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TRACE

inTegration & haRmonizAtion of logistiCs opErations

D5.1 Barriers and Business opportunities

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Executive Summary

This deliverable provides an in-depth analysis of TRACE offering a high-level, executive summary of the key factors impacting its adoption and evolution within the logistics and supply chain industries. Aimed at stakeholders, decision-makers and potential adopters of TRACE, the deliverable sets out a detailed review of the ecosystem, identifies existing gaps in the industry landscape and defines a roadmap for further development of the platform building on the gathered insights into the market applications and the key factors determining wider adoption.

Ecosystem analysis contextualizes TRACE in a wider ecosystem to understand how it can serve as a unifying digital solution and its value proposition. Existing and new players are described along with their relationships and revenue streams. The Gap Analysis then pinpoints the identified deficiencies in existing solutions, such as lack of optimization and automation, lack of real-time information, lack of vehicle and delivery innovation etc., all of which TRACE aims to resolve. The third section, Roadmapping, focuses on the market adoption and evolution of TRACE solutions, identifying the critical criteria—such as enhanced system performance, synchromodal logistics features, business strategy alignment, and flexibility—that affect adoption rates and stakeholder engagement.

Readers will benefit from a deeper understanding of the TRACE platform's potential to address complex logistics needs through tailored, innovative features. The deliverable concludes by emphasizing TRACE's strategic advantages in promoting cost efficiencies, regulatory compliance, and secure data transfer, making it a compelling tool for modern logistics transformation towards a more efficient and greener industry. The analysis and roadmap outlined here will provide valuable insights into TRACE's expected impact and evolution, supporting stakeholders in making informed decisions about its integration and long-term value.

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Definitions, Acronyms and Abbreviations

Abbreviation	Definition
3PL	Third-Party Logistics
4PL	Fourth-Party Logistics
AHP	Analytic Hierarchy Process
AI	Artificial Intelligence
AWS	Amazon Web Service
B2B	Business-to-Business
B2C	Business-to-Customer
CI	Consistency Index
CR	Consistency Ratio
ETA	Estimated Time of Arrival
EV	Electric Vehicles
GPS	Global Positioning System
HW	Hardware
ICT	Information and Communication Technology
IT	Information Technology
LSP	Logistic Service Provider
ML	Machine Learning
MNO	Mobile Network Operator
SW	Software
TMS	Transport Management Systems
UAV	Unmanned Aerial Vehicle
UC	Use Case
WMS	Warehouse Management Systems
WP	Work Package

1 Introduction

This deliverable assesses TRACE platform which is an innovative solution addressing issues related to logistics and supply chain management. It identifies factors that will shape TRACE adoption and evolution in the market through a blend of ecosystem analysis, gap analysis, and strategic roadmapping. By defining specific needs across logistics operations and offering insights into how TRACE aligns with these needs, the deliverable provides an in-depth view of the platform's potential to foster operational efficiency, interoperability, and real-time responsiveness for logistics service providers and stakeholders.

1.1 Scope

The main objective of this deliverable is to determine the drivers, barriers and enabling factors influencing the adoption of TRACE platform by analyzing the existing logistics environment and identifying gaps where TRACE will bring significant advancements. The scope includes a deep-dive into the ecosystem dynamics that define TRACE's relevance and an evaluation of current sector gaps that the platform could fill. By assessing the platform's features and benefits in addressing these identified industry gaps, this document serves as a blueprint for TRACE's development and market strategy, outlining how it can offer value to various stakeholders. Additionally, the deliverable provides a roadmap detailing actionable steps for TRACE's integration, scalability, and sustained evolution within an ever-changing logistics environment. This deliverable aims to serve multiple functions: first, as a comprehensive reference for stakeholders who seek to understand TRACE's market positioning; second, as a strategic document for the platform's future roadmap based on identified industry trends and user needs; and third, as an evaluative report that outlines factors influencing TRACE's adoption and long-term market success. In this manner, the deliverable provides a foundation for ongoing development and market alignment efforts for TRACE.

1.2 Relation with Other Work Packages/Deliverables

This deliverable integrates findings and strategic insights derived mainly from WP2, ensuring TRACE's alignment with broader project goals and stakeholder requirements. Work packages addressing technical specifications, user requirements, regulatory compliance, and market analysis have contributed to shaping the recommendations presented in this deliverable. Specifically, inputs from technical work packages concerning interoperability, data management, and system architecture have guided the gap analysis and ecosystem assessment, aligning TRACE's design with technical needs across the logistics ecosystem.

Additionally, the analysis and recommendations within this deliverable provide foundational guidance for subsequent deliverables that will further develop TRACE's business models, technoeconomic analysis and stakeholder engagement strategies. By providing a strategic roadmap and identifying critical success factors, this deliverable aids in harmonizing TRACE's development process, ensuring that subsequent activities are aligned with both market demands and user expectations.

1.3 Intended Audience

Key stakeholders include logistics service providers (LSPs), supply chain managers, policymakers, technology providers, and decision-makers in transport and logistics firms who seek to streamline operations, increase transparency, and optimize resources. Additionally, TRACE developers and project managers will find this deliverable valuable for understanding the market's requirements and aligning platform features with those requirements.

For policy and regulatory stakeholders, this deliverable provides insight into the project's efforts to align with industry standards, making it relevant for those overseeing industry standards and regulations. The document is also intended for business strategists and innovation teams within logistics and technology firms who are looking to leverage TRACE as part of their broader digital transformation and efficiency-optimization efforts.

1.4 Structure

The deliverable has the following structure:

- Section 2: The ecosystem around the TRACE platform is presented: the roles and the actors are defined along with their interactions. Additionally, the main benefits of the TRACE platform for each of the actors are illustrated.
- Section 3: The results of the gap analysis are listed and discussed in detail.
- Section 4: Findings of an online survey regarding the ranking of the factors that will affect the market adoption and evolution of TRACE solutions, are analysed.
- Section 5: Concluding remarks.

2 The TRACE Ecosystem

Synchromodality is a transformative paradigm in logistics, which likely disrupts the way goods travel within and between urban areas [1]. Synchromodality can be guided by advanced technologies and components including AI, blockchain, data analytics, data sharing. Synchromodality is analysed as follows in terms of components, drivers of adoption, challenges and benefits.

Components of synchromodality in logistics [1]

- **Multimodal Transportation Network:** Synchromodality works on the basis of a fully connected network combining all available modes of transportation (road, rail, inland waterway and air). It should be noted that this network must be flexible in real time, meaning the cargo can move easily on and off between modes in an on-demand way.
- **Advanced Technologies:** The use of AI and predictive analytics can lead to route optimization, combinations of the different modalities and proactive responses to disruptions based on the evaluation of fuel prices, route congestion and capacity availability leading to increased efficiency and network resilience. In parallel, blockchain technology is frequently used to provide data integrity, transparency and trustworthiness helping to mitigate fraud, facilitate paperwork and build confidence in the network. Interestingly, blockchain technology can facilitate the increase between logistics companies by securing the 'ownership' of shipments when those are transferred by different players. Last, but not least, the availability and use of alternative automated means of transport and fuel (like e.g. autonomous vehicles of various kinds, robots, drones, electricity or hydrogen powered) can both alleviate heavy urban traffic conditions, reduce time to the customer, energy spent, emissions and associated costs.
- **Real-Time Data Sharing and ICT Systems:** ICT systems like transport management systems, demand forecasting tools and data sharing platforms can enable real-time data exchange and visibility across the supply chain, which is the very basis for synchromodal logistics.

Drivers for the Adoption of Synchromodality in logistics

- **High and Irregular Fuel Prices:** Fuel prices are volatile, even spiraling upwards over time. They push up the cost of transport significantly and are especially damaging to road transporters. This unpredictability also means that alternative modes for lowering logistics costs - shifting more goods onto trains or waterways where possible - become necessary. Synchromodality offers the flexibility to choose the most economical and fuel-efficient mode based on current market conditions, helping logistics providers better manage costs [2].

- **Overloaded Road Networks and Increased Pollution:** Already in 2021 [3], it was estimated that urban logistics already accounted for 20% of all traffic and for 30% of pollution in cities. Roads get congested in many local areas, especially those near major ports, but also in the city centre for the last mile deliveries. With the extra volume, more vehicles come onto the road. This leads to delays and increased fuel consumption. Synchromodal logistics reduces air pollution and traffic congestion by using modes that are less congested (such as rail or alternative vehicles in urban environment) or combinations of these that spread freight more evenly across several transport channels [4].
- **Ever More Complicated Supply Chains Globally:** As supply networks become more interconnected and complex, the probabilities of disturbances occurring (e.g. delayed shipments, shortages of equipment or port backlogs) grow. Synchromodality offers elasticity: when a transportation mode is unavailable, it can be bypassed by other modes whose resources are available in real time. This means that logistics managers can build up preventive systems, thus reducing the probability of failure in their operations.
- **Environmental Awareness and Regulatory Pressure:** Public and Governmental demand to minimize the environmental impact of logistics are forcing logistics companies to operate more environmentally friendly practices. Synchromodality, with its emphasis on flexibility, can enable a shift to greener transport modes (like rail or waterways), thereby reducing carbon emissions and pollution, aligning logistics practices with environmental regulations and sustainability goals.

Challenges to Implementation

- **Interconnectivity and Collaboration:** Synchromodality is not just an operational concept, it needs complete coordination between the stakeholders — shippers, carriers, logistics providers and port authorities. The cooperation between them derives from a trust based on mutual benefit and not from direct competition. Still, many value chain entities are reluctant or even resistant about information (data) sharing or collaborating with competition. This requires a mindset change about collaboration and cooperation, but also the setup of a trustworthy environment of mutual shared trust, where people from different organizations will be willing to share information freely. When that happens, cooperative planning and operations planning will become a reality. In addition, there may be issues of available standards, protocols and interfaces between different systems or transport means that need to be resolved for synchromodality to take off.

- **Planning and Execution Complexity:** Synchromodal logistics relies heavily on planning and availability of data – often real-time data, while it also requires a great number of continuous updates in real-time. Even aspects like traffic patterns, available transport modes, customer preferences and resource availability have to be incorporated into the decision making in real-time. Additionally, forecasting tools and predictive analytics are also needed for anticipating disturbances that hamper operations, e.g. shortage of equipment or route closure. The complexity of logistics and the need for continuous monitoring can make planning a challenging matter. Thus, advanced technologies, such as AI, predictive analytics, open data & data analytics are required to accommodate the dynamic requirements.
- **Connectivity of ICT Systems and Data-Sharing Platforms:** The essence of synchromodal logistics lies in the continuous exchange of information between multiple stakeholders and systems, each relying on different IT infrastructures. It is a huge challenge to harmonise all these systems to ensure that the data are seamlessly flowing through and to update them in real time. The integration of ICT systems (transport management software, demand forecasting tools, and data-sharing platforms) requires standardization and compatibility that may not be possible without shared investments and coordinated technological upgrades across the supply chain.

Benefits of Synchromodality

- **Greater flexibility and resilience:** Synchromodal solutions enable logistics providers to switch modes between transports on purpose or dynamically, due to various events such as traffic congestion, fuel prices or changing customer demand. Real time adaptability enhances supply chain resilience, allowing them to avoid potential delays and disruptions.
- **Cost Reduction and Minimization of Carbon Footprint:** Operational costs can be minimized by switching to more economical modes (lower fuel usage etc.) when needed and applicable. The shift to more sustainable types of transportation such as (electric) rail, water or other types of vehicles, which are less polluting compared to typical road transportation can help in decreasing greenhouse emissions, air pollution and noise and achieving sustainability goals.

- **Improved Transport Efficiency and Resource Utilization:** In synchromodal transportation, transport modes are assigned to specific transport flows based on cost factors, reducing not full runs and increasing the utilization rate of the vehicles. This can help boost productivity in transport through optimised routing and scheduling.
- **Greater Customer Satisfaction:** Because synchromodal logistics allows for faster changes to logistics routes and modes, it can lead to more reliable delivery times, and thus better service levels which helps improve customer satisfaction along with their loyalty by allowing businesses to fulfil time-critical or specific delivery requirements.
- **Improved Regulatory Compliance:** Synchromodal logistics helps companies stay compliant with regulations on emissions and sustainability by facilitating cleaner and more sustainable practices (e.g. decrease the number of transport means used in total) [5], reducing the risk of penalties, and enhancing their green credentials.

Within TRACE, an innovative synchromodal logistics platform is envisaged which will overcome the limitations of existing logistics systems by providing a seamlessly integrated multimodal transport solution. The main goal of TRACE is to build a flexible network that utilizes available resources most efficiently across transport modes with data-driven decision-making. Signifying not just implementation of novel infrastructure and tech but also promoting high collaboration between different partners throughout the logistics chain. Achieving this is the essence of today's logistics operations and a key enabler of TRACE's success.

Traditional logistics systems are network-centric and typically do not integrate data from different sources in real-time; these networks tend to be mono-modal or, at best, predicted by a static multimodal environment. These systems are being stretched to their breaking point due to the abovementioned challenges.

TRACE seeks to overcome these limitations by creating an interconnected logistics network that actively leverages AI, Machine Learning (ML), blockchain and smart contracts. By automating functions and creating full visibility from end to end, these technologies help foster predictive capacity, quick redistribution of resources, and trust among stakeholders.

By constantly improving and coordinating around the fundamental elements, TRACE will create a flexible and dynamic logistics platform that brings us closer to a reliable, greener, more effective, less costly and moral approach to logistics.

This section outlines the relationships and interactions among various roles within the TRACE ecosystem. This initial step is crucial for gaining a comprehensive understanding of the ecosystem and its characteristics. It will prove instrumental in exploring associated business models concerning the TRACE platform in the subsequent phases of the project.

Initially, the various roles of actors participating in the ecosystem are presented. The section concludes by presenting the initial reference model for the TRACE platform. The following definitions are used in the following sections:

- **Actor**: an entity that participates in the business model, either by providing or consuming services.
- **Role**: the functionality of each actor that participates in the business model. An actor can take one or more of the roles, while a role can be undertaken by several actors.
- **Relationship**: the interaction between two roles within the model.

2.1 Actors and Roles

In this new era, logistics involves a number of actors cross-collaborating in the value chain. These actors include not only traditional ones like logistics companies and carriers but also actors from other industries – ICT etc.

Many actors are entering the market following different approaches, either collaborating or competing with traditional actors/players. Given the rapid growth of logistics, these actors/players are actively positioning themselves in the value chain, assessing all opportunities to deliver enhanced value and maximize profit potential.

Considering the TRACE architecture and UCs, the proposed platform plays a central role in the ecosystem, adopting the proposed solutions and tools. The subsequent paragraphs (Table 1) describe the key actors and roles in this dynamic landscape.

Table 1 Actors and their Roles with examples, of TRACE ecosystem

Actors	Roles	Example
Fixed and Mobile Network Operators (MNO)[1]	The success of TRACE and in general of logistics heavily relies on seamless communication between vehicles, infrastructure, and other elements of the ecosystem. Telecommunication providers play a vital role in deploying and providing the necessary connectivity infrastructure, including 5G networks, to support real-time communication and data exchange among vehicles and with the surrounding environment. They own the physical equipment such as fiber, base stations, antennas, switches, etc.	Orange, Cosmote/Deutsche Telekom, Telefonica, Verizon, AT&T etc.
Cloud Infrastructure Providers	They provide the required storage, cloud computing and corresponding networking resources (CPUs, RAM, storage). These can be in a central cloud location or locally deployed in edge servers.	Amazon Web Services (AWS), Microsoft Azure, Google Cloud, Alibaba Cloud, IBM Cloud, Oracle, Salesforce, SAP, Rackspace Cloud, VMWare
HW Vendors	They provide all types of hardware to all interested parties, for example, switches, routers, servers, network cards, sensors, cameras, CPUs, etc.	Huawei, Cisco, Ericsson, Nokia, NVIDIA, Bosch, HP, Dell, Accelleran, ADVA, Athonet, Robotnik Automation SLL, CSEM, Difly srl,

[1] Neutral Host, like Cellnex, American Tower, and similar entities, can also be included in this category. These organizations own and manage essential physical telecom infrastructure—such as fiber cables, base stations, antennas, and switches—that is crucial for enabling advanced logistics applications.

Actors	Roles	Example
SW Providers	They provide all the necessary generic software that is required by all parties. For example, the firmware that is required for the hardware devices and the platforms, etc. This role does not include the development and provision of 3rd parties' services and apps.	Microsoft or Linux Foundation, APEX AI, eclipse foundation, Netcompany-Intrasoft S.A., Blockchain 5.0, AC Codewheel LTD, UNISYSTEMS LUXEMBOURG SARL, AV Living Lab, d.o.o.
3rd parties' services and apps developers/providers	They develop and/or provide 3rd parties services and apps to logistics infrastructure providers, LSPs, vehicle manufacturers etc.	OptimoRoute, Onfleet, Route4Me, Fishbowl, NetSuite WMS, Infor WMS, Project44, Flexport, Shipwell, FourKites, ClearMetal, Transporeon, ShipBob, TradeGecko, Cin7, Convoy, Uber Freight, Transfix, Kuebix, Llamasoft
Vehicle Manufacturers	They are developing and deploying trucks for logistics transport. Such companies invest heavily in research and development to create advanced driving systems.	Mercedes-Benz, Volvo, Paccar, Scania, Navistar, Ford, General Motors, Isuzu motors, Rivian, Arrival, BYD, Hyundai, Renault, Nissan, ONE LESS VAN SRL, URBICO SRL etc.
Customers	All types of users who are the recipients of the provided services. or interact directly with LSPs and/or carriers. They can be individual users (Business-to-	Manufacturers, Suppliers, General Firms, Logistics Firms.

Actors	Roles	Example
	Customer (B2C)) or business customers (Business-to-Business (B2B)).	
Road Infrastructure Providers/Operators	They are responsible for the deployment, operation, and maintenance of the road infrastructure. They can also own and operate road-side facilities such as ICT equipment, cameras and sensors located in the road networks	Government transportation agencies such as the Department of Transportation in the USA, Transport for London (TfL) in the UK, and the Roads and Transport Authority (RTA) in Dubai.
Hub Managers	They establish and manage incoming and outbound shipping schedules. They manage the flow of resources and goods throughout an organisation. They collaborate with different divisions within the business to enhance logistics. They supervise the remainder of the logistics team's job.	
Port Authorities	They can play an important role in facilitating the movement of goods into and out of a particular port area. By owning and maintaining key infrastructure investments within the port, a Port Authority can help to ensure that port operations run smoothly and efficiently.	National port authorities
Carriers	Carriers play a crucial role in logistics by executing the transportation of goods according to the logistics plan provided by shippers. Their responsibilities include	

Actors	Roles	Example
	loading, transporting, unloading, and occasionally even providing warehousing or storage services.	
3rd party logistics (3PL) service providers	They provide outsourced logistics and supply chain services to other businesses. These services can include warehousing, inventory management to transportation, freight forwarding etc. They allow companies to work more efficiently and save costs as they can largely concentrate on their main sector while the 3PL takes care of distribution and logistics, using their own expertise.	C.H. Robinson, Kuehne + Nagel, Expeditors International, DB Schenker, Ryder System, ACS
4th party logistics (4PL) service providers	They provide integrated supply chain solutions by managing the complete logistics process on behalf of their clients. While 3PL providers typically focus on individual functional areas (such as warehousing or transportation), 4PLs assume a broader, more consultative role as an overall end-to-end logistics partner. Instead, they oversee the entire supply chain—frequently coordinating numerous 3PLs and other service providers, together—to provide a streamlined, holistic logistics solution for the customer.	DHL Supply Chain, UPS Supply Chain Solutions, DB Schenker, Kuehne + Nagel, CEVA Logistics, XPO Logistics, DSV Panalpina, Geodis & CH Robinson

2.2 Platform's benefits/incentives per role

This section discusses the anticipated developments and benefits in the different actors/roles of the ecosystem stemming from the introduction of the TRACE platform.

2.2.1 Infrastructure providers: Network operators and cloud providers

Infrastructure providers are expected to gain significant benefits as enablers of logistics. Engagement with the TRACE platform can assist Infrastructure Providers in discerning emerging market and business challenges, recognizing potential opportunities, and promptly identifying novel business models. Furthermore, this interaction enables Infrastructure Providers to venture into the lucrative logistics market and expand their portfolio of applications and services. This extension enables seamless connectivity to vehicles, trucks and UAVs, facilitating the exchange of crucial information. In addition, both MNOs and Cloud Infrastructure Providers can experience an increase in the consumption of their edge and cloud services due to the need for local data processing and decision making.

2.2.2 Logistics Infrastructure Providers/Terminals

Logistics infrastructure providers/Terminals stand to gain valuable insights from the data shared, enabling the implementation of innovative strategies and tactics for effective traffic and flows management. The ability to interact with other stakeholders of the ecosystem empowers them to regulate demand by establishing guidelines for transportation means behavior. In TRACE, they receive mobility data allowing the implementation of optimal traffic management strategies. This optimization not only enhances logistics services but also improves overall traffic flow and channels capacity.

Moreover, the utilization of their infrastructure during the UCs provides them with valuable insights into necessary upgrades. This may include the introduction of new equipment with enhanced capabilities. Collaborating with big players in the industry becomes crucial, as they can articulate their expectations and requirements for future logistics applications, guiding the creation of innovative solutions.

2.2.3 HW vendors

Providers of equipment closely monitor the relevant markets and their evolving trends. While many technical features adhere to standards, vendors concentrate their product development efforts on features that exhibit a growing and stable future demand, ensuring a reliable revenue stream. The logistics industry's robust demand for products like the TRACE platform serves as a compelling indicator for vendors to align their development strategies accordingly.

Deploying equipment during UCs aids in validating products in new applications and services, enabling the identification of areas for future improvement to meet evolving requirements. An additional benefit lies in the increased knowledge gained in advanced techniques and technologies. This engagement provides valuable insights into incorporating these sophisticated features into upcoming products.

2.2.4 SW providers and 3rd party's services and apps developers/providers

The open development principles adopted during the design and development of the TRACE platform, the availability of a high volume of data from different sources as well as the need to combine different systems allows SW Vendors and 3rd party services and apps developers/providers to develop advanced SW pieces as well as services and applications. These factors also contribute to the establishment and growth of dedicated software development teams, specifically focused on crafting platform solutions, expansions, and interfaces.

2.2.5 Vehicle manufacturers

The automotive industry is expected to enhance the capabilities of vehicles (trucks, UAVs etc.) to meet the evolving needs of logistics. New strategies for data generation and sharing will be developed, enabling vehicles to share information. Vehicles will incorporate new functionalities to improve road safety and traffic efficiency as well as to allow tracking. These functionalities may include platooning and dynamic route optimization contributing thus to a reduction in environmental impact. Furthermore, active involvement in TRACE UCs empowers them to comprehend the essential requirements for deploying novel services. This understanding enables the adaptation of both hardware and software in their vehicles, ensuring preparedness for the market entry of these applications.

2.2.6 Customers

End Users are expected to gain significant benefits from the introduction of the TRACE platform in terms of efficiency, environment and economy.

2.2.7 Third-Party Logistics (3PL) Service Providers

TRACE is a game-changer for 3PLs offering real-time visibility, resource optimization and secure collaboration. With the help of TRACE's enhanced logistics technologies, 3PLs can reduce costs, improve operational efficiency along with ensuring compliance, and provide a better, agile service experience to customers. With this feature, TRACE aligns well against an ever competitive and digitized logistics ecosystem and will help 3PL service providers maintain a competitive advantage.

2.2.8 Fourth-Party Logistics (4PL) Service Providers

TRACE provides 4PLs with an end-to-end AI-driven, blockchain-based logistics service that improves operational efficiency, increases visibility, lowers the costs of logistics operations and better collaboration along the supply chain. TRACE equips 4PLs to deal with complex logistics networks more efficiently by facilitating enhanced resource optimization, real-time decision making while ensuring secure and transparent processes. This flexible and sustainable platform not only addresses current needs of the logistics industry, but also future proofs 4PLs with solutions that can be scaled up.

2.3 TRACE reference model

The second step is to define the interrelations amongst stakeholders in the TRACE landscape. The value network is multi-faceted, with a large number of actors/roles who play their part in the associated reference model. Figure 1 illustrates all roles/actors involved with the format of relationship interfaces and revenue streams between them.

Definitions:

- The direction of arrows in the model signifies the flow of services.
- Revenue flow is considered to move in the opposite direction. In certain instances, there is bidirectional revenue sharing between two roles.
- The rectangle with a dotted line symbolizes an actor and an actor may assume one or more roles. The rectangular boxes within the dotted-line rectangles depict these roles.

It should also be noted that there are some other relationships among the roles, such as HW (hardware) vendors selling equipment to all other parties in the ecosystem. However, these relationships go unexplored, precisely because they do not affect the TRACE platform provider's business model.

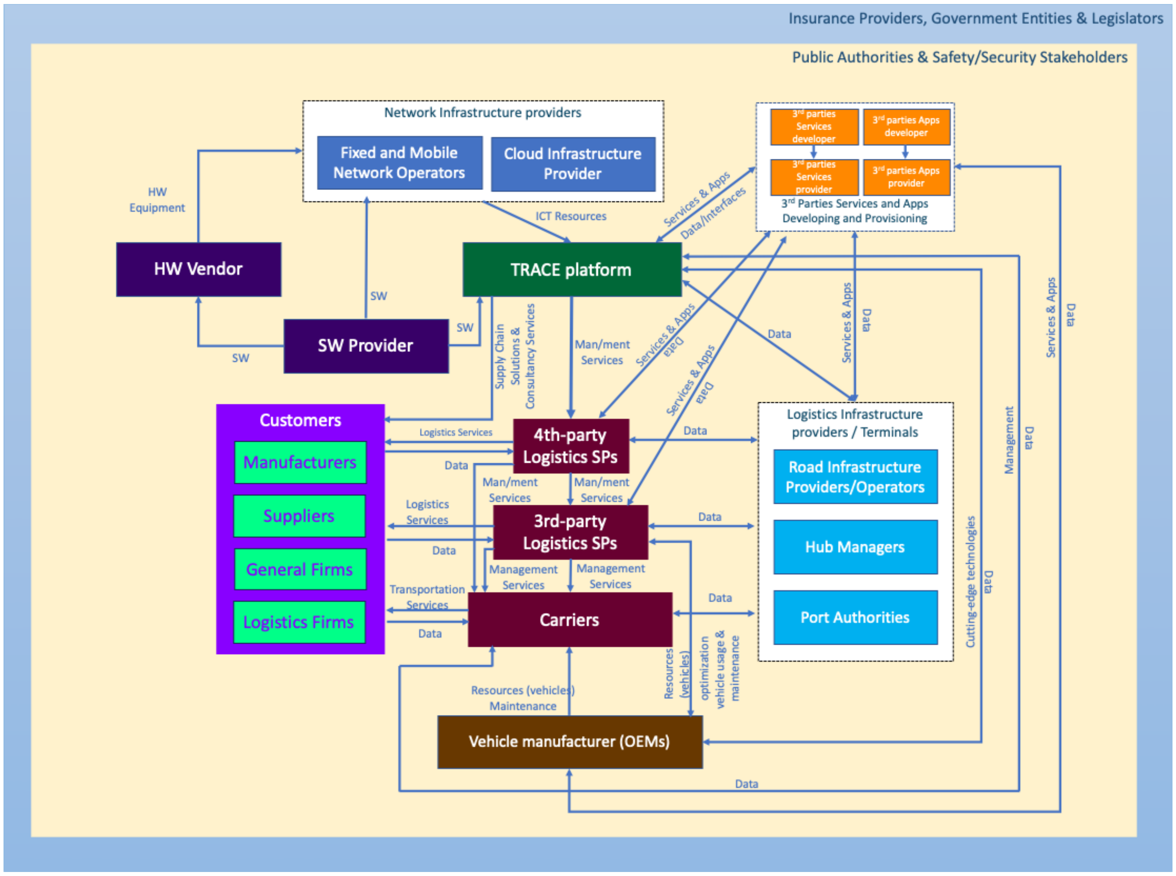


Figure 1. TRACE Reference Model. Roles/actors, relationship interfaces and revenue streams

The business relationships within the reference model are outlined as follows:

- **HW equipment:**
    - **Description:** Represents the relationship between actors for the provisioning of ICT-related equipment.
    - **Participants:** HW vendor provides hardware equipment to infrastructure providers and the TRACE platform.
- **SW:**
    - **Description:** Represents the relationship between actors for the provisioning of software.
    - **Participants:** SW providers deliver SW to the HW vendors, infrastructure providers, and the TRACE platform.

- **ICT resources:**
    - **Description:** A broad term encompassing various resources (connectivity, computational resources, etc.) provided by infrastructure providers.
    - **Participants:** Involves the fixed network operators, MNOs and the Cloud Infrastructure Providers
- **Resources (Vehicles):**
    - **Description:** Represents the relationship between actors for the provisioning of vehicles provided by the vehicle manufacturer to end users.
    - **Participants:** Vehicle manufacturers provide vehicles to carriers
- **3rd party's services and apps:**
    - **Description:** Represents the relationship between actors for the provisioning of 3rd party's services and apps including optimization and management apps etc.
    - **Participants:** 3rd parties services and apps developers/providers provide such services and apps to TRACE platform, 3PL, 4PL, logistics infrastructure providers and vehicle manufacturers.
- **Management Services:**
    - **Description:** Represents the portfolio of management services provided by the TRACE platform, 3PLs and 4PLs.
    - **Participants:** TRACE platform provides services to 4PLs, 4PLs to 3PLs, carriers and/or customers.
- **Logistics Services:**
    - **Description:** Represents the portfolio of logistics services provided by 3PLs and 4PLs.
    - **Participants:** 3PLs and 4PLs provide services to customers.
- **Transportation Services:**
    - **Description:** Represents the portfolio of transportation services provided by carriers.

