectives, indicators and units of measurement. These have been determined by mining the ULaaDS project description, consulting ULaaDS partners and reviewing literature and project documentation. The project description in the Grant Agreement has formed the point of departure, and has been validated, updated and detailed through consultations with ULaaDS partners and findings from research and project experience. Relevant indicators used in the projects NOVELOG, CITYLAB and STRAIGHTSOL have been used to supplement and validate the ULaaDS KPIs.

The impact assessment framework described below is a preliminary version, based on the first iteration. This version will be further developed and validated in the 2nd iteration (see chapter 3 for information on the 2nd iteration). Data collection methods will be defined in WP4, after the KPIs have been validated and prioritised.

The main elements of the framework are shown in Figure 5.

Figure 5. Main elements of the ULaaDS impact assessment framework

4.1 Areas of impact

Descriptions of impact areas and expected impacts, as defined in the Grant Agreement, form the basis for the defining the final areas of impact. ULaaDS divides the impact assessment in two main categories, reflected in two separate tasks assessing the impacts of the trials (GA 2020). There are several areas of impact within each category: 1) Impacts on logistics efficiency, traffic efficiency, land-use and the environment (Task 5.2), and 2) Economic impacts, user experience, user acceptance, willingness to pay and awareness (Task 5.3). The first category is mainly dealing with societal impacts, i.e. impacts the trials have on issues of concern for the city, the local community, the citizens and society at large. The second category is dealing with business model impacts, i.e. impacts the new business models have on the competitive value for the logistics service providers and their customers. Some minor adjustments have been made to the areas of impact mentioned above. The adjustments mainly involve regrouping of some of the impact areas.

The assessment of the ULaaDS trials will be based on the following areas of impact:

- Environment,
- land-use,
- traffic conditions,
- logistics efficiency,
- economic impacts,
- user experience and acceptance, and
- awareness.

The areas of impact are described in table 1.

Table 1. Description of each area of impact

Area of impact	Description
Environment	Urban freight transport contributes to greenhouse gas (GHG) emissions, air pollution and noise. Liveability and quality of life in cities depends on the quality and attractiveness of the urban environment, and air quality and noise level influence this. Also, the access for both residents and businesses to services such as on-demand deliveries can contribute to the liveability of cities. Carbon dioxide (CO_2) is a key measure of GHG emission and an important causes of climate change. Other GHGs are commonly translated into CO_2 equivalents. GHGs enters the atmosphere through the burning of fossil fuels in freight vehicles. GHG emissions from urban freight transport are influenced by the type of vehicle used, driving behaviour and distance driven. Air quality can be described by the concentration level of pollutants in the air. The main air pollutants from urban freight transport are nitrogen dioxide (NO_2) and Particle matter (PM_{10} and $PM_{2.5}$). The burning of fossil fuels in vehicles produces NO_x emissions, and NO_x turns into NO_2, which is dangerous to health. Particle matter result from tire and break wear. For cities with cold winters the use of studded tires will contribute significantly to air pollution. Noise from both transport and loading / unloading activities can be a nuisance and a health risk for people. Noise emissions from urban freight transport will be affected by the use of electric vs internal combustion engine powertrains, as well as vehicle speed. The physical environment, such as buildings, fences and vegetation, influences the level of noise pollution. Loading and unloading activities are often noisy, and can be a nuisance for nearby residents, as well as pedestrians and cyclists. The time of day and the general level of ambient noise will affect to what extent noise is perceived as a nuisance. Perceived noise level can differ from actual noise level.
Land-use	Urban freight transport uses urban public space. Area is occupied by the vehicles and their safety zones, as well as for maneuvering the vehicles and for loading and unloading activities. This includes area needed to drive and park the vehicles, i.e. roads, streets, shared spaces, squares, loading bays, etc. In addition, urban freight uses land for reloading and storage, such as in hubs and parcel lockers. These types of land use are important for urban last-mile deliveries, but can also generate more traffic locally.

