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An Impact Assessment Methodology Development for Transport Automation within the Concept of Logistics as a Service

Facoltà di Ingegneria Civile e Industriale

Dipartimento di Ingegneria Civile, Edile e Ambientale
Dottorato di Ricerca in Infrastrutture e Trasporti (trentacinquesimo ciclo)

Sevket Oguz Kagan Capkin

Matricola 1784288

Relatore
Prof. Luca Persia

Correlatore
Prof. Davide Shingo Usami

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CHE HANNO PERSO LA VITA IN TURCHIA
A CAUSA DEI TERREMOTI DEL FEBBRAIO 2023

THIS THESIS IS DEDICATED TO THE PEOPLE
WHO LOST THEIR LIVES IN TURKEY
DUE TO EARTHQUAKES IN FEBRUARY 2023

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An Impact Assessment Methodology Development for Transport Automation within the concept of Logistics as a Service

Sevket Oguz Kagan Capkin

PhD Thesis in Infrastructure and Transportation

Tutor. Prof. Luca Persia

Rome, February 2023

This research study for "An Impact Assessment Methodology Development for Transport Automation within the Concept of Logistics as a Service" presents an advanced impact assessment methodology for assessing the impacts of transport automation on the field of logistics as a service context. This research aims to address the lack of a standardized and comprehensive methodology for evaluating the impacts of transport automation on logistics as a service, which is essential for decision-making processes.

The proposed automated logistics as a service impact assessment methodology consists of four main steps: defining the scope and boundaries of the analysis while having a literature review, identifying the impacts areas and performance indicators of transport automation on logistics as a service while addressing prioritization, a scenario definition and case study associations while having data collection approach, and evaluating of the impacts with three logistics assessment indexes. The study also presents a case study deployment of the proposed methodology in the context of simulation and automated vehicle presence in real-life application. Moreover, the research also provides a smart tool design for adaptation and integration of such a service into existing society.

The results of the case study show that the proposed methodology can provide valuable insights into the impacts of transport automation on logistics as a service, including the potential benefits and challenges. The findings indicate that transport automation can bring significant benefits in terms of cost savings while having time and distance saved, efficiency increase, but also raise stakeholder concerns about job displacement, social acceptance, and cybersecurity.

Overall, the research study provides a valuable contribution to the field of logistics and transport automation by proposing a new methodology for impact assessment, which can help decision-makers and stakeholders to make informed decisions regarding the implementation of transport automation in logistics as a service.

Keywords: automation, logistics, automated logistics, impact assessment, digital solutions

Abstract in Italiano

SVILUPPO DELLA METODOLOGIA PER LA VALUTAZIONE DELL'IMPATTO SULL'AUTOMAZIONE DEI TRASPORTI NEL CONTESTO DEL LOGISTICS AS A SERVICE

Sevket Oguz Kagan Capkin

Tesi di Dottorato in Infrastrutture e Trasporti

Tutor. Prof. Luca Persia

Roma, Febbraio 2023

Il presente studio dal titolo "Sviluppo di una metodologia di valutazione dell'impatto per l'automazione dei trasporti nell'ambito del concetto di Logistics as a Service" illustra una metodologia avanzata di valutazione dell'impatto dell'automazione dei trasporti nel contesto della logistica come servizio. L'indagine si propone di ovviare alla mancanza di una metodologia standardizzata e completa per la valutazione degli impatti dell'automazione dei trasporti sulla logistica come servizio, essenziale per i processi decisionali.

La metodologia per la valutazione dell'impatto della logistics as a service automatizzata qui proposta si compone di quattro fasi principali: la definizione dell'ambito e dei confini dell'analisi con una revisione della letteratura, l'identificazione delle aree di impatto e degli indicatori di performance dell'automazione dei trasporti sulla logistics as a service con la definizione delle priorità, la definizione di uno scenario e l'associazione di casi di studio con un approccio di raccolta dei dati e la valutazione degli impatti con tre indici di valutazione della logistica. Lo studio presenta anche un caso di applicazione della metodologia proposta nel contesto della simulazione e della presenza di veicoli automatizzati in situazioni reali. Inoltre, fornisce un progetto di strumento intelligente per l'adattamento e l'integrazione di tale servizio nell'attuale società.

I risultati del caso di studio dimostrano che la metodologia proposta può fornire preziose indicazioni sull'impatto dell'automazione dei trasporti sulla logistica come servizio, compresi i potenziali benefici e le sfide. I risultati indicano che l'automazione dei trasporti può apportare benefici significativi in termini di risparmio di costi, di tempo e distanze, nonché in termini di aumento dell'efficienza, anche se solleva preoccupazioni da parte degli stakeholder circa la delocalizzazione dei posti di lavoro, l'accettazione sociale e la sicurezza informatica.

Nel complesso, lo studio fornisce un utile contributo al settore della logistica e dell'automazione dei trasporti proponendo una nuova metodologia per la valutazione dell'impatto, che può essere di supporto ai decisori e agli stakeholder nell'adozione di decisioni informate relative all'implementazione dell'automazione dei trasporti nella logistica come servizio.

Parole chiave: automazione, logistica, logistica automatizzata, valutazione d'impatto, soluzioni digitali

AN IMPACT ASSESSMENT METHODOLOGY DEVELOPMENT FOR TRANSPORT AUTOMATION WITHIN THE CONCEPT OF LOGISTICS AS A SERVICE

1. Introduction

Automated Logistics as a Service (ALaaS) is an up-and-coming logistics strategy which has the remarkable potential to transform the logistics sector. ALaaS deploys such advanced techniques as artificial intelligence, machine learning, and the Internet of Things in order to automatize various logistics activities, including transportation, warehousing, and supply chain management. It has been consistently argued that the deployment of ALaaS could decrease operational costs, improve efficiencies along with enhancing the stakeholder experience. Even though, the pervasive adoption of ALaaS equally generates some concerns about the associated potential impacts upon various stakeholders, such as those of staff, users-customers as well as public as a whole.

Thus, a need for a comprehensible and systematized impact assessment framework for ALaaS could not be over-emphasized. Such a framework is expected to facilitate a comprehensive and structured approach to identifying, assessing, and mitigating the possible impacts of ALaaS on various scenarios and stakeholders. Such a framework shall further support the identification of necessary measures to both maximize the benefits and minimize the negative impacts associated with ALaaS.

The objective of this research is to develop an ALaaS impact assessment framework that addresses both the complex interrelationships among different stakeholders and broader societal, economical, and environmental considerations. As such the framework will be further elaborated through a rigorous existing literature review, as well as empirical studies and stakeholder and academic discussions. The impact assessment framework will then be tested and validated through both case studies and simulations.

It is expected that the contribution of this presented thesis will be meaningful in guiding the deployment as well as the adoption of such ALaaS concept in a reliable and sustainable path. Thus, the impact assessment framework is being developed throughout this thesis will also have a valuable roadmap and digital tool for policy-makers, logistics providers and other stakeholders to ensure that the advantages of ALaaS are realized while minimizing adverse impacts on existing operations and society.

The foreword chapter emphasizes the automated vehicles and intelligent technologies in cargo transport and logistics, impact assessment on cargo transport and logistics, and the concept of the Logistics as a Service (LaaS). The principal purpose of the chapter is to furnish a piece of essential facts regarding automation in transportation, in particular cargo transport, and to provide what is an impact assessment and why it is crucial for the executions.

Automation is the future of mobility regarding sustainability innovations that will fundamentally transform each kind of transport system into intelligent approaches respecting a sustainable and efficient method with respect to the European horizons. This will reinforce to avoid bothering about car driving when the vehicle will totally operate itself for greener, safer, and more efficient transportation. Several investigations endeavouring to assess the impacts of automation but automated transport has some impacts that are not known well. The primary matters of the capability of these investigations seek to capture the impact of the service; to do that, there are different barriers such as the lack of a few various illustrations and a variety of assessed impact area(s). Several impacts are nevertheless not known sufficiently because several enforced projects/studies are not much and sot of them is not enough to feed different viewpoints.

Most of the examinations and assignments have been performed on the automated vehicles and intelligent technologies for passenger transport with respect to the common impact areas which are road safety, traffic efficiency, energy consumption, environment, social effects, socio-economic, and user acceptance.

Starting from this point of view, the impacts would likewise be correlated to cargo transport and logistics operations, though there are few studies that are concentrating on the automated logistics service and its impacts. Correspondingly, in forthcoming undertakings, there should be a general framework to assess the impacts of automated logistics services, and a pattern to support the understanding of the consequences of automation in transportation. Several impacts of the LaaS (Logistics as a Service) concept are well-known thanks to assignments on passenger transport, nevertheless, the different impact areas require better emphasis to provide more reasonable impact examinations.

Concerning this gap, the research objective is defined to develop an impact assessment framework for the automation in logistics fields, to provide a better understanding of the effects of automation on logistics operations with respect to specified impact areas (that will be prioritized according to the European targets for sustainable transportation), and to furnish a framework (which will be characterized thanks to the previous case studies) for automated logistics services to underline its impacts and assessment technique. On the other hand, regarding this intent, the research performs on a product of technique for the impact assessment on automated logistics services, the characterization of automated logistics scenarios for further assignments, investigation of the performance indicators, having a case study to test the developed impact assessment framework; in the end, deliver an automated logistics impact assessment framework in terms of sustainable and efficient logistics assuming safety, acceptance, service efficiency, and environmental concerns.

1.1. Information about Automation in Freight Transport and Logistics

Automated services and vehicles in the transport sector are increasingly becoming more common and preferred approaches for the tomorrow of passengers and goods mobility by having sustainable and efficient inventions which will adjust individuals of the transport system to bypass human intervention in driving/operation tasks while the services and vehicles will totally be functional by intelligent services backed.

The automated logistics subjects of a supply chain, involving the logistics services, processes, goods mobility, and distribution centroids, have a possibility to improve efficiency by especially interesting in an automated logistics processing or automated vehicle operations. Regarding that, various automated logistics technologies would be mentioned such as automated delivery or vehicle tracking/control, automated handling, automated vehicles to transport materials (such as driving tasks, loading/unloading, and storage), and automated data collection.

Automated logistics processing directs to the usefulness of techniques or software to enhance the safety, sustainability, and efficiency of procedures within a logistics operation. It usually involves to procedures that should be completed with a minimal human intervention. As a consequence of this reality, along with automated logistics processing, there are numerous required processes that would be an automated service. This is the reason why an automated logistics transformation is foreseen in a near future in terms of more efficiency, sustainability, and a higher level of service quality for European citizens.

The projects and investigations are attempting to evaluate the consequences of automated services and vehicles in transport sectors, though automation in transportation has some impacts that are not comprehended sufficiently because the capability of these investigations is missing the aim of catching the impacts of automated services on logistics fields. This occurs because the passenger transport is more observable and the technology is still unexplored to address the main barriers, which are a lack of a number of different illustrations and a variety of assessed impact areas, of automation in transportation. Concerning that, different impacts of automated logistics services are still not comprehended pleasingly, and an impact assessment framework is not presented because the number of executed projects/examinations is not adequate and not enough to furnish distinct viewpoints. [1, 41]

1.2. Impact Assessment on Freight Transport and Logistics

The impact assessment, in general terms, guides the evaluation of the consequences of a project or assignment. Moreover, the impact assessment is a theory-based analysis that evaluates the impacts of a service or project by an examination that is supervised by a theoretical design subsidized by the implementation. It also assesses the consequences of an innovation in service or approach through an increased technique in the broader evaluation of new implementations, in particular, an automated transport mode such as an automated logistics service or an automated logistics processing. To make this impact assessment, there are two performance forms that have been summarised below: [46]

- *Ex-ante impact analysis:* This is an aspect of the necessities study and planning actions of the automated logistics process cycle. It interests accomplishing a forthcoming investigation of what the impact of an automated logistics service or project.
- *Ex-post impact assessment:* This is the other aspect that is an evaluation and management action of the cycle. Considerably, evaluation targets to comprehend the capacity of an automated logistics service or project to update the innovation.

Impact assessment concentrates on the consequences of a project or service (such as an automated logistics service, etc.), whereas evaluation is feasible to substitute a more comprehensive matters such as an automated logistics scenario design, the economy and efficiency of such automated logistics service, environmental impacts, etc. to enhance the innovation of forthcoming projects or investigations.

Regarding this sort of impact assessment, the anticipated impact areas are road safety, traffic efficiency, energy consumption, environment, social effects, socio-economic, and user acceptance [23]. Besides, the impacts are correspondingly connected to logistics processes, but there are occasional analyses that are concentrating on the automated goods mobility and automated logistics impacts. Likewise, in forthcoming undertakings, there should be a general framework to evaluate the consequences of automated goods mobility and logistics processes, and a pattern to support the understanding of the outcomes/developments of automated logistics processes. Several impacts of the LaaS (Logistics as a Service) are well-known; nevertheless, the other impact areas require more additional preoccupation to have more satisfactory impact assessments. [2, 7, 23]

1.3. Logistics as a Service with Automated Vehicles and Intelligent Technologies

Over recent decades, the logistics sector has experienced remarkable shifts, led by the appearance of new kinds of logistics IT solutions and advancing stakeholder perceptions. Among the many exciting trends in this regard is the emergence of logistics as a service (LaaS), which is enabling logistics services and relevant stakeholders to enable their logistics management requirements to be successfully outsourced using these technologies.

Logistics as a Service (LaaS) is a newly emerging concept for the logistics chain over the past few decades, as organizations are seeking to utilize external logistics providers that provide a variety of services, including freight transport, inventory management and warehousing. The LaaS providers focus on providing organizations with more flexibility, efficiencies, cost-effectiveness, and sustainability in terms of the logistics operations (Chen, J., Liu, Y., & Zhang, G. (2019)).

In parallel, automated techniques are also transforming the logistics sector, with an ever-increasing number of organizations deploying such technologies as automated vehicles, delivery drones, and automation robotics to boost the efficiency and reliability of their logistics operations. Although such technologies have the potential to transform the logistics sector, such technologies also bring up concerns regarding their impact on various stakeholders, such as the environment, society, and economy (Chua, S. C., Lim, Y. M., & Lee, K. H., 2019).

Although, LaaS itself is still in its initial steps, though, and there are many unique challenges that need to be addressed for it to achieve its full capability. One of the more crucial of those challenges is the necessity of reliable, efficient, and cost-effective cargo transportation. To achieve that, LaaS providers are looking further and further to automated vehicles and digital solutions, such as automated service applications or algorithms to improve their logistics operation managements.

Since organizations are relying more and more on LaaS service providers that exploit innovation and automation technologies to manage their logistics operations, it is therefore significant to address how those services affect the various aspects of sustainability, safety, cost-effectiveness, and acceptability. Doing so requires the development of an impact assessment framework capable of measuring and evaluating the effects of LaaS and automated technologies on those different dimensions (Mollenkopf, D., Stolze, H., Tate, W. L., & Ueltschy, M. G., 2020).

Within this context, then, there is an increasing necessity for research that could further advance the understanding of how to plan and implement LaaS systems, considering impact assessment, that make use of such techniques to fulfill their potential, as well as to understand the possible impacts and outcomes. That is where this research thesis comes in. Through exploring the various technological and operational considerations of implementing such LaaS together with automated vehicles and intelligent technologies, it will contribute to the further development of a more efficient, sustainable, and cost-effective logistics system.

Besides, since logistics keeps being increasingly significant in global trade, that research could have considerable implications in practice within organizations, administrations as well as society as a whole. By providing hints on how to optimize logistics as a service with automated vehicles and smart solutions, it could contribute to further paving the way toward a more efficient and sustainable future (Delgado, J. A., & Sousa, J. M., 2018)

Over the last decades, innovation and advanced techniques have become more favorable, supporting sustainable and smarter urban areas. To transform changes more adequately into automated logistics services, it is fundamental to have a proper way of using such an automated logistics service when booking, tracking, and monitoring the status of a delivery transfer from one point to another. In this respect, an automated logistics mobile application is being presented that enables service users to pre-book a delivery transfer from an origin to a destination while also tracking delivery and vehicle positions by logging in using the users' individual data. Besides, such an application either authorizes the accumulation of user points for the utilization of the mobile application's functionalities or penalizes users who do not respect the loading or unloading schedule. Further chapters specify the Automated Logistics Mobile App (ALMA) segments.

This research project is intended to present an overview of the cross-over between LaaS and automated solutions and to explore the various elements that shall be taken into account when designing an impact assessment framework for such solutions, as well as how to properly deploy such an innovation through designing an intelligent tool with the appropriate characteristics. To this end, the research project will be drawing on relevant literature in the areas of logistics operations, sustainability, and impact assessment to provide a comprehensive understanding of such a subject (Kusi-Sarpong, S., & Gupta, M., 2021).

2. Research Objectives

The proposed research study assumes an impact assessment procedure development for automated logistics services and processes. The research targets to deliver an assessment framework, bringing a reference from the literature review, analyzing prioritization techniques, to understand stakeholders' priorities and concerns with respect to the performance areas to provide a more efficient performance assessment for the forthcoming execution of automated logistics services. The assessment procedure will concentrate on the automated logistics service impact assessment from the European standpoint. For this intent, the scientific and technical objectives are specified as detailed below:

- The understanding of references from Literature Review to identify and comprehend prior reflections and/or assignments on urban logistics and freight transport with automated techniques to examine these encountered references regarding impact assessment of logistics involving also operational variables and potential impact areas with respect to the European horizon,
- Selection of possible impact assessment frameworks (to be enhanced based on prior undertaking necessities and stakeholders' essentials), prioritization of various key performance indicators according to the prioritization approaches from literature search to evaluate impact areas and techniques,
- Designing the impact assessment framework for Logistic as a Service within automated technologies regarding assets from previous pearls of wisdom,
- During the impact assessment framework examinations in literature, conceivable barriers will be investigated,
- Characterizing the new impact assessment framework (with support of prioritization and prior essentials of stakeholders) and foreseen impacts and conceivable performance indicators for the Automated Logistics as a Service concept for standardization and/or reusability,
- Evaluation of the links between Automated Logistics as a Service concept in diverse European member states.

Behind the research project, the impact assessment framework on logistics will be comprehensible and practical to the possible similar projects' expected impacts, performance indicators, and assessment of the Automated Urban Logistics concepts in the future. For this reason, the research study will also be capable to answer the questions that are:

I. According to an example research project and other illustrations, what are the impact assessment frameworks and tools for automated technologies in transportation and logistics fields?
II. Which sort of key performance indicators and their characterizations have been presented based on the European targets and essentials?
III. What is the relationship between the concept of Logistics as a Service and automated technologies? How this link would be valuable to avoid the existing impacts of logistics services?
IV. What are the probable barriers to such a methodology of developing an impact assessment framework in terms of logistics services and automated technologies?
V. How would be generalized an impact assessment framework of automated transport within the concept of Logistics as a Service, starting with an example research and innovation project?

To achieve these objectives, various learning subjects are demanded to be acquired as summarized in the following:

- LaaS (*Logistics as a Service*) concept, model, characteristics, research matters, prior tasks, challenges, and implementations,
- Impact assessment tools, foreseen impacts with respect to standard impact areas, conceivable Key Performance Indicators and their prioritization,
- A-LaaS (*Automated Logistics as a Service*) concept advantages and expenditures, previous studies and developed projects, project executions, challenges, impact areas, performance indicators, measurements, and techniques,

- Automated processing and LaaS (Logistics as a Service) concept development, parameters, model elements, process attributes, research and integration analysis, prior projects and possible grants, barriers and challenges, performance indicators, and implementation,
- Logistics impact assessment indexes and their integration into an automated logistics impact assessment framework with respect to standard impact areas, Logistics Key Performance Indicators, and their prioritization,
- Automated Logistics Service scenario definition, concerning prerequisites and parameters, to be implemented for furnishing data collection for the assessment framework,
- Automated Logistics Service simulation scenario characterization to be applied for the data collection of possible absent indicators,
- Modelling and Designing of an Automated Logistics Service Implementation Plan,
- Identification of the performance areas interesting in urban logistics problems, automated vehicles implementations (legal issues and infrastructure availability), and their barriers and challenges,
- Logistics relevant projects critique to emphasize the logistics impact assessment techniques, performance indicators and prioritization, evaluation indexes and their implementation, and transferability for further applications concerning automated vehicles and automated-digitalized logistics processing.

The logistics industry has undergone significant changes over the past decade, with the emergence of new technologies and business models that have transformed traditional supply chain practices. One such model is Logistics as a Service (LaaS), which offers a range of logistics services on-demand and via the cloud. Along with the rise of LaaS, the industry has also seen a growing interest in automation technologies, such as robotics, automated vehicles, and artificial intelligence, which have potential to streamline operations and reduce costs.

While these technologies offer several benefits, they also raise concerns regarding their impact on sustainability and society. Therefore, it is crucial to assess the impact of LaaS and automation technologies on the environment, society, and the economy, and to develop tools that can help logistics stakeholders make informed decisions that promote sustainability.

The research objectives of this study are to identify the key factors that influence the adoption and implementation of LaaS and automation technologies in the logistics industry, to develop an impact assessment framework that can evaluate the effects of these technologies on sustainability, to design and develop a smart tool that can assist logistics stakeholders in the decision-making process, and to evaluate the effectiveness and usability of the smart tool through a case study or pilot implementation.

By achieving these objectives, the study aims to provide insights and recommendations for logistics organizations and policymakers on how to effectively adopt and implement LaaS and automation technologies while ensuring sustainability and minimizing negative impacts. The research objectives for "*Logistics as a Service and Automation, considering impact assessment need, and a smart tool development*" are:

- To identify the key factors that influence the adoption and implementation of Logistics as a Service (LaaS) and automation technologies in the logistics industry.
- To develop an impact assessment framework that can evaluate the effects of LaaS and automation technologies on various dimensions of sustainability; environmental, social, and economic impacts.
- To design and develop a smart tool that can assist logistics stakeholders in the assessment and decision-making process related to LaaS and automation technologies.
- To evaluate the effectiveness and usability of the smart tool through a case study or pilot implementation in a logistics organization.
- To provide insights and recommendations for logistics organizations and policymakers on how to effectively adopt and implement LaaS and automation technologies while ensuring sustainability and minimizing negative impacts.

By achieving these research objectives, the study aims to contribute to the development of a more sustainable and efficient logistics industry, where the adoption of LaaS and automation technologies is informed by a thorough assessment of their impact on various stakeholders and dimensions of sustainability.

3. Methodology

The impact assessment of automated logistics services performance is a complex approach that is demanded to point out the service type, the stakeholders involved and their engagement level, as well as the application-sites/case-study particularities and objectives (expected outcomes). For the availability of various aspects and making decisions, the logistics indexes are more convenient for the proposed logistics assessment framework because the indexes are able to capture these different aspects and deliver a complete overview of the status of the automated logistics services, and support decision making.

Consequently, the index-based assessment approach is designed, and various specific evaluation criteria and indicators are considered. This activity directs to an automated logistics impact assessment framework that consists of three indexes: logistics sustainability index, logistics maturity index, and logistics transferability index.

In particular, such a framework qualifies diverse automated logistics services and processes to be assessed. For instance, the impact assessment on Automated Logistics as a Service (*ALaaS*) is modeled, developed, and tested during the case study of the reference research and innovation project including also defined supplementary case studies that are achieved to acquire various results to test the developed methodology.

For this intent, the developed automated logistics assessment methodology is examined in order to point out the performance of an automated logistics services during case studies, showing impacts at a different level, including sustainability of the application (business, social and environmental), maturity as for innovation (Logistics 4.0 paradigm) and transferability.

Based on the comprehensive intention of the research project to attempt to answer the research questions, the research methodology, with several phases, was encountered to be crucial. Because of this, the methodology, which will carry out the presented work, is split into the following steps that are also recapitulated in the following figure.

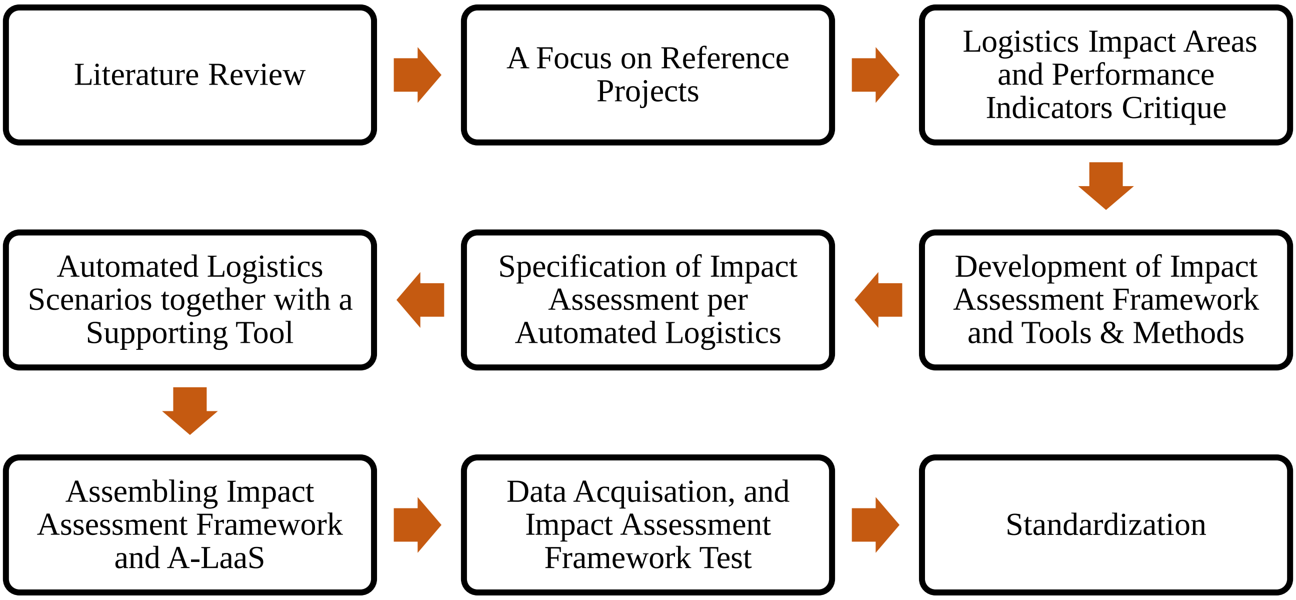


Figure 1: *Methodology of the PhD Thesis*

(1) Literature review and studies analysis for the elaboration of criteria for the exploitation of impact assessment frameworks in general terms. A comprehensive literature review will be conceived, with a focus on three major topics: impact assessment framework, logistics performance indicators, and automated logistics services within the concept of LaaS (Logistics as a Service).

(2) A focus on the reference research and innovation project as a leading example. As expressed, the reference research and innovation project will include an impact assessment framework (these tasks will be carried out for both project objectives and research study targets by collaboration from the candidate) emphasizing its main components. Starting from that, an automated logistics impact assessment framework will be designed and tested by acquiring data from project cases and defined case studies (involving simulation). After that, some equivalent undertakings will be examined as reference techniques (as mentioned, by collaboration from the candidate).

(3) Automated Logistics Impact areas and performance indicators critique. To assemble an automated logistics impact assessment framework starting from various preferred ones regarding general aspects, the prior reflections and assignments will be explored, and the different utilized/preferred impact areas, *with respect to already illustrated European targets of sustainable and efficient transportation*, will be selected to be valuable to construct an automated logistics impact assessment approach.

(4) Development of an automated logistics impact assessment framework, methodology, performance indicators extraction, and methods for prioritization. Behind the already selected impact areas (which will be esteemed to the European horizons; based on that, impact areas will be such safety, efficiency, user acceptance, etc.), to design an automated logistics impact assessment framework, the data collection instruments (such as surveys, workshops, simulations, etc.) and the logistics performance indicators per impact area will be indicated and characterized. The logistics performance indicators will be prioritized to emphasize the stakeholders' priorities by utilizing workshops or questionnaires. This prioritization will enable to bring a more efficient framework that will be produced based on prior occasions and essentials/necessities.

(5) Specification of impact areas and performance indicators per automated logistics fields. The key performance indicators, which are associated with specified logistics impact areas, will be researched, and will be presented to apprehend which auxiliary performance indicators would be assumed. Regarding this objective, other impact areas and performance indicators will be pointed out from the literature review and prior reference research and innovation projects involving automated logistics fields. After that, the impact areas and key performance indicators will be prioritized through workshops.

(6) Automated Logistics Scenarios or Models illustration and supporting tool development. To evaluate the impacts of automated logistics services, the conceivable simulation scenarios will be utilized regarding illustrations from comparable assignments or other models will be designated for the impact assessment.

(7) Assembling an association between impact assessment framework within Logistics as a Service, and mitigation of conceivable barriers. According to all the above, the impact assessment framework phases will correspondingly be revised and specified per automated logistics implementations regarding the reference research projects and further comparable samples (for instance research and innovation projects funded by European Commission such as SHOW, Drive2theFuture, etc.) and the literature review. Initiating from that, the construction of an impact assessment procedure will be achieved with several indications from literature reviews and identical schemes from reference research projects.

(8) Case Study and approach testing for inference of an impact assessment framework per automated logistics approaches. Regarding the developments-outputs of the aforementioned activities as *the specification of impact areas and performance indicators* (phase 5) and *assembling an association between impact assessment framework within Logistics as a Service* (phase 7), an automated logistics impact assessment framework and corresponding performance indicators will be produced and tested-experimented with respect to implementations, or simulations in terms of its functionality for the further research and innovation or application projects per automated freight transport and logistics services.

(9) Standardization. Standardization helps to ensure that the impact assessment framework is consistent and comparable across different logistics activities. This allows organizations to compare the impact of different logistics activities and identify areas for improvement. Standardization enables benchmarking and performance improvement. In conclusion, standardization is crucial for the successful implementation of an impact assessment framework on logistics. It helps to improve consistency and comparability, enhance credibility and transparency, enable benchmarking and performance improvement, support compliance with regulatory requirements, and facilitate communication and collaboration among stakeholders.

As an overall research intention, an impact assessment approach for the concept of automated logistics as a service will be developed, designed, and trialled. Subsequently, a simulation scenario will be defined for the areas of logistics as a service related to intermediate logistics hubs, together with an intelligent tool for the implementation and adaptation of such a service. As a synthesis of this collaborative approach, the research project will produce an impact assessment framework for automated logistics as a service together with a tool for the successful deployment of such services. Thus, the impact assessment framework will be a further developed process that will assess the needs and essentials of stakeholders captured through questionnaires or workshops, as well as supported by a simulation plan as a further illustration of the deployment. On the basis of that, the final product of the research will be an impact assessment scheme/technique for automated logistics domains with impact areas, prioritization of performance indicators, execution scenarios as well as simulation samples. Simultaneously, an intelligent tool will be designed and elaborated that takes into account the requirements of automated logistics as a service and the needs of stakeholders for a well-balanced deployment of such a service.

The automated logistics scenarios will be associated with research purposes and logistics fields that are hub-to-hub, which refers to material flow from a major distribution center to a minor (local) distribution center, and hub-to-customer, which refers to material flows from a distribution center to the final customers, approaches. Furthermore, the demonstration and simulation plans will be illustrated by the scenarios (hub-to-hub and/or point-to-point, detailed in further chapter) referring to logistics fields "*with automated logistics service*" and "*without automated logistics service*". Behind that, the logistics impact areas will be correlated to the European Green Transport targets; respecting that, the impact areas will be appointed as safety, security, environment, efficiency, acceptance, etc. Based on the determined impact sorts, the performance indicators will be picked from prior reference projects and the literature review to be prioritized with workshops or questionnaires that will be directed to stakeholders and supported by prior occasions. For the automated logistics simulation and real-life deployments, in detail, based on the designed logistics scenarios, data collection will be conducted with previous data samples and reference studies. Subsequently, such a simulation technique will evaluate time and distance considerations with the "Shortest-Path Approach" and "Multiple-Path Technique", by using existing data (obtained from prior assignments or surveys respecting the designed logistics scenarios) and data gathered from specialized stakeholder groups according to the approaches: "with" or "without" automated logistics services towards "with" or "without" interim logistics nodes. On another side, different statements or critiques (from reference research assignments or literature reviews) could be valuable for data supplementation, such as cost-benefit analysis for socio-economic impact, in order to simulate such an impact assessment framework.

4. Literature Review

Both automation and logistics as a service (LaaS) are an up-and-coming trend within the logistics sector that is becoming increasingly widespread. It is a union of both automation technology and logistics services, in which logistics management organizations bring a wide range of automated services to one another and to stakeholders. LaaS is also becoming increasingly well-known due to its capacity to decrease costs, improve efficiency, and enhance service to its stakeholders. In this literature review, we will be exploring the most recent research and developments in LaaS as well as automated technologies within this concept considering impacts and possible adaptation solutions.

Concerning the scientific literature review that evaluates proper studies and researches about the fields as automated vehicles, digitalization of logistics processing, urban freight flows, impact assessment approaches, impacts on logistics fields, and impact assessment frameworks in automated logistics specializations, the acquired data as assumed to design a framework, specify similar impact assessment tools, conceivable Key Performance Indicators (KPIs) for the evolution of Automated Logistics as a Service impact assessment procedure. Moreover, this research review works on the preceding prioritization of the performance indicators, the assessment techniques for the details of the logistics-related indexes for the evaluation and assessment of the indicators, the characterization of the various logistics scenarios for demonstrations prospects, and the illustration of the various logistics simulation scenarios that would be interested in the data collection of non-reached performance indicators.

Figure 2: *Methodology of Literature Review*

Based on review objectives, the literature review examines appropriate undertakings and studies in the fields of automated logistics, urban freight, impact assessment on automated transport and logistics, impacts of logistics, and impact assessment approaches for Logistics. The data will be acquired to be supposed to design a framework, selecting similar assessment instruments, and conceivable performance indicators for the development of the Automated – Logistics as a Service impact assessment tool.

This chapter of the research work mentions figuring out the links between automated transport and urban logistics, handling the achievable impact assessment tools, and exploring relevant Key Performance Indicators. After that, profitable techniques for the performance indicators prioritization in logistics fields. The literature review is based on a previously funded projects analysis and some further assignments and studies. For the further phases of the research, the subsequent fact investigation, accumulated from prior studies and projects, will be examined, comprehended, clarified, and will be utilized.

The principal objective of the literature review is expressed as *the analysis of prior studies and projects in terms of urban logistics, automated transport and logistics fields, impact assessment techniques regarding automated logistics and relevant performance indicators respecting prioritization and prior example case studies* to be a reference initiating point to design an automated logistics impact assessment procedure.

4.1. Urban Logistics

There are many definitions of urban logistics, but common to each of them is finding efficient and effective ways to transport goods in urban areas while considering the negative effects on congestion, safety, and environment. As mentioned above, the trends of growing e-commerce and urbanization have led to an increasing number of transport activities in cities. To make our approach more relevant for practical urban applications, concentration is shifted on the optimization and operational perspective of last-mile delivery. Within the supply chain of goods, the last mile represents the final and most expensive section of the transport chain (Gevaers et al., 2009). Today, trucks and light commercial vehicles perform many urban logistic activities. However, different strategies and concepts are likely to be needed to improve the efficiency and effectiveness of last-mile delivery in general. It is believed that the problem of last-mile delivery can be addressed in innovative ways thanks to the development of information and communication technologies (ICTs) and environmentally friendly vehicles.

Therefore, many studies with several approaches for urban logistics (e.g., parcel lockers, crowdsourcing, food delivery, and electric vehicles) have been published. Lemke et al. (2016) focused on the analysis of the usability and efficiency of parcel locker logistics in a case study of a Polish company. They showed that the most important factor for efficiency in this kind of solution is the location of the machines.

Then, Deutsch and Golany (2017) considered designing a parcel locker network as a solution to the last-mile problem in logistics. They formulated a 0–1 integer linear program to solve the problem and applied it to an industrial-sized network. In their model, the optimal number of locations and the optimal size of the parcel lockers were addressed. Devari et al. (2017) investigated peoples' motivation to participate in crowdsourced delivery. It was found that using friends in a social network to assist in last-mile delivery greatly reduced delivery costs and total emissions while ensuring fast and reliable delivery. Kafle et al. (2017) considered urban parcel deliveries where trucks serve a network of transhipment points and crowd shippers perform the last-mile deliveries from those points to the customers. Here, crowd shippers are neither restricted by existing trips nor by an upper bound on detouring. Instead, they place bids on delivery jobs. The authors developed a tailored tabu search-based algorithm to solve the system design problem.

Tarantilis and Kiranoudis (2002) addressed an open multiplot vehicle routing problem (VRP) for distributing fresh meat from depots to customers located in an area of the city of Athens. To solve the problem, a new stochastic meta-heuristic search algorithm termed the list-based threshold accepting algorithm was proposed. Song and Ko (2016) also solved the food delivery problem in metropolitan cities. Generally, the problems of last-mile route planning for cold-chain distribution can be modelled as a VRP with time windows, which considers the costs involved in cold-chain logistics and the characteristics of temperature-sensitive products.

Although urban logistics has been investigated in academia as described above, the subject is still evolving because of the continuous changes in urban environments and citizens' lifestyles. In particular, the increase in mobile shopping and improvements in technological developments might lead to another delivery mode, such as drone-based parcel delivery using the rooftops of buildings in urban areas (Kim et al., 2020).

More specifically, city logistics (CL) has been investigated for many years, but the topic is still evolving because of the changes, firstly in the environment, secondly in citizens' habits. City logistics is mainly associated with freight transportation issues; therefore, it is likely to be the point of interest of private businesses. Nowadays, much review-based research has been conducted to define city logistics more precisely and widely. More contemporary approaches tend to define city logistics in a more holistic way, treating it as a coordination process of all flows within the urban areas—of freight as well as of passengers. Passengers' mobility, mainly related to public transport in cities, is naturally organized by public administration, thus, city logistics covering the flows of cargo and people deserves interests of both private and public stakeholders. Considering the strong interactions between city logistics and urban development—the coordination in the management process in the cities whilst considering mobility issues tends to be crucial. Thus, there is a strong need to identify all stakeholders within the urban transport system. Heterogeneous stakeholders operating in cities, in fact, interact, both by competing and cooperating, but are characterized by different objectives.

Additionally, they are most often considered as entities that are interested in the final decisions to be made, even though those decisions do not affect them. The stakeholders can be divided into several main groups:

- Authorities,
- Shippers,
- Freight carriers,
- Public transport operators,
- Residents,
- Other traffic participants.

Generally, all stakeholders may be divided into two groups: public and private. Public ones are represented by authorities (the local government, the national government) and public transport operators. Private groups include entrepreneurs (shippers and freight carriers) as well as individuals (residents and other traffic participants). Authorities, most often the local ones, are mainly interested in increasing the safety of road traffic reduction and minimizing of congestion and environmental nuisances. From their point of view only urban freight transport (UFT) itself is considered as the main contributor of external effects. From a more general perspective, the authorities focus on implementing sustainable urban transport system. Therefore, taking care for the development of the consensus between other stakeholders is needed. Although most commonly, it is the municipalities who own public transport operators, any particular case depends on the model of the public transport adopted in a city. Hence, public transport services may be provided by the private and public companies.

Shippers' interest is to maximize quality of service in terms of costs and reliability of transport. Freight carriers are usually mostly interested in minimizing their costs by maximizing the efficiency of their pick-up and delivery tours. Additionally, they are expected to provide a high level of service at a low cost. Dwellers can experience nuisance generated by urban freight transport as external effects; therefore, they care about sustainable urban transport system. Other traffic participants include cyclists and pedestrians sharing the same infrastructure with freight transport vehicles, especially in the urban area, as well as with passenger vehicles. Visitors and tourists can also be included in this group, because they are affected by urban freight transport, albeit only to a minor degree. Wishing to attract tourists and visitors to come, city authorities should be vitally interested in minimizing the nuisance caused by urban freight transport. Taking into consideration the processes that are fundamental in city logistics, the decision makers are gradually implementing city logistics measures from the perspective of the needs of future generations.

4.2. Automation and Logistics as a Service

Logistics as a service (LaaS) refers to a concept in which logistics organizations perform a variety of services for their users/customers via more organized and affordable approach. Such services could include transportation, warehousing, storage, stock management, and customs-bureaucracy matters. LaaS is becoming progressively more common because of its capability to serve all stakeholders with flexible and scalable digitalized logistics solutions. Those logistics stakeholders could externalize their logistics operations to LaaS service providers, enabling them to concentrate on their primary operations (DHL, 2018).

A key contributor to LaaS being with automated solutions. The use of automated services and solutions in logistics operations has been expanding in recent decades. Automated solutions on logistics covers logistics robotics, artificial intelligence (AI) and machine learning (ML). However, as technology advances, automated solutions is now being used in operations of logistics, such as last-mile delivery and freight transportation (Mckinsey & Company, 2019).

Both AI and ML are being used to automatize logistics processes as well. AI could be used to optimize route planning and vehicle scheduling, while ML could be deployed to predict demand and optimize stock keeping levels and operation arrangements. As well, automated systems technology could improve the time and distance savings. (DHL, 2018)

Logistics automation is the application of computer software or automated machinery to improve the logistics operations efficiency undertaken by supply chain management and enterprise resource planning systems.

Logistics automation is sufficient effectiveness way to:

- Optimize both operational efficiencies and the customer experience,
- Streamline your processes while reducing related operational costs,
- Provide full visibility and communicate effectively using technology,
- Customize customer experiences to build long-term loyalty.

There are several main logistics automation components:

1. Hardware (fixed machinery, conveyors, sortation, industrial robots, automated storage, and retrieval systems),
2. Software (integration software, operational control software).

The application of intelligent technologies, especially intelligent transportation systems (ITS) technologies, in transportation planning, operations, and AVs can significantly improve operation efficiency and level of service of existing transportation systems.

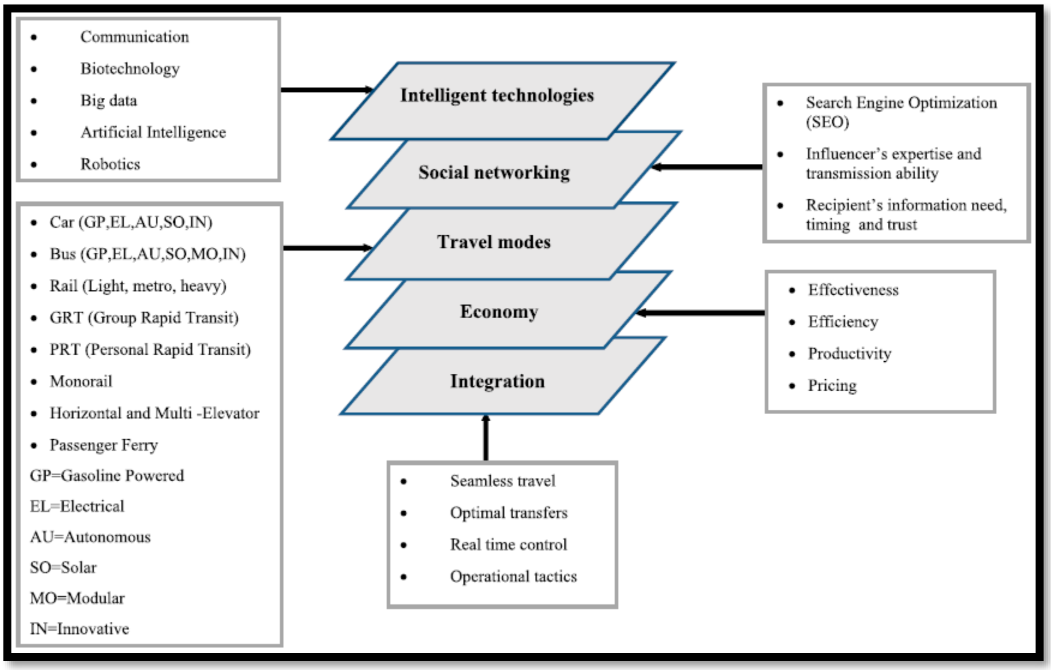


Figure 3: *Five layers of elements essential for having an impact on future of urban transportation*

A logistics automation system can provide automated goods in processes, automated goods retrieval for orders, automated dispatch processing (Inbound logistics 2018).

There are limitations to logistics automation such as:

- Current technology is unable to automate all the desired task,
- As a process becomes increasingly automated there is less and less labor to be saved or quality improvement to be gained, and
- Like the above, as more and more processes become automated there are fewer remaining non-automated processes.

In general, logistics management can be one of the major success factors increasing the competitive advantage of small- and medium-sized enterprises (SME) and industrial enterprises. During recent years, logistics-related technologies have fundamentally changed. They have become more affordable and therefore within reach of SMEs. These technologies assist them in improving their efficiency by using transport management systems (TMS), warehouse management systems (WMS), enterprise resource planning systems (ERP), product lifecycle management solutions, inventory management software, etc. (Inbound logistics 2018).

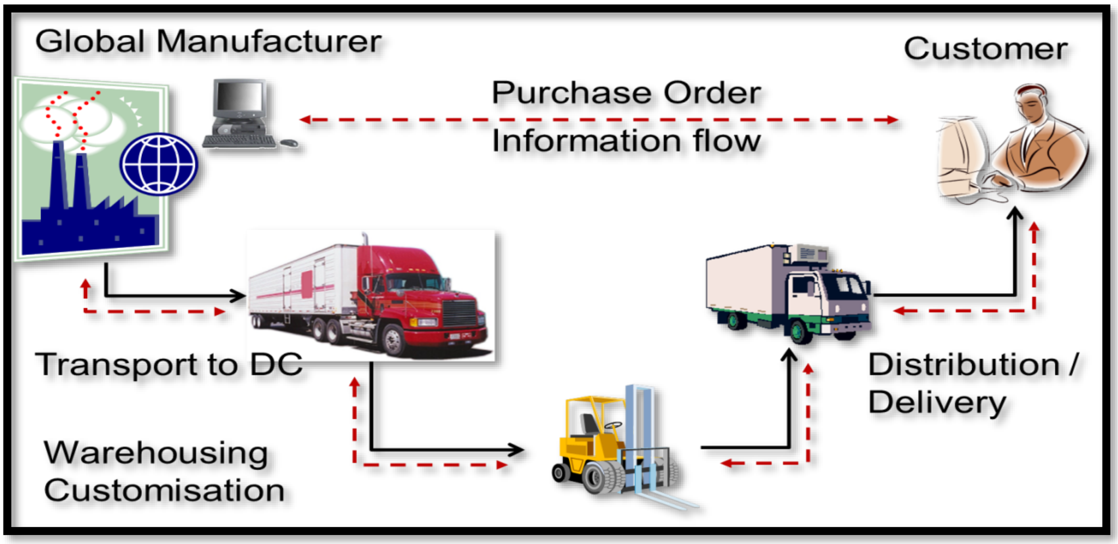


Figure 4: *Logistics Supply Chain Factors*

The technological barriers to automated driving systems (ADS) are being quickly overcome to deploy on–road vehicles that do not require a human driver on–board. ADS have opened possibilities to improve mobility, productivity, logistics planning, and energy consumption. However, further enhancements in productivity and energy consumption are required to reach CO2–reduction goals, owing to increased demands on transportation.

In the freight sector, incorporation of automation with electrification can meet necessities of sustainable transport. However, the profitability of battery electric heavy vehicles (BEHVs) remains a concern (Ghandriz et al., 2020). The advantages and disadvantages of the automation and logistics are the following:
Advantages of logistics automation:

- Increased input and productivity
- Improved quality or predictability of quality
- Improved robustness
- Increase consistency of output
- Reduced direct human labor costs and expenses

Disadvantages of logistics automation:

- Causing unemployment and poverty by replacing human labor
- Security threats/vulnerability
- Unpredictable/excessive development costs
- High initial cost

For a clear understanding of automation in road transport some definitions are needed to enable a common understanding. Automation in this document refers to the transport system as a whole and all its components:

- Vehicles
- Drivers
- Users
- Road based infrastructure
- Information systems and applications

The further deployment of automation in road transport will be a shared responsibility among the actors namely infrastructure operators and automotive industry.