- **Participants:** Carriers provide services to customers.

The business model(s) to be adopted/followed is of paramount importance since this will also define TRACE's service delivery method. As shown in the general reference model of Figure 1, there are several options to deliver TRACE's services. TRACE services can be delivered directly to customers from the TRACE platform in the form of supply chain solutions and consultancy services. Moreover, TRACE services can also be delivered to 4PLs and the latter to provide them either to 3PLs and carriers in the form of management services or to customers directly as logistics services.

It is interesting to note that the success of any logistics/synchromodal platform including the TRACE platform is based on the availability and exchange of a high volume of data. This is also illustrated in the reference model of Figure 1. TRACE platform exchanges data with 3rd parties services and apps developers/providers, logistics infrastructure providers/terminals, vehicle manufacturers and carriers. In addition, logistics infrastructure providers/terminals exchange data with 3rd parties services and apps developers/providers, 3PLs, 4PLs and carriers. On the other hand, customers are providing data to 3PLs, 4PLs facilitating the decision making, traffic management and optimization and other processes and functionalities of the involved roles.

3 TRACE GAP Analysis

3.1 Methodology

The gap analysis performed aims to identify the differences between the current state of logistics operations and the future/TRACE-based desired state. It employs a twofold approach, namely an internal gap analysis engaging TRACE pilot leaders and an external one focused on wider logistics companies. Both are dependent on structured data collection using tailored set of questionnaires, carefully designed and distributed to get a holistic view of the operational gaps and the areas of potential improvement. TRACE can use this approach to test its development aspirations and align with the stakeholders' needs.

3.1.1 Internal Gap Analysis

The internal gap analysis was based on the methodology initially developed by the FENIX project [6]. This is a three-step process aiming to collect and analyze inputs from UCs/pilots leaders. Thus, the first step of this process is the distribution of questionnaires that have been carefully prepared in order to understand the logistics operations of TRACE UCs/pilots. The data collection focuses on:

- **Background Information:** This part of the questionnaire aims to collect information about the topic of the pilots, the actors involved, the ambitions of the use cases, the motivations behind the need for a change.
- **Recording the as-is situation (pre-TRACE)**: The goal of the next part of the questionnaire is to collect information about the current state of logistics processes, performance levels, available resources, existing skill sets, and technologies used by TRACE pilot leaders. Such information can reveal areas of potential improvement, that is areas where TRACE is expected to have a significant impact.
- **Describing the desired situation (post-TRACE)**: In this part, pilot leaders describe the desired future state in a TRACE-enabled logistics environment characterized by increased efficiency, enhanced performance, optimized flows, traffic and resources usage, advanced technology infrastructure etc. The derived future state must be used to direct TRACE's efforts.
- **Identifying the gaps and their root causes**: Using insights from the current and desired states, the questionnaire gathers input on the perceived gaps. It investigates the root causes behind these gaps by asking stakeholders to specify the limitations in technology, operational practices, or resources that inhibit them from reaching the ideal TRACE-supported logistics environment.

- **Identifying potential actions to close the identified gaps**: The aim of the last part is to collect suggestions for closing the defined gaps. These will help TRACE to align its strategy with the identified areas of improvement.

The designed questionnaire is shown in Table 2.

Table 2 Internal Gap Analysis Questionnaire

Item	Description
Pilot partners and actors	Please provide a complete list of all the partners and actors who are involved in your UC, specifying their roles in detail. If there are any differences between the pre and post TRACE actors and partners, please specify it.
UC Goals	Please specify in detail the goals and the expected results of your UC.
Pre-TRACE UC	Please describe in detail how the process of your UC took place before the innovations introduced within the TRACE project (baseline scenario).
Problems of the status pre-TRACE	Please list all the problems found in your UC pre-TRACE. Which are the motivations that push you to change the situation before TRACE?
Measurement of the baseline scenario	How do you intend to measure the baseline scenario?
Post-TRACE UC	Please describe in detail how you foresee the process of your UC after the innovations introduced with the TRACE project
Gap between pre- and post-TRACE	Please, describe carefully what are the necessary measures to solve the identified problems and get to the ideal post TRACE state of your UC.
Measurement of these gaps	How do you intend to measure these gaps?
Action Plan to overcome these gaps	Please list in detail the implementation phases of your UC including all the necessary resources
Timeline	Please specify the timeline that you have foreseen to implement your UC

Following data collection, the **data processing** stage involves grouping similar gaps into meaningful macro-areas to streamline the analysis. Each macro-area represents a core challenge in logistics operations where TRACE could drive improvements. For each macro-area, a root cause analysis is performed to delve deeper into the underlying issues, answering the critical "why?" questions. This phase provides TRACE with clarity on the primary constraints affecting logistics operations, whether related to system interoperability, data integration, workforce skills, or operational inefficiencies.

Recommendations are also provided in order to address the defined gaps.

3.1.2 External Gap Analysis

The external gap analysis mirrors the design of the internal methodology but aims to a broader viewership of transportation organizations to validate the results of the interior analysis. This more comprehensive outreach is intended to ensure that the distinguished gaps are not restricted to TRACE's prompt pilot stakeholders but resonate across the broader transportation sector too. Just like the internal way, the external gap examination involves customized questionnaires made to seize transportation companies' present and wanted states, perceived gaps, and proposals for enhancement. The external gap analysis questionnaires can be found in Annex I.

While the external analysis lacks the grouping and macro-region approach, it gives critical external validation of the TRACE system's likely impact and importance across the transportation business. This stage is critical for confirming that TRACE addresses both the exact needs of its pilot users and the more comprehensive challenges inside the transportation ecosystem. The external gap analysis offers TRACE a beneficial industry-wide point of view, testing the findings of the internal analysis and ensuring that the system's development is led by a holistic understanding of market demands.

Together, the internal and external gap analyses form a comprehensive view of the transportation sector's pain points, paving the way for TRACE to design targeted solutions that successfully address these issues. By combining both views, TRACE is well-positioned to craft a development roadmap that better aligns with stakeholder needs, maximizes the desired effect, and positions the platform as an indispensable instrument for next-generation transportation operations.

3.2 Brief Description of the pilots

Below follows a brief description of each TRACE Pilot case that provided input for the internal gap analysis.

3.2.1 Greek pilot:

The Greek Pilot consists of three parts. Parts A and B focus on the Thessaloniki-Athens corridor, where trucks and trains will be used to test intermodal logistics operations and responses to disruptive events.

ACS and HT are coordinating the transportation of shipments between warehouses across Greece, utilizing TRACE logistics services.

Part C takes place on the NKUA campus, concentrating on safe exchange areas for deliveries carried out by autonomous vehicles. Multiple parcels will be delivered to various customers on campus using unmanned vehicles, combining services from different last-mile delivery companies.

In Part A and B intermodal logistics operations will be optimized with TRACE logistics services to coordinate shipments between ACS and Hellenic Train. Key activities comprise the planning and execution of shipments between ACS hubs in Thessaloniki and Athens, reducing trucks by 50% through the integration of railway services provided by HT. TRACE will be responsible for facility shipment allocation, real-time monitoring, and operational integration with ACS and HT, thus assuring seamless and effective logistics.

The general idea behind this pilot is thus to develop better efficiency in shipment transfers, reduce operational costs, and minimize environmental impact due to the logistics operation. By putting fewer trucks on the road, this pilot adds rail transport in targeting large cuts in fuel use, emissions, and general energy expenditure. This contributes to sustainable logistics and helps outline how the TRACE platform might be resilient and flexible to optimize intermodal operations.

Key steps of the approach are highlighted below: TRACE does the allocation of the roller cages, containing shipments, and computes the estimated time of arrival for every route. Further, it provides optimized schedules to both ACS and HT. Continuous monitoring is done for each roller cage using sensors. TRACE handles real-time communication and integration with the two companies' systems for data integration. It applies Blockchain on TRACE to enable secure, transparent tracking of the Shipment ID and creates Smart Contracts for firming up the agreement between ACS and HT. TRACE goes ahead to calculate the best route and monitors all stages of shipment transfer; it readjusts schedules when necessary and assures dependable delivery from Thessaloniki to Athens.

3.2.2 Italian pilot 1:

It performs a feasibility analysis of fast/urgent deliveries in an urban/peri-urban setting, integrating a drone for urgent deliveries, as well as with potential integration of other innovative alternative logistics urban solutions for automated deliveries, e.g., autonomous bikes.

It defines new business models for optimized planning decisions (load factor, routing optimization) for time constrained deliveries (fast/urgent vs. regular deliveries).

3.2.3 Italian pilot 2:

It includes the Implementation of autonomous bikes with platooning capabilities for automated deliveries in urban environment and optimized/automated route planning decisions based on time & cost.

It also aims at the connection of micro-hubs to support last mile goods delivery in the city of Modena.

3.2.4 Slovenian pilot:

This pilot tests and studies urban deliveries in Ljubljana shopping, business and leisure center area (BTC City), focusing on optimizing first and last-mile deliveries through the integration of heterogeneous delivery systems and different logistics service providers (synchromodal operation readiness improvement) with the aim to reduce traffic & emissions, and enhance urban logistics efficiency through adapting existing business models or introducing new ones, with the support of the TRACE platform.

3.3 Survey Distribution Process

The internal gap analysis questionnaire was initially distributed to the pilots' leaders. Online meetings with the leaders were then followed in order to go through the questionnaires and provide guidelines to them on how to fill in the questionnaires. Pilots' leaders completed the questionnaires and returned them back. A second round of online meetings was held in order for the leaders to provide some clarifications on the completed questionnaires.

Regarding the external gap analysis, questionnaires have been distributed by email to more than 50 logistics companies. Although quite a few of them were initially positive to respond, later on they declined to participate citing high workload and lack of time. Trying to resolve their issue by minimizing the time required to fill in the questionnaire, it was offered to perform face to face or online interviews with the designated stakeholders in order to expedite the completion of the questionnaires. Unfortunately, even after the decision for face to face or online interviews, only three companies agreed to participate in the survey on the assumption that they will keep their anonymity.

Due to the limited number of the completed questionnaires (small sample), the results from the external gap analysis were not used to derive secure conclusions but rather to verify and confirm – if possible - the results of the internal gap analysis as mentioned above.

However, in the second half of the project, a quantitative survey will be conducted based on the derived results/gaps of the internal and external analysis. In the second survey, the aim is to contact a high number of companies and associations.

3.4 Gap Thematic Areas and Gaps

First, an exhaustive list of all the gaps reported by the different key stakeholders was created as illustrated in Table 3.

Table 3. Reported Gaps

Code	Identified Gap
Greek Pilot (Pilot 1)	
G1	Inefficient Resource (trucks, vehicles, ships etc.) utilization
G2	Suboptimal Allocation of Roller Cages (to the available transport means)
G3	Lack of an accurate ETA Calculation system
G4	Limited Operational Integration
G5	Lack of Real-Time Monitoring and tracking
G6	Manual and Time-Consuming Hub Operations
G7	Non-Optimized Routes
G8	Lack of cost optimization (cost reduction strategies)
G9	Limited Communication and Coordination
G10	No use of unmanned vehicles for last mile deliveries
G11	Lack of legal framework for autonomous driving.
Italian Pilots (Pilot 2 and Pilot 3)	
I1	Suboptimal Route Planning
I2	Inexistent integration among drones and cargo bikes.
I3	Inadequate logistics data management (demand and offer)
I4	Low quality simulation tools in order to understand the key requirements for full drone utilization in urban logistics
I5	Lack of drones equipped in the right way for emergency/urgent deliveries.
I6	Insufficient Monitoring and Improvement
I7	Lack of autonomous cargo bikes
I8	Inefficient parcel reloading

Code	Identified Gap
I9	Lack of optimized route planning
I10	Lack of Centralized Decision-Making
I11	No-flight zones in urban areas
I12	Lack of an appropriate drone flight authorization regime for urgent deliveries in urban environment
Slovenian Pilot (Pilot 4)	
S1	Lack of use of multiple types of vehicles
S2	Lack of costs, emissions, and time calculations and monitoring
S3	Lack of collaboration between logistics companies
S4	Lack of automatic scheduling and routing
S5	Lack of real-time tracking
S6	Lack of optimized use of different vehicles
S7	Minimal use of green and automation technologies

Out of the 30 gaps that have been reported and collected in total, after careful study it was clear that the different pilots shared quite similar or even the same challenges. This step was crucial in making the data more comparable, as different pilots used varied language to describe similar issues.

Consequently, the reported gaps were rephrased to ensure consistency and clarity across all pilots. Similar gaps expressed differently were standardized into a unified language, resulting in 17 consolidated Gap Categories – to be referred as Gaps from now on, as per Table 4.

Table 4. Gap Categories

		GR	IT	IT	SL
Gap Category	Description	Pilot1	Pilot2	Pilot3	Pilot4
Lack of real-time information	Gaps in obtaining or sharing real-time data throughout the logistics process. (G5, S5, I3)	x	x		x

		GR	IT	IT	SL
Gap Category	**Description**	**Pilot1**	**Pilot2**	**Pilot3**	**Pilot4**
Lack of cost and time estimation information	Inability to accurately predict delivery times and calculate logistics costs. (S2)				x
Lack of data sharing platform	No centralized system for sharing data between logistics partners. (S3)				x
Lack of monitoring system and improvement recommendation system	Insufficient systems for tracking performance and suggesting enhancements. (G3, I6)	x	x	x	
Minimal use of green technologies	Low adoption of eco-friendly technologies, such as electric trucks or solar-powered facilities. (S7)				x
Lack of appropriate monitoring and reporting of environmental impact	Insufficient systems to track and report emissions and environmental data, impacting sustainability goals. (S2)				x
Lack of optimization	Inefficiency in resource use, including underutilized trucks, routes, and storage space. (G1, G2, G7, G8, S6, I1, I8, I9)	x	x	x	x
Lack of automation	Over-reliance on manual processes, creating inefficiencies and slowing down operations. (G6, S4, I7)	x		x	x
Lack of integrated communication systems	Inefficient communication within and across logistics teams and partners. (G9, I3)	x	x		
Lack of collaborative platforms	No systems to facilitate collaboration between logistics companies and stakeholders. (G9, S3)	x			x
Lack of Centralized Decision-Making System	Fragmented decision-making processes can lead to inefficiencies, miscommunication, and delays in response to operational challenges. (I10)			x	
Lack of advanced (state of the art) technologies	Not use of technologies like AI, big data, blockchain that will increase efficiency, speed, accuracy and security. (S7, I4)		x		x
Lack of vehicle and delivery innovation	Gaps in utilizing advanced transportation technologies like unmanned vehicles, drones, and multi-modal systems for	x	x		x

		GR	IT	IT	SL
Gap Category	Description	Pilot1	Pilot2	Pilot3	Pilot4
	optimized last-mile and emergency deliveries. (I5, G10, S1)				
Lack of integration of different systems	Siloed digital systems that don't effectively communicate with one another. (G4, I2)	x	x		
No-flight zones in urban areas	Restrictions on drone flights in cities create operational challenges for last-mile logistics. (I11)		x		
Lack of strategies to streamline drone flight authorization	Slow and complex approval processes for drone use in logistics. (I12)		x		
Lack of legal framework for autonomous driving	The absence of a legal framework for autonomous driving hinders its regulation, deployment, and adoption. (G11)	x			

Revisiting this new list of rephrased Gaps, five (5) relevant key Thematic macro-areas were defined and each one of the processed Gaps was assigned to the most relevant Thematic macro-area, ensuring alignment with the Project's objectives. The five Gap Thematic macro-areas that were selected are shown in Table 5.

Table 5 Gap Thematic Macro Areas

Thematic Macro Areas	Colour Code	Description
Information & Data Flows		Gaps in real-time data access, monitoring, sharing and analysis, resulting in inefficient decision-making and limited operational visibility.
Environmental Sustainability		Challenges in reducing emissions and adopting green technologies, because of limited environmental impact tracking.
Operational & Process Management		Inefficiencies in communication, decision-making, and optimization, hindering process flow and resource utilization.
Technological Innovation		Lack of integration, automation, and infrastructure needed to enhance logistics operations through advanced technologies.
Regulatory Compliance & Legal		Difficulties navigating legal constraints, especially in areas like drone usage and environmental regulations.

The detailed allocation of the Gaps to the above-described Thematic macro-areas is as follows. For completeness, at the end of each Thematic Area chapter below, Comparative Insights have been added which outline the findings from the comparison with the input from the external stakeholders (external gap analysis) for the specific Thematic Area.

3.4.1 Information & Data Flows

This thematic macro-area includes Gaps that are related to accessing, monitoring, sharing and analyzing real-time data. According to the input collected, such challenges result in inefficient decision-making and limited operational visibility.

Interesting to note that this is the area with the second largest number of Gaps reported - four, after the Operational & Process Management thematic macro-area. In addition, a total frequency of occurrence of the included Gaps equal to 8 is observed.

Table 6. Information & Data Flows macro-area and the pilots' gaps

Area		GR	IT	IT	SL		
	Gap Category	Pilot1	Pilot2	Pilot3	Pilot4	TOTAL PER GAP	TOTAL PER AREA
Information and Data Flows	Lack of real-time information	x	x		x	3	8
	Lack of cost and time estimation information				x	1	
	Lack of data sharing platform				x	1	
	Lack of monitoring system and improvement recommendation system	x	x	x		3	
		2	2	1	3		

Comparative insights

Still paper-based operations: all three interviewed LSPs have confirmed the struggle with inefficient **real-time data collection & integration** and **limited data-sharing (if any)**. Both stakeholder groups (LSPs and Pilots) have emphasized the need for synchronized, real-time updates to improve decision making.

It is also noted that the interviewed LSPs are in the process of introducing or about to introduce some digital logistics tools, like Warehouse and Transport Management Systems (WMS and TMS) in order to resolve the above issues and significantly improve their operations.

The observations for this thematic area are also valid for the thematic areas of Operational & Process Management and Technological Innovation.

3.4.2 Environmental Sustainability

This macro-area includes Gaps in taking measures to reduce emissions and adopt green technologies. The key root cause is because of limited – if any - environmental impact tracking. It is interesting to note that just 1 out of the 4 pilots has identified gaps related to environmental sustainability.

It is important to note that the remaining three pilots that have not identified similar Gaps, either publish annual sustainability reports, where emissions are calculated and particular targets to reduce emissions are included or are using alternative transport means (drones and autonomous bikes), which in any case are expected to contribute to reduced emissions as they are both considered green technologies.

Table 7. Environmental Sustainability macro-area and the pilots' gaps

Area		GR	IT	IT	SL		
	Gap Category	Pilot1	Pilot2	Pilot3	Pilot4	TOTAL PER GAP	TOTAL PER AREA
Environmental Sustainability	Minimal use of green technologies				x	**1**	**2**
	Lack of appropriate monitoring and reporting of environmental impact				x	**1**	
					2		

<u>*Comparative insights*</u>

With the exception of the largest interviewed LSP, reducing emissions and use of green technologies appears to be less relevant for the other two interviewed LSPs, since they both do not own any trucks but use third parties for the transport. However, they both do mention emissions and fuel reduction as one of the indirect results of their constant drive for reducing costs, while they do follow related market rules and regulations and provide relevant certifications where/as required.

It is noted that technology tools for **route optimization, load consolidation** or **sharing** also align closely with sustainability goals.

On the other hand, the largest LSP interviewed is actively experimenting with green technologies and have plans for reducing emissions, fuel and environmental impact in general. They are decarbonizing their delivery fleet by introducing EVs and charging stations, bikes (e-cargo or regular), as well as experimenting with alternative clean fuels, like e.g. hydrogen. However, they do highlight that there is a lack of or slow growth of cost-effective green technologies which hinders investments in green technologies from their side. So **immature green technologies** and related **high costs** for their introduction are key challenges, slowing down the green transition.

In Annex III, we provide a description of the envisioned pilots and elaborate on measurable KPIs that expose the TRACE contribution in the environmental sustainability by reducing the emissions through the reduction of the use of vehicles with high negative impact in the environment. Our intention is to focus on such KPIs towards achieving the goals of the Green Deal strategy and convince logistics actors to collaborate and use more environmental friendly means of transportation.

3.4.3 Operational & Process Management

This macro-area is about Gaps and inefficiencies in communication, decision-making and optimization, which hinder efficient process flow and effective resource utilization. It includes the greatest number of Gaps – 5 in total – and all four pilots have reported multiple Gaps in this thematic macro-area with a frequency of occurrence equal to 12.

The main shortcomings identified by the pilots in this macro-area are lack of defined processes for multimodal scenarios (lack of collaborative platforms, integrated communication, centralized decision making), lack of optimization (resources, infrastructure, planning) as well as lack of automation.

Table 8 shows the Gaps declared by the pilots in the macro-area of Operational & Process Management.

Table 8 Operational & Process Management macro-area and the pilots' gaps

Area		GR	IT	IT	SL		
	Gap Category	Pilot1	Pilot2	Pilot3	Pilot4	TOTAL PER GAP	TOTAL PER AREA
Operational & Process Management	Lack of optimization	x	x	x	x	4	12
	Lack of automation	x		x	x	3	
	Lack of integrated communication systems	x	x			2	
	Lack of collaborative platforms	x			x	2	

Area	Gap Category	GR Pilot1	IT Pilot2	IT Pilot3	SL Pilot4	TOTAL PER GAP	TOTAL PER AREA
	Lack of centralized decision-making system			x		**1**	
		4	**2**	**3**	**3**		

Comparative insights

The interviewed LSPs have reported similar challenges as the pilots, struggling with **manual processes/data exchange** and **lack of process automation & optimization**, which impacts efficiency and resource utilization, as it is also stated under the thematic area of Information & Data Flow.

In addition, all three LSPs report the **need for upskilling/reskilling** their resources, while they consider the **lack/shortage of (skilled) resources** in the market as their key challenge. Lastly, one of them refers to **the mindset of people** as the biggest shortcoming when it comes to changing technologies and introducing new systems.

3.4.4 Technological Innovation

This macro-area is about Gaps in the area of technological innovation like e.g. advanced technologies (AI, machine learning, blockchain etc.), vehicle and delivery innovation, lack of integration of different systems (standards, protocols, …).

Table 9 Technological Innovation macro-area and the pilots' gaps

Area	Gap Category	GR Pilot1	IT Pilot2	IT Pilot3	SL Pilot4	TOTAL PER GAP	TOTAL PER AREA
Technology Innovation	Lack of advanced (state of the art) technologies		x		x	**2**	7
	Lack of vehicle and delivery innovation	x	x		x	**3**	
	Lack of integration of different systems	x	x			**2**	
		2	**3**		**2**		

Comparative insights

Both the pilots and the interviewed LSPs recognize the great value of technological innovation, emphasizing the strong need for introducing enhanced digital tools as an integral part of their ongoing digitalization. They particularly mention **real-time data acquisition, management & sharing**, **intelligent scheduling** and **automation of core processes**.

The interviewed LSPs are limited by paper-based or semi-digital processes, clearly affecting efficiency and negatively impacting decision-making capabilities. Limited integration of systems across platforms and collaborators and a reliance on manual processes create inefficiencies across both groups.

Digitalization, starting with adopting WMS and TMS tools, is just about to start at the LSPs and will take time to implement, learn and adopt the new tools and processes, while there are also challenges related to **reskilling**, **upskilling** and **people mindset**, as mentioned also under the Operational & Processes thematic above.

3.4.5 Regulatory, Compliance & Legal

This macro-area is about Gaps related to the regulatory and legal environment and compliance obligations thereof. Some of the regulations cannot be avoided (e.g., no-flight zones for aerial vehicles), however, TRACE can contribute in the development of a framework that will administrate the use of unmanned vehicles and autonomous driving by exposing the key points that should be adopted. For instance, the use of the virtual cockpit giving the opportunity of the remote management of vehicles may assist towards this direction instead of using a human in the field. The testing of such a functionality should reveal the benefits and the added value to convince the regulatory bodies to make specific updates. Additionally, to build a collaborative approach in the logistics domain requires the relevant regulatory frameworks or the updates of the current ones to facilitate the automated exchange of data not only between the logistics actors but also the exchange of data with the authorities (e.g., customs, IRS, etc). Finally, another point for innovation and study is the legal binding of the smart contracts and the potential automated payments envisioned by the TRACE platform (automated payments are technically covered but the platform can be easily updated towards this direction). Smart contracts as those being generated by the TRACE platform should be valid in legal terms and cover various aspects, e.g., contract negotiation issues, contract interpretation issues, the ability to engage in contact modification, and how contract execution occurs to setup a clear and strong basis for collaboration between different logistics actors.

Table 10. Regulatory, Compliance & Legal macro-area and the pilots' gaps

Area		GR	IT	IT	SL		
	Gap Category	Pilot1	Pilot2	Pilot3	Pilot4	TOTAL PER GAP	TOTAL PER AREA
Regulatory Compliance & Legal	No-flight zones in urban areas		x			**1**	**3**
	Lack of an appropriate drone flight authorization regime for urgent deliveries in urban environment		x			**1**	
	Lack of legal framework for autonomous driving	x				**1**	
		1	**2**				

Comparative insights

The interviewed LSPs consider that regulatory obligations like e.g. ESG reporting etc. and legislation related challenges when it comes to introducing alternative transport means like e.g., autonomous vehicles or self-driving robots consist key challenges for them going forward.

One of the interviewed LSPs mentioned that to introduce synchromodal operations there needs to be an appropriate regulatory & legal regime.

3.5 Gap Analysis Results and Interpretation

3.5.1 Gap Analysis Results

In this section, an in-depth analysis of the data collected is provided, comparing current state versus ideal state or best practices. In figure 2, we can see that the vast majority of reported (macro) Gaps – 38% (12 Gaps) - falls under the macro-area of Operational & Process Management, followed by Gaps in Information and Data Flows – 25% (8 Gaps), in Technological Innovation (22%, 7 Gaps), in Environmental & Sustainability (6%, 2 Gaps) and lastly we have the gaps in Regulatory, Compliance & Legal (9%, 3 Gaps).

It is interesting to note that none of the pilots have reported any Gaps related to **Security**.

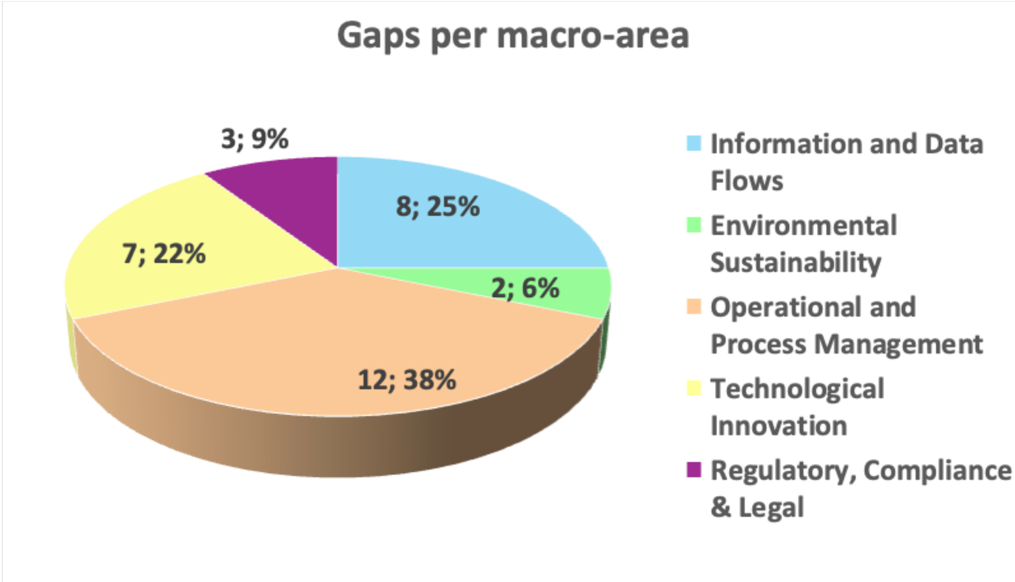


Figure 2 Percentage of gaps per macro-area in the current situation

In addition, **the weight** of each Gap (i.e., how many times a Gap appears) has been analyzed, as this provides a better understanding of where the key painpoints are, and the value that can be derived by resolving first such Gaps.

At Figure 3, there is evidence that the Gap with the largest weight (4) belongs to the Operational & Process Management thematic area, followed by four other Gaps of the same weight (3): two of them belonging in the thematic macro-area of Information & Data Flows, a second one in Operational & Process Management and the last one on Technological Innovation.

