TRACE

inTegration & haRmonizAtion of logistiCs opErations

D2.1 TRACE Technical Requirements (A)

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Executive Summary

This TRACE deliverable document, D2.1 TRACE Technical Requirements (A), outlines the essential technical specification, which is required for the development and implementation of the TRACE platform. It is a crucial component of Work package 2 (WP2) Conceptual framework and sets the basis of other work packages.

As defined in Task 2.2 (T2.2), this deliverable is oriented towards "*identifying, recording and classifying, from multiple viewpoints, all the requirements of scientists, analysts, stakeholders and end users*", including focus group interviews and questionnaires. It defines all components and modules of the architecture, detailing the interoperability and connections between them. The requirements described in this document focus on the behaviour of the platform's inputs and outputs, ensuring that the functional specifications satisfy end-user needs and support the generation of use cases, as performed in Task 2.7. Additionally, this deliverable addresses the crucial requirements for security and privacy aspects of the platform.

The document provides detailed insights and specifications which are crucial for understanding the technical requirements of the TRACE platform.

TRACE Technical Requirements (A) is structured in several key sections:

- Scientific Literature Review, providing a detailed review of existing literature and research on logistic operations integration and synchromodal activities.
- Stakeholder engagement, an analysis of feedback from project partners, demonstration partners, workshops and questionnaires.
- Functional and Non-functional requirements, technical specifications, necessary for TRACE platform development, deployment, and operation, aligned with end-users requirements and demonstration requirements.
- Validation of requirements, ensuring requirements meet project and demonstration objectives.

The key outcomes of the TRACE deliverable D2.1 are:

- Technical requirements, necessary for the development and deployment of TRACE platform and ensure integration between logistic operators, contributing to optimisation of logistic flows, reducing redundancies and reducing energy consumptions and CO2 emissions,
- Use of participatory model to involve different stakeholders, such as end-users, project partners, government institutions, and logistic operators to improve the relevance of the requirements,
- Focus on the inclusion of advanced technologies, such as autonomous delivery, blockchain, AI, and consolidation centers to enable safer, more transparent, and efficient logistic operations.

This deliverable will have another release in M30, implementing also feedback from demonstration.

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Definitions, Acronyms and Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
BLE	Bluetooth
BMS	Battery Management System
CAD	Connected and Automated Driving
CSO	Civil Society Organisation
CSV	Comma Separated Values
dApps	Decentralised Applications
DB	Database
DBMS	Database Management System
DMN	Decision Model and Notation
dNFTs	Dynamic Non-Fungible Tokens
DoF	Degrees of Freedom
DSRC	Dedicated Short Range Communications
DTLF	Digital Transport and Logistics Forum
ELK	Elasticsearch, Logstash, and Kibana
ETA	Estimated Time of Arrival
ETH	Ether
FoV	Field of View
fps	Frames per second
GLPK	GNU Linear Programming Kit
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
ICT	Information and Communication Technology
IMU	Inertial Measurement Unit
IoT	Internet of things
IR	Infrared
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
KPIs	Key Performance Indicators

Abbreviation	Definition
LIDAR	Light Detection & Ranging
LNSD	Local Networks for Smart Delivery
MP	Mega Pixels
MQTT	Message Queuing Telemetry Transport
MR	Mixed Reality
NFC	Near Field Communication
OBD	On Board Diagnostics
OBU	On Board Units
PoD	Proof of Delivery
QR	Quick Response
REST	Representational State Transfer
RFID	Radio-Frequency Identification
RSU	Road-Side Units
RTTT	Road Transport and Traffic Telematics
SADR	Sidewalk Autonomous Delivery Robots
SLF	Smart Life Festival
SOTA	State of the Art
SQL	Structured Query Language
STOMP	Streaming Text Oriented Messaging Protocol
TMS	Transport Management System
TPM	TRACE Participatory Model
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
ULaaDS	Urban Logistics as a Service
UML	Unified Modeling Language
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VR	Virtual Reality
WMS	Warehouse Management System

1 Introduction

1.1 Scope of deliverable

The scope and purpose of this deliverable document is to define and document the technical requirements necessary for the development of the TRACE platform. This deliverable is crucial output of WP2, which focuses on technical planning and specifications to guide the development of the platform.

In addition, this deliverable ensures that the requirements are aligned with the objectives of the project and contribute to the successful implementation of the platform, while following the requirements of three pilot sites to perform successful demonstrations.

1.2 Relation with other work packages/deliverables

This deliverable is closely linked to other work packages and deliverables, in particular deliverable D2.4 where demonstrations/use cases are described in detail, together with ecosystem requirements and development, including safety aspects.

1.3 Intended audience

The primary audience for the D2.1 deliverable includes project stakeholders and external partners, involved in the either development, deployment, or demonstrations. These stakeholders will use the deliverable to guide the development, integration, and validation of other project deliverables and the TRACE platform as well.

As this document will be publicly available, it will be available to regulators and policy makers, industrial and commercial stakeholders, academic and research institutions, civil society and general public which are interested in the methodology and means of accommodating new technologies, identify new business opportunities, use it as a reference for academic studies and future research, and particularly to understand how we aim to reduce carbon footprint and improve resilience in logistic operations.

1.4 Deliverable structure

This deliverable is divided into several sections to provide a comprehensive overview of the technical requirements for the TRACE platform. The requirements are based on a scientific literature review, which provides a comprehensive review of relevant literature covering the integration of logistics operations, synchromodal activities and other aspects of future logistics operations.

Stakeholder engagement (section 3), analysing feedback from workshops and questionnaires and how the results are being applied to the development of the demonstration.

While Section 4 analyses the requirements analysis methodology, Section 5 addresses the functional requirements needed for the TRACE platform, and Section 6 addresses non-functional requirements such as data management, security, monitoring, interface requirements, vehicle and sensor requirements.

In Section 7 we discuss the validation process and identification of requirements to ensure that they meet the project objectives and the requirements of the pilot sites.

1.5 Scientific Literature Review

1.5.1 Logistics Operations Integration and Synchromodal Activities

In the ever-evolving landscape of logistics, the integration of operations and the adoption of synchromodal activities are emerging as key drivers of efficiency and adaptability. Logistics operations integration involves the strategic amalgamation of diverse processes within the supply chain, facilitated by cutting-edge technologies and collaborative platforms. Concurrently, synchromodal activities emphasize the dynamic utilization of multiple transportation modes, optimizing routes and resources. In the following table, we provide a list of relevant research and industrial activities.