Traffic conditions	Urban freight activities contribute to reduced efficiency of movement (flow) of traffic, including congestion. This includes the flow of pedestrians, bikes and vehicles, and traffic flow in public spaces such as streets, shared spaces, bike paths, pavements and squares. Freight vehicles parking on pavements, shared spaces or in squares for loading / unloading activities can interrupt micro-mobility flows. Stopping on the pavement or (partially) on the street will likely jam traffic. Deliveries during rush hour and in busy streets contribute to congestion. Traffic safety is an important issue, as urban freight transport can cause road injuries, fatalities and damages.
Logistics efficiency	Efficiency is the utilization of input factors in relation to the use of resources in production. The better the resource utilization, the more efficient the production. Logistics efficiency in the ULaaDS trials is linked to resource utilization in last mile distribution and logistics activities in cities. Production is last mile distribution and logistics activities, while the most important input factors are terminals, vehicles, labour and goods receipt. The production and the last mile distribution must be seen in relation to each other in order to be able to measure efficiency. Logistics efficiency and economic impacts overlap. Therefore, some of what is described above will be addressed under economic impacts when later introducing objectives and KPIs for each impact area.
Economic impacts	New urban freight transport (UFT) solutions require certain capital investment and may change operational costs compared to existing solutions. Economic impact focuses on the estimation of the effectiveness or benefits derived from a measure in relation to the costs associated with its preparation, implementation and operation. In economic efficiency terms, the balance between the impact of a measure and the willingness of users to pay the cost of achieving this impact has to be considered. The impact of the UFT solution must have a net positive effect to be economically viable. Sometimes it is not enough to only have a net positive effect, and the investment must be earned back in short time period. Economic impacts overlap with logistics efficiency and awareness. Therefore, some of what is described above will be addressed under logistics efficiency and awareness when later introducing objectives and KPIs for each impact area.
User experience and acceptance	New urban freight transport solutions can result in a change in satisfaction among customers and other users, compared to existing solutions. User satisfaction is the average reported satisfaction with the overall quality of a service. A measure is deemed to be well-accepted if users are satisfied with its existence and / or use. Acceptance level is the share of the population or target group who favourably receive or approve of the measure. Users are both actual and potential users of the on-demand services in the trials (shippers, last mile distributors, retailers / stores, customers, recipients of goods). Potential users are relevant in order to gain knowledge on potential for upscaling and replicability.
Awareness	In order to assess the market potential for the business model in question, there is a need to know whether there is demand and willingness to pay for the sustainable last mile delivery. Awareness is a prerequisite for willingness to pay (more) for the sustainability of a delivery. Therefore, recipients' awareness of sustainable delivery must be addressed.

	Recipient awareness is the share of the target population with knowledge of a measure on account of provided information. Both current recipients as well as potential recipients are relevant to investigate. Potential recipients are relevant in order to gain knowledge on potential for upscaling and replicability.

4.2 Objectives and expected impacts

Objectives for ULaaDS in general and for the trials specifically, should govern the definition of KPIs. Objectives relevant for both the cities and the logistic companies should be part of this.

Within the areas of impact (cf. chapter 4.1), some objectives and expected impacts are defined and described in the Grant Agreement. Others have been identified through literature review, study of project documentation and consultation with ULaaDS partners.

Objectives and expected impacts are closely interlinked, and to some extent overlapping. Objectives and expected impacts within the areas of impact, found in the Grant Agreement, are described in the text box below.

Objectives and expected impacts in the Grant Agreement

Social and societal impact:
ULaaDS will increase the quality and attractiveness of the urban environment by providing and implementing solutions and measures for shared and low emissions logistics operations. Those will significantly reduce air pollution, noise emissions and space occupancy, and contribute to increase traffic safety and service accessibility and availability in functional urban areas (as part of the impact and evaluation framework of WP5). (GA, Part B, p. 34)

ULaaDS has two categories of solutions, and for each category the following potential impacts are identified (GA, Part B, p. 4):
1) Collaborative delivery models:
Increase the load factor and vehicle utilisation rate by 25 % and reduce the lead time by 10 % (matching the expected delivery reliability increase of cargo bikes while leading to reduction of handling time and costs).
Effectively deploy dual mobihubs, contributing to improve the use of existing infrastructure by at least 20 %.
2) Integration of passenger and urban freight mobility services and networks:
Increase at least a 25 % load factors and vehicle utilisation rates.
Effectively integrate dual transport flows, reducing passenger transport cost by 5 % (through additional revenues for the public transport companies).