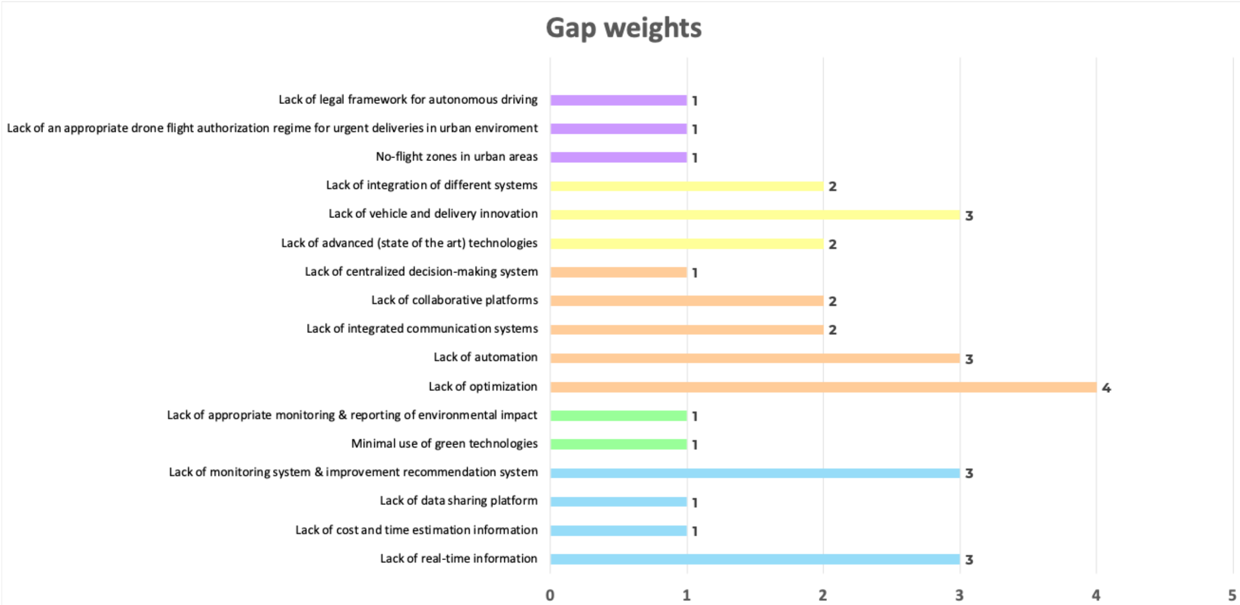


Figure 3 Weights of the identified gap categories

It is also important to note that many of the Operational & Process Management Gaps, as well as the ones reported under Information & Data Flows, can be also viewed upon as Gaps that are related and/or heavily dependent on Technological Innovation & automation which are the key drivers of process and results optimization.

This is easily explained because Gaps in Operational & Process Management are often the result of lack of real-time data availability and usage for enhancing and improving the logistics processes and the related decision making. In turn, the acquisition and processing of real-time data requires increased automation of logistics processes and better integration of different systems and market players, especially in the case of synchromodal logistics that is currently being worked in the TRACE Project.

Hence, the above gap analysis results are in line with both the common sense and the reality as it was reported by the stakeholders who participated in the study. They all reported low levels of automation and lack of integration of different systems and market players.

Lastly, it is of value to also take a look at to what grade the different Gap macro-areas are present in each one of the pilots (Figure 4).

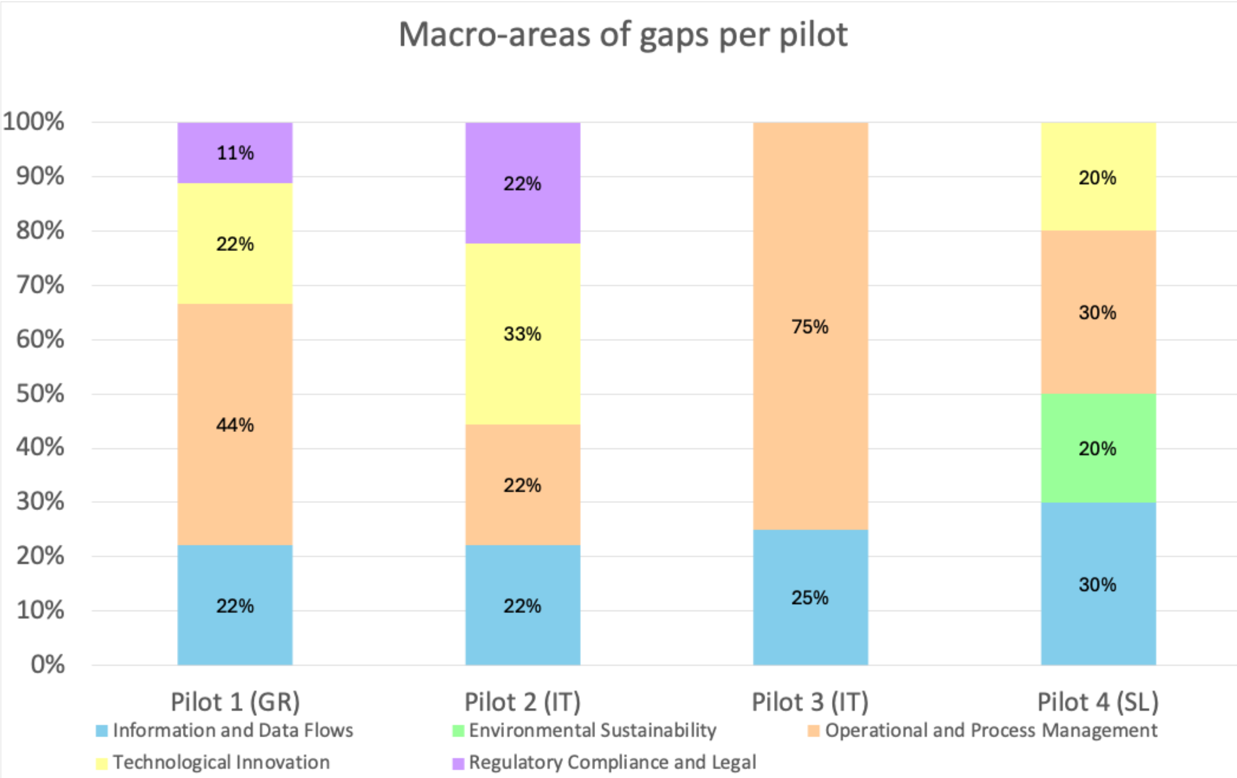


Figure 4 Percentage of macro-areas of gaps within each pilot

In addition to the above quantitative analysis, an alternative, **qualitative** way to look upon the received feedback from the TRACE Pilots and the identified gaps (Table 11).

Table 11 Qualitative Analysis

a/a	Gap	Details	Comment
1	**The cost (inefficiency) gap**	**High operational costs** (number one issue for most of the participating companies) due to inefficiencies in logistics operations and lack of collaboration/integration	This is a gap which emerges from all four Pilots, with a certain urgency as well.
2	**The real-time gap**	**Limited or lack of real-time monitoring/tracking of deliveries**	This is a gap which emerges from all four Pilots.
3	**The optimization gap**	**Lack of optimization** (route, time, resources, etc.) due to mostly manual and/or uncoordinated processes - low use of technology and automation	This gap is also related to the ways of working, mentality, know-how and skills.

a/a	Gap	Details	Comment
4	**The manual labour gap**	**Lots of uncoordinated manual labor** leads to unpredictability of deliveries, bad tracking & monitoring (if any), lower customer satisfaction, high emissions and cost	Similar to the above.
5	**The alternative delivery ways gap**	**Lack of alternative ways of delivery within cities**, at least for the last mile, either automated vehicles of different types (not only trucks or vans but also autonomous cars, robots, drones, cargo bikes), or different business models (collaborative business modesl, eg. synchromodal logistics), or both	This is a gap which emerges either directly or indirectly from all four Pilots and in addition to the relevant technologies, it requires also regulatory intervention as well as potentially relevant city/hub infrastructure (e.g, city corridors for alternative transport means, traffic priority, etc.) to some degree.
6	**The collaboration gap**	**Lack of collaboration**/practical (tools, technology) and mentality issue	This may need policy/regulatory intervention to force collaboration at least in city centers and/or urban environments in order to reduce traffic and emissions in urban settings.
7	**The technology gap**	**Minimal use of green and automation technologies**	**Lack of zero-emission/environmental policies & measures** by the logistics companies; potential lack of regulatory push for such policies and measures.
8	**The regulatory/ infrastructure gap**	Potential **lack of** or **hindering laws, regulations and possibly infrastructure** inside the city that can favor other means of transport and new, collaborative business models	Potential lack of/insufficient regulatory push for environmental policies & measures by the logistics companies and/or lack of enabling infrastructure for greener, more collaborative and more automated logistics operations.

3.5.2 Root cause analysis

Next, the Gaps within each thematic macro-area were further analyzed and discussed with the key stakeholders in order to conduct a root cause analysis, i.e. to understand the underlying reasons behind these gaps and identify common root causes and barriers.

The identified root causes were then grouped into four main types of barriers:

1 **Technology & Innovation limitations**

Outdated systems, lack of automation, innovation and related tech tools, lack of standards & integration, etc.

2 **Organizational & People limitations**

Resistance to change, lack of awareness and/or skills, lack of processes, mindset, strategy and associated key priorities.

3 **Financial limitations**

High costs of technology adoption coupled with insufficient investment.

4 **Regulatory & Legislation limitations**

Lack of legal framework, regulations and associated infrastructure to introduce autonomous vehicles of various types for use by logistics service providers in cities, etc.

Based on the above categorization, we analyzed thoroughly the root causes and identified the following barriers, in order of the most frequent appearance Table 12.

Table 12. Root causes

Barrier Type	Root Cause/Barrier to modernization	GR Pilot 1	IT Pilot 2 &3	SL	TOTAL
Technology & Innovation	**Lack of technological tools & automation** for a series of activities: detailed data analytics for prediction purposes (e.g., real-time route optimization, ETA estimation, etc.), real-time monitoring & tracking, automated decision making, etc.	G4, G5, G6, G7, G10	I3, I4, I6, I8, I9, I10	S2, S3, S4, S5	**15**
Technology & Innovation	**Integration** related challenges including lack of standards & interoperability issues. *Examples:* Lack of universal or European standards/ interoperability for using robots/unmanned vehicles. Lack of standardized, open protocols for data sharing and integration of different logistics systems.	G4, G5, G6, G7, G8, G9, G10	I1, I2, I3, I6	S1, S6	**13**

Barrier Type	Root Cause/Barrier to modernization	GR Pilot 1	IT Pilot 2 &3	SL	TOTAL
	Lack of standardized performance metrics across different logistics channels/networks.				
Financial	**Financial constraints**/lack of investment/funds	G2, G5, G6, G7, G9	I5, I6, I7, I9	S4, S5	**11**
Organization & People	**Lack of knowledge, skills and/or resources** - mainly IT/digital related	G4, G10	I2, I7	S1, S2, S4	**7**
Regulation & Legislative	**Regulatory & legislative** framework hurdles including **infrastructure** related issues (absent or inadequate)	G11	I2, I7, I11, I12	S1, S6	**7**
Organization & People	**Lack of specific strategy** & related goals eg with regards to reducing environmental impact, etc.		I7	S1, S2, S3	**4**
Organization & People	**Lack of awareness** of new solutions and new technologies benefits	G10		S1, S2	**3**
Organization & People	**Resistance to change** and skepticism/concerns for the use of new technologies by the workers		I4, I6	S1	**3**
Organization & People	**Competition** related issues; fear of losing competitive advantage etc.	G4	I3	S3	**3**

*Gx: Gap Number x Identified in the Greek pilot, Ix: Gap Number x Identified in the Italian pilots and S: Gap Number x Identified in the Slovenian pilot

As shown in Figure 5, the vast majority of identified barriers lie in the **Technology & Innovation (42%)** and **Organization & People areas (30%)**, which implies that the implementation of TRACE can directly address and resolve if not all, the majority of those. In the Technology level, TRACE supports the implementation of a set of tools that target to automate deliveries (especially, with the use of unmanned vehicles), improve the continuous monitoring of shipments, support of synchromodal and collaborative models for shipments transfer, use of blockchain to secure the ownership and monitoring of shipments and events management that will secure the smooth deliveries managing any unexpected scenarios. For the remaining pillars, TRACE devotes significant efforts, mainly in WP5, to change the behavioural aspects of logistics actors by exposing the benefits of the platform while, at the same time, elaborates on multiple studies for exposing gaps (like in this deliverable), needs for possible updates in the relevant legislation/regulations and the social impact of the proposed technologies. In WP7, TRACE will disseminate the results in a wide audience and assess the financial viability of the solutions together with innovative business models that may come up from our platform.

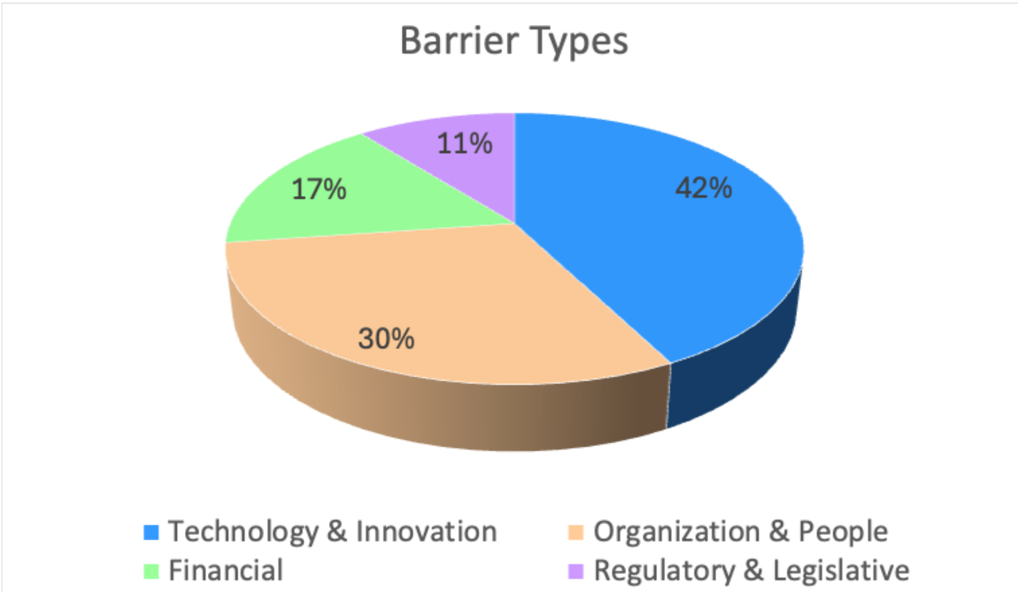


Figure 5. Percentage of Gaps per barrier type

3.5.2.1 Technology & Innovation limitations

Across all use cases, **low automation levels**, **lack of** appropriate **technology tools** to collect, process, use and share **real-time data** and **lack of or poor integration** between different stakeholders and their IT systems, were reported as key barriers hindering operational efficiency and resulting in higher costs, emissions and poorer use of available resources.

Inconsistent or even inexistent **data-sharing protocols and standards** add to the complexity of integrating innovative collaboration technological tools, solutions and systems across different logistics market players.

Comparative insights

The participants of both the internal and external gap analysis recognize the great value of technological innovation, emphasizing the strong need for introducing enhanced digital tools as an integral part of their ongoing digitalization. They particularly mention **real-time data acquisition, management & sharing**, **intelligent scheduling**, **route & resources optimization**, and **automation of core processes**.

The interviewed LSPs are limited by paper-based or semi-digital processes, clearly affecting efficiency and negatively impacting decision making capabilities. Limited integration of systems across platforms and collaborators and a reliance on manual processes create inefficiencies across both types of stakeholders.

It is also noted that the interviewed LSPs are in the process of introducing, modernizing or about to introduce basic digital logistics tools, like Warehouse and Transport Management Systems (WMS and TMS) in order to resolve the above issues and significantly improve their operations.

Recommendations for addressing the above identified limitations:

- Investments in shared/integrated advanced **real-time tracking & monitoring systems** to enhance transparency and coordination across the supply chain. This would address gaps in information flow and improve decision-making.
- **Automative** resource management, load & delivery planning and other key logistics processes by adopting the appropriate technology tools. This would address inefficiencies in space utilization and routing delays
- Development of integrated, easy to use, cross-service providers **data-sharing platforms** and introduce related standardized protocols for data-sharing across all stakeholders to improve overall process efficiency.
- Establishment of a **technology adoption roadmap** to guide phased implementation of advanced technologies (e.g. drones, AI-driven routing, etc.).

3.5.2.2 Organization & People limitations

Lack of knowledge or even awareness, **skills and/or resources** (especially IT-related resources) have been identified as the key organization & people related limitation across all four pilots.

In fact, in a recent article by McKinsey [7] on the challenges logistics companies face and will increasingly face in the near future, it is mentioned that **the logistics industry faces significant workforce challenges**. The post-pandemic turnover of logistics employees is up by 33% compared with the pro-covid era, while at the same time the rapid growth of e-commerce platforms—with 10% to 20% of every e-commerce dollar going toward logistics, McKinsey research shows—is ratcheting up general demand for logistics workers. In addition, this rise of e-commerce has fuelled heightened consumer expectations about service speed (for example, same day) and experience (for example, seamless ordering and tracking), increasing pressure on logistics providers.

Soft issues like **resistance to change/technology** and **lack of collaborative mindset** due to competition issues have been also identified as barriers to change and adopt new, innovative collaborative practices & processes, such as the ones that are in the core of the TRACE Project.

Last, but not least, there seems that often **no strategy** with associated goals and KPIs is in place e.g. related to reducing the environmental impact of urban logistics. We believe that regulatory & legislative initiatives coupled with financial incentives could help remove such barriers and accelerate the transition to innovative, collaborative and sustainable logistics solutions.

Comparative insights

In full accordance with the pilots, the three LSPs consider the **shortage of resources** in the market and the **skills gaps** in digital and technological competencies as their key challenge and report the **need for upskilling/reskilling** their resources. One of them refers to the mindset of people and their resistance to change as the biggest shortcoming when it comes to adopting new digital systems or processes or collaborative logistics approaches.

Important to note that larger LSPs can easier afford and have more structured training programs aimed at equipping staff with digital skills. In contrast, smaller LSPs lack the resources for extensive training programs and rely on gradual, in-house and/or on the job upskilling initiatives.

Lastly, while the pilots identify **collaboration and coordination** challenges between logistics players, some LSPs are proactively engaging to some degree in collaborative logistics through logistics sharing with customers and/or partners.

Recommendations for addressing the above identified limitations:

- **Automation of processes and introduction of technology tools,** such as AI-based transport means could contribute to address lack of resources & skills issues to a certain extent
- Cultivation of a mindset for adopting advanced technologies and a **culture of continuous learning** and skills development. Work together with government agencies to design, plan and incentivize related up/reskilling and communicate widely the need and the benefits of such efforts.

3.5.2.3 Financial limitations

Financial constraints, insufficient investment and lack of funds or financial incentives for introducing new technologies, automation tools and sustainable logistics technologies have been identified as the root cause and key barrier for eleven different Gaps across all four pilots. In addition, high costs of adopting new technologies (or perceived), such as drones, autonomous bikes or unmanned vehicles in general limit full-scale implementation.

Comparative insights

Financial constraints are cited as a key barrier to investing in new technology, automation, and sustainability initiatives. The participants (representatives from the pilot cases and the LSP's involved) of both the internal and external gap analysis are cautious about large investments without clear ROI. For example, the relatively high costs of introducing green technologies in combination with their immaturity are clearly stated as factors slowing down the green transition by one of the LSPs.

It should also be highlighted that larger LSPs have larger budgets allocated to technology, making them slightly more capable of adopting advanced systems (e.g. automated forklifts and robots in the warehouse) or experimenting with alternative transport means (eg. EVs, hydrogen-fuelled vehicles or autonomous vehicles/robots/drones), unlike smaller LSPs and pilots, which focus on gradual improvements in order to minimize costs.

Recommendations for addressing the above identified limitations:

- Governments need to provide appropriate **incentives** to logistics stakeholders for **digital and green transition.** This will bring multiple benefits to the society (reduce traffic in cities, reduce pollution leading to the increase of citizens happiness and wellbeing etc.) [4]**.**

3.5.2.4 Regulatory & Legislative limitations

A lack of adequate regulatory & legislative frameworks, including the lack of city infrastructure in some cases (eg. lack of autonomous vehicles corridors in the city) for using alternative means of transport in urban areas, such as autonomous vehicles or robots of various types (bikes, cars, vans, drones for urgent deliveries, etc.), was reported by all pilots in one way or another.

This presents a significant barrier for introducing innovative, alternative, and in some cases greener, means of transport inside cities, in order not only to reduce traffic but also to help decrease the pollution.

Comparative insights

Regulatory constraints are significant in relation to using unmanned vehicles of various types and robots or operating drones in urban environment. In addition, digital data regulations may affect data-sharing abilities. LSPs also report lack of infrastructure, like more city hubs or roads as one of the key limitations.

Last, but not least, while some pilots face stringent regulations that slow the deployment of drones and autonomous vehicles, some LSPs report fewer barriers for environmental regulations, aided by government incentives promoting sustainability in logistics.

Recommendations for addressing the above identified limitations:

- Working collaboratively with regulatory bodies and local government agencies, in order to introduce the required infrastructure, set the appropriate rules for use and expedite the approval process for emerging logistics technologies and alternative transport means (drones, autonomous vehicles of various kinds) within cities.
- Partnering with regulators, in order to establish a sandbox environment for testing can streamline regulatory approval, reducing the time and cost of compliance.
- Development of compliance frameworks: Create clear, industry-wide compliance guidelines for the integration of new technologies in logistics operations, particularly in urban logistics.

The above would allow logistics companies who wish to integrate new technologies and ways of working like the ones described in the TRACE Project Pilots to operate within a structured, clear and effective legal framework, especially when introducing innovative delivery methods.

4 Factors affecting the success of TRACE

This section aims to assess the various challenges related to the successful adoption of TRACE solutions. In order to identify the barriers and drivers of the uptake of TRACE an expert survey was conducted to rate the different criteria that are expected to be relevant to its success. To assess the relative importance of these criteria, the Analytic Hierarchy Process (AHP) method was selected as the most appropriate. A set of criteria and their corresponding sub-criteria were selected and an online survey was implemented. Experts from the TRACE project were invited to express their opinions regarding the factors that will mostly influence the future of the TRACE solution. The responses collected and processed to derive the final results.

4.1 Decision making using the AHP framework

In this sub-section, the methodology used to identify the factors affecting TRACE market adoption and evolution is initially presented. The hierarchy along with the identified factors and sub-factors are provided and explained. The questionnaire drafted to conduct the survey is then described. Finally, the results derived from the implementation of the AHP methodology are discussed.

4.1.1 Methodology

AHP was proposed and developed by Thomas Saaty [8] in the early 1970s mainly for military purposes. The AHP is a multi-criteria decision-making approach. In the past, AHP was extensively used covering several application areas such as education [9], engineering [10], industry [11], manufacturing [12] and resource allocation [13]. Recently, AHP was widely used for selecting and ranking alternatives in the field of ICT [14]-[17].

AHP is a structured technique for dealing with complex decisions. It describes a rational and comprehensive framework for decomposing an unstructured complex problem into a multi-level hierarchy of interrelated criteria, sub-criteria and decision alternatives. By incorporating judgments on qualitative and quantitative criteria, AHP manages to quantify decision makers' preferences. The priorities of criteria, sub-criteria and alternatives are finally reached by combining these judgments.

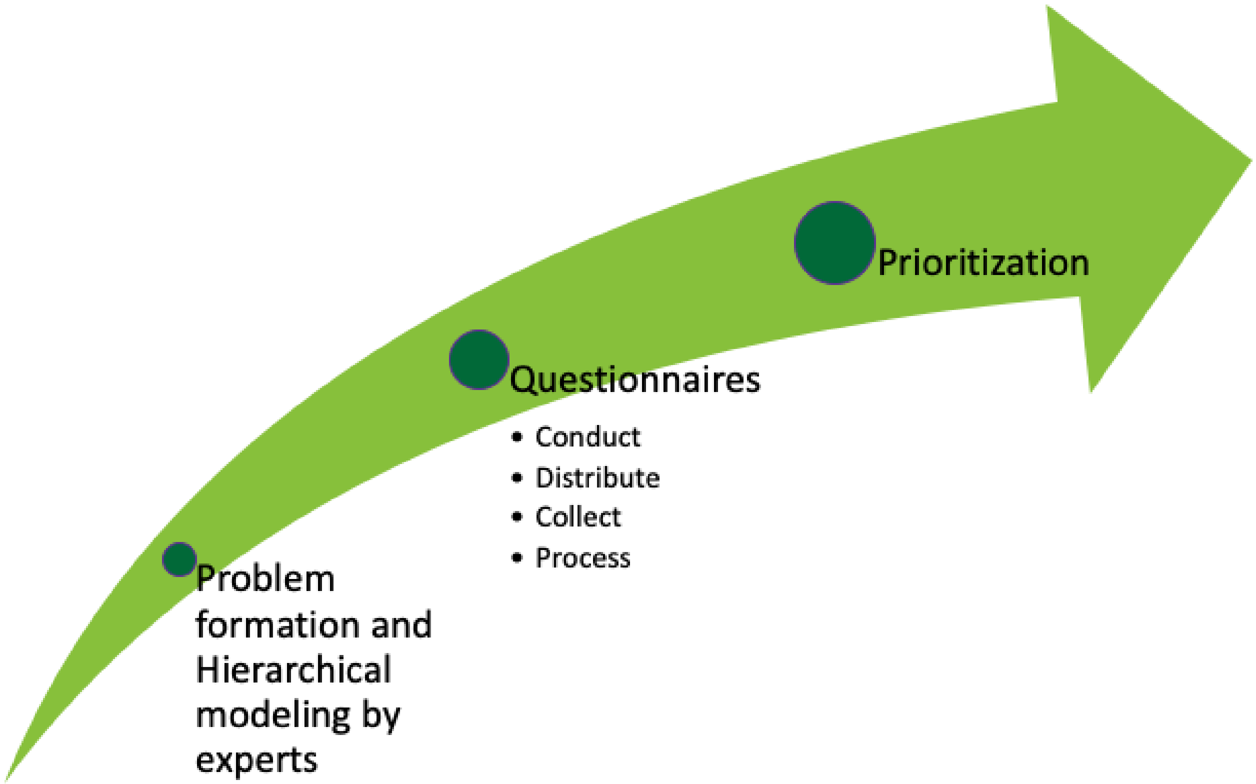


Figure 6. Analytic Hierarchy Process steps

Figure 6 illustrates the required steps of AHP. In the first step, the problem that is investigated is formed while criteria and sub-criteria contributing to objective's satisfaction are determined through interviews and/or group discussions with experts. The multi-level hierarchy is then constructed (Figure 7) consisting of three levels. In the first level, the objective under investigation is shown. In this work, the factors affecting the adoption and evolution of TRACE and its proposed solution in general are examined. In the next level, the criteria, C_{rk} with k=1, 2, …, N and N the total number of criteria, participating in the decision-making process are determined. Criteria should be general enough, incorporating several features resulting in a rough description of the objective. In the lower level, criteria are further analysed into their sub-criteria SC_{rjk}, where j=1,2,…,M_k and M_k is the number of sub-criteria under criterion k. Sub-criteria represent a specific feature characterizing a criterion. Identification of criteria and sub-criteria is accomplished based on the focus of their preferential independence.

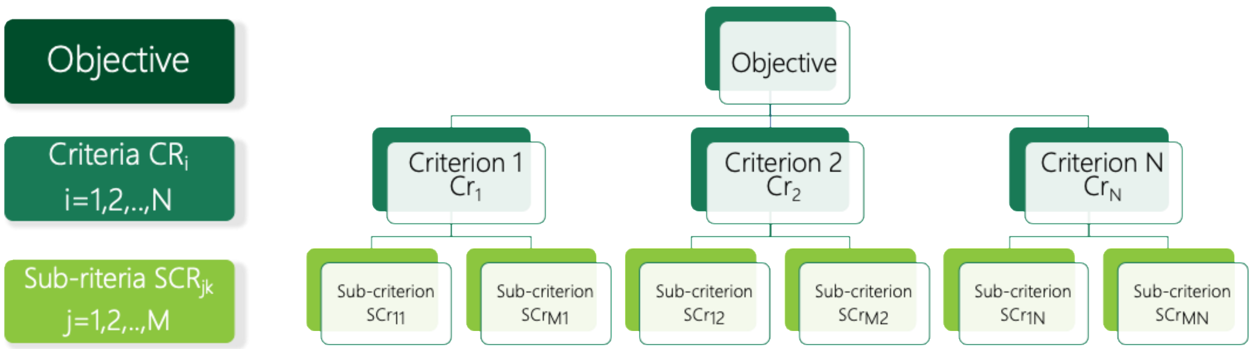


Figure 7. Multi-level hierarchy of interrelated criteria and sub-criteria

Once the hierarchical structure is constructed and criteria and sub-criteria are determined, appropriate questionnaires are conducted and distributed to experts (step 2). This procedure is based on pairwise judgments of experts from the second to the lowest level of the hierarchy. In each level, the criteria (sub-criteria) are compared pairwise according to their degree of influence and based on the specified criteria in the higher level. The comparisons described are performed using the standardized nine-level scale shown in Table 13.