Automation is often used to define something to be "smart", in which automation takes over control from humans to do the right thing in complex events or circumstances. Automation can in addition also prove valuable in non-complex circumstances and it is not necessarily the one or the other. Concepts where driver and automation can control a vehicle together, cooperatively have proven very successful and intuitive.

Definitions	Descriptions
Driver Only	Human driver executes manual driving task
Driver Assistance	The driver permanently controls either longitudinal or lateral control. The other task can be automated to a certain extent by the assistance system
Partial automation	The system takes over longitudinal and lateral control the driver shall permanently monitor the system and shall be prepared to take over control at any time
High automation	The system takes over longitudinal and lateral control, the driver must no longer permanently monitor the system. In case of a take-over request, the driver must take-over control with a certain time buffer
Full automation	The system takes over longitudinal and lateral control completely and permanently. In case of a take-over request that is not carried out, the system will return to the minimal risk condition by itself.

Table 1: *Transport Automation levels*

4.2.1. Automated Vehicles

Automated vehicles, also known as autonomous vehicles, have the potential to revolutionize logistics operations by reducing costs, improving efficiency, and increasing safety. As automated vehicles become more prevalent in the transportation industry, researchers and practitioners are exploring the potential impact of these vehicles on logistics operations.

One area where automated vehicles could have a significant impact is in last-mile delivery, which is the final stage of the supply chain where goods are transported from a distribution center to the customer's doorstep. Last-mile delivery is often the most expensive and time-consuming part of the supply chain, and it can be difficult to optimize due to the complexity of urban environments (Taniguchi et al., 2018). Automated vehicles could help overcome these challenges by providing more efficient and cost-effective last-mile delivery options (Baskerville et al., 2019).

Another potential application of automated vehicles in logistics is in long-haul transportation. Automated trucks have the potential to reduce the cost and time required for long-haul transportation by allowing drivers to rest during the journey (Jaller et al., 2017). This could result in faster and more efficient transportation, as well as improved safety by reducing the risk of driver fatigue.

The following key areas (not exclusive) should be subject to further research and development regarding maneuver and trajectory planning:

- Human compatible planning algorithms that enable an intuitive interaction and arbitration with the driver at navigation, guidance (maneuver) and stabilization (control) level and easy mode transitions (e.g., changing from assisted to partial, highly, or fully automated driving),
- Cooperative planning algorithms for the interaction with other road users (vehicles, their automation and their drivers, pedestrians, cyclists, etc.) exploiting the potential of V2X communication,
- Cooperative planning algorithms for the interaction with intelligent infrastructure components and a smart traffic management system,
- Integration of navigational level with guidance (maneuvers) (and stabilization) level, especially in cooperation with traffic management,
- Integration of sensor (or map) uncertainties and actuator characteristics in planning algorithms,

- Guaranteed safety of planned maneuvers and trajectories. This includes e.g. guaranteeing the possibility of a minimum risk maneuver in failed take-over situations of the automation in emergency situations,
- Controllability of the execution (control) of planned maneuvers.

However, there are also challenges associated with the implementation of automated vehicles in logistics. One significant challenge is the lack of regulatory frameworks for automated vehicles. The development of regulatory frameworks for automated vehicles is essential to ensure their safe and efficient use on public roads (Lindholm et al., 2017).

Another challenge is the need for significant investment in infrastructure and technology to support automated vehicles. For example, automated vehicles require high-quality digital mapping and communication infrastructure to function effectively (Baskerville et al., 2019). Furthermore, the adoption of automated vehicles in logistics operations will require significant changes in supply chain management and coordination (Taniguchi et al., 2018).

Finally, there are also concerns about the potential impact of automated vehicles on employment in the transportation industry. While automated vehicles could improve efficiency and reduce costs, they could also displace workers who are currently employed in transportation-related jobs (Baskerville et al., 2019).

In conclusion, automated vehicles have the potential to revolutionize logistics operations by improving efficiency, reducing costs, and increasing safety. However, their implementation in logistics operations presents several challenges, including the need for regulatory frameworks, significant investment in infrastructure and technology, changes in supply chain management, and concerns about the impact on employment in the transportation industry. Further research is needed to address these challenges and fully realize the potential of automated vehicles in logistics.

4.2.2. Automated Logistics Processes

As to automated solution within logistics processes, the successful combination of automated solutions and LaaS brings many benefits to logistics organizations as well as their users/customers. Thus, the automated solutions could effectively minimize costs while simultaneously improving efficiencies as well as mitigating failures. Furthermore, LaaS itself can provide both a cost-effective, resilient and sustainable logistics solutions. The automated solutions on LaaS can also improve service quality and stakeholders' acceptance by providing real-time shipment tracking, management, and visibility (Yuan et al., 2019).

Both automation and logistics as a service (LaaS) are an emerging movement in the logistics sector that is growing very rapidly. The utilization of automated solutions in logistics operations is on the increase, and LaaS is becoming even more widely accepted due to its ability to offer flexible and scalable logistics solutions to users and customers. The combination of automation and LaaS provides numerous advantages to logistics organizations as well as those of their users-customers and public, among them lowering costs, improving efficiencies, and strengthening customer satisfaction (Christopher & Peck, 2004).

4.3. Impact Assessment on Logistics

Logistics is a strategic element of global supply chains as well as it plays an essential role in ensuring the effective cross-border movements of goods and services. There has been growing concern in recent years over the environmental and social impacts of logistics operations, which has led eventually to a need of the development of impact assessment frameworks.

The research has also indicated that impact assessment frameworks could be successfully deployed to identify opportunities to improve logistics operations, such as lowering emissions and waste, improving resource effectiveness, and enhancing social and economic performance. Nonetheless, there are also associated challenges to successfully implementing impact assessment frameworks in logistics, such as the data availability as well as data quality and the complexities of supply chains and their management.

Such frameworks could eventually help identify those areas where logistics operations could be enhanced to lower the environmental impacts. On the other hand, the implementation of such frameworks has several challenges, including data availability and trustworthiness, as well as the sophistication of logistics supply chains along with the necessity of cross-disciplinary cooperation.

4.3.1. Impact Assessment Frameworks

The one of the commonly adopted impact assessment frameworks in logistics is the life cycle assessment, which it is a comprehensive method to quantify the environmental impacts of logistics activities. LCA takes into account the entire life cycle of a product, from raw material extraction to disposal, and examines the environmental impact of each stage of the product's life cycle (Seuring & Müller, 2008).

In addition to the life cycle assessment, several different impact assessment frameworks have been developed particularly for the logistics sector, such as carbon foot-printing, ecological foot-printing, and social impact assessment. Such frameworks could be used for evaluating the environmental and social impacts of logistics operations, among them transportation, warehousing, and delivery distribution (Yuan et al., 2019).

Beyond that, there is an increasing concern about the integration of impact assessment frameworks with various other sustainability management processes, such as corporate social responsibility reporting and sustainability procurement. Such integration can further support logistics organizations to reach their sustainability targets as well as improve their comprehensive environmental and social performance (Yuan et al., 2019).

Additionally, the Trilateral Study has an impact mechanism that would be useful in the research purposes. The study’s impact mechanism steps are addressed below:

- Direct modification of the driving task, drive behaviour or travel experience
- Direct influence by physical and/or digital infrastructure
- Indirect modification of AV user behaviour
- Indirect modification of non-user behaviour
- Modification of interaction between AVs and other road-users
- Modification of exposure / amount of travel
- Modification of modal choice
- Modification of route choice
- Modification of consequences due to different vehicle design

To summarize, impact assessment frameworks are an important instrument for measuring the environmental and social impacts of logistics operations. Use of such frameworks could potentially support organizations in identifying opportunities for improvement and strengthening their overall sustainability performance (Trent & Monczka, 2003). However, there are also challenges associated with implementing these frameworks, and further research is needed to address these challenges and improve the effectiveness of impact assessment in logistics.

A significant challenge in the impact assessment on logistics operations is the absence of utilized, harmonized approaches and methodologies. At the present stage, there is no consensus on how to evaluate the social and environmental impacts on logistics operations. Therefore, such an absence of harmonization complicates the comparison of the impacts of various logistics aspects as well as the development of best practices (Yuan et al., 2019).

Another challenge is the necessity to have a balancing act between the objectives of economic, social, and environmental sustainability aspects within logistics operations. Achieving sustainability in logistics operations demands that these three pillars to be successfully combined, and at times these objectives might be conflicting with one another. For instance, the reduction of transport emissions could lead to increased transport costs or longer delivery times, thus impacting the economic sustainability of logistics operations (Seuring & Müller, 2008).

Eventually, there are also some challenges associated with stakeholders' involvement within the impact assessment process. Logistics operations do involve numerous relevant stakeholders, among them forwarders, transporters, users/customers and societies. Engaging all these interested actors in the impact assessment process might be challenging, although it is fundamental to developing effective solutions (Christopher & Peck, 2004).

As a conclusion, impact assessment frameworks are a key element for assessing both the environmental and social impacts of logistics operations. Nevertheless, there are various associated challenges to the deployments of such frameworks, including the availability and reliability of data, a lack of a standardized approach, weighing the objectives of economic, social, and environmental sustainability, and the involvement of stakeholders in the impact assessment processes. There is a need for further research in order to address those challenges and to improve the performance of impact assessment on logistics.

4.3.2. Impact Areas

In the near future, transportation will experience substantial development in the domain of automated driving systems (ADS), which will revolutionize the way people and freight move on-road, as reported by Wadud et al. (2016) and Flämig (2016). Remarkable advantages in terms of user experience, efficiency, safety, mobility, productivity, energy, environment, and economy have been reported with ADS by Alessandrini et al. (2015), Anderson et al. (2014), Brown et al. (2014), Chan (2017), Harper et al. (2016), Levin and Boyles (2015), Maurer et al. (2016), Wadud (2017), Wadud et al. (2016), Taiebat et al. (2018) and Khan et al. (2019), though significant increases in traffic safety due to highly or fully automated vehicles are not certain as revealed by Kalra and Paddock (2016). However, user objectives and motivations differ for passenger cars and freight transport, as reported by Wadud (2017) and Nowakowski et al. (2015).

For passenger cars, the major motivations are user experience and environment, whereas in freight transport, the most important driving forces are productivity and profitability. For example, increasing the cost of a vehicle related to automation hardware is less important in freight transport, owing to the lower proportion of the automation hardware cost with respect to the total purchase cost, compared to that of passenger cars. Furthermore, automated driving systems permit increased profitability in freight transport, mainly due to a reduction in labor cost as well as due to facilitated logistics and increased utilization and efficiency, as reported by Wadud et al. (2016). Moreover, driver cost reduces significantly in high or full driving automation, resulting in an early adoption of automated driving systems in freight sector.

After the automated driving systems, the diffusion of global positioning systems, sensors and mobile communication technology has already resulted in substantial benefits in terms of improved navigation and congestion mitigation. A network of connected and identifiable devices is commonly labeled as the Internet of Things is taking shape. These devices can be embedded in transportation modes, such as vehicles and containers, which then can be more effectively managed and routed. This reliance on large volumes of data which provides effective support for better routing and demand forecast. A vehicle can thus be rerouted if congestion or another form a disruption takes place and any transport asset can be better maintained through predictive analysis and reports from sensors.

Traffic Management, highly automated driving offers even higher potential benefits if combined with traffic management, especially within urban environments. Traffic management can then “intervene” cooperatively at different levels of the driving task, such as navigation or vehicle guidance, its intervention can range from purely informative systems to influencing the vehicle motion by communicating advisory information or limiting certain levels of automation, and it could influence the availability and selection of a certain automation level within the vehicle.

The reduction in energy use achieved with automated driving systems owing to enhanced vehicle usage and controlled energy management is reported to be only up to 10% in passenger cars, depending on the traffic scenario, compared to that when a human driver is involved, according to Mersky and Samaras (2016).

The reduction in fuel consumption achieved with automated driving systems is expected to be higher in freight transport, considering that heavy vehicles can form platoons, which reduce the energy intensity of the following vehicle by up to 25% in theory, according to Wadud et al. (2016), if the gap between vehicles reaches zero; while, measurements showed the average fuel saving of 8% and 15% for 10 m and 4 m gap, respectively, according to Tsugawa et al. (2016).

However, as revealed by the European Commission (2016), heavy-duty vehicles contribute to about 25% of the CO2 emissions from road transport in Europe, which is increasing owing to increasing road freight traffic, despite enhanced fuel consumption efficiency. These figures point to that, despite being a profitable business, the increased efficiency offered by automated driving systems may not result in a reduction in CO2 emissions in the long term; thus, a further decrease in emissions is required in the transportation sector motivating the development of more environmental-friendly solutions.

The following key impact areas can be subject to further research and development:

- Reliable object recognition and tracking,
- Situation awareness (including future path, maneuver identification),
- Highly accurate positioning (longitudinally and laterally) to driving direction,
- Accurate road representation,
- Detection of free space,
- Classification of objects,
- Advanced fusion techniques,
- Common Perception architecture,
- Plug and Play concepts,
- Quality assessment of perception systems as a further input for automation.

4.3.3. Key Performance Indicators

The rapid increase in freight vehicles in urban and metropolitan areas contributes to congestion, air pollution, noise, and increased logistics costs, and hence the price of products. In addition, a combination of different types of vehicles on the road increases the risk of crashes. An efficient freight distribution system is required as it plays a significant role in the competitiveness of an urban area, and it is in itself an important element in the urban economy, both in terms of the income it generates, and the employment levels it supports (Russo and Comi, 2010).

Automation in logistics holds considerable potential and great opportunities for performance-enhancing incentives. According to Groover (2008), the reasons for implementing automated processes can be summarized as follows:

- Increased labour productivity,
- Lower labour costs,
- Mitigation of the effects of labour shortage,
- Reduction and/or elimination of routine manual and clerical tasks,
- Improved workplace safety,
- Improved product quality,
- Reduced lead time,
- The accomplishment of processes that cannot be done manually, and
- The avoidance of high costs in comparison to manual processes.

Thereby, the automation of material flow processes in logistics systems depends on the integration of information and communication technologies, the compatibility of hardware and software, standardized interfaces, modular designed systems, consistent storage of information, and interoperable hardware and software (Krämer 2002).

Logistics is among those areas strongly affected by the upcoming technologies associated with Industry 4.0, both as an opportunity and a risk. Above all, logistics is still the imperative for providing a superior service level at feasible costs. Automation and IT are not applied for their own sake, to be consistent with market trends, or to satisfy expectations. Automation can help to increase productivity, to lower costs, to gain flexibility, to make routine tasks more efficient, to provide workplace safety, to reduce lead times and times to market, and to improve product and service quality (Woschank et al., 2020).

Today, there is a worldwide focus on setting up a Sustainable Development Strategy to identify and define measures to achieve a continuous long-term improvement in quality of life by creating sustainable (economic, environmental and social sustainability) communities, able to manage and use resources efficiently, tap the ecological and social innovation potential of the economy and in the end ensure prosperity, environmental protection and social cohesion.

Referring to the definition of sustainable development given during the World Commission on Environment and Development (1987), to meet the needs of the present without compromising the ability of future generations to meet their needs. Moreover, many indicators can be found with different goals and targets in the literature, the common considered indicators are related to economic and social sustainability in terms of efficiency and safety, and environmental sustainability in terms of air pollution. Importantly, the objectives of sustainable development can be obtained by measures that are sometimes conflicting and generate impacts that are influenced by the acceptance of stakeholders and external factors (Russo and Comi, 2010). The impact areas of the automation and logistics are found on the literature search below:

- **Mobility:** These can be general and more societal oriented such as ageing and fragmentation, fading borders, environmental sustainability, and the network society but also more specific megatrends like energy transition, smart infrastructures etc. Some examples of the impact on mobility in general and quality of life are accessibility to enhanced personalized public transport, automated servicing (car repositioning) but also on the way we design and build our urban areas where for example urban platoons can be foreseen not conflicting traffic of VRU’s.
- **Environmental sustainability:** To exploit the full potential of energy efficient transportation it is necessary to make the transition from driver coaching to automated energy efficient longitudinal vehicle control. Based on current advances in enhanced automated driving the next step can now be taken where the driver’s impact on fuel efficiency performance is reduced in combination with optimizing the vehicle’s internal energy management systems.
- **Traffic efficiency:** Congestion is more than a nuisance for road users; it also results in an enormous waste of fuel and productivity. Many manufacturing processes depend on just-in-time deliveries and free flow transport for efficient production. Automation will improve the maximum capacity in the road transport network by deploying technological developments like Intelligent Transport Systems advanced logistics transport planning and slot management for resilient supply chains and better suited solutions for modal shift.
- **Road safety:** Moreover, 95% of the accidents are human error related. The need to increase traffic safety by reducing such accidents as well as maximizing the comfort of the driver while driving also supports the research findings towards systems which enable increased automated driving at different levels. Automated driving at different levels has the potential to reduce such accident by eliminating the human factor. On the other hand, increased automation at the vehicle level, brings new challenges especially for interaction with other traffic participants like vulnerable road users.

After that, to understand the perspective of European Commission for measure criteria, EN 13816 that defines a set of recommended criteria to measure the quality of public transport services; these are divided into eight categories (Comité Européen de Normalisation, EN 13816):

- Availability – the extent of provided services in terms of geography, time, and frequency.
- Accessibility – access to the public transportation system including the connection between different transport modes.
- Information – systematic presenting of information and observations about the public passenger transportation system that help to plan and realize the journeys.
- Time – all time aspects important for planning and realizing journeys.
- Customer care – the service elements introduced in order to harmonize individual customer requirements and provided service standard.
- Comfort – the service elements introduced in order to make the public transport services usage comfortable and pleasant to passengers.
- Safety – the feeling of personal safety truly perceived by passengers that arising from actual established measures and activities.
- Ecological impact – the minimization of a negative impact on the environment.

4.4. Tools and Prioritization

A questionnaire for the prioritization of performance indicators is an essential instrument that could provide numerous advantages to decision-making. Among the following points, there are a number of arguments as to why a performance indicators prioritization questionnaire is important:

- Assists in identifying key performance indicators (KPIs): A questionnaire could support decision-making in identifying the most relevant key performance indicators (KPIs) to measure the ongoing performance of such an ALaaS deployment. Thereby asking targeted questions to various stakeholders, the questionnaire could possibly assist in identifying more strategic KPIs that are to be monitored (Alhassan et al., 2019).
- Alignment with objectives: A questionnaire could assist to ensure that the shortlisted KPIs are aligned with the overall objectives of such an ALaaS deployment. This guarantees that all stakeholders are contributing to the same objectives as well as that the identified KPIs are relevant to the achievement of such an ALaaS deployment's objectives.
- Providing information on performance gaps: While gathering feedback from various stakeholders through a questionnaire, institutions could gather valuable information about performance gaps. Doing so could assist with prioritizing the improvement initiatives and more effectively assigning resources available (Bialas et al., 2018).
- Assist decision-making using data: A questionnaire can support decision-makers to make data-driven determinations by giving them robust data on which KPIs to measure and monitor. It ensures that decision-making is driven by objective data, rather than subjective judgements (Burke et al., 2018).
- Increasing responsibility: Identifying and measuring the more critical KPIs, a questionnaire could contribute to enhancing accountability throughout the decision-making. Doing so guarantees that every individual is conscious of what they are supposed to provide and that they are held responsible for such an ALaaS performance (Burke et al., 2018).

In an overall view, a performance indicator prioritization questionnaire is a valuable instrument that could support institutions in identifying and monitoring the more critical KPIs, bringing performance in line with defined objectives as well as steering data-driven decision-making.

Beyond that, ***a workshop for prioritizing*** performance indicators is a significant asset that could bring various advantages to decision-making. Among the reasons why a performance indicator prioritization workshop is valuable are as follows:

- Facilitating collaboration and communication: A workshop brings together stakeholders from different parts and layers of decision-making to collaborate and communicate on the crucial KPIs. It facilitates cross-functional communication and encourages a shared understanding of the such an ALaaS deployment objectives.
- Providing a discussion and feedback forum: A workshop gives a forum for discussion and feedback on the more critical KPIs. This enables stakeholders to share their views, concerns, and ideas, all of which could assist in identifying gaps in understanding and aligning diverse prospects.
- Encourage appropriation and responsibility: By getting stakeholders involved in the process of identification and prioritization of logistics KPIs, a workshop promotes appropriate adoption and responsibility. It contributes to assuring that all decision-making is committed to such ALaaS deployment goals and that all are held responsible for the performance of the deployment.
- Promoting consistency with ALaaS objectives: A workshop could also assist in making sure that the selected logistics KPIs are being aligned with the defined objectives and targets. This guarantees that decision-making is carried out to ensure that is working towards the same objectives and that the targeted KPIs are relevant to the success of such an ALaaS deployment.
- Providing a structured approach to performance measurement: A workshop gives a structured approach to performance measurement by identifying and prioritizing logistics KPIs. This would assist in ensuring that the decision-making is measuring the more critical aspects of the performance and that it is using a consistent approach to performance measurement.

As a whole, a performance indicator prioritization workshop is a valuable asset that could enhance collaboration, communication and stakeholder contribution. It further assists in ensuring that the decision-making is measuring the more critical aspects of the performance and that it is matching performance with objectives.

Beyond that, as above-mentioned, the questionnaires and/or workshops can be considered for the prioritization of KPIs, the impact area, and further impacts and/or KPIs. For the definition of KPIs, the following may also be useful:

- Observation
- Simulation
- Post-processing
- Questionnaire

As mentioned above, this research study aims to understand how to assess and monitor user acceptance in relation to the benefits and costs of automation technologies on the development of a greener and more sustainable logistics service implementation, with reference to safety, perceptions of efficiency, needs, desires and expectations for improving a smarter logistics service concept. On this basis, this literature review aimed to identify guidelines for the design of an acceptance questionnaire to propose and recommend guidelines for the acceptance analysis of automated logistics implementations. On this basis, the literature review aims to provide various studies and projects on logistics and acceptance assessment to analyze the parameters involved, key elements and areas for research; the review also presents the treatment of questionnaire preparation in terms of steps and key elements. Based on an analysis of previous research cases, the questionnaire on automated logistics was developed from a preliminary understanding of the issues listed below: [1]

- Which kind of decisions are expected to be obtained?
- What kind of criteria would be considered to support the research?
- Who are the stakeholders that would be taken into account?

To that purpose, the analysis focuses initially on the characteristics of the implementation sites, the socio-demographic and economic situation, and the objectives of the research study. In addition, the questionnaire should represent various research topics and a detailed overview of the study area, addressing additional points that are briefly summarized as follows:

- supporting applicants in the decision-making process,
- preparation of the questions in a synthesized way (short explicit questions, easily readable and logic structure, comprehensible and lucid language) to support a clear decision-making approach and to reach a better understanding of the sample area,
- defining the objectives (to reach goals) to be undertaken, including the criteria (to clarify the answer, to eliminate irrelevant ones) o be considered within the questionnaire,
- the decision process of the questionnaire to decide which answers-feedbacks are relevant or not,
- the distribution pathway of the questionnaire (online, app, in persona, phone, etc.) by checking targeted stakeholders-applicants.

Besides, for the logistics impact assessment, in the benchmark project "SHOW," the Research Center for Transportation and Logistics plays the role of assessing the overall impacts on logistics, which is led by the author of this research study. Such an assessment can be useful for this research objectives. A set of the indicators modelling different evaluation criteria will be selected as more representative of the specific evaluation objective and demonstration case.

Building on that, three logistics assessment indexes will be adopted to assess the objectives as well as the impact of the reference project, as presented in the following subsection:

- *The Logistics Sustainability Index (LSI)* is a Multi-Criteria Decision Analysis technique calculated according to a multi-step process: define the application (demo case specifications); select impact areas (e.g. economy and energy, environment, transport and mobility, society, policy and measure maturity, social acceptance, and user uptake); select indicators for each impact area, measurement methods, and data collection sources (direct, indirect, estimation, quantitative, qualitative); establish weights to assign to indicators and criteria involving stakeholders of the demo case; normalize and harmonize measurements of indicators and calculate the overall index. This is to be done before implementation (ex-ante) and after implementation (ex-post) to measure the effect on each of the criteria.
- *The Logistic Maturity Index* is used to describe the comprehensive digitization and networking of all logistics objects in an autonomous, logistical system. The calculation method is based on the Fraunhofer IFF's stage model of Industry 4.0. The model consists of five stages: standards (stage 1), big data (stage 2), smart data (stage 3), dark factory (stage 4), industrial ecosystem (stage 5). In the beginning, the general business case information is requested. Then the data for determining the degree of maturity are collected by using multiple-choice questions.
- *The Logistic Transferability Index* involves a multi-step analysis process to qualitatively give a dimension to the propension of the logistics automated application to be successfully transferred in other urban contexts and according to what conditions. The first step concerns the detailed description and characterization of the receptor city, the second consists of a benchmarking analysis of eventual similar context, the third deals with the definition of the automated applications that can be valid of the receptor city including a general assessment on specific criteria identified by the city itself.

4.5. Prior Experiences of Automation and Logistics as a Service

Automation and Logistics as a Service (LaaS) represent two advances in technology that have transformed the way organizations perform. While automation involves the use of technology to perform tasks that would otherwise require human intervention, logistics as a service refers to the outsourcing of logistics operations to outsourced service providers.

While the concept of automation has been around for decades, the early forms of automation were observed in the production sector. However, with the quick development of such technology, automation has expanded to other sectors, such as those in human resources, finance, and transportation.

Equally, logistics as a service has also been gaining increasing demand for efficient and cost-effective supply chain management in recent times. This has led to the rise of organizations that focus on providing logistics services such as warehousing, transportation, and order processing.

Bringing automation and logistics as a service together successfully has led to the development of automated logistics solutions, which provide organizations with a more streamlined as well as efficient approach to logistics management. Such solutions exploit technologies such as artificial intelligence, smart solutions, and the Internet of Things (IoT) to automatize processes such as managing inventory, order processing, and shipment.

In this research study, it will explore previous experiences with automation and Logistics as a Service as well as how they have reshaped the existing panorama of automated logistics solutions. Then it will examine the advantages and challenges of such technologies, as well as their impact on the logistics sector and the future.

CityMobil2

The aim is to develop a revolutionary vision based on automated collective public transport, automated vehicles for urban freight distribution, and a shift of paradigm, consisting in the decline of car ownership and the rise of purchase of mobility services.

NOVELOG

The mission of the Novelog project is to enable knowledge and understanding of urban freight distribution and service trips for cities to implement effective and sustainable policies and measures and facilitate stakeholder collaboration for sustainable city logistics. The Novelog project is a research project (not a business case) that is funded by the European Commission.

The vision of the project is that strengthened capacity of local authorities & stakeholders for sustainable policy making in Sustainable Urban Mobility Planning, by providing tools for managing the “implementation chain” (problem capture – decision – planning – testing – assessment – adjustment – implementation). Sustainable Freight Policy, bringing improved understanding of cost-effective strategies, measures & business models to reduce the carbon footprint of logistics operations in cities.

The NOVELOG project focuses on the enabling of knowledge and understanding of freight distribution and service trips by providing guidance for implementing effective and sustainable policies and measures. This guidance will support the choice of the most optimal and applicable solutions for urban freight and service transport and will facilitate stakeholder collaboration and the development, field testing and transfer of best governance and business models. The objectives are set as follows:

- To understand, assess and capture current needs and trends in Urban Freight Transport, revealing the reasons for failures in city logistics implementations and to identify the key influencing factors and develop future Sustainable Urban logistics scenarios.
- To enable determination of optimum policies and measures, based on city typologies and objectives, link them to tailored business models and test and validate them.
- To develop a modular integrated evaluation framework for city logistics that will portray the complexity of the life cycle of UFT systems and implement it to assess the effectiveness of the policies and measures.
- To incorporate the best fitting policies and measures in integrated urban planning and SUMPs, at local level, to facilitate and guide multi-stakeholder cooperation for improved policy making.
- To field test, implement and validate all the above, in selected EU cities, and demonstrate applicability and sustainability of the tools and ensure the continuity of the impacts by creating and establishing take-up strategies and roadmaps for the best city logistics solutions.
- The key concept of the project is to initiate and enable city logistics policy formulation and decision-making as part of a city’s sustainable urban mobility planning, and to support implementation and take up of appropriate policies and measures. This will be achieved through guidance provision to policy makers, based on sustainable business and logistics models, and the facilitation of cooperative schemes and consensus among stakeholders.

The indicators of the Novelog project are the following:

- Number of deliveries per establishment per week
- Share of deliveries between 7:00-10:00 [percentage]
- Empty running [percentage]
- Average vehicle dwell time-minutes per delivery [minute]
- Average size of goods delivered per drop [pallet]
- Overall distance travelled [kilometre]
- Average daily distance travelled [kilometre/day]
- Average speed [kilometre/hour]
- Overall energy consumed [kW*h]
- Unit consumption [kWh/kilometre]
- Average % of daily use of the charge [% / day]
- Estimation of saved CO2 [kg]
- Diesel equivalent unit consumption [litre/kilometre]
- Saved fuel (diesel equivalent) [litre]

In summary, this EU-funded research project, called NOVELOG, aims to enable knowledge and understanding of urban freight distribution and service trips for cities to implement effective and sustainable policies and measures and facilitate stakeholder collaboration for sustainable city logistics. On this purpose, an understanding cities tool questionnaire has been developed in terms of economic-demographic characteristics (such as GDP, operational costs, population, consumers etc.), ecologic-social issues (such as environmental concerns, ethics, waste, local inclusion, etc.), logistics solutions and business models, new technology development alternatives (such as digitalization, driverless, etc.), and fleet characteristics and service features (such as number of vehicles, number of deliveries, travel time etc.).

SULPITER

Another example study case is the SULPITER project that considers a transport operator questionnaire to provide a brief analysis of the logistics service and processing details in terms of fleet size and management, vehicle type and features, trip information as motivation and movement sequence, delivery movement frequency and loading/unloading operations, time preferences, and delivery type and purpose.

Delivery-Match

In the Delivery-Match, the aim is to increase sales and reduce costs with the shipping. Delivery-Match has world-wide software, and it has more functionality. For each order Delivery-Match will real-time calculate the complete supply chain for the best fitting and/or cheapest delivery options. Delivery-Match can also manage the complete logistic operations from checkout towards doorbell in a simple way. Expensive peaks and drops while processing the orders will be history, as well high transport costs. On top of that the sales will increase because the consumer will reward the logistics service and the reliability of it. Three main targets of the Delivery-Match are the following:

1. Reliable shipping options in the web shop checkout
2. Simplification and cost reduction for order processing and transport
3. More sales

The performance indicators of the Delivery-Match are:

- Number of LCV + Trucks
- Number of movements per week
- Delivery at home [*percentage*]
- Pick up at a pickup point of a carrier [*percentage*]
- Delivery at an alternative address [*percentage*]
- Delivery at a secured home parcel box [*percentage*]
- Preferences for delivery at a certain day and a specified time window [*percentage*]
- Willingness to wait for the delivery if the delivery time is reliable and one can choose a suitable delivery time [*percentage*]

- Savings potential warehouse operation by transform push>pull [*euro per month*]
- Savings potential last mile by transform push>pull [*euro per month*]
- Sales increase by transform push>pull [*euro per month*]

As a conclusion, the guidelines of the Novelog and Sulpiter projects were identified as reference studies for this research project, which is taken into consideration to develop a guideline for the acceptance analysis of automated logistics concepts as a service. Furthermore, logistics KPIs are mentioned in all those previous experiences as best practices along with impact assessment applications, which could be taken into consideration for this research study when the KPIs relevant for ALaaS will be defined and specified.

4.6. Effects of Freight Transport and Logistics Services

The use of automated solutions in freight transportation and logistics services has a number of effects on the sector. There are some of the main effects which are summarized in the following parts.

Increased efficiency and productivity: Automated solutions have been shown to increase efficiency and productivity in the freight and logistics sector. A study by DHL found that the use of autonomous robots in warehouses led to a 25 percent increase in productivity (DHL, 2016). Similarly, a study by the Fraunhofer Institute for Material Flow and Logistics found that the use of automated guided vehicles in logistics centers increased productivity by up to 50 percent (Fraunhofer IML, 2018).

Improved safety: Automated solutions can also improve safety in the freight and logistics sector. A study by the National Institute for Occupational Safety and Health found that the use of automated solutions in material handling operations reduced the risk of injury to workers (NIOSH, 2018). Similarly, a University of Leeds study found that the use of automated systems in logistics operations reduced the risk of theft and cargo damage (Hobbs et al., 2017).

Cost savings: Automated solutions can also provide cost savings in transportation and logistics services. A study by PwC found that the use of autonomous vehicles in logistics operations could result in cost savings of up to 40 percent (PwC, 2016). Similarly, a study by the Fraunhofer Institute for Material Flow and Logistics found that the use of automated guided vehicles in logistics centers reduced labor costs by up to 80 percent (Fraunhofer IML, 2018).

Increased capacity and flexibility: Automated solutions can also increase capacity and flexibility in the freight and logistics sector. A study by the National Renewable Energy Laboratory found that the use of autonomous trucks in logistics operations could increase transportation capacity by up to 10 percent (National Renewable Energy Laboratory, 2017). Similarly, a study by the European Commission found that the use of autonomous vehicles in logistics operations could increase delivery flexibility and reduce delivery times (European Commission, 2017).

Skilled workforce requirements: A potential challenge of automated solutions is that they may require a more skilled workforce to design, implement, and maintain the systems. A World Economic Forum study found that the adoption of automation in the logistics sector could lead to job losses, particularly for low-skilled workers (World Economic Forum, 2018). However, the study also found that the adoption of automation could create new job opportunities in areas such as systems design, maintenance, and monitoring.

Overall, the effects of automated solutions in freight transportation and logistics services are largely positive. These solutions can increase efficiency and productivity, improve safety and security, lead to cost savings, and increase capacity and flexibility. However, the adoption of automated solutions may also require a more skilled labour-force and close consideration of the potential impact on jobs in the sector.

5. Assessment Approach

Automated Logistics as a Service (ALaaS) is a rapidly expanding field within the logistics sector that emphasizes the integration of advanced techniques such as artificial intelligence, the Internet of Things (IoT) and smart tools for logistics to optimize logistics operations and its performance. ALaaS is intended to minimize human intervention as well as optimize logistics processes, thus leading to improved efficiency, reduced costs, and boosted viability for the organizations. However, the efficiency of ALaaS equally depends on the accuracy of its assessment approaches, which are fundamental points for measuring the performance as well as capabilities of such an automated logistics service as a whole.

With this in view, this present research presents a concept for assessing ALaaS that incorporates various elements such as service reliability, availability, maintainability as well as safety and security, among other items. The proposed approach thereby establishes a structured framework for measuring ALaaS performance along with the identification of additional improvement points, enabling organizations to optimize logistics operations to achieve optimum performance.

5.1. Impact Assessment Framework for Logistics

The adoption of the Automated Logistics as a Service is likely to have considerable impacts on a variety of stakeholders, such as those customers and service providers, the economy, and the environment. Hence, it is important to assess the different impact areas of the ALaaS as a key focus for implementation to guarantee that it is in line with the already established targets, objectives, and values.

In that context, this research study presents an impact assessment framework for the ALaaS that intends to further identify and assess the individual impact areas of the ALaaS regarding the various stakeholder clusters, economic aspects, and environmental issues. This logistics impact assessment framework incorporates the three pillars of the sustainability concept, as economic, social and environmental impacts, as well as providing a methodical approach for assessing the impacts of ALaaS.

The proposed impact framework could enable organizations to bring together advised findings on the adoption of ALaaS together with the identification of opportunities for advancing to further the understanding of its comprehensive impacts. Collectively, such a framework could support the development of a sustainable and responsible approach to the successful deployment of ALaaS, while ensuring that it is in line with objectives, targets, and values with a favourable impact on society, the economy, and the environment.

In this outline, the following scheme outlines the designed impact assessment framework along with its components for the concept of automated logistics as a service while also presenting a brief description of those elements.

The following diagrams illustrate the developed and proposed impact assessment methodology for an automated logistics as a service concept deployment involving research activities, studies or projects, whereas the general scheme is presented in the subsequent section.

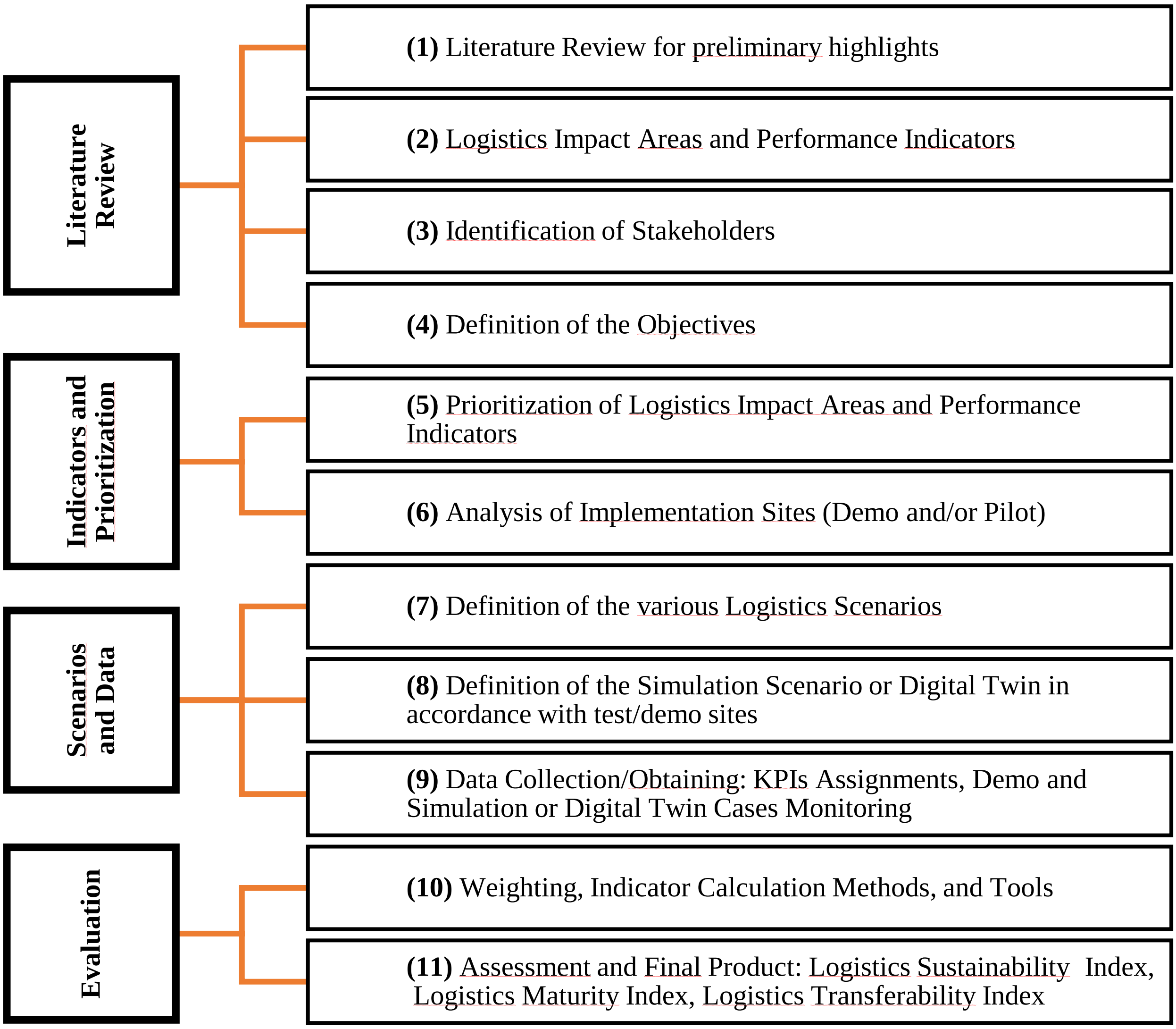


Figure 5: *Automated Logistics as a Service Impact Assessment Framework*

The developed and proposed methodological approach for an impact assessment framework of automated logistics as a service is presented in the subsequent sections. The methodology comprises a number of steps: defining, prioritizing, and collecting data, weighting, adjusting, and producing the final product comprising the estimations and assessment. Besides, several observations and recommendations could be introduced, while the monitoring strategy for the mentioned indicators could be further elaborated.

Part A: Literature Review

As previously presented in the diagram, the impact assessment methodology starts with a literature review, which is supported together with a short statement of the targets and objectives.

Step 1: Beyond the literature review, as a first point in which is cross-supported by literature analysis, the content of the impact assessment should be defined by identifying the aims, objectives and stakeholders involved in the assessment. Subsequently, the impact assessment methodology then proceeds with the literature review in order to analyse studies, benchmark frameworks, and best practices related to the impact assessment on automated logistics solutions. Hence, this step is fundamental to identifying potential impact categories and relevant performance indicators to be assessed along with indicator calculation methods.

Step 2: In the next stage, the impact areas of the logistics sector are mainly associated with process management, the transfer of materials, and the obtaining/sharing of information. Therefore, economy, service acceptance, sustainability, and transferability, in particular, are the main impact areas of logistics to be considered. In a parallel process, performance indicators are defined to address the highlighted impact areas. For this intention, performance indicators were extracted from the priority-setting literature. Besides, the best practices could mention several performance indicators that should be taken into account. Based on the literature review together with best practices, identify the impact categories and indicators that will be used to assess the impact of automated logistics services. These could include economic, social and environmental impacts.

Step 3: Those stakeholders are to be identified during the demonstration site deployment planning progress phasis along with best practices analysis and some additional surveys on the field. The stakeholders are related to the management process, the material flow tracking, and the logistics services information flow. On the other hand, the stakeholders are predominantly logistics managers, receivers, forwarders, and transfer personnel.

Step 4: Afterwards, the objectives will be further elaborated and detailed-specified in accordance with the automated logistics concept work definitions of the demonstration sites. Beyond that, the objectives shall be related to the sustainability, technology readiness and transferability of logistics services related to material transfer and process management.

Part B: Indicators and Prioritization

According to the presented diagram, the impact assessment methodology continues with a prioritization of already defined ALaaS relevant performance indicators and impact areas along with the deployment plans alignments to understand foreseen data availability for defined indicators.

Step 5: The prioritization of logistics impact areas and performance indicators involves several key steps:

- Define the evaluation scope: Establish clearly the evaluation focus, including the logistics processes and stakeholders that will be covered,
- Identify potential impact areas: Identify potential impact areas of logistics operations, such as economic, social, and environmental impacts. This may involve stakeholder consultation and examination of standards and best practices,
- Prioritization, Assessment of the weight of impact areas: Assess the significance of each impact area based on its potential impact on the organization and its stakeholders. This may involve using a scoring system or ranking impact areas according to their importance. Moreover, selecting also performance indicators to measure the performance indicators for each impact area based on their relevance, reliability and measurability,
- Prioritization, Assessment of the weight of performance indicators: Evaluate the significance of each performance indicator based on its ability to measure the area of impact and provide useful indications for improvement. This may involve the use of a scoring system or ranking of performance indicators according to their importance, and
- Development of a monitoring and evaluation plan: Develop a plan for monitoring and evaluating performance indicators over time. This could comprise setting targets, establishing data collection and reporting arrangements, and using data analysis tools to monitor progress and identify areas for improvement.

In generalizing, the prioritization of logistics impact areas and performance indicators requires a systematic approach that involves a detailed consideration of the objectives and prioritization of such an ALaaS deployment, stakeholder input and standards with best practices. This approach could support decision-makers to focus on resources and efforts in the areas that have the greatest potential for improving logistics performance and achieving sustainable results.

Step 6: Demonstration sites are the application sites for the projects. Those sites are interested in obtaining various operational data that will be used for impact assessment with logistic indices. The analysis of implementation sites (demo and/or pilot) involves a number of key processing steps:

- Define the scope of the analysis: Clearly define the scope of the analysis, including the specific implementation sites that will be analysed and the objectives of the analysis,
- Data collection: Collect data from ALaaS concept implementation sites, including operational data, stakeholder feedback, and other relevant information. This could involve site visits, stakeholder interviews, and review of documentation and reports,
- Data analysis: Analyse the data collected, using appropriate statistical and analytical tools. This could involve identifying trends and patterns, comparing performance across implementation sites, and assessing the impact of implementation on automated logistics operations as a service and stakeholders,
- Identify strengths and weaknesses: Identify the strengths and weaknesses of implementation sites, based on data analysis,
- Develop recommendations: Develop recommendations for improving the implementation of the logistics solution, based on the strengths and weaknesses identified. This may involve identifying best practices and areas for improvement and developing an action plan to address any issues. Also, communicate the findings and recommendations of the analysis to stakeholders, including management, project teams, and other relevant parties. This may involve preparing reports, presentations, and other communication materials, and
- Implementation: Execution of scenarios/changes to the automated logistics concept as a developed service, working closely with implementation teams and other stakeholders to ensure that changes are effectively implemented, and their impact monitored over time.

To sum up, analysis of implementation sites (*demonstration and/or pilot*) requires a detailed approach that involves gathering and elaborating data, identifying strengths and weaknesses, developing recommendations, and communicating findings and recommendations to stakeholders. This approach could support decision-makers to further improve the implementation of automated logistics as a service solutions and achieve better outcomes for logistics operations and stakeholders.

Part C: Scenarios and Data

On an ongoing pattern, based on the diagram presented, the impact assessment methodology moves forward with scenario definition, association and matching of data availability to the ALaaS-relevant performance indicators which have already been defined and prioritized, to highlight the scenario-indicator coupling as well as monitor and orchestrate the data collection process in detail.

Step 7: The framework scheme comprises the processes of the development methodology, including impact areas, indicators and prioritization, defined logistics scenarios as well as various logistics configuration scenarios for automated logistics processing, even together with automated vehicle implementations. The scenarios are 'with automated vehicle for hub-to-hub' and 'with automated vehicle for point-to-point'. Subsequently, the demonstration sites will address the impact areas of safety, efficiency and acceptance. In addition, environmental and operational parameters should be analysed by a simulation logistics scenario defined on the basis of the literature review (and would also be affected by stakeholder questionnaires). Thereafter, demonstration sites from specified best practices-projects will be considered, providing descriptions of the various logistics scenarios regarding stakeholder definitions, impact areas, objectives and performance indicators.

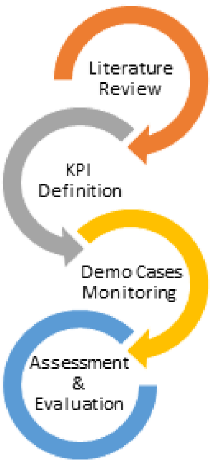
Step 8: Building a definition of the simulation scenario or digital twin in accordance with the test/demonstration sites involves several key elements:

- Defining the simulation scope to clarify the purpose of the simulation or digital twin regarding automated logistics as a service concept, including the specific use case, the desired results, and the intended targets; moreover, to assist in assuring that the simulation scenario or digital twin is tailored to the needs of the stakeholders,

- Identify the main characteristics of the test/demonstration site to identify the main characteristics of the test/demonstration site that will be simulated or modelled. This may include physical infrastructure, equipment and processes regarding automated logistics as a service concept,
- Determining the simulation scope: Determine the simulation scope, including the level of detail and complexity required,
- Select appropriate simulation instruments: Select appropriate simulation instruments based on the scope and purpose of the simulation,
- Develop the simulation model: Develop the simulation model according to the main characteristics of the test/demonstration site and the chosen simulation tools,
- Validation of the simulation model: Validate the simulation model by comparing the simulated results with real-world data or observations. This will help ensure that the simulation accurately represents the test/demonstration site and produces reliable results,
- Test and refine the simulation: Test the simulation model and refine it if necessary to improve its accuracy and reliability, and
- Document the simulation scenario or digital twin: Document the simulation scenario or digital twin, including the purpose, scope, simulation model and validation results.