The potential for the ULaaDS schemes to contribute to zero emissions logistics by 2030 has been estimated for the lighthouse cities using 2019 as a baseline (GA, Part B, pp. 31-32).

Based on the Grant Agreement and input from ULaaDS partners, we get a set of objectives as summarised in table 2.

Table 2. Areas of impact and related objectives

Area of impact	Objectives
Environment	Reduced greenhouse gas (GHG) emissions
	Reduced air pollution
	Reduced noise pollution
	Increased service accessibility
Land-use	More efficient use of existing public space
Traffic conditions	Reduced congestion
	Improved traffic safety
Logistics efficiency	Increased utilisation of load capacity of vehicles
	Increased speed of delivery
	More efficient use of vehicle fleet
Economic impacts	Economically sustainable business models
User experience and acceptance	Same or better level of service as existing schemes and increased acceptance
Awareness	Increased awareness of sustainable delivery solutions

According to the Grant Agreement, impacts will be categorised under the following impact orders: 1) First order impacts, which occur in the transport system, on a trip-by-trip basis, 2) Second order impacts, which involve system-wide changes in the transport system, and 3) Third order impacts, which are wider societal impacts. In the 2nd iteration, when the exhaustive list of preliminary KPIs is reduced to the final list, the final KPIs will be categorised according to these impact orders if applicable.

4.3 Key Performance Indicators

Key Performance Indicators (KPIs) are quantifiable and clearly defined measurements, that reflect the core goals and targets of the intended measure based on the stakeholders' perspectives (Balm and Quak, 2012). KPIs are the critical (key) indicators of progress toward an intended result. KPIs provide a focus for strategic and operational improvement, creates an analytical basis for decision making and help focus attention on what matters most.

The objectives (cf. 4.2) are operationalised into KPIs. In addition, some KPIs are already defined in the Grant Agreement. The KPIs described and defined in this chapter are preliminary and will be further developed and validated in the 2nd iteration of the impact assessment framework. As part of this validation process, the preliminary KPIs will be rated according to relevance (importance) and data availability, resulting in a list of selected KPIs to be used in the impact assessment.

In order for the KPIs to be useful tools in the ULaaDS impact assessment, they should be:

- **Understandable and informative.** A range of different stakeholders should perceive the KPIs as easy to grasp, while providing sufficient useful information. Relevant stakeholders are amongst other cities (administration and politicians) and companies (logistic service providers etc.).
- **Relevant and important**. I.e. essential for assessing if the objectives of the ULaaDS trials have been reached, and limited to what matters the most. Not all the KPIs will be equally relevant for all the trials.
- **Comparable**. I.e. the KPIs should be the same for all the ULaaDS trials. The KPIs will be used for assessing impacts of trials in the three lighthouse cities. To be able to compare results across the trials it is necessary to use the same KPIs.
- **Realistic**. It must be possible to collect necessary data, of adequate quality, and it must be possible to do so within the resources available in the project. Also, it is important to have a limited number of KPIs in order to keep focus on what is important and to make it manageable to use the them.
- **Quantifiable.** It should be possible to express each KPI in a numerical measure, e.g. a pure number, an index, ratio or percentage.

These criteria translate into questions to be answered by the ULaaDS partners as part of the validation and prioritisation of the preliminary KPIs:

- Is the indicator understandable and informative for different stakeholder groups?
- Is the indicator relevant?
- Is the indicator measurable?
- Is the data available?
- Are there relevant and important indicators which are missing?
- Which indicators are the most important?

Based on the ULaaDS impact assessment process described in chapter 3.3 and the aforementioned criteria, we get a set of preliminary KPIs summarised in table 3.