Table 1: List of research and industrial activities in synchromodal logistics operations

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
[1]	Research	The article provides an overview of synchromodal logistics, exploring its critical success factors, enabling technologies, and open research issues. It emphasizes the importance of real-time information, collaboration, and technology integration in enhancing supply chains. The article also proposes the concept of a 5PL orchestrator and suggests future research directions for implementing synchromodality on a global scale.	The targets of the article on synchromodal logistics are to give an overview of the concept, identify critical success factors and enabling technologies, propose the role of a 5PL orchestrator, and suggest future research directions.	• Real-time information systems • Internet of Things (IoT) • Cloud computing • Big data analytics • Artificial Intelligence (AI) and Machine Learning (ML)
[2]	Research	The article focuses on synchromodal transport (SmT) as a logistics concept and addresses the need for a common understanding and terminology. It provides a systematic literature review to propose a foundation for future research and clarifies the concept of SmT, its prerequisites, activities, and effects. The research aims to facilitate the adoption of SmT by logistic companies and contribute to a theoretical basis for further studies.	The targets of the article are to establish a common understanding and terminology for synchromodal transport (SmT), provide clarity on the concept, prerequisites, activities, and effects of SmT, facilitate the implementation of SmT by logistic companies, and offer a theoretical foundation for future research in the field.	• Internet of Things • Advanced Data Analytics • Blockchain Technology • Artificial Intelligence • Cloud Computing
[3]	Research	This article presents an architecture for business transaction management in	The targets of the article are to propose an innovative architecture for business	The article discusses the use of an innovative architecture that leverages real-time data for

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		Transport Management Systems (TMS) using real-time data. The focus is on developing rules to handle exception handling, value chain coordination, and transaction coordination in dynamic value chains.	transaction management in TMS, enable real-time handling of exceptions and transaction coordination, develop rules for value chain coordination based on real-time data, and explore the separation of concerns between value chain design and implementation.	exception handling and transaction coordination in TMS. It focuses on developing rules for value chain coordination, enabling flexibility and responsiveness to real-time data changes.
[4]	Research	This article explores the concept of synchromodal logistics and evaluates key indicators influencing its efficiency, particularly in the context of reconfiguring European-Asian supply chains. The study utilizes questionnaire research, interviews, and artificial intelligence methods to determine the critical factors and potential benefits of synchromodal logistics.	The targets of the article are to assess the key indicators influencing the efficiency of synchromodal logistics, explore the potential for developing sustainable transport corridors in European-Asian supply chains, and evaluate the effects of critical factors on the implementation of synchromodal logistics.	The article mentions the utilization of questionnaire research, interviews with experts, and selected artificial intelligence methods to determine the weights of essential indicators and evaluate the effectiveness of synchromodal logistics.
[5]	Research	This article examines the concept of synchromodal logistics, focusing on critical success factors and enabling technologies. It emphasizes the importance of integrating technologies within a common platform and explores the role of 5PL service providers in the supply chain. The article also highlights the need for further research, leveraging real-world applications and considering the impact of social media and digital marketing.	The targets of the article are to survey the existing literature and real-life developments on synchromodality, identify critical success factors, explore enabling technologies, propose the role of 5PL service providers, and discuss open research issues. The article aims to contribute to the understanding and implementation of synchromodal logistics in supply chain management.	This article utilized a comprehensive literature review to explore the concept of synchromodality in logistics. It examined various stakeholders, their relationships, and the role of logistics service providers in coordinating supply chain activities. The research highlights the need for rethinking and redesigning stakeholder engagement in response to evolving supply chain management trends.
[6]	Research	This article focuses on the integration of contextual data in synchromodal transport, highlighting the benefits and exploring the interoperability challenges. It presents a data format for handling real-time contextual data and discusses its usage in a 4PL process for	The targets of the article are to give the benefits of integrating contextual data in synchromodal transport, investigate the challenges associated with interoperability, present a data format for handling real-time contextual data, and showcase	• Data Format Standardization • Internet of Things • Cloud Computing • Interoperability Solutions • Real-time Data Handling

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		Synchromodal Logistic Services (SLS).	its usage in a 4PL process for SLS. The article aims to contribute to the improvement of logistic planning and execution through the utilization of context-aware data.	
[7]	Research	This article proposes a decision-making system for perishable goods logistics service providers to reduce freshness loss using synchromodal transport. It emphasizes the importance of real-time information and the concept of synchromodality in improving the planning and control of perishable goods transport. Simulation experiments demonstrate how the approach can enhance quality and reduce operation time in transport processes.	The targets of the article are to propose a decision-making approach for perishable goods logistics service providers, reduce freshness loss in perishable goods transport, utilize real-time information and synchromodal transport concepts, improve the quality and reduce the operation time in transport processes, and contribute to reducing wastage in agricultural products supply chains.	The article highlights the use of real-time information, sensing technology, communication technology, and the emerging concept of synchromodality in perishable goods logistics.
[8]	Research	This article introduces the concept of synchromodality in supply chain management, focusing on its key elements: visibility, integration, multi-modal transport, and flexibility. It presents the first validated measurement model for synchromodality and discusses its potential implications for supply chain performance, logistics differentiation, and sustainability.	The targets of the article are to develop and validate a measurement model for synchromodality, explore its key elements and capabilities, investigate its potential impact on supply chain performance, logistics differentiation, and sustainability, and provide guidance for managers in implementing synchromodality in their supply chains. The article aims to contribute to the understanding and adoption of synchromodality from a supply chain management perspective.	The article suggests that the digitization of supply chains and the adoption of technologies like blockchain, digital twins, and IoT are promising avenues for further research in the context of synchromodality.
[9]	Research	This article presents a model for comparative analysis of intermodal and synchromodal freight transport systems. The	The target of the article is to develop a model that enables a comparative analysis of intermodal and synchromodal	The article incorporates a dynamic super-network representation, schedule-based rail and inland

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		model captures dynamic aspects of demand and supply, flexible multimodal routing, and capacitated schedule-based assignment. A case study on container transport in the Rotterdam hinterland demonstrates that synchromodal transport can improve service levels, capacity utilization, and modal shift, but may not reduce delivery costs.	freight transport systems. The article aims to investigate the economic, societal, and environmental impacts of synchromodality and provide insights into its potential benefits and challenges.	waterway services, flexible multimodal routing, and a capacitated schedule-based assignment algorithm. These technological components facilitate the analysis and evaluation of intermodal and synchromodal freight transport systems.
[10]	Research	The article explores the synchronization of intermodal transport activities and the optimization of freight flows between maritime and land terminals. It proposes a model that combines medium and small intermodal transport flows into an efficient intermodal transport system. The research emphasizes the importance of information access, technological systems, and communication in enhancing the overall efficiency and competitiveness of transport corridors.	The main objectives of the research are to improve the utilization of infrastructure, reduce service time, and increase the interoperability of maritime and land terminals. The focus is on optimizing freight flows, minimizing costs, and enhancing transport synchronization to achieve better overall performance in intermodal freight transport.	The research emphasizes the utilization of innovative technological systems, particularly the Information Transport System (ITS). ITS plays a vital role in evaluating real-time container transport information, facilitating information exchange among participating countries, and supporting freight transport planning. Integration of information systems, such as the KIPIS system used in Klaipeda Seaport and the "Krovinys" information system for rail transportation, is also highlighted.
[11]	Research	The article discusses the concept of synchromodality as a solution to improve the efficiency, sustainability, and resilience of the European transport system. It explores the challenges and benefits of synchronized multimodal transport services and emphasizes the importance of information exchange and cooperation among transport stakeholders.	The main target of the article is to contribute to the field of multimodal freight transport systems with synchronized services. It aims to promote the implementation of synchromodality as a standard approach to optimize transport systems and achieve the objectives set by the European Commission, such as reducing greenhouse gas emissions and dependency on oil.	• Internet of Things (IoT) • Cyber Physical Systems (CPS) • Logistics 4.0
[12]	Research	This paper provides an overview of the most recent advances in the literature	The paper's main research questions are:	• Optimisation and Sustainability