Table 13. The Saaty Rating Scale

Intensity of importance	Definition	Explanation
1	Equal importance	The two criteria contribute equally
3	Moderate importance	Experience and judgment favour one of the criteria
5	Strong importance	A criterion is strongly favoured
7	Very strong importance	A criterion is very strong dominant
9	Extreme importance	A criterion is favoured by at least an order of magnitude
2, 4, 6, 8	Intermediate values	Used to compromise between two of the above numbers

The set of pairwise comparisons on the *N* criteria results in an *N* x *N* evaluation matrix A=[A_{ij}] in which the elements A_{ij} (>0) represent the relative importance of criterion Cr_i compared to Cr_j. It should be noted that A_{ii}=1 for every i while matrix A is symmetrical across the main diagonal that is $A_{ji}=1/A_{ij}$. The same steps are followed regarding sub-criteria of each criterion *k* and the results are summarized in a similar to A matrix called A_k.

The last step (step 3) towards the evaluation of the objectives is the estimation of criteria and sub-criteria weights, w_k and s_{jk} respectively. This requires the calculation of the principal eigenvector v=[v_k] (or u_k=[u_{ik}]) that is the eigenvector corresponding to the maximum eigenvalue λ_{max} (principal eigenvalue) of matrix A (or A_k). The weights of criterion *k* and its sub-criterion *j* are given by:

$$w_k = \frac{v_k}{\sum_{i=1}^{N} v_i} \tag{1}$$

$$s_{jk} = \frac{u_{jk}}{\sum_{i=1}^{M_k} u_{ik}} \tag{2}$$

where *N* and M_k is the number of criteria and sub-criteria of criterion *k* respectively.

4.1.2 Consistency of pairwise comparison matrices

In order to maintain a certain quality level of a decision, the consistency of the data should also be investigated during the analysis. It should be noted that the rank of matrix A (or A_k) equals 1 and λ_{max}=N (or M_k) if the pairwise comparisons are completely consistent. In this case, weights can be estimated by normalizing any of the columns or rows of A (A_k). A consistency index (*CI*) was introduced by Saaty in 1977 [8]:

$$CI = \frac{\lambda_{max} - N}{N-1} \tag{3}$$

where λ_{max} is the largest (maximum) eigenvalue and *N* is the number of criteria. The final consistency ratio (*CR*), showing how consistent the judgments have been relative to large samples of purely random judgments, is given by:

$$CR = \frac{CI}{RI} \tag{4}$$

where *RI* is the random index calculated as the average *CI* across a large number of randomly filled matrices using the scale described earlier in this section. The random indices for several values of *N* were calculated by Saaty in 2003 [18] and are given in Table 14. The consistency ratio should be less than 0.1. A *CR* larger than the tolerable level of 0.1 demonstrates the need to exclude the pairwise comparison matrix of this respondent for further analysis so as not to affect the overall accuracy of the results.

Table 14. RI values for different values of n

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

4.2 Determining the set of criteria and factors to be used in the surveys

In order to identify the factors that influence the adoption of TRACE solutions, a survey was designed in WP5 in line with the AHP methodology. For this purpose, the following set of criteria covering a wide range of factors were initially defined:

- Basic TRACE features for enhanced system performance / capabilities
- Synchromodal logistics add-on features
- Business and Strategy
- Acceptance / Flexibility

Each of these criteria was further broken down into sub-criteria which are usually indicative attributes that can be quantified and are closely related to the criteria. A brief description of the criteria and their sub-criteria is shown in Table 15.

Table 15 Description of criteria and sub-criteria

(sub-)Criterion	Explanation
Cr1: Basic TRACE features for enhanced system performance / capabilities	Aspects associated with the performance/quality of service of TRACE such as low latency, reliability etc.
SCr1.1: Interoperability between different logistic operations	Seamless integration and coordination of various transportation modes, logistics processes/operations, and stakeholders within a supply chain network.

(sub-)Criterion	Explanation
SCr1.2: Support heterogeneity of processes and data	The ability of the logistics system to accommodate diverse processes and data formats seamlessly without requiring significant customization or manual intervention.
SCr1.3: Platform resiliency/tolerance	The ability of logistics platforms or systems to maintain functionality, performance, and service availability despite disruptions, failures, or adverse conditions.
SCr1.4: Seamless connectivity – Efficient communication	Smooth and effective exchange of information among various stakeholders, systems, and processes within the logistics ecosystem.
SCr1.5: Real-time communication, processing and optimization	The ability of logistics systems to exchange information, analyze data, and make decisions instantaneously to maximize efficiency and responsiveness within the supply chain.
Cr2: Synchromodal logistics add-on features	Features of the system that manage the operation of the involved parties.
SCr2.1: Collaboration and coordination	Efforts among various operations, means and stakeholders within the supply chain to work together effectively and synchronize their activities to achieve common goals.
SCr2.2: Optimization, Planning and Management	Optimization of resources, routes, flows, and loads, along with intelligent planning, real-time fleet management, forecasting, and facilities management enabling the strategic management of various assets and processes within the supply chain to achieve maximum efficiency and effectiveness.

(sub-)Criterion	Explanation
SCr2.3: Transportation Efficiency	The ability to move goods from point of origin to destination in the most cost-effective, timely, and environmentally sustainable manner possible.
SCr2.4: Real-Time Tracking and Traceability	The ability to monitor the location, status, and movement of goods in the supply chain in real time, from the point of origin to the destination.
Cr3: Business and Strategy	Aspects related to the business perspectives such as new market opportunities, cost and new business model.
SCr3.1: Cost - Pricing models and affordability for stakeholders	Induced Cost related to hardware, software, installation and maintenance translated into an affordable for customers' price.
SCr3.2: Potential for savings in costs, energy, and emissions	Opportunities for reducing operational expenses, minimizing energy consumption, and lowering greenhouse gas emissions within the transportation and logistics sector through synchromodal approaches and sustainable practices in general and the adoption of TRACE platform in particular.
SCr3.3: New business models	New players entering the market and traditional roles will be changed. Advanced applications/services will emerge changing the current revenue streams.
SCr3.4: New market opportunities	New value propositions. Advanced synchromodal logistics solutions can be a means for market growth.
Cr4: Acceptance / Flexibility	It refers to the overall usability of the system and incorporates many user-related concerns.
SCr4.1: Secure data transfer (Security and Privacy)	Measures and protocols implemented to ensure the confidentiality, integrity, and availability of data exchanged between stakeholders, systems, and devices within the logistics ecosystem.

(sub-)Criterion	Explanation
SCr4.2: End-to-end transparency	Utilization of blockchain technology and smart contracts to enable visibility, traceability, and accountability across the entire supply chain process, from the point of origin to the destination.
SCr4.3: Regulatory issues	Regulatory issues related to transportation, the use of automated transfers or the adoption of real time smart contracts, financial operations that may cause problems in the actual deployment of the TRACE platform.
SCr4.4: Compliance with standards and requirements	The system must follow requirements imposed by the standardization bodies and fora. In addition, the system meets the listed acceptance criteria. It also includes compatibility of Equipment with legacy systems.
SCr4.5: Dynamic and flexible scalability	The ability of logistics systems and processes to adapt and expand or contract dynamically in response to changing demand, market conditions, and multi-model operational requirements.

The full list of the criteria and their sub-criteria is illustrated in the hierarchy of Figure 8.

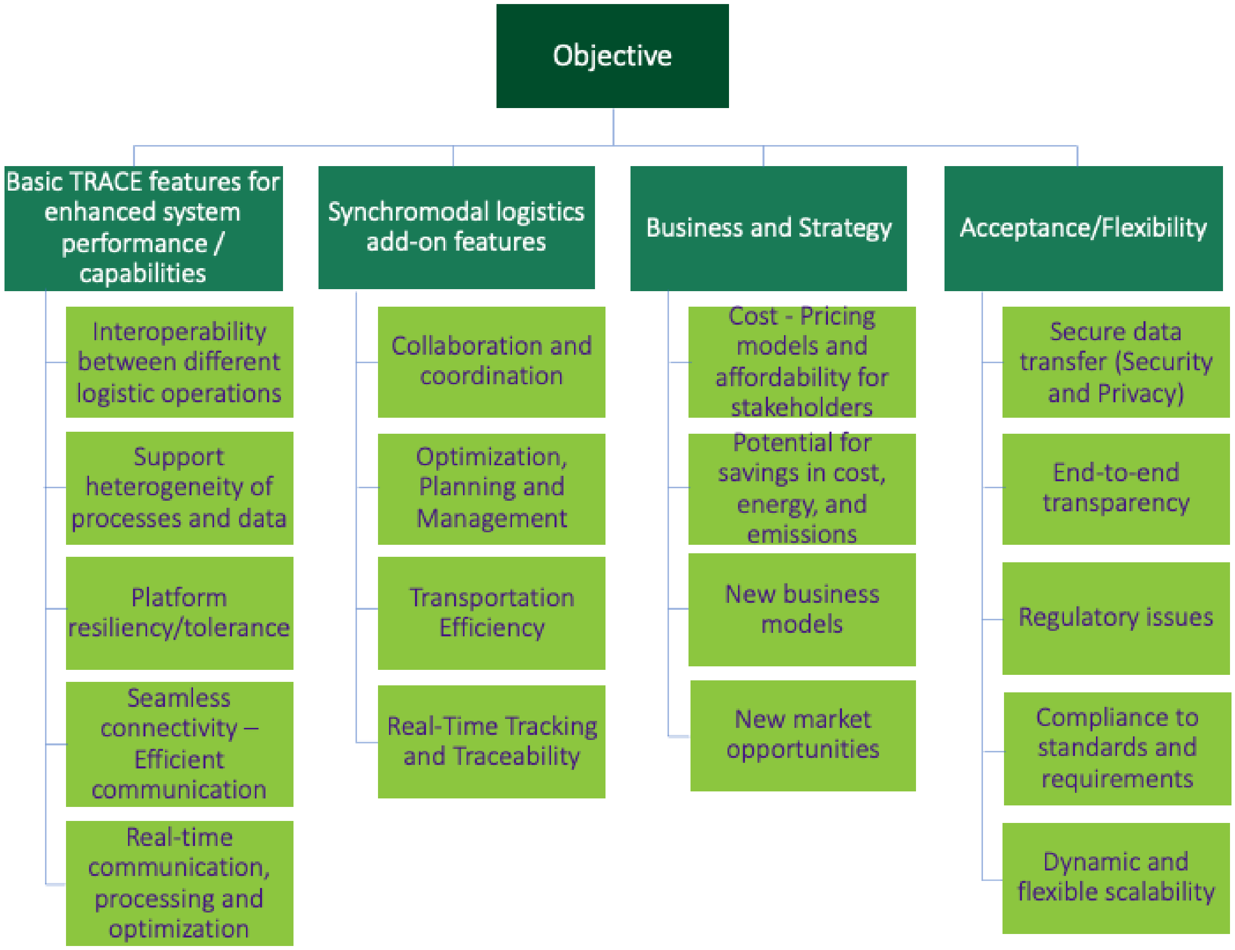


Figure 8. TRACE hierarchy

4.2.1 Survey description

The survey was implemented in the form of an online set of questions created using LimeSurvey (https://www.limesurvey.org/), an open-source tool for web surveys, and hosted at: https://incites.eu/TRACE/index.php/343784.

An introductory page provides information on the project and the AHP methodology as portrayed indicatively in the following figures.

TRACE market adoption survey

TRACE inTegration & haRmonizAtion of logistiCs opErations

This is asurvey conducted by theTRACE Horizon EUrope project with the objective to identify the factors that can affect the market adoption of TRACE. The responses are anonymous, the aggregated data will be used in the upcoming deliverable D5.1: Barriers and Business Opportunities of TRACE.

In the following figure, the hierarchy used in the analysis is shown. In the first level, the objective under investigation is shown, which consists of the factors affecting the adoption and evolution of the TRACE solution. In the next level, the criteria affecting the objective are determined. The criteria are general enough to incorporate several features resulting in a rough description of the objective. In the next level, the criteria are further analyzed into their sub-criteria. Sub-criteria represent a specific feature characterizing a criterion.

You can download the list of criteria and subcriteria and their definition using the following link

TRACE objective is to develop a universal platform with functionalities related to planning, scheduling, optimization and events management as well as the use of blockchain technology to facilitate the real time conclusion of smart contracts and financial operations, thus, becoming one of the first attempts to provide an 'intelligent cover' upon the current logistics frameworkst. You can learn more about the project on the website and follow us on the social media:

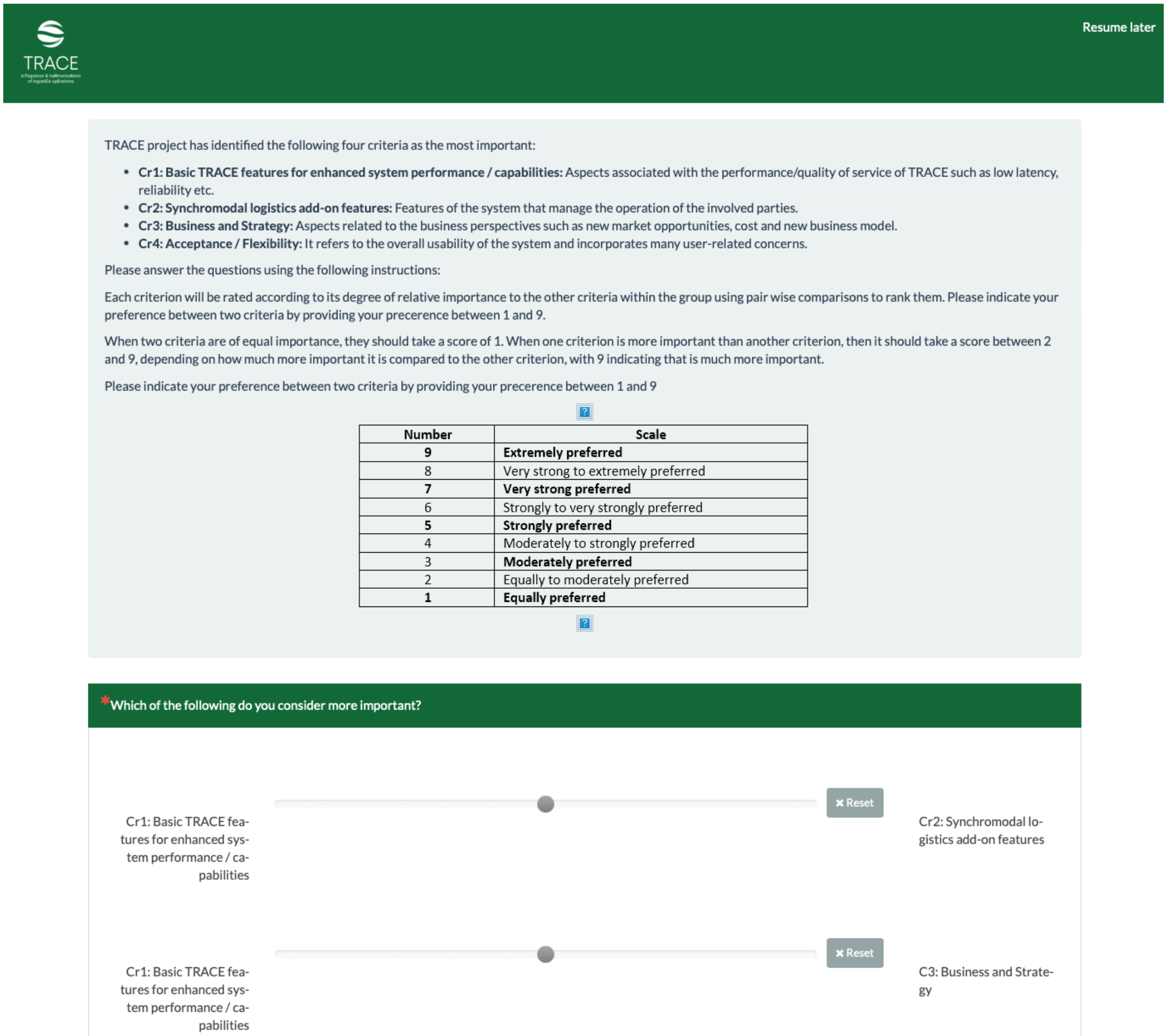
Twitter: @trace_horizon

LinkedIn: TRACE HORIZON Project

Co-funded by the European Union

Figure 9 TRACE survey introductory page

The following Figure depicts an example of the AHP question implementation in the survey. The necessary calculations were performed using Matlab, leading to an estimation of the weights signifying the importance of criteria and sub-criteria. The responses were strictly anonymous. A brief info sheet was presented to inform responders about the purpose of the survey. In addition, a downloadable file containing detailed descriptions of the criteria and sub-criteria has been incorporated for further reference. Participants in the survey can access this document to gain a comprehensive understanding of the analytical framework used in assessing TRACE solutions.



TRACE

Resume later

TRACE project has identified the following four criteria as the most important:

- **Cr1: Basic TRACE features for enhanced system performance / capabilities:** Aspects associated with the performance/quality of service of TRACE such as low latency, reliability etc.
- **Cr2: Synchromodal logistics add-on features:** Features of the system that manage the operation of the involved parties.
- **Cr3: Business and Strategy:** Aspects related to the business perspectives such as new market opportunities, cost and new business model.
- **Cr4: Acceptance / Flexibility:** It refers to the overall usability of the system and incorporates many user-related concerns.

Please answer the questions using the following instructions:

Each criterion will be rated according to its degree of relative importance to the other criteria within the group using pair wise comparisons to rank them. Please indicate your preference between two criteria by providing your precerence between 1 and 9.

When two criteria are of equal importance, they should take a score of 1. When one criterion is more important than another criterion, then it should take a score between 2 and 9, depending on how much more important it is compared to the other criterion, with 9 indicating that is much more important.

Please indicate your preference between two criteria by providing your precerence between 1 and 9

Number	Scale
9	**Extremely preferred**
8	Very strong to extremely preferred
7	**Very strong preferred**
6	Strongly to very strongly preferred
5	**Strongly preferred**
4	Moderately to strongly preferred
3	**Moderately preferred**
2	Equally to moderately preferred
1	**Equally preferred**

*Which of the following do you consider more important?

Cr1: Basic TRACE features for enhanced system performance / capabilities — Reset — Cr2: Synchromodal logistics add-on features

Cr1: Basic TRACE features for enhanced system performance / capabilities — Reset — C3: Business and Strategy

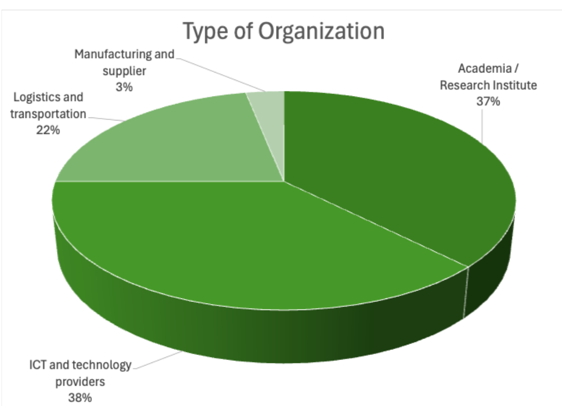
Figure 10 Example of AHP questions

The survey consisted of 40 questions, some of which were not AHP based. Table 16 presents an analysis of the number of questions in terms of criteria and sub-criteria.

Table 16. Analysis of the number of questions

Type	Description	Number	Number of questions
Criteria	Criteria that will affect TRACE	4	6
Sub-criteria	Related to Basic TRACE features for enhanced system performance / capabilities criterion	5	10
Sub-criteria	Related to Synchromodal Logistics Add-on features criterion	4	6
Sub-criteria	Related to Business and Strategy criterion	4	6
Sub-criteria	Related to Acceptance / Flexibility criterion	5	10
Demographic	Type of organization and Position	2	2

At the beginning of the survey two questions were posed about the type of organisation and the position of the participants.



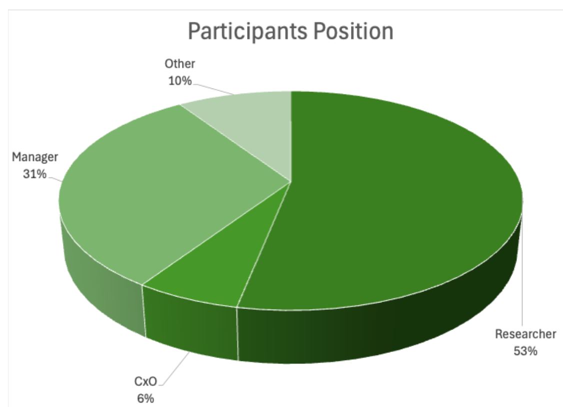


Figure 11. Statistics about the participants

The left part of Figure 11 highlights the distribution of participants based on type of their organization. The largest groups, each comprising 12 participants, are from Academia/Research Institutes and ICT and Technology Providers, reflecting a strong representation from these knowledge-driven sectors. Following this, seven participants belong to the Logistics and Transportation sector, indicating a notable, though smaller, involvement. Lastly, only one participant represents the Manufacturing and Supplier sector, suggesting minimal engagement from this category. This distribution underscores a predominant contribution from academia and technology sectors, with comparatively limited input from manufacturing organizations.

The right part of Figure 11 reveals the positions held by the participants within their respective organizations. The majority of participants, 17 in total, are Researchers, indicating a strong representation from individuals involved in academic or investigative roles. Managers make up the second-largest group, with 10 participants, reflecting substantial input from leadership and operational roles. Meanwhile, only 2 participants hold CxO positions, indicating limited engagement from top-level executives. Additionally, 3 participants fall into the "Other" category, representing a small but diverse group of unspecified roles. This distribution emphasizes the prominence of researchers and managers in the survey while highlighting relatively minimal participation from executive-level professionals.

4.2.2 Results and discussion

In this Section, we present and discuss the results of the survey concerning the evaluation of the importance of the criteria and sub-criteria that are expected to affect the market adoption of TRACE solutions. From the thirty-two experts who initially participated in the survey, thirteen questionnaires were discarded as inconsistent, since their associated CR was greater than 0.1. The questionnaires were conducted and completed over a period of 1 month. This can be assumed to be a sufficient size for an AHP analysis since as shown in [19], [20], the changes in the probability of rank reversal when an additional expert is added to the group are below 1% at M = 15 (where M is the number of experts). Using the methodology described above, one can easily estimate the weights prioritizing the criteria and sub-criteria (Table 17).

Table 17. Weights prioritizing the criteria and sub-criteria

(sub-)Criterion	Weight
Cr1: Basic TRACE features for enhanced system performance / capabilities	**0,223**
SCr1.1: Interoperability between different logistic operations	0,238

(sub-)Criterion	Weight
SCr1.2: Support heterogeneity of processes and data	0,140
SCr1.3: Platform resiliency/tolerance	0,170
SCr1.4: Seamless connectivity – Efficient communication	0,193
SCr1.5: Real-time communication, processing and optimization	0,259
Cr2: Synchromodal logistics add-on features	**0,280**
SCr2.1: Collaboration and coordination	0,198
SCr2.2: Optimization, Planning and Management	0,247
SCr2.3: Transportation Efficiency	0,282
SCr2.4: Real-Time Tracking and Traceability	0,273
Cr3: Business and Strategy	**0,234**
SCr3.1: Cost - Pricing models and affordability for stakeholders	0,203
SCr3.2: Potential for savings in costs, energy, and emissions	0,369
SCr3.3: New business models	0,168
SCr3.4: New market opportunities	0,260
Cr4: Acceptance / Flexibility	**0,263**
SCr4.1: Secure data transfer (Security and Privacy)	0,250
SCr4.2: End-to-end transparency	0,150
SCr4.3: Regulatory issues	0,199

(sub-)Criterion	Weight
SCr4.4: Compliance to standards and requirements	0,215
SCr4.5: Dynamic and flexible scalability scalability	0,186

4.2.3 Weighting of criteria

The results concerning the weights of the criteria that are expected to affect TRACE penetration are shown in Figure 12. According to the experts' opinion, TRACE's market adoption is driven first and foremost by **synchromodal logistics add-on features** (0.280), indicating that efficient, flexible, and coordinated operations, that optimize routes and resources across modes, are highly desired. Just behind it, **Acceptance/Flexibility** (0.263) indicates that the industry is prioritizing secure data management and transparency to achieve regulatory compliance while ensuring scalability which are critical for establishing trust and allowing a greater range of stakeholders to participate. **Business and Strategy** (0.234) takes the third slot, previously pointing out that cost efficiency, energy savings along with new business models are critical to making TRACE financially and strategically valuable for users. Finally, it is interesting to note that **Basic TRACE Features for enhanced system performance and capabilities** (0.223) receive the lowest weights although these are core performance aspects such as interoperability, real-time processing, and resiliency. Maybe these have been ranked lower since such features are taken for granted for the provision of the more advanced features like the synchromodal add-on features.

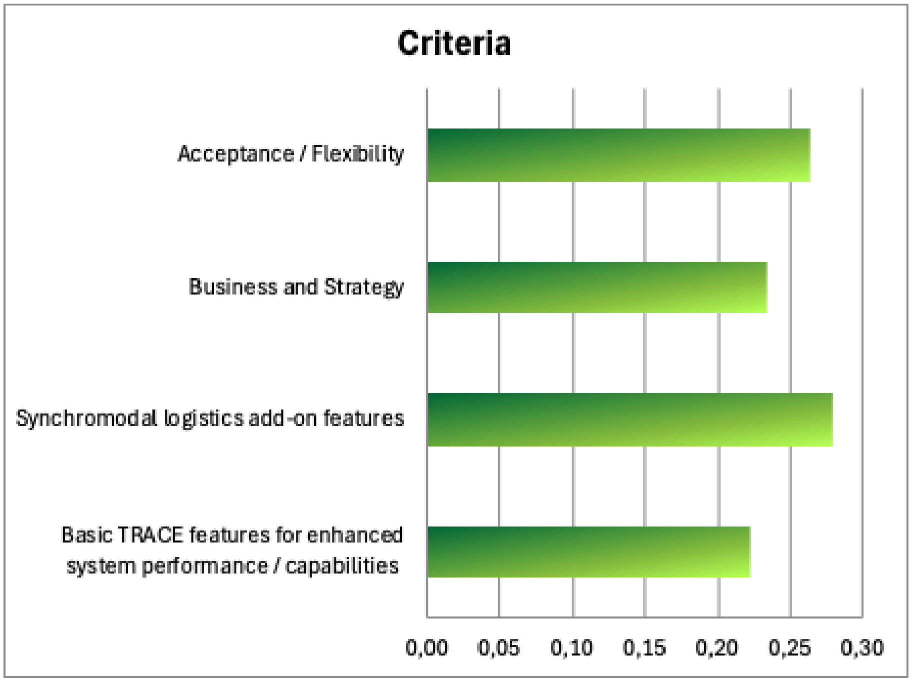


Figure 12. Relative weights of criteria

4.2.4 Weighting of sub-criteria under each criterion

It is also interesting to examine the weights of the sub-criteria under each criterion. Regarding Basic TRACE features for enhanced system performance/capabilities, experts seem more concerned about **real-time communication, processing, and optimization** (0.259) as well as **interoperability between different logistic operations** (0.238). The former indicates that managing and adapting logistics workflows according to real-time data in a step-by-step fashion underpins TRACE functionality, allowing for immediate responses to disruptions or optimization requirements. On the other hand, the latter highlights the need to ensure smooth and seamless integration across different logistics networks and platforms, which will enable a common approach towards shared resources, routing and multimodal operations. It is thus evident that these two priorities suggest that core TRACE attributes must orchestrate complex, multi-stakeholder operations, in order to optimize performance across sectors.

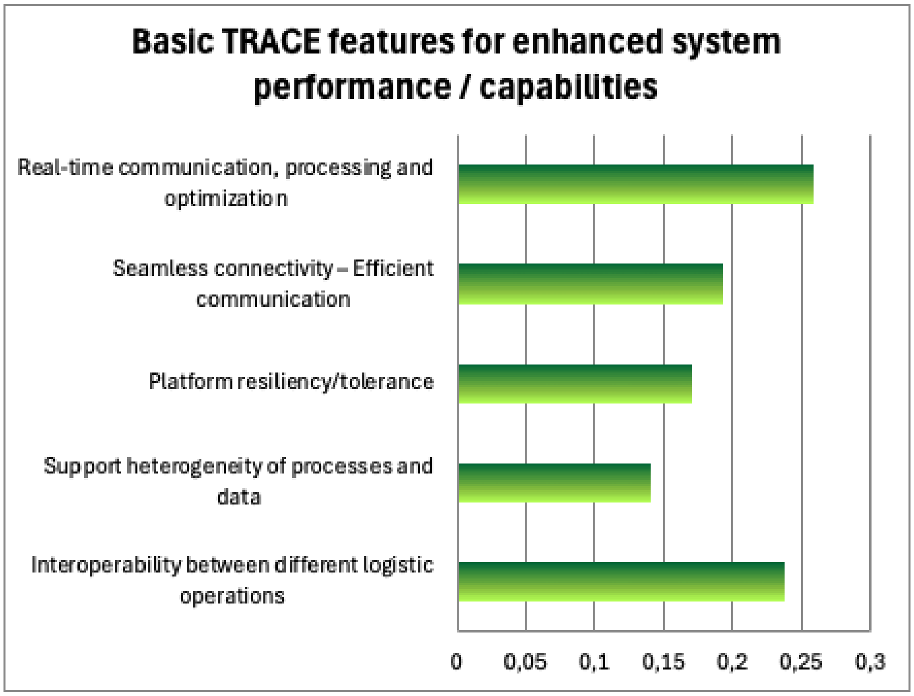


Figure 13. Relative weights of Basic TRACE features for enhanced system performance / capabilities Sub-criteria

Additional sub-criteria, such as **seamless connectivity and efficient communication** (0.193), and **platform resilience/tolerance** (0.170) are also crucial as they emphasize the significance of high-performance connectivity reliability and system stability. This stresses that TRACE's platform needs to be always-on, resilient to unexpected events, ensuring constant logistics coordination. Finally, **support for heterogeneity of processes and data** (0.140) received the lowest importance ranking which indicates that although it is important for the platform to allow a variety of data types and processes to be incorporated, this capability appears more as an enabler than a primary driver.