In principle, creating a simulation scenario definition or digital twin for automated logistics as a service concept, depending on the test/demonstration sites, requires careful planning, attention to detail and collaboration between stakeholders with expertise in simulation, modelling and the specific test/demonstration site to be simulated.

Step 9: The principal objective is to develop a data collection plan to gather information on the impact categories and indicators identified in the previous step. This could involve surveys, interviews or secondary data sources. The data collection/detection methodology is developed through the following key phases, as listed below:



The literature review is intended to provide preliminary information on logistics performance indicators, the evaluation framework and evaluation criteria and methods,

Definition of KPIs (obtaining information from the cited projects) and index objectives to analyse the various indicators of logistics service characteristics and the definition of logistics indices for evaluation and estimation,

The monitoring of the project demonstration cases and the acquisition of results (obtaining information from the mentioned projects and simulation) highlights the collection of data from the demonstration cases regarding indices and indicators, and

The evaluation and assessment seek to establish an evaluative link between the data, indicators, and assessment approaches.

***Figure 6:** Data Collection Steps*

Part D: Evaluation and Assessment

As in the last part of the ALaaS impact evaluation approach presented, weighting, execution of estimation methods for measurement, and assessment techniques will be conducted to measure the overall performance findings of ALaaS deployment and to monitor the performance of ALaaS deployment through simulations and/or real-life implementations. Beyond that, a smart tool as well as recommendations could be valuable to better enhance the adaptation, integration, and measurement of the developed ALaaS concept.

Step 10: The impact assessment methodology then proceeds with prioritization and weighting process to collect and analyse data according to the data collection plan. This phase could involve using smart tools, statistical tools, and software to collect-analyse the gathered data for implementing assessment approaches of automated logistics as a service towards simulations, digital twins, or real-life implementations. Subsequently, interpret the findings of the data analysis and identify the impact of automated logistics services on the defined categories and impact indicators. Establishing and applying weighting, indicator calculation methods and tools involves several key steps, as summarized below:

- Determining evaluation criterion: Define explicitly the evaluation concepts that will be used to assess the performance of such an ALaaS solution. Those could possibly include economic, social and environmental criteria, as well as other relevant factors,
- Identify ALaaS performance indicators: Focus on identifying the performance indicators that will be utilized to measure the performance of the developed automated logistics solution against the assessment criterions,
- Weighting: Relatively determine the weighting or relative importance of each evaluation criterion and ALaaS impact areas, performance indicators, and would be done also for evaluation indexes,
- Development of calculation methods for ALaaS performance indicators: Further develop methods for calculating performance indicators, taking into account weighting and data availability,
- Select assessment instruments: Do choose the appropriate assessment instruments to analyse data and calculate performance indicators,
- Implement weighting and indicator assessment procedures: Apply weighting and indicator assessment methods to the collected data to measure the performance of the developed ALaaS solution against the assessment criteria, and
- Perform assessment of ALaaS deployment outcomes: To interpret the evaluation findings, considering the weighting, performance indicators and evaluation criteria.

As a general matter, determining and implementing weighting, indicator calculation methods and tools requires a well-structured approach involving a detailed consideration of evaluation criteria, performance indicators and weighting, along with appropriate evaluation tools and methods. This approach could then support decision makers in assessing the performance of logistics solutions in a rigorous and systematic approach and identifying opportunities for improvements.

Step 11: At the final stage, the impact assessment methodology finalizes the process with a developed ALaaS impact assessment procedure in which various performance measurement techniques are involved, as summarized (*and detailed in further chapters*) in the following:

- <u>The Logistics Sustainability Index</u> refers to an integrated assessment method to quantify the sustainability performance indicators of the freight transport and/or logistics based on various criteria.
- <u>The Logistics Maturity Index</u> is looking for the maturity models are tools for being defined to understand the logistics sector, by using indicators, concerning measuring, comparing, describing, or determining a path or roadmap of the highlighted issue.
- <u>The Logistics Transferability Index</u> is responsible for the knowledge and experience exchanging between one application, that has been applied in one time and/or one zone, and another.

Subsequently, there could be a focus on developing the recommendations based on the findings of the impact assessment to improve the impact of automated logistics services. Such recommendations could lead to changes in policies, practices, or technologies used within the logistics services.

This would be followed by communicating the results of the impact assessment to stakeholders and other interested stakeholders, providing clear and concise information on the impact of automated logistics services and recommendations for improvement. In addition, monitoring and evaluation of the progress of the ALaaS solution over time could be conducted to determine the effectiveness of the recommendations and identify areas for further improvement.

5.2. Definition of the Key Performance Indicators for Logistics

The definition of ALaaS Key Performance Indicators (KPIs) are done in accordance with the prior studies and best practices along with the logistics stakeholders' involvement and further observations. Following that, this chapter aims to identify various acceptance-relevant sub-categories concerning also various example performance indicators due to effects of safety and efficiency perspectives on the service acceptance level.

Moreover, another objective of this chapter of the study is to provide an overview of the potential-possible performance indicators that would be effective on the acceptance and performance level of the automated logistics service implementations. In particularly, there groups of the ALaaS relevant performance indicators have been defined (*see Annex IV*).

Based on this purpose, the logistics and automation relevant performance indicators, with also supporting coordination and cooperation analysis indicators, are represented to provide an overview for the evaluation, as briefly listed below (*and further defined in the Chapter 7.1.1 and ANNEX IV*):

- Punctuality of deliveries
- Precision of deliveries
- Customer satisfaction
- Unit cost of delivery
- Load factor patterns
- Public acceptance
- Willingness to pay for AV urban deliveries/logistics
- Number of accidents on site
- Incidents of crime / theft
- Number of incidents involving vandalism
- Loss and damage parcels
- Fair and equal access to AV
- Ratio of average load
- Number of cargo transported
- City population share
- Empty running
- Journey length
- Journey speed
- Loading/Unloading activities (quantity and duration)
- Number of deliveries including quantity of goods delivered/collected
- Time of delivery (pick-up)
- Vehicle size/type
- Customer satisfaction
- Final user-customer acceptance
- Managerial and Operational costs
- Public acceptance
- Punctuality
- Quantity
- Stakeholder acceptance
- User acceptance
- Vehicle data (vehicle-kms, average load factor, utilization factor)
- Experience
- Information flow problems
- Lack of a system to monitor the efficiency and effectiveness
- Lack of involvement of stakeholders
- Lack of knowledge about stakeholders' requirements
- Lack of knowledge about the operation of logistics process
- Access availabilities (time-windows, load-factor)
- Changes in legislation (national or EU level)
- Loading/Unloading areas and parking
- Lockers (availability in vehicle or external places)
- Transferring rate

After the summarized automated logistics performance indicators, it is important to highlight that logistics performance indicators are aimed to be determined for acceptance and performance evaluation based on research targets together with sustainability, transferability, and maturity assessment; on the other hand, these automated logistics indicators would be taken into account to be questionnaire targets that can be searched, for data collection of acceptance assessment, during the implementation.

Furthermore, the logistics performance indicators questionnaire guideline is summarized as in the diagram that is represented below: [13]

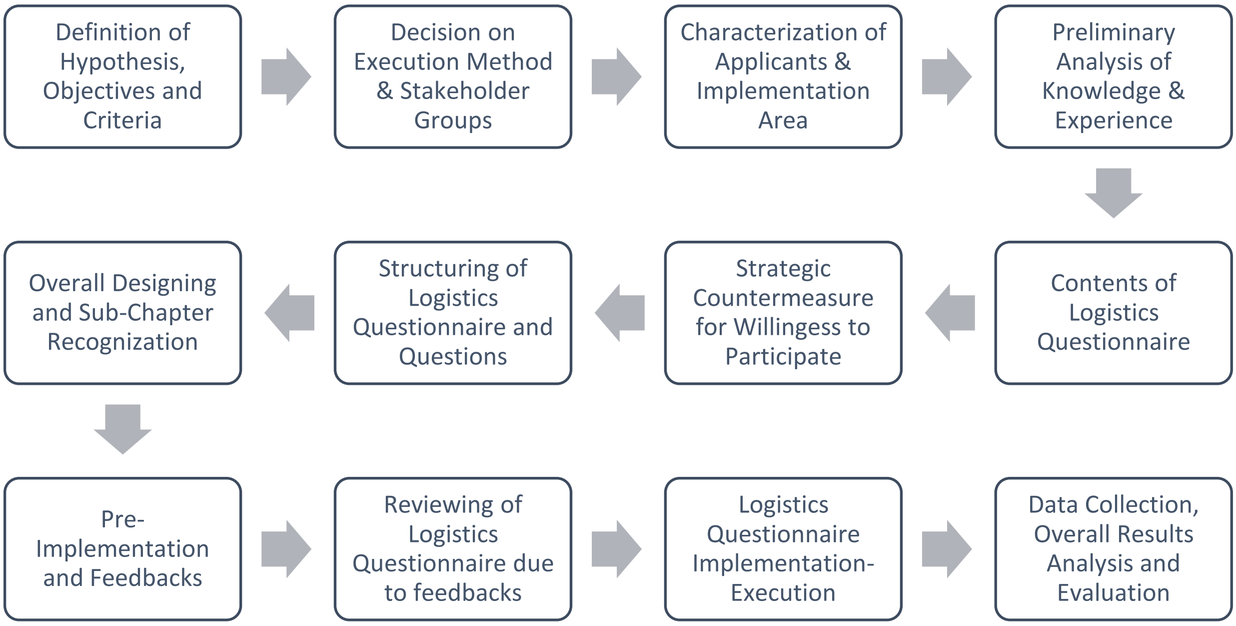


Figure 7: *Proposed guideline of ALaaS performance indicators selection*

(1) Firstly, the definition of hypothesis and relevant targeted information that would be analyzed. This step would also define the overall research objectives, collected data (responses) for indicator evaluation with defining a methodology, and data assessment method with respect to selection criteria to understand which data would be considered or neglected. In addition to this, the logistics questionnaire applicants would be identified as stakeholder groups.

(2) The second step is related to the decision on the technique/method for the implementation of the questionnaire. This step requires planning the questionnaire distribution methods (by online, in presence, getting feedback, or phone-call), and the organization of the questionnaire implementation providing targeted stakeholders and expected number of applicants.

(3) As a third step, an overview of the customers (receivers) and senders (facilities) characteristics would be preliminarily analyzed concerning the stated hypothesis to collect basic information about stakeholders (such as age group, income level, resident-working area, shopping type-frequency, etc.) including an analysis of the expectations and needs (preferences for delivery total time, receiving time-slot, booked delivery option, delivery vehicle parking, automated-robotic deliveries, etc.) on freight transport and logistics service.

(4) The fourth step would involve preliminary work on the understanding of the current status of defined stakeholders' knowledge and experience, both for customers-providers, in terms of logistics automation, automated vehicles in logistics, and digitalization of logistics processing for paperwork to direct the applicants for relevant sub-chapter based on stakeholder category and-or knowledge. In addition, this step also analyzes the infrastructural conditions (such as warehouses, transport infrastructure availability, etc.) and technical specifications.

(5) After that, the fifth step would be to focus on the contents of the questionnaire by highlighting individual questions for each sub-chapter. The logistics questions are needed to be created significantly for the targeted contribution and be clarified for understanding any crossing, ambiguity, and any manipulation possibility on the correctness of the answers. On this basis, the questions would be chosen and-or described according to the logistics-based research hypothesis.

(6) The sixth step would be to define a strategic countermeasure methodology for potential unwillingness to participate due to lack of questionnaire research topic clarification, ability to answer questions, not feeling familiar with logistics research field, emotions (aggressiveness, etc.), feeling embarrassed or making irrelevant work. To avoid the unwillingness to participate, several countermeasures are required such as well-structured questions placement, a preliminary introduction for questions/chapters, preparation of the questionnaire for third-person interviews, and categorization of the questions answers based on the preliminary characterization of stakeholders.

(7) After that, the seventh step of the logistics questionnaire continues with the structuring of questions in terms of language clearance, type and specification (yes-no questions or multiple-choice questions instead of open-ended questions), provision of required instruction, and arrangement to make clear the questions and questionnaire layout concerning the determination of the order of the questions. All the targeted information is to be based on the identified stakeholder characteristics and hypothesis without any complexity, embarrassment, sensitivity, political complexity, etc. This step concentrates on providing more clarity-understandability and easy-to-participate feeling for the applicants.

(8) The eighth step focuses on the questionnaire form designing and recognition of the sub-chapters to support less tiredness due to the number of questions and chapters (while also administrating the color-use of the template). This step would be also related to dividing the questions in terms of logistics fields such as paperwork-related questions, warehouse processes, transportation and routing relevant information, use of tracking of deliveries, etc.

(9) Another step, the ninth step, would be the pre-application phase to test the logistics questionnaire for an understanding of first feedback from chosen applicants to improve the quality of the questionnaire, avoid any misleading information, and collect comments and suggestions.

(10) The tenth step is reviewing the logistics questionnaire based on pre-execution testing feedback to modify and improve.

(11) The eleventh step is the implementation-execution of the logistics questionnaire according to the defined stakeholder groups by using a determined distribution strategy. In this step, the potential customers (receivers), logistics service providers (including warehouse operations and transportation), and delivery flow routing determination (route choice, travel time reducing, tracking) relevant partners are highly important to be considered.

(12) For the targeted-information collection, the twelfth step is the data gathering (response collection) from the applicants, and the analysis of collected data (response suitability) to decide which responses might be irrelevant or inconsequential. In the final part, the aim is the analysis of the overall results based on research purpose, objectives, and evaluation methodology. In this step, chosen assessment indicators will be evaluated-assessed according to the obtained data from the logistics questionnaire.

5.3. Logistics Scenarios and Demonstrations

The context of automated logistics as a service demands a balanced and adjusted scenario setting for those innovative logistics services in terms of operational approaches to urban logistics.

[***hub-to-hub***] As a first type of deployment, hub-based delivery for logistics services is being addressed. According to the scenario projection, there are two different loading/unloading areas linked together within a hub-to-hub approach in order to transfer deliveries to each other. In the scenario, there are two hubs within a designated coverage area (to be serviced); specifically, the hub's coverage area would be the distribution or collection area for deliveries to be sent to another hub. The freight service (loading/unloading) would be available by appointment. Besides, deliveries from local points to the hubs would be made by citizens/customers, which implies that the senders/receivers would collect the deliveries; conversely, deliveries could be distributed from the hubs to the final destinations (in the covered area, service zone) by the logistics service provider using an automated electric vehicle or automated unmanned vehicles.

The logistics service hubs serve as interim transfer points between the origin and destination of the material flows. Such hubs, which provide an intermediate flow of materials, have the potential to reduce freight operations costs and environmental effects along with total shipping time by increasing the efficiency and effectiveness of freight transport operations between two points. The logistics service hubs are supposed to be established as the places where materials/deliveries are either stored, in warehouses or urban consolidation centers or transferred from one transport mode or vehicle to another.

In the following, the hub-to-hub scenario defines the logistics hubs as freight distribution/collection areas for the transshipments of the material flows between two zones by an intermodal transport mode as "electric automated van for freight or passenger-freight transport"; so that, the hub-related scenario would be interested in the transport between hubs and distribution of the materials in the covered zones. In particular, the scenario includes two hubs, two areas of influence, IT service of the appointments for loading/unloading, an electric automated vehicle transport between hubs, and the vehicle logistics capacity and speed. The hub-related scenario in this context can be modeled in the diagram below:

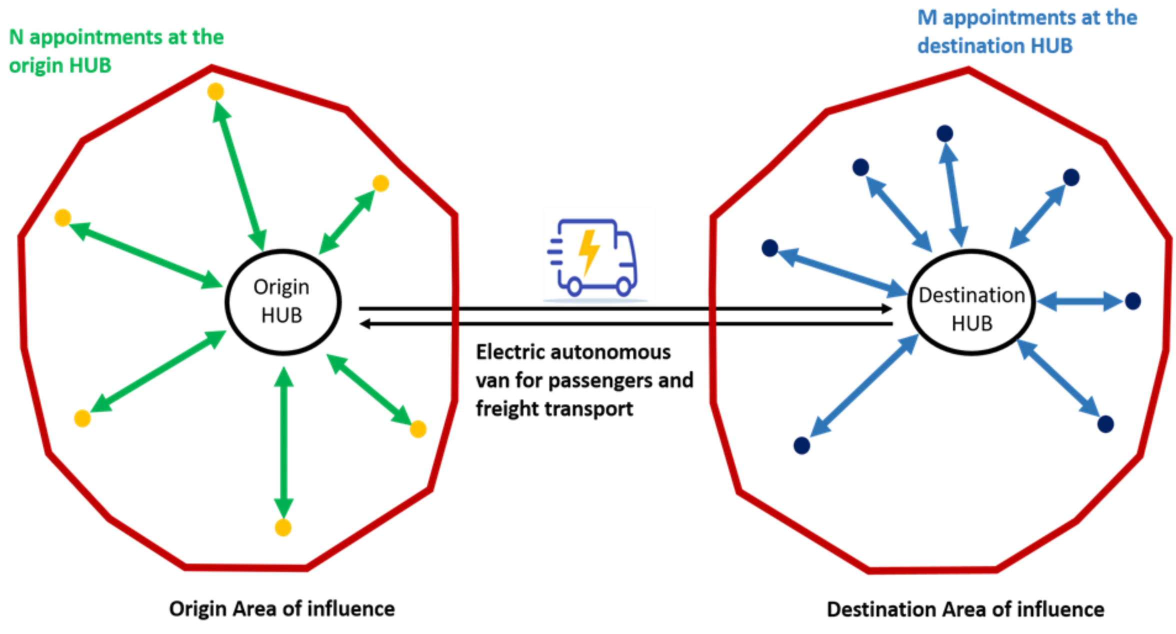


Figure 8: *Scenario 1 Area-based Hub-to-Hub OR Hub-related Model*

The above-illustrated diagram indicates a HUB-to-HUB freight transport scenario. There are then only two points at which the goods carrier can interchange cargo for either loading or unloading, depending on the scheduled appointments.

Besides, the logistics service provider can arrange the distribution of freight by appending a certain number of last-mile pick-up points. The specifications of the hub-based scenario are outlined as follows:

- Dimensions of origin/destination influencing areas,
- Dimensions of storage spaces,
- Maximum handling capacity,
- Number of platforms,
- Geographical positioning of hubs,
- Number of points in origin/destination influencing areas for appointments,
- If last-mile delivery, number of pick-up spots,
- Types of cargo handled/transferred,
- Technical-operational specifications of the vehicle (number of spots available as volume, speed, travel distance).

Within this context, logistics service hubs are considered such as airports, ports, terminals, etc. for intermodal freight transport, handling, storage, and loading/unloading operations. Such logistics services would be conducted in a fully automated and digitized manner along with an appointment.

Logistics hubs, on the other hand, are oriented toward the stocking of cargo materials for transfer and distribution. Beyond that, this scenario is supposed to overview the processing steps as described hereunder:

- Development of the projections,
- Analysis of the stakeholders,
- Definition of the experts,
- Application areas analysis,
- Preliminary-Search such as preliminary questionnaire, national-local regulations control, etc.,
- Scenario writing concerning detailed analyses of the application area,
- Performance Indicators matching,
- Scenario implementation and monitoring,
- After-Implementation analysis such as secondary questionnaires, etc.,
- Data collection, data sharing, and evaluation.

[***point-to-point***] Under this scenario, the point-based logistics service projection is being considered. In this model, the projected scenario is based on several (more than two stops) inter-connected loading/unloading spots, using a point-to-point approach, along the route to transfer the consignments from one stop to another. Under the scenario, there is a departure and an arrival point together with at least an intermediate stop throughout its designated route; more specifically, an automated electric vehicle would work along a prescribed route that could serve both passengers and goods, bypassing those individual stops one after another and eventually returning to its departure point when it arrives at its final stop.

Within this scenario, there could be first-to-last stops as well as several intermediate stops to be served; more specifically, each stop is supposed to be a delivery or collecting spot for freight to be transferred to another stop. Such logistics loading/unloading activities would be made available on scheduled appointments, which would be continuously monitored during the transfer period by an IT service or a mobile-app.

Logistics service stops are defined as the places where materials/deliveries, which are transferred from one stop to another, are unloaded/loaded by an automated electric vehicle according to respected and time-defined appointments.

Below, the point-to-point scenario defines logistics stops as areas for transshipping and picking up materials between two stops along the route defined by a transportation mode such as "automated electric van for transporting goods or passengers" with time-dependent respected appointments; thus, the point-based approach would be concerned with the transportation of goods between stops and the process of loading/unloading materials from receivers with time-dependent appointments.

Specifically, the point-based scenario includes two starting and ending points (start of the route and return to the starting point), several intermediate stops, the computer service of loading/unloading appointments, an automated electric vehicle for transportation between stops, and the logistic capacity and speed of the vehicle. The point-based scenario in this context can be modeled in the diagram below:

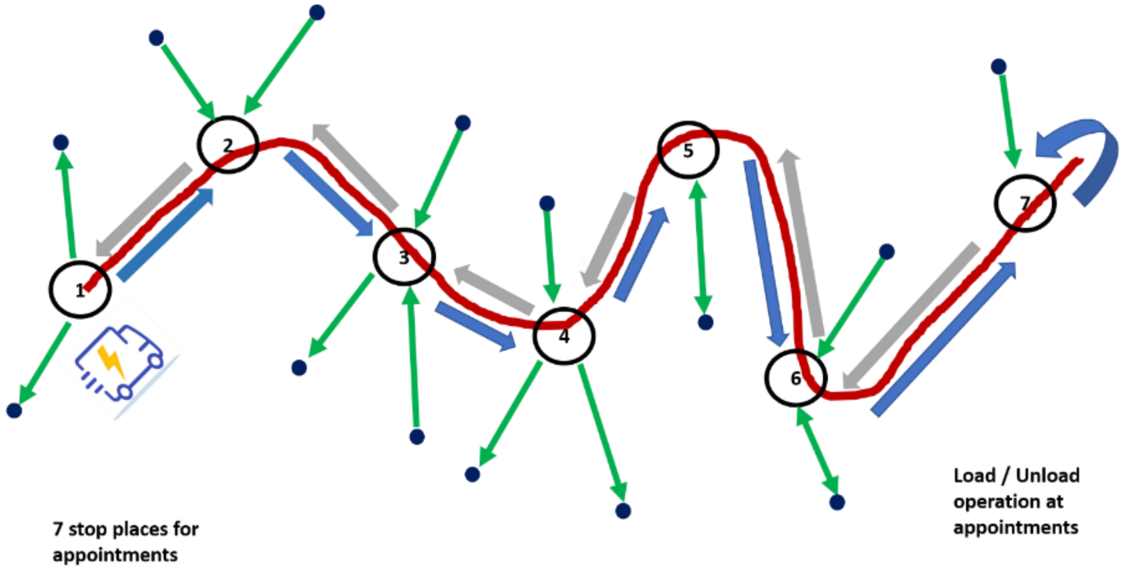


Figure 9: *Scenario 2 Stop based Point-to-Point OR Point-based Model*

In the second scenario, we have multiple points where the cargo van could stop to load/unload goods, in accordance with scheduled appointments. As a matter of fact, the scheduled appointments are required to be maintained in precisely specified time windows at specific stopping points where goods can be loaded/unloaded. The characteristics of the point-based scenario are as follows:

- Number of stops for loading/unloading,
- Loading/Unloading required time (*time-loss*) for each stop along the route,
- Geographical locations of the stops,
- Types of goods handled/transferred,
- Number of appointments available (*for each stop during the route*),
- The efficiency of appointments (*number of un-respected appointments*), and
- Technical-Operational features of the vehicle (*number of available places "volume", speed, travel distance*).

In this regard, logistics service points/stations are considered for material flow and loading/unloading operations. All logistics services would be provided as fully automated and digital processing with appointment request. Logistics service stops, on the other hand, are geared for material flow and loading/unloading operations. The automated electric service vehicle can also serve both passengers and freight because the stops are able to serve both passenger and logistics; however, the only concern would be the time lost due to loading/unloading processes. Furthermore, the scenario is expected to have an overview of the following processing steps:

- Development of the projections,
- Analysis of the stakeholders,
- Definition of the experts,
- Application areas analysis,
- Preliminary-Search such as preliminary questionnaire, national-local regulations control, etc.,
- Scenario writing concerning detailed analyses of the application area,
- Performance Indicators matching (*to highlight which KPIs would be interested*),
- Scenario implementation and monitoring,
- After-Implementation analysis such as secondary questionnaires, etc., and
- Data collection, data sharing, and evaluation.

5.4. Prioritization and Weighting

The impact areas and key performance indicators have been defined as abovementioned. After those definitions for logistics matters, there is a need of prioritization and weighting to address principally important performance indicators to measure such a deployment performance for an assessment. To this point, there is an organized workshop to rank the already assigned key performance indicators and assessment approach weighting.

Regarding above-mentioned points, the following aspects are identified to understand how to organize a workshop for performance indicators prioritization, as summarized in the following:

- Determine the purpose and scope of the workshop: Before organizing a workshop to prioritize performance indicators, it is essential to determine the purpose and scope of the workshop. The purpose of the workshop could be to identify and prioritize KPIs, review and refine existing KPIs, or align KPIs with organizational objectives. The scope of the workshop could include specific departments, processes, or functions of the organisation.
- Identify key stakeholders: The success of the workshop depends on the participation of key stakeholders from different departments and levels of the organisation. Identifying key stakeholders is essential to ensure that workshop is inclusive, and representative of needs and objectives.
- Develop a workshop plan: A workshop plan needs to be developed to ensure that the workshop is well organized and achieves its objectives. The plan should include the workshop agenda, objectives, goals, activities and expected outcomes.
- Selection of Facilitators and Subject Matter Experts: The selection of the right facilitators and subject matter experts is essential to the success of the workshop. Facilitators must be skilled in managing group dynamics, encouraging participation, and guiding discussions. Subject matter experts must have a deep understanding of the organization’s processes, goals, and objectives.
- Develop a guide for participants: A guide for participants must be developed that provides them with the necessary information on the workshop's objectives, goals and activities. The guide should also contain instructions on how to participate in workshop activities, provide feedback and contribute to discussions.
- Conducting the workshop: During the workshop, participants should be encouraged to share their perspectives and ideas on the most critical KPIs. Facilitators should lead the discussions to ensure that the workshop objectives and goals are met.
- Analysis of results: After the workshop, the results should be analyzed to identify the most critical KPIs that need to be measured and monitored. The results should be reviewed with key stakeholders to ensure that they are aligned with the organization’s objectives.
- Communicate results: The results of the workshop should be communicated to all stakeholders to ensure that everyone is aware of the most critical KPIs. This helps promote accountability and ownership among stakeholders and ensures that everyone is working towards the same goals.

Overall, organizing a workshop to prioritize performance indicators requires careful planning, active participation and effective communication. The success of the workshop depends on the participation of key stakeholders.

After that, the workshop implementation methodology has been specified involving the general steps to consider when arranging a workshop for performance indicators prioritization, as pointed in the following:

1. *Define Objectives and Goals:* The first step in arranging a workshop for performance indicators prioritization is to define the objectives and goals of the workshop. This includes identifying the stakeholders who will participate in the workshop, determining the scope of the workshop, and outlining the specific outcomes that the workshop should achieve.
2. *Identify Key Performance Indicators:* The next step is to identify the key performance indicators (KPIs) that will be the focus of the workshop. This involves reviewing the organization's strategic objectives, analyzing performance data, and engaging with stakeholders to identify the most critical KPIs.

3. *Develop a Workshop Agenda:* Once the KPIs have been identified, it's important to develop a workshop agenda that outlines the specific activities that will be undertaken during the workshop. This should include a mix of presentations, group discussions, and exercises designed to identify and prioritize KPIs.
4. *Assign Roles and Responsibilities:* Assigning roles and responsibilities is important to ensure that the workshop runs smoothly. This includes identifying a facilitator who will guide the workshop, a recorder who will document the outcomes of the workshop, and participants who will contribute to the discussion and decision-making process.
5. *Communicate with Stakeholders:* Effective communication is essential to ensure that stakeholders are engaged and informed about the workshop. This includes sending invitations to participants, providing information about the workshop objectives and agenda, and providing regular updates about the workshop.
6. *Conduct the Workshop:* During the workshop, participants should be encouraged to share their perspectives, ideas, and concerns about the KPIs that have been identified. The facilitator should guide the discussion and decision-making process, and the recorder should document the outcomes of the workshop.
7. *Follow-Up and Review:* After the workshop, it's important to follow up with participants and review the outcomes of the workshop. This includes sharing the results of the workshop, identifying next steps, and ensuring that the selected KPIs are integrated into the organization's performance measurement and management practices.

As for the objective, arranging a workshop for performance indicators prioritization requires careful planning, effective communication, and strong facilitation skills. By following these steps, organizations can ensure that their workshop is effective, engaging, and delivers meaningful outcomes that support their strategic objectives.

5.5. Assessment Methods

The logistics impact assessment addresses an evaluation of the deployment characteristics of automated logistics as a service. Accordingly, the logistics impact assessment framework will comprise a number of different arrangements to emphasize the presented logistics services in order to have a piece of preliminary information, gathered from a literature review, as a milestone for further development processes; supported by the literature review, a number of specific performance indicators, previous evaluation approaches along with best practices of such a service could be targeted. Later on, the key performance indicators to be measured will be identified for a better understanding of the achievements of the logistics application that can be taken as a reference for further deployment and for the provision of automated logistics services. Thus, a demonstration sample, which will be observed by the referenced project, will be in various locations, associated with the collection of data on the basis of the defined key performance indicators. Both the key performance indicators and the outcomes were elaborated from the logistics concepts within the demonstration scenarios with regard to various logistics indexes, which are being defined to be evaluated.

5.5.1. Acceptance Analysis

The new approach for urban logistics requires a well-balanced acceptance level, as well as good perspectives from both stakeholders and public opinion. The acceptance assessment for automated logistics as a service concept requires a newly adapted method and roadmap in which will support such a tool development. As it is crucial, the idea is to offer a guideline for the creation of the logistics-related questionnaire for acceptance concerning different processing approaches to reach the search objective such as understanding of an automated vehicle implementation into Logistics as a Service concept, or digitalization requirement on the logistics processing paperwork, etc.

The argument of the logistics questionnaire is understanding, monitoring, and evaluation of the user satisfaction, user acceptance, needs & wants of the improvements in the logistics as a service concept. So that, a questionnaire guideline would be helpful to prepare and implement a survey to monitor the new trends and IT system implementations on logistics, and to provide an overview of the current status, considering user needs, wants, requirements, etc.

Objectives

The questionnaire preparation is initiated with an identification of the objective which is the main data source in the research activity. In addition to this, the questionnaire main research objective is predicted with the help of the information obtained by the questionnaire as summarized below: [3]

- ➔ A correlation analysis between dependent and independent variables,
- ➔ Identification of important independent variables that would be determined, and
- ➔ Alternatives and hypotheses would be defined by providing further development suggestions-comments.

Questioning

After that, to prepare the questions of a successful questionnaire, it is important to reach the requested-targeted information with easy-to-understand and clarified surveys, which is one of the challenges for preparing the questions. In particular, various key points are required specifically taken into consideration while the question-designing phase of the questionnaire as summarized in the following: [3]

1. Socio-Economic and overall characteristics of the target (potential) applicants,
2. The research purpose of the questionnaire,
3. Design of the questionnaire in terms of the overall structure and question placements based on sub-groups (if applicable).

Preparation

The preparation of a logistics questionnaire would be designed to focus on various key elements as summarized below: [4]

- ➢ Identification of logistics stakeholders (especially customers) needs, wants, requirements, and acceptance,
- ➢ Highlighting of the logistics processing strengths and weaknesses, and
- ➢ Overall assessment of logistics service and providers in terms of easy-to-use, innovation & digitalization, effectiveness, and automatization.

Implementation Methods

After all these, the logistics questionnaire implementation methods are considered in three ways that are sub-grouped as follows:

- Interviewing as face-to-face and/or phone-call to apply the questionnaire in presence to the applicants,
- Sharing the questionnaire with the applicants online (email, online platform, mobile apps, etc) and getting the feedbacks in the same virtual mode, and
- Creating Specific Focus Groups with the aim to identify a number of the specified groups of potential customers to apply the questionnaire.

5.5.2. Logistics Sustainability Index

The ***Logistics Sustainability Index (LSI)***, relying on a Multi-Criteria Decision Analysis technique, can be assessed through a multi-step approach, as illustrated as well in the following figure:

- Definition of the application (demo case specifications),
- Selection of the impact areas (for example, economy and energy, environment, transport and mobility, society, policy and measure maturity, social acceptance and user uptake),
- Selection of the indicators for each impact area, measurement methods and data collection sources (direct, indirect, estimation, quantitative, qualitative),
- Estimation of weights for combining the criteria; such a task foresees the involvement of stakeholders of the demo case,
- Normalization and harmonization of the measurements of indicators and calculate the overall index.

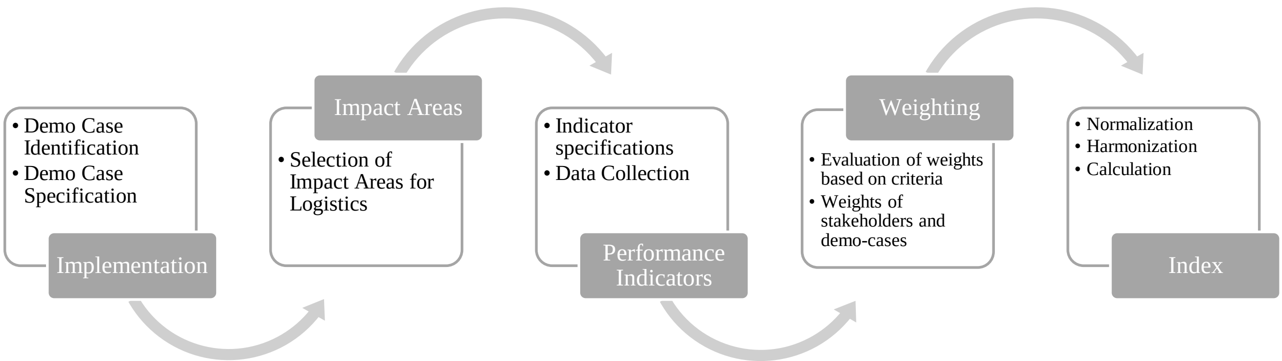


Figure 10: *Logistics Sustainability Index evaluation process*

The index can be calculated pre-implementation (ex-ante) and post-implementation (ex-post) to make a comprehensive comparison between benefits achieved. Consequently, the logistics sustainability index is able to collectively measure one or more impact areas together on the one hand as well as on the other it becomes valuable in cases where a comparison between the current state and a potential scenario is demanded, or in cases where a comparison has to be made between two prospective scenarios.

As given an impact area *i* (for instance, energy consumption, emission of pollutants, etc.), the corresponding LSI_i can be assessed using the following calculation approach (Novelog, 2016, Comi et al., 2020):

Equation 1
$$LSI_i = \sum_m I_m w_m$$

Equation 2
$$LSI = \sum_i LSI_i w_i$$

where;
$\boldsymbol{I_m}$ is the normalized value of indicators,
i is the items,
m with a minus or plus sign, according to its contribution to sustainability (positive if benefit, negative if costs),
Wm is the weight given to the impact area indicator/metric,
m which can be estimated for example using AHP or a Delphi approach.

5.5.3. Logistics Maturity Index

The ***Logistics Maturity Index*** is being used to express the extensive digitalization and network connection of various logistics assets in an autonomous logistics system. The calculation approach is behind the Fraunhofer Industry 4.0 staged process model. This model is made up of five different phases: standard (phase 1), big data (*phase 2*), smart data (*phase 3*), dark factory (*phase 4*), and industrial ecosystem (*phase 5*). At the start, a general business case information is being queried. Subsequently, data is then collected in order to measure the maturity level through multiple-choice questioning.

The successful deployment of the technologies of Industry 4.0 is significantly influential for those organizations that wish to optimize their work processes along with their organizational frameworks. Nevertheless, several organizations experience some challenges while trying to implement a reasonable roadmap to achieve a technology-oriented business as well as a service delivery concerning the Industry 4.0 concept. Thus, this Industry 4.0 context brings even several ambiguities for the logistics and freight transport service suppliers as regards supply chain management and processing. Hence, rather essential technology deployment solutions and operational adjustment are fairly strategic in order to achieve smarter, more efficient and sustainable logistics services. As such, Industry 4.0 deployments ought to be assessed along with researched through a developed maturity model for logistics services and freight transport (Facchini et al., 2019).

Besides, the methodology is specifically constructed for such a logistics maturity level assessment scenario. Therefore, the evaluation process of the logistics maturity index is outlined hereunder:

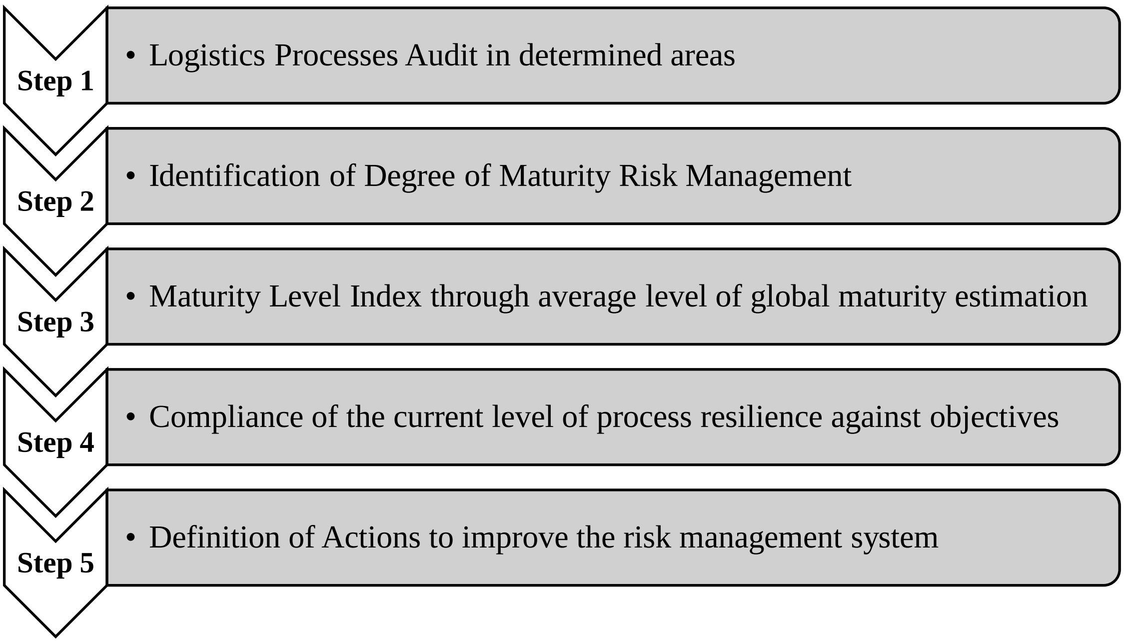


Figure 11: *Logistics Maturity Index evaluation process*

Although, for the clarity and comprehensiveness of the methodology, the approach of Facchini et al. (2019) will be adopted as a reference point. The Logistics Maturity Index (LMI) can be measured through a weighted average of all the maturity items/entries in accordance with the equation as given below:

Equation 3

$$M_D = \frac{\sum_{i=1}^{n} M_{DIi} * g_{DIi}}{\sum_{i=1}^{n} g_{DIi}}$$

where;
M: maturity, D: dimension,
i: item, n: number of maturity items,
g: weighting factor.

5.5.4. Logistics Transferability Index

The ***Logistics Transferability Index*** comprises a multi-step analysis procedure in order to provide a qualitative measure of the propensity of the implementation of automated logistics applications towards being successfully transferred to another urban context under different conditions. The very first step covers a detailed identification and specialization of a receiving city, the second step comprises a benchmarking analysis of eventually comparable contexts, and finally, the third step regards the identification of the automated logistics applications that are likely to be valuable in the receiving city, along with a comprehensive evaluation on the specific criteria determined by that city itself.

Subsequently, the proposed index calculation process is commenced with a preliminary literature review to indicate the existing logistics transferability assessment. Accordingly, the following diagram illustrates the evaluation of the logistics transferability being proposed, which would be an adaptability-based deployment model, along with the following steps of the framework:

1. Site Characterization (city, region, etc.) is referring to an overview of the city to which the relocation of the logistics policies would be affected as regards the population, density, area, socio-economic situations, etc.,
2. An analysis of the urban logistics challenges brings to light such logistics-related problems as traffic loads, lack of parking areas available for loading/unloading, etc.,
3. A logistics stakeholder analysis seeks to pinpoint the operational decision-makers, considering customers, forwarders, receivers, delivery personnel, carriers, managers, etc.,
4. Identifying the similarities and risks/barriers to establish the similarities between the benchmark and deployment areas, as well as indicating potential obstacles or threats to policy transfer,
5. The emphasis is on defining impact areas and performance indicators, such as environment, safety, efficiency, and performance indicators, to measure the effectiveness and monitoring of the policy transferability,
6. Measurements and Sources are used for an evaluation of both the reference site and the deployment site depending on the problem dimensions,
7. Assessments and Evaluation analyses the theoretically transferred policy and its potential outcomes concerning impact areas and performance indicators, and
8. Sources-Destination City Similarity Level Analysis is the last step of the logistics transferability process that works out to compare the transferability index consisting of applicability of one successful logistics policy, from source site to the determined implementation site.

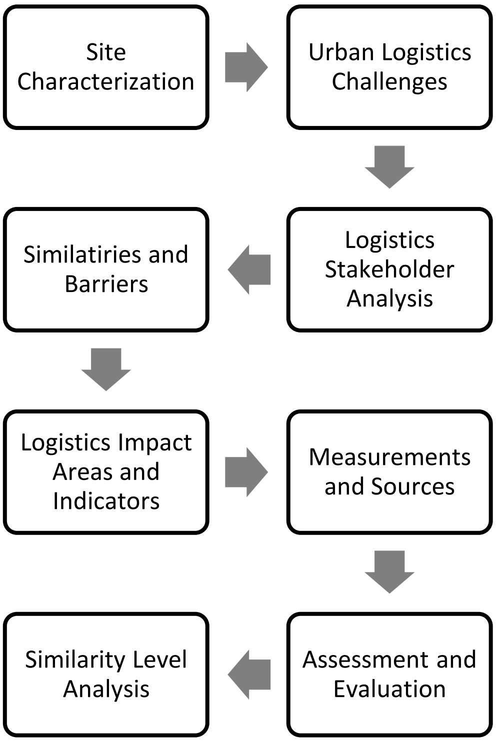


Figure 12: *Logistics Transferability Index evaluation process*

In a similar manner to the Logistics Sustainability Index, the Logistics Transferability Index is going to be a weighted average value by:

Equation 4

$$LTI_m = \sum_i I_i w_i$$

where;
$\boldsymbol{I_i}$ is the normalized value of indicator **I**,
$\boldsymbol{w_i}$ is the weight given to the impact area indicator/metric,
m estimated for example using AHP or a Delphi approach.

5.6. Adaptation Tool for Automated Logistics as a Service

In recent decades, technology and innovation technologies became more favored by subsidizing sustainable and more intelligent urban environments. For more adequate transformation of modifications in the automated logistics services, it is essential to have a sufficient technique to utilize such an automated logistics service to book, track, and control the status of a delivery transfer from one point to another. A tool is need to better implementation of such an automated logistics as a service concept in accordance with the users, customers, and all citizens. Regarding that, an automated logistics mobile app has been presented to enable service users to book a delivery transfer from an origin to destination and track the delivery and vehicle positions by registering to equip users' personal data. Moreover, this app correspondingly authorizes to accumulation of user points to utilize the mobile app functionalities, or it disciplines the users who would not respect the appointment to load or unload the delivery. In the subsequent chapters, the segments of the Automated Logistics Mobile App (ALMA) have been designed and specified.

Based on these objectives, the following functionalities will be provided by an automated logistics web-app/mobile-app to the users in terms of the following areas:

- **Registration:** The act or process of entering information about potential users-customers to sign up to automated logistics mobile-app or website by entering:
    - name-surname,
    - phone number (to reach the users if there would be any difficulty while delivery transfer),
    - address (to send the delivery back if needed),
    - e-mail address (to check the users' reality-reliability), and
    - a password to log in (to protect the users' data and values).

  Automated Logistics website/mobile-app may offer free information, news and other services but require registration to learn more about the user to provide more reliable and trustful service with avoiding any fake-order. The registration will make logging faster, more trustful ordering, and enable to earn credits to utilize the logistics service.

- **Delivery Tracking:** Tracking of the delivery aims to track the product in order to follow and monitor the progress of deliveries in terms of purchase of a material-product, a request for food in a restaurant, etc. This is a type of "package tracking" that has a process of localizing shipped product at different points of the time, during sorting and delivery, to verify provenance and predict delivery. *Delivery Tracking* is able to provide users with information about the route of delivery, the foreseen time, and the date of delivery which will be anticipated according to the vehicle route and chosen timeslot. This is also very crucial to have a reliable and trusted service that will be time-respected, while various environmental circumstances that would cause the delivery to get lost (resilience).

  When the delivery will be loaded on the shuttle, the automated logistics app will allow the customers to take a photo to send by platform. After the arrival to final destination, the final users will also take a photo while having delivery to upload into the platform and certify that the pack has been correctly delivered.
- **Vehicle Tracking:** The vehicle tracking aims to monitor the vehicle's position by tracking that combines the use of automated location of individual vehicles with software which collects the fleet data to have all vehicles locations. Based on this purpose, the modern approach to tracking a vehicle is generally used to be based on the vehicle location data from such a system as GPS, Galileo, etc. This vehicle location can be also visible with a separated sub-function of the app via the Internet and-or developed software.
- **Booking:** This function aims to book the service to pick up or send materials with respect to be chosen timeslot with also having a chosen place/box where to leave the delivery that will be transferred.

6. Case Study

6.1. Methodology

The acceptance assessment case studies are elaborated into the three main implementations categories to highlight the different aspects of such an ALaaS impact assessment framework, in order to evaluate the performance and adaptation. Those case study categories are summarized in below:

- Case Study for Acceptance Assessment
- Case Study for Simulation Case for scenario performance regarding time and distance
- Case Study for real-life implementation

Acceptance Assessment Case Study Methodology

Afterward, the acceptance assessment case study is regarding the previously mentioned accomplishment of the logistics acceptance questionnaire guideline, it is expected to have a test application for an overall acceptance assessment of a potential automation technology concept application on logistics studies and projects.

Before going into detail, a preliminary introduction of key points of the logistics questionnaire guideline has been done; in addition to this, the logistics-related questionnaire has been designed to be tested for reviewing of the questionnaire and improvements based on the feedback and propose several further development suggestions and comments.