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		related to last-mile delivery optimization techniques. The techniques were selected from the document "State of the Art in Optimization and Machine Learning Algorithms Applied to last-mile Logistics" (SENATOR, 2021) developed in the SENATOR project.	1)what are the most authoritative academic works to refer to in the study of urban logistics operations? 2)What problems have been investigated in the sector in recent years? 3)What are the main methods and algorithms that emerge from the analysis of these studies and to which problems are they applied?	• Machine Learning - Artificial Intelligence • Vehicle Routing Problems
[13]	**Research**	This review categorizes the related works according to machine learning methodologies to present the methods' evolution through time, their combinations and their connection with the various applications in the specified fields.	present recent machine learning techniques in the optimization of different operations related to freight transportation, supply chain and logistics. The articles are selected and categorized according to their application areas, which are: (a) arrival time forecasting, (b) demand forecasting, (c) industrial processes optimization, (d) traffic flow and location prediction, (e) vehicle routing problem and (f) anomaly detection on transportation data.	• Optimisation • Machine Learning • AI
[14]	**Industrial**	This paper examines the literature on Machine Learning (ML) in Logistic and Supply Chain Management (LSCM) in a systematic approach, examining the available literature in such a way that it allows a clear conclusion on what is known and what is not.	The authors split in categories the papers found in the literature according to the following research questions: 1)What are the different types of research methodologies and data analysis adopted to assess the application of ML in LSCM? 2)How have the following themes such as publishers, geographic locations, author affiliations and industry engagement changed over the years?	Machine Learning Techniques • Supervised • Unsupervised • Reinforced Learning with implementations in Logistic and Supply Chain Management (LSCM). Specifically, they found the following three categories: • Detection • Optimisation • Prediction based ML algorithms in LSCM

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
			3)What ML concentration, techniques and algorithms are frequently used in LSCM? 4)What are the main roles of ML in LSCM, and how could they contribute to the success of LSCM and future research directions? **with the aim to provide:** 1) a comprehensive analysis of ML capabilities to contribute to LSCM. 2)a correlation analysis between ML techniques and LSCM tasks on which they are applied. 3)a detailed description of research gaps and relevant future directions aiming to harness the untapped potential of current advancements in ML research in the context of LSCM.	
[15]	**Research**	This paper integrates two important problems of the Vehicle Routing Problems (VRP) class, namely, the production routing problem and the pollution routing. The authors combine them in one problem called the Production and Pollution Routing Problem (PPRP), with the objective to minimise both the operation cost and, at the same time, the total emissions.	They propose a Self-Learning Particle Swarm Optimization (SLPSO) algorithm with a Mutation Operation (MOSLPSO). They compare their algorithm with NSGA-II to establish its computational effectiveness. A numerical experiment is performed on multiple instances varying in size from 15 customers to 200 customers dispersed in different cities. MOSLPSO calculates a Pareto front that determines the trade-off between the total operational cost and total fuel	• Multi Objective Optimisation • Pareto efficient solution • Self-Learning Particle Swarm Optimization

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		They assume vehicles with the same capacity and delivery within a time window.	consumption, resulting in total carbon emissions. Also, it provides insights that assist in the decision-making process. Decision-makers can choose a solution from the front as an optimum policy according to their relative preferences for the two objectives.	
[16]	**Research**	The authors apply deep learning to solve the VRP problem. They propose a deep neural network which takes the transportation network node features as inputs and generates a complete tour of these nodes with well-trained π model parameters.	The authors apply deep learning to solve the VRP problem. DRL-based distributed neural optimization strategy to develop online vehicular routes with minimal computation time. Compare with baseline strategies from mixed integer programs (MIP@1min, M-MOEA/D@1min, MIP@10min, M-MOEA/D@10min, MIP@60min, M-MOEA/D@60min) with Gurobi solver. Show Efficiency through case studies.	• Deep Learning • Neural Combinatorial Optimisation • Gradient Descent • Monte Carlo Sampling • LSTM
[17]	**Research**	This paper presents a framework to solve the capacity VRP problem with reinforced learning. The authors consider the Markov Decision Process (MDP) formulation of the problem, in which the optimal solution can be viewed as a sequence of decisions. They propose a structure that performs well on any problem from a given distribution. This means that if we generate a new VRP instance with the same number of nodes and vehicle capacity, and the same	Solve the capacity VRP problem with reinforced learning. Get an efficient solution that does not need retraining every time a demand changes. Compare the implementation of their AI model to state-of-the-art algorithms (Clarke-Wright savings heuristic, Sweep heuristics, Google Optimisation Tools) Their solution is competitive because unlike many classical heuristics, our proposed method scales well as the problem size increases, and it	<u>AI model of Reinforcement Learning</u> 1)Sequence to Sequence Models • RNN networks 2)Neural Combinatorial Optimisation • Attention Mechanism

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		location and demand distributions as the ones that we used during training, then the trained policy will work well, and we can solve the problem right away, without retraining for every new instance.	has superior performance with competitive solution-time. It does not require a distance matrix calculation, which might be computationally cumbersome, especially in dynamically changing VRPs.	
[18]	**Industrial**	The main contributions of the paper are outlined as follows: 1)By comparing the efficiency of traditional and AI methods in facing big data 2)By reviewing, summarizing, and classifying the most frequently used AI methods in SCM 3)By providing a detailed framework to explain the outputs of the application of ML techniques in supplier selection and segmentation, predicting supply chain risks, and estimating demand and sales, roduction, inventory management, transportation and distribution, sustainable development (SD), and circular economy (CE).	The main purpose of this paper is to identify the applications of machine learning (ML) in SCM as one of the most well-known artificial intelligence (AI) techniques. By developing a conceptual framework, this paper identifies the contributions of ML techniques in selecting and segmenting suppliers, predicting supply chain risks, and estimating demand and sales, production, inventory management, transportation and distribution, sustainable development (SD), and circular economy (CE). To discuss the benefits and concerns in using ML techniques in Supply Chain Management.	Presents ML algorithms for the following problems: 1. Supplier Selection Using DT and P-SVM Combined Technique and RL 2. Application of ML in Supplier Segmentation 3. ML in Managing Supply Chain Risks 4. ML in Demand/Sales Estimation 5. ML in Inventory Management 6. ML in Transportation and Distribution 7. ML in Production 8. ML in Sustainable Development 9. ML in Circular Economy
[19]	**Research**	This paper is a high-level overview of ML techniques and presents their application in the field of logistics. This review identifies four categories of logistics problem.	To review and identify the major logistics problems and presents proposed ML solutions.	Presents the ML algorithms used in: • Intermodal Transportation • Demand Uncertainty • Reverse logistics • User Behaviour
[20]	**Industrial**	The authors conduct a systematic literature review on AI, ML, and DL technologies in the timeframe from 2014 to 2019. The identified studies can be used to provide an overview of research on these emerging topics that can be	To systematically analyse the scientific literature on artificial intelligence, machine learning, and deep learning in the context of Smart Logistics management in industrial enterprises	Through the Systematic Literature Review found the following Clusters that they used for their proposed conceptual model: 1. Strategic and tactical process optimization