Regarding the sub-criteria of Synchromodal Logistics Add-on features criterion, Figure 14 shows that **transportation efficiency** and **real-time tracking and traceability** ranked first (0.28 and 0.27 respectively) indicating their increased importance. This ranking is fully consistent with the vision of TRACE to optimize stakeholders shared logistic operations in terms of costs, emissions, time and fuel requirements. The real-time tracking and traceability of shipments are integral components of TRACE, enhancing logistics oversight and maintaining high levels of transparency and accountability while significantly contributing to sharing and reduction of individual logistics costs.

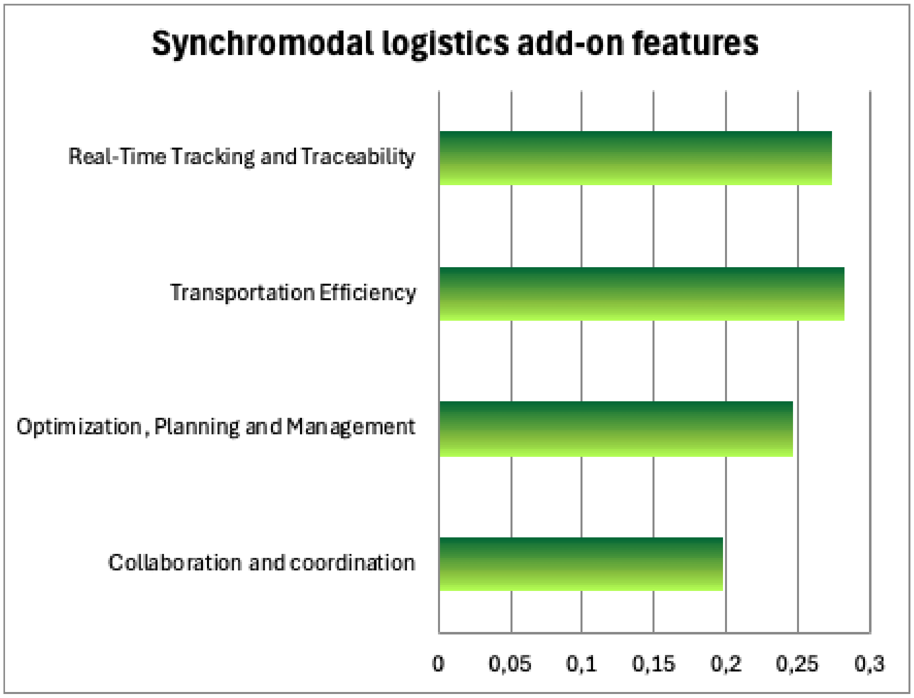


Figure 14. Relative weights of Synchromodal Logistics Add-on features Sub-criteria

Optimization, planning, and management (0.247) can be found at the third place of experts' preference. The quite high weight of this sub-criterion indicates its high importance towards the strategic management of various assets and processes within the supply chain leading to efficiency and effectiveness maximization. Surprisingly enough, **collaboration and coordination** (0.198) ranked slightly lower at the last position. This is somehow unexpected since collaboration and coordination are the most important prerequisites for synchromodal processes. Without them, the mandatory information and resource sharing cannot be achieved limiting the success of both TRACE and synchromodality vision.

The ranking of sub-criteria under the **Business and Strategy** category highlights the importance placed on **potential for savings in costs, energy, and emissions** (0.369), which emerges as the most significant factor. This indicates that TRACE's stakeholders prioritize tangible cost-saving benefits and environmental impact reductions, as these directly influence operational efficiency and sustainability—key concerns in modern logistics. With logistics providers facing increasing pressures to reduce carbon footprints and operational expenses, this sub-criterion's weight reflects a strategic emphasis on implementing solutions that offer both economic and environmental benefits. Thus, TRACE's potential to optimize resource use and minimize waste not only positions it as a cost-effective solution but also supports the industry's broader shift toward greener logistics practices.

At the second place, one can find **New Market Opportunities** sub-criterion with weight 0.26. Identifying and capitalizing on market growth opportunities is essential for the long-term success and sustainability of TRACE. The potential for market expansion, meeting evolving consumer needs, and staying competitive in a growing market are crucial for the ongoing development and adoption of TRACE.

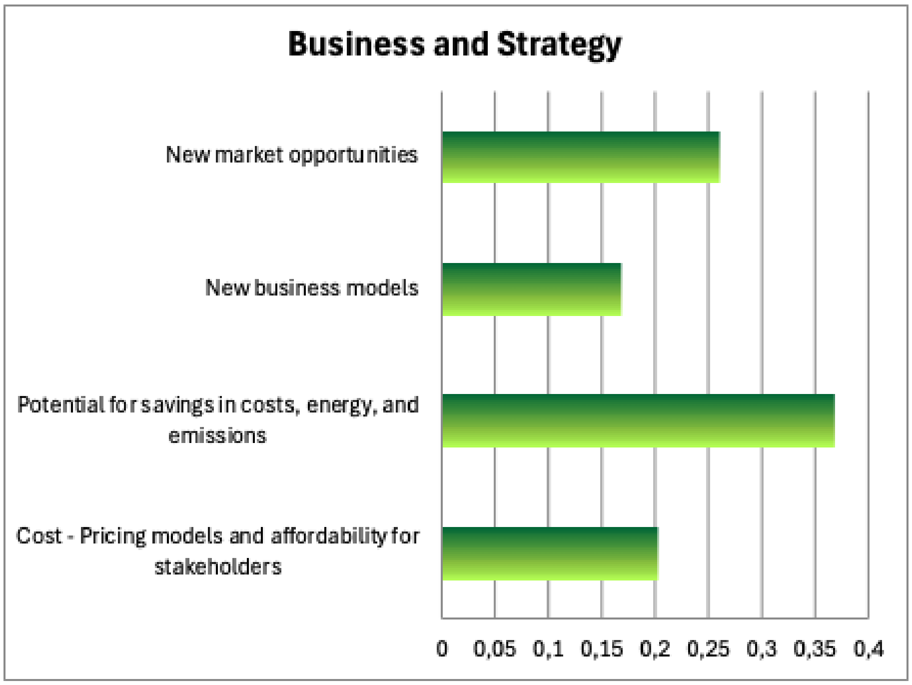


Figure 15. Relative weights of Business and Strategy Sub-criteria

According to the experts' opinions, sub-criterion **cost – pricing models and affordability for stakeholders** is in the third place (weight: 0.20). This is not surprising as both the cost of development/deployment and the market price are very important for the adoption of a new system. Affordability plays a crucial role in the widespread acceptance of these systems, influencing both consumers and businesses. Reducing costs can enhance accessibility and drive broader adoption.

It is evident that the relative importance of these three sub-criteria depends on TRACE's phase. During the initial stages of market introduction, compliance and safety might take precedence, while in later stages, cost reduction and capitalizing on market growth opportunities could become more prominent. Thus, it evolves over time as technology matures and the market dynamics change. A balanced approach that considers all three factors is often necessary for the successful adoption and sustainability of TRACE.

In the last position, one can find New Business Models sub-criterion. This is somehow strange since new business models are integral to the business and strategy of TRACE. They offer avenues for revenue generation, provide a competitive advantage, enable adaptability to market changes, foster collaboration within the ecosystem, and enhance the overall user experience. Ignoring the importance of innovative business models could limit the success and widespread adoption of TRACE.

Regarding the sub-criteria of the Acceptance / Flexibility criterion, **secure data transfer (security and privacy)** is the most important (weight: 0.25). The very high importance of security and privacy in TRACE and logistics systems, in general, is driven by the need to protect sensitive data, build user trust, comply with legal requirements, and ensure the reliability of critical transportation infrastructure. Addressing these concerns is integral to the responsible and successful deployment of TRACE.

As shown in Figure 16, **Compliance to Standards and Specifications** and **Regulatory issues** are ranked as the second choice among the experts with weight 0.215 and 0.199 respectively. Compliance with standards and specifications as well as with National and International regulatory frameworks is critical for the successful implementation and adoption of TRACE. This ensures interoperability, safety, smooth and continuous operation as well as reliability building trust among users and other stakeholders.

The inability to comply with existing national or European regulations and standards related to information exchange, flows management, data privacy, and emergency services could hinder the market adoption of TRACE.

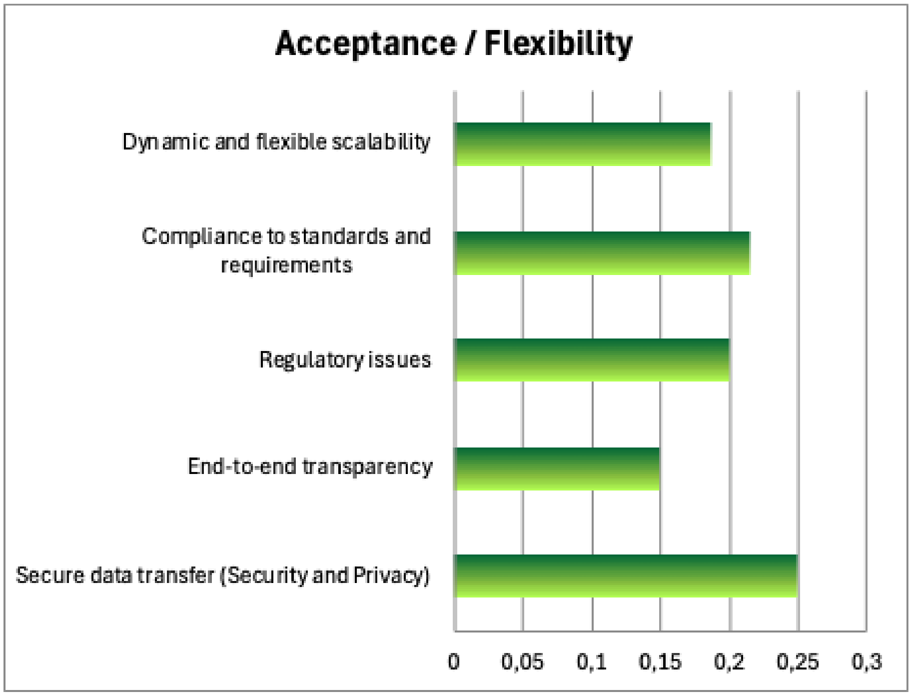


Figure 16. Relative weights of Acceptance / Flexibility Sub-criteria

Dynamic and flexible scalability follows with weight 0.186. As the adoption of TRACE increases, scalability becomes essential to accommodate a larger number of users. In addition, the ability to scale ensures that TRACE will remain efficient and effective as data volumes increase. In general, scalability supports the vision of creating an ecosystem that can seamlessly integrate with existing infrastructure and accommodate future developments. While **end-to-end transparency** is ranked lower at 0.149, this remains a key element; having visibility into the logistics value chain promotes confidence between stakeholders and enables better decision-making.

4.2.4.1 Global priorities of sub-criteria and Policy Implications

In order to capture a global view of the sub-criteria ranking, the global priorities need to be calculated. The global priorities are obtained by multiplying the local priorities (sub-criteria weights) by their parent's priority (weight). The global priorities for all the sub-criteria add up once again to 1. Table 18 presents the global weights (in descending order) for the top 10 sub-criteria.

Table 18. Global Priorities of sub-criteria

Sub-criteria	Global Priority
Potential for savings in costs, energy, and emissions	0,0864
Transportation Efficiency	0,0788
Real-Time Tracking and Traceability	0,0764
Optimization, Planning and Management	0,069
Secure data transfer (Security and Privacy)	0,0658
New market opportunities	0,061
Real-time communication, processing and optimization	0,0577
Compliance with standards and requirements	0,0567
Collaboration and coordination	0,0553
Interoperability between different logistic operations	0,053

Global priorities indicate that the factors most crucial to the adoption of TRACE in descending order of importance are:

- Potential for savings in costs, energy, and emissions;
- Transportation Efficiency;
- Real-Time Tracking and Traceability;
- Optimization, Planning and Management;
- Secure data transfer (Security and Privacy).

Notably, the majority of the top 5 factors fall within the second criterion “Synchromodal logistics add-on features”. This alignment underscores TRACE's core objective, aiming to provide an integrated solution to support the synchromodal logistics paradigm that enables stakeholders to optimize shared logistic operations in terms of costs, emissions, time and fuel requirements.

5 Conclusions

While the first commercial deployments of synchromodal systems are under way, it is crucial to deeply understand and successfully address the identified challenges. The embryonic stage of these systems, coupled with the multi-disciplinary nature of impacting factors, adds complexity to the situation. Consequently, a well-defined roadmap encompassing technical, economic, regulatory, people and other considerations is needed. Critical decisions should be highlighted within this roadmap, and a successful rollout strategy requires clearly defined business cases.

In this deliverable, we initially defined the ecosystem around the TRACE platform to guide the definition of profitable business models and cases. We then carried out a gap analysis, in order to identify and highlight any missing aspects or necessary requirements. Finally, we performed a roadmapping exercise, addressing technological, techno-economic, standardization, and regulatory issues integral to a successful deployment strategy.

An analysis of the TRACE ecosystem was also conducted, defining involved actors, identifying new players, and describing their relations along with the associated revenue streams. The benefits from the use of the TRACE platform were identified and thoroughly described per stakeholder.

Next, a detailed Gap analysis of the Project's Pilots was performed, in order to identify the key differences between the as-is situation and the desired one, after implementation of the TRACE Project. Once identified and meaningfully classified in larger thematic areas, these Gaps were subsequently crosschecked and verified with the market players. In addition, the root causes of these Gaps and key barriers that hinder the closing of the Gaps at present, were also uncovered and analyzed in detail.

The key findings from the Gap analysis point to both hard and soft barriers that need to be overcome in order to successfully introduce synchromodality and relative business models. The key gaps are related to vehicle & transport innovations that require trustworthy collection and use of real-time data across the complete value chain, including open data from relevant authorities. Such data will then be fed into advanced technological tools and systems in order to automate and optimize the logistics processes to the benefit of all key stakeholders.

It is important to emphasize that all these hard barriers can be effectively addressed through the innovative TRACE platform, which integrates various advanced technologies and tools. However, to be able to introduce such advanced solutions though, soft issues related to the skills and the mindset of the labour force, as well as communication to the public need to take place, while related city infrastructure, laws and regulations need to also be introduced. In addition, financial and/or regulatory incentives need to be addressed by the local authorities, in order to help accelerate the transition, especially for the smaller logistics players that are engaged.

This work provides key insights into the anticipated challenges when broadly introducing synchromodal logistics operations, as well as valuable recommendations on what can be done to plan and incorporate actions that will help overcome such challenges, early in the implementation of such new, innovative ways of logistics operations.

To assess factors influencing the market adoption and evolution of TRACE solutions, the AHP methodology was employed. Through discussions with experts, a hierarchy of the main objectives was established, and the key criteria and sub-criteria were selected. A questionnaire was then distributed, and collected responses were processed and analyzed, leading to the following conclusions.

Synchromodal Logistics Add-on features are considered the most crucial criterion, followed by "**Acceptance / Flexibility**" and "**Business and Strategy**" with "**Basic TRACE features for enhanced system performance / capabilities**" having the lowest weight. Among sub-criteria, the "**Potential for savings in costs, energy, and emissions**" ranked highest, followed by "**Transportation Efficiency**", "**Real-Time Tracking and Traceability**", "**Optimization, Planning and Management**" as well as "**Secure data transfer (Security and Privacy)**". The emphasis on the savings and efficiency is aligned with the main goals and challenges of the logistics sector.

The deliverable aims to provide initial insights into the business aspects of TRACE and logistics/synchromodality in general, serving as guidance for TRACE partners and other stakeholders interested in synchromodal systems rollout. Beyond investment strategies, efforts should focus on increasing awareness of the benefits arising from such systems. Finally, through collaboration, transparency, as well as market-related issues such as cost, and business models might not be among the top priorities of experts, relevant aspects should be seriously considered, as they can significantly impact the success of logistics/synchromodality systems.

6 References

[1] B. Acero, Maria Jesus Saenz and Davide Luzzini, "Introducing Synchromodality: One Missing Link Between Transportation And Supply Chain Management," Journal of Supply Chain Management. Vol. 58, No. 5, 2021, DOI: 10.1111/jscm.12269.

[2] G. N. Kapetanis, H. N. Psaraftis and D. Spyrou, "A simple synchro - modal decision support tool for the Piraeus container terminal," Transportation Research Procedia, pp. 2860–2869, 2016. https://doi.org/10.1016/j.trpro.2016.05.403

[3] Urban Logistics 4.0 [Accessed at: https://escp.eu/news/urban-logistics-40]

[4] McKinnon, A., 2015. The role of government in promoting green logistics. In: McKinnon, A., Browne, A., Whiteing, M., Piecyk, M. (Eds.), Green Logistics. Kogan Page, London, pp. 341–360.

[5] R. Giusti, D. Manerba, G. Bruno, R. Tadei, "Synchromodal logistics: An overview of critical success factors, enabling technologies, and open research issues," Transportation Research Part E: Logistics and Transportation Review, Vol. 129, 2019.

[6] FENIX project [Accessed at: https://fenix-network.eu]

[7] AI can transform workforce planning for travel and logistics companies, September 2024, [Accessed at: https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/ai-can-transform-workforce-planning-for-travel-and-logistics-companies?stcr=8ED25CDDB84A4B55A438FF14E04B183D&cid=other-eml-alt-mip-mck&hlkid=521eb074574a492cadbbf77ee648c7f0&hctky=10389658&hdpid=4e1f3846-766d-451f-8263-0366f11671eb#/]

[8] T. L. Saaty, "A scaling method for priorities in hierarchical structures," Journal of Mathematical Psychology, vol. 15, pp. 234-281, 1977.

[9] A. M. A. Bahurmoz, "The analytic hierarchy process at DarAl-Hekma, Saudi Arabia," Interfaces, vol. 33, pp. 70-78, 2003.

[10] A. Kengpol and C. O'Brien, "The development of a decision support tool for the selection of advanced technology to achieve rapid product development," International Journal of Production Economics, vol. 69, pp. 177-191, 2001.

[11] G. Noci and G. Toletti, "Selecting quality-based programmes in small firms: A comparison between the fuzzy linguistic approach and the analytic hierarchy process," International Journal of Production Economics, vol. 67, pp. 113-133, 2000.

[12] M. M. Albayrakoglu, "Justification of New Manufacturing Technology: A Strategic Approach Using the Analytical Hierarchy Process," Production and Inventory Management Journal, First Quarter, vol. 37, pp. 71-76, 1996.

[13] T. L. Saaty, The analytic hierarchy process: planning, priority setting, resource allocation. New York: McGraw-Hill International Book Co., 1980.

[14] G. Dede, et al., "Towards a Roadmap for Future Home Networking Systems: An Analytical Hierarchy Process Approach," IEEE Systems Journal, vol. 5, pp. 374-384, 2011.

[15] G. Dede, et al., "Evaluation of Optical Wireless Technologies in Home Networking: An Analytical Hierarchy Process Approach," IEEE/OSA Journal of Optical Communications and Networking, vol. 3, pp. 850-859, 2011.

[16] S. Nikou, et al., "Analytic Hierarchy Process (AHP) Approach for Selecting Mobile Service Category (Consumers' Preferences)," in 2011 10th International Conference on Mobile Business, 2011, pp. 119-128.

[17] S. Qingyang and A. Jamalipour, "Network selection in an integrated wireless LAN and UMTS environment using mathematical modeling and computing techniques," IEEE Wireless Communications, vol. 12, pp. 42-48, 2005.

[18] T. L. Saaty and M. S. Ozdemir, "Why the magic number seven plus or minus two," Mathematical and Computer Modelling, vol. 38, pp. 233-244, 2003.

[19] G. Dede, et al., "Convergence properties and practical estimation of the probability of rank reversal in pairwise comparisons for multi-criteria decision-making problems," European Journal of Operational Research, vol. 241, pp. 458-468, 2015.

[20] G. Dede, et al., "Theoretical estimation of the probability of weight rank reversal in pairwise comparisons," European Journal of Operational Research, vol. 252, pp. 587- 600, 2016.

Annex I: External Gap Analysis Questionnaire Template

Logistics Modernization & Innovation Gap Analysis – Qualitative Questionnaire

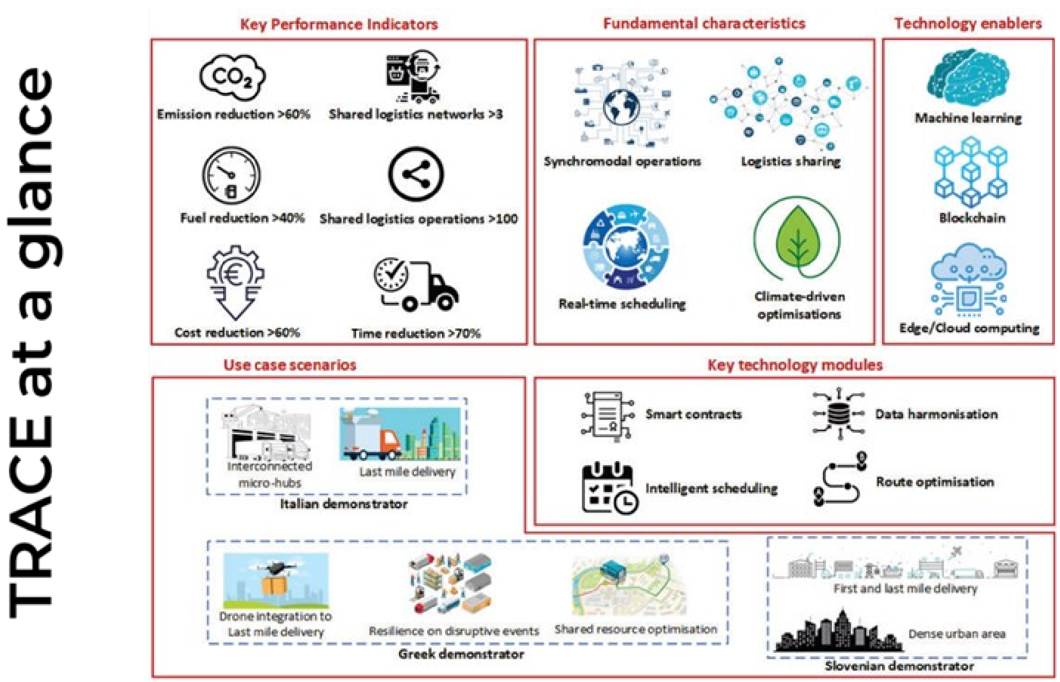
Responding organization: …….

Introduction

WHY: Being a key player in Logistics for such a long time, you know better than anyone that challenges such as securing uninterrupted deliveries amidst disruptions while optimizing available resources in terms of cost, energy & time spent, and emissions, requires constantly introducing new technologies and exploring novel, innovative business models based on shared logistics operations and synchromodality.

ABOUT TRACE: This is exactly where the EU Research HORIZON Project TRACE comes into play in order to help optimize logistics operations through innovation and new business models, based on an integrated platform which uses of state-of-the-art technologies: Machine Learning/AI, Blockchain and Edge/Cloud.

Such smart platform will provide functionalities related to advanced planning, intelligent scheduling, route optimization and events management, as well as real time conclusion of smart contracts and financial operations, see figure below for an outline.



WHAT: We have now reached the Project phase where we aim to identify, study and analyse the **current gaps and barriers** for modernization & innovation in Logistics. This is where we consider your input of key importance, hence we would like to capture it through this Qualitative Questionnaire.

We suggest that you go through it in order to identify the appropriate person(s) for providing the required input, and/or raise any questions you may have. As a next and final step, we will schedule a face-to-face or online meeting (whichever suits you best) at your earliest convenience, to properly capture your views.

DISCLAIMER: It is noted that this activity complies with Regulation (EU) 2016/679 known as GDPR and 2002/58/EC Directive on privacy and electronic communications. No personal data will be stored and processed. Any and all information provided will be treated as strictly confidential and it will not be possible to identify the information provider from the Project's public material.

QUESTIONNAIRE

1. ABOUT YOUR CURRENT OPERATIONS

In this chapter, we will go through some questions in order to better understand your current operations in terms of applied business model, processes, resources & skills, technology & automation, and performance.

1. **Business model & key objectives:**
   a. Briefly describe your company's vision, mission, key objectives & KPIs, strategy.
   b. Do you have any goals related to reducing fuel, time, emissions and ultimately costs? If yes, please describe along with the identified actions to achieve these goals. Are you happy with the progress you are making? If not, please specify why not.
   c. Briefly describe your company's current business model (value proposition, services offered, who are your customers & partners, cost & revenue structure, as well as the parts of the logistics value chain you are covering).
2. **Current Processes and Procedures:**
   a. Briefly describe the **key processes and procedures** involved in your logistics operations, like eg. procurement, warehousing, transportation, distribution etc.
   b. What are the **bottlenecks or inefficiencies** in the current processes – what would you like to improve? Please list them per process. Do you have any improvement plans in place? Please share.
   c. How do you manage **innovation** in your operations/processes? Is there a systematic way of doing this? Please describe.
   d. What is your view and the level of your organization's knowledge specifically about:
      1. Synchromodal operations
      2. Logistics sharing
      3. Real-time (re-)scheduling

4. Climate-driven optimizations

3. **Resource Utilization & skills:**
   a. How effectively are resources (e.g., transportation vehicles, warehouse space, time, fuel, personnel, etc.) utilized in your logistics operations?
   b. Are there any underutilized resources or identified areas of resource wastage? Do you have any improvement plans in place to overcome this? Please share.
   c. Does your staff possess the necessary skills to achieve the company's goals and objectives as per above? If not, in which areas/processes/ job positions do you lack which skills and what actions are being taken to close the gap?
4. **Technology and Automation:**
   a. What technologies and automation tools are currently employed in your logistics operations?
   b. How do these technologies contribute to operational efficiency and effectiveness?
   c. Are you using smart contracts today? If yes, in which areas/how? If not, why and do you have any plans for doing so in the future?
   d. Do you use any tools for intelligent scheduling, data harmonization and/or route optimization today? If yes, please specify which ones, how and where. If not, why not? Do you have any plans for doing so in the future?
   e. How does your organization ensure effective implementation and adoption of new technologies and practices?
5. **Performance and Quality of Service:**
   a. How do you measure Quality of Service?
   b. How do you measure Customer Satisfaction with your logistics services?
   c. What feedback have you received from customers regarding the quality and reliability of your logistics operations?

d. What measures (if any) are currently in place (or planned for) with regards to the following issues:

    i. avoiding empty capacity,

    ii. reducing transportation by trucks in favor of railroads/ships/ barges,

    iii. reacting to disruptions.

e. What other performance improvement measures do you have in place or are planning? Please specify the existing gaps between wanted position and as-is for each one of these.

2. MARKET TRENDS & STRATEGY

In this chapter, we will go through some questions in order to better understand your point of view on the future market demands on logistics, and if/how is your organization being prepared to successfully respond to the challenges that lie ahead, applying innovation and modernization to maximise the benefits for your organization.

1. **For the next 5-7 years:**
    a. To your view, which are the top5 key logistics **industry trends**?
    b. To your view, which are the top5 key logistics **industry challenges**?
    c. Do you see any emerging trends or market opportunities that could be leveraged to develop new, innovative and potentially disrupting business models in logistics?
2. **Improvement Areas for Modernization & Innovation:**
    a. Which specific areas of your logistics operations require modernization, and/or innovation (including optimization) to optimally respond to the above market trends & challenges?
    b. Which new technologies do you foresee that you will need to apply for achieving that?
    c. Please specify the key gaps between your current modus operandi in terms of processes, resources & skills, technology & automation and performance, and the desired state of operations to effectively respond to the above market trends & challenges.

d. Is there an action plan with a specific timeline in place for closing such key gaps? Can you please share in broad lines?

3. **Exploring Innovative Business Models:**

How open is your organization to exploring innovative unconventional approaches, business models or partnerships to drive improvements?

Thank you for your valuable input in this Gap Analysis Questionnaire.

Your perspectives will contribute to shaping the future of Logistics Operations.

Annex II: External Gap Analysis Questionnaire Responses

QUESTIONNAIRE – Logistic company #1

ABOUT YOUR CURRENT OPERATIONS

Business model & key objectives:

Briefly describe your company's vision, mission, key objectives & KPIs, strategy.