Table 3. Objectives and related KPIs

Objective	Key Performance Indicator (KPI) (unit of measurement)
Reduced greenhouse gas (GHG) emissions	CO_2 eq. emissions (kg)
Reduced air pollution	Cargo bikes replacing diesel vans (number)
	NO_x and Particle matter (PM_{10}, $PM_{2.5}$) emissions (kg)
Reduced noise pollution	Noise emissions (dB(A))
	Perceived noise level (index)
Increased service accessibility	Travel distance to services for residents and businesses (number)

More efficient use of existing public space	Public space used for UFT activities (hrs per m^2)
Reduced congestion	Obstruction of other road users during loading / unloading (Veh-hrs)
	UFT vehicles travelling on congested streets / shared spaces (Veh-hrs)
Improved traffic safety	Road accidents, injuries and fatalities (number)
	Damages to freight vehicles (number)
	Interactions between vehicles and other road user groups (number)
	Perceived safety (index)
Increased utilisation of load capacity of vehicles	Vehicle load factor (percentage (%))
	Integration of goods and passenger flows (number)
Increased speed of delivery	Time per delivery / pick up (minutes)
	Number of delivery attempts (number)
More efficient use of vehicle fleet	Deliveries per tour per vehicle (number)
	Dimension weight / day per vehicle (kg, m^3)
	Drop density per vehicle (percentage (%))
	Days in operation per vehicle (percentage (%))
Economically sustainable business models	Last mile delivery cost per delivery / pick up
	Distribution and warehouse cost per delivery / pick up (percentage (%))
	Investment costs for the city (percentage (%))
Same or better level of service as existing schemes and increased acceptance	On time in full (OTIF) (percentage (%))
	Customer satisfaction (index)
	Level of acceptance (percentage (%))
Increased awareness of sustainable delivery solutions	Recipient awareness of sustainable delivery options (index)
	Recipient willingness to pay for sustainable delivery (index)

4.4 Data collection and processing

In order to assess the impact of the ULaaDS trials it is essential to collect and analyse data before and after the implementation of the trials, i.e. *baseline* and *ex-post* data respectively. It is important to distinguish changes that can be attributed to the trials from changes due to other activities or influences. Furthermore, it is necessary to collect and review data iteratively to capture potentially new and / or changed conditions and conclusions during the trials.

Due to the relatively small scale of the individual trials their impact on the environment, land-use and traffic conditions on a (larger) city scale may be difficult to observe and measure. The expected impact when the solutions are more broadly adopted can be modelled, based on the impact in trial.

Sources of data for the indicators are:

1) Public data (from cities, open data sources or others)

2) Technical data (from LSP and operators)

3) Theoretical premise (e.g. m^2 taken by a vehicle)

4) Trial data: registered during trials (by LSP, operators or others),

5) Result derived from recorded trial data

In order to capture the data above, interrelations between the different WPs are necessary. The goal is to gather information about public and technical data, as well as theoretical premises, in advance of the trials. An occasion to address the initiation of the collection process of these three data classifications are e.g. the local fora as part of WP2 (Task 2.2). In the next step, formats like (electronic) surveys are considered to be spread among the relevant stakeholder to gather information about the KPIs during Task 2.3. As Task 2.2 and 2.3 are starting before the research trials, this creates a certain lead time to pre-evaluate the public and technical data as well as the technical premises, and integrate them into the examination of the research trials as well as focusing on the recording of actual trial data afterwards. Furthermore, preliminary data gaps will become apparent to address at the latest during the trials.

The definition of the data collection methods, as well as the data collection during the research trials, will be done as part of WP4 (task 4.5). Corrections and extensions to the methods and definitions of data to be collected must be possible at any time to adjust to changes and challenges in the surrounding conditions of the trials. It is a clear aim to use as much primary data as possible, i.e. integrating real-life data of the research trials. The data collection during the research trials is planned to be organised in an iterative way. Additionally, the task leader will take care to inform about data gaps occurring using an internal alert system (e.g. informing the WP leader after a certain tolerance period).

There is a need to collect data from the ULaaDS industry partners involved in the trials. Some of this data will probably be considered business sensitive, and must be treated confidentially. A non-disclosure agreement will be signed amongst the ULaaDS partners. These issues will be dealt with in the Data Management Plan (WP4). The data will be used to compare the two stages of “pre-implementation” and “trial implementation”.