The preliminary definition of key points of the logistics questionnaire guideline was elaborated and represented; because of that, an example case of the logistics-related questionnaire has been designed to be tested as processing elaborated in the following: [13]

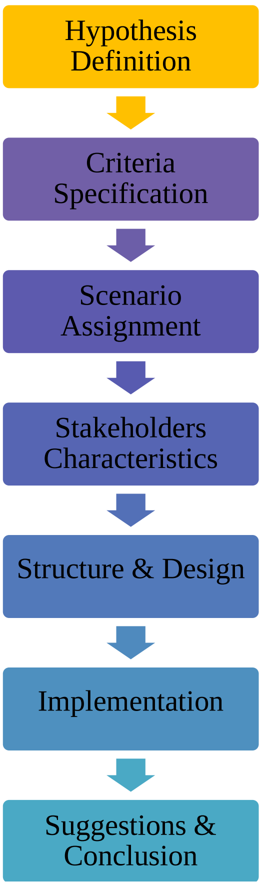


Figure 13: Case Study Methodology

(1) Definition of the hypothesis, overall research purpose and objectives of logistics questionnaire to be worked, data is obtained, results are evaluated and assessed; on the other hand, this step is the first analysis of the questionnaire in terms of targets, processing of collected data, needs and requirements analysis, and reporting procedure,

(2) Criteria specification to determine the usefulness and acceptability of collected data,

(3) Scenario assignment with providing an introduction, technical specifications, and relevance with the hypothesis,

(4) Identification of stakeholders concerning the understanding of their knowledge and experiences in automated logistics services, who would be the applicants, what are the social and economic (expected) features of application area, and dataset size that refers to a number of applicants (needed, required),

(5) Questionnaire structuring and chapters design in terms of questions preparation and placement,

(6) Implementation-Execution of example case questionnaire to identify and understand the chosen stakeholders' opinions in terms of difficulties, clarification needs, and any feedback to improve the guideline,

(7) Reviewing and improving suggestions based on the feedback from the preliminary test application and further development comments, and conclusion.

As a study case hypothesis, this example logistics questionnaire aims to evaluate the potential customer acceptance analysis on automated logistics as a service implementation in an urban area. This example logistics questionnaire analysis which questions (from determining guideline structure) would be more relevant in terms of sub-groups as listed below:

- ➢ Question 1 - Characteristics of Applicants
- ➢ Question 2 - Knowledge Analysis
- ➢ Question 3 - Safety concerns
- ➢ Question 4 - Efficiency performance
- ➢ Question 5 - Overall Acceptance analysis

These questions would be defined to assess the acceptance level of potential automated vehicles considered logistics as a service implementation at the main campus of the Sapienza University of Rome.

For the scenario definition, a scenario defines an automated logistics service around the Main Campus of the Sapienza University of Rome. This scenario considers a logistics service processing with a driverless-automated vehicle to identify efficiency and acceptance analysis with safety concerns. Moreover, the study case would be organized to have 5 stops to provide various pick-up points, and an expected time requirement (in minutes) by using maximum speed from national regulation. The logistics service would be “theoretically” planned to operate by one fully automated vehicle along a fixed route (in kilometers) as a circle that starts and finishes at the same point to provide the second pick-up opportunity to the customer in case of missing the booked loading/unloading operation. Based on this scenario, the logistics questionnaire would be applied by using this study case concerning potential users’ characterization and acceptance due to efficiency and safety concerns.

The objective is to conduct a questionnaire to assess the acceptance of automated logistics service facilities in the urban area of Rome around the main campus of Sapienza University of Rome. The methodology proposed for this study consists of the following steps. Before proceeding with the acceptance analysis, the target groups need to be determined. The needs of potential customers for the transfer of goods and their willingness to use such a logistics service must be identified through user needs analysis.

Hence, after conducting user needs analysis and determining the target user group, a scenario of automated logistics services is designed. On this basis, an acceptance questionnaire is developed and implemented. Then, the responses to the acceptance questionnaire are statistically analyzed in terms of correlation and regression to highlight which parameters are most valuable for an automated logistics service to have greater integration into society. Statistical analysis is to be carried out (using IBM SPSS and MS Excel) respecting that acceptance is the dependent variable; and characteristics, scenario specifications and general opinions (at the city level) are the independent variables. Correlation analysis is used to highlight associations between the level of acceptance and quantitative variables. In addition, it is an approach to measure how acceptance and the chosen variables are related (Azarko and Capkin, 2022).

On that basis, the case study was designed to provide a potential implementation of automated vehicles within the concept of Logistics as a Service in an urban area such as the main campus of Sapienza University of Rome (Italy). The cited case study can support the application of a guideline on automated logistics acceptance questionnaire in terms of usefulness and effectiveness. The case study was defined as an example of evaluation of the concept of automated logistics. In addition, a possible implementation of this concept was tested to evaluate its acceptance through a questionnaire developed using the defined guideline (Azarko and Capkin, 2022). In addition, this paper aims to highlight how to proceed with a questionnaire to evaluate the acceptance of an automated logistics service. The questionnaire is considered an evaluation tool or method to provide results for the execution of a case study in Rome. This tool considers how the performance of the automated logistics concept as a service would be evaluated by meeting relevant acceptance criteria, such as user perception, safety, and efficiency.

The objective is to address the lack of an automated logistic acceptance analysis tool as a service by building a case study and then offering comments and recommendations for further research studies (Azarko and Capkin, 2022). The assumptions of the study are summarized below:

- Logistics acceptance is directly related to users/customers' acceptance of service preferences.
- Automated Logistics concept covers automated vehicles for freight transport, IT-based tracking, processing with data digitalization.
- Preparation of an acceptance assessment questionnaire is assumed as general-aimed questionnaire concerning only logistics fields.

In the basis of the findings of the automated logistics acceptance questionnaire being applied to the Sapienza University case study, the behaviors of the applicants (university students, academic staff, and private sector stakeholders) were analyzed. The case study scenario was implemented to assess safety, efficiency and overall acceptability in order to develop a strategy to characterize the automated logistics scenario and its expected results in further projects.

Simulation Case Study Methodology

The logistics simulation scenario is assumed as located in Rome. In this scenario, the conventional (for the baseline scenario) and electric logistics vehicles (which might be even automated and electrified vehicle option to simulate for comparison with/without automation) operates on a fixed route comprising two determined cases, as summarized below:

(1) between two hubs (from main storage-hub to secondary-hubs) in the Rome metropolitan area, and
(2) from secondary hubs, where located in optimized positions with respect to distribution routes, to final customers.

The objective is to create simulation scenarios that form a virtual twin site for similar real-world demonstration sites within the SHOW project. This logistics simulation plan is intended to be a transferable implementation of the Rome pilot simulation to a pilot site within the SHOW project. This serves to have similar Italian logistics data that will ideally be useful for the objectives of the SHOW project's logistics matters.

The logistics simulation scenario examines the effects of transfer points and automated vehicles on traffic congestion, routing, distance travelled and time before the real-world scenarios take place during the SHOW demonstrations. Driving behaviors will be analyzed and the various stakeholders will be integrated into the simulation tool as in the SHOW pilot sites. Different parameters and logistical variants within the simulation scenarios will be used and tested involving speed, automated vehicle option, and transfer points.

The logistics simulation plan is designed to evaluate the effects of logistics services in terms of environmental impact and efficiency. To this end, the collection of the necessary data for the logistics simulation is also carried out to fulfil the requirements of the SHOW; therefore, this logistics simulation plan is based on the "Rome Logistics Case Study". On this basis, the data required for the simulation is collected from the case study of "Santa Palomba, Rome (Smart Packaging project, 2019)" within the framework of the objectives of SHOW and the defined simulation scenario. The characteristics of this collected study site are slightly similar to the pilot logistics sites of the SHOW program in terms of study area and characteristics of logistics services.

Based on this information, the logistics simulation scenario, with respect to the mentioned case study (Smart Packaging, 2019), was defined in terms of objectives, data availability and scenario characteristics, as summarized in further subsections. In this logistic simulation scenario, the route, the road network and the predefined areas of influence are modelled and validated within the objectives of the SHOW project. Furthermore, the virtual representation of the real-world road network for the simulation can have several geographical errors that will be detected and corrected during the bilateral connections with the Italian site and the SHOW pilot sites as satellite sites. Subsequently, the logistical simulation will examine energy consumption, travel times, delays, interchanges, effects on other road users and driving behaviors.

The purpose of the data collected is to deepen some analysis on the distribution of e-commerce materials in the province and/or city of Rome. It is therefore to provide a service to intermediate distribution centers from the permanent distribution hub. To this end, the main distribution hub (Santa Palomba - Pomezia) transfers products to the intermediate distribution hubs that will deliver the materials to the final customers. On this basis, the secondary hubs, which will be transit points, will be located as different intermediate hubs in the territory of the Municipality of Rome (or the Province of Rome). These transit points will deliver products/materials to final customers according to the on-time delivery approach.

As above mentioned, the defined logistics scenarios are intended as illustrations of potential logistics flows among the application sites. The scenario development is based on two logistics service types as area-based and stop-based. The scenarios are summarized by the following definitions as summarized below:

- **Without Scenario** aims to provide an approach for the demo sites that would like to have a material flow as *Hub-to-Hub* that targets to transfer materials from one hub to another (vice-versa) by preliminarily collecting the individual deliveries from several appointments' points to the origin hub to send to the destination hub for the receiving by the final receivers.
- **With Scenario** aims to provide an approach for the demo sites that would like to have material flow as *Point-to-Point* that transfers the deliveries from origin to destination by using various appointment points (stops) for loading/unloading operations

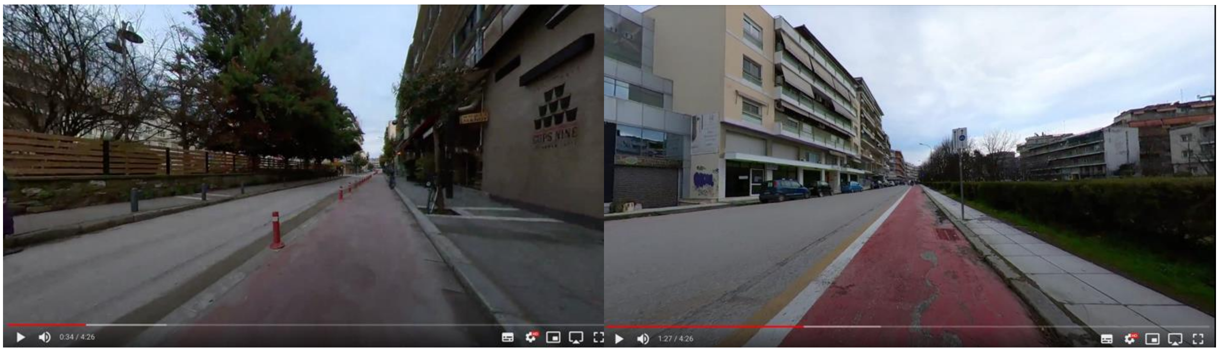
Real-Life Case Study Methodology

The real-life case study is implemented in the reference project, namely SHOW project. The real-life implementation site is in Trikala (in Greece), which covers a projected automated logistics service, with no human intervention needed on board.

A logistics service has been designed and provided among the City Council building, the projected pick-up points and the delivery points that are the couriers together with various kiosks located in the pedestrian area of the Trikala City.

A fleet of delivery-droids (no-human intervention needed) deliver packages/envelopes between the City Council building and the couriers and other goods from vendors between the City Council parking lot and the three kiosks. Services have been carried out once or twice a day, depending on demand.

The droids were moving on a nearly flat bike path. The width of the bike lane is generally 1.50 m, with some narrower parts where it is 1.20 m. The bike lane is on the roadway and runs parallel to the pedestrian lane. The bike lane is partly physically separated by posts from the vehicular lane and partly separated only by painted stripes on the roadway.



Following that, the delivery service route is designed and projected as a circular route (within approximately 1,11 km long) that connects the delivery points, and the pick-up point has been selected and it is shown in the following figure:

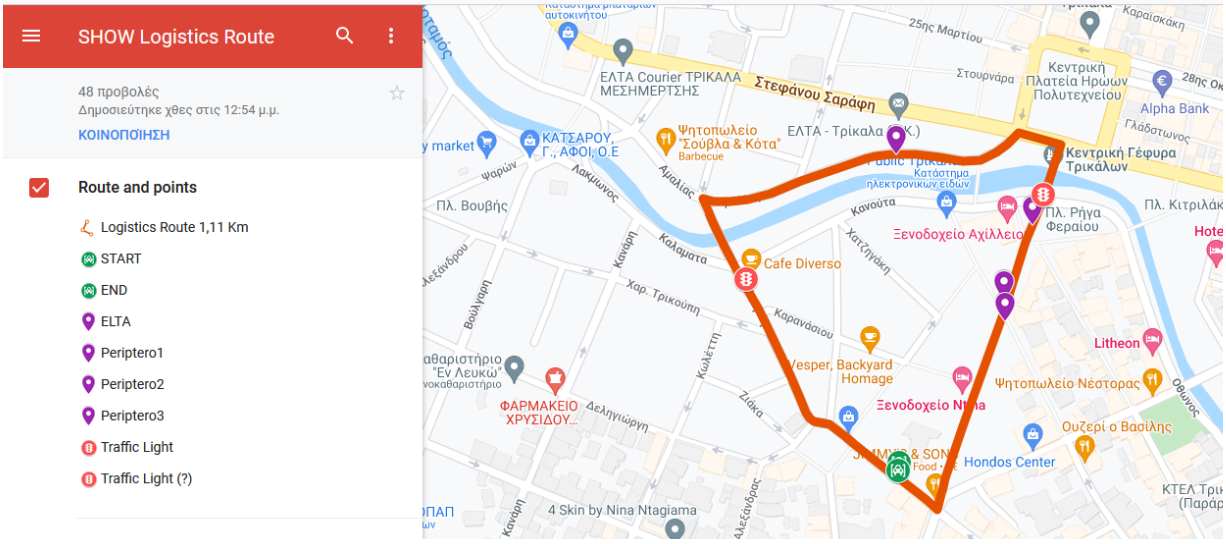
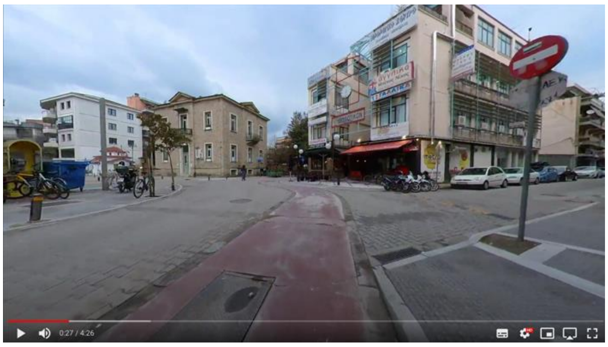


Figure 14: Real-life deployment area in Trikala (under the project SHOW)

Along the circular route, the logistics delivery-robots have to cross several road intersections, and some of which are controlled by traffic lights, as represented in the figure below:



After the real-life deployment operations, the developed ALaaS impact assessment framework has various components to monitor the performance of such an implementation, as they are illustrated as the following:

- Impact areas definition
- Stakeholders' identification
- Objective's analysis
- Performance indicators prioritization
- Demo Sites (pilot cities) for data collection
- Indexes for the logistics related evaluation
- Assessment and Final Product

6.2. Implementation

The case studies in this research project are designed to be implemented in three different stages: the acceptance assessment case study, the simulation case study, and the real-life implementation case study (with respect to the reference project" SHOW").

Acceptance Assessment Case Study Implementation

After that, an acceptance analysis has been conducted with respect to the defined automated logistics as a service concept scenario, and designed acceptance questionnaire guideline. Based on the reference project (Azarko and Capkin, TraVision2022), the case study is developed and a recommendation for an acceptance evaluation scenario is provided for further studies. During the Final Project of TraVision2022 Young Researcher Competition namely *Surveys of the future's transport concept: a guideline for the questionnaires on the Automated Logistics as a Service concept uptake from a test in Rome* by "RomAnKa Group" (Azarko and Capkin, 2022), a guideline for preparation of the questionnaire on logistics automation acceptance was produced. Based on that, this paper aims to test a case study for an acceptance assessment of automated logistics scenario.

A Case Study Scenario was designed to be located at the main campus of the Sapienza University of Rome to offer an automated logistics service - a driverless automated vehicle (robot rider) - that drives around the faculty buildings providing flows of goods (such as papers, documents and other bureaucratic files, delivery of food, cleaning materials and personal belongings). A logistics vehicle (fully automated) operates along a route with predefined stops (with possible changes) to provide the customer with a series of pick-up/delivery services. This logistics service provides the expected delivery time and constantly displays the position of the robot driver.

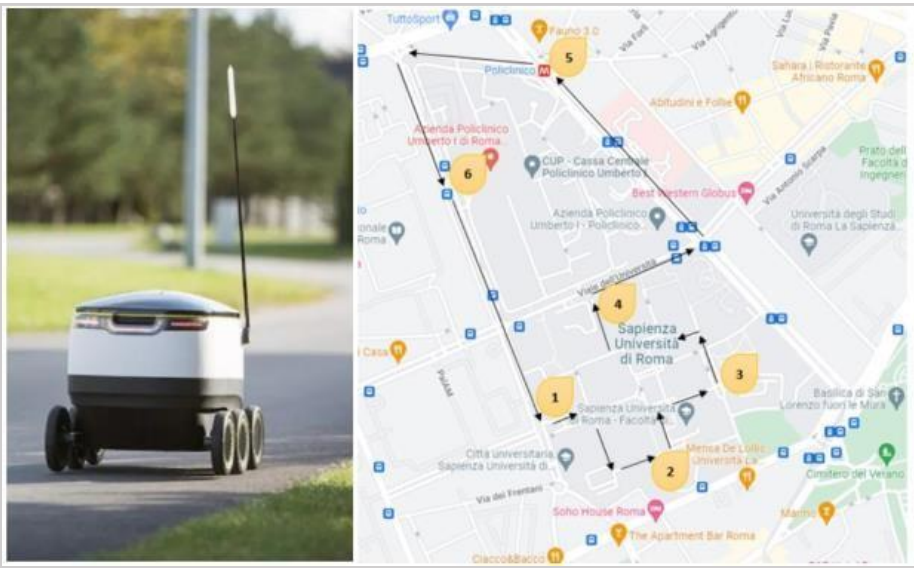


Figure 15: *Example of a robot-rider and its route in Sapienza Main Campus*

A questionnaire hypothesis was developed, according to which a fully automated logistics service would be evaluated in terms of its level of acceptance, considering the prospects of safety and efficiency. On this basis, and according to the guidelines established by the aforementioned project (Azarko and Capkin, 2022), the logistics questionnaire was created and distributed to the target users to collect their characteristics, opinions and concerns about such a service.

Prior to the acceptance questionnaire, a user needs analysis was performed to determine the target user groups and assess whether their needs could be met using the automated logistics service. We defined the potential user clusters to be academic staff, students, technical and administrative staff of the university, and non-academic staff, such as bank employees, staff of the Italian Post Office, the transport sector, etc. The results of the pre-assessment of user needs and requirements are highlighted in the further chapters.

After this part, referring to the guideline for logistics questionnaires (Azarko and Capkin, 2022), a case study acceptance assessment questionnaire was created and disseminated online. The questionnaire was prepared in two languages (English and Italian) to reach a larger number of potential users and collect their characteristics. The following table summarizes the questions of the implemented automated logistics questionnaire.

Question groups	**Questions**
Participants characteristics	1. Age group clusters (sub-groups for 18-28; 29-39; 40-49; 50-64; 65-over) 2. Profession of applicants (Student, Operator, Industry, Academy, Private Sector, Public Sector) 3. Frequency of attendance of activities at university (one time in week, two times in a month, or more) 4. Previous experience with automation technology in terms of logistics (yes or no) 5. Preference for new technology use in logistics service over traditional transportation (by 1-5 scale)
Case Study: Scenario acceptance	1. Easy-to-Use and automated technology in logistics (1-5 scale) 2. Usefulness (1-5 scale) 3. Effectiveness and Efficiency (1-5 scale) 4. Safer than traditional logistics methods (1-5 scale) 5. Automated Logistics Service will improve the environment (1-5 scale) 6. Automated Logistics Service will be favored by students and university staff (1-5 scale) 7. Preference for the new automated logistics service use (1-10 scale)
Safety concerns	1. Trust on safety effectiveness (1-5 scale) 2. Feeling safe to send materials (1-5 scale) 3. Feeling more secure instead of traditional services (1-5 scale)
Efficiency perspective	1. Easier tracking of deliveries (1-5 scale) 2. Processing Time-saving due to automated service availability (1-5 scale) 3. Saving time so you do not spend it for delivery/ transfer (1-5 scale)
Overall automated logistics service acceptance	1. Economical acceptance perspectives of the automated logistics service (pay-for-service) 2. Determination of the types of bonuses that would encourage and stimulate the customers to choose service instead of traditional services 3. Opinion analysis about the defined automated logistics service would be well-accepted in society if that service is available within the whole city 4. Customers' perspectives about the use of such an automated logistics service in the city frequently 5. Analysis of customers' opinions about any problems or conflicts between traditional transportation and automated one (potentially more accidents, more delays, etc.)

Table 2: *Automated logistics service acceptance questionnaire.*

In the first step, the survey aims to capture the relevant characteristics of the participants (age, profession, frequency of attendance in the study area), as well as their previous experience with automated logistics and preference for using the new automated technology over traditional transport. Secondly, focusing on the case study scenario, the survey asks participants to reflect on their opinions of the proposed service (ease of use, usefulness, safety issues, efficiency and effectiveness), concluding with their overall acceptance of the service and their perspectives on the use of this automated logistics service on a city scale.

Based on the questions identified, the questionnaire was implemented online by sending e-mails to potential users of the identified target groups: students, academic staff and technical-administrative staff.

Simulation Case Study Implementation

The simulation implementation has been done on TransCAD software to analyze the time and distance performance of the developed logistics operation scenarios, along with having distribution data from a case study in Rome Capital Area. Following that, the scenario is defined on the basis of distribution zones; in particular, deliveries that are being currently made directly to the final customer (main hub to secondary hub, secondary hub to end customer). For the simulation, the logistics scenario is that the main distribution zone delivers to the secondary hubs (in an area close to the end customer); then there will be another service (with smaller vehicles, perhaps simulating electric or environmentally friendly vehicles) that departs from these secondary hubs and operates in the relevant area to deliver to the end customer.

As already mentioned, the automated logistics service scenario involves two phases. The first part of the scenario is the delivery from the main-hub to the secondary-hub (also called transit or transfer points) to serve certain areas according to the delivery shipping postcodes. Subsequently, the second phase will consist of time-responsive deliveries related to customer requests to transfer materials, which will be delivered, from the transit points to the final customers. In summary, the simulation scenario envisages two approaches: the first works on deliveries to the transfer points; the second transfers shipments from the transfer points to the final customers. Apparently, the conception is about timing (when the customer places the request-order, how the company-organization handles the delivery) and the simulation predicts these process times.

Figure 16: *Simulation road network for logistics case study*

Scenario data relating to these shipping situations and data on where deliveries are made will be taken into account. Shipments to final customers may be even delivered on a different day. Perhaps, if it is organized with transit points, this means that deliveries will be transferred a few days earlier than the requested day from the main hub to these transit points. After that, the shipment will be ready to be delivered to final customers in the preferred day.

For the simulation scenarios; the positioning of the transit points (e.g., they would be positioned east-west-north-south of Rome) is based on simulation projections that also depend on numerous parameters. A centroid, respecting an area to be served, would very reasonably be positioned in the center of the communication network between the commercial-business area and the distribution hubs.

From the central hub (main-hub) in Pomezia to the transit points, the simulation scenario also analyses the service variables with respect to the delivery flow to final customers - which means - from main-hub to transit points (to locate these points efficiently) and then from there to final customers with respect to the booked delivery time. The routing optimization works on these transit points positioned as the first routing from the main hub to them; subsequently, the routing will consider the optimization of the final deliveries with respect to the time from the transit points to the final customers. The logistics simulation can even include a hub-to-hub case and a hub-to-customer case related to previously defined cases.

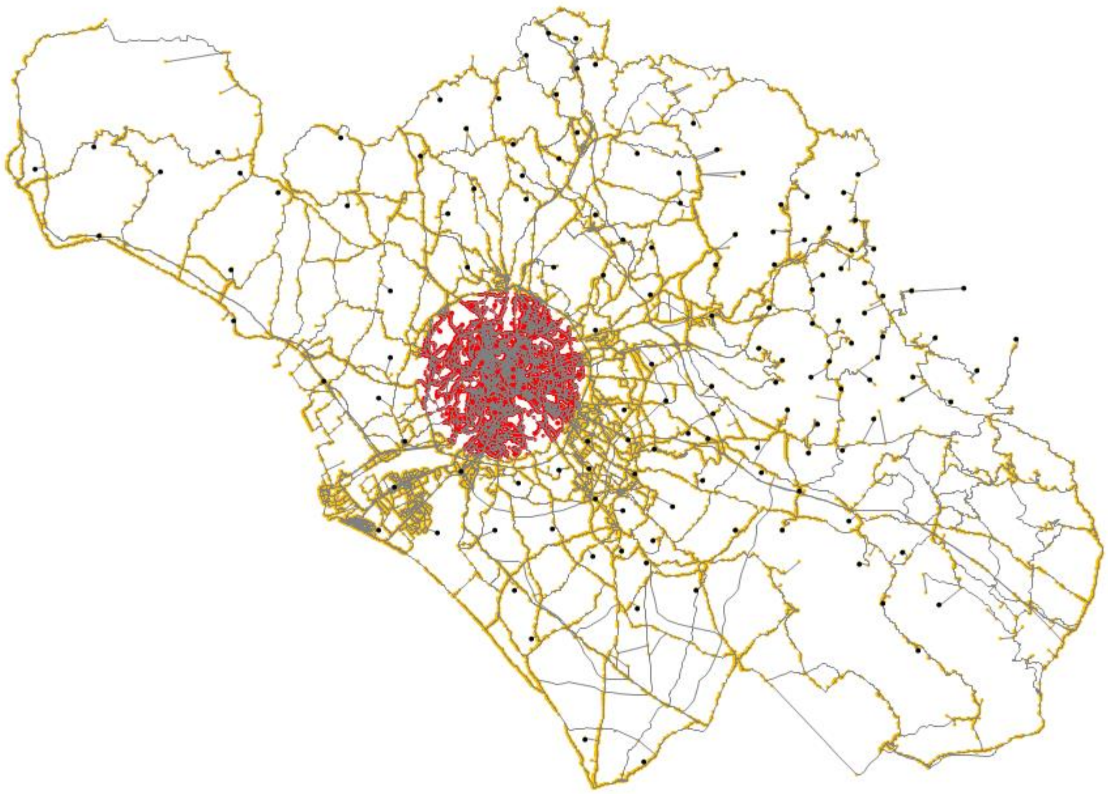


Figure 17: *simulation road network, and designed logistics intermediate nodes*

For the pre-demo data used; the data are available for approximately 34788 different products, with product delivery codes, transferred during the observed time period between 2 March 2017 and 5 December 2018. However, the deliveries (in total) are about 1.380 million for the orders that were placed; obviously, this is a study that was done throughout Italy. It is therefore necessary to filter only those recipients that are in the province (or city) of Rome.

For this objective, a clustering of the postcodes of the city/province of Rome is necessary; therefore, the postcodes of the province of Rome distinguish 138 sets of clusters. For concentration, the analysis must work on the city of Rome (or the province of Rome) for further clustering based on postcodes.

With the Rome postcodes, one should emphasize those areas to designate essentially a secondary distribution pole. Furthermore, each postcode can have an intermediate distribution hub; otherwise, there would be many secondary hubs that would not make sense for the distribution of materials to final customers on time. Consequently, more in-depth grouping according to certain postcodes is required; for example, grouping by a dozen postcodes or postcode meaning zones (one secondary hub per municipality, from the main one to this secondary one, then to the end customer via distribution hubs).

Real-life Case Study Implementation

The real-life implementation has been done in the SHOW project deployments, in particularly under the pilot site implementation in Trikala City. The aim is to have an introduction of new kind of service with droids (supply kiosks on the pedestrian zone with goods in order to avoid entering the pedestrian zone big vehicles such as mini vans), having an overview of the technical Implementations, enhancement of vehicles and infrastructure if needed, and technical assessment in pre-demo activities and demo activities.

# wheels	2
Weight	50 [kg]
Max load	10 [kg]
Max speed	Up to 3.6 [km/h] indoor Up to 6 [km/h] on sidewalk
Dimensions	70 L - 70 W - 90 H [cm]
Load compartment	45 L - 38 W - 37 H [cm]
# cameras	3 HD cameras + 1 stereocamera
LiDAR type	360 ~ 3D
Powertrain	2 electric motors 250 W.
Batteries	Li-Ion
Battery Duration	8h
Charging Duration	4h
Batteries temp. range	– 20 °C ~ +55 °C
Human Robot interface	Lights; turn signals; acoustic signals
Slope	12% of inclination
Connectivity	WiFi; 4G (mobile router and SIM will be provided by the customer); 5G (if available)
Rotation on place	Yes
IoT compliancy	Yes

As mentioned, this automated logistics vehicle consists of 3 main elements:

- AUTONOMOUS NAVIGATION: autonomously moving from A to B
- ENERGY EFFICIENCY: optimized to reduce energy consumption
- HIGH MANEUVERABILITY: zero turning radius thanks to two-wheels architecture. Two-wheels and symmetry make Yape maneuverable, agile and let the droid reverse its driving sense. Thanks to its self-stabilized technology, Yape take care about packages both on slope or over rough terrain!

For the docking station, there are various advantages as listed below:

- AUTOMATIC PARKING: High precision navigation approach for automatic parking
- ENERGY EFFICIENCY: High efficient energy flow with magnetic droid–dock connection
- SMOOTH CONNECTION: Spring mounted magnetic interface
- FAST CHARGING: Base with integrated fast charger

After that, the control room is needed to arrange the operations. It is a software package that allows the droid to be monitored and, if necessary, allows the operator to take control and manage critical operations.

For the data collection, direct and indirect benefits have been identified. Till now, the quantities considered are inhomogeneous with regard to units of measurement and non-directional (some are utilities, others disutilities). The measuring instruments have not yet been specified.

7. Results and Standardization

This section of the research study is intended to address the identification of key performance indicators regarding the concept of automated logistics as a service, along with calculation methods and prioritization, the design of a smart adaptation and integration tool, along with the evaluation of acceptance (user acceptance and social inclusion, with perceived safety and efficiency), logistics simulation case study, and real-life deployment (with respect to the reference project, SHOW) achievements analysis. In the end, the developed impact assessment framework for automated logistics as a service concept will be overviewed to address a standardization analysis of such a development.

7.1. Results of the Case Studies and Smart Solution Design

This chapter intends to analyse the outcomes of the acceptance evaluation theoretical case study and the logistics simulation to highlight acceptance, time and travelled-distance aspects, on the one hand, and the implementation case of an automated logistics operation in real-life to understand the situation in terms of time, distance, the number of deliveries, etc., on the other hand. Beyond that, performance indicators for automated logistics as a service were identified, together with calculation methods and prioritization. In addition to that, a smart solution was designed to enhance the adaptation and integration of such automated logistics-as-a-service concepts in real-life applications. In short, this section concentrates on: the definition of performance indicators, calculation methods, and prioritization; the design of a smart solution for adaptation and integration; and the analysis of findings corresponding to a case study of the acceptance of automated logistics as a service, a simulation scenario, and real-life implementation.

7.1.1. KPIs Definition, Calculation Methods, and Prioritizations

The impact assessment framework for automated logistics as a service shall proceed through an overview of the performance indicators, their calculation methods, and a sort of prioritization implementation to highlight the significance and organization of those assessments. The performance indicators and prioritization are essential for the successful impact assessment framework implementation for Automated Logistics as a Service (ALaaS). A number of reasons for that are as shown below:

- Performance Measurement: The performance indicators assist decision-makers to measure the impacts of ALaaS. Through the tracking of key performance indicators (KPIs), such as delivery times, order accuracy, and cost savings, decision-makers can measure the impacts of automation on logistics operations. Such information could be used to identify further improvement areas and adaptation strategies to get appropriate deployment.
- Prioritising Focus: The performance indicators could also assist decision-makers to prioritise focus areas in ALaaS. Through analysing KPIs, decision-makers can identify those issues in which automation could have the highest impact as well as assign resources correspondingly. Thus, it is guaranteed that the organization's investments in ALaaS give the most significant returns on provided investment.
- On-going Improvements: Prioritisation is fundamental to the continuous improvements of ALaaS. Having prioritized focus areas for improvement, decision-makers could thus elaborate approaches to address process bottlenecks and streamline procedures. Doing so can guarantee that ALaaS keeps improving over a period of time, thereby bringing ongoing advantages to the logistics stakeholders.
- Defining Objectives: Determining targets and objectives is essential for a successful implementation of impact assessment for ALaaS. Through setting performance indicators, decision makers can establish explicit objectives and targets for ALaaS impact assessment implementation. Doing so can further ensure that the decision-makers is moving in the right direction and that progress towards achieving the intended outcomes is being pursued.
- Communication and Collaboration: The performance indicators and prioritization could contribute to facilitating communication and collaboration among the various stakeholders involved in

implementing ALaaS. Setting shared objectives and targets could help decision-makers to ensure that framework and such a service are working towards the achievement of the targeted outcomes for all. By doing so, this can make collaboration simpler than ever and guarantee that all work together to achieve the optimum results.

To summarize, those performance indicators and prioritization are essential to measure performance, prioritize, continuously optimize, establish objectives, and facilitate effective communication and collaboration. By using such measures effectively, decision-makers can successfully implement ALaaS and measure impacts of it to achieve intended outcomes, such as increased efficiency, cost savings, and improved stakeholder satisfaction.

In this regard, the following tables outline the defined and pre-prioritized, along with various stakeholders' interviews, key performance indicators together with the corresponding definitions, relevant logistics evaluation indexes, and associated calculation methods, as represented below.

Index	Performance Indicator	Definition	Calculation Methods
LSI	Punctuality of deliveries	Proportion of deliveries and pickups executed in their scheduled time slot.	***Direct Observation*** [(Number of items delivered on time) / (Total number of deliveries)] * 100
LSI	Precision of deliveries	Precision of deliveries & pickups: the proportion of packages that arrived at their destination without being lost, stolen, or damaged.	***Direct Observation*** [(Number of deliveries arrived to destinations) / (Number or deliveries planned)] * 100
LSI	Customer satisfaction	The perceived customer satisfaction stated by customers based on their experience with the AV delivery or pick-up service.	***Survey and/or Questionnaire***
LSI	Unit cost of delivery	Cost of delivery/pick-up service (per km, per shipment, per vehicle)	***Direct Observation*** [(Number of shipments) / (total cost of the service)] [((number of shipments)*km) / (total cost of the service)]
LSI	Load factor patterns	Load factor patterns (e.g., load factor proportion per AV stop/pick-up delivery) during the operation hours of the AV.	***Direct Observation or Simulation*** [(Number of deliveries arrived to stop) / (Total number of deliveries arrived at destinations)] *Load factor proportion per AV stop/pick-up delivery for each stop*
LSI	Public acceptance	Public acceptance towards the use of an AV for urban deliveries compared to a non-AV service.	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LSI	Willingness to pay for AV urban deliveries/logistics	The willingness to pay for AV urban delivery/logistics service	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them) *A comparison with the actual cost of shipping (e.g., would you pay more, the same or less than shipping without WTP?)*

LSI	Number of accidents on site	The number and type of accidents that occurred	***Direct Observation*** [(Number of accidents occurred) / (Total number of runs)] * 100 [(Number of accidents occurred at each run) / (Total kilometer of each run)] * 100 [(Number of hard-braking occurred at each run) / (Total number of runs)] * 100
LSI	Accidents in AV	Number of damaged parcels resulting from an accident in the AV	***Direct Observation or Simulation*** [(number of parcels damaged) / (number of parcels not damaged resulting from the accident)]*100
LSI	Incidents of crime / theft	Number of incidents involving crime / theft. The number of violation on the shuttle's cargo transport area before/during/after the transfer	***Direct Observation or Simulation*** [(cargo transport incidents) / (total number of cargos transported)]*100
LSI	Number of incidents involving vandalism	Number of incidents involving vandalism in the AV	***Direct Observation or Simulation*** [(number of incidents involving vandalism) / (total number of incidents)] [(total number of incidents involving vandalism) / (total number of cargo transport operations)]
LSI	Loss and damage parcels	Number of loss or damaged parcels (therefore not because of a crime)	***Direct Observation or Simulation*** [(number of packages lost/damaged) / (total number packages)]*100
LMI – LTI	Fair and equal access to AV	User feeling of Fair and Equal access to AV	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LMI – LTI	Ratio of average load	Ratio of average load to total vehicle freight capacity	***Direct Observation*** [(number of packages loaded) / (total number of availability of packages to be loaded)]*100 [(volume of packages loaded) / (total volume of availability of logistics packages)]*100
LMI – LTI	Number of cargo transported	Number of cargo transported throughout the project per automated vehicle/service type	***Direct Observation*** [(number of cargo transported) / (total number of cargo vehicles operated)] [(number of logistics orders generated) / (number of cargo delivered to final customer)]

Table 3: *Preliminary prioritized first-level logistics performance indicators*

In the aforementioned table, the key performance indicators were preliminarily prioritized on the basis of the stakeholder interviews and workshops with the various logistics actors, in order to determine which of those logistics performance indicators could be more decisive for such deployment's performance analysis.

Afterwards, an additional number of key performance indicators have been enlisted, with respect to the preliminary prioritization analysis carried out with the logistics stakeholders as an interview approach, as shown in the table below:

Index	Performance Indicator	Definition	Calculation Methods
LTI	City population share	Urban population by city size is determined by population density and commuting patterns; this better reflects economic function of cities.	***Survey***
LMI	Empty running	Empty runs are trips by a transport vehicle without any freight loaded, i.e., all trips of a truck without freight are empty runs.	***Direct Observation or Simulation*** [(Number of freight vehicles with load) / (Total number of freight vehicles operations)] *100
LSI	Journey length	The time taken to make a journey	***Direct Observation*** Total vehicle*km taken to cover the distance
LSI	Journey speed	The effective speed of the vehicle on a journey between two points	***Direct Observation*** Total kms / time taken to cover the distance
LMI	Loading/Unloading activities	Loading and unloading means the process of getting goods and equipment in and out of stallholders' vehicles and setting up or taking down stall or pitch.	***Direct Observation*** Time spent for loading and unloading packages into the AV [(number of deliveries) / (total time spent for loading/unloading)]
LSI	Number of deliveries	Number of deliveries that are reserved to be delivered to final customer by freight vehicle (including quantity of goods delivered/collected)	***Direct Observation*** [(number of logistics booking generated) / (number of materials transferred)]
LMI	Time of delivery (pick-up)	The amount of time that it takes for goods that have been bought to arrive at the place where they are wanted	***Direct Observation*** Time spent from logistics order generated to delivery arrived to final customer [(number of deliveries) / (time spent for Loading and Unloading operations)] [(number of deliveries) / (total time spent from logistics order to arrival of delivery)]
LTI	Vehicle size/type	Capacity of vehicle to load/carry deliveries (volume, number of places, etc.)	***Direct Observation*** [(Logistics volume of vehicle) / (Total volume of vehicle)] *100 Number of available logistics loading slots

Table 4: *Preliminary prioritized second-level logistics performance indicators*

Eventually, the further preliminary key performance indicators for automated logistics as a service have been shortlisted in the following table, in which it could be further instrumental to have an assessment on how such a service adaptation and implementation would perform in real-life integrations.

Index	Performance Indicator	Definition	Calculation Methods
LSI	Customer satisfaction	Customer satisfaction is defined as a measurement that determines how satisfied/pleased customers are with an automated logistics service	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LSI	Final user-customer acceptance	The acceptance by the users/customer that an automated logistics service was delivered as specified	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LSI	Managerial and Operational costs	Operating and Managerial costs include both costs an automated logistics service and other operating-managing expenses	***Direct Observation*** [Total managerial cost] [Total operational cost] [Other costs]
LSI	Public acceptance	Acceptance of an automated logistics service is the act of using it or agreeing to have it by public (citizens)	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LSI	Punctuality	Proportion of deliveries and pickups made in the right time slot.	***Direct Observation*** [(Number of items delivered on time) / (Total number of deliveries)] * 100
LSI	Quantity	Proportion of deliveries and pickups made in right quantity (no loss/theft)	***Direct Observation*** [(Number of items picked-up or dropped-off on time) / (Total number of deliveries)] * 100
LSI	Stakeholder acceptance	A stakeholder is defined as an individual or group that has an interest in any decision or activity of an organization.	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LSI	User acceptance	Acceptance of an automated logistics service to use or have it by users/customers	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LSI	Vehicle data	vehicle-kilometers, average load factor, utilization factor	***Direct Observation*** Vehicle*KMs for each logistics run The occupied volume of vehicles for logistics at each logistics stop The occupied volume of logistics space utilized for each running
LMI	Experience	Customer experience is how the users/customers or potential users receive and interact with an automated logistics service	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)

LMI	Information flow problems	Information flow policies define the way information moves throughout a system. In an automated logistics service, it is an availability of tracking, booking to choose time of arrival, etc.	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LMI	Lack of a system to monitor the efficiency and effectiveness	Monitoring systems are responsible for controlling the technology used (hardware, networks and communications, operating systems or applications, among others) to analyze operations and performance	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LMI	Lack of involvement of stakeholders	Stakeholder involvement means sharing a common understanding and involvement in the project's decision-making process.	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LMI	Lack of knowledge about stakeholders' requirements	An automated logistics service should fulfill to satisfy the stakeholder needs and requirements, and non-functional requirements (evaluated by a questionnaire)	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LMI	Lack of knowledge about the operation of logistics process	A process that combines automated logistics service elements to form complete or partial system configurations to create a service specified in the stakeholders' requirements.	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LTI	Access availabilities (time-windows, load-factor)	Availability of access to a logistics service to send-receive materials with time-respected final deliveries	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LTI	Changes in legislation (national or EU level)	Availability of a regulation or decree for automated logistics service. The modification analysis if it is available	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LTI	Loading/Unloading areas and parking	Number of parking slots for loading/unloading operations in study area	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LTI	Lockers (availability in vehicle or external places)	Number of delivery lockers for loading/unloading operations in study area	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)
LTI	Transferring rate	Transfer rate is a standard metric that is used to measure the speed at which data or information travels from one location to another.	***Survey and/or Questionnaire*** Survey based on a 5-scale rating (very low to very high and analyzing them)

Table 5: *Preliminary prioritized third-level logistics performance indicators*

In summary, the above-mentioned tables are representing the preliminarily prioritized logistics performance indicators in which would be further elaborated.

In parallel, the calculation methods also determined to evaluate the corresponding above-mentioned logistics performance indicators for any use of defined impact assessment framework evaluations. In this study, some of the chosen indicators are calculated to test the methodology (*according to the further weighted indicators, with logistics stakeholder, under the reference project workshop*).

Furthermore, the preliminarily defined logistics key performance indicators have been further elaborated in a workshop which is done in the reference project meeting (*SHOW project, Partner Board #5 meeting, on 09/12/2022 in Thessaloniki*). The findings are illustrated in the following graphs, in which are representing the weight of the indexes and impact areas.

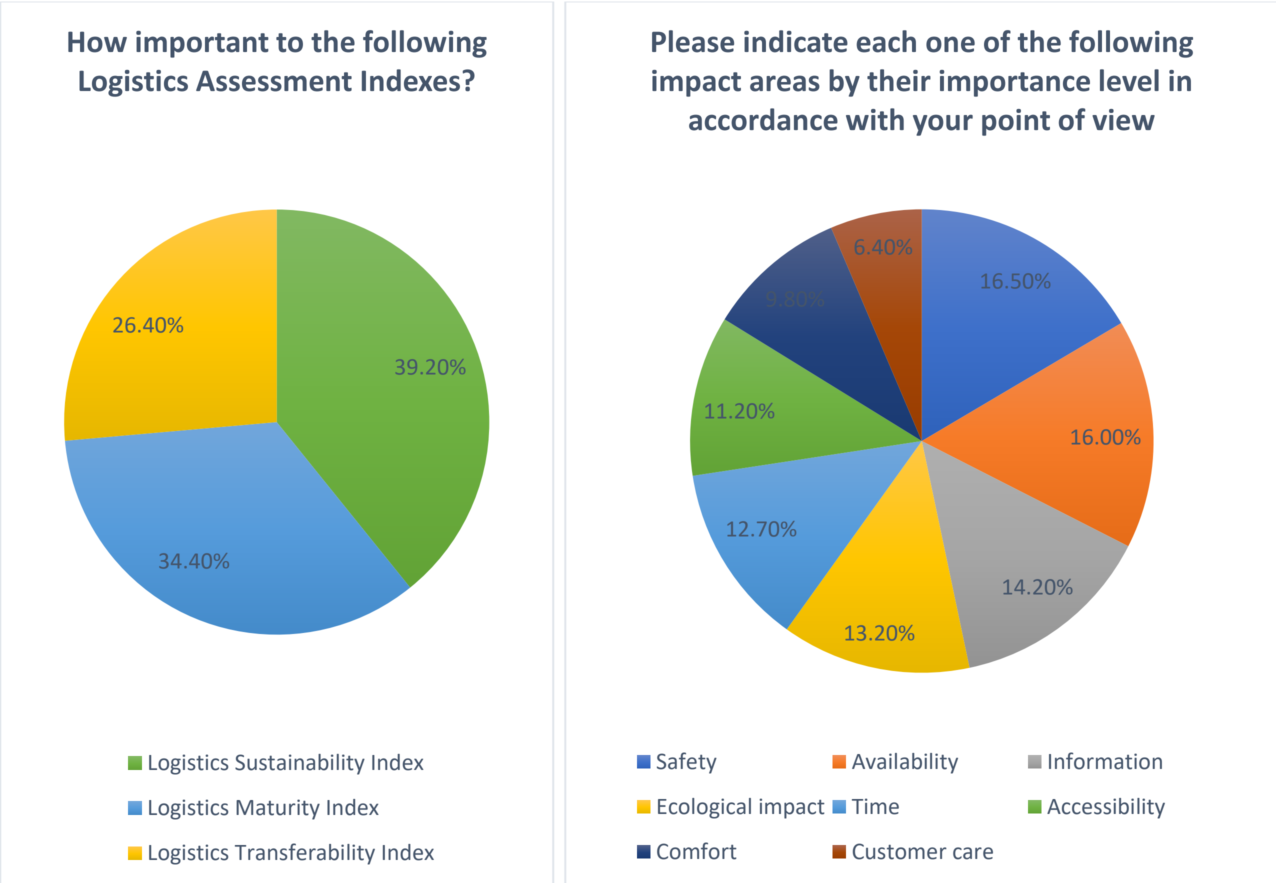


Figure 18: *Weights of Logistics Assessment Indexes (a) and Impact Areas (b)*

In regard to the graphs illustrated above, the developed impact assessment evaluation methods as well as the impact areas related to automated logistics as a service have been prioritized and weighted within the reference project workshop, along with stakeholder interviews of logistics sector actors. As it turned out, the sustainability analysis was ranked as the predominant assessment instrument for the performance assessment of the integration and adaptation of such an innovative concept of automated logistics as a service into real-life deployments. Accordingly, thereafter, the successful deployment of automated logistics as a service performance could be measured by the logistics maturity index, which is ranked as being of secondary importance, and by the logistics transferability index, which is ranked as the third.

After that, the following graphs are representing the KPIs prioritized and weighted for the logistics index calculations. As a first one, the key performance indicators, which are related to the logistics sustainability index evaluation ranked as first-importance performance evaluation method , are illustrated in the following graph, as shown below.