Our company aims to become the top third-party logistics provider in the fast-moving consumer goods industry. We provide top-quality logistics solutions for this fast-paced sector.

Our goal is to cut costs by using digital technology to make processes more efficient. We measure our success by specific KPIs. Our strategy is to keep improving and innovating to stay ahead of the competition.

Do you have any goals related to reducing fuel, time, emissions and ultimately costs? If yes, please describe along with the identified actions to achieve these goals. Are you happy with the progress you are making? If not, please specify why not.

We're working on ways to cut fuel use, time, emissions, and costs. We are upgrading our warehouse and transport management systems. Upgrades will reduce costs, which will improve productivity, emissions, and efficiency.

It's important for us to stay up to date with the best technology and systems for logistics. For example, we combine trips and consolidate pallets in our vehicles. This saves customers money and reduces emissions.

We also aim to go paperless. This fits with our wider sustainability goals. We are making progress, but we are always looking for ways to improve.

Briefly describe your company's current business model (value proposition, services offered, who your customers & partners are, cost & revenue structure, as well as the parts of the logistics value chain you are covering).

We are a 3PL (third-party logistics) provider working with multiple vendors. We offer a range of services, including logistics and warehousing. Additionally, we handle manufacturing and other value-added services within our warehouses.

Our costs include labor, warehousing, IT, technology, and robotics. We generate income through warehousing, value-added processes, and transportation.

Current Processes and Procedures:

Briefly describe the key processes and procedures **involved in your logistics operations, like eg. procurement, warehousing, transportation, distribution etc.**

Our main processes are warehousing and transportation. As a 3PL provider, we store goods for our clients and then transport them to their end destinations. These two processes are essential for meeting customer needs and ensuring smooth logistics operations.

What are the bottlenecks or inefficiencies **in the current processes – what would you like to improve? Please list them per process. Do you have any improvement plans in place? Please share.**

Our processes are slow because they are not automated or digitalised. Without data, it's hard to find waste and see where costs are being wasted. We are overhauling our digital infrastructure to improve data collection and process visibility.

We are implementing new technologies, including a new warehouse management system (WMS) and transport management system (TMS), to tackle inefficiencies. These systems will help us identify bottlenecks and streamline our operations.

How do you manage innovation in your operations/processes? Is there a systematic way of doing this? Please describe.

We manage innovation in a systematic way. We have a department that drives innovation across the company. This team optimizes IT processes to reduce manual labor and costs. Our approach to innovation is not about reducing the workforce. We aim to make our employees more efficient by implementing new technologies and processes.

What is your view and the level of your organization's knowledge specifically about:

Synchromodal operations: We proactively engage in synchromodal operations through the integration of our WMS, TMS, and ERP systems. These systems communicate in real time, allowing us to enhance service levels for our customers by ensuring optimal synchronization and efficient management of all processes.

Logistics sharing: Sharing logistics resources is a key part of our approach. We collaborate with customers to share workloads, which helps us maximize efficiency and expand our reach across different customer portfolios.

Real-time (re-)scheduling: We work closely with our transport partners, providing them with live data on the quantity of pallets and other goods that need to be transported. This real-time feed ensures that scheduling remains up-to-date and synchronized, allowing for efficient rescheduling as needed.

Climate-driven optimizations: We are committed to using minimal resources to meet our logistics goals, as this has a direct impact on the cost for our customers. We optimize our operations with the objective of reducing our environmental impact while maintaining efficiency.

Resource Utilization & skills:

How effectively are resources (e.g., transportation vehicles, warehouse space, time, fuel, personnel, etc.) utilized in your logistics operations?

We are committed to optimizing the use of resources through the integration of advanced systems, including WMS and TMS. These systems enable us to optimize warehouse space, consolidate trips and ensure the effective use of transportation vehicles.

However, as with any complex logistics operation, there is always room for improvement, and we are continually working to enhance our resource management.

Are there any underutilized resources or identified areas of resource wastage? Do you have any improvement plans in place to overcome this? Please share.

Our current inefficiency is primarily due to the necessity for further digitalization and automation. In the absence of comprehensive visibility of specific data points, it is challenging to identify and eliminate resource wastage. To address this, we are currently upgrading our digital infrastructure, including new WMS and TMS systems. These systems will enable us to track and manage resources in real time, reducing wastage and improving overall efficiency.

Does your staff possess the necessary skills to achieve the company's goals and objectives as per above? If not, in which areas/processes/ job positions do you lack which skills and what actions are being taken to close the gap?

We know that new processes require new skills. To help our staff learn, we have training programmes led by dedicated trainers. These trainers work with our development and support teams to make sure our employees are trained in new systems and processes. We are also developing our operational team to support the wider workforce and make sure all employees have the skills they need to meet the company's goals.

Technology and Automation:

What technologies and automation tools are currently employed in your logistics operations?

We use self-driving robots and half-automated forklifts in our logistics. These help us automate parts of our warehousing and transportation, making us more efficient.

How do these technologies contribute to operational efficiency and effectiveness?

These tools help our workers do their jobs better. They can do simple tasks like moving goods around the warehouse, so our workers can do more complex tasks, which makes everything faster and better.

Are you using smart contracts today? If yes, in which areas/how? If not, why and do you have any plans for doing so in the future?

At the moment, we are not using smart contracts in our logistics operations. It is not currently part of our strategy, but we are exploring various technologies and will evaluate the potential of smart contracts in the future to make transactions more efficient and transparent.

Do you use any tools for intelligent scheduling, data harmonization and/or route optimization today? If yes, please specify which ones, how and where. If not, why not? Do you have any plans for doing so in the future?

We use a combination of our warehouse management system (WMS) and transport management system (TMS) for intelligent scheduling and route optimization. These systems are important to ensure efficient resource utilization and help us to consolidate trips and improve delivery times. We continue to invest in these systems to ensure optimal performance and keep pace with technological advancements.

How does your organization ensure effective implementation and adoption of new technologies and practices?

We train our staff to use new technologies successfully. Our trainers work with our development and support teams to teach employees how to use new systems and tools. This allows our team to adapt quickly and integrate new technologies into our processes.

Performance and Quality of Service:

How do you measure Quality of Service?

We measure quality of service through key performance indicators (KPIs) such as on-time deliveries, order accuracy and overall efficiency. We focus on meeting our customers' standards.

How do you measure Customer Satisfaction with your logistics services?

We get feedback, do surveys and keep in touch with customers. We value their input and work with them to meet their expectations.

What feedback have you received from customers regarding the quality and reliability of your logistics operations?

We have received positive feedback from customers, particularly regarding our responsiveness to disruptions and our collaborative approach to resolving issues. When disruptions occur, we act promptly and work closely with our customers to find solutions, whether through manual intervention or IT support.

What measures (if any) are currently in place (or planned for) with regards to the following issues:

Avoiding empty capacity: We optimize our WMS and TMS systems to consolidate shipments, ensuring that our transportation vehicles are fully utilized, minimizing empty trips.

Reducing transportation by trucks in favor of railroads/ships/barges: We primarily use trucks, but we are exploring more sustainable options for the future, like rail, but also drones.

Reacting to disruptions: We try to foresee disruptions, and they are handled on a case-by-case basis. We either resolve them manually or through IT solutions, and always in close collaboration with customers.

What other performance improvement measures do you have in place or are planning? Please specify the existing gaps between wanted position and as-is for each one of these.

We are improving through new technology. Our IT systems and data architecture are designed to make us more efficient. Our development department works with partners to manage risks and share the workload on large projects. We are addressing gaps between our current and desired state by staying up to date with the latest technology.

MARKET TRENDS & STRATEGY

To your view, which are the top5 key logistics industry trends?

The first big trend is real-time stock visibility. You need to know what's going on with your stock at all times. The second trend is that all systems need to be connected. Then there's the push to reduce paper and move toward paperless processes. The fourth trend is flexibility for the end user; customers want options and convenience. And speed in logistics, especially with last-mile delivery.

To your view, which are the top5 key logistics industry challenges?

Legislation is a big challenge when it comes to robotics and self-driving robots on the roads. The current laws just don't allow it. There is also a shortage of workers. Another challenge is infrastructure. We need more hubs for trucks, rail, and ships. For example, Luka Koper lacks a second rail to help reduce road congestion. Another challenge is a lack people with the right IT and logistics skills.

Do you see any emerging trends or market opportunities that could be leveraged to develop new, innovative and potentially disrupting business models in logistics?

Logistics providers can offer visibility and data exchange as part of their services. Many manufacturing companies don't know how to manage logistics. A logistics partner can provide IT solutions, not just move goods. This gives logistics providers a competitive advantage, as they can offer a broader range of services that reduce disruptions and improve efficiency. For example, by handling changing legislation and documentation for multiple customers, logistics providers can offer a full-service solution, helping businesses adapt quickly and stay compliant.

Improvement Areas for Modernization & Innovation:

Which specific areas of your logistics operations require modernization, and/or innovation (including optimization) to optimally respond to the above market trends & challenges?

Frankly, every part of the process is suitable for modernization or innovation, because logistics works fast. However, modernization comes at a high cost. Whether it is modernizing the fleet, fully automating warehousing or adding robotic arms, these technologies are extremely expensive. As a 3PL provider, you never know when you will get a new customer, so making these large investments is difficult unless you have long-term customers that allow you to reap the benefits of the investment.

Which new technologies do you foresee that you will need to apply for achieving that?

To achieve the modernizations objectives, we foresee the need for a Transport Management System (TMS) that will ensure full visibility from the point of order to delivery. This system is essential for real-time tracking and ensuring that everything is paperless, with communication between computers so that there is no need to involve staff. In addition, the aim is to fully automate the warehouse, ensuring efficiency and reducing manual labor wherever possible.

Please specify the key gaps between your current modus operandi in terms of processes, resources & skills, technology & automation and performance, and the desired state of operations to effectively respond to the above market trends & challenges.

One of the biggest shortcomings is the mindset of people when it comes to changing technologies and introducing new systems. The mindset of the people involved in the process needs to change, and that is something we are working lately. We have set up a new department to teach people how new processes should work and to make sure they have the skills and resources they need. This is particularly important when opening new centers where you need trained staff to support automation and new operating models. This is one of our biggest challenges.

Is there an action plan with a specific timeline in place for closing such key gaps? Can you please share in broad lines?

Logistics is a continuous process of continuous improvement. There is no fixed timeframe as innovation does not stop. Every day we must be better than the day before, and that is the mindset we follow. It is a continuous effort to improve and adapt our activities.

Exploring Innovative Business Models:

How open is your organization to exploring innovative unconventional approaches, business models or partnerships to drive improvements?

I would say that we are partly open to exploring innovative or unconventional approaches. The challenge is that we are operating in a small market and it is difficult to invest several million euros in something like a fully automated warehouse if we are not sure that it will pay us back in a reasonable timeframe. We cannot take the risks of large-scale innovation that larger countries can.

In this country, we tend to go for approaches that have worked elsewhere, especially when the costs of a semi-new technology become acceptable. Although we are open to new ideas, being truly unconventional is difficult because we simply do not have the money or resources to do it on a large scale.

QUESTIONNAIRE – Logistic company 2

ABOUT YOUR CURRENT OPERATIONS

Business model & key objectives:

Briefly describe your company's vision, mission, key objectives & KPIs, strategy.

So, our strategy is more or less focused on prioritizing parcel delivery instead of mail delivery, since mail deliveries have been on the decline for a couple of years now for obvious reasons. We are also trying to find a substitute service for mail delivery. Additionally, we are focused on the digitalization of our business logistics processes.

The key objective is in line with our vision and mission, which is to streamline parcel delivery and increase the added value per worker. We are a big company with 5000+ employees. We cover the whole country with our infrastructure, which consists of 400+ contact points. We have a workforce that is daily on the field, ranging up to 3000 people, so it's quite big. Restructuring and reorienting the company can be quite challenging.

Do you have any goals related to reducing fuel, time, emissions and ultimately costs? If yes, please describe along with the identified actions to achieve these goals. Are you happy with the progress you are making? If not, please specify why not.

We plan to reduce emissions, fuel consumption, time, and costs by introducing low emission technologies and vehicles. Additionally, we are trying to develop and introduce the carbon calculator for our customers and for our sustainability managers as well. We are decarbonizing our delivery fleet with electric vehicles and are also looking at other technologies that involve alternative fuel sources, such as hydrogen.

In line with the electrification of our delivery fleet, we are also introducing EV charging stations where necessary. We are introducing E cargo bikes or just regular bikes, and during this project, we are trying to develop or integrate autonomous vehicles in our delivery processes as well.

The progress in this regard is more or less slow due to restrictions stemming from the unavailability of cost-effective technologies. Additionally, there is some unwillingness to invest in this area from us, which is one of the reasons for the slow green transition. We may need more results to support decision-making in this area.

Briefly describe your company's current business model (value proposition, services offered, who are your customers & partners, cost & revenue structure, as well as the parts of the logistics value chain you are covering).

Our business model revolves around the delivery of parcels and letters. We aim to support e-commerce as much as possible, since this is the main source of postal items for us. With the largest delivery fleet in the country, we can cover all areas in the country. Not only do we offer delivery services, but we also provide services tied to data centers and other digital services like E-signature.

As a universal service provider, we have to deliver mail and parcels to every household in the country, regardless of the cost, and under the same price and conditions for every customer. This is similar to other postal operators in European countries. We cover all parts of the value chain, performing first-mile and last-mile operations. Our focus is mainly on national and regional delivery.

International mail or parcel delivery is not our strongest part, as it is not within our own network. We rely on other postal operators and logistics operators to execute international deliveries. After acquiring another logistic company a years ago, we have also tapped into the field of classical logistics in the wider region. Through this company, we offer warehousing services along with larger logistics services.

Current Processes and Procedures:

Briefly describe the key processes and procedures **involved in your logistics operations, like eg. procurement, warehousing, transportation, distribution etc.**

In our case, our key processes and procedures revolve around our big contractual customers who send shipments through us to their end customers. We cover e-commerce and industrial clients in regard to postal logistics services. Since postal operations are usually focused on capillary fragmented delivery operations, we mainly cover B2C deliveries. This means that for us, it is crucial to perform pickups, shipment processing, and last mile delivery. These processes are our bread and butter.

What are the bottlenecks or inefficiencies **in the current processes – what would you like to improve? Please list them per process. Do you have any improvement plans in place? Please share.**

These shortcomings are quite obvious. Our bottlenecks more or less stem from paper-based operations which are not appropriately digitalized. Due to this, we do not have access to real-time knowledge on business and logistics performance, leading to poor management and underutilization of key company assets.

Due to poor digitalization of key processes, we also do not have the right platform to develop additional innovative services, which usually demand a data-rich and digitally enabled environment. Stemming from all of this, we would like to firstly digitally support core postal operations in their entirety, which will lead to route optimization services and better utilization of key assets.

As we are speaking, we are running a digitalization project which will enable route optimization and create a data-rich environment that will enable better decision-making."

How do you manage innovation in your operations/processes? Is there a systematic way of doing this? Please describe.

This is something that is covered by Department of Innovation. We have two ways of approaching innovation in our company. Internally, we have a Kaizen system and a system for managing incremental improvements within our company. Our upper management and supporting staff also pursue innovation through other big or strategic projects.

On the other hand, we have external innovation which engages with the public and external stakeholders through the Department of Innovation. This kind of cooperation is usually formulated through publicly funded projects, such as the Horizon program or other national and European Union incentives.

What is your view and the level of your organization's knowledge specifically about:

Synchromodal operations: Synchro modal operations are seen as promising and interesting, but somewhat wishful in a capitalistic system. Different normative and legislative conditions need to be met to enable such a system.

Logistics sharing: Logistics sharing is more plausible if certain conditions are met, especially in the area of trust and governance. However, more good practices need to be developed to provide evidence for companies to pursue this further.

Real-time (re-)scheduling: Real-time rescheduling is considered very useful and even desirable once the necessary technology is available. Currently, there is some level of rescheduling, but it is not digitally supported.

Climate-driven optimizations: Climate-driven optimizations can be achieved through the incremental introduction of new green technologies. However, cost considerations need to be taken into account for a successful green transition, as this can often be a costly endeavor.

Resource Utilization & skills:

How effectively are resources (e.g., transportation vehicles, warehouse space, time, fuel, personnel, etc.) utilized in your logistics operations?

Even though we do not have the necessary digital tools for better utilization of our resources, we think that we still fairly utilize our key assets. We believe that once we digitalize all the processes and assets, we will achieve better utilization rates.

Are there any underutilized resources or identified areas of resource wastage? Do you have any improvement plans in place to overcome this? Please share.

I think that in three main areas we have room for improvement. One area is our workforce, the second one is our infrastructure, and the third one is our delivery fleet. These are the main operational networks that are important in this regard. We are planning to implement digital support for these three areas, and through that, we plan to streamline the utilization of these key assets. So, plans are in place, firstly for vehicles and our workforce.

Does your staff possess the necessary skills to achieve the company's goals and objectives as per above? If not, in which areas/processes/ job positions do you lack which skills and what actions are being taken to close the gap?

Currently, we think that there needs to be a considerable upgrade of employee skills due to the current technological gap that we are facing, especially regarding digitalization. In this regard, we can say that we lack digital skills, agile methodologies, and quick innovation. This is something lacking in our organization, and we think that implementing a logistics environment while using the new system to its fullest potential will be a challenge in itself.

Some actions have already been taken regarding the use of new tools, such as AI tools, but still, once we have everything in one digital environment, I think we will see that these gaps are more prominent and transparent. Then, we will probably have some mitigation activities in regards to that.

Technology and Automation:

What technologies and automation tools are currently employed in your logistics operations?

For core processes, as mentioned earlier, we are using our key assets such as the delivery fleet, which consists of multiple types of vehicles and has around 3000 vehicles. We also have the infrastructure with 450 contact points and sorting machines at the postal logistic centers and in logistic centers as well. We use DWS machines, which are dimensioning weight system machines.

We are using mobile phones and laptops for executing last mile processes. In our day-to-day operations, we also use Microsoft Office tools. Additionally, we have smaller tools that we use for streamlining our operations, such as the tool for classification of postal items that come from outside the European Union, which speeds up the importing process. There are also other very small tools used in a very specific and minor way.

How do these technologies contribute to operational efficiency and effectiveness?

Since they are tied to our core business, these tools are crucial for the execution of our basic business activity, which is delivery of mails and parcels.

Are you using smart contracts today? If yes, in which areas/how? If not, why and do you have any plans for doing so in the future?

No, we do not use smart contracts and currently we do not have any plans of using them. The reason why? Maybe because nobody from management was notified about the potential benefits of such technology. Additionally, there is no recognized threat that would need addressing from the perspective of such technology. Also, there might not be a significant gap between smart contracts and our current mechanisms for security.

Do you use any tools for intelligent scheduling, data harmonization and/or route optimization today? If yes, please specify which ones, how and where. If not, why not? Do you have any plans for doing so in the future?

As mentioned earlier, we have the AI classification tool for easier importing of postal items. We have also just developed a location intelligence tool. This tool is for micro-optimization of last mile processes. It means that when executing deliveries, the delivery personnel would have more information about the point of delivery, such as where exactly to put the parcel, where the entrance of the building is, where you can park, and other metadata connected to the delivery area, which is crucial for the execution of delivery and also which vehicle to use.

These tools are already in place. Through the digitalization project, we expect to have the main route optimization tool and other optimization services as well. This will be implemented in one year or two.

How does your organization ensure effective implementation and adoption of new technologies and practices?

The effective implementation and adoption of new technologies and processes is usually done through large strategic projects. This is something that we in the Innovation Department do not like as much. Some new technologies and practices are implemented via our Innovation Department, which takes care of smaller controlled experiments and relevant commercial areas. So, these are the two ways of introducing new technologies: bigger projects and small iterative experiments.

Performance and Quality of Service:

How do you measure Quality of Service?

The speed of delivery is the most crucial part in our quality of service. Successful handover of postal items to the recipients is also one metric. Additionally, customer satisfaction is a relevant metric for measuring the quality of service.

How do you measure Customer Satisfaction with your logistics services?

We measure customer satisfaction through polls, through other methods for capturing data, focus groups and other relevant methodologies for obtaining such data. Additionally, there is an independent measurement of the time of delivery for postal items conducted by the regulator responsible for the communication and mobility of goods2. This assessment is usually tied to the speed of service, such as how many days are needed to execute the deliveries of a certain percentage of shipments.

What feedback have you received from customers regarding the quality and reliability of your logistics operations?

Feedback on our services is more or less positive. We think that in this industry, we are still at the forefront of quality execution of deliveries. We also have supporting staff and customer support to address any potential mishappenings. So, I think that we are currently more on the positive than on the negative side.

What measures (if any) are currently in place (or planned for) with regards to the following issues:

Avoiding empty capacity: Shipment consolidation.

Reducing transportation by trucks in favor of railroads/ships/barges: None (railroads: postal logistics centers are not next to railway lines and country is relavitely small; ships: no internal waterways, small coastline)

Reacting to disruptions: We just have ad hoc planning of deliveries. So let's say the delivery manager receives the information that disruption is on the field and they they do ad hoc plan how to execute deliveries.

What other performance improvement measures do you have in place or are planning? Please specify the existing gaps between wanted position and as-is for each one of these.

We plan to introduce new tools and technologies for better business logistics performance and execution. Through that, we would like to better utilize our key resources. As mentioned earlier, examples of how we would like to approach this include carbon calculators, AI tools, micro-optimization tools, and location intelligence tools.

MARKET TRENDS & STRATEGY

To your view, which are the top5 key logistics industry trends?

- Autonomous technologies: The use of autonomous vehicles and drones for delivery is becoming increasingly prominent.
- Digitization: an ongoing trend, with a focus on digitalizing logistics processes to improve efficiency and effectiveness.

- Alternative fuels like hydrogen to reduce emissions and promote sustainability.
- Decarbonization.
- Health and safety: Ensuring the health and safety of workers and customers is a critical focus, along with adapting to the future of work.

To your view, which are the top5 key logistics industry challenges?

- Lack of employees.
- Rising (and undpredictable) cost of fuels.
- Regulation, especially related to ESG reporting and other measures.
- Supply chain disruptions.
- Technological integration.

Do you see any emerging trends or market opportunities that could be leveraged to develop new, innovative and potentially disrupting business models in logistics?

Drones are one area that may become more interesting in the near future if the legislative requirements are met. Additionally, advanced analytics and blockchain present significant opportunities. Autonomous delivery robots on the ground are also promising. While drones are more demanding from a legislative perspective, autonomous delivery robots could be more feasible.

Improvement Areas for Modernization & Innovation

Which specific areas of your logistics operations require modernization, and/or innovation (including optimization) to optimally respond to the above market trends & challenges?

We think that especially the first and last mile processes are the objects of potential development. The last mile is the most demanding process of them all and the costliest one. We are more or less looking at that part in order to streamline operations and costs. The biggest potential for improvement is also in the last mile.

Which new technologies do you foresee that you will need to apply for achieving that?

Advanced route optimization, location intelligence and autonomous operations.

Please specify the key gaps between your current modus operandi in terms of processes, resources & skills, technology & automation and performance, and the desired state of operations to effectively respond to the above market trends & challenges.

So, these gaps stem from the fact that we are a big company, and if we would like to digitalize our whole business logistics environment, this is a very big project. This is the gap that we have right now—covering all the business logistics aspects. Transitioning from paper-based transactions towards digital transactions on all levels creates other gaps. Once we have everything in one digital environment, which will be quite challenging, I think we will cover those gaps.

Is there an action plan with a specific timeline in place for closing such key gaps? Can you please share in broad lines?

It is, as mentioned earlier, we have strategic projects which are addressing this area. To be honest, I think we cannot disclose this through this questionnaire, but this project began a couple of months ago and the plan is for it to end in two years' time.

Exploring Innovative Business Models:

How open is your organization to exploring innovative unconventional approaches, business models or partnerships to drive improvements?

We are very open to these activities, as the company supports this and through the Department of Innovations, we try to facilitate such activities as much as possible.

QUESTIONNAIRE – Logistic company #3

1. ABOUT YOUR CURRENT OPERATIONS

In this chapter, we will go through some questions in order to better understand your current operations in terms of applied business model, processes, resources & skills, technology & automation, and performance.

1. **Business model & key objectives:**

    a. Briefly describe your company's vision, mission, key objectives & KPIs, strategy.

Vision: to have technology as an ally in order to know the status of their shipments for customers and correspondents.

KPIs: transport time, proactiveness, communication, on time delivery, delay to deliveries.

b. Do you have any goals related to reducing fuel, time, emissions and ultimately costs? If yes, please describe along with the identified actions to achieve these goals. Are you happy with the progress you are making? If not, please specify why not.

They don't own any trucks. They use suppliers. But they have done emissions certification for both 2022 and 2023 certification in accordance with the law.

c. Briefly describe your company's current business model (value proposition, services offered, who are your customers & partners, cost & revenue structure, as well as the parts of the logistics value chain you are covering).

The services offered are: International Transport, Warehousing and Distribution/Delivery.

Customers: B2B companies.

Partners: a network of correspondents within the country and abroad.

They are active in forwarding, transportation, warehousing and logistics value added-services.

Key cost contributors:

- Cost of fuel
- insurance
- drivers
- labour
- lawyers

Revenues come from:

- freight
- freight forwarding

- warehouses
- distribution

2. **Current Processes and Procedures:**

   a. Briefly describe the **key processes and procedures** involved in your logistics operations, like eg. procurement, warehousing, transportation, distribution etc.

   b. What are the **bottlenecks or inefficiencies** in the current processes – what would you like to improve? Please list them per process. Do you have any improvement plans in place? Please share.

   The biggest problem is the lack of staff, specific specialties, IT skills. There is huge rotation (ie turnover of employees).

   Lack of warehouse space for logistics: there are no plots of land to build on, or existing buildings are not as needed.

   Digital exchange of information with their partners or workers via electronic files is an issue, because the market mentality in the country is not there. There is too much paper used and no automation or digital tools used, especially with their external collaborators.

   c. How do you manage **innovation** in your operations/processes? Is there a systematic way of doing this? Please describe.

   Change and transfer to Transport Management System (TMS) and Warehouse Management Systems (WMS). User training is required/ongoing including operations demos.

   d. What is your view and the level of your organization's knowledge specifically about:

      1. Synchromodal operations: Transport is mainly done by road, the train is inadequate and the plane is expensive. Collaborative transport is difficult, only for road transport via Italy by sea/ships
      2. Logistics sharing: No joint use of logistics is use.

3. Real-time (re-)scheduling: Only ad-hoc, but they have permanent partners for re-programming transportation.
4. Climate-driven optimizations: For transportation within the country, they do not own any trucks; they use subcontractors

3. **Resource Utilization & skills:**

   In general, IT and SW engineering positions are difficult to fund!

   a. How effectively are resources (e.g., transportation vehicles, warehouse space, time, fuel, personnel, etc.) utilized in your logistics operations?

      They have subcontracted carriers, and they use files

   b. Are there any underutilized resources or identified areas of resource wastage? Do you have any improvement plans in place to overcome this? Please share.

   c. Does your staff possess the necessary skills to achieve the company's goals and objectives as per above? If not, in which areas/processes/ job positions do you lack which skills and what actions are being taken to close the gap?

4. **Technology and Automation:**

   a. What technologies and automation tools are currently employed in your logistics operations?

      They are currently in the phase of introducing new tools to be launched early next year.

      Delivery is monitored by GPS, between the two biggest cities and outside these cities only by phone.

      There is track and trace for *internal* transport *(inside the country).*

   b. How do these technologies contribute to operational efficiency and effectiveness?

   c. Are you using smart contracts today? If yes, in which areas/how? If not, why and do you have any plans for doing so in the future?

      They provide intelligent route planning manually; to be automated next year.

d. Do you use any tools for intelligent scheduling, data harmonization and/or route optimization today? If yes, please specify which ones, how and where. If not, why not? Do you have any plans for doing so in the future?

e. How does your organization ensure effective implementation and adoption of new technologies and practices?

5. **Performance and Quality of Service:**

   a. How do you measure Quality of Service?

   Through feedback surveys

   b. How do you measure Customer Satisfaction with your logistics services?

   They use feedback surveys

   c. What feedback have you received from customers regarding the quality and reliability of your logistics operations?

   More than 90% of those providing feedback said that they are satisfied by the customer service. The limited negative opinions can mainly be attributed to the response to urgent orders, the ability-effectiveness of order management and the consistency in the offer-contract terms

   d. What measures (if any) are currently in place (or planned for) with regards to the following issues:

      i. avoiding empty capacity, none; they do not own the trucks

      ii. reducing transportation by trucks in favor of railroads/ships/ barges,

      iii. reacting to disruptions.

   e. What other performance improvement measures do you have in place or are planning? Please specify the existing gaps between wanted position and as-is for each one of these.

2. MARKET TRENDS & STRATEGY

In this chapter, we will go through some questions in order to better understand your point of view on the future market demands on logistics, and if/how is your organization being prepared to successfully respond to the challenges that lie ahead, applying innovation and modernization to maximise the benefits for your organization.

They don't follow the market trends & developments systematically.

1. **For the next 5-7 years:**

    a. To your view, which are the top5 key logistics **industry trends**?