4.5 KPI and support indicator table

The KPI and support indicator table below sum up areas of impact, objectives and KPIs (cf. chapter 4.1-4.3). For each KPI there is a set of support indicators, which help understand and interpret the outcome of the KPIs. The same support indicator can support multiple KPIs. The KPIs, support indicators and units of measurement are preliminary, and constitute an exhaustive list. The KPIs will be further validated and prioritised in the 2nd iteration of this framework, and as a result the number

of KPIs is likely to be reduced. A detailed description of the objectives, KPIs and support indicators will follow in the 2nd iteration of this deliverable when the final list of KPIs is completed. This provides a necessary room for interpretation in the work of reviewing and prioritizing KPIs in the 2nd iteration. In addition, 2nd iteration will provide explanations on how we reach the final KPI value coming from several support indicators, which vary in shape, units etc .

Table 4. Areas of impact, objectives, KPIs and support indicators

Objective	Key Performance Indicator (KPI) (unit of measurement)	Support indicator
ENVIRONMENT		
Reduced greenhouse gas (GHG) emissions	CO_2 eq. emissions (kg)	No. of vehicles
		Km driven
		Vehicle type (diesel, petrol, bio fuel, electric)
		Size / category of vehicle (cargo bike, van, truck)
		Energy consumption
Reduced air pollution	Cargo bikes replacing diesel vans (number)	No. of diesel vans replaced by cargo bikes
	NO_x and Particle matter (PM_{10}, $PM_{2.5}$) emissions (kg)	No. of vehicles
		Km driven
		Vehicle type (diesel, petrol, bio fuel, electric)
		No. of vehicles running on fossil fuel and electricity respectively
Reduced noise pollution	Noise emissions (dB(A))	No. of vehicles running on fossil fuel and electricity respectively
		Speed
	Perceived noise level (index)	No. of people experiencing nuisance
		Time of day
		Type of district / neighbourhood
		Type of activity (driving, loading, unloading)
Increased service accessibility	Travel distance to services for residents and businesses (number)	Average distance between homes / businesses in the city centre and location of services (parcel locker, shared cargo bike station, etc)
		No of residents in the city centre
		No of businesses in the city centre

Objective	Key Performance Indicator (KPI) (unit of measurement)	Support indicator
LAND-USE		
More efficient use of existing public space	Public space used for UFT activities (hrs per m^2)	Area occupied by vehicle in traffic and parked, incl. safety zone and area for loading / unloading
		Duration of time in traffic and parked respectively
		Speed of vehicle when in traffic
		Area occupied by UFT facilities (hubs, parcel lockers, cargo bike stations)
		Duration of time which UFT facilities occupy space
		No. of deliveries / pick-ups
TRAFFIC CONDITIONS		
Reduced congestion	Obstruction of other road users during loading / unloading (Veh-hrs)	Total time obstructing other road users
		No. of times obstructing other road users
		Type and no. of road user being obstructed (pedestrian, cyclist, mico-mobility user, driver of vehicle)
		Type of public space (pavement, bike lane, square, street, shared space)
		Size / category of UFT vehicle (cargo bike, van, truck)
	UFT vehicles travelling on congested streets / shared spaces (Veh-hrs)	Time travelled on congested and non-congested streets / shared spaces respectively
		No. of vehicles travelling on congested and non-congested streets / shared spaces respectively
		Size / category of vehicle (cargo bike, van, truck)
Improved traffic safety	Road accidents, injuries and fatalities (number)	No. of accidents
		No. of injuries
		No. of fatalities
		Vehicle kilometres
	Damages to freight vehicles (number)	No. of damages
		Vehicle kilometres
	Interactions between vehicles and other road user groups (number)	No. of interactions between UFT vehicles and pedestrians / cyclists / micro-mobility users / drivers of vehicles

Objective	Key Performance Indicator (KPI) (unit of measurement)	Support indicator
		Vehicle kilometres
	Perceived safety (Index)	No. of pedestrians / cyclists /micro-mobility users experiencing discomfort / lack of safety
		Speed of vehicle
		Size / category of vehicle (cargo bike, can, truck)
		Type of district / neighbourhood
LOGISTICS EFFICIENCY		
Increased utilisation of load capacity of vehicles	Vehicle load factor (Percentage (%))	Speed of vehicle
		Size / category of vehicle (cargo bike, van, truck)
		Type of district / neighbourhood
	Integration of goods and passenger flows (number)	No. of passengers transported with UFT vehicles
		No. of trips
		No of veh-km
Increased speed of delivery	Time per delivery / pick up (minutes)	Driving time
		Stop time
		Cut off time pick ups
		Stem time
		No. of deliveries/pick ups
	Number of delivery attempts (number)	No of deliveries attempts
		Total no of deliveries
More efficient use of vehicle fleet	Deliveries per tour per vehicle (number)	No. of deliveries / pick ups
		No. of tours per day
		No. of stops
		No. of deliveries / stop
	Dimension weight / day per vehicle (kg, m^3)	Volume of deliveries / pick ups
		Weight of deliveries / pick ups
		Average weight per delivery
		Needed capacity
	Drop density per vehicle (Percentage (%))	Number of drops on a delivery route
		Days in operation per vehicle