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		used as a starting point for further studies in Smart Logistics.	To propose a conceptual framework, which provides fruitful implications based on recent research findings and insights to be used for directing and starting future research initiatives in the field of artificial intelligence (AI), machine learning (ML), and deep learning (DL) in Smart Logistics	2. Cyber-physical systems in logistics 3. Predictive maintenance 4. Hybrid decision support systems 5. Production planning and control systems 6. Improvement of operational processes in logistics 7. Intelligent transport logistics.
[21]	**Research**	This paper is a deliverable from the project LEAD. The present paper contributes to research in the field of digital twins applied to city logistics by proposing a framework for designing and assessing targeted urban logistics policies to develop a range of logistics solutions for shared, connected, and low-emission logistics operations, empowered by an adaptive modelling approach.	This research work aims to advance research in the field of digital twins applied to city logistics, by proposing a framework enabling new applications for designing and assessing targeted urban logistics policies and to develop a range of logistics solutions for shared, connected, and low-emission logistics operations, empowered by an adaptive modelling approach.	Digital Twins
[22]	**Research**	This paper is a deliverable from the project LEAD. This paper deals with cognitive digital twins, namely twins that can exhibit a high level of intelligence that can replicate human cognitive processes and execute conscious actions autonomously.	One objective is to promote self-adaptive analysis and proactive/intelligent decision making/updates in an info-symbiotic manner between the two worlds and to operate on richer and finer-grained knowledge base. Systems, which are characterised by openness, dynamism and uncertainty in their operations. The authors introduce a conceptual framework that builds on theories in human self-awareness in psychology and cognitive science and leverage on the concept of Dynamic Data-Driven Application Systems (DDDAS)	Digital Twins Decision-Making Dynamic Data Driven Application Systems

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
			to provide a reference architecture model for a Self-aware Digital Twin.	
[23]	**Industrial**	This review is part of the PLANET project. Discusses Traceability by blockchain.	The authors are focused on conducting a review of available modern and intelligent solutions that not only optimize logistics processes but also improve the competitive position of enterprises in supply chains.	Provides literature of the following technologies with applications in logistics: • Blockchain DLT solutions • Intelligent Transport Systems (ITS) – PWC 14 • Robotic Processes Automation (RPA) • Internet of Things (IoT) • Big Data Analytics • Cloud &API's
[24]	**Industrial**	Deliverable from the project PLANET. One of the results is that with adaptive routing as sample innovative transport concept that uses advanced technologies. The authors explain: 1) How performance enhancement can be attained at the micro level. 2) How this logistics concept has an impact at the macro level, both in a positive and in a negative way.	Discusses the impact of the EGTN concept. This concept can be understood as an advanced European strategy vision that implies the development of the Smart, Green and Integrated Transport and Logistics Network of the future.	Adaptive Routing
[25]	**Research**	A survey on the Vehicle Routing Problem. This work surveys the state of the art in the field, summarizing problem combinations, constraints defined, and approaches found in the literature. Also refers to Green VRP which focuses on reducing emissions etc.	Summarizes the Vehicle Routing Problems according to their constraints. Provide approaches for the VRP variants.	Exact Methods (for small instances) Integer Linear Programming Mixed Interger Programming Constraint Programming Heuristics Metaheuristics A* algorithm and variations
[26]	**Research**	This paper studies a VRP VRP with relaxed priority rules (VRP-RPR) in which customers	To address the introduced VRP variant and provide marginally better results from a meta	Mixed Integer LP

Ref No	Activity (Research, Industrial)	Short Description	Targets	Technologies
		are assigned to several priority groups and customers with the highest priorities typically need to be served before lower priority ones.	heuristic that was recently developed at the time.	Metaheuristic based on Adaptive Large Neighbourhood Search
[27]	**Research**	A paper that defines the family of VRP problems.	Provides literature Review on the variations of the VRP which points to their computational complexity.	Worst-Case performance of approximation algorithms

1.5.2 Relevant Software Tools

The following SOTA analysis of the relevant software tools is implemented as SOTA research on generic software areas present in TRACE. As the architecture matures and we create a more concrete list of components, the list will be updated to focus on specific, more relevant aspects of the platform.

1.5.2.1 Blockchain Frameworks

Blockchain is a significant part of the platform as the relevant operations will be adopted to secure the efficient definition of smart contracts and the secure storage of the allocated shipments. The following paragraphs try to provide high level information on the components that could be adopted into our platform.

Blockchain Platforms:

- **Ethereum[1]:** Still the most popular platform for building decentralised applications (dApps) and smart contracts, which automate and execute code when specific conditions are met. As a permissionless network, anyone can join and participate. Beyond its native cryptocurrency, Ether (ETH), Ethereum serves as the foundation for many decentralized applications (dApps) and projects in the blockchain space, thanks to its versatile and robust development environment. Its widespread adoption and vibrant ecosystem position it as a leading force in the blockchain industry.
- **Hyperledger Fabric[2]:** An enterprise-grade, permissioned distributed ledger platform under the Hyperledger umbrella by the Linux Foundation. Unlike public blockchains like Ethereum, Fabric is tailored for enterprises with identified participants, offering a modular design to plug in desired components. It optimises for scalability, confidentiality, and resilience, employing "Chaincode" (its version of smart contracts) and "Channels" for private communication within the network. With support for CouchDB, it enables rich data querying, making it a preferred choice for businesses prioritising data privacy and controlled access.

[1] https://ethereum.org/en/
[2] https://www.hyperledger.org/projects/fabric

- **Cardano[3]:** A research-driven, open-source blockchain platform with a focus on sustainability, scalability, and transparency. Built on a peer-reviewed academic approach, it aims to create a more secure and scalable blockchain and is distinguished by its two-layered architecture: one for settling transactions (Cardano Settlement Layer) and another for handling smart contracts (Cardano Computation Layer). Beyond its native cryptocurrency, ADA, Cardano emphasises a community-driven approach and seeks to provide solutions for developing countries, particularly in areas like identity verification and supply chain tracking.

Development Frameworks:

- **Truffle[4]:** A comprehensive Ethereum development environment, Truffle offers a suite of tools for smart contract development, testing, and deployment, making it a go-to for many Ethereum developers.
- **Hardhat[5]:** An advanced Ethereum development environment tailored for professionals, Hardhat emphasizes developer experience with features like stack traces, console.log functionality, and a robust plugin system.
- **Brownie[6]:** A Python-based framework, Brownie caters to Ethereum developers who prefer Python over JavaScript, offering smart contract deployment, testing, and interaction capabilities.

Smart Contract & dApp tools:

- **Metamask[7]:** A browser extension and mobile application, Metamask serves as both a cryptocurrency wallet and a gateway for users to interact with Ethereum-based decentralized applications (dApps) directly from their browser.
- **Remix[8]:** An open-source platform accessible via web and desktop, Remix assists developers in writing, testing, and deploying smart contracts for Ethereum, making it an invaluable tool for both beginners and experts.

1.5.2.2 Data Management

It becomes obvious that TRACE tries to serve a high number of logistics companies, thus, huge volumes of data will be present. Consequently, a concrete and efficient data model will be the basis for the integration of information coming from different actors. In the following paragraphs, we provide a list of technologies and tools that could be adopted to store and process the collected data.