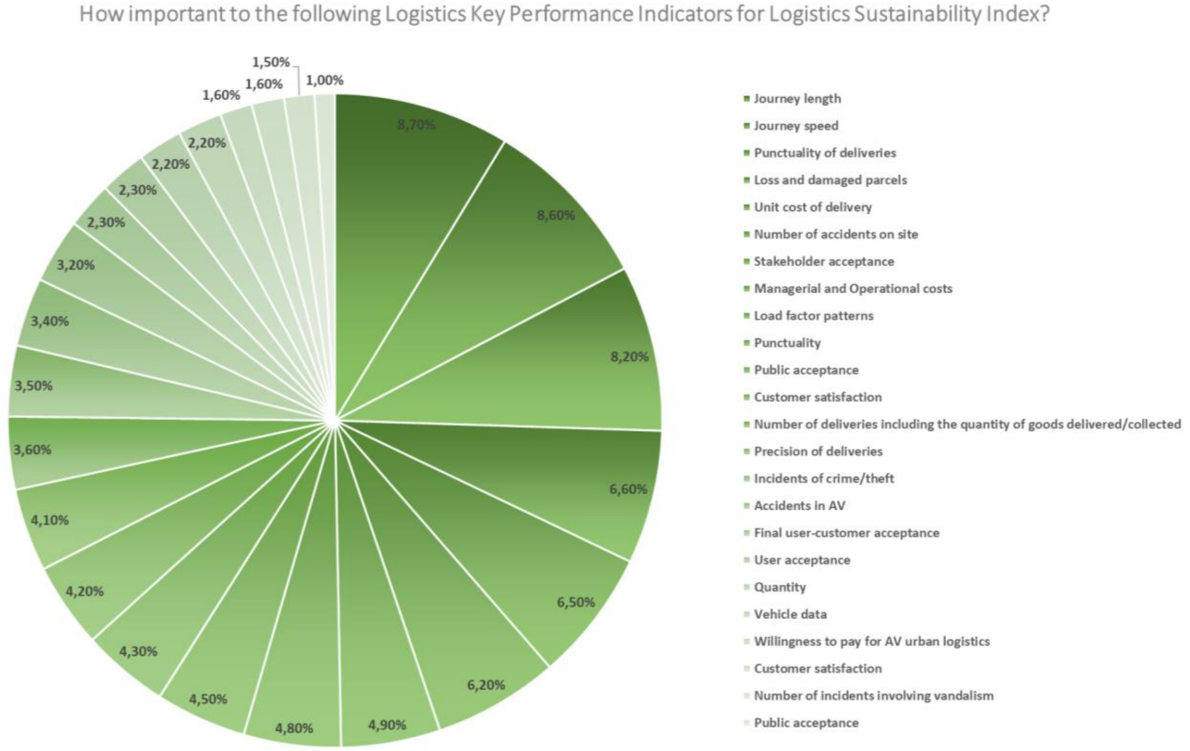


Figure 19: *Weights and Prioritization of KPIs for LSI*

Then another prioritization and weighting were carried out for the key performance indicators regarding the logistic maturity index, which was ranked in the second-importance performance evaluation method, as summarized in the chart below:

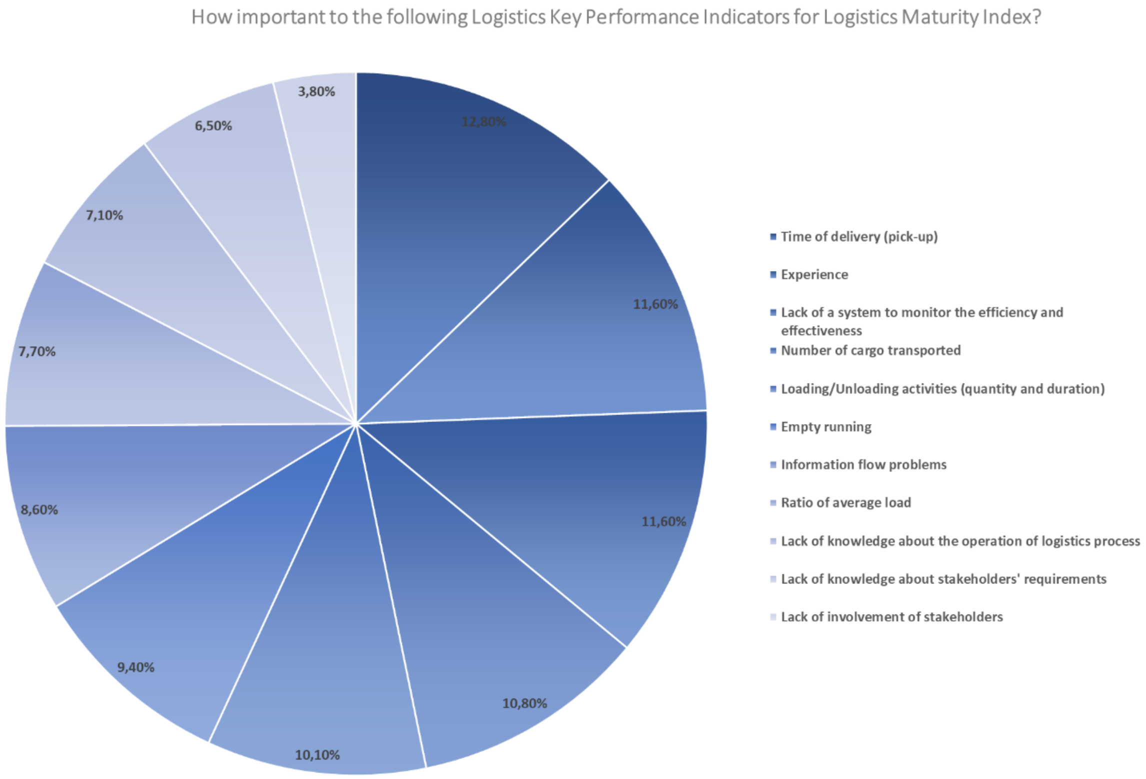


Figure 20: *Weights and Prioritization of KPIs for LMI*

Eventually, a further prioritization and weighting of the key performance indicators regarding the logistic transferability index was also conducted, which was classified as the third-importance performance evaluation method, as mentioned chart below:

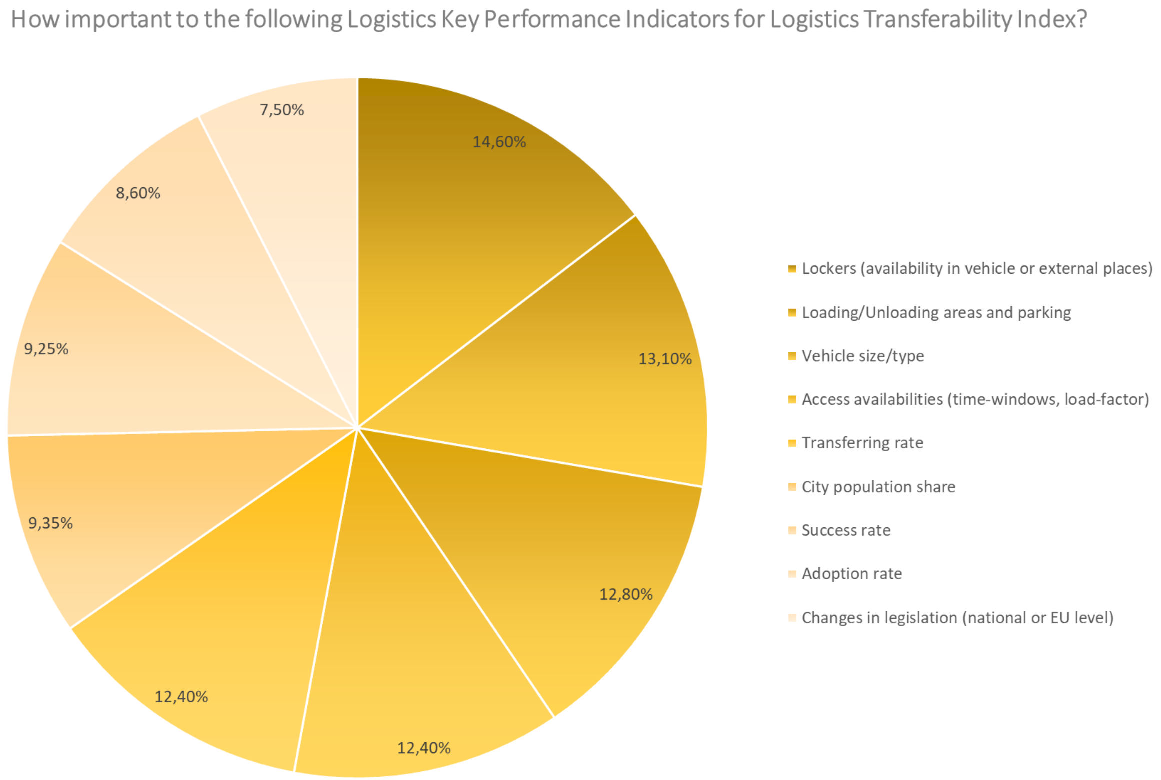


Figure 21: *Weights and Prioritization of KPIs for LTI*

According to the graphs above, the sustainability assessment is ranked as the most important parameter for measuring the performance of ALaaS implementation. In addition, the results indicate that journey length, speed, and punctuality of deliveries are the most important parameters among logistics stakeholders to be highlighted for a success of ALaaS deployment in urban areas.

After that, the maturity assessment is ranked as the second most important for the performance analysis of ALaaS implementation. This assessment addresses the technological readiness of the logistics stakeholders. The outcomes indicate that delivery time and experience are the most important performance indicators for measuring the success of ALaaS implementation in urban areas.

In the last round, the evaluation of transferability was ranked as the third important performance measure of ALaaS implementation. The findings demonstrate that the availability of lockers and parking opportunities are the most important performance indicators for measuring the success of ALaaS implementation in urban areas.

7.1.2. An Application for Automated Logistics as a Service

The innovative and ecologic solutions for the logistics operations in urban areas need to be adapted to work with optimum efficiency, as well as with all necessities integrated. To have such an adaptation and integration of automated services into logistics as a service concept, a mobile app for Automated Logistics as a Service (ALaaS) is essential for several reasons:

- Accessibility: A mobile application provides a convenient method to access and use the ALaaS for users and stakeholders. Those users could place orders, track deliveries as well as communicate with logistics service providers through mobile devices. Thus, this can increase customer satisfaction and trust.

- Efficiency: A mobile app could assist in simplifying ALaaS operations. Logistics service providers can use such an app to manage orders, track deliveries and communicate with both drivers and customers. This could contribute to reducing the time and costs associated with traditional processes.
- Real-Time Monitoring: A smart delivery app could also provide real-time status monitoring of deliveries. Those users can keep monitoring and get notifications when the deliveries are on the way. Logistics service providers could use the app to reach out to users individually within the organization to provide status updates on delivery schedules.
- Data Collection: A mobile app can gather data on the behaviors and preferences of stakeholders. Such information could be used to enhance ALaaS operations and customize services to satisfy stakeholders' needs. Logistics service providers could equally utilize the data to determine trends and opportunities for further growth.
- Competitive Edge: A smart logistics service app could bring a strategic advantage to logistics service providers. By enabling stakeholders to provide a convenient as well as efficient path for accessing the ALaaS, logistics service suppliers could differentiate from the competition to attract new users-clients.

In conclusion, an ALaaS mobile app is a key instrument to bring efficiency and convenience to stakeholders, real-time status updates on deliveries, and data capture along with a competitive advantage for logistics service providers. A mobile app for ALaaS can also improve logistics service providers' operations, boost satisfaction and gain a competitive advantage on the market.

Based on the above-mentioned objectives, the aim of the automated logistics mobile app is to serve potential customers while having some material-product transfers from an origin to destination during logistics pilot sites. The pilot implementations will be supported in terms of booking of the delivery slot to load materials, booking for the pick-up time for the final customers, tracking of the deliveries to be sure it is loaded and received without any harm, and continuously tracking of the vehicle positions by support from GPS or any location providers.

After that, the following figures illustrate an example of the designed-developed automated logistics mobile-app, in particular, automated logistics mobile app functionalities as mentioned below:

- The first ability will be able to register users-customers on the platform to reach functionalities that would be viewed like in the following figures:

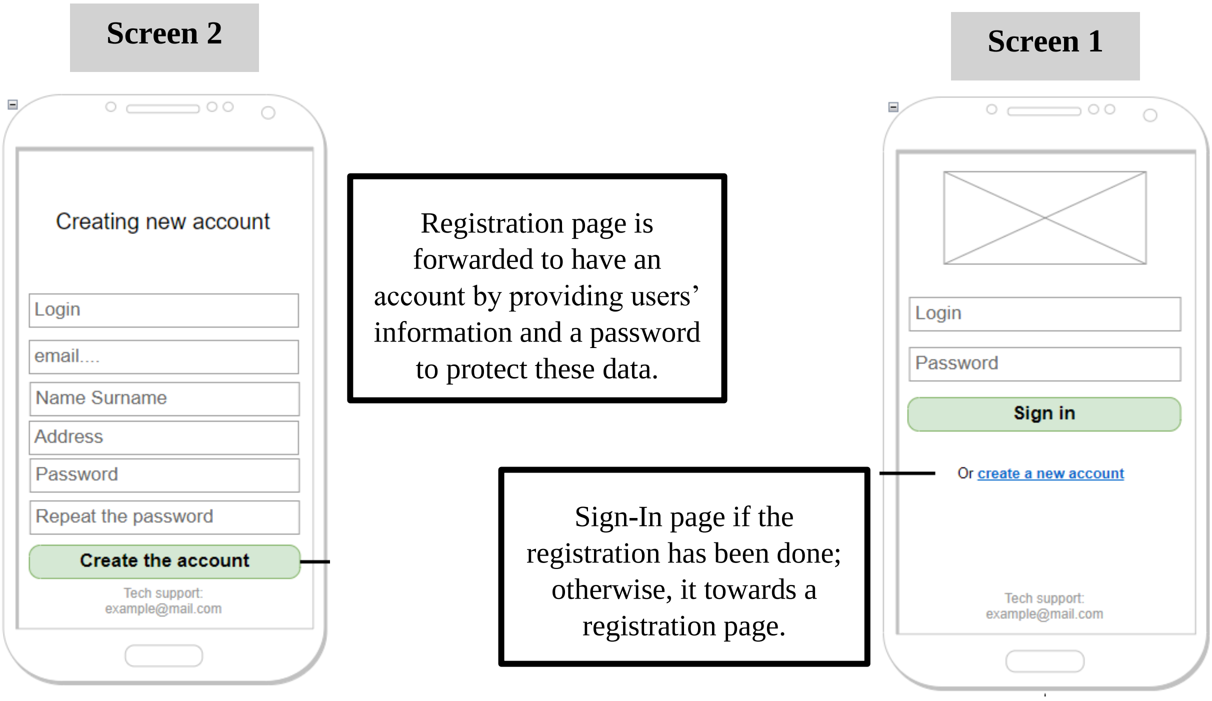


Figure 22: *ALMA, Screen 1 and Screen 2*

- After that, when users have been logged-in, the platform will be able to represent users profile details and gained-utilized "user points" that would be viewed like in the following figure:

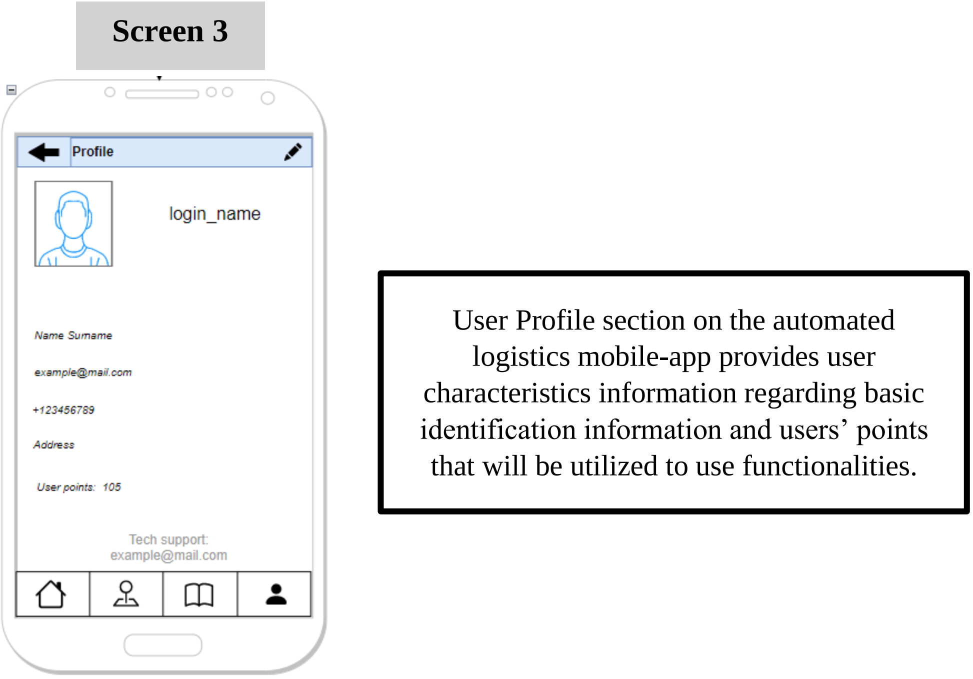


Figure 23: *ALMA, Screen 3*

- Furthermore, the automated logistics mobile-app will provide an ability of booking a delivery service to choose sending address and pick-up time, by inserting also loading address receivers e-mail address, that would be viewed like in the following figures:

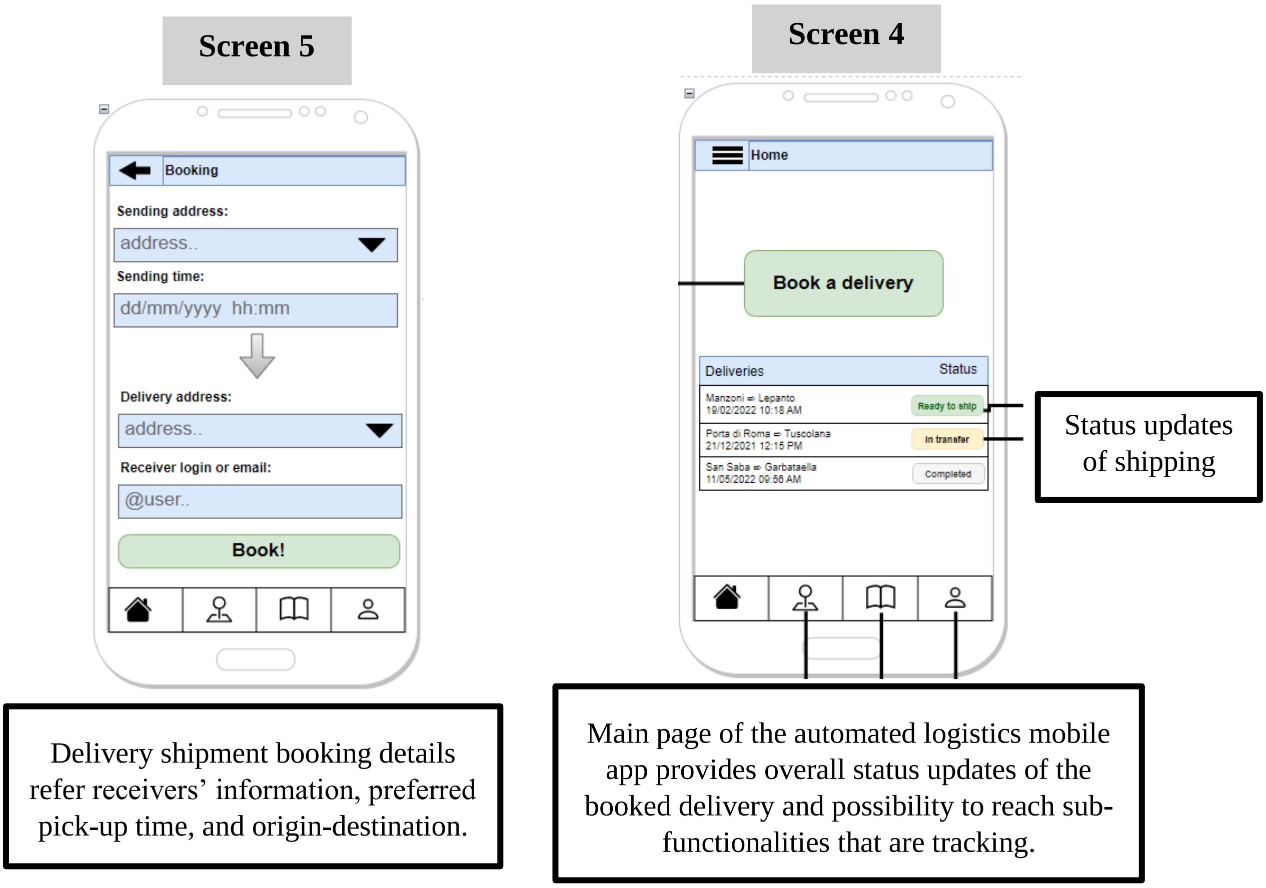


Figure 24: *ALMA, Screen 4 and Screen 5*

After the illustrated functionalities, there will be two more abilities of the automated logistics mobile app when the second version of app will be developed. These abilities are illustrated in the following figures:

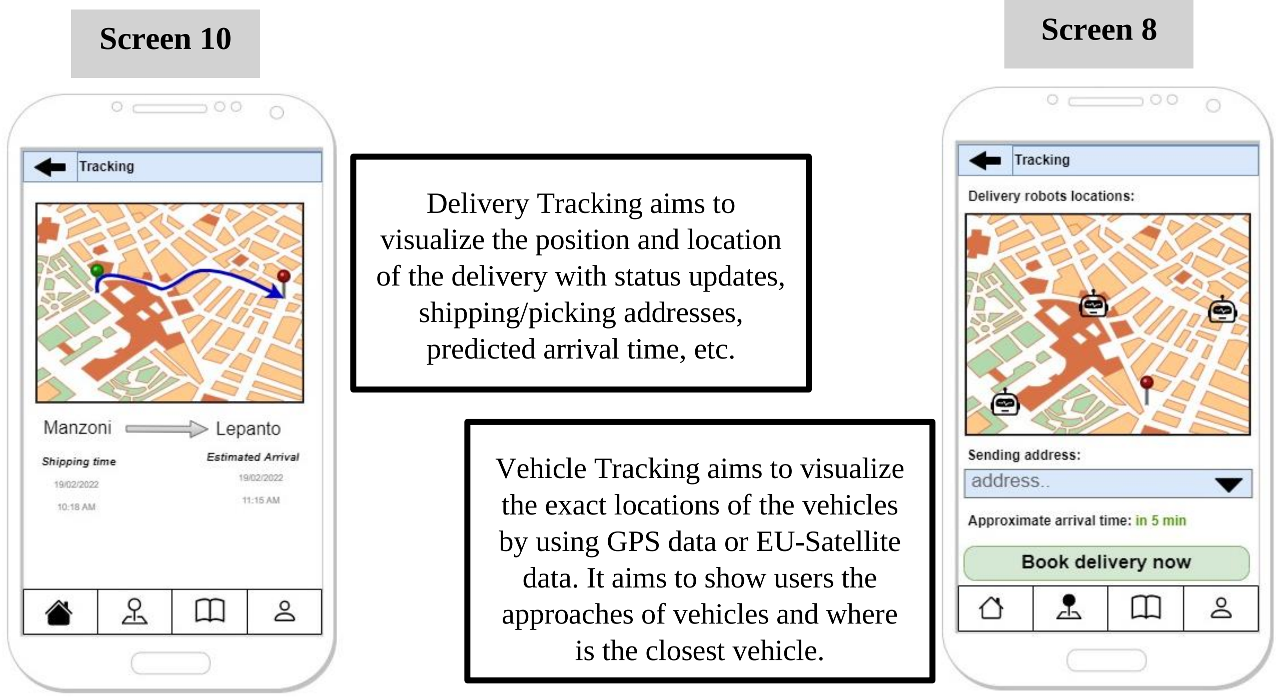


Figure 25: *ALMA, Screen 8 and Screen 10*

7.1.3. Case Study Implementation Findings

As for all case study steps are developed for a real-life deployment of such an automated logistics as a service concept, the real-life demonstrations of automated logistics as a service (ALaaS) are reviewed to be considered as essential for various aspects to highlight the importance of such implementation:

1. *Proof of Concept:* ALaaS demonstrations give evidence of the fact that automation could work in the logistics domains. Such demonstrations could further assist in overcoming criticism and change resistance by proving that automated logistics services can improve efficiency, reduce costs, and increase safety.
2. *Learning and Improvement:* These demonstrations create an opportunity for organizations to learn from the real-life deployments of automation. Through observing the performance of ALaaS in real-life scenarios, organizations can identify improvement areas and make the necessary adjustments. That could lead to advanced technology and processes, which in turn could lead to better performance and increased adoption.
3. *Risk Management:* ALaaS demonstrations are able to support organizations to mitigate the risk associated with new technology being adopted. Through testing the advanced technique within a monitored scenario, organizations can evaluate the impacts of automated processes on existing operations, identifying potential challenges, and developing approaches to address those issues.
4. *Stakeholders Confidence:* Real-life demonstrations can contribute to increasing the trust in automated logistics services. It is through seeing ALaaS in real-life could give an understanding of how it works and its potential advantages. Doing so could further establish confidence and boost adoption rates as well.
5. *Marketing and Promotion:* ALaaS demonstrations are able to be utilized as a marketing and promotion tool. By illustrating such advanced automated services and their capabilities, organizations could appeal to a prospective range of stakeholders and distinguish among their competitors.

To summarize, real-life demonstrations of ALaaS are essential for proving the concept of automated logistics services, learning and enhancement, risk management, building trust, marketing, and promotion. Through demonstrating the advantages of ALaaS in real-life deployments, organizations could enhance adoption rates, as well as building confidence among the competitive advantages.

After that, the case study is firstly designed and executed to evaluate the understanding of the acceptance of automated logistics as a service concept, in which an Automated Logistics as a Service (ALaaS) is a quickly growing domain that focuses on simplifying the delivery process of goods and services by using the combined strength of automation technology. Within this context, the acceptance analysis has a crucial part to play to ensure the ALaaS is successfully deployed. Hence, some of the main arguments why acceptance analysis is important in ALaaS are represented below:

- Guaranteeing customer satisfaction: ALaaS service providers have to fulfill the expectations and requirements of those in order to keep themselves competitive. The acceptance assessment assists in identifying and addressing any problems that either customer may have with the service, thus ensuring that they are satisfied with the service provided.
- Quality assurance: An acceptance assessment assists in guaranteeing that the ALaaS scheme complies with the demanded quality performance requirements. By conducting tests on the entire system under a variety of scenarios and other conditions, the analysis makes it possible to pinpoint any possible shortcomings or failures that could affect the system's performance.
- Optimization of service performance: By performing an acceptance assessment, ALaaS service providers are able to determine which areas of the service are in need of improvements, such as system bottlenecks, inefficiencies, or those areas of the service that require optimization. Such information then can be used to make adjustments that can lead to a more efficient and effective logistics service.
- Cost reduction: Through identifying the possible problems and inefficiencies in the ALaaS scheme, acceptance analysis can contribute to reducing costs by improving the overall efficiency of the whole service. This can bring cost reductions for customers and increased profits for ALaaS providers.
- Compliance: The acceptance assessment is even intended to guarantee that the ALaaS system complies with any regulatory requirements or standards applicable to the sector. This is especially critical in areas such as public health or finance, where regulatory adherence is essential.

In a general context, the acceptance assessment is an important process for any ALaaS service provider who intends to increase the quality, performance, and reliability of its service. Through conducting an acceptance assessment, service providers can identify and address any possible problems or inefficiencies, thus improving customer satisfaction, reducing costs, and making the service more competitive.

Regarding above-mentioned aspects, an acceptance analysis is done starting from a preliminary user needs analysis. The objective of the user needs assessment is to determine the intended user clusters and to investigate whether the demands of those clusters can be covered by an automated logistics service that was designed for a case study. Thus, the user needs analyses questionnaire was given face-to-face with a total of 28 respondents. In the following graphs, the assessment results of user needs and requirements are briefly summarized (*see following Figure 26*).

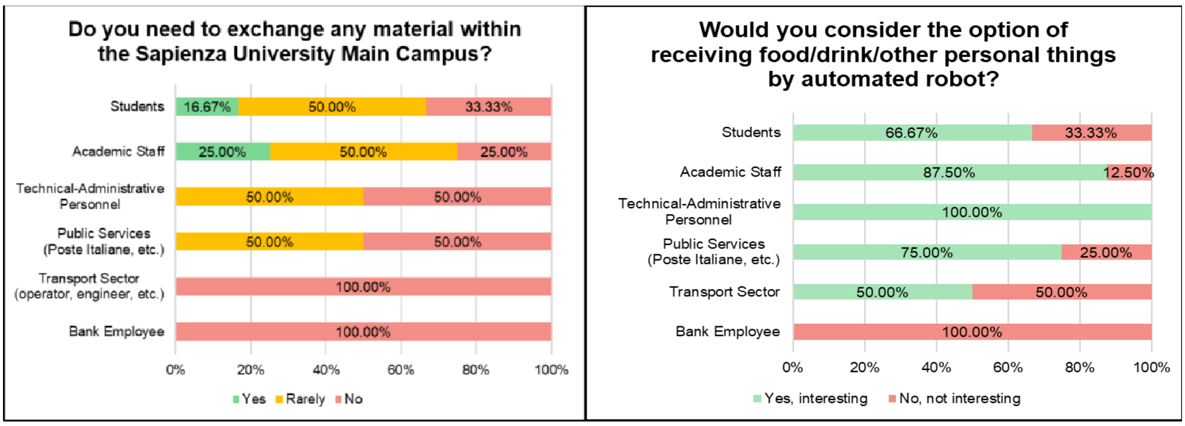


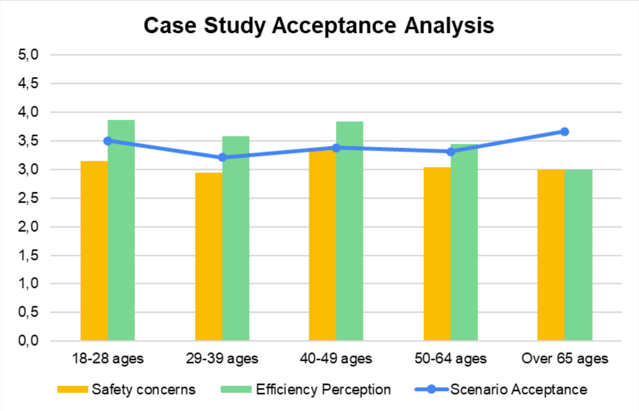
Figure 26: *Age clusters (a) need for material exchange; (b) consideration of new automated logistics option*

According to the findings, there is no necessity to exchange any documents or any other materials for bank employees (as it is understood, this is due to the nature of banking, where every operation requires personal appearance and no packages are sent to clients), as well as for transport sector participants.

To conclude, the user needs analysis identified which user groups are particularly relevant to such automated logistics service, which are further addressed in the acceptance questionnaire:

- The university's technical staff could be both interested in and in need of such a service (primarily for the transport of cleaning materials),
- The academic staff of the university could be also both interested in and in need of such an automated logistics service,
- The university students could be also concerned to assess the acceptance of such a service.

Subsequently, as a consequence of an acceptance assessment of such automated logistics as a service context, such an acceptance analysis was conducted from the analysis of the first set of questions, the age groups and professions of the respondents were studied with regard to acceptance of the case study (considering safety concerns and perceptions of efficiency), willingness to use the automated logistics service and preference to use it over the traditional mode of transport (*see following Figure 27*).



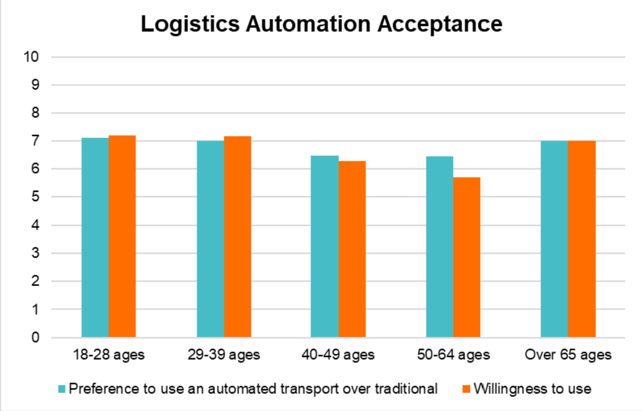


Figure 27: *Age clusters: (a) case study acceptance assessment; (b) automated logistics service acceptance assessment*

Across the board, all respondents were rather positive regarding safety (with a mean rating of more than 3 out of 5). Overall, they usually feel safe (that no damage would have occurred to deliveries), secure (that no theft/delayed deliveries could occur) and trust the service (that the delivery could reach their destination). Besides that, all the respondents were more favorable towards the efficiency of the proposed automated delivery service; for the younger groups (18 to 50 years) the score is above 3.5/5, while it is slightly lower for the older respondents. The figure shows a medium to high level of acceptance of the case study (around 3.5 out of 5) for all clusters, which allows us to assume that there are no significant differences between age and acceptance: in general, respondents expect the service to be safe, efficient, and reliable.

The second graph (*Figure 27b*) indicates a medium to high willingness to use such a service, particularly for the 18-39 age group. Remarkably, the elderly respondents have a greater willingness to use the service than those middle-aged ones. The same tendency can be seen about users' preference for using a delivery robot over transit transport. Some of those interviewed consider that "it would be much easier to track the route" and that "the delivery robot shortens the time compared to traditional approaches through automation of the process". Even so, they do express various concerns regarding possible accidents, damage, and steal.

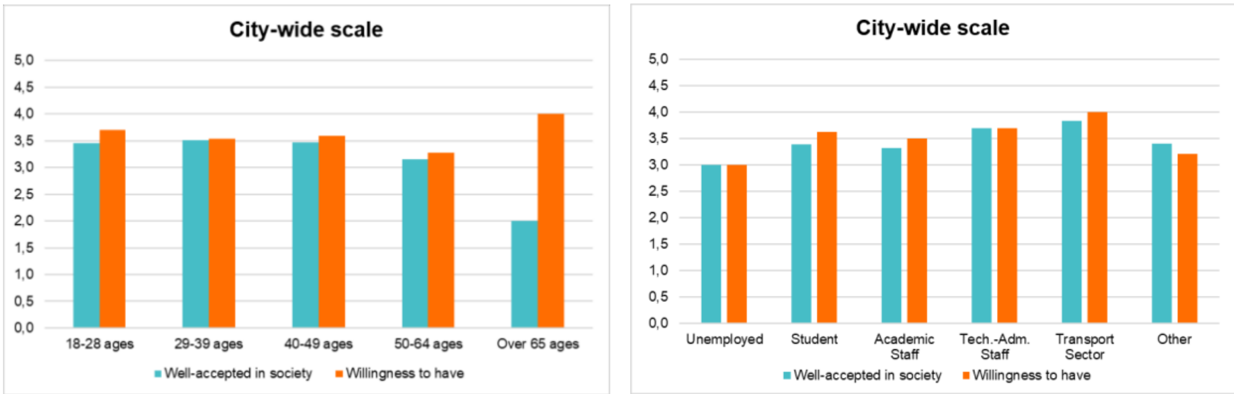


***Figure 28**: Automated service implementation on a city-wide scale: (a) age; (b) profession*

As a preliminary analysis, it is concluded that such a service is likely to be used more predominately by those in the younger age group although older respondents have also expressed an interest. Afterward, an analysis of perceptions on the possible extension of the automated service implementation from a case study to an urban context was conducted (*see Figure 28a*). While the younger groups consider that such an automated service will be well-accepted by society, the elderly respondents (50+) were more skeptical about it. Remarkably, nevertheless, those respondents indicate a stronger willingness to have such a service in the urban context.

As regards the users' professions (*see Figure 28*), transport service users perceive that they are more confident and protected by such a service. Thereby, they evaluate the efficiency more than others and thus have a higher level of acceptance of robot-delivery. Technical administrative staff, academic staff as well as students similarly have a fairly high level of acceptance, assessing their perceived safety over 3.0/5 as well as the anticipated efficiency of automated vehicles over 3.5/5.

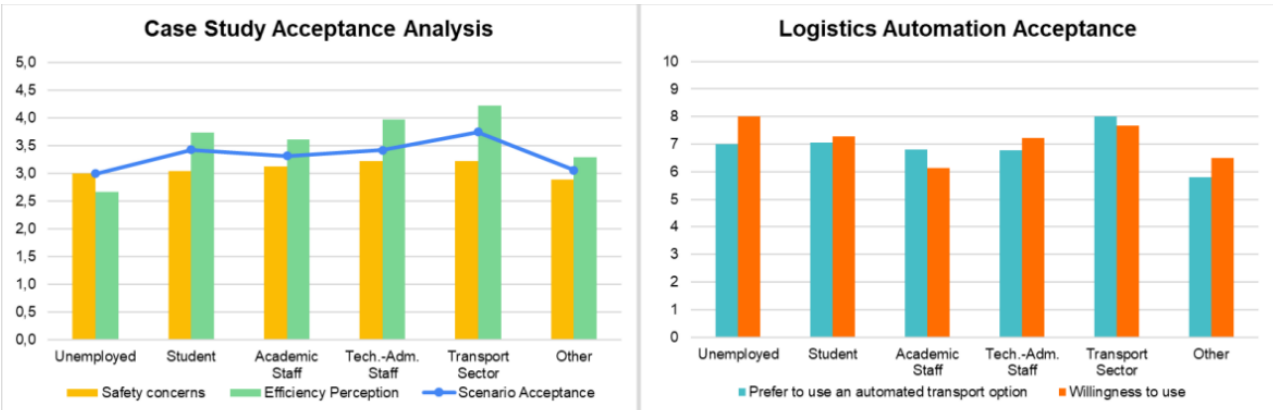


***Figure 29:** Occupancy clusters: (a) case study acceptance assessment; (b) automated logistics service acceptance assessment*

By the same way, those users engaged in transportation have a higher preference than other groups to utilize an automated logistics service as compared to traditional transportation approaches. Both transportation employees and unemployed citizens generally express the highest willingness to use of such an automated logistics service. The primary concerns are connected to job loss (reduction of job positions), the fact that the automated service "*is an extra element that might not work*" "*people's curiosity about this new (automated) service would lead to some delays*" and "*being without supervision (no humans on board) there is a potential risk of damage and vandalism*". It is interesting to note that the findings demonstrated that unemployed citizens are most likely to be willing to use such a service; nevertheless, they do not particularly desire to have such a city-scale service (*due to concerns about losing their jobs*).

When discussing a possible expanding of automated logistics service deployment from such a case study to an urban context (*see Figure 29*), as above-mentioned, the transportation sector is most positive regarding the societal acceptance of the service as well as expressing a willingness to use such a service.

The citizens have various attitudes and concerns, both of which are mentioned below:

- robot-delivery brings challenges to citizens, as city streets are narrow,
- those services would require "easy-to-use" smartphones and apps, as otherwise they would not be convenient for whole public participants,
- lower negative environmental impacts, together with an improved quality of life.

Beyond that, the respondents were then analyzed by using MS Excel and the IBM SPSS program for a regression analysis between "acceptance" as the dependent variable, and the characteristics of respondents, the characteristics of the scenario, and the area of safety-efficiency impact as the independent variables. The findings of the statistical analysis of the responses are clustered in the following *Table 6*.

Clusters	Variables	Coefficients	Standard Error	Stat t	Lower 95%	Higher 95%
Characteristics	**Acceptance (dependent)**	6,2853	0,6949	9,0448	4,9101	7,6605
	Age	-0,1752	0,1912	-0,9166	-0,5536	0,2031
	Automation Experience	0,7486	0,3576	2,0935	-0,0410	1,4562
	R-Square *(characteristics)*	*0,044177162*				
Scenario	**Acceptance (dependent)**	0,3367	0,7981	0,4219	-1,2442	1,9177
	Easy-to-use	0,2285	0,2459	0,9291	-0,2587	0,7157
	Useful	-0,2684	0,3055	-0,8786	-0,8737	0,3368
	Effective and efficient	-0,1066	0,3150	-0,3383	-0,7306	0,5175
	Safer	0,3679	0,2076	1,7726	-0,0432	0,7791
	Improve environment	0,2004	0,2063	0,9714	-0,2082	0,6090
	Will be favored	0,1685	0,2826	0,5963	-0,3913	0,7283
	Like to use this service	0,5839	0,1073	5,4436	0,3714	0,7963
	Safety - trust the service	0,1905	0,3197	0,5957	-0,4428	0,8238
	Safety - feel safe	-0,3326	0,3377	-0,9850	-1,0015	0,3363
	Safety - more secure	-0,0654	0,2416	-0,2707	-0,5441	0,4132
	Efficiency - easier tracking	-0,1823	0,2416	-0,7545	-0,6607	0,2962
	Efficiency - less process-time	0,3293	0,2881	1,1432	-0,2413	0,8999
	Efficiency - less transfer-time	0,2181	0,2954	0,7384	-0,3670	0,8032
	R-Square *(scenario)*	*0,518342928*				
Overall	Acceptance (dependent)	1,5089	0,6553	2,3026	0,2121	2,8058
	Well-accepted in society	-0,0603	0,2077	-0,2903	-0,4714	0,3508
	Use in the city frequently	1,5639	0,2100	7,4461	1,1482	1,9795
	R-Square (*overall*)	*0,407077698*				

Table 6: *Response statistical analysis results.*

Further statistical analysis also indicates that the coefficients have both positive and negative effects on service acceptance. For instance, the analysis of acceptance with the independent variables of Characteristics strongly indicates that acceptance would be adversely influenced by age (the older the user, the less acceptance he or she expresses, vice versa); on the contrary, it is positively influenced by previous automation experience (more experience, more acceptance). Another such case is that acceptance would be positively biased when respondents perceive the service to be easy to use (more favorable than unfavorable); in contrast, it is adversely biased when the respondents have a negative attitude that tracking the proposed automated delivery robot would be easier than tracking the traditional way of delivery (responses have a negative mean meaning they have more concerns than feeling safe).

In a further elaboration, the mean of responses regarding societal acceptance is closer to the fact that *the service would not be well-accepted than to being accepted*; on this basis, the variable does have a negative effect on acceptance of automated logistics. To conclude above-mentioned context, the findings indicate that safety-related variables have a slightly negative effect on the acceptance (the more people perceive themselves to be safe and secure, the more they would be inclined to accept such a service). The findings indicate that respondents also tend to accept the service if they have confidence in such a service. On the contrary, the efficiency variables have a more positive effect: if those users perceive that such a service involves a reduction in processing and transfer time, the acceptance also increases. It is interesting to note that those users who are concerned about the ease of tracking the fully automated logistics vehicle do express a higher acceptance. Somewhat remarkably, the respondents are willing to use such a service frequently, but they do not believe that the society would actually accept such a service on a city scale.

At the last point, according to the statistical regression analysis, for the cluster "characteristics and acceptance" the regression, with *R-square=0.04*, does not indicate more significance. On the contrary, the regression statistics of the clusters "scenario and acceptance", with R-*square=0.52*, and "general acceptance", with *R-square=0.41*, do indicate significant regression values.

As it is also important for real-life execution of such a developed assessment framework implementation and such a service deployment, a simulation analyses are a valuable instrument that could be utilized to evaluate and optimize the performance of an automated logistics as a service (ALaaS) framework. Some of the principal reasons why a simulation analysis could be important in ALaaS are given as follows:

- *Predictive Modelling:* A simulation analysis enables ALaaS decision-makers to establish realistic models of the performance and behaviours of such a service under various circumstances. This makes it possible for decision-makers to test and optimize the service before it is deployed, thus minimizing the risk of failures or costly inefficiencies.
- *Risk Mitigation:* By simulating the ALaaS model, decision-makers can identify and mitigate potential risks and problems that might occur during deployment. This can also include items such as bottlenecks, delays, and failures, which could affect the efficiency and overall performance of the entire service.
- *Optimising Resources:* Simulation analysis can support ALaaS decision-makers to optimize the use of assets such as logistics vehicles, personnel, and facilities. Thus, by simulating various automated logistics as a service scenario and a variety of conditions, decision-makers can specify the more efficient and cost-effective approaches to allocate resources, thereby reducing costs and boosting performance.
- *Process Improvements:* While simulating an ALaaS concept, decision-makers can also identify those areas in which the concept could be improved or optimized. This can also involve factors such as scheduling routes, cargo balancing, and delivery schedules, which could have a considerable impact on the overall efficiency and effectiveness of such a service solution.
- *Scale-up:* A simulation analysis can also enable ALaaS decision-makers to assess the scalability of such a solution to identify any problems or limitations which may occur over time as the solution expands. Doing so gives decision-makers the ability to plan and prepare for future scale-up, thereby guaranteeing that the solution can keep satisfying stakeholder needs over time.

As a matter of overview, a simulation assessment is a valuable tool for ALaaS providers who wish to optimize the performance as well as the efficiency of those automated logistics services. Through simulating various scenarios and conditions, service stakeholders could identify any potential risks and challenges, optimize the use of resources, and enhance the overall performance of such automated logistics service. Doing so could eventually lead to higher stakeholder satisfaction, reduced costs, and more competitive automated logistics as a service concept.

As for an automated logistics simulation scenario, a number of assumptions will need to be determined. With regard to that point, various assumptions for the "time and distance challenges on traffic that could be saved with automated logistics as a service" could include:

- Increasing traffic congestion in urban areas leads to longer travel times and higher transport costs.
- Traditional logistics models rely on manual coordination and routing, which can be time-consuming and lead to inefficiencies in delivery schedules.
- Automated logistics as a service (ALaaS) uses advanced technologies such as machine learning, artificial intelligence, and smart tools to optimise logistics operations, reducing delivery times and costs.
- ALaaS can also provide real-time tracking and monitoring of shipments, enabling better visibility and control of the supply chain.
- The use of ALaaS may require a significant initial investment in technology and infrastructure, as well as employee and stakeholder training.
- The adoption of ALaaS may entail regulatory and legal challenges related to safety, security and privacy issues.

- ALaaS may have the potential to revolutionise the logistics industry by increasing efficiency, reducing costs and improving sustainability.

The automated logistics as a service simulation scenario further have various assumptions. As first, the city of Rome receives goods from the logistics center in Pomezia. Logistics operations are continuously based on Pomezia Logistics Hub, as the origin, and final customers, as the destination. The concept behind this is: What if we could have intermediate logistics distribution centers for each municipality, instead of having only one? With this approach, time and distance will be evaluated to determine whether there are any savings. Meanwhile, weighted performance indicators will further explore the efficiency and effectiveness of implementing this scenario. The simulation data is comparing the distance and time between points to logistics centre as well as points to centroids and then centroids to logistics centre. 30% of the time loss is assumed for a service time, in accordance with three years of monitoring which has been done for a regional project (*PRMTL Monitoraggio Lazio, 2022*). Furthermore, the scenario will assume last-mile freight operations by means of automated logistics vehicles. With regard to the choice of logistics vehicle, the simulation concept assumes the following aspects, summarised below:

- With designed intermediate logistics distribution nodes to represent automated vehicle method, in Rome City Centre: Vehicle Type 1
- Limited Traffic Zones and Logistics Vehicles Allowance in Rome City Centre: Vehicle Type 2
- With designed intermediate logistics distribution nodes, between main logistics distribution centre and designed intermediate logistics distribution nodes: Vehicle Type 3

According to the data collected in the PRMTL Monitoring project, as well as all data collected from the benchmark monitoring project (*PRMTL Monitoring Lazio, 2022*), 35 streets representing the commercial and delivery zones in the city of Rome were identified (*see Appendix II*). The data were then collected from real logistics operations and analysed to identify logistics impart streets, as listed below for the chosen representative ones (on behalf of identified 35 logistics streets in Rome City) in capital area, as detailed below:

All Streets	Number of Deliveries	Percentage of Deliveries	
Representative Streets	1534	80,06%	out of identified streets
Identified Streets	1916	24,16%	out of Roma’s streets
Roma	7932	7,92%	out of whole Italy
Italia	100212	100,00%	---

Table 7: *Number of deliveries occurred in Rome, and in Italy*

In accordance with the demand of the citizens/merchants of Roma Capitale, as well as the further investigation of the report *'Annual report on Logistics in the Roma Capitale Area'*, the following streets have been identified for the zoning, to be aggregating the closer ones into those that are representative in the Roma Capitale Area, as listed in the following table.