Objective	Key Performance Indicator (KPI) (unit of measurement)	Support indicator
	Days in operation per vehicle (Percentage (%))	Days in operation per facility
ECONOMIC IMPACTS		
Economically sustainable business models	Last mile delivery cost per delivery / pick up (Percentage (%))	Cost per person/day
		Hour worked/day
		Absenteeism
		Cost/vehicle/day
		IT cost/delivery
	Distribution and warehouse cost per delivery / pick up (Percentage (%))	Depreciation costs of investment
		Operating costs
		Maintenance costs
		No. of deliveries / pick-ups
	Investment costs for the city (Percentage (%))	Amount of money spent by the local authority to invest in infrastructure.
		Amount of money spent to facilitate and support trials, and / or enforce regulation / legislation
USER EXPERIENCE AND ACCEPTANCE		
Same or better level of service as existing schemes and increased acceptance	On time in full (OTIF) (Percentage (%))	No. of deliveries / pick-ups on time
		No. of errors (loss, theft, damaged)
		ETA (expected time of arrival)
		Total no. of deliveries / pick ups
	Customer satisfaction (Index)	Satisfaction with services
		Loyalty
		Likelihood of recommending to others
		Information availability, visibility and accessibility (real time updated)
	Level of acceptance (Percentage (%))	Understanding level
		Willingness to change
AWARENESS		
Increased awareness of	Level of awareness of sustainable delivery (index)	Recipient awareness of sustainable delivery options

Objective	Key Performance Indicator (KPI) (unit of measurement)	Support indicator
sustainable delivery solutions	Willingness to pay for sustainable delivery (index)	Recipient willingness to pay for sustainable delivery

5. Conclusions

The ULaaDS impact assessment framework builds on existing knowledge and expertise in the field obtained through literature review, studying documentation from other EU projects and by leveraging the ULaaDS partners' expertise.

The impact assessment of the ULaaDS trials will be based on the principles of topical application, multi-criteria, multi-actor views, co-production and iterative processes, as well as comparability. The methodology for the impact assessment framework is largely based on the bottom up 7-stage approach from the TRIANGULUM project. Key elements in this approach is the extensive cooperation with city stakeholders, and co-production of both the framework and the impact assessment indicators. The TRIANGULUM methodology is used in combination with the STRAIGHTSOL approach to assure stakeholder objectives are fully considered, as well as the SUCCESS approach to ensure the quality and relevance of the indicators. The review criteria used in the SUCCESS project form the basis for the review of KPIs in ULaaDS. In addition, indicators used in the NOVELOG, CITYLAB and STRAIGHTSOL projects have been used to validate and supplement the ULaaDS indicators within relevant areas of impact.

The ULaaDS trials will have societal impacts, i.e. impacts on issues of concern for the city, the local community, the citizens and society at large. The trials will also have business model impacts, i.e. impacts the new business models have on the competitive value for the logistics service providers and their customers. Impact areas to be assessed in ULaaDS are: environment, land-use, traffic conditions, logistics efficiency, economic impacts, user experience and acceptance, and awareness. Objectives for the area *environment* include reduced greenhouse gas (GHG) emissions, reduced air pollution, reduced noise pollution and increased service accessibility. For *land-use* and *traffic conditions* the objectives are more efficient use of existing public space, reduced congestion and improved traffic safety. In addition, increased utilisation of load capacity of vehicles, increased speed of delivery and more efficient use of vehicle fleets are objectives for *logistics efficiency*. The areas *economic impacts* and *user experience and acceptance* include the objectives of economically sustainable business models, as well as same or better level of service as existing schemes and increased acceptance. Finally, increased awareness of sustainable delivery solutions is an objective for the impact area of *awareness*.