    They don't know; they guess it is last mile deliveries for city logistics.

    b. To your view, which are the top5 key logistics **industry challenges**?

    c. Do you see any emerging trends or market opportunities that could be leveraged to develop new, innovative and potentially disrupting business models in logistics?

    Technology is the key to cover the needs which are increasing in the country in tourism, health, etc. everyone needs logistics.

2. **Improvement Areas for Modernization & Innovation:**

    a. Which specific areas of your logistics operations require modernization, and/or innovation (including optimization) to optimally respond to the above market trends & challenges?

    b. Which new technologies do you foresee that you will need to apply for achieving that?

    c. Please specify the key gaps between your current modus operandi in terms of processes, resources & skills, technology & automation and performance, and the desired state of operations to effectively respond to the above market trends & challenges.

    The lack of skilled resources to work in logistics is a huge issue; Country's labour force is the least qualified across Europe; they hardly have any basic knowledge of MS office tools and languages.

    d. Is there an action plan with a specific timeline in place for closing such key gaps? Can you please share in broad lines?

    Scanners to be able to monitor incoming and outgoing loads & items

3. Exploring Innovative Business Models:

How open is your organization to exploring innovative unconventional approaches, business models or partnerships to drive improvements?

They are open to new tools and training in new tools. They are even open to new business models but not to data sharing with competitors.

Thank you for your valuable input in this Gap Analysis Questionnaire.

Your perspectives will contribute to shaping the future of Logistics Operations.

Annex III: Internal Gap Analysis Questionnaire Responses

Greek Pilot

UC partners & actors	ACS (Courier Service) Role: Plans and executes shipments. Courier services Uses its own fleet of trucks for transportation. Responsibilities: Initial resource planning. Internal allocation of shipments. Managing transportation logistics from Thessaloniki to Athens. HT (Transport Service Provider) Role: Provides additional transport services. Facilitates part of the shipment route. Responsibilities: Transporting shipments between specific hubs. Handling transfer logistics at their hubs. TRACE Platform Role: ● Provides logistics services and algorithms for optimization. ● Integrates ACS and HT operations. Responsibilities: ● Runs allocation algorithms. ● Calculates ETAs considering various factors. ● Monitors shipments continuously. ● Creates blockchain records and smart contracts. ● Calculates optimal routes. Drivers (ACS and HT) Role:

	• Drive trucks with TRACE integration for monitoring. Responsibilities: • Ensure timely transport and update status via TRACE. • Adhere to optimal routes calculated by TRACE. <u>Warehouse Staff (ACS and HT)</u> Role: • Handle loading and unloading with TRACE integration. Responsibilities: • Propose alternative transport means of the cages. • Ensure shipments are ready as per TRACE schedules. <u>Blockchain Infrastructure Provider</u> Role: • Manages the blockchain for smart contracts and records. Responsibilities: • Ensure secure and accurate recording of transactions. • Maintain interoperability between ACS and HT using the TRACE platform as the intermediate <u>ICT Systems (ACS and HT)</u> Role: • Integration with TRACE for data synchronization. Responsibilities: • Update records based on TRACE data. • Facilitate real-time communication between systems. <u>Sensor Providers</u> Role: • Provide GPS, environmental sensors, and cameras. Responsibilities: • Ensure continuous monitoring of shipment status. • Provide real-time data to TRACE for analysis.
UC goals	**Goals:** • Optimize Resource Utilization

	○ Goal: Reduce the number of trucks used by ACS for shipments by 50%. ○ Expected Result: Reduce by 50% the number of trucks used, supplemented by HT's transportation services. ● Enhance Shipment Allocation ○ Goal: Implement TRACE's algorithm to accurately allocate roller cages to transport means based several parameters. ○ Expected Result: Improved allocation leads to better utilization of space and weight capacity, reducing the number of trips and overall cost. ● Improve Estimated Time of Arrival (ETA) Accuracy ○ Goal: Use TRACE to calculate precise ETAs considering various factors like traffic, hub delays, and scheduling issues. ○ Expected Result: Enhanced reliability and predictability of delivery times, leading to increased customer satisfaction and better planning for downstream operations. ● Integrate Operations of ACS and HT ○ Goal: Seamlessly integrate the operational activities of ACS and HT through TRACE. ○ Expected Result: Smoother handovers and coordination between ACS and HT, reducing delays and operational inefficiencies. ● Continuous Monitoring and Real-Time Updates ○ Goal: Equip roller cages with processing units for continuous monitoring and real-time updates via TRACE. ○ Expected Result: Immediate detection and resolution of issues during transit, maintaining shipment integrity and reducing losses. ● Implement Blockchain for Transparency and Security ○ Goal: Create and manage blockchain records and smart contracts for transactions between ACS and HT.

- Expected Result: Enhanced transparency, security, and trust in the logistics process, with immutable records of transactions and shipment statuses.

- Calculate Optimal Routes
  - Goal: Utilize TRACE to determine the most efficient routes for transporting shipments.
  - Expected Result: Reduced travel time and fuel consumption, lowering operational costs and environmental impact.

- Monitor Environmental and Resource Parameters
  - Goal: Use sensors to monitor environmental conditions (temperature, humidity) and resource status (location, speed) during transit.
  - Expected Result: Ensuring the safety and integrity of sensitive shipments, with proactive measures taken in case of deviations.

- Achieve Cost and Emission Reductions
  - Goal: Lower operational costs and emissions by optimizing logistics operations.
  - Expected Result: Significant reductions in fuel consumption, emissions, and overall operational costs, contributing to sustainability goals.

- Ensure Interoperability and Scalability
  - Goal: Ensure the success of interoperable operations between ACS and HT and enable scalability for future expansions.
  - Expected Result: High success rate of integrated operations and the capability to scale the solution to other routes or partners.

Expected Results:

- Resource Utilization
  - 50% reduction in the number of trucks used.

	● More efficient use of transportation resources. ● Shipment Allocation ○ Improved space and weight utilization in roller cages. ○ Fewer trips needed to transport the same amount of goods. ● ETA Accuracy ○ Reliable and predictable delivery times. ○ Better planning and coordination with customers and downstream processes. ● Operational Integration ○ Seamless coordination between ACS and HT. ○ Reduced delays and increased efficiency in handovers. ● Continuous Monitoring ○ Real-time tracking and updates on shipment status. ○ Quick identification and resolution of issues in transit. ● Blockchain Transparency ○ Secure and transparent transaction records. ○ Increased trust between ACS and HT and with customers. ● Optimal Routes ○ Reduced travel time and fuel consumption. ○ Lower operational costs and environmental impact. ● Environmental Monitoring ○ Safe transportation of sensitive shipments. ○ Proactive measures taken to maintain shipment integrity. ● Cost and Emission Reductions ○ ~50% reduction in fuel consumption and emissions. ○ ~50% reduction in operational costs.

	• Interoperability and Scalability
	  ○ High success rate of interoperable operations.
	  ○ Capability to expand the solution to other routes and partners.

Pre-TRACE UC	In the baseline scenario before the introduction of the TRACE project, the logistics operations between ACS and HT for transporting shipments from Thessaloniki to Athens were less integrated and optimized. Here is a detailed description of how the process took place:
	
	1. Initial Planning and Scheduling
	• ACS (Courier Service):
	  ○ ACS independently plans and schedules the shipments.
	  ○ Uses of trucks for transporting shipments from Thessaloniki to Athens.
	  ○ Allocates shipments to roller cages based on internal operations and experience.
	
	2. Resource Allocation
	• ACS:
	  ○ Allocates shipments to roller cages without advanced optimization algorithms.
	  ○ Determines the weight and volume manually or using basic internal tools.
	
	3. Transportation Execution
	• ACS:
	  ○ Trucks are loaded with roller cages at the ACS warehouse in Thessaloniki.
	  ○ Drivers are provided with a fixed route to Athens.
	  ○ Trucks travel directly to Athens, facing potential traffic and delays without real-time route optimization.
	• HT (Transport Service Provider):
	  ○ ACS can use HT services to reduce the amount of trucks used for daily operations
	  ○ HT operates independently with minimal coordination with ACS.

	4. Monitoring and Tracking ● ACS: ○ Limited monitoring infrastructure. ○ No specialised tracking devices are used ○ No real-time updates on shipment status. **5. Hub Operations** ● ACS and HT: ○ Handling of roller cages and shipments at hubs is done manually. ○ Transfer times and waiting times are not optimized. ○ Minimal coordination between ACS and HT for handling shipments. **6. Delivery and Last Mile** ● ACS: ○ Upon arrival in Athens, ACS handles further destinations and last mile delivery from their Athens hub to the end customers. ○ Last mile delivery schedules are finalised upon the shipments' arrival at the local ACS stores. No dynamic routing is applied **7. Operational Challenges** ● Inefficiencies: ○ Increased operational costs from using more trucks and manual processes by LSPs. ○ Delays due to traffic and lack of real-time adjustments. ○ Limited visibility and real-time tracking of shipments leading to potential delays. ○ Also, particular shipments cannot be located in cases of emergency. ● Environmental Impact: ○ Emissions ○ No systematic approach to reducing carbon footprint. **8. Communication and Coordination** ● Between ACS and HT: ○ Communication is limited to basic coordination for transport needs.

	○ No integrated systems or platforms to streamline operations and data sharing. **9. Customer Satisfaction** ● Issues: ○ Limited real-time tracking information available to customers. **<u>Summary of Pre-TRACE UC:</u>** In the pre-TRACE baseline scenario, the logistics operations were characterized by: • Lack of Optimization: Shipments were allocated and transported based on manual planning without advanced optimization algorithms. • Limited Integration: ACS and HT operated independently with minimal coordination, leading to inefficiencies. • Minimal Monitoring: Tracking and monitoring of shipments were limited, with no real-time updates or adjustments. • Higher Operational Costs and Environmental Impact: Inefficient use of resources and routes resulted in higher costs and emissions. • Customer Dissatisfaction: Unpredictable delivery times and limited tracking information negatively impacted customer satisfaction. • Manual Delivery System: Before the TRACE project, the last mile delivery to the NKUA campus was conducted by human couriers. • Traditional Vehicles: Deliveries were made using traditional fuel-powered vehicles, such as vans or motorbikes. • Centralized Drop-off Points: Couriers would deliver parcels to centralized locations within the campus where recipients would collect their items. • Limited Real-Time Tracking: Tracking of parcels was limited, often relying on manual updates and customer inquiries. • Higher Human Involvement: Significant human labor was required for loading, unloading, and delivering parcels.

Problems of the status pre-TRACE	1. Inefficient Resource Utilization ➔ Problem: ACS uses its own trucks for transporting shipments between Thessaloniki and Athens, Motivation: Reduce the number of trucks required and improve overall resource utilization. 2. Suboptimal Shipment Allocation ➔ Inefficient allocation of roller cages to transportation means ➔ Motivation: Implement advanced algorithms for optimal allocation of roller cages to improve efficiency. 3. Limited Operational Integration ➔ Problem: ACS and HT operated independently with minimal coordination, leading to inefficiencies and delays in the logistics process. ➔ Motivation: Seamlessly integrate the operations of ACS and HT to streamline handovers and improve overall efficiency. 4. Lack of Real-Time Monitoring ➔ Problem: Limited monitoring capabilities and manual tracking led to a lack of real-time updates on shipment status. ➔ Motivation: Equip roller cages with processing units for continuous monitoring and real-time updates to quickly detect and resolve issues during transit. 5. Manual and Time-Consuming Hub Operations ➔ Problem: Handling of roller cages and shipments at hubs was done manually, resulting in longer transfer and waiting times. ➔ Motivation: Optimize hub operations to reduce transfer times and improve efficiency. 6. Non-Optimized Routes

	➔ Problem: Drivers followed fixed routes without real-time optimization, leading to higher fuel consumption and increased travel time due to traffic. ➔ Motivation: Use TRACE to calculate and update optimal routes in real-time, reducing fuel consumption and travel time. 8. High Operational Costs ➔ Problem: Inefficient logistics operations resulted in higher fuel consumption, increased operational costs, and resource wastage. ➔ Motivation: Lower operational costs through optimized resource utilization, route planning, and shipment allocation. 9. Environmental Impact ➔ Problem: Higher emissions due to inefficient logistics operations, contributing to environmental pollution. ➔ Motivation: Reduce carbon footprint and environmental impact by optimizing logistics operations and reducing fuel consumption. 10. Limited Communication and Coordination ➔ Problem: Minimal integration and communication between ACS and HT, leading to coordination challenges and inefficiencies. ➔ Motivation: Improve communication and coordination through integrated systems and real-time data sharing. 11. Customer Dissatisfaction ➔ Problem: Limited tracking information led to customer dissatisfaction and potential loss of business.

	➔ Motivation: Enhance customer satisfaction by providing real-time tracking information. **Motivations for Change** The primary motivations for adopting TRACE and changing the pre-TRACE situation include: ● Efficiency: Achieve higher efficiency in logistics operations through optimized resource utilization, shipment allocation, and route planning. ● Cost Reduction: Significantly reduce operational costs by improving logistics processes and reducing resource wastage. ● Integration: Seamlessly integrate operations between ACS and HT to streamline processes and reduce delays. ● Sustainability: Lower the environmental impact of logistics operations by reducing fuel consumption and emissions. ● Real-Time Monitoring: Implement continuous monitoring and real-time updates to ensure the safety and integrity of shipments. ● Improved Coordination: Enhance communication and coordination between ACS and HT through integrated systems and data sharing. Unmanned Vehicles/Last mile Delivery ❖ Identified Problems: • Inefficiency: Manual deliveries were time-consuming and prone to delays due to traffic, human error, and inefficient routing. • High Operational Costs: The reliance on traditional fuel-powered vehicles resulted in high fuel costs and maintenance expenses. • Environmental Impact: Fuel-powered vehicles contributed to higher emissions, negatively impacting the environment. • Limited Tracking: Lack of real-time tracking led to uncertainties about parcel locations and delivery times. • Human Resource Constraints: High dependence on human labour increased the potential for errors and was not scalable.

	❖ Motivations for Change: • Efficiency Improvement: Automating deliveries with autonomous vehicles aimed to streamline the process, reduce delays, and improve delivery times. • Cost Reduction: Transitioning to electric autonomous vehicles promised lower operational costs through reduced fuel consumption and maintenance. • Environmental Benefits: Reducing emissions by using electric vehicles aligned with sustainability goals. • Enhanced Tracking: Implementing real-time tracking systems would provide better transparency and reliability for customers. • Scalability: Reducing dependency on human labor would allow the delivery system to scale more effectively with growing demand.
Measurement of the baseline scenario	To measure the baseline scenario, which represents the current state of operations before the implementation of TRACE, we need to collect data on various key performance indicators (KPIs) and operational metrics. These measurements will serve as a benchmark for comparison with the post-TRACE state to assess the effectiveness of the implementation. Here's how we intend to measure the baseline scenario: Key Performance Indicators (KPIs) for Baseline Measurement: **Resource Utilization:** • Measure the number of trucks used for shipments. • Track the utilization rate of trucks (volume and weight capacity). **Shipment Allocation:** • Assess the average space and weight utilization per roller cage. • Record the number of trips required to transport a given volume of shipments.

	ETA Calculation Accuracy: ● Evaluate the accuracy of estimated time of arrival (ETA) predictions. ● Monitor the on-time delivery rate of shipments. **Operational Integration:** ● Measure the coordination efficiency between ACS and HT. ● Record the frequency and duration of delays due to coordination issues. **Real-Time Monitoring:** ● Assess the availability and accuracy of real-time monitoring data. ● Measure the response time to address issues detected in real-time. **Hub Operations Efficiency:** ● Measure the handling time at hubs. ● Evaluate the efficiency of hub operations by tracking throughput. **Route Optimization:** ● Assess the efficiency of existing routes in terms of distance and time. ● Monitor fuel consumption per route to identify inefficiencies. **Operational Costs:** ● Calculate total operational costs, including fuel, labor, and maintenance. ● Determine the average cost per shipment.

	Environmental Impact: ● Measure carbon emissions per trip. ● Track fuel efficiency to assess environmental impact. **Communication and Coordination:** ● Evaluate the effectiveness of communication channels between ACS and HT. ● Record instances of coordination issues and delays. <u>Data Collection Methods:</u> **Internal Systems:** ● Retrieve data from ACS and HT's internal systems, including logistics management software, fleet management systems, and operational databases. **Surveys and Interviews:** ● Conduct surveys and interviews with key personnel to gather qualitative insights on operational challenges and pain points. **Observations:** ● Observe daily operations at hubs and during transportation to identify inefficiencies and bottlenecks. **Document Analysis:** ● Review existing documentation, such as operational reports, schedules, and performance metrics, to gather historical data on operations.

	Technology Assessment: ● Evaluate the effectiveness of existing technology solutions, such as tracking systems and communication tools, in supporting operations. Unmanned Vehicles/Last Mile Delivery ● Average Delivery Time: Measure the time taken from dispatch to delivery for each parcel. ● Operational Costs: Calculate total costs including fuel, vehicle maintenance, and labor. ● Fuel Consumption: Track the amount of fuel consumed per delivery. ● Emission Levels: Measure emissions produced by delivery vehicles. ● Customer Satisfaction: Conduct surveys to gauge customer satisfaction with the delivery service. ● Delivery Accuracy: Record the number of deliveries made accurately and on time.
Post-TRACE UC	**Step 1: Initial Planning and Resource Request** ACS Planning: ● ACS plans the shipment schedule but now leverages TRACE's advanced algorithms. ● Instead of multiple trucks, ACS aims to use only 50% of trucks, reducing resource usage by 50%. Resource Request: ● ACS requests available resources and defines the routes, along with the number of roller cages per route. ● TRACE assists in identifying optimal resources based on real-time data and past performance. **Step 2: Shipment Allocation and ETA Calculation** Internal Allocation: ● ACS defines the weight and volume of each roller cage through an internal operation. TRACE Optimization:

	• TRACE runs sophisticated algorithms to finalize the allocation for each roller cage, optimizing space and weight utilization. **Step 3: Integration and Approval** Operational Integration: • TRACE partially integrates the operations of ACS and HT, facilitating seamless coordination. Schedule Approval: • ACS reviews and approves the optimized schedule provided by TRACE. • ACS sends the IDs (barcodes, QR codes) of the roller cages to TRACE. **Step 4: Continuous Monitoring and Blockchain Recording** Equipping Roller Cages: • Roller cages are equipped with processing units for continuous monitoring, providing real-time data on location, status, and environmental conditions. Blockchain Records: • TRACE creates blockchain records and delivers smart contracts between ACS and HT, ensuring transparency and security. • The blockchain records are based on combined IDs from ACS and HT. **Step 5: Optimal Route Calculation** Route Optimization: • TRACE calculates the optimal route for ACS trucks to transfer the selected shipments to the HT hub. • Routes are optimized in real-time based on traffic conditions, roadwork, and other dynamic factors. **Step 6: Transfer and Monitoring** ACS to HT Hub Transfer: • ACS trucks follow the optimized routes to the HT hub.

	• TRACE continuously monitors the transfer, updating the status and providing real-time alerts if deviations occur. HT Transportation: • HT receives the shipments at the hub and transfers them to the Thriasio hub in Athens. • TRACE monitors the HT transportation phase as well, ensuring smooth operations and timely transfers. **Step 7: Final Delivery** ACS Final Delivery: • Upon arrival at HT's Athens hub, ACS takes over the shipments. • TRACE provides the final optimized routes for ACS to deliver the shipments to their final destinations. Real-Time Monitoring: • TRACE continues to monitor the shipments until they reach the end customers, ensuring any issues are promptly addressed. • Autonomous Vehicle Integration: Use autonomous ground vehicles and drones for the last mile delivery within the NKUA campus. • Designated City Corridors and Exchange Areas: Establish specific routes and safe exchange areas for efficient and secure parcel transfer. • Real-Time Monitoring and Management: Utilize the TRACE system for real-time tracking, route optimization, and monitoring of deliveries. • Human Supervision at Critical Points: Human supervisors will assist in the safe loading and unloading of parcels at exchange areas. • End-to-End Automation: Automate the delivery process from parcel handover at the exchange area to final delivery to the customer.
GAP between pre and post TRACE	To transition from the pre-TRACE to the post-TRACE state, several necessary measures need to be implemented. These measures address the identified problems and bridge the gap between the current inefficiencies and the desired optimized state.

	1. Inefficient Resource Utilization **Problem:** ACS uses a high number of trucks for transporting shipments, leading to inefficient resource use. **Measures:** ● Resource Optimization Algorithms: Implement TRACE algorithms to optimize the number of trucks required for transportation. ● Real-Time Resource Management: Use TRACE for real-time tracking and allocation of resources, ensuring efficient utilization of trucks. 2. Suboptimal Shipment Allocation **Problem:** Manual allocation of shipments to roller cages leads to poor utilization of space and weight. **Measures:** ● Advanced Allocation Algorithms: Integrate TRACE algorithms to allocate shipments to roller cages based on weight and volume, maximizing space and weight utilization. ● Automated Systems: Implement automated systems for shipment allocation, reducing human error and inefficiencies. 3. Inaccurate ETA Calculation **Problem:** Delivery times are unpredictable due to a lack of advanced ETA calculations. **Measures:** ● ETA Prediction Algorithms: Use TRACE to calculate ETAs by considering traffic, hub delays, and other scheduling constraints. ● Data Integration: Integrate real-time traffic data and historical patterns into the TRACE platform for accurate ETA predictions. 4. Limited Operational Integration

	Problem: ACS and HT operate independently with minimal coordination, leading to inefficiencies. **Measures:** ● Platform Integration: Use TRACE to integrate ACS and HT operations, enabling seamless data sharing and coordination. ● Unified ICT Systems: Develop and integrate ICT systems for real-time communication and operational coordination between ACS and HT. 5. Lack of Real-Time Monitoring **Problem:** Limited monitoring capabilities and manual tracking lead to a lack of real-time updates. **Measures:** ● Equipping Roller Cages with Sensors: Install processing units with GPS, temperature, and humidity sensors on roller cages for continuous monitoring. ● TRACE Monitoring Platform: Implement TRACE to provide real-time updates and alerts on shipment status, location, and environmental conditions. 6. Manual and Time-Consuming Hub Operations **Problem:** Manual handling at hubs results in longer transfer and waiting times. **Measures:** ● Automated Hub Operations: Use TRACE to automate and optimize the handling of roller cages and shipments at hubs. ● Optimized Transfer Processes: Implement streamlined processes for transferring and handling shipments at hubs, reducing waiting times. 7. Non-Optimized Routes **Problem:** Fixed routes without real-time optimization lead to higher fuel consumption and

increased travel time.

Measures:

- Dynamic Route Optimization: Use TRACE to calculate and update optimal routes in real-time based on current traffic conditions and other dynamic factors.
- Real-Time Navigation: Provide drivers with real-time navigation updates through TRACE to avoid delays and reduce travel time.

8. High Operational Costs

Problem: Inefficient logistics operations result in higher fuel consumption, increased operational costs, and resource wastage.

Measures:

- Cost Reduction Strategies: Implement TRACE's optimization algorithms to reduce fuel consumption and operational costs.
- Efficiency Improvements: Streamline logistics processes to reduce resource wastage and improve overall efficiency.

9. Environmental Impact

Problem: Higher emissions due to inefficient logistics operations.

Measures:

- Emission Reduction Initiatives: Use TRACE to optimize routes and reduce the number of trips, lowering emissions.
- Sustainability Goals: Implement sustainability practices and monitor environmental impact through TRACE's reporting tools.

10. Limited Communication and Coordination

	Problem: Minimal integration and communication between ACS and HT, leading to coordination challenges. **Measures:** • Integrated Communication Systems: Develop integrated communication systems through TRACE for real-time data sharing and coordination. • Collaborative Platforms: Use TRACE to create a collaborative platform for ACS and HT, ensuring smooth and efficient communication. 11. Customer Dissatisfaction **Problem:** Unpredictable delivery times and limited tracking information lead to customer dissatisfaction. **Measures:** • Reliable Delivery Times: Use TRACE's accurate ETA predictions to provide reliable delivery times to customers. • Real-Time Tracking: Offer customers real-time tracking information through TRACE, enhancing transparency and satisfaction. Unmanned Vehicles/ Last mile delivery • Infrastructure Development: Create dedicated city corridors and secure exchange areas equipped with necessary technology and security. • Vehicle and Sensor Deployment: Equip autonomous vehicles with sensors for collision avoidance, GPS for navigation, and cameras for monitoring. • System Integration: Integrate the TRACE system with existing ICT systems of ACS and other stakeholders for seamless data flow and management. • Training and Supervision: Train human supervisors on the new processes and safety protocols involved in handling autonomous deliveries. • Regulatory Compliance: Ensure that the deployment of autonomous vehicles complies with local regulations and safety standards.
Measurement of these GAPS	1. Inefficient Resource Utilization **Measurement Metrics:** Number of Trucks Used:

	• Pre-TRACE: Track the number of trucks used for shipments (e.g., 4 trucks). • Post-TRACE: Measure the reduction in the number of trucks used (target: 2 trucks). Truck Utilization Rate: • Calculate the percentage of capacity used in each truck (weight and volume). Tools and Methods: • TRACE platform data. • Fleet management system reports. 2. Suboptimal Shipment Allocation **Measurement Metrics:** Space and Weight Utilization: • Pre-TRACE: Measure average space and weight utilization per roller cage. • Post-TRACE: Compare with post-TRACE optimized allocation. Number of Trips Required: • Track the number of trips required to transport the same volume of shipments. Tools and Methods: • Shipment allocation reports. • TRACE optimization algorithms output. 3. Inaccurate ETA Calculation **Measurement Metrics:** ETA Accuracy: • Compare predicted ETA with actual arrival times (pre-TRACE vs. post-TRACE). On-Time Delivery Rate: • Measure the percentage of shipments delivered on time. Tools and Methods:

	• TRACE platform's ETA calculations. • Delivery tracking data. <u>4. Limited Operational Integration</u> **Measurement Metrics:** Coordination Efficiency: • Measure the time taken for handovers between ACS and HT. Operational Delays: • Track the frequency and duration of delays due to coordination issues. Tools and Methods: • Integrated ICT system logs. • TRACE coordination data. <u>5. Lack of Real-Time Monitoring</u> **Measurement Metrics:** Real-Time Data Availability: • Measure the percentage of shipments with real-time monitoring data available. Response Time to Issues: • Track the time taken to respond to and resolve issues detected in real-time. Tools and Methods: • Data from sensors and processing units on roller cages. • TRACE monitoring platform. <u>6. Manual and Time-Consuming Hub Operations</u> **Measurement Metrics:** Handling Time at Hubs: • Measure the average time taken to handle and transfer shipments at hubs. Hub Efficiency: • Calculate the throughput of shipments through the hubs. Tools and Methods:

	● Hub operation reports. ● TRACE optimization data. 7. Non-Optimized Routes **Measurement Metrics:** Route Efficiency: ● Measure the average distance and time taken per route (pre-TRACE vs. post-TRACE). Fuel Consumption: ● Track fuel consumption per route. Tools and Methods: ● GPS and routing data. ● Fuel consumption reports from fleet management. 8. High Operational Costs **Measurement Metrics:** Total Operational Costs: ● Compare total costs incurred in logistics operations (fuel, labor, maintenance). Cost per Shipment: ● Calculate the average cost per shipment. 9. Environmental Impact **Measurement Metrics:** Emissions: ● Measure CO_2 emissions per trip. Fuel Efficiency: ● Track fuel efficiency (miles per gallon or liters per 100 km). Tools and Methods: ● Emission tracking tools. ● Fuel consumption data from TRACE. 10. Limited Communication and Coordination

	Measurement Metrics: Communication Response Time: ● Measure the time taken for communication between ACS and HT. Coordination Issues: ● Track the number of coordination-related issues and delays. Tools and Methods: ● Integrated communication system logs. ● TRACE coordination data. <u>11. Customer Dissatisfaction</u> **Measurement Metrics:** Customer Feedback: ● Collect and analyze customer satisfaction surveys. Delivery Time Reliability: ● Measure the consistency of delivery times. Tracking Information Availability: ● Track the availability and accuracy of real-time tracking information for customers. Tools and Methods: ● Customer surveys and feedback tools. ● TRACE customer service integration. ● Overall Monitoring and Continuous Improvement **<u>Performance Dashboards:</u>** ● Implement performance dashboards in the TRACE platform to monitor key metrics in real-time. ● Use visualizations to track progress towards goals and identify areas needing improvement. **<u>Regular Audits and Reviews:</u>** ● Conduct regular audits and performance reviews to assess the effectiveness of the measures. ● Adjust strategies and processes based on findings and continuous feedback. **<u>KPIs for Success:</u>** ● Define clear KPIs to measure success, such as fuel consumption reduction, on-time delivery rate,

	customer satisfaction scores, and operational cost savings. ● Regularly report on these KPIs to stakeholders and use them to drive continuous improvement. 12. Unmanned Vehicles / Last mile delivery ● Pre- and Post-Implementation Comparison: Compare key metrics such as delivery time, operational costs, fuel consumption, emissions, and customer satisfaction before and after the TRACE project. ● Pilot Testing: Conduct pilot tests to identify any operational gaps or issues in the new system and make necessary adjustments. ● Continuous Monitoring: Use real-time data from the TRACE system to continuously monitor performance and address any deviations promptly. ● Customer Feedback: Regularly gather feedback from customers to identify areas for improvement and ensure the new system meets their expectations.