Database Management Systems (DBMS):

[3] https://docs.cardano.org/
[4] https://archive.trufflesuite.com/
[5] https://hardhat.org/
[6] https://eth-brownie.readthedocs.io/en/stable/
[7] https://metamask.io/
[8] https://remix-project.org/

- **PostgreSQL[9]:** An advanced, open-source relational database system, PostgreSQL is known for its extensibility, data integrity, and SQL compliance. It supports both structured and semi-structured data types and is widely used in applications ranging from web services to analytics.
- **MongoDB[10]:** As a NoSQL database, MongoDB stores data in flexible JSON-like documents, allowing for diverse data structures. It's especially favoured for its scalability and developer-friendly approach, making it suitable for modern web applications that require fast iterations.
- **Elasticsearch[11]:** A powerful, open-source, distributed search and analytics engine, Elasticsearch excels at real-time data search and analysis. Built on Apache Lucene and written in Java, it's particularly popular for log or event data analysis, enabling users to dive into vast amounts of structured and unstructured data rapidly. Its scalable nature, combined with an easy-to-use RESTful API, makes it an industry favourite for search applications.
- **Neo4j[12]:** A leading graph database management system, Neo4j stores structured data in graphs rather than tables. It's built on the idea that data relationships are as crucial as the data itself. Using its query language, Cypher, users can explore and visualize data connections with ease, making Neo4j particularly useful for applications where intricate relationships, like social networks or recommendation engines, are at the core.
- **InfluxDB[13]:** Developed by InfluxData, InfluxDB is an open-source time series database designed to handle high write and query loads. It's particularly optimized for fast, high-availability storage and retrieval of time series data in fields such as operations monitoring, application metrics, IoT sensor data, and real-time analytics. With its purpose-built query language, InfluxQL, InfluxDB provides efficient time-based analysis and supports continuous queries to compute real-time results.

Data Ingestion:

- **Logstash[14]:** An open-source data processing pipeline, Logstash helps users ingest, transform, and send data from multiple sources to their desired destination. As part of the Elastic Stack (previously ELK stack, with Elasticsearch and Kibana), Logstash supports various inputs, filters, and outputs, allowing for the easy transformation and enrichment of data before sending it to a plethora of destinations, including, notably, Elasticsearch.
- **Apache NiFI[15]:** A robust and scalable data ingestion software, NiFi offers visual design and allows for the automation of data flows. Its interactive UI enables users to manage, process, and distribute data between disparate systems seamlessly.

[9] https://www.postgresql.org/
[10] https://www.mongodb.com/
[11] https://www.elastic.co/
[12] https://neo4j.com/
[13] https://www.influxdata.com/products/influxdb/
[14] https://www.elastic.co/logstash
[15] https://nifi.apache.org/

Data Visualisation:

- **Kibana[16]:** The visualization counterpart to Elasticsearch, Kibana is an open-source analytics and visualization platform designed to work seamlessly with Elasticsearch data. It provides real-time histograms, line graphs, pie charts, and maps on large datasets. Through its intuitive interface, users can create complex queries, inspect their data, and build comprehensive dashboards, making the analysis of big datasets interactive and insightful.
- **Grafana[17]:** An open-source platform for monitoring and observability, Grafana allows users to create, explore, and share dashboards visualizing time series data. It supports a plethora of data sources, including but not limited to, Prometheus, MySQL, and InfluxDB. With its customizable panels, alerting features, and extensible plugin architecture, Grafana has become a preferred tool for teams looking to understand their metrics, logs, and traces, all under a unified and interactive interface.

1.5.2.3 Event Management Systems

Event management systems play a pivotal role in orchestrating seamless communication and data flow features necessary for the operation of TRACE as in the followings:

- **RabbitMQ[18]:** An open-source message broker software, RabbitMQ facilitates the communication between applications by sending and receiving messages in various formats. Built on the Erlang language, it's known for its robustness, scalability, and reliable message delivery. RabbitMQ supports multiple messaging protocols and provides a vast array of plugins, making it versatile for diverse application architectures, from microservices to traditional applications.
- **Apache Kafka[19]:** Primarily known as a distributed event streaming platform, Kafka effectively integrates data in real-time. It's highly scalable and ensures that data flows seamlessly between your applications, databases, and analytics platforms.

The Drools rule engine operates using the following basic components:

- Rules: Business rules or DMN decisions that you define. All rules must contain at a minimum the conditions that trigger the rule and the actions that the rule dictates.
- Facts: Data that enters or changes in the Drools rule engine that the Drools rule engine matches to rule conditions to execute applicable rules.
- Production memory: Location where rules are stored in the Drools rule engine.
- Working memory: Location where facts are stored in the Drools rule engine.
- Agenda: Location where activated rules are registered and sorted (if applicable) in preparation for execution.

Some known drools supported by Python are the following:

[16] https://www.elastic.co/kibana
[17] https://grafana.com/
[18] https://www.rabbitmq.com/
[19] https://kafka.apache.org/

1. **Pyke:** Pyke is a knowledge-based inference engine (expert system) that allows developers to build rule-based systems using the Python programming language. It is designed for creating rule-based expert systems and decision support systems. Pyke uses knowledge-based programming principles, where facts and rules are expressed in a human-readable format. This makes it accessible to both developers and domain experts.
2. **Python-rule:** Python-rule is a lightweight and easy-to-use Python library for implementing rule engines. It offers a simple way to define rules and conditions in Python code. While it may not be as feature-rich as some other rule engines, it is well-suited for smaller-scale projects and applications where a more extensive rule engine might be overkill.
3. **PyCLIPS:** PyCLIPS is a lightweight rule engine that is easy to use and understand.
4. **PyKnow:** PyKnow is a powerful rule engine that supports a variety of rule formats.
5. **PyRules:** PyRules is a lightweight rule engine that is easy to use and understand.
6. **Nected:** Nected is lightweight cloud-based rule engine that is easy to setup, easy to use and supports variety of rule formats including option to custom code giving unlimited flexibility

Camunda is an open-source platform for workflow automation, decision management, and process automation. It includes a powerful business rule engine that enables organizations to define, manage, and execute business rules effectively. Here's a brief overview of the Camunda rule engine:

- **Decision Management:** Camunda's rule engine is part of its broader decision-management capabilities. It allows businesses to model and execute decision logic using the Decision Model and Notation (DMN) standard. DMN provides a standardized way to define and represent decision-making processes.
- **Integration with Processes:** One of Camunda's strengths is its ability to integrate rules seamlessly with workflow and process automation. This means that decision rules can be incorporated directly into your business processes, ensuring that decisions are made consistently and in alignment with your processes.
- **Decision Tables:** Camunda supports decision tables, a tabular representation of decision logic. Decision tables are a user-friendly way to define complex rules, and Camunda provides tools for creating and managing these tables.
- **Versioning and Auditing:** Camunda offers version control and auditing features for decision rules. This is crucial for maintaining transparency and compliance in decision-making processes.
- **Execution:** Camunda's rule engine can execute decisions in real-time as part of workflow processes. It evaluates rules based on input data and produces the desired outcomes.
- **Integration:** Camunda seamlessly integrates with Spring Boot, making it a popular choice for Java developers building Spring Boot applications. This integration allows you to leverage Camunda's rule engine within your Spring Boot projects.
- **Community and Support:** Camunda has an active community and provides professional support options, making it a reliable choice for organizations of varying sizes.

1.5.2.4 Optimization Modules

Optimization modules are crucial components in enhancing efficiency and performance across various systems of TRACE.

- **OR-Tools[20]:** Developed by Google, OR-Tools is an open-source software suite for optimization, tackling a range of problems from linear programming to constraint programming and vehicle routing. With its robust solvers and a comprehensive set of APIs in multiple languages, it serves as a one-stop-shop for various optimization challenges.
- **Optuna[21]:** An open-source hyperparameter optimization framework, Optuna automates the process of finding optimal hyperparameters for machine learning models. With its efficient search algorithms and integration with popular ML libraries, it streamlines model optimization, ensuring peak performance.
- **PuLP[22]:** A Python library for linear optimization problems, PuLP provides tools to model and solve linear programming problems. Using a natural, expressive syntax, it allows users to focus on the modelling aspect while delegating the solving to underlying solvers like CBC or GLPK.