Preliminary Key Performance Indicators (KPIs) are defined for each objective, and for each KPI there is a set of support indicators. The support indicators will help understand and interpret the outcome of the KPIs. The KPIs will be further validated and developed in consultation with the ULaaDS partners, as described in chapter 6.

6. Next steps

The impact assessment methodology described in this deliverable (cf. Chapter 3) is partially implemented in the 1st iteration of the impact assessment framework. The implementation will be completed in the 2nd iteration, resulting in an updated version of the framework. Following steps will take place in the 2nd iteration:

- **Finalise set of KPIs.** The final definition, selection and description of the KPIs to be used in the impact assessment of the ULaaDS trials will take place**.** This includes validating and prioritising the preliminary KPIs found in this deliverable, in a systematic way based on feedback from the ULaaDS partners. Criteria for validating and prioritising include data availability, as well as relevance and measurability of the KPIs (cf. 4.3). The process for feedback will planned and conducted in close cooperation between WP2, WP4, WP5 and WP6. The preliminary KPIs, support indicators and quantifiable units will be aligned and tailored further to the ULaaDS trials. The work on evaluation criteria for assessment of other pilots (benchmarking) in WP3 will provide input to – and as far as possible be aligned with - the KPIs. The collective target system being produced for Deliverable 2.2, with its co-relation of opinions and objectives of important stakeholder groups, will provide input to the selection and prioritisation of KPIs. Opportunities to align relevant KPIs with the sustainable urban mobility indicators (European Commission, 2021) will be considered, in order to facilitate the integration of ULaaDS results in SUMPs / SULPs (cf. WP6).
- **Categorise according to impact orders.** When the final KPIs have been selected, they will, if applicable, be categorised according to these impact orders: 1) First order impacts, which occur in the transport system, on a trip-by-trip basis, 2) Second order impacts, which involve system-wide changes in the transport system, and 3) Third order impacts, which are wider societal impacts (GA 2020).
- **Alignment with data collection activity.** Task 4.5 will collect, process and analyse data from the trials and other stakeholder engagement initiatives. This includes a continuous monitoring of the trials' progress based on the KPIs defined in the updated version of the impact assessment framework. This will thus be an iterative process between WP4 and WP5. Data collection methods will be defined in WP4, after the KPIs have been validated and prioritised.
- **Define evaluation methods.** Methods to be used in evaluating the impacts of the trials will be defined. The methods will take into account the fact that the trials are small scale and will in themselves have limited impact on the environment, traffic safety, land use and traffic efficiency in the city as a whole. The use of extrapolation of impact will be considered. Relevant methods and information from the Logistics Sustainability Index (LSI) will be extracted and incorporated in the evaluation methods to be used in the ULaaDS impact assessment.

- **ULaaDS' sister projects.** Dialog with the ULaaDS' sister projects LEAD and SENATOR on impact assessment could give valuable input to the framework.

The updated version of the impact assessment framework will be used for the impact assessments taking place in Task 5.3 and Task 5.4.

In order to align the impact assessment indicators with work in other work packages, the 2nd iteration is likely to start in March 2021. The updated version of the framework will be completed after completing the research trial planning (due November 2021).

Acronyms

Acronym	Meaning
AI	Artificial Intelligence
AV	Autonomous Vehicles
D	Deliverable
EC	European Commission
GA	Grant Agreement
ICT	Information and Communication Technology
KPI	Key Performance Indicator
LF	Load Factor
LSP	Logistics Service Provider
O	Objective
ODD	On-demand Delivery
P	Product
PPP	Public Private Partnership
PM	Person Month
SUMP	Sustainable Urban Mobility Plan
SULP	Sustainable Urban Logistics Plan
T	Task
UC	Use Case
UCC	Urban Consolidation centre
UFT	Urban Freight Transport
ULaaDS	Urban Logistics as an on-Demand Service
WBS	Work Breakdown Structure
WP	Work Package
VUR	Vehicle Utilisation Rate
ZEV	Zero Emission Vehicle

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