No	Street Name (Via)	Number of Deliveries	Percentage of Deliveries
1	VIA TIBURTINA	451	23,54%
2	VIA NAZIONALE	344	17,95%
3	VIA CRISTOFORO COLOMBO	311	16,23%
4	VIA NOMENTANA	290	15,14%
5	VIA DEI CONDOTTI	138	7,20%
	Total	**1534**	**80,06%**

Table 8: *Number of deliveries occurred in Rome transferring representative streets*

In accordance with the specified logistics paths as well as some others, a platform (*namely TransCAD*) has been used to estimate the time matrix from those paths to the designed intermediate logistics nodes and from these designed intermediate logistics nodes to the main logistics distribution center in Pomezia, as it is summarized (to be used for "*with scenario analysis*") in the following table.

	From Street to Centroids						
	Lazio 58091044	**Lazio 58091033**	**Lazio 58091056**	**Lazio 58091030**	**Lazio 58091017**	**Node to Pomezia**	**Total Time**
Via Cristoforo Colombo	**3,218**	7,639	8,413	11,936	13,899	20,594	**23,812**
Via dei Condotti	7,622	**1,385**	8,811	7,892	8,107	26,977	**28,362**
Via del Corso	7,369	**1,131**	8,648	7,729	7,944	26,977	**28,108**
Via Nazionale	7,106	**1,308**	7,311	6,669	7,107	26,977	**28,285**
Via Nomentana	13,113	7,041	9,946	5,772	**2,690**	33,169	**35,859**
Via Tiburtina	12,815	8,576	8,326	**3,933**	5,810	31,964	**35,897**
Via Appia Nuova	8,191	8,077	**2,994**	7,582	10,697	27,343	**30,337**

Table 9: *Time Matrix with designed intermediate logistics hubs (in minutes)*

After that, there is a time matrix estimation between the designed intermediate logistics nodes, which are placed to serve between the main logistics centre and the final customers, as illustrated (to be used for "*with scenario analysis*") in the following table:

	Lazio 58091044	**Lazio 58091033**	**Lazio 58091056**	**Lazio 58091030**	**Lazio 58091017**
Lazio 58091044	--	6,527	9,004	12,174	14,119
Lazio 58091033	6,527	--	8,446	7,837	8,062
Lazio 58091056	9,004	8,446	--	6,123	9,779
Lazio 58091030	12,174	7,837	6,123	--	5,559
Lazio 58091017	14,119	8,062	9,779	5,559	--

Table 10: *Time Matrix between the designed intermediate logistics hubs (in minutes)*

Thereafter, the estimation of the time matrix is also performed for the estimation of times from the logistic streets to the main logistic distribution center in Pomezia without any designed intermediate logistic nodes, as shown (to be used for the "*without scenario*" analysis) in the following table.

	Via Cristoforo Colombo	**Via dei Condotti**	**Via del Corso**	**Via Nazionale**	**Via Nomentana**	**Via Tiburtina**	**Via Appia Nuova**
Pomezia	20,164	28,072	27,819	27,555	31,252	29,157	25,798

Table 11: *Time Matrix without designed intermediate logistics hubs (in minutes)*

Based on the specified logistics paths and some others, the platform (*TransCAD*) was also applied to estimate the distance matrix from those logistics streets/paths to the designed intermediate logistics nodes as well as from these designed intermediate logistics nodes to the main logistics distribution center in Pomezia, as outlined (to be used for *'with scenario analysis'*) in the table below.

	From Street to Centroids						
	Lazio 58091044	**Lazio 58091033**	**Lazio 58091056**	**Lazio 58091030**	**Lazio 58091017**	**Pomezia**	**Total Distance**
Via Cristoforo Colombo	**3,034**	7,100	7,477	9,946	12,531	25,262	**28,296**
Via dei Condotti	6,290	**1,038**	7,229	6,494	6,572	30,611	**31,648**
Via del Corso	6,228	**0,976**	7,168	6,432	6,510	30,611	**31,587**
Via Nazionale	5,902	**1,139**	5,790	5,392	5,672	30,611	**31,750**
Via Nomentana	11,380	6,423	9,126	5,628	**2,631**	36,650	**39,281**
Via Tiburtina	10,969	7,284	7,316	**3,869**	5,344	34,113	**37,982**
Via Appia Nuova	7,057	7,080	**2,535**	6,545	10,033	31,003	**33,538**

Table 12: *Distance Matrix with designed intermediate logistics hubs (in kilometers)*

Following that, a distance matrix is then estimated between the designed intermediate logistics nodes, which are placed to serve between the main logistics center and the final customers, as presented (to be used for "*with scenario*" analysis) in the table below:

	Lazio 58091044	**Lazio 58091033**	**Lazio 58091056**	**Lazio 58091030**	**Lazio 58091017**
Lazio 58091044	--	5,445	7,351	9,586	11,485
Lazio 58091033	5,445	--	6,533	6,449	6,527
Lazio 58091056	7,351	6,533	--	5,028	8,616
Lazio 58091030	9,586	6,449	5,028	--	4,915
Lazio 58091017	11,485	6,527	8,616	4,915	--

Table 13*: Distance Matrix between the designed intermediate logistics hubs (in kilometers)*

Later on, the estimation of the distance matrix is also conducted for the estimation of distances from the logistic streets to the main logistic distribution center in Pomezia without any designed intermediate logistic nodes, as shown (to be used for the "without scenario" analysis) in the following table.

	Via Cristoforo Colombo	**Via dei Condotti**	**Via del Corso**	**Via Nazionale**	**Via Nomentana**	**Via Tiburtina**	**Via Appia Nuova**
Pomezia	24,372	31,455	31,394	31,067	36,545	35,595	29,709

Table 14: *Distance Matrix without designed intermediate logistics hubs (in kilometers)*

According to the data gathered, the delivery size is about 3 kilograms, and 16 packages can fit on a first level of a pallet; in addition to that, it is also possible to have 4 levels or 6 levels in a single pallet. Based on that, the logistics vehicle capacities, which will be used while calculating the time and distance of defined scenarios, are illustrated in the following table. [59, 60]

Vehicle Type 1	**Vehicle Type 2**	**Vehicle Type 3**
Capacity: 64	Capacity: 192	Capacity: 768

Table 15: *Logistics Vehicles Capacity to be used for logistics simulation scenario*

On the basis of the defined scenarios, there are therefore two different approaches: *with scenario* and *without scenario*. In the first approach, the "with scenario" involves the designed intermediate logistics nodes (one per municipality, namely Lazio 58091XXX) as well as automated logistics vehicles (vehicle type 1, with a delivery capacity of 64) option. Beyond that, this "with scenario" entails the material transfers between the principal logistics distribution center and the designed intermediate logistics nodes (by vehicle type 3, with a delivery capacity of 768). In the second scenario, it is the "without scenario", which contemplates the material transfers from the principal logistics distribution center to the final customers; in this case, the logistics paths/streets are representatives of a case study in the Roma Capitale Area.

In accordance with the TransCad simulation approach, the identified representative paths will be allocated according to the two projected intermediate logistics distribution nodes, as indicated in the overview here below: (*regarding the shortest path, and the logistics vehicle capacity*)

- Via Nazionale, Via Dei Condotti, and Via Nomentana will be arranged by the designed node "Lazio-58091033", and
- Via Cristoforo Colombo and Via Tiburtina will be arranged by the designed node "Lazio-58091056".

After that, the following graphs are showing the data gathered from such a logistics simulation scenario implementation through comparing with-without scenarios, as well as any efficiency improvement (*for the further results, see the Annex III*) regarding time and distance saving. As for that purpose, the following graphs are representing the time and distance estimations from those logistics streets in Rome to principal logistics distribution center in Pomezia (without scenario: no designed intermediate logistics distribution node presented) corresponding with the two different vehicle capacity (one for as traditional approach – vehicle type 2, another for automated option – vehicle type 1) as shown below:

without	**Route**	**Time**	**N.V**	**Travel Time**	**Service Time**
Vehicle Type 1	Via Tiburtina to Pomezia	35,595	7	249,165	323,9145
	Via Nazionale to Pomezia	31,067	6	186,402	242,3226
	Via C. Colombo to Pomezia	24,372	5	121,86	158,418
	Via Nomentana to Pomezia	36,545	5	182,725	237,5425
	Via dei Condotti to Pomezia	31,455	2	62,91	81,783
without	**Route**	**Distance**	**N.V**	**Travel Distance**	**Service Distance**
Vehicle Type 1	Via Tiburtina to Pomezia	29,157	7	204,099	265,3287
	Via Nazionale to Pomezia	27,555	6	165,33	214,929
	Via C. Colombo to Pomezia	20,164	5	100,82	131,066
	Via Nomentana to Pomezia	31,252	5	156,26	203,138
	Via dei Condotti to Pomezia	28,072	2	56,144	72,9872

Table 16: *Time and Distance Matrixes for without scenario, and vehicle type 1 (for automated vehicle)*

Subsequent to the scenario without an automated approach, the time and distance matrix analysis was also conducted for the traditional approach (*in which a vehicle type 2 is hypothesized*), as is summarised in the following table.

without	**Route**	**Time**	**N.V**	**Travel Time**	**Service Time**
Vehicle Type 2	Via Tiburtina to Pomezia	35,595	3	106,785	138,8205
	Via Nazionale to Pomezia	31,067	2	62,134	80,7742
	Via C. Colombo to Pomezia	24,372	2	48,744	63,3672
	Via Nomentana to Pomezia	36,545	2	73,09	95,017
	Via dei Condotti to Pomezia	31,455	1	31,455	40,8915

without	Route	Distance	N.V	Travel Distance	Service Distance
Vehicle Type 2	Via Tiburtina to Pomezia	29,157	3	87,471	113,7123
	Via Nazionale to Pomezia	27,555	2	55,11	71,643
	Via C. Colombo to Pomezia	20,164	2	40,328	52,4264
	Via Nomentana to Pomezia	31,252	2	62,504	81,2552
	Via dei Condotti to Pomezia	28,072	1	28,072	36,4936

Table 17: *Time and Distance Matrixes for without scenario, and vehicle type 2 (for traditional vehicle)*

After conducting the above-mentioned analysis, the following graphs illustrate the assessment of the findings in terms of service time and distance corresponding to the vehicle types, as shown in the following charts.

Figure 30: *Logistic distribution without scenario, for time and distance estimation regarding vehicle types*

In the first stage of the 'with scenario', the goods will be transported from the principal logistic distribution center in Pomezia to the designed and projected intermediate logistic distribution nodes, to be served from those intermediate logistic distribution nodes to the final customers (receivers). Afterwards, the materials will be transferred from the designed intermediate logistic distribution nodes to the last receivers (as represented as logistic paths identified in Rome Capital Area). The first step of with scenario is as summarised in the table below (time is in minutes, and distance is in kilometres).

Route Name	Travel Time	Service Time
Pomezia to L.58091033	26,977	35,0701
Pomezia to L.58091056	27,343	35,5459
Route Name	**Travel Distance**	**Service Distance**
Pomezia to L.58091033	30,611	39,7943
Pomezia to L.58091056	31,003	40,3039

Table 18: *Time and Distance estimations from Pomezia to designed intermediate logistics nodes*

After that, as a second phase of the "with scenario", the freight transport works from the designed intermediate logistics distribution centres to the final customers (receivers), which is aggregated as representative streets in Rome Capital City. The findings, in which are corresponding to the with scenario and automated vehicle opportunity, are represented as in the following table.

with	**Route**	**Time**	**N.V**	**Travel Time**	**Service Time**
Vehicle Type 1	Via Tiburtina to L.58091056	8,326	7	58,282	75,7666
	Via Nazionale to L.58091033	1,308	6	7,848	10,2024
	Via C. Colombo to L.58091056	8,413	5	42,065	54,6845
	Via Nomentana to L.58091033	7,041	5	35,205	45,7665
	Via dei Condotti to L.58091033	1,385	2	2,77	3,601
with	**Route**	**Distance**	**N.V**	**Travel Distance**	**Service Distance**
Vehicle Type 1	Via Tiburtina to L.58091056	7,316	7	51,212	66,5756
	Via Nazionale to L.58091033	1,139	6	6,834	8,8842
	Via C. Colombo to L.58091056	7,477	5	37,385	48,6005
	Via Nomentana to L.58091033	6,423	5	32,115	41,7495
	Via dei Condotti to L.58091033	1,038	2	2,076	2,6988

Table 19: *Logistic distribution with scenario findings, for time and distance estimation regarding vehicle type 1*

Subsequently, as the second phase of the 'with scenario', freight transport operates from the planned intermediate logistics distribution centers to the final customers (receivers), aggregated in representative streets of Roma Capitale. The results, corresponding to the 'with scenario' and the opportunity of traditional vehicles, are shown in the table below.

with	**Route**	**Time**	**N.V**	**Travel Time**	**Service Time**
Vehicle Type 2	Via Tiburtina to L.58091056	8,326	3	24,978	32,4714
	Via Nazionale to L.58091033	1,308	2	2,616	3,4008
	Via C. Colombo to L.58091056	8,413	2	16,826	21,8738
	Via Nomentana to L.58091033	7,041	2	14,082	18,3066
	Via dei Condotti to L.58091033	1,385	1	1,385	1,8005
with	**Route**	**Distance**	**N.V**	**Travel Distance**	**Service Distance**
Vehicle Type 2	Via Tiburtina to L.58091056	7,316	3	21,948	28,5324
	Via Nazionale to L.58091033	1,139	2	2,278	2,9614
	Via C. Colombo to L.58091056	7,477	2	14,954	19,4402
	Via Nomentana to L.58091033	6,423	2	12,846	16,6998
	Via dei Condotti to L.58091033	1,038	1	1,038	1,3494

Table 20: *Logistic distribution with scenario findings, for time and distance estimation regarding vehicle type 2*

All the aforementioned charts indicate that such designed intermediate logistics distribution nodes could have the potential to shorten travel times and service distances caused by unnecessary traffic congestion as well as to prevent unnecessary rides from the principal logistics distribution centre to the Roma Capital City outskirts.

After conducting the above-mentioned analysis, the following graphs illustrate the assessment of the findings in terms of service time and distance corresponding to the vehicle types, as shown in the following charts.

Figure 31: *Logistic distribution with scenario, for time and distance estimation regarding vehicle types*

In the conclusions, the tables and graphs indicate the calculated distances and the estimated times that correspond to the scenario definitions and vehicle types. Vehicle type 1 is assumed to be an automated vehicle, vehicle type 2 is assumed to be for the distribution technique for without scenario and vehicle type 3 is assumed to be for the transport of goods from the principal logistics distribution center to the designed intermediate logistics nodes (according to the benchmark designs and preceding studies). [*12*, *13*, *60*, *SHOW PROJECT*]

After these achievements, the comparison of the with-without scenarios was carried out with the corresponding also to the automated vehicle opportunity (*in which the vehicle type 1 is hypothesised due to vehicle capacity and referenced project "SHOW"*), as represented in the following table.

No	Street Name (Via)	Number of Deliveries	Without Scenario		With Scenario	
			Time Spent	Distance Travelled	Time Spent	Distance Travelled
1	VIA TIBURTINA	451	323,91	265,33	111,31	106,88
2	VIA NAZIONALE	344	242,32	214,93	45,27	48,68
3	VIA CRISTOFORO COLOMBO	311	158,42	131,07	90,23	88,90
4	VIA NOMENTANA	290	237,54	203,14	80,84	81,54
5	VIA DEI CONDOTTI	138	81,78	72,99	38,67	42,49

Table 21: *With-Without scenario comparison, corresponding to with automated solutions*

Following that, based on those achievements, the comparison of the with-without scenarios was carried out with the corresponding also to the traditional vehicle opportunity (*in which the vehicle type 2 is hypothesised due to vehicle capacity and referenced project "SHOW"*), as represented in the following table.

No	Street Name (Via)	Number of Deliveries	Without Scenario		With Scenario	
			Time Spent	Distance Travelled	Time Spent	Distance Travelled
1	VIA TIBURTINA	451	138,82	113,71	68,02	68,84
2	VIA NAZIONALE	344	80,77	71,64	38,47	42,76
3	VIA CRISTOFORO COLOMBO	311	63,37	52,43	57,42	59,74
4	VIA NOMENTANA	290	95,02	81,26	53,38	56,49
5	VIA DEI CONDOTTI	138	40,89	36,49	36,87	41,14

Table 22: *With-Without scenario comparison, corresponding to without automated solutions*

After those statements, the performance comparison of the with-without scenarios was carried out also corresponding to the traditional approach (*without AI, in which the type 2 vehicle is assumed*) automated vehicle opportunity (*with AI, in which the type 1 vehicle is assumed*) in terms of time saving, as represented below.

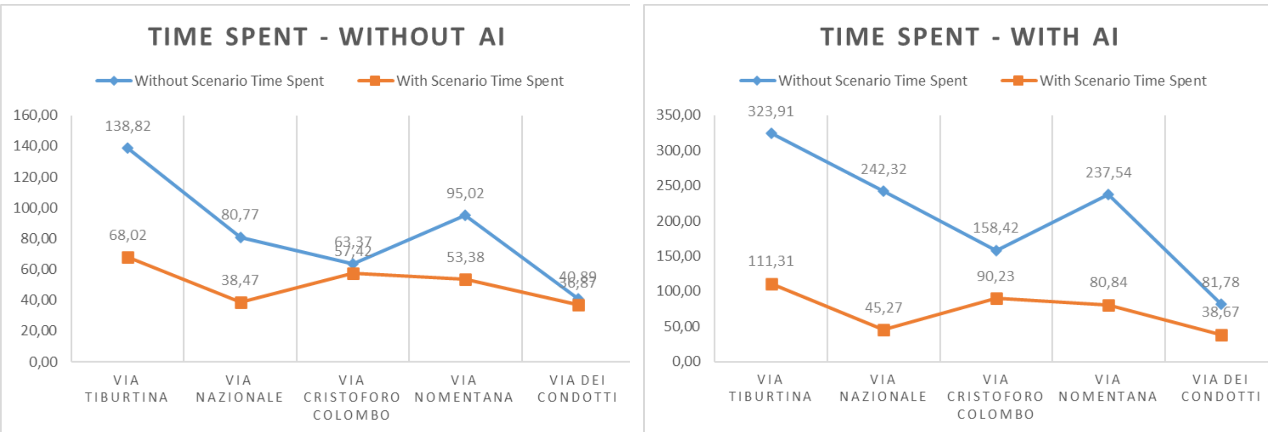


Figure 32: *Time Performance comparison of the with-without scenarios (with-without AI)*

Once these statements were made, the performance comparison of the with-without scenarios was even carried out also corresponding to the traditional approach (*without AI, in which the type 2 vehicle is assumed*) automated vehicle opportunity (*with AI, in which the type 1 vehicle is assumed*) in terms of distance saving, as represented below.

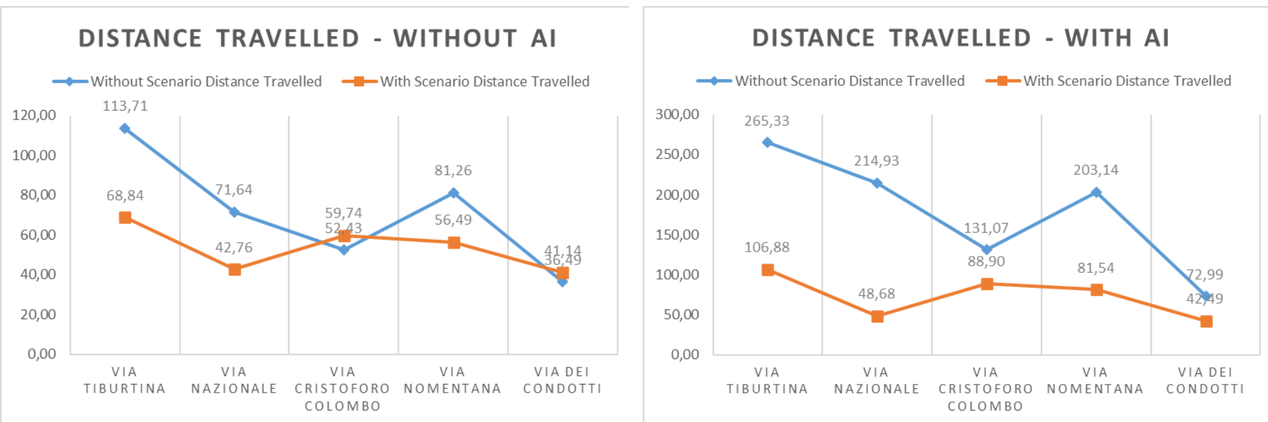


Figure 33: *Distance Performance comparison of the with-without scenarios (with-without AI)*

The above-illustrated graphs are showing the performance comparison (*savings compare to current status*) between the with-without scenarios corresponding to the traditional approach (without AI, in which the type 2 vehicle is assumed) and automated vehicle opportunity (with AI, in which the type 1 vehicle is assumed) in terms of time and distance saving all pointed out in one (*time is in minutes, and distance is in kilometres*), as represented below.

	With AI	Without AI	With AI	Without AI
Street Name (Via)	Time	Time	Distance	Distance
VIA TIBURTINA	212,60	70,80	158,45	44,88
VIA NAZIONALE	197,05	42,30	166,25	28,89
VIA CRISTOFORO COLOMBO	68,19	5,95	42,16	-7,32
VIA NOMENTANA	156,71	41,64	121,59	24,76
VIA DEI CONDOTTI	43,11	4,02	30,49	-4,65

Table 23: *Time and Distance Performance in comparison between with-without AI opportunities*

The graph below compares the performance (*savings compare to current status*) between the with-without scenarios corresponding to traditional approach (*without AI, vehicle type 2 is assumed*) and automated vehicle opportunity (*with AI, vehicle type 1 is assumed*) in terms of time and distance savings, represented together (*in percentage*), as shown.

	With AI	Without AI	With AI	Without AI
Street Name (Via)	Time	Time	Distance	Distance
VIA TIBURTINA	65,6%	51,0%	59,7%	39,5%
VIA NAZIONALE	81,3%	52,4%	77,4%	40,3%
VIA CRISTOFORO COLOMBO	43,0%	9,4%	32,2%	-14,0%
VIA NOMENTANA	66,0%	43,8%	59,9%	30,5%
VIA DEI CONDOTTI	52,7%	9,8%	41,8%	-12,7%

Table 24: *Time and Distance Performance in comparison between with-without AI opportunities (percentage)*

As mentioned in the previous table, the following chart is illustrating the time spent saving comparison between with-without scenarios in accordance with the vehicle types, as shown below (*in percentage*).

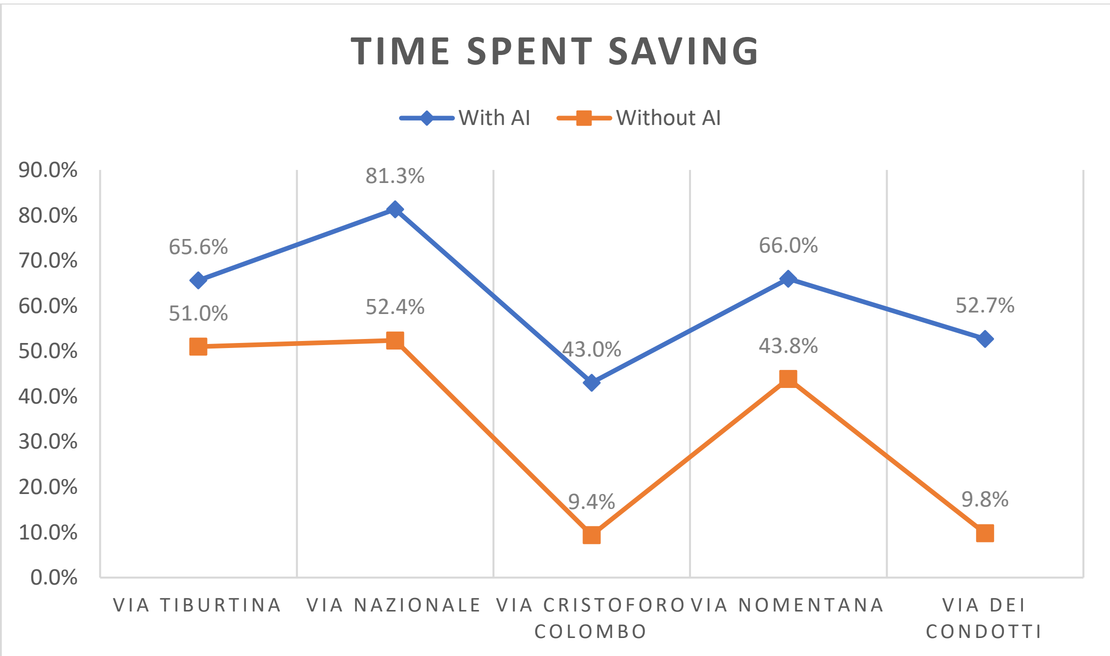


Figure 34: *Time Performance comparison between with-without AI opportunities (percentage)*

As mentioned in the previous table, the following chart is illustrating the time spent saving comparison between with-without scenarios in accordance with the vehicle types, as shown below (*in percentage*).

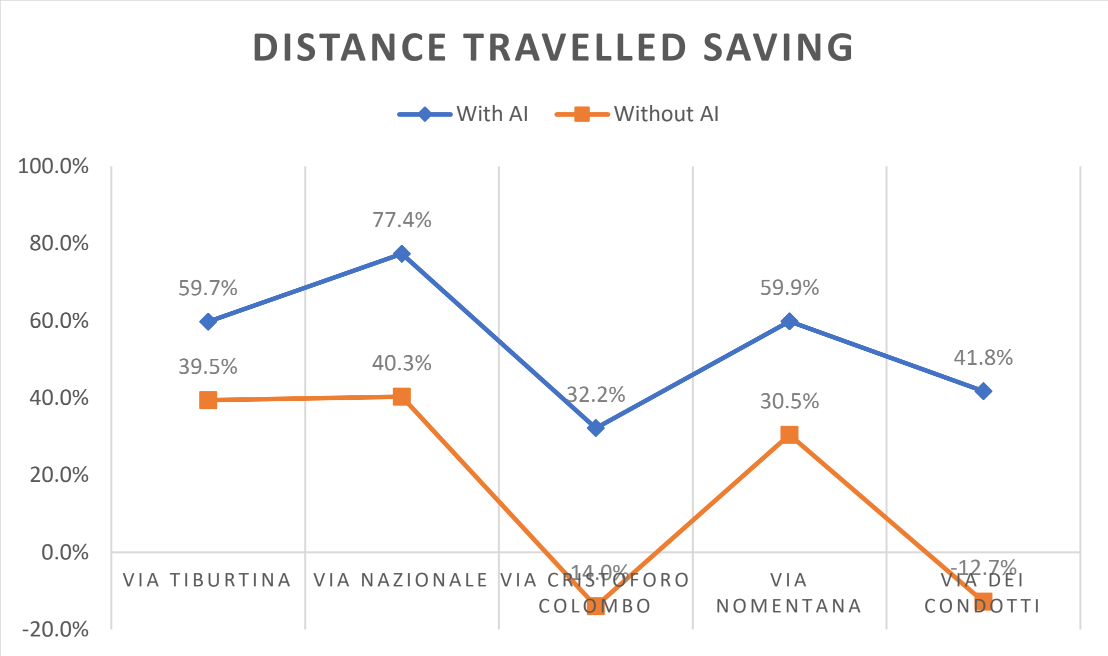


Figure 35: *Distance Performance comparison between with-without AI opportunities (percentage)*

Based on the comparisons previously done in the above-illustrated graphs, the following outcomes are found from such an ALaaS simulation deployment, as summarized below:

The time savings demonstrate that logistics paths have a time-saving tendency when designed intermediate logistics nodes are presented; similarly, they have a time-saving tendency if an ALaaS solution is also presented. On the other hand, logistics routes have a higher time-saving trend if an ALaaS solution could also be implemented. In the final analysis, the results indicate that the trend in time spent is approximately 40% in favour of reduction when both of the improvements (both the designed intermediate logistics routes and the ALaaS solution) are being implemented.

The distance travelled savings illustrate that logistics paths generally have a distance saving tendency; however there are some individual cases that they have an increased distance travelled while having the scenario for designed intermediate logistics nodes are presented. If also an ALaaS solution is presented, most of the cases are illustrating that distance travelled is saved if it is compared with the current status. Beyond that, if both improvements are presented, namely designed intermediate logistics nodes and ALaaS solution are presented, the distance travelled has an increased saving than without ALaaS solution scenario and current status. So that, the findings show that with designed intermediate logistics nodes some logistics paths could save distance travelled, some not. In parallel, if an ALaaS solution would be deployed, all logistics paths could become distance travelled saved.

The results show that the implementation of ALaaS saves time and distance compared to the current state and even more than scenario for designed intermediate logistics nodes are presented. The scenario designed for intermediate logistics nodes also has the advantage of saving time and distance in most cases.

In conclusion, the designed intermediate logistics nodes scenario has the potential to make a logistics service more efficient and effective, as well as sustainable. In the meantime, the implementation of an ALaaS solution has a higher potential to make it efficient more than before and even more than the designed intermediate logistics nodes scenario.

A performance analysis is critical for the success of Automated Logistics as a Service (ALaaS) concepts in real-life deployments. Regarding this matter, there are some key factors why performance analysis in real-life implementations is important in ALaaS concept, as listed below:

- Assuring safe and reliable operations: A safety assessment is key to guaranteeing that ALaaS installations are both safe for operators and users. Among other things, this means identifying potential threats, such as collisions or equipment failures, and adopting measures to mitigate such risks. Performance analysis is needed to make sure that the performance of the whole concept is reliable and works as intended.
- Standards compliance: ALaaS providers are required to meet several regulations and standards related to safety and performance. A safety analysis assists in ensuring conformity with regulations related to equipment, vehicle operation as well as other aspects of the overall concept. After that, a performance analysis then contributes to ensuring compliance with regulations on speed, efficiency as well as other factors.
- Increasing stakeholder satisfaction: A safe and reliable real-life deployment is essential to assure stakeholder satisfaction. If stakeholders perceive the ALaaS concept as unsafe or unreliable, those stakeholders are likely to be unwilling to use such a service or to change to another one. Such an analysis for security and performance could contribute to guaranteeing that the service is reliable and works as expected, increasing stakeholder satisfaction.
- Optimize disruptions: A real-life deployment performance analysis assists in identifying any potential problems before they lead to outages, thereby allowing stakeholders to take preventative measures and minimize the impact of outages when they do occur.
- Improving efficiency: Performance analysis helps to identify areas of the system that can be optimized to improve efficiency. This includes factors such as route planning, load balancing, and delivery scheduling. By optimizing these factors, ALaaS can reduce costs and improve overall efficiency.

Across the board, performance analysis is essential for the success of such an ALaaS concept deployment. Through guaranteeing safe and reliable real-life deployments and operations, respecting regulations, increasing customer satisfaction, minimizing disruptions, and improving efficiency, ALaaS concepts are able to establish a service that satisfies customer and stakeholder needs, while at the same time remaining market competitive. Furthermore, ALaaS is a complex concept that requires an accurate review to guarantee safety, efficiency, and performance aspects. As above-mentioned, those principal arguments are important to address while the analysis of safety, efficiency and performance is important within real-life deployment findings of such an ALaaS concept testing.

In the respect of the previously mentioned issues, a real-life deployment is planned and studied in relation to the reference project (*EC funded SHOW project*). As far as this aspect is concerned, the deployment site is supported by this research study's arguments through automated logistics scenarios, performance indicators and definitions and calculation methods, as well as general assistance and support before, during, and after the deployment phases.

In this line, the real-life deployment is to have an introduction of new kind of logistics service with droids (*supply kiosks on the pedestrian zone with goods in order to avoid entering the pedestrian zone big vehicles such as mini vans*), having an overview of the technical Implementations, enhancement of vehicles and infrastructure if needed, and technical assessment in pre-demo activities and demo activities. Beyond that, the following table represents the real-life deployment findings, which occurred on 14/02/2023 in Trikala (Greece), in association with the reference project under the demonstration site planning of "Project SHOW".

		Start Time Stamp	Finish Time Stamp	Duration (*min*)	Speed Forward (*m/s*)	Speed Return (*m/s*)	Delivery Booked	Delivery Received
UNIT 04	Stand-Up	2023-02-14 T07:22:37	2023-02-14 T09:24:59	122	0.0155738	-0.03641	--	--
	Cargo	2023-02-14 T07:26:33	2023-02-14 T09:24:37	118	0.161497	-0.03544	34	30
UNIT 05	Stand-Up	2023-02-14 T07:20:50	2023-02-14 T10:13:59	173	0.025251	-0.05496	--	--
	Cargo	2023-02-14 T07:50:53	2023-02-14 T10:10:04	130	0.0256985	-0.05469	28	25

Table 25*: Real-life deployment results, in Trikala*

After that, because of the limited data available and having an efficient comparison, ten performance indicators (*specified in accordance with previously defined and prioritized key performance indicators*) are chosen to calculate (*not possible to perform with the data available due to implementation shortages happened during the Covid-19 pandemic*), as listed in the following:

- Journey Length
- Journey Speed
- Time of Delivery
- Distance of Delivery
- Number of Cargo Transported
- Loading/Unloading Duration
- Vehicle Data (*vehicle-kilometre*)
- User Acceptance
- Stakeholder Acceptance
- Satisfaction Level

As a reminder, the theoretical acceptance analysis and simulation are making one part of comparison parameters; on the other part, the real-life deployment results will be tried to have a senseful comparison.

The real-life deployment results demonstrate that, in 120 minutes, approximately 30 deliveries can be made at a speed of about 0.5 km/h. This is a relatively poor operational speed when considering the traditional approaches. This is a rather low operational speed when considering the traditional approach. Nevertheless, it does not require the presence of a human on board so as to save operational and management costs; besides, it does require a skilled user experience and an adapted stakeholder attitude.

7.2. Standardization: Developed Impact Assessment Framework on Automated Logistics as a Service

Logistics technologies have undergone significant changes in recent years due to technological advances. Automation is an important aspect of logistics technology that could contribute to increasing efficiency, reducing costs and improving customer satisfaction. However, the implementation of automation in logistics technology requires standardization to ensure seamless integration and interoperability between different systems. This standardization provides an overview of the prior experienced standardization of automated logistics technology for implementation.

One of the main advantages of standardization in automated logistics technology is the ability to achieve seamless integration between different systems. Standardization thus can serve to reduce the complexity of logistics systems by establishing common protocols, interfaces and data formats. This can eliminate the need for customised integrations, which can be time-consuming and costly.

In a study by Zhang and colleagues (2019), the authors examined the impact of standardization on the adoption of automated logistics technology. The study identified that standardization has a fundamental role to take in the successful implementation of automated logistics technology, especially in large-scale logistics operations.

Another important aspect of standardization in automated logistics technology is inter-operability. Interoperability is referred to as the ability of various systems to continuously communicate and exchange data-information. Such an aspect is particularly important in logistics, in which different systems and technologies are used to manage various aspects of the supply chain.

The study by the European Commission (2016) stated that interoperability is a crucial factor for the success of automated logistics technology deployment. It was pointed out in the study that the absence of interoperability is one of the main barriers to the adoption of automated logistics technology in Europe. The study recommends the further development of shared standards and protocols to make interoperability easier and reduce the complexity of logistics systems.

Standardization could even contribute to improving the quality of logistics services by ensuring consistency and reliability. In a study by Rahman and colleagues (2019), the authors remarked that standardization has a key role to guarantee the quality of logistics services, especially in the context of e-commerce logistics.

Eventually, standardization could potentially help to reduce the costs of logistics operations by eliminating the need for customized integrations and reducing the complexity of logistics systems. In a study by the National Institute of Standards and Technology (2015), the authors found that standardization could significantly reduce the implementation costs of automated logistics technology by up to 50%.

In summary, standardization is an important aspect of the implementation of automated logistics technology in real-life operations. Standardization could facilitate seamless integration and interoperability among different processes and enhance the quality of logistics services while reducing the costs of logistics operations. Standardization efforts can be expected to focus on the development of shared protocols, interfaces, and data formats to enable interoperability across logistics processes and reduce the complexity of those services. Following that, the following steps can be undertaken to further develop a standardised framework for the implementation of automated logistics technologies:

- Identifying the scope and objectives of the framework: The first step is to clearly define the scope and objectives of the framework. This involves identifying the specific types of automated logistics technology to be standardised and the objectives that the framework intends to achieve.
- Conduct a gap analysis: The next step is to conduct a gap analysis to identify the current state of automated logistics technology implementation and any gaps or deficiencies in existing systems. This can be done through surveys, interviews, and site visits.
- Develop standardised protocols and interfaces: Based on the results of the gap analysis, develop standardised protocols and interfaces that can be used between different automated logistics systems. This includes the development of common data formats, communication protocols and application programming interfaces (APIs).
- Establish interoperability requirements: Define interoperability requirements to ensure that different automated logistics systems can communicate and exchange data seamlessly. This includes defining the specific data elements that must be exchanged between systems, as well as the frequency and format of data exchanges.
- Develop testing and certification procedures: Develop testing and certification procedures to ensure that automated logistics systems comply with standardised protocols and interfaces. This includes the development of test scenarios and test scripts, as well as the definition of specific performance metrics that automated logistics systems must fulfil.
- Implement and monitor the framework: Implement the framework and monitor its effectiveness over time. This includes monitoring the adoption of standardised protocols and interfaces, monitoring the performance of automated logistics services and collecting feedback from stakeholders to continuously improve the framework.

In general, standardising the implementation of automated logistics technology requires a systematic approach that involves identifying the scope and objectives of the framework, conducting a gap analysis, developing standardised protocols and interfaces, defining interoperability requirements, developing testing and certification procedures, and implementing and monitoring the framework over time.

Following that, the determined and recommended automated logistics as a service impact assessment framework has been standardized as summarised in the following:

- Purpose and Objective,
- State of Art – Literature Review,
- Impact Areas and KPIs and Prioritization while having a questionnaire-workshop development,
- Tools and Methods together with workshop, questionnaire guideline, roadmap, and a smart integration-adaptation instrument,
- Data Gathering through demonstrations towards pilot/test sites and digital twin, and
- Evaluation Process through logistics performance assessment techniques

Based on the above-mentioned approach, the Demo Sites are the application sites of the projects are interested in obtaining several operational data that would be used for the impact assessment that has the logistics indexes.

The Stakeholders would be defined during the demo site applications to be related to the management process, tracking of the material flows, and flow of the information parts of the logistics services. On the other hand, the stakeholders are mainly logistics managers, receivers, senders, and transfer-related personnel.

The Objectives would be defined according to the demo sites logistics works definitions to be related to the sustainability and transferability of the logistics services concerning material transfers and process management.

The Logistics Impact Areas are mainly related to processing management, material transfers, and getting/sharing information. For this reason, the economy, service acceptance level, sustainability, transferability are the main areas of the logistics impacts.

The Performance Indicators are defined to answer highlighted impact areas. For that, the indicators are extracted from the literature concerning prioritization. Additionally, the Grand Agreement mentions several performance indicators that would be also considered.

The Data Collection/Obtaining methodology has been developed through the following key steps:

- Literature Review aims to give preliminary information about the logistics performance indicators, assessment framework, and evaluation criteria-methods,
- KPIs definition (obtaining information from mentioned projects) and Indexes targets to analyse various indicators for the logistics service features and logistics index definition for the evaluation and assessment,
- Project demo cases monitoring and results taking (obtaining information from mentioned projects and simulation) highlights the data collection from demo cases concerning indexes and indicators,
- Assessment and Evaluation seek to establish an evaluated link between data and indicators and indexes.

The Assessment procedure refers to the Logistics Indexes (which are detailed in the annexes) that are the following:

- Logistics Sustainability Index (LSI)
- Logistics Maturity Index (LMI)
- Logistics Transferability Index (LTI)

7.3. Connected Cooperative Automated Logistics

The chapter will be about for further analysis how to integrate new technologies and digitalized logistics services with the current-traditional logistics processing. As a preliminary, key objectives are listed as following:

- Increasing the efficiency of logistics processing by digitalization,
- Ensuring the interoperability of automated freight transport and traditional logistics services,
- Reduce the environmental-related impacts of the logistics services from road transport,
- Increase the efficient operations between automated and traditional logistics considering cooperation and connection,
- Knowledge-based gaining and improvements for further automated logistics service implementations.

The Connected Cooperative Automated Logistics (CCAL) Analysis would be considered concerning real-time implementations outcomes, impact assessment results to identify the user/customer expectations and social harmonization for further developments and automated logistics services. The CCAL would be targeted to increase the logistics service efficiency, sustainability in the urban areas, and interoperability of new-old logistics technologies.

Connected Cooperative Automated Logistics (CCAL) is a new logistics paradigm involving the integration of connected and cooperative technologies with automated logistics systems. This review provides an overview of CCAL, its potential benefits and challenges.

One of the main benefits of CCAL is improving efficiency and cost effectiveness. Connected technologies, such as the Internet of Things (IoT) or smart adaptation tools, can provide real-time visibility into logistics operations, enabling logistics managers to make better decisions on inventory management, routing and scheduling. Cooperative technologies, such as collaborative and automated vehicles, can improve the efficiency of logistics operations while reducing the demand for human intervention and simplifying processes.

In a study by Lee and peers (2020), it is proposed a CCAL framework that integrates connected and cooperative technologies with automated logistics systems. The study identified that the proposed framework could boost the efficiency of logistics operations, reduce the costs of logistics services and improve customer satisfaction.

A further significant aspect of CCAL is the associated potential for increasing safety and sustainability. Connected and cooperative logistics services can contribute to reducing the risk of accidents and casualties in logistics operations, while reducing the environmental impact of logistics operations through more efficient routing and decreased fuel consumption.

In a study by Hasko and colleagues (2020), the study is examined the potential of CCAL for reducing logistics sector emissions of greenhouse gases. The study found that CCAL could significantly reduce emissions by optimising routes and reducing empty runs.

Even so, there are also several challenges related to the deployment of CCAL. Among others, the main challenge is the need for interoperability and standardisation. CCAL implies the integration of multiple technologies and systems, which demands the development of joint protocols and user interfaces to ensure seamless integration and interoperability.

In a study by the International Organisation for Standardisation (2019), the authors have identified the need for standardisation in the implementation of CCAL. The study recommends the development of common protocols and interfaces for data exchange, as well as the definition of interoperability requirements for connected and cooperative technologies.

Another challenge is the necessity of a qualified workforce and training. CCAL includes the integration of automated systems with related and cooperative technologies, which require a qualified workforce with expertise in those technologies. This requires a significant amount of training and education to guarantee that the labour force has the necessary skills to operate and maintain CCAL systems.

To conclude, CCAL is a promising logistics technology paradigm that involves the integration of connected and cooperative technologies with automated logistics systems. CCAL has the further potential to improve efficiency, reduce costs, increase security and sustainability, but its implementation requires standardisation, interoperability, and a qualified labour force. Efforts should focus on developing shared protocols and interfaces, defining interoperability requirements and investing in training and education to ensure a qualified labour force.

Beyond that, Connected Cooperative Automated Logistics is an up-and-coming logistics management paradigm that integrates connected and cooperative technologies with automated logistics solutions. As above-mentioned, CCAL has the potential to transform logistics operations by improving efficiency, reducing costs, increasing safety and sustainability, and improving customer satisfaction. There are some of the main features of CCAL, as summarized in the following:

- Increased efficiency: CCAL is able to drastically improve the efficiency of logistics operations by giving real-time insight into logistics processes, thereby allowing logistics decision-makers to make improved decisions on inventory management, routing and scheduling. This can also lead to a decrease in delivery times, inventory costs and productivity.
- Cost reduction: CCAL could also reduce the costs of logistics services by reducing the need for human intervention as well as optimising logistics processes. This could result in a reduction of labour costs, fuel consumption and maintenance costs.
- Enhanced safety: Connected and cooperative technologies could assist in reducing the risk of accidents and injuries in logistics operations by enhancing the transparency of logistics processes and reducing the demand for human intervention. This could improve safety in the workplace for logistics professionals while reducing the risk of accidents involving other vehicles and VRUs.
- Improved sustainability: CCAL can likewise enhance sustainability by decreasing the environmental impact of logistics operations. Connected and cooperative technologies could optimize routes, reduce fuel consumption, and minimize empty runs, resulting in reduced greenhouse gas emissions and carbon footprint.
- Improved stakeholder satisfaction: CCAL can also boost stakeholder satisfaction by providing improved and more reliable delivery services. Real-time transparency of logistics processes could assist logistics service stakeholder in providing precise delivery estimates and providing proactive notifications to stakeholders about delays or problems.

As a whole, CCAL is a significant development in logistics related advancements that have the potential to substantially upgrade logistics operations by boosting efficiency, reducing costs, increasing safety and sustainability, and improving stakeholder satisfaction. As the logistics sector keeps evolving, CCAL is set to take an ever more important place in modelling the future of logistics sector. Subsequent to that point, the development of a roadmap addressing automated logistics services is fundamental for various motives:

- Efficiency: Developing a roadmap for automated logistics services could contribute to increasing supply chain efficiency. Automated logistics services are likely to reduce the time and costs associated with human intervention processes, such as sorting, packing, and transporting goods. A roadmap could assist in identifying impact areas in which automation could have the greater impact as well as ensuring that the necessary resources are allocated to those particular areas.
- Safety: Automation could contribute to improving safety in the logistics sector. Automated vehicles and equipment are likely to reduce the risk of accidents and injuries associated with human handling. Developing a roadmap is likely to also provide help in ensuring that appropriate safety measures are in effect, such as employee training programs and implementation of safety protocols.
- Scale-up: Automation can support decision-making in scaling logistics operations quickly and efficiently. A roadmap is likely to assist in identifying the necessary moves to scale automation at different phases of the supply chain. Doing so could involve identifying the most mission-critical focus areas for automation and prioritizing efforts to invest in those areas.
- Data-driven decision making: Automated logistics services generate a huge amount of data that could be used to improve operations. A roadmap can then help identify the most valuable data to collect and

analyse, as well as the tools needed to do so. In that process, decision-makers could make data-driven decisions that improve efficiency and reduce costs.

- Competitive benefit: Developing a roadmap for automated logistics services could give decision-makers a competitive advantage. By investing in such an ALaaS concept, decision-makers can improve logistics operations and reduce costs, which can then convert into lower prices for stakeholders. Furthermore, decision-makers can adopt automation as first in which can earn a reputation for being innovative and forward-thinking, which can further attract new stakeholders and retain existing ones.

In short, the development of a roadmap for automated logistics services is imperative for decision-making that want to improve efficiency, safety, scalability, data-driven decision making, and gain a competitive advantage. By having identified the performance areas in which automation could have the most impact and then investing in the necessary resources, decision-makers could potentially transform the logistics operations and foster further growth.

The guideline is developed and produced for such an innovative ALaaS solution deployment in real-life operations while having sufficient integration and adaptation. Regarding that, this part intends to determine a guideline for an automated logistics service implementation in operational aspects, in particular industrial stakeholders, to support the efficient adaptation of new technologies.

Automation and Digitalization of Logistics Services (Automated Logistics as a Service) support several subjects regarding easier management and operational processing. The automated logistics guideline targets to avoid possible implementation mistakes and consequences of the manual order fulfillment technique as listed below:

- Lack of process visibility
- High order processing costs
- Order processing errors
- Slower processing cycles

To avoid these sorts of process difficulties, various automated logistics services have been offered regarding digitalized and intelligent processing, management, and monitoring strategies. Having an efficient implementation of the offered automated logistics services in an organization, it is recommended to follow a set of essential phases as detailed below:

1. Digitalized Ordering process
2. Automated Order Analysis
3. Intelligent Packaging
4. Automated Shipping
5. Intelligent Confirmation of Arrival and Approval

Based on project objectives, the automated service and digitalization of logistics process have been designed and summarized for each abovementioned phase in the following.