1.5.2.5 System Interfaces and APIs

System interfaces and APIs play a pivotal role in facilitating seamless interactions and integrations within the realm of logistic chain.

- **Kong[23]:** An open-source API Gateway and platform, Kong manages the traffic between microservices and APIs. With its plugin architecture, Kong can be extended to provide additional functionalities like authentication, rate limiting, logging, and more. It's designed to handle varying service traffic, ensuring high availability and offering an added layer of security.
- **Nginx[24]:** Initially developed as a web server, Nginx has evolved to include a reverse proxy, and load balancer. Known for its high performance, stability, and low resource consumption, Nginx is commonly used in scenarios where high concurrency and low latency are essential. When used as an API gateway, it can handle API traffic, secure APIs, and manage multiple API versions.
- **GraphQL[25]:** Developed by Fac[26]GraphQL is a query language for APIs and a runtime to execute those queries. It allows clients to request precisely the data they need, making it a flexible alternative to traditional REST APIs.
- **Swagger[27][28]OpenAPI):** A framework for API specification, Swagger offers a set of tools for auto-generating documentation, API testing, and other essential tasks. With its interactive documentation, it simplifies both the development and consumption of APIs.

1.5.3 Relevant Equipment

In the following paragraphs, we present potential equipment that could be adopted in the TRACE platform.

[20] https://github.com/google/or-tools
[21] https://optuna.org/
[22] https://coin-or.github.io/pulp/
[23] https://konghq.com/products/kong-gateway
[24] https://www.nginx.com/
[25] https://graphql.org/

[27] https://swagger.io/specification/

1.5.3.1 Bicycles

Cargo bicycles offer a non-motorized, low carbon transport model, predominantly within urban centers, and provide a more sustainable alternative for the commercial delivery of goods and general transportation throughout cities. There is great potential for cargo bikes to substitute urban small-scale vehicle trips especially within logistics operations and companies can benefit from their ability to utilize alternative routes when roadways are impacted due to traffic or disruptive events. The integration of cargo bicycles as a component of logistic provider fleets, as well as the economic feasibility of such bicycles, has been trialled and proven through various use case studies and pilot projects (Rudolph & Gruber, 2017[29]).

1.5.3.2 Tools and Products (Software/Hardware)

Software: An **application platform** for the management of bicycles/e-bikes fleets in terms of obtaining the position of the bikes in real time, info data for the use of the bike, data for the security of the bicycles fleet, maintenance data and manage the diversity of the fleet. Indicative examples of such platforms are: Velco[30], Powunity [31]and ESB[32].

GPS tracking: Receive alerts when bicycles are moved outside of their predetermined range. Indicative examples are:

- Lightbug Zero[33] GPS tracker communicates on 4G and 2G networks and has a battery life that lasts for weeks and months. Moreover, it supports NFC and alarm functionalities.
- Bike Trax[34] that communicates with a free mobile app on a mobile device where you can locate the bike every moment.

Battery level monitoring: Devices for the monitoring of the e-bikes battery level. A battery management system (BMS) is a must of an e-bike to ensure safe and reliable operation of the battery pack. A BMS is monitoring parameters such as cell voltages, battery temperature and charging/discharging current.

Infrastructure: For the infrastructure of a cargo bike network there is a need for sufficient capacity of the cycling road schemes. Furthermore, specific needs for cargo bikes such as parking and maintenance facilities, micro-hubs, parcel-pickup boxes, and rechargeable stations (for e-cargo bikes) should be specified properly in such a network. Also, a dedicated wireless network could be set up to facilitate the cargo drivers' routes, cargo sharing and tracking of freight through GPS devices on the cargo bikes.

1.5.4 Train Transportation

Trail transport of goods is a reliable and efficient way nowadays. It offers a great carrying capacity over long distances comparing to other transportation means such as trucks. Furthermore, trains operate on independent fixed lanes that reduce the chances of delays and make them a predictable form of

[29] https://www.researchgate.net/publication/318444034_Cargo_cycles_in_commercial_transport_Potentials_constraints_and_recommendations

[30] https://velco.tech/

[31] https://powunity.com/

[32] https://www.esb.bike/

[33] https://lightbug.io/product/zero/

[34] https://powunity.com/en/product/e-bike-gps-tracker

transportation. Trail transportation usually requires other forms of transportation (i.e., truck freight) to be combined to as not every area has access to railroad tracks. Most of the trail transportation companies try to ensure that all processes carried out from packaging to delivery of goods can be monitored through information management systems[28].

1.5.4.1 Tools and Products (Software/Hardware)

Technologies like GPS tracking, wireless communication networks, and a reduction in the size (and cost) of electronics have given logistics managers a powerful tool such as a portable GPS shipment tracker. These devices are small, small enough to fit on pallets or within packages, which makes them easy to transport on a shipment and back. These devices are wireless, which means there's no complex installation or removal necessary, just tag a shipment, and the tracker keeps you updated via the Internet. These devices are power packed to last for months on a single charge, can connect to several on-board sensors that can tell you more about your shipment than just its location.

STEVAL-STRKT01 LoRa® IoT tracker[29].

The STEVAL-STRKT01 LoRa® IoT tracker is designed and optimized to implement the latest technologies in IoT tracker applications such as asset, people and animal tracking as well as fleet management. The STEVAL-STRKT01V1 allows acquiring position, managing geofence, data logging, monitoring motion and environmental sensors. Its main characteristics are:

- Optimized IoT tracker solution over LoRaWAN™ network with simultaneous multi-constellation GNSS positioning and geofencing support
- Battery operated solution with smart power management architecture
- First IoT ST reference embedding a USB Type-C connector and a port controller
- Environmental and motion sensors
- Data logging
- STM32Cube function pack (FP-ATR-LORA1)
- High flexibility to cover different application profiles:
- asset tracker
- people and animal tracker
- fleet management
- WEEE and RoHS compliant
- 2006/66/EC Directive compliant
- Contains transmitter module FCC ID: VPYCMABZ and IC ID: 772C-CMABZ
- CE certified

HoopoSense Titan[30].

HoopoSense Titan is a ruggedized tracker equipped with multiple technologies. It leverages GPS, cellular, and other wireless communication technologies to transmit location data in real-time, which can be accessed through our intuitive dashboard. By using Hoopo tracking[31] dashboard, businesses can enjoy several benefits, including improved asset visibility, enhanced operational efficiency, optimized resource allocation, reduced downtime, and increased productivity.

Its main characteristics are:

- Real-time tracking, including breadcrumb reporting (Interchanging geolocation and connectivity protocols)
- Unprecedented battery life - up to 12 years (with a dedicated battery pack)
- Durable & Rugged (IP67, proven to withstand harsh environments)
- Wide global coverage (LTE-M / NB-IoT / 2G)
- Fast installation (up and running in 90 seconds)
- Adaptive tracking configuration (fits any operational need)
- BLE Gateway (Enabling add-on wireless sensing)
- Tamper detection (using magnetic and accelerometer sensing)
- Built in container mount detection for real-time availability monitoring
- Impact Detection
- Accurate power monitoring (based on actual usage)
- Zero maintenance

Optional real-time track condition monitoring

An RFID-Sensor tag can be placed on or near cargo inside the wagon to provide real-time cold chain temperature/humidity data rather than the wagon temperature. The same technology can be used for real-time reporting of any intrusion into the wagon during transit. Access of the data can be done through mobile device real time web-based application to check the condition of the goods including intrusion, tampering, temperature, moisture and other sensor-based status from anywhere[32].