Action plan to overcome these GAPS	The transition from the pre-TRACE state to the post-TRACE state requires a structured and detailed action plan. This plan outlines the implementation phases, necessary resources, and key activities to ensure a successful transformation.
	
	Phase 1: Planning and Preparation
	Objectives:
	● Establish a clear roadmap for the TRACE implementation.
	● Identify and allocate necessary resources.
	● Ensure stakeholder alignment and commitment.
	
	Key Activities:
	❖ Project Kickoff:
	    ● Define project scope and objectives.
	    ● Formulate a project team including key stakeholders from ACS, HT, and TRACE.
	❖ Resource Allocation:
	    ● Allocate budget for TRACE implementation.
	    ● Identify and procure necessary hardware (sensors, processing units).
	    ● Assign internal resources (IT staff, logistics managers).
	❖ Stakeholder Engagement:

	● Conduct workshops to align stakeholders on project goals and benefits. ● Communicate the implementation plan and timelines. ❖ Baseline Data Collection: ● Collect pre-TRACE operational data for benchmarking. ❖ Necessary Resources: ● Project management team. ● Budget for hardware and software. ● Internal and external stakeholders. **Phase 2: System Integration and Technology Deployment** Objectives: ● Integrate TRACE systems with existing ACS and HT systems. ● Deploy necessary hardware and software. Key Activities: ❖ ICT Systems Integration: ● Integrate TRACE platform with ACS and HT ICT systems for seamless data exchange. ● Ensure interoperability of different systems and databases. ❖ Hardware Deployment: ● Install sensors (GPS, temperature, humidity) and processing units on roller cages. ● Set up real-time monitoring infrastructure. ❖ Blockchain Implementation: ● Implement blockchain infrastructure for secure and transparent transactions. ● Create smart contracts between ACS and HT. ❖ Training: ● Conduct training sessions for ACS and HT staff on using TRACE systems and hardware. ❖ Necessary Resources: ● IT integration specialists. ● Sensors and processing units. ● Blockchain developers. ● Training materials and facilitators. **Phase 3: Optimization and Automation** Objectives:

	● Optimize shipment allocation and route planning using TRACE algorithms. ● Automate key processes to improve efficiency. Key Activities: ❖ Algorithm Deployment: ● Implement TRACE algorithms for shipment allocation and route optimization. ● Test and refine algorithms to ensure optimal performance. ❖ Automation of Hub Operations: ● Automate handling and transfer processes at hubs using TRACE. ● Reduce manual intervention to decrease waiting times and errors. ❖ Real-Time Monitoring: ● Enable continuous monitoring of shipments using TRACE platform. ● Set up alerts and notifications for real-time issue resolution. ❖ Necessary Resources: ● Data scientists and algorithm developers. ● Automation tools and software. ● Real-time monitoring and alert systems. **Phase 4: Continuous Improvement and Performance Monitoring** Objectives: ● Monitor performance metrics to ensure continuous improvement. ● Address any issues and refine processes as needed. Key Activities: ❖ Performance Dashboards: ● Implement performance dashboards to track key metrics such as ETA accuracy, resource utilization, and customer satisfaction. ● Use visualizations to provide real-time insights. ❖ Regular Audits and Reviews: ● Conduct regular audits to assess the effectiveness of TRACE implementation. ● Review performance data and identify areas for improvement.

- Feedback Loops:
  - Establish feedback loops with drivers, hub operators, and customers.
  - Use feedback to refine algorithms and processes continuously.
- KPI Tracking:
  - Define and track KPIs for success, such as fuel consumption reduction, operational cost savings, and emission reductions.
- Necessary Resources:
  - Data analytics tools.
  - Performance management team.
  - Feedback collection and analysis systems.

Phase 5: Full Deployment and Scaling

Objectives:

- Fully deploy TRACE across all operations.
- Scale the solution to cover all relevant routes and hubs.

Key Activities:

- Full-Scale Deployment:
  - Roll out TRACE to all ACS and HT operations.
  - Ensure all shipments and routes are managed through TRACE.
- Scaling Up:
  - Expand the use of TRACE to additional routes and hubs as needed.
  - Continuously monitor and optimize operations.
- Sustainability Initiatives:
  - Implement measures to reduce the environmental impact, such as route optimization and reduced emissions.
  - Monitor and report on sustainability goals.
- Necessary Resources:
  - Full deployment team.
  - Continuous support and maintenance resources.
  - Sustainability monitoring tools.

Summary of Necessary Resources

Human Resources:

	• Project managers, IT specialists, data scientists, blockchain developers, trainers, and performance analysts. Technological Resources: • TRACE platform, sensors (GPS, temperature, humidity), processing units, real-time monitoring systems, and blockchain infrastructure. Financial Resources: • Budget for hardware, software, training, and ongoing support. Operational Resources: • Training materials, feedback collection systems, and performance dashboards.
Timeline	Please specify the timeline that you have foreseen to implement your UC

Phase	Month	Key Activities	Milestones
Phase 1: Planning and Preparation	5-16	Project kickoff, resource allocation, baseline data collection	Project team formation baseline data.
Phase 2: System Integration and Technology Deployment	17-22	Systems integration, hardware deployment, staff training	Successful integration, initial training.
Phase 3: Optimization and Automation	23-27	Algorithm implementation, automation, real time monitoring	Optimization algortithms, automation

	Phase 4: Continuous Improvement and Performance Monitoring	28-36	Performance monitoring feedback loops, audits	Performance dashboards, KPI tracking
	Phase 5: Full Deployment and Scaling	28-36	Full deployment, scaling, sustainability initiatives	Full-scale deployment, sustainability

Italian Pilots

Pilot A

UC partners & actors	Please provide a complete list of all the partners and actors involved in your UC, specifying their roles in detail. If there are any differences between the pre and post TRACE actors and partners, please specify it. The key actors of the Drone UC in Modena (case A) are: - **ITL Foundation:** UC scientific coordinator and expert in the urban logistic aspects; - **DiFly:** Drone Provider and Demo Leader of Use case A; - **Modena Municipality:** Political support to Modena test activities (letter of support collected); - **UNIMORE**: Italian UCs coordinator in the TRACE project and responsible for the simulation aspects; - **Policlinico di Modena hospital**: Interested in testing the transport of emergency medical materials in Modena using also drones (letter of support collected); - **Emilia-Romagna Region:** Regional authority with interest on developing innovative solutions for more sustainable urban logistic. Moreover, it is interested in the promotion of drones as sustainable logistic solutions.
UC goals	Please specify in detail the goals and the expected results of your UC The key UC goals are: - Feasibility analysis of urban/peri-urban logistic fast/urgent freight deliveries integrating a drone; - Test the potential integration of drone deliveries with other innovative logistic urban solutions (for example autonomous bikes foreseen in the Italian case b);

	- Define new models for optimized planning decisions based on time constraints (fast/urgent vs regular deliveries).
Pre-TRACE UC	How the process of your UC took place before the innovations introduced within the TRACE project (baseline scenario) Pre-TRACE urban delivery of fast/urgent/ freight encounters many limitations and problems as nowadays they are generally conducted with traditional vans. These vans often, considering the urgency/last minute aspects, are usually empty/not optimised and they are affected by the congestion during peak hours. In cases of fast/urgent deliveries in the medical sector for example, the delays in the delivery of medical supplies can lead to delayed surgery operations and other risks related to the safeguarding of human life. In general, fast/urgent deliveries during peak hours represent a problem for logistic operators and the traditional vans used for these operations are not optimized in terms of load factor and routing optimization.
Problems of the status pre-TRACE	Please list all the problems found in your UC pre-TRACE. Which are the motivations that push you to change the situation before TRACE? The key problems in the pre-TRACE context are related to: - Drone deliveries did not exist as a regular service. At the Italian level, freight deliveries conducted using drones were close to zero. - Limited tests with drones were conducted in different Italian cities. Some tests were related to the transport of medical supplies.

	- There are big "no-fly zones" covering large part of the urban areas. - Obtain flight authorization from the Italian National Aviation Regulator (ENAC) on an effective drone flight requires long times and it is particularly difficult (mainly if the drone flight is foreseen in an urban area). Nevertheless, there is a growing attention to the potential contribution drones can provide in managing emergency deliveries and/or substituting high-value freight deliveries affected by strict times of delivery.
Measurement of the baseline scenario	How do you intend to measure the baseline scenario? Key indicators for the baseline scenario: - **Number of used vehicles**: How many traditional motor vehicles is it possible to substitute with a drone? - **Delivery Time:** Measure the time taken to deliver an urgent parcel from one point to its destination. - **Operational Costs:** Calculate the total operational costs associated with urgent parcel delivery, including labour, fuel (if applicable), etc. - **Key Stakeholders Satisfaction:** Gather feedback from key stakeholders involved (hospital, etc.) regarding the reliability, speed, and quality of deliveries. - **Route Efficiency:** Analyze the routes taken by operators to identify any inefficiencies or suboptimal paths. - **Error Rate:** Track the occurrence of delivery errors or failed deliveries.
Post-TRACE UC	Please describe in detail how you foresee the process of your UC after the innovations introduced with the TRACE project Post TRACE delivery process can be summarized as follows: - An urgent/fast delivery is needed. The interested stakeholder (a hospital for example) imputed the request in the TRACE platform;

	- The TRACE platform, considering the available different logistic solutions and the drone no-flight zones, elaborates a delivery plan (delivery in 1 or 2 hours); - The TRACE platform confirms the delivery to the final user (another hospital for example) and to the drone operator (DiFly). The TRACE platform combines different logistic solutions (drone in the sub-urban areas and a cargo bike where the drone can't fly) and create an optimized route; - The drone, provided with a dedicated protected capsule, is charged by a trained person with the urgent freight to be delivered. Once the capsule is closed, Difly is in charge of managing the drone flight. - Once reached a no-flight zone, the drone lands at a predefined point and the capsule are uploaded on a cargo bike which will manage the last-mile delivery in due time. In this way, it is possible to avoid the utilization of a traditional van for the transport of only one item (in the case of medical freight of an ambulance).
GAP between pre and post TRACE	Please describe carefully what are the necessary measures to solve the identified problems and get to the ideal post TRACE state of your UC The key gap is related to the integration of drone(s) into existing and planned urban/peri-urban logistic operations (in particular urgent deliveries). In the post-TRACE, thanks to the new synchromodality platform, it will be possible to identify the conditions in which a drone can be used to improve freight delivery effectiveness in different contexts. Necessary measures to solve the identified problems are: - **Gap 1.** Suboptimal Route Planning/Better integration among drones and cargo bikes. - **Gap 2.** Better logistic data management (demand and offer).

	- **Gap 3.** Better simulation tools in order to understand the key requirements for full drone utilization in urban logistics; - **Gap 4.** Lack of drones equipped in the right way for emergency/urgent deliveries. - **Gap 5.** Insufficient Monitoring and Improvement.
Measurement of these GAPS	How do you intend to measure these GAPS? As defined in the AF: - **Reduce time to delivery (-30-40%)** - **Reduce vans empty travel (-30-40%)** - Average energy reduction: -50% - Average fuel consumption reduction: -50% - Average emission reduction: -50% - Operational costs reduction: -50% - Blockchain Block throughput: >10-20 operations/node/sec - Success of interoperable operations: 100% - Means of transport combined: 2
Action plan to overcome these GAPS	Please list in detail the implementation phases of your UC including all the necessary resources Action plan in relation to the main gaps: - **Gap1.** TRACE outcoming scheduler is used to achieve advanced route planning algorithms considering various factors. Integrate route planning software with operational systems. Establish centralized decision-making processes for dynamic route optimization. Train decision-makers on interpreting real-time data and optimizing routes accordingly. - **Gap2.** Integrate real-time data streams for dynamic decision-making. Provide training for decision-makers on using real-time data to optimize routes. - **Gap3.** TRACE outcoming scheduler is used to achieve advanced route planning algorithms considering various factors.

	- **Gap4.** Develop drones with adapted freight boxes. - **Gap5.** Implement monitoring systems to track key performance indicators (KPIs). Analyze KPI data regularly to identify areas for improvement. Establish feedback mechanisms for operators to provide input on delivery performance.
Timeline	Please specify the timeline that you have foreseen to implement your UC Part (a) Drone + Box [Difly]: - Operation activities plan + Flight requests issue - 04/24 - 10/24 - First test – 04/25 - Technology Box deploy - 04/24 - 11/24 - Technology and integration with MASA - 04/24 - 04/25 - R&D: drone-to-bike communication [CSEM] - 10/24 - 06/25

Pilot B

UC partners & actors	Please provide a complete list of all the partners and actors involved in your UC, specifying their roles in detail. If there are any differences between the pre and post TRACE actors and partners, please specify it. UNIMORE [Demo leader of Use Case B] URBICO [Logistic Partner involved as a UseCase as a Logistic for Last Delivery Mile with Cargo Bikes] OLV [bicycle manufacturer that create the Autonomous Cargo Bike] DIFLY [Drone Provider and Demo Leader of Use case A]
UC goals	Scenario B Goals: Implementation of autonomous bikes (previously non-existent). Autonomous bikes capable of platooning, able to carry loads that previously required multiple bikes and operators (previously, URBICO had its employees return to the warehouse at least 3 times a day).

	Optimized planning decisions based on time and cost (previously, delivery plans were autonomously decided by operators).
Pre-TRACE UC	Before the innovations introduced within the TRACE project (baseline scenario), the process of our Use Case unfolded as follows: Autonomous guides did not exist previously; each bike required operator guidance. Each operator had to return multiple times to the main HUB to recharge parcels for delivery. In certain conditions, operators found it challenging to deliver parcels in specific hilly areas due to the weight of the parcels. Delivery operators independently decided on the route to take to deliver the daily parcels via bike.
Problems of the status pre-TRACE	Here are the problems identified in our Use Case pre-TRACE: Lack of autonomous cargo bike vehicle: Operators had to manually guide each bike, which was inefficient and time-consuming. Inefficient parcel reloading: Operators had to return multiple times to the main HUB to reload parcels for delivery, leading to wasted time and resources. Difficulty in hilly areas: Operators faced challenges delivering parcels in certain hilly zones due to the weight of the parcels, impacting delivery efficiency. Lack of optimized route planning: Operators independently decided on delivery routes, which may not have been the most efficient or cost-effective. The motivations that drove us to change the situation before TRACE include: Efficiency: We aimed to streamline operations and improve efficiency by introducing autonomous guides and optimizing route planning. Cost Reduction: By minimizing manual interventions and optimizing delivery routes, we sought to reduce operational costs.

	Improved Delivery Performance: We aimed to enhance delivery performance by addressing challenges such as reloading inefficiencies and difficulties in hilly areas. Customer Satisfaction: Optimizing delivery processes would lead to faster and more reliable deliveries, improving overall customer satisfaction.
Measurement of the baseline scenario	We can use the daily data provided by URBICO in the past in order to have a baseline and then measure: Delivery Time: Measure the time taken to deliver parcels from the main HUB to their destinations. Number of Deliveries per Day: Count the total number of deliveries made by operators within a specified timeframe. Operational Costs: Calculate the total operational costs associated with parcel delivery, including labor, bike maintenance, and fuel (if applicable). Customer Satisfaction: Gather feedback from customers regarding the reliability, speed, and quality of deliveries. Route Efficiency: Analyze the routes taken by operators to identify any inefficiencies or suboptimal paths. Parcel Handling Time: Measure the time taken by operators to come back and reload parcels at the main HUB. Error Rate: Track the occurrence of delivery errors or failed deliveries?
Post-TRACE UC	After the innovations introduced with the TRACE project, we envision a significantly improved process for our Use Case. Here's a detailed description of how we foresee the process unfolding: Implementation of Autonomous Stack and Vehicle capable of handling the AV Software: With the introduction of smart and automated bikes, each bike is now equipped with self-navigation capabilities. This eliminates the need for manual guidance by operators, freeing them to focus on other tasks and increasing overall efficiency and brings more bikes together to increase their transportation capabilities. Parcel Reloading multiple times: The TRACE project introduces a platooning of vehicles. Instead of operators having to return multiple times to reload parcels, this process is now optimized and automated, reducing downtime and increasing productivity.

	Optimized Route Planning: Through advanced algorithms and data analytics, the TRACE project optimizes route planning for parcel delivery. Factors such as parcel weight, delivery location, traffic conditions, and terrain are taken into account to determine the most efficient and cost-effective routes. Adaptation to Terrain Challenges: Autonomous guides are programmed to adapt to various terrain challenges, including hilly areas. They are equipped with sensors and algorithms that enable them to navigate through difficult terrain with ease, ensuring reliable and timely deliveries regardless of the landscape. Centralized Decision-Making: The TRACE project centralizes decision-making for delivery routes, taking into account real-time data and external factors such as weather conditions and traffic patterns. This ensures that routes are dynamically adjusted to optimize delivery efficiency and minimize delays. Continuous Monitoring and Improvement: The TRACE project incorporates monitoring and feedback mechanisms to continuously evaluate and improve the delivery process. Performance metrics are tracked in real-time, allowing for immediate adjustments and optimization of operations. Overall, the innovations introduced with the TRACE project revolutionize our Use Case, making the delivery process more efficient, cost-effective, and reliable. By leveraging advanced technology and data-driven approaches, we are able to meet customer expectations more effectively and adapt to changing market dynamics.
GAP between pre and post TRACE	Gap 1: Lack of Autonomous Cargo Bikes (Pre-TRACE): Measure: Implementation of Autonomous vehicle (Cargo Bikes) and Autonomous SW Stack. Actions: Develop cargo bike with sensors and actuator to have an autonomous vehicle. Develop or integrate navigation software for autonomous operation. Gap 2: Inefficient Parcel Reloading/Operation (Pre-TRACE): Measure: Parcel Reloading. Actions: Based on a Platooning scenario that can be splitted and merged in different intersection points, the parcels are already loaded and carried once on different cargo bikes during the beginning of the delivery phase.

	Gap 3: Suboptimal Route Planning (Pre-TRACE): Actions: TRACE outcoming scheduler is used to achieve an advanced route planning algorithms considering various factors. Integrate route planning software with operational systems. Establish centralized decision-making processes for dynamic route optimization. Train decision-makers on interpreting real-time data and optimizing routes accordingly. Gap 4: Lack of Centralized Decision-Making (Pre-TRACE): Actions: TRACE establish centralized decision-making processes for route optimization. Integrate real-time data streams for dynamic decision-making. Provide training for decision-makers on using real-time data to optimize routes. Gap 5: Insufficient Monitoring and Improvement (Pre-TRACE): Actions Implement monitoring systems to track key performance indicators (KPIs). Analyze KPI data regularly to identify areas for improvement. [Establish feedback mechanisms for operators and customers to provide input on delivery performance?]
Measurement of these GAPS	How do you intend to measure these GAPS? With targeted KPIs: a. Average energy reduction -50% b. Average fuel consumption reduction -50% c. Average emission reduction -50% d. Operational costs reduction -50% e. Blockchain Block throughput >10-20 operations/node/sec f. Success of interoperable operations 100% g. Means of transport combined 2 h. Degree of interconnection (seconds of disconnection in an hour) Covered Gaps: Gap 1: covered by KPI f Gap 2: covered by KPIs d, f, g Gap 3: covered by KPIs d, f, g Gap 4: covered by KPI f Gap 5: covered by KPIs [a...h]
Action plan to overcome these GAPS	(present in the GAP analysis)

Timeline	Custom Extensions to Modena Automotive Smart Area (MQTT Broker) [UNIORE] - 04/24 - 12/24 Trace Infrastructure Development (testing) - 11/24 - 03/26 **Part (a) Drone + Box [Difly]:** Operation activities plan + Flight requests issue - 04/24 - 06/24 First test – 04/25 Technology Box deploy - 04/24 - 11/24 Technology and integration with MASA - 04/24 - 04/25 R&D: drone-to-bike communication [CSEM] - 10/24 - 06/25 **Part (b) Bike:** Operation activities plan + requests for “diagonale verde” (cycle road) for testing [UNIMORE] - 01/25 - 07/25 Bike set up + AV SW [UNIMORE] - 12/24 - 08/25 (1st AV bike end 06/25, 2nd in end 98/25) Bikes productions [OLV] - 04/24 - 04/25 (1st smart cargo bike 12/24, 2nd in end 04/25) Prototype with Camera Based Platooning [UNIMORE] - 04/24 - 09/24 Platooning Simulation [UNIMORE] -04/24 - 12/24 V2V for platooning [CSEM] - 04/24 - 12/24 Platooning Simulator [UNIMORE] - 09/24 - 06/25 Operation activities plan + Flight requests issue - 04/24 - 06/25 V2V onto Bike – 01/25 - 06/25 + more testing later

Slovenian Pilot

UC: First and list mile delivery/pickup

UC partners & actors

Please provide a complete list of all the partners and actors involved in your UC, specifying their roles in detail. If there are any differences between the pre and post TRACE actors and partners, please specify it.

- as project partners: University of Maribor, Pošta Slovenije, AV Living Lab
- as actors/stakeholders:
  - logistic companies: Pošta Slovenije, BTC Logistics
  - as customers/retailers (final confirmation still needed): A1, Telemach, Baby Center
  - government: Ministry of public administration, Ministry of infrastructure, Municipality of Ljubljana

UC goals

Please specify in detail the goals and the expected results of your UC.

Goals:

- integration and harmonization of two independent logistics service providers networks (BTC and Slovenian Post)
- testing of various types of heterogeneous delivery methods in a live and content-rich ecosystem under real traffic conditions in an urban environment, with pedestrians, cyclists, and cars from different demographic groups
- testing TRACE platform/services for the use of different types of vehicles in different ecosystems and for different purposes/business models
- demonstrating the ability of the TRACE platform to manage and optimize first and last mile logistics services for the purpose of an urban consolidation center (merging parcels, route optimization, delivery and pick-up of parcels, pick-up hubs)
- provide, study, and adapt existing business models to the needs of synchro-modal delivery systems and share existing resources
- demonstrate and study the reliability and efficiency of heterogeneous delivery systems in a dense environment with passengers and traffic
- reduction of traffic and emissions by consolidating first/last mile delivery and pickup
- enhancing urban logistics efficiency
- improved readiness for synchromodal operations in urban settings
- integration of TRACE platform

Expected results:

- increased reliability and efficiency of delivery processes
- more efficient utilization of logistic infrastructure
- more efficient utilization of transport vehicles (improved load factor)
- decreased operational costs (long-term)
- peak demand smoothening with resource-shared logistics operations
- reduction in environment impact, such as energy/fuel consumption, emissions
- enhanced customer satisfactions
- new business models

Pre-TRACE UC

How the process of your UC took place before the innovations introduced within the TRACE project (baseline scenario)

Before: delivery using only one type of conventional vehicle, without calculation of costs, emissions, and time; independent operations without collaboration with other logistic companies; manual or semi-automatic scheduling and routing; limited real-time tracking; minimal use of green and automatized technologies.

After: delivery using multiple means of vehicles, including autonomous robots, based on costs, emissions, and time; collaboration with other logistic companies, automatic scheduling and routing; real-time tracking; optimized use of different vehicles, including zero-emission and automated mobility.

Problems of the status pre-TRACE

Please list all the problems found in your UC pre-TRACE. What are the motivations that push you to change the situation before TRACE?

Before the implementation of TRACE, we detected several challenges and inefficiencies when operation in urban city centers. These issues formed a motivation to improve the processes and to showcase the optimization and automatization of deliveries, using a consolidation center.

The issues were (are) the following:

- high congestion due to frequent and redundant logistic operation by multiple companies, which lead to increased traffic congestion within the urban areas
- high carbon emissions
- overlapping (and non-optimized) routes and underutilized vehicles
- lower customer satisfaction because of non-flexible delivery
- lack of tech integration with manual processes and limited automatization

Motivations for change are:

- commitment to reduce the carbon and environmental footprint
- increasing operation efficiency in last mile delivery
- better customer satisfaction and flexibility
- competitive advantage

Measurement of the baseline scenario

How do you intend to measure the baseline scenario?

We will use KPIs, as defined in the Grant Agreement:

- fuel/energy/emissions reduction: decrease of average energy usage per vehicle
- operational costs reduction: decrease of operational costs, associated with logistics operations
- load factor: increase of load factor due to better space utilization
- success of interoperability: seamless operation between stakeholders
- multiple means of transport used: number of different transport vehicles used

Post-TRACE UC

Please describe in detail how you foresee the process of your UC after the innovations introduced with the TRACE project.

After the end of Trace UC, we expect more logistics operators delivering within BTC City to join the Trace platform. We also expect the Trace platform and its functionalities to be used in other Slovenian urban centers. We expect a greater recognition of the added values of the Trace platform, such as optimization of common logistics processes, reduction of negative environmental impacts, automation of certain logistics processes and indirect motivation of logistics operators to cooperate with each other, integration of logistics processes and greater acceptance of new technologies and automation of processes. Based on TRACE platform implementation and concrete pilot activities, the project partners and Slovenian ecosystem will be able to utilize urban consolidation center and automatization of delivery. Additionally, project partners already approached the national government to form interdisciplinary and multi-ministry teams to ease the implementation of robotic delivery in the future, which is also addressing the lack of work force.

GAP between pre and post TRACE

Please describe carefully what are the necessary measures to solve the identified problems and get to the ideal post TRACE state of your UC.

We see the following ways to implement the TRACE use case within out pilot:

- implementation of TRACE platform

The ideal post-UC Trace situation is that as many logistics operators as possible use the Trace platform. This will in turn also achieve all the aforementioned objectives of reducing the negative impact of transport on the environment, reducing congestion, increasing the utilization of vehicles and logistics infrastructure, and optimizing logistics processes, which will result in increased savings and reduced costs for logistics operators.

Increasing the number of participating logistics operators in the Trace platform will be achieved by raising awareness on the benefits of logistics operators' participation through the Trace platform, through the organization of online and physical workshops with logistics operators, presenting analyses of the results of pilot demonstrations where the positive effects of using the Trace platform have been proven. Then also promotional activities within the project, establishing a good business model for the Trace platform.

As for the Slovenian UC directly, we need to further ensure an appropriate business model for the long-term operation and use of the UCC. Slovenian UC will also be more successful in the future, when the BTC City area will actually become zero-emission zone. With the increasing establishment of zero-emission zones in urban areas and the potential cooperation of logistics operators through the Trace platform, the Slovenian UC will also reach an ideal situation after the end of the Trace project.

To summarize, the necessary measures are:

- Maximizing activities on raising awareness about the benefits of using the Trace platform (workshops, promotion campaigns, etc.).

- A successful Trace platform and UCC business model for collaboration in city logistics.
- Establishing zero-emission zones, which will limit access for logistics operators to end customers in the city center. This will encourage them to use UCCs on the outskirts of the zero-emission zones and to use the Trace platform to optimize logistics processes in urban logistics.
- Adjustment of logistics infrastructure, specifically UCCs, and infrastructure that will be suitable for various modes of transport, including autonomous transport vehicles.

Measurement of these GAPS

How do you intend to measure these GAPS?

Number of participating logistics operators will be measured through Trace platform, the same will be for measuring emissions, utilization of vehicles and logistics infrastructure, reduction of costs, energy and fuel and successfulness of interoperable operations.

Action plan to overcome these GAPS

Please list in detail the implementation phases of your UC including all the necessary resources

1. Obtain confirmation of participation from BTC City logistics center (not a partner of the Trace project).
2. Identify customers—clients of logistics services—and secure their commitment to participate.
3. Review legislative obstacles to the implementation of UC and collaborate with policymakers.
4. Determine the necessary optimization capabilities of the Trace platform required for UC implementation.
5. Review all necessary data sources and identify any missing data from participating logistics operators (and customers—clients of logistics services).
6. Review all required vehicles and infrastructure and identify those that are already available.
7. Determine suitable logistics infrastructure within the pilot area (transport routes, delivery facilities, and potential locations for UCCs).
8. Prepare and possibly adjust logistics infrastructure to meet UV needs.
9. In the first phase, test autonomous and other transport vehicles to adequately prepare them for use in the pilot area.
10. Conduct a trial implementation of UC, integrating the Trace platform.
11. Analyze the results of the trial implementation and identify necessary corrections or improvements (platform, vehicles, infrastructure, data sources, etc.).
12. Repeat the demonstration until the UC successfully meets the set KPIs.

Timeline

Please specify the timeline that you have foreseen to implement your UC.

Draft timeline

2024				2025										
SEP	OKT	NOV	DEC	JAN	FEB	MAR	APR	MAJ	JUN	JUL	AVG	SEP	OKT	NOV
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
UC/pilot preparation phase Defining concrete objectives, scopes and resources. Engagement of stakeholders and suppliers of delivery robot.				**UC/pilot setup** Ensuring all logistical and technical requirements are met to perform a pilot.				**UC/pilot operation*** Execution of pilot, monitoring performance and gathering data.		**UC/pilot evaluation** Analysis of collected data to access pilot and platform performance.				

*The duration and timeline of the UC/pilot operation phase are estimated and may be adjusted based on the availability of delivery robots and the readiness of the platform for testing.