Phase 1: *Digitalized Ordering Process*

- *Receiving orders via software (digital purchasing, e-mail or phone call)* is the first step to having an online purchase procedure for the digital order process. It aims to have a “no human intervention” when a company would create orders. An automated purchase order technique digitalizes the buying-process to save time and resources. To implement it, a Digital Request Software installation is required for approval, sending the purchase to a vendor, tracking the purchase order, and create a digital receipt.
- *Ordering and Stocking goods for warehouses with a digitalized process:* an automated warehouse management system (a variety of mobile applications/QR-code/RFID + RPA) would be a substantial opportunity to simplify the process. To have it, as a first step, sensors and software are required to be implemented to monitor stock numbers, quality, and product details by registering on software. After that, sensors would be placed in a warehouse with scanners and QR or Barcodes on the products. Then, the

software will keep the data continuously updated, and monitor the quality and numbers to provide notifications to the operational manager if purchasing or management is needed.

- *Inventory management and goods replacement:* By installing an IoT-based sensor to identify products quickly and efficiently, the materials will be located efficiently, placement and numbers (counting) process can be simplified. Detectors will monitor the warehouse continuously and advise the manager if there would be a lack of products and/or it will inform software to make an online order purchase.
- *Storage systems for monitoring the status of products* maintain the IoT/Sensors and web/mobile applications for real-time monitoring of the temperature and status (refers to quality loss, damage, etc.) of the products in any environment
- *Digitalized Distribution (warehouse, inventory, assets)* re-organizes three key processes for warehouse, inventory, and distribution. This regards material movements from the storage area (by an automated logistics vehicle) to the transfer point that will be loaded on transport mode or vice-versa.

Phase 2: *Automated Order Analysis*

- *Replacing existing control procedures with an automated approach* would enhance the assuring quality and legal aspects significantly. Automated controlling would give real-time monitoring of products (after receiving orders, counting of existing products), it is manageable to measure and check the status of products from anywhere and anytime. Likewise, automated control techniques assure convenience for detecting damaged or defective products in real-time controlling if any accident occurs during the delivery-transport. This action also implicates the legal status inspection for each order-purchasing before and during the transfer (regarding custom checks, legal-regulative concerns, etc.)
- *Automated Stock Keeping and Control,* the logistics personnel/staff will be able to easily organize and monitor the products and assemble them effortlessly searchable. By setting up an automated stocking, keeping, and detecting, each product will be efficiently accessible. The automated stock keeping and control (by software and sensors) will sustain the monitoring, product counting, and placement while having no complications in exploring any product within the warehouse.
- *Digital customer service* leads to the use of automated/digital business transformation solutions to overcome shortcomings (available full-time) and generate positive customer service all the time.
- *Automated labor and asset management* is for managing and accounting for assets and works to maintain processes and interests in laborious actions (regarding order analysis professions). With manual-only strategies to track the efficiency and overall performances of assets and works would direct to incurred costs. It is always more acceptable for a digital method (software-based) to maintain entire management over resource control.

Phase 3: *Intelligent Packaging*

- *Intelligent Product Picking* is all about selecting the right material from the inventory for packing. Specifying the proper material out of multiple is consistently demanding and needs severe action. This consumes more time and causes delays packing procedure before transshipment. With an intelligent inventory management approach, materials would be efficiently located within a warehouse (storage area). As the real-time detectors (supported by software) are bound to the materials/products, there will be assistance with signs when materials will be scanned to be selected for transfer.
- *Intelligent Packing* is an action in which the product will be packed in pallets, containers, or boxes for transshipment. It is all about choosing and locating the right materials on the right package; however, performing this activity manually would cause some misconceptions in the form of misplaced or missed materials. By labeling the products with automated assistance (from storage to pallet/box), sensors and software will sustain the packing right items uncomplicated and gives a value of assistance during unpacking. As known the entire data of what kind of products are packed in which container, it is easy to scan and unpack them post shipping and for legal procedures (custom check, if needed). Automated packing systems also support monitoring the overall packed containers and prevent missing any during the transfers. Furthermore, physical movement of the products inside the

warehouse would be done by an automated logistics vehicle from stored area to packaging, from packaging to container or vehicle.

Phase 4: *Automated Shipping*

- *Automated Shipping* directs to the picking and packing time of products would affect the shipping phase, there are other factors that could delay such as environmental conditions, route optimization problems, and package storage temperatures. With automated shipment processing for order fulfillment, sensors and software will support real-time monitoring of environmental conditions and rough sea conditions to determine alternate routes to ensure fast and safe delivery. Also, automated management of shipping will guarantee continuous route optimization and design for the shipments.
- *Automated Transportation* encloses intelligent route optimization, fuel cost estimation, and shortest distance traveled by using assistance from sensors-supported software that continuously evaluates the optimum route during the transfer respecting environmental conditions, dangers, traffic conditions, etc.
- *Intelligent Costly Errors* mean an inaccurate data estimation about fuel expenses, travel distance, and delivery time during the transfer (after the transfer started). With an intelligent solution (software and detectors), the routing will be simplified for managers/drivers to plan the transfer perfectly and deliver products on-time when there would be unexpected problems such as bad weather, traffic congestion, etc. by informing cost changes and savings.
- *Route optimization* mentions preventing routes that have possible troubles, and determining alternate routes to deliver the products within the prescribed time. Precise data monitoring will enable the material shipment with real-time cautions about the product damages and traffic/environmental conditions to allow delivery transfer with optimized routing (continuously provided by software with support of detectors/sensors) for defect-free product delivery. The digitalized route optimization will be provided before and during the shipment -means- from the sender to the final customer.
- *Intelligent Siloed Data for Logistics Management* refers to assisting a logistics service with intelligent systems, monitoring the real-time data of the logistics operation, and accumulating them in a centralized software if possible. Having this intelligent data approach, processing the data and assembling decisions at required times will be effortlessly done to avoid delays and any risky movements that would cause damage or product losing. This is a prediction phase that will be done with help of siloed data to allow efficient optimization, time prediction, and risk management.

Phase 5: *Intelligent Confirmation of Arrival and Approval*

- *Intelligent Confirmation by mobile application or software* would be an option for the last step of management actions: the digital confirmation will provide real-time data and status updates about the performance of logistics operations from anywhere at any time. With an automated approval/confirmation in a centralized web dashboard, the internal destination operators and final customers will efficiently approve (send feedback) the transfer and declare the problems (if any damage happens). This method assembles the approval of the arrival of materials in an efficient way and sustains the notifications if there would be any damage during the transfer to improve the efficiency and performance of resources to reduce costs.

8. Conclusion

The case study on the acceptance of automated logistics as a service concludes that the assessment of the acceptance of automated logistics services is not well represented in previous studies. The analysis of the questionnaire responses shows that the respondents generally have a medium to high level of acceptance of an automated logistics service; however, they express some significant concerns regarding safety and security, questioning the loss of jobs, the risk of vandalism and theft, and the risk of collision-accident while operating in the city. Respondents declared themselves willing to use such an automated logistics service, showing that they expect high efficiency. Differences between age groups were also shown to have an effect on the level of acceptance of such a service, with younger ages in particular having more interest and expectations in transport automation. The same can be said for transport users: they expect greater social acceptance and willingness to use automated delivery systems. It is interesting to note that unemployed citizens are more willing to use such a service; however, they do not want to have such a service on a city scale (due to concerns about losing their jobs).

In conclusion, it is surprising that citizens generally have greater trust in automated services and their efficiency; however, they do not feel safe without the presence of a human on board. In the same succession, this service would have fewer processes and journey times due to automation; however, respondents think that tracking the automated logistics vehicle would not be easy. Interestingly, almost all citizen clusters have a higher willingness to use and mention automated logistics services; however, they do not assume that society would accept them on a city scale.

Subsequently, the regression analysis indicates that acceptance is significantly influenced by the characteristics of the case study scenario, the age group of the users, their profession and their previous knowledge and experience of automated transport.

Concerning the respondents' comments on improving the quality of the automated logistics service, the following points are mentioned: difficulties in implementing such a service due to poor infrastructure quality and architectural design problems; potential increase in the number of accidents (for both vehicles and pedestrians); exposure risks. Conversely, it is expected to increase the efficiency of the delivery service and reduce negative environmental impacts.

Consequently, the recommendation is to have a roadmap that mentions a preliminary assessment of user needs and requirements for logistics acceptance evaluation guidelines. Furthermore, the acceptance of automated logistics services depends on security concerns, with a marginally negative dependency (due to the precaution of theft and collision risks) and a significantly positive dependency in relation to efficiency and sustainability.

In regard to the case study for the logistics simulation, there are various findings to be understood. As regards the service time, the time spent is saved by a mean of about 35% compared to the existing approach if the planned intermediate logistics nodes are presented; furthermore, the time spent could be saved by a mean of about 60% compared to the traditional approach if an ALaaS solution were also implemented in the scenario of the planned intermediate logistics nodes presented. On the other hand, the time spent could be saved in all logistics paths represented in the city of Rome if the designed intermediate logistics nodes were presented; furthermore, there is more time saving if an ALaaS solution could be also implemented. However, the more congested and narrow logistics routes (*according to the traffic data collected during last three years; 2020-2022, under the PRMTL project, in Lazio Region*) show better performance for the implementation of the ALaaS solution, which saves time by displacing unnecessary vehicle movements and managing them in real time routing. This is why some logistics paths in Roma Capital City show lower time savings than others. Meanwhile, most cases show that this automated logistics solution has the potential to save more time and more distance travelled for the same number of deliveries made.

As far as the service distance is concerned, the distance travelled is saved on average by about 25% (*because there are two identified logistics paths in which they had more distance travelled than in the current state*) compared to the existing approach if the planned intermediate logistics nodes are presented; in addition, the distance travelled could be saved on average by about 55% (*there is no logistics path in which they would have more distance travelled than in the current state*) compared to the traditional approach if an ALaaS solution were also implemented in the scenario of the planned intermediate logistics nodes presented. On the other hand, the distance travelled could be saved in more than half of the chosen logistics paths represented in the city of Rome if the designed intermediate logistics nodes were presented; furthermore, the distance travelled could be lowered in all logistics paths if an ALaaS solution could be implemented together with such planned intermediate logistics nodes are presented. However, as similar to the time spent saving, the most congested and narrow logistics routes show better performance for the implementation of the ALaaS solution, which saves distance travelled by displacing unnecessary vehicle movements and managing them in real-time routing. This is why some logistics paths in Roma Capital City show an increase on the distance travelled, and others show distance travelled saving. Meanwhile, most cases show that this automated logistics solution has the potential to save more time and more distance travelled for the same number of deliveries made. When an ALaaS solution is presented, all logistics paths are showing the distance travelled saving; on the contrary, without ALaaS solution, some logistics paths are having more distance travelled than current status as well as than without planned intermediate logistics nodes are presented.

As for the case study of real-life implementation, and according to the previously mentioned weighting, sustainability assessment is ranked as the most important measure of the performance of ALaaS implementation. Besides, the results indicate that trip length, speed and on-time delivery are the most important parameters among logistics stakeholders to highlight for the success of ALaaS implementation in urban areas.

Following that, the maturity assessment is ranked as the second most critical assessment matter for performance analysis of ALaaS implementation. This assessment is concerned with the technological readiness of logistics sector actors. The outcomes point to delivery time and experience as the most important performance indicators for measuring the success of ALaaS implementation in urban areas.

In the last the final set of results, the evaluation of transferability was ranked as the third important performance measure of ALaaS implementation. The results show that locker availability and parking facilities are the most important performance indicators for measuring the success of ALaaS implementation in urban areas.

Real-life deployment results demonstrate that, in 120 minutes, about 30 deliveries can be made at a speed of about 0.5 km/h. This is a relatively low operational speed when considering traditional approaches. This is a relatively low operational speed when considering traditional approaches. This is a rather low operational speed when considering traditional approaches. However, it does not require the presence of a human being on board, so as to save on operating and management costs; it also requires a qualified user experience and an appropriate attitude from stakeholders.

During the real-life implementation, it has been realized that an intelligent tool for the adaptation and integration of such an automated logistics service in the present society is highly valuable. In this regard, this designed and defined intelligent tool is being further developed (updated with some new services) and will be further presented on the market.

In the end, the case studies are showing an opportunity for automated logistics as a service concept as being one of the pioneers in research on the improvements in various research areas of automated logistics services, such as: (*considering acceptance, time spent and distance travelled savings*)

- Cost reduction, such as lower energy consumption, personnel costs, management costs, etc.,
- Improved usefulness of interaction, instead of personnel, infections, etc.,
- Simplified communication between the operations and stakeholders,
- Decreased environmental impacts,
- Enhanced availability for disability and disutility,
- Increased safety and security,
- Higher efficiency through reduction of being lost and damaged materials.

Next Steps

The research study will continue in the further data collection phase in order to have an overall implementation of the developed impact assessment framework. The current availability of data does not allow the successful implementation of logistic evaluation indexes, which could produce significant outcomes when more data become available.

Due to the COVID-19 pandemic, there were a number of restrictions that caused a lack of real-life implementations and applications. While these restrictions are being removed, there is an opportunity to further process the data and perform logistics impact assessment indexes.

In this regard, the "EC funded project SHOW", as it is reference project, will continuously work together to get more data available for the further implementation of those logistics indexes. Meanwhile, another reference project is funded by the European Commission under the Horizon Europe programme, which will involve this develop automated logistics evaluation methodology presented as implemented.

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Annexes

Annex I: Questionnaire

The acceptance assessment case study findings are represented below:

Scelga la sua professione:	Per favore, indica il range che comprende la tua età:	Hai bisogno di scambiare carta o documenti con la Segreteria della Sapienza che si trova nella Città Universitaria?	Ha bisogno di scambiare carta o documenti con gli altri dipartimenti situati nella Città Universitaria?	Ha bisogno di scambiare carta, documenti o merci con le Poste Italiane situate nella Città Universitaria?	Hai bisogno di scambiare carta o documenti con la Banca (o le Banche) situate nella Città Universitaria?	Aggregation	Potrebbe considerare l'opzione di ricevere qualsiasi cibo e bevanda dai bar/ristoranti più vicini che ordinano direttamente al suo posto di lavoro?	Avete qualche commento, suggerimento, raccomandazione?
Dipendenti della Banca	Tra 29-39 anni	No	No	No	No	No	No, non mi interessa	Per la banca, in-presenza è mandataria per fare le operazioni. Solo i documenti per "riassuntivi mensili" può trasferire con quest
Dipendenti della Banca	Tra 40-49 anni	No	No	Sì, ma raramente	No	No	No, non mi interessa	Forse può essere utile per inviare documenti per pubblicità o offerta della banca
Dipendenti della Banca	Tra 40-49 anni	No	No	No	No	No	Sì, la banca può trasferire offerte-pu	Lavori bancarie richiedono in-presenza partecipazione dai clienti
Personale accademico	Tra 18-28 anni	Sì, ma raramente	No	No	No	Raramente	Sì, potrebbe essere interessante e potrei usare un tale servizio	
Personale accademico	Tra 18-28 anni	Sì, ma raramente	No	No	usually i need to go to bank	Raramente	Sì, potrebbe essere interessante e potrei usare un tale servizio	
Personale accademico	Tra 40-49 anni	Sì, ma raramente	si, ma raramente, usually it	No	also only for personal reas	Sì	Sì, potrebbe essere interessante e potrei usare un tale servizio	
Personale accademico	Tra 50-64 anni	Sì, ma raramente	Sì, ma raramente	No	No	Raramente	No, non mi interessa	No
Personale accademico	Tra 18-28 anni	Sì, ma raramente	No	No	Non per il lavoro	No	Sì, potrebbe essere interessante e p	No
Personale accademico	Tra 29-39 anni	Si, spesso	No	Sì, ma raramente	Sì, ma raramente (solo per	Sì	Sì, potrebbe essere interessante e potrei usare un tale servizio	
Personale accademico	Tra 18-28 anni	con amministrazione	No	No	No	No	se mi evita la fila, posso ordinare il m	forse il servizio può trasferirsi alcuni libri o materiali didattici agli studenti o tra il personale accademico
Personale accademico	Tra 40-49 anni	Sì, ma raramente	No	Sì, ma raramente	No	Raramente	Sì, potrebbe essere interessante e potrei usare un tale servizio	
Personale tecnico dell'università	Tra 40-49 anni	No	No	No	No	No	Sì, potrebbe essere interessante e p	alcuni materiali di pulizia verrebbero trasferiti
Personale tecnico dell'università	Tra 40-49 anni	Sì, ma raramente	Sì, ma raramente	No	No	Raramente	Sì, potrebbe essere interessante e p	il servizio può servire anche all'ufficio della sicurezza nell'entrate
Personale tecnico dell'università	Tra 50-64 anni	Sì, ma raramente	No	No	No	Raramente	Sì, potrebbe essere interessante e p	Il servizio servirebbe anche per i materiali personali (per inviare ai altri colleghi, ecc.)
Personale tecnico dell'università	Tra 40-49 anni	No	No	No	No	No	Sì, potrebbe essere interessante e p	Il servizio servirebbe anche per i trasferimenti dei materiali della pulizia (anche per le possibilità con alcune fermate-punti interme
Personale tecnico dell'università	Tra 50-64 anni	Sì, ma raramente	Sì, ma raramente	No	non per il lavoro	Raramente	Sì, se sarebbe un'opportunità di evita	Materiali pulizie sono trasferibili
Personale tecnico dell'università	Tra 40-49 anni	No	No	No	No	No	Sì, può traferire i materiali delle puliz	Possiamo anche ordinare qualcosa dal bar-ristorante se il sistema evitare la fila
Servizi pubblici (Poste italiane, ecc.)	Tra 40-49 anni	Sì, ma raramente	Sì, ma raramente	Si, spesso	No	Raramente	Sì, potrebbe essere interessante e p	Trasferirsi alcuni merci dalle poste italiane ai clienti nell'università
Servizi pubblici (Poste italiane, ecc.)	Tra 40-49 anni	Sì, ma raramente	Sì, ma raramente	Si, spesso	No	Raramente	Sì, potrebbe essere interessante e p	Possiamo inviare bollette e ricevute con il servizio
Servizi pubblici (Poste italiane, ecc.)	Tra 40-49 anni	No	No	Sì, ma raramente	No	No	Sì, potrebbe essere interessante e p	everything is mostly online now and maybe it can be a case to help people who have difficulties to walk, for example, that the robo
Servizi pubblici (Poste italiane, ecc.)	Tra 50-64 anni	No	No	No	No	No	sembra strano il servizio, non lo so, preferisco di andare a comprare il caffe o pranzo da solo	
Settore dei trasporti (operatore, ingegnere	Tra 29-39 anni	No	No	No	No	No	Sì, potrebbe essere interessante e p	Se mi farà risparmiare tempo, vorrei usufruire di questo servizio. perché la maggior parte delle volte il bar è così affollato che dov
Settore dei trasporti (operatore, ingegnere	Tra 29-39 anni	No	No	No	No	No	No, non mi interessa	
Studente/Studentessa	Tra 18-28 anni	Sì, ma raramente	No	Sì, ma raramente	No	Raramente	Sì, potrebbe essere interessante e p	il servizio può avere l'opportunità di consegnare agli studenti documenti, libri, ecc.
Studente/Studentessa	Tra 18-28 anni	No	No	No	No	No	yes, if the robot, for example, skips the line in the bar so suring my pausa I have more time to emjoy the sun then spend in the queue, otherwise if this service is not pr	
Studente/Studentessa	Tra 18-28 anni	No	Sì, ma raramente	Sì, ma raramente	No	Raramente	Sì, potrebbe essere interessante e p	la tecnologia sarebbe accettabile; tuttavia, dovrebbe essere più veloce e senza tempo d'attesa per ricevere caffè o qualcosa
Studente/Studentessa	Tra 18-28 anni	Si, spesso	No	Sì, ma raramente	Si, spesso	Sì	Sì, potrebbe essere interessante e p	They should send the documents even from students to students
Studente/Studentessa	Tra 18-28 anni	No	Sì, ma raramente	No	si ma si fa solo in presenza	Raramente	yes if this robot skips the line and brings it directly to me in a safe and secure manner so i can enjoy more my free time	
Studente/Studentessa	Tra 18-28 anni	No	No	No	No	No	Sì, potrebbe essere interessante e p	Può trasferire i documenti degli studenti agli altri studenti (amici, ecc.)

After that, the following table is illustrating the user acceptance assessment findings, as shown in the following:

Informazioni cronologic	Language selection | S	Please choose your ag	Please choose your pr	Please indicate how fre	Do you have any previ	Please indicate how m	Based on the defined s	Based on the defined s	Based on the defined s	Based on the defined s	Based on the defined s	Based on the defined s	Based on the defined s	Based on the defined s	Based on the defined s
3/17/2022 18:02:40	I would like to answer t	Between 18-28	Student	Three or more times in	No	7	5 (Agree)	5 (Agree)	4	5 (Agree)	5 (Agree)	5 (Agree)	10	Yes, most probably	Absolutely yes
3/18/2022 10:43:58	I would like to answer t	Between 18-28	Transportation Sector (	Very rarely	Maybe, I am not sure	9	3	5 (Agree)	5 (Agree)	3	5 (Agree)	5 (Agree)	9	Maybe	No, most probably
3/18/2022 12:04:10	I would like to answer t	Between 18-28	Student	Once in a week	No	9	4	4	5 (Agree)	3	3	4	9	Yes, most probably	Absolutely yes
3/19/2022 18:19:25	I would like to answer t	Between 18-28	Private Sector	Very rarely	No	6	4	4	3	2	5 (Agree)	3	7	Maybe	Yes, most probably
5/10/2022 12:51:52	I would like to answer t	Between 18-28	Student	Three or more times in	No	9	4	4	4	3	3	4	8	Yes, most probably	Maybe
5/10/2022 13:06:47	I would like to answer t	Between 18-28	Transportation Sector (	Very rarely	No	9	4	4	4	3	4	4	9	Yes, most probably	Yes, most probably
5/10/2022 13:08:40	I would like to answer t	Between 18-28	Student	Three or more times in	No	10	3	4	3	4	4	4	9	No, most probably	Maybe
5/10/2022 13:15:35	I would like to answer t	Between 29-39	ml engineer	Very rarely	No	10	4	4	4	2	3	2	9	Maybe	No, most probably
5/10/2022 13:16:22	I would like to answer t	Between 29-39	Student	Very rarely	No	6	2	2	2	1 (Not at all)	3	2	5	No, most probably	No, most probably
5/10/2022 13:18:45	I would like to answer t	Between 29-39	Student	Two times in a week	Yes	7	3	4	4	3	3	3	7	Yes, most probably	Yes, most probably
5/10/2022 13:36:43	I would like to answer t	Between 18-28	Student	Once in a week	Yes	10	4	5 (Agree)	4	2	5 (Agree)	3	7	Maybe	Absolutely yes
5/10/2022 13:37:47	I would like to answer t	Between 18-28	Transportation Sector (	Very rarely	Maybe, I am not sure	4	4	4	3	3	5 (Agree)	4	6	No, most probably	Yes, most probably
5/10/2022 13:37:49	I would like to answer t	Between 18-28	Academic Staff	Three or more times in	No	6	4	4	3	3	5 (Agree)	3	8	Yes, most probably	Maybe
5/10/2022 13:52:30	I would like to answer t	Between 18-28	Academic Staff	Very rarely	No	8	3	3	2	2	5 (Agree)	4	7	Yes, most probably	Absolutely yes
5/10/2022 13:56:34	I would like to answer t	Between 18-28	Student	Very rarely	No	9	4	5 (Agree)	3	3	5 (Agree)	4	8	Maybe	Maybe
5/10/2022 14:05:22	I would like to answer t	Between 18-28	Student	Very rarely	No	8	3	3	4	3	4	4	8	Yes, most probably	Absolutely no
5/10/2022 14:05:39	I would like to answer t	Between 18-28	Transportation Sector (	Very rarely	Maybe, I am not sure	8	3	3	3	3	3	3	7	Maybe	Maybe

Annex II: Simulation

The Identified Streets and corresponding delivery numbers are listed in the following table:

Number of Deliveries	Identified Streets in Delivery Zone of Rome Capital
23	CSO VITTORIO EMANUELE II
403	VIA ALDO MORO
51	Via Appia Nuova
104	Via Borgognona
14	VIA CANDIA
26	VIA CASILINA
38	VIA CASSIA
12	VIA COLA DI RIENZO
204	VIA CRISTOFORO COLOMBO
32	VIA DEGLI ZINGARI
34	Via dei Condotti
28	Via dei Due Macelli
34	Via dei Giubbonari
10	VIA DEI SERPENTI
10	Via del Babuino
6	Via del Boschetto
7	Via del Campo Marzio
15	Via del Corso
18	Via del Governo Vecchio
15	Via del Pellegrino
18	Via del Tritone
8	Via della Vite
47	VIA DELLA LIBERAZIONE
11	VIA DELLA MAGLIANA

Number of Deliveries	Identified Streets in Delivery Zone of Rome Capital
30	Via delle Carrozze
12	Via Frattina
5	VIA MERULANA
344	VIA NAZIONALE
28	VIA NOMENTANA
14	VIA OSTIENSE
31	VIA OTTAVIANO
16	VIA PRENESTINA
33	VIA SALARIA
48	VIA TIBURTINA
23	VIA TUSCOLANA
23	VIA VITTORIA
107	VLE EUROPA
24	VLE MARCONI
10	VLE MARCONI

Table for the Time Evaluation between the points, centroids (*intermediate logistics nodes*), and identified-representative streets in Rome City

Origin	Centroidi	47003	47004	47005	47006	47007	47008	47009	47010	47011
46995	Pomezia	23,337452	24,094204	22,77154	25,660585	24,043839	23,294458	26,655785	25,423309	24,941133
Origin	Strada	Lazio - 58091037	Lazio - 58091041	Lazio - 58091042	Lazio - 58091036	Lazio - 58091043	Lazio - 58091019	Lazio - 58091004	Lazio - 58091018	Lazio - 58091020
14972	Corso Vittorio Emanuele II	10,605371	11,532118	12,409458	7,118496	6,94175	9,302377	15,323701	9,231236	4,949049
15522	Corso Vittorio Emanuele II	10,335371	11,262117	12,499456	6,848496	6,67175	9,032376	15,0537	8,961235	4,679049
16181	Corso Vittorio Emanuele II	10,815372	11,742117	12,199457	7,328496	6,961752	9,512377	15,533701	9,441236	5,159049
16236	Corso Vittorio Emanuele II	11,165371	12,022117	11,849457	7,548497	6,611752	9,862377	15,883701	9,791235	5,509049
16273	Corso Vittorio Emanuele II	11,455371	11,732116	11,559456	7,258496	6,321752	10,152377	16,173702	10,081236	5,799049
16607	Via Borgognona	11,925371	12,852118	13,379457	8,438496	8,141752	10,622379	16,643705	10,551235	6,269049
9434	Via Candia	8,86537	10,302116	12,419456	6,218496	6,671752	7,562373	13,583696	7,321228	3,209049
15333	Via Candia	9,325371	10,752117	12,869457	6,668497	7,131752	8,022374	14,043698	7,731227	3,669049
10892	Via Casilina	19,735382	19,07213	18,089466	15,018503	13,441757	18,882391	23,483709	18,191233	14,529067
22476	Via Casilina	20,545383	19,882128	18,899466	15,828506	14,25176	19,692394	24,28371	18,991236	15,339067
22532	Via Casilina	21,255386	20,592127	19,609465	16,538509	14,961761	20,402397	24,023703	19,701237	16,049068
22788	Via Casilina	20,485371	21,55212	19,919456	17,598515	16,021763	20,442379	22,973703	20,761238	17,109072
23038	Via Casilina	18,105375	17,442122	16,459461	13,388502	11,811756	17,25239	23,17371	17,18125	12,899065
23224	Via Casilina	16,675373	16,012121	15,029463	11,9585	10,381754	15,592384	21,523705	15,521242	11,239057
29892	Via Casilina	18,915373	19,982121	18,349461	19,178516	17,601765	18,872377	21,403706	21,001226	18,689079
15248	Via Cola di Rienzo	10,275371	11,202118	12,899458	7,118498	7,071751	8,972376	14,9937	8,68123	4,619049
15664	Via Cola di Rienzo	10,875372	11,862118	13,529457	7,778499	7,70175	9,572378	15,593702	9,28123	5,21905
17143	Via Cola di Rienzo	10,905372	12,152118	14,249458	8,068498	8,421751	9,602378	14,683702	8,84123	5,24905
3398	Via Cristoforo Colombo	11,185368	12,072116	9,699455	12,558498	9,491753	11,142374	14,553697	13,271229	12,789048
11094	Via Cristoforo Colombo	13,155369	11,832112	8,639456	8,438498	6,861751	15,012381	19,793699	14,941238	10,559053
11158	Via Cristoforo Colombo	12,965368	10,602114	7,409457	8,248498	6,671751	14,82238	18,5637	14,751238	10,369053
11967	Via Cristoforo Colombo	13,755368	11,162112	7,969457	9,698499	7,761752	13,712375	17,123699	15,841229	11,819055
14245	Via Cristoforo Colombo	14,165373	13,032116	10,479456	9,448502	7,871755	15,522379	21,3237	15,451237	11,069052
14471	Via Cristoforo Colombo	13,335371	12,552116	11,309456	8,6185	7,041753	14,692378	20,4937	14,621236	10,239051
14610	Via Cristoforo Colombo	13,485371	12,702117	11,719458	8,768499	7,191752	14,172381	20,053699	14,101239	9,79905
MEDIA	Via Cristoforo Colombo	13,14965543	11,99354329	9,603742143	9,397070571	7,556038143	14,15380686	18,84369914	14,71123514	10,94905171
18797	Via degli Zingari	13,675367	13,822116	13,47946	9,348497	8,411752	12,372378	18,393703	12,301236	8,01905

Table for the Distance Evaluation between the points, centroids (*intermediate logistics nodes*), and identified-representative streets in Rome City

	Origin	47003	47004	47005	47006	47007	47008	47009	47010	47011	47012	47013	47016	47019
Pomezia	46996	31,02591	30,43674	28,55016	31,00577	28,81403	34,449993	38,96705	36,38214	32,71168	35,11749	34,86079	23,19915	21,58466
	Origin	47003	47004	47005	47006	47007	47008	47009	47010	47011	47012	47013	47016	47019
Via Cristoforo Colombo	3398	13,63974	11,10443	8,097402	10,53673	8,340723	15,944569	20,95988	15,91312	12,24265	14,64846	14,39175	6,883773	1,275703
Via Cristoforo Colombo	11094	10,9571	9,881752	7,073932	7,060688	5,719319	12,468527	17,48384	12,43707	8,766604	11,15986	10,90315	6,870826	5,061505
Via Cristoforo Colombo	14471	10,99434	10,31442	9,282636	7,097933	5,756564	12,171767	17,18708	12,14031	8,469845	9,226892	8,97019	8,164248	7,304856
Via Cristoforo Colombo	Media	11,86373	10,43353	8,151323	8,231783	6,605535	13,5282877	18,5436	13,49683	9,826365	11,6784	11,4217	7,306282	4,547355
Via dei Condotti	16626	9,875866	10,54739	11,08531	6,99754	6,757917	8,797299	13,49416	8,5832	5,182706	4,948545	4,599706	12,98641	11,01883
Via dei Condotti	Media	9,875866	10,54739	11,08531	6,99754	6,757917	8,797299	13,49416	8,5832	5,182706	4,948545	4,599706	12,98641	11,01883
Via del Corso	16621	9,960663	10,63218	11,14421	7,082337	6,816819	8,882096	13,57895	8,667998	5,267503	5,033342	4,684504	12,87596	10,90839
Via del Corso	16625	9,863041	10,53456	11,07248	6,984715	6,745092	8,784474	13,48133	8,570376	5,169881	4,93572	4,586882	12,97359	11,00601
Via del Corso	Media	9,911852	10,58337	11,10835	7,033526	6,780956	8,833285	13,53014	8,619187	5,218692	4,984531	4,635693	12,92478	10,9572
Via Nazionale	18687	11,42042	11,46212	11,44192	7,828465	7,114525	10,341854	15,25994	10,3104	6,727263	6,717937	6,369101	12,2111	10,9605
Via Nazionale	18767	10,51494	10,55664	10,53644	6,922987	6,209045	9,436376	14,45169	9,404922	5,821783	6,127581	5,870878	11,66364	10,30061
Via Nazionale	Media	10,96768	11,00938	10,98918	7,375726	6,661785	9,889115	14,85581	9,857662	6,274523	6,422759	6,11999	11,93737	10,63056
Via Nomentana	20574	12,62053	12,84671	12,82651	9,213058	8,499118	11,501959	15,36609	11,07694	7,893406	7,442283	6,732416	13,65968	12,4119
Via Nomentana	24911	16,53183	16,91004	16,88984	13,2764	12,56245	15,37784	16,67363	12,53373	11,78737	11,0594	10,01146	17,36034	16,47524
Via Nomentana	41333	19,49623	19,87444	19,85424	16,24079	15,52685	18,145926	19,44173	15,30181	14,75176	13,85928	12,97585	20,32474	19,43963
Via Nomentana	Media	16,2162	16,54373	16,52353	12,91008	12,19614	15,008575	17,16048	12,97083	11,47751	10,78699	9,906574	17,11492	16,10892
Via Tiburtina	19917	13,04166	13,08335	12,32835	9,449702	8,225101	11,963095	16,91246	11,93164	8,348502	8,49752	8,081511	11,81781	11,43658
Via Tiburtina	25987	17,18473	17,24198	16,69461	13,60833	12,60594	16,106163	19,05713	14,91722	12,49157	12,04894	11,32892	15,73664	15,66768
Via Tiburtina	31224	21,24403	21,30128	20,75392	17,66762	16,66524	20,165468	22,14753	18,00761	16,55088	16,10824	15,38822	19,79594	19,72697
Via Tiburtina	Media	17,15681	17,20887	16,59229	13,57522	12,49876	16,078242	19,37237	14,95216	12,46365	12,21823	11,59955	15,78346	15,61041
Via Appia Nuova	10990	13,33001	12,65009	11,88276	9,433603	8,092235	13,185884	18,2012	13,15443	9,571292	9,93459	9,677887	10,383	10,08795
Via Appia Nuova	21532	14,71861	14,03869	13,07649	10,8222	9,480837	14,772735	19,78805	14,74128	11,15814	11,59509	11,33839	8,94529	11,0587
Via Appia Nuova	21948	18,01569	16,98649	14,80112	14,11928	12,77792	18,586082	23,60139	18,55462	14,97149	15,40844	15,15173	7,391935	10,72928
Via Appia Nuova	Media	15,35477	14,55842	13,25346	11,45836	10,117	15,5149003	20,53021	15,48344	11,90031	12,31271	12,056	8,906741	10,62531

Origin	47003	47004	47005	47006	47007	47008	47009	47010	47011	47012	47013	47016	47019	47020	47021
1	15,70675	16,71258	17,06215	13,44145	12,73476	13,29723	14,59302	10,45312	10,96228	9,010582	8,366998	17,89814	16,64755	11,9187	10,90527
2	15,57887	16,58471	16,93428	13,31358	12,60689	13,16935	14,46515	10,32525	10,83441	8,882707	8,239122	17,77027	16,51967	11,79082	10,77739
3	18,4016	18,77981	18,75961	15,14616	14,43222	16,98211	18,27791	14,138	13,65713	12,69546	11,88122	19,23011	18,345	13,61615	12,60273
4	18,25201	18,63022	18,61002	14,99657	14,28263	16,83253	18,12832	13,98842	13,50755	12,54588	11,73163	19,08052	18,19542	13,46657	12,45314
7	20,07774	20,45595	20,43575	16,82229	16,10836	18,73965	20,03545	15,89554	15,33327	14,453	13,55736	20,35405	20,02114	15,29229	14,27887
8	19,76019	20,1384	20,1182	16,50474	15,79081	18,4221	19,7179	15,57799	15,01572	14,13545	13,23981	20,5887	19,70359	14,97474	13,96132
9	19,30076	19,67896	19,65876	16,04531	15,33137	17,96266	19,25846	15,11855	14,55629	13,67601	12,78037	20,12926	19,24415	14,5153	13,50188
10	19,31573	19,69394	19,67373	16,06028	15,34634	17,97763	19,27344	15,13353	14,57126	13,69099	12,79535	20,14424	19,25913	14,53028	13,51685
11	19,1967	19,5749	19,5547	15,94125	15,22731	17,8586	19,1544	15,01449	14,45223	13,57196	12,67632	20,0252	19,14009	14,41125	13,39782
12	18,82252	19,20073	19,18053	15,56708	14,85314	17,48443	18,78023	14,64032	14,07806	13,19779	12,30214	19,65103	18,76592	14,03707	13,02365

Table for the Time Evaluation between the centroids (*intermediate logistics nodes*) in Rome City

Origin	46993	46994	46995	46996	46997	46998	46999	47000	47001	47002	47003	47004	47005	47006
46993	--	26,49319	25,58671	26,67001	31,63543	7,310012	9,682469	13,60846	19,49126	30,61345	25,33913	24,74996	22,86338	27,00828
46994	26,49319	--	16,53929	41,45799	48,75819	27,52899	33,94455	23,59885	16,15668	15,15266	22,09581	21,85738	23,16755	24,24222
46995	25,58671	16,53929	--	34,75552	42,05572	22,94381	27,24208	16,89638	7,241983	8,893998	11,48278	11,24436	14,5196	13,62919
46996	26,66999	41,458	34,75552	--	9,181552	27,14676	28,37811	19,04765	28,66007	37,89245	31,02591	30,43674	28,55016	31,00576
46997	31,63542	48,75818	42,0557	9,181553	--	34,44694	33,34353	26,34783	35,96025	45,19264	38,32609	37,73692	34,73899	36,16059
46998	7,31001	27,52899	22,94382	27,14676	34,44695	--	9,619106	9,315092	16,84836	26,08073	19,2142	18,62503	16,73845	20,88335
46999	9,682467	33,94456	27,24208	28,37812	33,34354	9,619104	--	11,14241	21,14662	30,379	23,51247	22,9233	21,03671	25,18162
47000	13,60846	23,59885	16,89638	19,04765	26,34783	9,315092	11,14241	--	10,80092	20,03329	13,16676	12,57759	10,69101	14,26625
47001	19,49126	16,15668	7,241982	28,66007	35,96027	16,84836	21,14662	10,80093	--	12,26872	9,948236	9,359069	9,202668	11,7439
47002	30,61345	15,15265	8,893999	37,89243	45,19263	26,08072	30,37899	20,03329	12,26872	--	12,1252	13,86793	17,14317	13,6077
47003	25,33913	22,09582	11,48278	31,02591	38,3261	19,21419	23,51246	13,16676	9,948236	12,1252	--	3,378131	6,653368	3,921072
47004	24,74996	21,85739	11,24436	30,43674	37,73693	18,62503	22,92329	12,5776	9,359068	13,86793	3,378131	--	4,716846	3,698577
47005	22,86338	23,16756	14,51959	28,55016	34,739	16,73845	21,03671	10,69101	9,20267	17,14317	6,653368	4,716846	--	5,216809
47006	27,00828	24,24223	13,6292	31,00577	36,16057	20,88335	25,18161	14,26626	11,7439	13,6077	3,921071	3,698577	5,21681	--
47007	24,59782	25,89881	16,16818	28,81403	34,81921	18,47289	22,77045	12,07025	11,90823	16,23626	6,654887	5,766641	4,999319	2,758477
47008	28,76322	22,89184	12,81475	34,44999	41,56841	22,63829	26,93656	16,59085	13,54858	11,93931	6,457086	8,199818	11,47505	6,883518
47009	33,28029	26,74499	16,50755	38,96705	46,26725	27,15534	31,45361	21,10791	18,13592	15,93897	11,8196	13,56233	16,83757	11,89883
47010	31,01617	25,14479	15,0677	36,38214	41,53695	24,89123	29,1895	18,8438	15,80153	14,19226	8,710034	10,1232	12,01223	6,852061
47011	28,97253	23,80023	13,7273	32,71168	37,86649	22,84759	26,97821	15,97218	14,00542	12,85185	4,929864	6,452729	8,341768	3,181595
47012	31,66257	28,18629	18,11336	35,11749	40,25974	25,53763	29,38402	18,37798	17,80425	17,23791	9,315926	10,25156	12,05931	6,98043
47013	31,40789	28,6004	18,52746	34,86079	40,00303	25,28295	29,12731	18,12128	18,22635	17,65202	9,730032	10,67366	12,48153	7,402527
47014	25,51945	35,59839	28,89592	10,71392	18,01411	21,28715	23,03894	13,18804	22,80046	32,03283	25,1663	24,57713	22,45249	24,35869
47015	22,33696	30,09756	23,39508	20,36018	25,37457	17,77564	19,85645	9,204504	17,29963	26,53199	19,66546	18,15826	15,15122	16,57279
47016	23,20048	31,03062	24,0754	23,19915	28,24842	18,7087	20,71997	9,727948	17,97995	27,25224	17,82792	16,08687	13,07983	13,93151

Table for the Distance Evaluation between the centroids (*intermediate logistics nodes*) in Rome City