USAT STAMP-I[33].

USAT STAMP-I is a sophisticated security seal for remote monitoring of containers in real time globally.

- Robust, high-quality design with continuous performance.
- Easy-to-use system where you can define the timing of alerts, events and reports.
- Transmission of location and events in real time through the GPRS network.
- Option for periodic transmissions from the unit to track location.

1.5.5 Truck Transportation

Trucks are probably the easier way to deliver and track goods than other modes of transportation, due to built-in navigational systems, real-time tracking abilities and road transportation accessibility. Furthermore, they offer plenty of options in delivering packages from small parcel sizes to oversized parcels. They also allow door-to-door shipment and last mile delivery due to the availability of the road network. Nevertheless, there are some factors that can cause delays and have unpredictable impacts on delivery times of a shipment due to road closures, of heavy traffic and bad weather conditions. In the case that such delays exist in the distribution of a package this information needs to be recorded and provided to the corresponding customer that the package belongs. For that reason, tracking mechanisms of delivery

goods have been adopted from most of the transport companies so that customers can track their parcels in real-time, reducing anxiety and improving satisfaction while couriers gain better control over their operations.

Data collected through these trucking mechanisms are transmitted to a central database via cellular networks or Wi-Fi, ensuring real-time updates for customers and logistics teams. Sophisticated software analyses the data, allowing courier companies to make informed decisions about routing, delivery times, and resource allocation.

1.5.5.1 Tools and Products (Software/Hardware)

Types of Tracking Systems[34].

GPS Tracking

Global Positioning System (GPS) tracking relies on satellites to pinpoint the exact location of a parcel. It's widely used for tracking vehicles and can provide real-time updates on a package's whereabouts.

Barcode and QR Code Tracking

Barcodes and Quick Response (QR) codes are attached to parcels. Scanners read these codes at various checkpoints along the delivery route, updating the system with location and status data.

RFID Tracking

Radio-Frequency Identification (RFID) technology uses radio waves to track parcels. It's highly efficient and can provide detailed information about a package's journey.

Bluetooth (BLE) tags for movable asset tracking

BLE tags are devices that continuously emit unique signals that can be picked up by Bluetooth-enabled devices. In order to collect the information from there, you still need either an app or a platform connection from a telemetry device that can interpret the signal. An active internet connection here is compulsory. Tags are used for active or movable assets and they can detect temperature and humidity, and information, such as a name or characteristics of an item. To get the information BLE asset tracking device has to be in a range of a receiving device (Mapon[35]).

Solo 5G Tracker[35].

World's first single-use multi-sensor tracker provides real-time visibility into the location, temperature, humidity, shock, and light of your goods in-transit, at the item-level, from end to end. Its main characteristics are:

- Location: GPS, Wi-Fi, and cell tower triangulation provide accurate real-time location data.
- Climate: Temperature and humidity sensors provide insight into your shipment's environment.
- Monitor at Item Level: Get real-time visibility into every package in your consignment, at a fraction of the cost. Beacons report temperature and proximity to a parent tracker, which then transmits that data for the whole shipment.

[35] https://www.mapon.com/en/blog/2023/05/everything-to-know-about-ble-asset-tracking

- Shipment Integrity: Light and shock sensors indicate whether the shipment has experienced any form of damage.
- Astounding Battery Life: A combination of innovative hardware design, cutting edge firmware, and integration of cloud computing delivers the world's longest lasting 5G tracker.
- Eliminate Return Logistics: The Tive Solo 5G can be used as a single-use tracker, so it's perfect for last-mile deliveries, where collecting and returning trackers poses a challenge.

USAT STAMP – S[36].

USAT-S is a powerful waterproof GPS tracker designed for mobile asset monitoring applications.

- Waterproof design, IPX66 standard.
- Internal 3-axis accelerometer for motion detection.
- Internal GSM and GPS antenna.
- Two-way voice channel
- Transmission of events in real time through the GSM/GPRS network.

Bolt2[37].

Plug-and-play OBDII GPS tracking device with backup battery for real-time vehicle and fleet management. More details:

- High-precision GPS tracking device plugs into existing OBDII ports for real-time tracking
- Internal backup battery – if the device is removed from power it will continue to track for a period of time
- Critical 'unplugged/power loss' alerts to notify users of device removal, tampering, unauthorized trips, or theft
- Speeding, harsh braking and cornering, accident and rollover detection
- Electronic Odometer Calculations
- Accelerometer for adaptive and movement-based tracking
- Plug and play or splitter installation options

1.5.6 Unmanned Ground Vehicles (UGVs)

Unmanned Ground Vehicles (UGV) are vehicles operating without the presence of humans and one example of these are Sidewalk Autonomous Delivery Robots (SADR) used for last-mile delivery. They are of crucial importance in last-mile delivery for several compelling reasons. They offer remarkable efficiency, operating continuously without rest, ensuring swift and precise deliveries. Moreover, their use significantly slashes costs in comparison to traditional delivery vehicles by eliminating the need for human drivers and minimizing expenses like fuel and maintenance.

UGVs also excel at following precisely programmed routes, reducing delivery errors and enhancing customer satisfaction. They also alleviate urban traffic congestion by not vying for road space with other vehicles, and their flexible scheduling permits deliveries at customer-friendly times.

Furthermore, UGVs can access challenging or remote areas where traditional vehicles often encounter obstacles. Their environmental impact is reduced, especially when powered by electricity or clean energy sources, promoting sustainability in last-mile delivery. They are also renowned for their safety, as the absence of human intervention lowers the risk of traffic accidents caused by human errors.

In essence, UGVs are revolutionizing last-mile delivery by improving efficiency, cutting costs, ensuring precise deliveries, and promoting more sustainable and secure logistics.

1.5.6.1 Tools and Products (Software/Hardware)

The software components play a vital role in navigation, movement, and UGV operations. They may involve perception systems, mapping and localization, route planning algorithms and motor control software. Perception software analyses data from these sensors to understand the environment and make decisions based on the collected information. Mapping and localization software uses sensor data to create maps of the environment, allowing the UGV to accurately determine its location on those maps and achieve accurate navigation. Route Planning software calculates the most efficient routes for the UGV to reach its destination by considering factors like obstacles, motion constraints, and the delivery point's location. Moreover, UGVs often require communication software to transmit data over wireless networks or perform coordination tasks with other UGVs or centralized control systems.

The combination of these types of software enables UGVs to operate autonomously, navigate safely, avoid obstacles, fulfil their delivery tasks, and communicate with other systems and operators when necessary. The choice of specific software depends on the application and the particular needs of each UGV.