Annex III: Pilot Demonstration

The automated logistics demonstration in Trikala (under SHOW project), Unit-04

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11	Column12	Column13	Column14	Column15
timestamp	system_state	pu_state	SoC	pu_door_status	vehicle_state	pu_lock_state	battery_state	vcu_state	imu_calibrated	controller_state	drive_mode	speed	position_x	position_y
2023-02-14T07:26:33.754105	3	42	100	1	2	3	0	48	1	21	0	0.011215	1.34473	3.19531
2023-02-14T07:26:34.754490	3	42	100	1	2	3	0	48	1	21	0	0.038559	1.34473	3.19238
2023-02-14T07:26:35.754538	3	42	100	1	2	3	0	48	1	21	0	0.060777	1.3457	3.18457
2023-02-14T07:26:36.755068	3	42	100	1	2	3	0	48	1	21	0	0.02681	1.34668	3.17773
2023-02-14T07:26:37.754220	3	42	100	1	2	3	0	48	1	21	0	-0.035782	1.34668	3.17676
2023-02-14T07:26:38.754235	3	42	100	1	2	3	0	48	1	21	0	-0.029374	1.34668	3.17676
2023-02-14T07:26:39.754121	3	42	100	1	2	3	0	48	1	21	0	-0.067399	1.3457	3.18457
2023-02-14T07:26:40.753999	3	42	100	1	2	3	0	48	1	21	0	-0.081712	1.34473	3.19238
2023-02-14T07:26:41.754296	3	42	100	1	2	3	0	48	1	21	0	-0.0392	1.34375	3.20215
2023-02-14T07:26:42.754484	3	42	100	1	2	3	0	48	1	21	0	0.013351	1.34375	3.20508
2023-02-14T07:26:43.753913	3	42	100	1	2	3	0	48	1	21	0	0.074235	1.34375	3.19922
2023-02-14T07:26:44.754017	3	42	100	1	2	3	0	48	1	21	0	0.088762	1.34473	3.18945
2023-02-14T07:26:45.753999	3	42	100	1	2	3	0	48	1	21	0	0.053727	1.34668	3.18066
2023-02-14T07:26:46.754191	3	42	100	1	2	3	0	48	1	21	0	0.046463	1.34668	3.18164
2023-02-14T07:26:47.755520	3	42	100	1	2	3	0	48	1	21	0	-0.023819	1.34668	3.18262
2023-02-14T07:26:48.754456	3	42	100	1	2	3	0	48	1	21	0	-0.050523	1.3457	3.18652
2023-02-14T07:26:49.754350	3	42	100	1	2	3	0	48	1	21	0	-0.067185	1.34473	3.19141
2023-02-14T07:26:50.754163	3	42	100	1	2	3	0	48	1	21	0	-0.046891	1.34375	3.19727
2023-02-14T07:26:51.754236	3	42	100	1	2	3	0	48	1	21	0	-0.018692	1.34375	3.2041
2023-02-14T07:26:52.754009	3	42	100	1	2	3	0	48	1	21	0	0.022965	1.34375	3.20508
2023-02-14T07:26:53.754055	3	42	100	1	2	3	0	48	1	21	0	0.083208	1.34375	3.19824
2023-02-14T07:26:54.754105	3	42	100	1	2	3	0	48	1	21	0	0.075303	1.3457	3.18652
2023-02-14T07:26:55.754346	3	42	100	1	2	3	0	48	1	21	0	-0.08748	1.3457	3.18652
2023-02-14T07:26:56.754155	3	42	100	1	2	3	0	48	1	21	0	0.055863	1.3457	3.1875
2023-02-14T07:26:57.754223	3	42	100	1	2	3	0	48	1	21	0	0.068254	1.3457	3.18848
2023-02-14T07:26:58.754490	3	42	100	1	2	3	0	48	1	21	0	0.049455	1.34668	3.18262
2023-02-14T07:26:59.754241	3	42	100	1	2	3	0	48	1	21	0	0.031296	1.34766	3.17676
2023-02-14T07:27:00.754410	3	42	100	1	2	3	0	48	1	21	0	-0.012283	1.34766	3.1748
2023-02-14T07:27:01.754471	3	42	100	1	2	3	0	48	1	21	0	-0.056077	1.34668	3.17871
2023-02-14T07:27:02.754167	3	42	100	1	2	3	0	48	1	21	0	-0.078081	1.3457	3.18848
2023-02-14T07:27:03.754181	3	42	100	1	2	3	0	48	1	21	0	-0.052232	1.34375	3.19824
2023-02-14T07:27:04.754250	3	42	100	1	2	3	0	48	1	21	0	0.007584	1.34375	3.20312
2023-02-14T07:27:05.754052	3	42	100	1	2	3	0	48	1	21	0	0.055223	1.34375	3.2002
2023-02-14T07:27:06.754201	3	42	100	1	2	3	0	48	1	21	0	0.090044	1.34473	3.19141
2023-02-14T07:27:07.754054	3	42	100	1	2	3	0	48	1	21	0	0.055009	1.34668	3.17871
2023-02-14T07:27:08.754076	3	42	100	1	2	3	0	48	1	21	0	0.006943	1.34766	3.1748
2023-02-14T07:27:09.754027	3	42	100	1	2	3	0	48	1	21	0	-0.035996	1.34766	3.17676
2023-02-14T07:27:10.754181	3	42	100	1	2	3	0	48	1	21	0	-0.060777	1.34668	3.18164
2023-02-14T07:27:11.754137	3	42	100	1	2	3	0	48	1	21	0	-0.075303	1.3457	3.1875
2023-02-14T07:27:12.754130	3	42	100	1	2	3	0	48	1	21	0	-0.0533	1.34473	3.19531
2023-02-14T07:27:13.754039	3	42	100	1	2	3	0	48	1	21	0	-0.020829	1.34375	3.2002
2023-02-14T07:27:14.754193	3	42	100	1	2	3	0	48	1	21	0	0.020401	1.34375	3.19922
2023-02-14T07:27:15.754220	3	42	100	1	2	3	0	48	1	21	0	0.077867	1.34473	3.19434
2023-02-14T07:27:16.754159	3	42	100	1	2	3	0	48	1	21	0	0.075517	1.3457	3.18457
2023-02-14T07:27:17.755343	3	42	100	1	2	3	0	48	1	21	0	-0.033005	1.34668	3.18066
2023-02-14T07:27:18.754087	3	42	100	1	2	3	0	48	1	21	0	-0.064408	1.34668	3.18359
2023-02-14T07:27:19.754266	3	42	100	1	2	3	0	48	1	21	0	-0.063554	1.34473	3.19141
2023-02-14T07:27:20.754065	3	42	100	1	2	3	0	48	1	21	0	-0.037491	1.34375	3.19824
2023-02-14T07:27:21.754078	3	42	100	1	2	3	0	48	1	21	0	-0.011429	1.34375	3.19922
2023-02-14T07:27:22.754075	3	42	100	1	2	3	0	48	1	21	0	0.02147	1.34375	3.19922
2023-02-14T07:27:23.754256	3	42	100	1	2	3	0	48	1	21	0	0.059068	1.34473	3.19238
2023-02-14T07:27:24.754310	3	42	100	1	2	3	0	48	1	21	0	0.064408	1.3457	3.18652
2023-02-14T07:27:25.754196	3	42	100	1	2	3	0	48	1	21	0	0.004379	1.34668	3.18164
2023-02-14T07:27:26.754162	3	42	100	1	2	3	0	48	1	21	0	-0.025101	1.34668	3.18066
2023-02-14T07:27:27.754029	3	42	100	1	2	3	0	48	1	21	0	-0.057145	1.3457	3.1875
2023-02-14T07:27:28.754203	3	42	100	1	2	3	0	48	1	21	0	-0.07039	1.34473	3.19238
2023-02-14T07:27:29.754379	3	42	100	1	2	3	0	48	1	21	0	-0.038987	1.34375	3.20215
2023-02-14T07:27:30.754310	3	42	100	1	2	3	0	48	1	21	0	-0.002029	1.34375	3.2041
2023-02-14T07:27:31.754047	3	42	100	1	2	3	0	48	1	21	0	0.052873	1.34375	3.20215
2023-02-14T07:27:32.754106	3	42	100	1	2	3	0	48	1	21	0	0.073167	1.34375	3.19824
2023-02-14T07:27:33.754011	3	42	100	1	2	3	0	48	1	21	0	0.068254	1.3457	3.18945
2023-02-14T07:27:34.754688	3	42	100	1	2	3	0	48	1	21	0	0.03685	1.3457	3.18457
2023-02-14T07:27:35.754351	3	42	100	1	2	3	0	48	1	21	0	0.000748	1.34668	3.18359
2023-02-14T07:27:36.754342	3	42	100	1	2	3	0	48	1	21	0	-0.038346	1.3457	3.1875
2023-02-14T07:27:37.755342	3	42	100	1	2	3	0	48	1	21	0	-0.07274	1.34473	3.19434
2023-02-14T07:27:38.754067	3	42	100	1	2	3	0	48	1	21	0	-0.056291	1.34375	3.2041
2023-02-14T07:27:39.753945	3	42	100	1	2	3	0	48	1	21	0	-0.003311	1.34375	3.20898
2023-02-14T07:27:40.754038	3	42	100	1	2	3	0	48	1	21	0	0.050736	1.34375	3.20605
2023-02-14T07:27:41.754188	3	42	100	1	2	3	0	48	1	21	0	0.055009	1.34375	3.2002
2023-02-14T07:27:42.754379	3	42	100	1	2	3	0	48	1	21	0	0.056291	1.34473	3.19238
2023-02-14T07:27:43.754111	3	42	100	1	2	3	0	48	1	21	0	0.010788	1.3457	3.18848
2023-02-14T07:27:44.754196	3	42	100	1	2	3	0	48	1	21	0	-0.031723	1.3457	3.18945
2023-02-14T07:27:45.754266	3	42	100	1	2	3	0	48	1	21	0	-0.05864	1.34375	3.20215
2023-02-14T07:27:46.754415	3	42	100	1	2	3	0	48	1	21	0	-0.097307	1.34375	3.20898
2023-02-14T07:27:47.754160	3	42	100	1	2	3	0	48	1	21	0	-0.045182	1.3418	3.21387
2023-02-14T07:27:48.754263	3	42	100	1	2	3	0	48	1	21	0	0.135118	1.33398	3.26953
2023-02-14T07:58:58.754379	3	42	100	1	2	2	0	48	1	21	0	0.007797	-15.9395	-23.5801
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2023-02-14T07:59:00.754452	3	42	100	1	2	3	0	48	1	21	0	0.044755	-15.9385	-23.5713
2023-02-14T07:59:01.754435	3	42	100	1	2	3	0	48	1	21	0	-0.047746	-15.9375	-23.5615
2023-02-14T07:59:02.754272	3	42	100	1	2	3	0	48	1	21	0	0.101793	-15.9365	-23.5576
2023-02-14T07:59:03.754385	3	42	100	1	2	3	0	48	1	21	0	0.069322	-15.9375	-23.5664
2023-02-14T07:59:04.755794	3	42	100	1	2	3	0	48	1	21	0	0.118456	-15.9375	-23.5615
2023-02-14T08:00:28.754444	3	42	100	1	2	2	0	48	1	21	0	0.001175	-6.00879	-21.2637
2023-02-14T08:00:29.754325	3	42	100	1	2	3	0	48	1	21	0	0.004593	-5.99902	-21.2588
2023-02-14T08:00:30.754634	3	42	100	1	2	3	0	48	1	21	0	0.037919	-5.99512	-21.2578
2023-02-14T08:00:31.754255	3	42	100	1	2	3	0	48	1	21	0	0.027665	-5.99316	-21.2568
2023-02-14T08:00:32.754650	3	42	100	1	2	3	0	48	1	21	0	0.006943	-5.98242	-21.252
2023-02-14T08:00:33.754072	3	42	100	1	2	3	0	48	1	21	0	-0.002029	-5.96875	-21.2471
2023-02-14T08:00:34.754215	3	42	100	1	2	3	0	48	1	21	0	-0.012497	-5.96094	-21.2422
2023-02-14T08:00:35.754266	3	42	100	1	2	3	0	48	1	21	0	-0.008224	-5.95215	-21.2393
2023-02-14T08:00:36.754185	3	42	100	1	2	3	0	48	1	21	0	-0.00502	-5.94238	-21.2363
2023-02-14T08:00:37.755384	3	42	100	1	2	3	0	48	1	21	0	-0.000107	-5.93457	-21.2314
2023-02-14T08:04:00.754191	3	42	100	1	2	2	0	48	1	21	0	-0.009293	4.25391	-16.8848
2023-02-14T08:04:01.754412	3	42	100	1	2	3	0	48	1	21	0	0.028946	4.25781	-16.8828
2023-02-14T08:04:02.754317	3	42	100	1	2	3	0	48	1	21	0	0.063127	4.25098	-16.8877
2023-02-14T08:04:03.754256	3	42	100	1	2	3	0	48	1	21	0	0.074235	4.24316	-16.8926
2023-02-14T08:04:04.755521	3	42	100	1	2	3	0	48	1	21	0	0.007797	4.23438	-16.8965
2023-02-14T08:04:05.754220	3	42	100	1	2	3	0	48	1	21	0	-0.065049	4.23633	-16.8955
2023-02-14T08:04:06.754351	3	42	100	1	2	3	0	48	1	21	0	-0.12401	4.25	-16.8887
2023-02-14T08:04:07.754404	3	42	100	1	2	3	0	48	1	21	0	-0.076158	4.26367	-16.8799
2023-02-14T08:04:08.754454	3	42	100	1	2	3	0	48	1	21	0	-0.089403	4.25	-16.8877
2023-02-14T08:05:14.754710	3	42	100	1	2	3	0	48	1	21	0	-0.029801	15.9775	-8.04785
2023-02-14T08:05:15.754203	3	42	100	1	2	3	0	48	1	21	0	-0.046891	15.9844	-8.04004
2023-02-14T08:05:16.754164	3	42	100	1	2	3	0	48	1	21	0	0.011002	15.9961	-8.02441
2023-02-14T08:05:17.754447	3	42	100	1	2	3	0	48	1	21	0	0.056718	16	-8.02148
2023-02-14T08:05:18.754595	3	42	100	1	2	3	0	48	1	21	0	0.091966	15.998	-8.02441
2023-02-14T08:06:27.754234	3	42	100	1	2	3	0	48	1	21	0	-0.010574	19.9385	-4.79688
2023-02-14T08:06:28.754244	3	42	100	1	2	3	0	48	1	21	0	-0.053086	19.9434	-4.79394
2023-02-14T08:06:29.753919	3	42	100	1	2	3	0	48	1	21	0	-0.062699	19.9502	-4.78809
2023-02-14T08:06:30.753923	3	42	100	1	2	3	0	48	1	21	0	-0.01442	19.9551	-4.78418
2023-02-14T08:06:31.753863	3	42	100	1	2	3	0	48	1	21	0	0.053086	19.96	-4.7793
2023-02-14T08:06:32.754177	3	42	100	1	2	3	0	48	1	21	0	0.067613	19.9521	-4.78516
2023-02-14T08:06:33.754170	3	42	100	1	2	3	0	48	1	21	0	0.163317	19.957	-4.78125
2023-02-14T08:07:22.754175	3	42	100	1	2	3	0	48	1	21	0	-0.03151	24.165	-0.607422
2023-02-14T08:07:23.754249	3	42	100	1	2	3	0	48	1	21	0	-0.065049	24.1729	-0.597656
2023-02-14T08:07:24.754143	3	42	100	1	2	3	0	48	1	21	0	-0.054795	24.1846	-0.583984
2023-02-14T08:07:25.755048	3	42	100	1	2	3	0	48	1	21	0	0.004166	24.1885	-0.579102
2023-02-14T08:07:26.754586	3	42	100	1	2	3	0	48	1	21	0	0.0533	24.1875	-0.581055
2023-02-14T08:07:27.754323	3	42	100	1	2	3	0	48	1	21	0	0.09453	24.1816	-0.586914
2023-02-14T08:07:28.754471	3	42	100	1	2	3	0	48	1	21	0	0.059495	24.1758	-0.59375
2023-02-14T08:07:29.754295	3	42	100	1	2	3	0	48	1	21	0	0.013565	24.1738	-0.597656
2023-02-14T08:07:30.754320	3	42	100	1	2	3	0	48	1	21	0	-0.03621	24.1738	-0.594727
2023-02-14T08:07:31.754241	3	42	100	1	2	3	0	48	1	21	0	-0.071458	24.1807	-0.588867
2023-02-14T08:07:32.754288	3	42	100	1	2	3	0	48	1	21	0	-0.07274	24.1865	-0.581055
2023-02-14T08:07:33.754680	3	42	100	1	2	3	0	48	1	21	0	-0.035355	24.1924	-0.575195
2023-02-14T08:07:34.754373	3	42	100	1	2	3	0	48	1	21	0	0.0439	24.1943	-0.572266
2023-02-14T08:07:35.754301	3	42	100	1	2	3	0	48	1	21	0	0.112261	24.1875	-0.581055
2023-02-14T08:07:36.754306	3	42	100	1	2	3	0	48	1	21	0	0.100725	24.1777	-0.592773
2023-02-14T08:07:37.754944	3	42	100	1	2	3	0	48	1	21	0	0.044541	24.1719	-0.598633
2023-02-14T08:07:38.754340	3	42	100	1	2	3	0	48	1	21	0	-0.037278	24.1719	-0.598633
2023-02-14T08:07:39.754705	3	42	100	1	2	3	0	48	1	21	0	-0.104143	24.1816	-0.587891
2023-02-14T08:09:26.754922	3	42	100	1	2	3	0	48	1	21	0	0.034928	30.7637	9.38379
2023-02-14T08:09:27.754976	3	42	100	1	2	3	0	48	1	21	0	0.02147	30.7617	9.37988
2023-02-14T08:09:28.755417	3	42	100	1	2	3	0	48	1	21	0	-0.015274	30.7627	9.37988
2023-02-14T08:09:29.755577	3	42	100	1	2	3	0	48	1	21	0	-0.038559	30.7637	9.38477
2023-02-14T08:09:30.754881	3	42	100	1	2	3	0	48	1	21	0	-0.032364	30.7676	9.39062
2023-02-14T08:09:31.754699	3	42	100	1	2	3	0	48	1	21	0	-0.006088	30.7686	9.39453
2023-02-14T08:09:32.756203	3	42	100	1	2	3	0	48	1	21	0	0.028733	30.7686	9.39355
2023-02-14T08:09:33.754852	3	42	100	1	2	3	0	48	1	21	0	0.037705	30.7656	9.38672
2023-02-14T08:09:34.755454	3	42	100	1	2	3	0	48	1	21	0	0.000107	30.7637	9.38281
2023-02-14T08:09:35.754875	3	42	100	1	2	3	0	48	1	21	0	-0.020829	30.7637	9.38379
2023-02-14T08:09:36.755600	3	42	100	1	2	3	0	48	1	21	0	-0.042191	30.7656	9.38867
2023-02-14T08:09:37.755138	3	42	100	1	2	3	0	48	1	21	0	-0.015915	30.7705	9.39746
2023-02-14T08:09:38.755295	3	42	100	1	2	3	0	48	1	21	0	0.024033	30.7705	9.39844
2023-02-14T08:09:39.754048	3	42	100	1	2	3	0	48	1	21	0	0.059922	30.7705	9.39844
2023-02-14T08:09:40.754069	3	42	100	1	2	3	0	48	1	21	0	0.046677	30.7705	9.39746
2023-02-14T08:09:41.755015	3	42	100	1	2	3	0	48	1	21	0	0.050096	30.7656	9.38867
2023-02-14T08:09:42.755645	3	42	100	1	2	3	0	48	1	21	0	0.103502	30.7568	9.36816
2023-02-14T08:10:39.754213	3	42	100	1	2	3	0	48	1	21	0	-0.006302	34.3252	18.165
2023-02-14T08:10:40.754761	3	42	100	1	2	3	0	48	1	21	0	-0.071031	34.3262	18.1689
2023-02-14T08:10:41.754545	3	42	100	1	2	3	0	48	1	21	0	-0.088548	34.3301	18.1797
2023-02-14T08:10:42.754449	3	42	100	1	2	3	0	48	1	21	0	-0.031083	34.332	18.1895
2023-02-14T08:10:43.754558	3	42	100	1	2	3	0	48	1	21	0	0.03621	34.3311	18.1895
2023-02-14T08:10:44.754614	3	42	100	1	2	3	0	48	1	21	0	0.081926	34.3301	18.1797
2023-02-14T08:10:45.753921	3	42	100	1	2	3	0	48	1	21	0	0.058854	34.3262	18.167
2023-02-14T08:10:46.754949	3	42	100	1	2	3	0	48	1	21	0	0.007797	34.3252	18.1611
2023-02-14T08:10:47.754124	3	42	100	1	2	3	0	48	1	21	0	-0.050523	34.3262	18.165
2023-02-14T08:10:48.754190	3	42	100	1	2	3	0	48	1	21	0	-0.108842	34.3301	18.1816
2023-02-14T08:10:49.754701	3	42	100	1	2	3	0	48	1	21	0	-0.062699	34.333	18.1982
2023-02-14T08:10:50.755064	3	42	100	1	2	3	0	48	1	21	0	0.090471	34.3408	18.2236
2023-02-14T08:13:45.754186	3	42	100	1	2	3	0	48	1	21	0	0.099229	35.3594	22.1797
2023-02-14T08:13:46.754210	3	42	100	1	2	3	0	48	1	21	0	0.131273	35.3574	22.166
2023-02-14T08:13:47.754003	3	42	100	1	2	3	0	48	1	21	0	0.076158	35.3564	22.1445
2023-02-14T08:13:48.754221	3	42	100	1	2	3	0	48	1	21	0	-0.058854	35.3564	22.1445
2023-02-14T08:13:49.754322	3	42	100	1	2	3	0	48	1	21	0	-0.164172	35.3584	22.166
2023-02-14T08:13:50.754350	3	42	100	1	2	3	0	48	1	21	0	-0.135332	35.3604	22.1934
2023-02-14T08:13:51.754420	3	42	100	1	2	3	0	48	1	21	0	-0.009293	35.3623	22.207
2023-02-14T08:13:52.754391	3	42	100	1	2	3	0	48	1	21	0	0.096239	35.3604	22.2012

The automated logistics demonstration in Trikala (under SHOW project), Unit-05

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11	Column12	Column13	Column14	Column15	Column16
timestamp	system_state	pu_state	SoC	pu_door_status	vehicle_state	pu_lock_state	battery_state	vcu_state	imu_calibrated	controller_state	drive_mode	speed	position_x	position_y	
2023-02-14T07:59:53.704651	3	42	100	1	2	2	0	48	1	21	0	-0.003952	-17.6982	44.418	
2023-02-14T07:59:54.708522	3	42	100	1	2	3	0	48	1	21	0	-0.051805	-17.6982	44.418	
2023-02-14T07:59:55.705054	3	42	100	1	2	3	0	48	1	21	0	-0.0392	-17.7041	44.4375	
2023-02-14T07:59:56.704711	3	42	100	1	2	3	0	48	1	21	0	0.007156	-17.7061	44.4453	
2023-02-14T07:59:57.704286	3	42	100	1	2	3	0	48	1	21	0	0.108842	-17.7041	44.4395	
2023-02-14T07:59:58.706592	3	42	100	1	2	3	0	48	1	21	0	0.074876	-17.7031	44.4336	
2023-02-14T07:59:59.704891	3	42	100	1	2	3	0	48	1	21	0	-0.030869	-17.7002	44.4277	
2023-02-14T08:03:58.704393	3	42	100	1	2	3	0	48	1	21	0	0.018265	-25.876	47.1797	
2023-02-14T08:03:59.705881	3	42	100	1	2	3	0	48	1	21	0	-0.064836	-25.876	47.1797	
2023-02-14T08:04:00.704611	3	42	100	1	2	3	0	48	1	21	0	-0.11867	-25.8926	47.1904	
2023-02-14T08:04:01.705032	3	42	100	1	2	3	0	48	1	21	0	-0.071031	-25.9072	47.1992	
2023-02-14T08:04:02.707018	3	42	100	1	2	3	0	48	1	21	0	0.022751	-25.916	47.207	
2023-02-14T08:06:09.704450	3	42	100	1	2	3	0	48	1	21	0	-0.041123	-34.5029	56.4521	
2023-02-14T08:06:10.704780	3	42	100	1	2	3	0	48	1	21	0	0.066972	-34.5078	56.4619	
2023-02-14T08:06:11.705218	3	42	100	1	2	3	0	48	1	21	0	0.105211	-34.498	56.4414	
2023-02-14T08:06:12.706720	3	42	100	1	2	3	0	48	1	21	0	-0.00267	-34.4775	56.4053	
2023-02-14T08:07:03.705274	3	42	100	1	2	2	0	48	1	21	0	0.000961	-37.8916	70.5518	
2023-02-14T08:07:04.706370	3	42	100	1	2	3	0	48	1	21	0	-0.008865	-37.8916	70.5654	
2023-02-14T08:07:05.704367	3	42	100	1	2	3	0	48	1	21	0	0.024674	-37.8916	70.5752	
2023-02-14T08:07:06.707179	3	42	100	1	2	3	0	48	1	21	0	0.178058	-37.8916	70.5713	
2023-02-14T08:08:15.704889	3	42	100	1	2	3	0	48	1	21	0	0.038346	-36.3115	75.0938	
2023-02-14T08:08:16.707522	3	42	100	1	2	3	0	48	1	21	0	0.045609	-36.3066	75.1045	
2023-02-14T08:08:17.704964	3	42	100	1	2	3	0	48	1	21	0	-0.0533	-36.3105	75.0977	
2023-02-14T08:08:18.704919	3	42	100	1	2	3	0	48	1	21	0	-0.055009	-36.3086	75.1006	
2023-02-14T08:08:19.705115	3	42	100	1	2	3	0	48	1	21	0	-0.046036	-36.3027	75.1133	
2023-02-14T08:08:20.705610	3	42	100	1	2	3	0	48	1	21	0	-0.04155	-36.2979	75.123	
2023-02-14T08:09:16.704899	3	42	100	1	2	3	0	48	1	21	0	-0.002884	-33.5479	80.1914	
2023-02-14T08:09:17.704201	3	42	100	1	2	3	0	48	1	21	0	-0.076158	-33.5352	80.209	
2023-02-14T08:09:18.705754	3	42	100	1	2	3	0	48	1	21	0	-0.01677	-33.5186	80.2305	
2023-02-14T08:09:19.705585	3	42	100	1	2	3	0	48	1	21	0	0.210315	-33.4863	80.2725	
2023-02-14T08:09:20.704634	3	42	100	1	2	3	0	48	1	21	0	0.073167	-33.499	80.2539	
2023-02-14T08:09:21.704994	3	42	100	1	2	3	0	48	1	21	0	-0.058	-33.5029	80.249	
2023-02-14T08:09:22.704555	3	42	100	1	2	3	0	48	1	21	0	-0.083421	-33.4668	80.2969	
2023-02-14T08:10:42.705967	3	42	100	1	2	2	0	48	1	21	0	-0.0486	-25.3594	88.3164	
2023-02-14T08:10:43.710120	3	42	100	1	2	3	0	48	1	21	0	-0.044755	-25.3525	88.3203	
2023-02-14T08:10:44.705765	3	42	100	1	2	3	0	48	1	21	0	0.006943	-25.3477	88.3232	
2023-02-14T08:10:45.705585	3	42	100	1	2	3	0	48	1	21	0	0.045609	-25.3486	88.3223	
2023-02-14T08:10:46.704707	3	42	100	1	2	3	0	48	1	21	0	0.053514	-25.3535	88.3193	
2023-02-14T08:10:47.705359	3	42	100	1	2	3	0	48	1	21	0	0.039841	-25.3584	88.3164	
2023-02-14T08:10:48.706210	3	42	100	1	2	3	0	48	1	21	0	0.003525	-25.3604	88.3164	
2023-02-14T08:10:49.705944	3	42	100	1	2	3	0	48	1	21	0	-0.035141	-25.3584	88.3164	
2023-02-14T08:10:50.704775	3	42	100	1	2	3	0	48	1	21	0	-0.045823	-25.3525	88.3193	
2023-02-14T08:10:51.705279	3	42	100	1	2	3	0	48	1	21	0	-0.053727	-25.3467	88.3242	
2023-02-14T08:10:52.704918	3	42	100	1	2	3	0	48	1	21	0	-0.003525	-25.3408	88.3271	
2023-02-14T08:10:53.704576	3	42	100	1	2	3	0	48	1	21	0	0.048387	-25.3428	88.3252	
2023-02-14T08:10:54.705722	3	42	100	1	2	3	0	48	1	21	0	0.06334	-25.3516	88.3203	
2023-02-14T08:10:55.704596	3	42	100	1	2	3	0	48	1	21	0	0.04155	-25.3574	88.3164	
2023-02-14T08:10:56.707099	3	42	100	1	2	3	0	48	1	21	0	-0.009933	-25.3594	88.3164	
2023-02-14T08:10:57.706726	3	42	100	1	2	3	0	48	1	21	0	-0.040909	-25.3545	88.3174	
2023-02-14T08:10:58.705283	3	42	100	1	2	3	0	48	1	21	0	-0.063554	-25.3486	88.3203	
2023-02-14T08:10:59.704513	3	42	100	1	2	3	0	48	1	21	0	-0.045182	-25.3428	88.3252	
2023-02-14T08:11:00.706497	3	42	100	1	2	3	0	48	1	21	0	0.002029	-25.3408	88.3271	
2023-02-14T08:11:01.704721	3	42	100	1	2	3	0	48	1	21	0	0.043686	-25.3438	88.3242	
2023-02-14T08:11:02.704485	3	42	100	1	2	3	0	48	1	21	0	0.055436	-25.3516	88.3203	
2023-02-14T08:11:03.705115	3	42	100	1	2	3	0	48	1	21	0	0.027878	-25.3584	88.3164	
2023-02-14T08:11:04.704772	3	42	100	1	2	3	0	48	1	21	0	-0.082567	-25.3945	88.2949	
2023-02-14T08:11:05.704376	3	42	100	1	2	3	0	48	1	21	0	0.000107	-25.3594	88.3145	
2023-02-14T08:15:06.706269	3	42	100	1	2	2	0	48	1	21	0	0.050309	-24.9102	79.4404	
2023-02-14T08:15:07.704906	3	42	100	1	2	3	0	48	1	21	0	0.023392	-24.9111	79.4375	
2023-02-14T08:15:08.705265	3	42	100	1	2	3	0	48	1	21	0	-0.024674	-24.9141	79.4316	
2023-02-14T08:15:09.706658	3	42	100	1	2	3	0	48	1	21	0	-0.099016	-24.9141	79.4346	
2023-02-14T08:15:10.705586	3	42	100	1	2	3	0	48	1	21	0	-0.028306	-24.9258	79.4062	
2023-02-14T08:15:55.705562	3	42	100	1	2	3	0	48	1	21	0	0.039414	-26.7529	76.4072	
2023-02-14T08:15:56.704909	3	42	100	1	2	3	0	48	1	21	0	-0.028306	-26.751	76.4131	
2023-02-14T08:15:57.705278	3	42	100	1	2	3	0	48	1	21	0	0.046677	-26.793	76.333	
2023-02-14T08:15:58.706029	3	42	100	1	2	3	0	48	1	21	0	0.012283	-26.7783	76.3594	
2023-02-14T08:15:59.704751	3	42	100	1	2	3	0	48	1	21	0	-0.06334	-26.7822	76.3535	
2023-02-14T08:21:15.704762	3	42	100	1	2	3	0	48	1	21	0	-0.062058	-35.0879	68.5889	
2023-02-14T08:21:16.705182	3	42	100	1	2	3	0	48	1	21	0	0.018265	-35.0977	68.584	
2023-02-14T08:21:17.705376	3	42	100	1	2	3	0	48	1	21	0	0.07808	-35.0879	68.5889	
2023-02-14T08:21:18.707424	3	42	100	1	2	3	0	48	1	21	0	0.157549	-35.0693	68.5986	
2023-02-14T08:21:19.706763	3	42	100	1	2	3	0	48	1	21	0	0.003525	-35.0605	68.6025	
2023-02-14T08:23:54.705138	3	42	84	1	2	3	0	48	1	21	0	0.087907	-40.1709	62.1221	
2023-02-14T08:23:55.704616	3	42	84	1	2	3	0	48	1	21	0	0.034714	-40.1582	62.1309	
2023-02-14T08:23:56.704400	3	42	84	1	2	3	0	48	1	21	0	-0.087694	-40.1816	62.1152	
2023-02-14T08:23:57.704681	3	42	84	1	2	3	0	48	1	21	0	-0.131701	-40.1895	62.1113	
2023-02-14T08:23:58.705412	3	42	84	1	2	3	0	48	1	21	0	0.0392	-40.2119	62.0967	
2023-02-14T08:27:41.705372	3	42	83	1	2	3	0	48	1	21	0	-0.02916	-40.3906	61.3174	
2023-02-14T08:27:42.704822	3	42	83	1	2	3	0	48	1	21	0	-0.084703	-40.3975	61.3164	
2023-02-14T08:27:43.705094	3	42	83	1	2	3	0	48	1	21	0	-0.057359	-40.4072	61.3135	
2023-02-14T08:27:44.704946	3	42	83	1	2	3	0	48	1	21	0	-0.014206	-40.4131	61.3135	
2023-02-14T08:27:45.704708	3	42	83	1	2	3	0	48	1	21	0	0.038346	-40.4111	61.3135	
2023-02-14T08:27:46.707686	3	42	83	1	2	3	0	48	1	21	0	0.11397	-40.4326	61.3115	
2023-02-14T08:27:47.708114	3	42	83	1	2	3	0	48	1	21	0	0.052018	-40.3945	61.3174	
2023-02-14T08:27:48.705170	3	42	83	1	2	3	0	48	1	21	0	0.026169	-40.3721	61.3203	
2023-02-14T08:29:34.708522	3	42	82	1	2	3	0	48	1	21	0	0.022538	-64.7559	65.5791	
2023-02-14T08:29:35.705531	3	42	82	1	2	3	0	48	1	21	0	0.091539	-64.7441	65.5723	
2023-02-14T08:29:36.708717	3	42	82	1	2	3	0	48	1	21	0	0.055436	-64.7305	65.5645	
2023-02-14T08:29:37.715084	3	42	82	1	2	3	0	48	1	21	0	-0.052445	-64.7227	65.5605	
2023-02-14T08:29:38.705637	3	42	82	1	2	3	0	48	1	21	0	-0.049027	-64.7334	65.5664	
2023-02-14T08:29:39.707373	3	42	82	1	2	3	0	48	1	21	0	-0.004593	-64.7686	65.5879	
2023-02-14T08:32:31.705149	3	42	81	1	2	3	0	48	1	21	0	-0.064408	-83.6914	88.3604	
2023-02-14T08:32:32.705057	3	42	81	1	2	3	0	48	1	21	0	-0.129351	-83.6963	88.3877	
2023-02-14T08:32:33.704828	3	42	81	1	2	3	0	48	1	21	0	-0.018479	-83.7139	88.4824	
2023-02-14T08:32:34.706035	3	42	81	1	2	3	0	48	1	21	0	0.161822	-83.7139	88.4814	
2023-02-14T08:34:27.705336	3	42	81	1	2	3	0	48	1	21	0	-0.074021	-77.0596	100.721	
2023-02-14T08:34:28.705062	3	42	81	1	2	3	0	48	1	21	0	-0.064836	-77.0381	100.713	
2023-02-14T08:34:29.704644	3	42	81	1	2	3	0	48	1	21	0	0.055009	-77.0332	100.711	
2023-02-14T08:34:30.705398	3	42	81	1	2	3	0	48	1	21	0	0.217578	-77.0068	100.702	
2023-02-14T08:34:31.706625	3	42	81	1	2	3	0	48	1	21	0	-0.042832	-76.9883	100.696	
2023-02-14T08:34:32.705206	3	42	81	1	2	3	0	48	1	21	0	-0.112902	-76.9512	100.683	
2023-02-14T08:34:33.704822	3	42	81	1	2	3	0	48	1	21	0	0.03386	-76.9297	100.675	
2023-02-14T08:36:06.707413	3	42	80	1	2	2	0	48	1	21	0	-0.017838	-75.1025	105.752	
2023-02-14T08:36:07.704647	3	42	80	1	2	3	0	48	1	21	0	-0.057572	-75.0986	105.756	
2023-02-14T08:36:08.705692	3	42	80	1	2	3	0	48	1	21	0	0.010574	-75.0732	105.803	
2023-02-14T08:36:09.705920	3	42	80	1	2	3	0	48	1	21	0	-0.01677	-75.0771	105.795	
2023-02-14T08:36:10.705251	3	42	80	1	2	3	0	48	1	21	0	0.089403	-75.0781	105.795	
2023-02-14T08:37:55.704538	3	42	80	1	2	3	0	48	1	21	0	0.053514	-38.6221	112.417	
2023-02-14T08:37:56.705114	3	42	80	1	2	3	0	48	1	21	0	0.077012	-38.6172	112.415	
2023-02-14T08:37:57.704357	3	42	80	1	2	3	0	48	1	21	0	-0.037278	-38.6182	112.415	
2023-02-14T08:37:58.704642	3	42	80	1	2	3	0	48	1	21	0	-0.113543	-38.6396	112.425	
2023-02-14T08:37:59.704819	3	42	80	1	2	3	0	48	1	21	0	-0.12401	-38.6182	112.415	
2023-02-14T08:40:43.704452	3	42	79	1	2	2	0	48	1	21	0	0.007797	-35.666	128.021	
2023-02-14T08:40:44.705973	3	42	79	1	2	3	0	48	1	21	0	-0.026169	-35.6641	128.019	
2023-02-14T08:40:45.705893	3	42	79	1	2	3	0	48	1	21	0	-0.053727	-35.666	128.022	

2023-02-14T08:53:42.704806	3	42	76	1	2	3	0	48	1	21	0	0.181262	-5.125	176.846
2023-02-14T08:53:43.704558	3	42	76	1	2	3	0	48	1	21	0	0.243	-5.17871	176.846
2023-02-14T08:53:44.704694	3	42	76	1	2	3	0	48	1	21	0	0.025956	-5.20996	176.846
2023-02-14T08:53:45.705381	3	42	76	1	2	3	0	48	1	21	0	-0.198993	-5.19141	176.845
2023-02-14T08:53:46.705422	3	42	76	1	2	3	0	48	1	21	0	-0.220569	-5.14062	176.843
2023-02-14T08:53:47.704725	3	42	76	1	2	3	0	48	1	21	0	0.020188	-5.11523	176.843
2023-02-14T08:53:48.706738	3	42	76	1	2	3	0	48	1	21	0	0.241077	-5.14648	176.843
2023-02-14T08:53:49.706109	3	42	76	1	2	3	0	48	1	21	0	0.153063	-5.19922	176.842
2023-02-14T08:53:50.704664	3	42	76	1	2	3	0	48	1	21	0	-0.062272	-5.21094	176.842
2023-02-14T08:53:51.704752	3	42	76	1	2	3	0	48	1	21	0	-0.248768	-5.17285	176.841
2023-02-14T08:53:52.704676	3	42	76	1	2	3	0	48	1	21	0	-0.130632	-5.125	176.84
2023-02-14T08:53:53.705634	3	42	76	1	2	3	0	48	1	21	0	0.122942	-5.12305	176.839
2023-02-14T08:53:54.704488	3	42	76	1	2	3	0	48	1	21	0	0.252186	-5.17188	176.839
2023-02-14T08:53:55.704743	3	42	76	1	2	3	0	48	1	21	0	0.059709	-5.20996	176.839
2023-02-14T08:53:56.704608	3	42	76	1	2	3	0	48	1	21	0	-0.277821	-5.17481	176.839
2023-02-14T08:53:57.704892	3	42	76	1	2	3	0	48	1	21	0	-0.078935	-5.11621	176.836
2023-02-14T08:53:58.705630	3	42	76	1	2	3	0	48	1	21	0	0.026383	-5.12402	176.836
2023-02-14T08:53:59.705133	3	42	76	1	2	3	0	48	1	21	0	0.037705	-5.12012	176.836
2023-02-14T08:54:00.704612	3	42	76	1	2	3	0	48	1	21	0	0.07808	-5.12891	176.836
2023-02-14T08:54:01.704509	3	42	76	1	2	3	0	48	1	21	0	0.014633	-5.13086	176.836
2023-02-14T08:54:02.704736	3	42	76	1	2	3	0	48	1	21	0	-0.016343	-5.13672	176.836
2023-02-14T08:54:03.705197	3	42	76	1	2	3	0	48	1	21	0	-0.028306	-5.12012	176.835
2023-02-14T08:54:04.704937	3	42	76	1	2	3	0	48	1	21	0	-0.009933	-5.11914	176.835
2023-02-14T08:54:05.704503	3	42	76	1	2	3	0	48	1	21	0	0.018052	-5.11914	176.835
2023-02-14T08:54:06.707603	3	42	76	1	2	3	0	48	1	21	0	-0.000534	-5.12109	176.835
2023-02-14T08:54:07.705841	3	42	76	1	2	3	0	48	1	21	0	-0.001602	-5.11523	176.835
2023-02-14T08:54:08.704474	3	42	76	1	2	3	0	48	1	21	0	0.01506	-5.11328	176.835
2023-02-14T08:54:09.704298	3	42	76	1	2	3	0	48	1	21	0	-0.009293	-5.11621	176.835
2023-02-14T08:54:10.705511	3	42	75	1	2	3	0	48	1	21	0	-0.002457	-5.11426	176.835
2023-02-14T08:54:11.704734	3	42	75	1	2	3	0	48	1	21	0	0.015488	-5.11816	176.835
2023-02-14T08:54:12.705283	3	42	75	1	2	3	0	48	1	21	0	0.008652	-5.11816	176.835
2023-02-14T08:54:13.705076	3	42	75	1	2	3	0	48	1	21	0	0.015274	-5.12402	176.835
2023-02-14T08:54:14.704816	3	42	75	1	2	3	0	48	1	21	0	-0.018479	-5.11914	176.835
2023-02-14T08:54:15.704547	3	42	75	1	2	3	0	48	1	21	0	-0.003311	-5.11328	176.835
2023-02-14T08:54:16.705870	3	42	75	1	2	3	0	48	1	21	0	-0.00032	-5.12305	176.835
2023-02-14T08:54:17.704925	3	42	75	1	2	3	0	48	1	21	0	0.000748	-5.11523	176.835
2023-02-14T08:54:18.704551	3	42	75	1	2	3	0	48	1	21	0	0.008652	-5.12598	176.835
2023-02-14T08:54:19.704626	3	42	75	1	2	3	0	48	1	21	0	-0.021897	-5.11231	176.835
2023-02-14T08:54:20.704541	3	42	75	1	2	3	0	48	1	21	0	0.003738	-5.10742	176.835
2023-02-14T08:54:21.704800	3	42	75	1	2	3	0	48	1	21	0	0.00032	-5.11035	176.835
2023-02-14T08:54:22.705760	3	42	75	1	2	3	0	48	1	21	0	-0.01506	-5.11231	176.835
2023-02-14T08:54:23.704763	3	42	75	1	2	3	0	48	1	21	0	-0.00737	-5.10938	176.835
2023-02-14T08:54:24.705342	3	42	75	1	2	3	0	48	1	21	0	0.002884	-5.11231	176.835
2023-02-14T08:54:25.704942	3	42	75	1	2	3	0	48	1	21	0	-0.000961	-5.11231	176.835
2023-02-14T08:54:26.705649	3	42	75	1	2	3	0	48	1	21	0	-0.003738	-5.11426	176.835
2023-02-14T08:54:27.704807	3	42	75	1	2	3	0	48	1	21	0	-0.000107	-5.11328	176.835
2023-02-14T08:54:28.705820	3	42	75	1	2	3	0	48	1	21	0	-0.000534	-5.11328	176.835
2023-02-14T08:54:29.704947	3	42	75	1	2	3	0	48	1	21	0	-0.000748	-5.11328	176.835
2023-02-14T08:54:30.704541	3	42	75	1	2	3	0	48	1	21	0	-0.000748	-5.11231	176.835
2023-02-14T08:54:31.704601	3	42	75	1	2	3	0	48	1	21	0	0.000534	-5.11328	176.835
2023-02-14T08:54:32.704710	3	42	75	1	2	3	0	48	1	21	0	0.001389	-5.11816	176.835
2023-02-14T08:54:33.706041	3	42	75	1	2	3	0	48	1	21	0	0.004166	-5.11914	176.835
2023-02-14T08:54:34.704875	3	42	75	1	2	3	0	48	1	21	0	-0.018906	-5.11816	176.835
2023-02-14T08:54:35.704939	3	42	75	1	2	3	0	48	1	21	0	-0.056718	-5.10938	176.835
2023-02-14T08:54:36.704625	3	42	75	1	2	3	0	48	1	21	0	0.014206	-5.09863	176.835
2023-02-14T08:54:37.704980	3	42	75	1	2	3	0	48	1	21	0	0.017838	-5.10742	176.835
2023-02-14T08:54:38.705244	3	42	75	1	2	3	0	48	1	21	0	-0.017624	-5.10547	176.835
2023-02-14T08:54:39.705954	3	42	75	1	2	3	0	48	1	21	0	-0.002243	-5.10254	176.835
2023-02-14T08:54:40.705784	3	42	75	1	2	3	0	48	1	21	0	0.042191	-5.09668	176.835
2023-02-14T08:54:41.705942	3	42	75	1	2	3	0	48	1	21	0	0.002029	-5.11328	176.835
2023-02-14T08:54:42.704536	3	42	75	1	2	3	0	48	1	21	0	-0.055436	-5.11914	176.835
2023-02-14T08:54:43.705012	3	42	75	1	2	3	0	48	1	21	0	-0.125719	-5.14551	176.835
2023-02-14T08:54:44.704723	3	42	75	1	2	3	0	48	1	21	0	-0.069108	-5.13477	176.835
2023-02-14T08:54:45.704493	3	42	75	1	2	3	0	48	1	21	0	0.085771	-5.12402	176.835
2023-02-14T08:54:46.704814	3	42	75	1	2	3	0	48	1	21	0	0.160113	-5.16602	176.835
2023-02-14T08:54:47.704412	3	42	75	1	2	3	0	48	1	21	0	-0.058854	-5.13574	176.834
2023-02-14T08:54:48.704726	3	42	75	1	2	3	0	48	1	21	0	-0.017411	-5.12109	176.834
2023-02-14T08:54:49.704487	3	42	75	1	2	3	0	48	1	21	0	0.017411	-5.12305	176.834
2023-02-14T08:54:50.705756	3	42	75	1	2	3	0	48	1	21	0	-0.011642	-5.11523	176.834
2023-02-14T08:54:51.705349	3	42	75	1	2	3	0	48	1	21	0	0.011215	-5.11621	176.834
2023-02-14T08:54:52.706636	3	42	75	1	2	3	0	48	1	21	0	-0.034928	-5.17773	176.835
2023-02-14T08:54:53.706095	3	42	75	1	2	3	0	48	1	21	0	-0.244495	-5.18457	176.834
2023-02-14T08:54:54.707103	3	42	75	1	2	3	0	48	1	21	0	-0.165881	-5.09668	176.832
2023-02-14T09:46:52.953026	3	42	56	1	2	3	0	48	1	21	0	-0.024888	-105.118	41.4434
2023-02-14T09:46:53.952871	3	42	56	1	2	3	0	48	1	21	0	0.024033	-105.124	41.4453
2023-02-14T09:46:54.953732	3	42	56	1	2	3	0	48	1	21	0	0.085771	-105.12	41.4434
2023-02-14T09:50:59.952520	3	42	55	1	2	2	0	48	1	21	0	-0.043686	-48.8857	75.4307
2023-02-14T09:51:00.952339	3	42	55	1	2	3	0	48	1	21	0	-0.107774	-48.8906	75.4434
2023-02-14T09:51:01.952319	3	42	55	1	2	3	0	48	1	21	0	0.080858	-48.8877	75.4395
2023-02-14T10:07:20.952556	3	42	51	1	2	3	0	48	1	21	0	-0.032792	-24.709	112.182
2023-02-14T10:07:21.953797	3	42	51	1	2	3	0	48	1	21	0	-0.091112	-24.7139	112.167
2023-02-14T10:07:22.954396	3	42	51	1	2	3	0	48	1	21	0	-0.004166	-24.7197	112.146
2023-02-14T10:07:23.953372	3	42	51	1	2	3	0	48	1	21	0	0.090257	-24.7158	112.161
2023-02-14T10:07:24.952606	3	42	51	1	2	3	0	48	1	21	0	0.079149	-24.709	112.18
2023-02-14T10:07:25.952694	3	42	51	1	2	3	0	48	1	21	0	-0.023179	-24.7061	112.191
2023-02-14T10:07:26.952670	3	42	51	1	2	3	0	48	1	21	0	-0.158404	-24.7148	112.17
2023-02-14T10:07:27.952627	3	42	51	1	2	3	0	48	1	21	0	-0.071458	-24.7217	112.146
2023-02-14T10:07:28.952708	3	42	51	1	2	3	0	48	1	21	0	0.065263	-24.7246	112.139
2023-02-14T10:07:29.952530	3	42	51	1	2	3	0	48	1	21	0	0.154559	-24.7148	112.166
2023-02-14T10:07:30.952664	3	42	51	1	2	3	0	48	1	21	0	0.070176	-24.7109	112.181
2023-02-14T10:08:40.952411	3	42	51	1	2	2	0	48	1	21	0	-0.059281	-24.7324	112.142
2023-02-14T10:08:41.952265	3	42	51	1	2	3	0	48	1	21	0	0.069108	-24.7363	112.129
2023-02-14T10:08:42.952325	3	42	51	1	2	3	0	48	1	21	0	0.054368	-24.7266	112.163
2023-02-14T10:08:43.952418	3	42	51	1	2	3	0	48	1	21	0	-0.013779	-24.7266	112.163
2023-02-14T10:09:56.953371	3	42	50	1	2	3	0	48	1	21	0	-0.031723	-24.7314	112.18
2023-02-14T10:09:57.952893	3	42	50	1	2	3	0	48	1	21	0	-0.108202	-24.7363	112.166
2023-02-14T10:09:58.953795	3	42	50	1	2	3	0	48	1	21	0	-0.05095	-24.7422	112.144
2023-02-14T10:09:59.952199	3	42	50	1	2	3	0	48	1	21	0	0.075089	-24.7393	112.154
2023-02-14T10:10:00.954334	3	42	50	1	2	3	0	48	1	21	0	0.110765	-24.7354	112.172
2023-02-14T10:10:01.953572	3	42	50	1	2	3	0	48	1	21	0	-0.001602	-24.7285	112.191
2023-02-14T10:10:02.954858	3	42	50	1	2	3	0	48	1	21	0	-0.161181	-24.7354	112.174
2023-02-14T10:10:03.955058	3	42	50	1	2	3	0	48	1	21	0	-0.114824	-24.748	112.128

Annex IV Logistics KPIs

The ALaaS relevant KPIs are listed in the following tables with respect to the previously defined measurement approaches. Firstly, the logistics sustainability index related KPIs are summarized below:

Index	Performance Indicator
LSI	Accidents (fatalities, injuries, damages)
LSI	Air quality
LSI	Business development
LSI	Conflicting interfaces of work
LSI	Crime/Theft events, and Violation
LSI	Customer satisfaction
LSI	Delays
LSI	Distance from city center (delivery zones; commercial areas, urban distribution center, etc.)
LSI	Emission Levels (concentrazioni di CO_2, N_2O, PMs)
LSI	Energy consumption
LSI	Equipment/Materials/ Infrastructure/Management Costs
LSI	Final user-customer acceptance
LSI	GHG emissions
LSI	Green reputation
LSI	Hacker disturbance
LSI	Investment costs
LSI	Lack of information technologies
LSI	Load factor
LSI	Local development
LSI	Maintenance cost
LSI	Managerial and Operational costs
LSI	Network barriers
LSI	Noise Level: Modelled / measured (based on vehicle type and speed)
LSI	Planning costs
LSI	Poor financial situation of stakeholders
LSI	Public acceptance
LSI	Punctuality
LSI	Quantity
LSI	Stakeholder acceptance
LSI	Strength and diversification of local economy
LSI	Training cost
LSI	User acceptance
LSI	Vehicle data (vehicle-kms, average load factor, utilisation factor)

After that, here is the logistics maturity index related KPIs:

Index	Performance Indicator
LMI	Adoptation and Integration issues
LMI	Automated Data Quality
LMI	Awareness level
LMI	Contract by subcontractor
LMI	Data sharing restrictions
LMI	Diversity of stakeholders
LMI	Excessive bureaucracy
LMI	Exchange of Data
LMI	Experience
LMI	Failure to inform the public and-or stakeholders
LMI	Information flow problems

LMI	Lack of a system to monitor the efficiency and effectiveness
LMI	Lack of cooperation
LMI	Lack of data
LMI	Lack of exchange of information on adverse events
LMI	Lack of identification of undesirable events and critical issues
LMI	Lack of involvement of stakeholders
LMI	Lack of knowledge about stakeholders' requirements
LMI	Lack of knowledge about the operation of logistics process
LMI	Lack of leadership
LMI	Lack of or insignificant number of stakeholders
LMI	Lack of organization about logistics process
LMI	Lack of proper task organization
LMI	Large number of stakeholders
LMI	Misestimated cargo flow
LMI	Obstackles and Impacts
LMI	Organizational cultures
LMI	Planning
LMI	Poor or lack of know-how
LMI	Replication
LMI	Research
LMI	Time planning misjudgement
LMI	Unknown requirements

In the end, logistics transferability index related KPIs are listed in the following table

Index	**Performance Indicator**
LTI	Access availabilities (time-windows, load-factor)
LTI	Adoption rate
LTI	Business recognition
LTI	Changes in legislation (national or EU level)
LTI	Contracting
LTI	Enforcement and adaptation
LTI	Harmonization and Simplification (logistics rules)
LTI	Integration
LTI	ITS for freight monitoring and planing
LTI	Loading/Unloading areas and parking
LTI	Lockers (availability in vehicle or external places)
LTI	Multimodality for urban freight
LTI	Penetration
LTI	Promotion
LTI	Regulations and Laws
LTI	Reverse logistics integration into supply chain
LTI	Routing
LTI	Stakeholder acceptance
LTI	Stakeholder percentage
LTI	Success rate
LTI	Transferring rate
LTI	Trans-shipment facilities