UGVs engage several hardware components for their tasks. In a UGV, it is possible to find proximity, position, and image sensors. Among the proximity sensors, LIDAR (Light Detection and Ranging) stands out, a technology for scanning, measuring, and detecting objects based on laser light pulses to detect objects and measure the distance to them, enabling the robot to understand its environment to create a map for navigation and planning. LIDAR sensors work well in a wide range of lighting conditions, including darkness and adverse weather, making them suitable for various environments and scenarios. In the domain of position sensors, GPS and odometry sensors are crucial for autonomous navigation and planning, allowing the robot to determine its position in space, contributing to their ability to operate autonomously and efficiently in various applications. GPS is usually combined with odometry to improve the UGVs' position estimation and localization accuracy, especially in challenging environments where GPS signals may be obstructed or unreliable. Finally, image sensors (such as RGB-D cameras) enable the robot to capture images of the surroundings, which is useful for object detection, autonomous navigation, and route planning.

On the other hand, UGVs need actuators, such as motors and servos, which are responsible for moving the UGV's wheels. They also require a power source, typically batteries, to provide electrical energy for the various components. Finally, UGVs need communication equipment for receiving commands, transmitting data, and interacting with operators, which can include radios, Wi-Fi modules, Bluetooth connectivity, and more.

UGV delivery systems[36]: There are already plenty of UGV delivery bot platforms that operate in the market.

Amazon scout[37]: The Amazon Scout[38] has 6 wheels and can move on sidewalks at a walking speed. It uses a camera as well as sensors to plan an effective route, navigation, and improve service. The customer's package is stored within the robot and is then driven to the customer's delivery address. The Amazon Scout has an estimated total length of 76.2cm, estimated width of 61cm, and estimated height of 73.7cm. Amazon Scouts weigh 45 kg and can carry a payload of 23 kg. The maximum movement speed of the Amazon Scout is 24 km/h.

Kiwibot[39]: Kiwibot is a semi-autonomous robot designed to perform last-mile deliveries. Kiwibot weights 17kg with the flagpole and battery. The Kiwibot average effective service speed is 3km/h. It operates in rain and in darkness. It uses cameras, full range lidar and proximity and cliff sensors to create a virtual picture of the world in real-time to interact with the community. A set of communication equipment and antennas improves the connectivity and location accuracy essentials in the robot monitoring and tracking process. Kiwibots are equipped with 4 cameras, 6 obstacle detectors and there is also a remote supervisor who is monitoring its entire operation. Its speed is about 3km/h. Kiwibots are able to correct their route when there will be destructed by obstacles on the road and are going to stop if an object is in front of them.

1.5.7 Unmanned Aerial Vehicles (UAVs)

Unmanned Aerial Vehicles (UAVs), also known as drones, are pivotal in last-mile delivery, delivering numerous advantages. They enhance speed and efficiency by avoiding road congestion, making them ideal for time-sensitive deliveries. Drones offer accessibility to remote and disaster-stricken areas where conventional vehicles face challenges, reduce urban traffic congestion, and lower costs with their ability to operate in airspace. They are eco-friendly and versatile, catering to diverse cargo. In emergency response situations, drones swiftly deliver vital supplies. Real-time tracking enhances transparency, and contactless delivery is invaluable in situations like the COVID-19 pandemic. Drones support healthcare logistics. However, they face regulatory, safety, and infrastructure challenges, requiring collaboration and effective drone traffic management for widespread adoption. In essence, UAVs offer a quicker, efficient, and often cost-effective approach to various last-mile delivery challenges.

1.5.7.1 Tools and Products (Software/Hardware)

Unmanned Aerial Vehicles (UAVs) employ a range of software for their functioning. Flight control software oversees navigation, stability, and autopilot functions, guaranteeing adherence to predefined flight routes, obstacle avoidance, and flight stability. GPS software provides precise location data for accurate positioning and navigation. Mission planning and management software enable operators to set flight missions, waypoints, and objectives. Image processing software is used for tasks like analyzing aerial imagery or videos captured by onboard cameras. UAVs also frequently utilize communication and data transmission software for relaying information between the vehicle and ground control stations. These

[36] https://www.practicalecommerce.com/10-autonomous-robots-for-last-mile-deliveries
[37] https://www.aboutamazon.com/news/transportation/meet-scout
[38] https://www.dimensions.com/element/amazon-scout
[39] https://www.kiwibot.com

software elements, coupled with advanced algorithms, impart versatility and capability to UAVs across various applications, including surveillance and package delivery.

Unmanned Aerial Vehicles (UAVs) employ a range of hardware components for their operation. These include flight control systems, which consist of gyroscopes, accelerometers, and other sensors to maintain stability and control. Power systems like batteries or fuel cells provide the necessary energy for propulsion and onboard systems. GPS receivers enable precise navigation and positioning. UAVs are equipped with cameras and sensors for data collection, and communication systems ensure real-time data transfer between the vehicle and ground control. Additionally, airframes, motors, and propellers play a vital role in the UAV's mechanical structure and propulsion. Overall, the hardware components in UAVs are carefully integrated to facilitate navigation, data collection, and communication during flight.

Drone delivery systems:

- **Flyzipline[40]: P2 Zips and P1 Zips. (Altitude, Speed, Range, payload)** - 2 Zips fly at about 90 m and can travel up to 112km/h. While they stay up high, deliver a droid case that carries the package to the ground. They can transport a weight of up to 3.6kg. With a 16km service radius, P2 Zips can fly up to 38 km in one trip. P1 Zips fly at about 90 m and lower to 20-30 m when it is time to deliver the package (package is released with a parachute). They can travel up to 97km/h and with a 100km service radius, they can fly 200 km in one trip. They can transport a weight of up to 1.8 kg.
- **Wing[41]:** Wing drones fly at about 45 m and can travel up to 104.4km/h. While a drone reaches its destination delivery the drone slows down, hovers, and descends vertically to a safe height about 7m above the ground. Using a winch, the drone lowers the package to the ground, and the package detaches from the hook. Wing drones can transport a weight of up to 1.2kg. Wing drones can fly up to 20km in one trip. They emit zero pollution during the flight. After a customer initiates an order, a central management software plans the flight (best route by using local weather data, terrain and airspace maps, and other drone activity). As the route plan being determined to be free of obstacles is sent to the drone to initiate its fly.
- **Walmart[42] and** Apian[43] are two companies that already use the wing platform for delivering goods.

1.5.8 Other transport means (e.g., e-scooters, other)

Apart from e-scooters, other personal mobility equipment such as bicycles (discussed in 1.1), roller skates, and even skateboards are gaining popularity as a means of assisting couriers and delivery employees in navigating urban environments and performing last-mile delivery.

Crowd shipping is another innovative solution that can significantly benefit logistics companies in reducing their fleet's cost per mile. This concept involves leveraging existing travellers and their unused luggage

[40] https://www.flyzipline.com/

[41] https://wing.com/

[42] https://corporate.walmart.com/news/2023/08/24/walmart-and-wing-team-up-to-provide-the-convenience-of-drone-delivery

[43] https://www.apian.aero/

space to transport packages. By utilizing crowd shipping platforms, logistics professionals can tap into a vast network of travellers already heading in the desired direction. This eliminates the need for maintaining a large fleet of vehicles and the associated costs such as fuel, maintenance, and insurance. Furthermore, this collaborative approach reduces costs and promotes sustainability by maximizing the utilization of existing transportation capacity.

The appropriate mix of these other transport means (e-scooters, bicycles & crowd shipping) within the TRACE project shall be evaluated upon these means capabilities & capacities to meet the target needs of last mile deliveries with respect to cost, speed, volume and weight of the parcel's delivery.

1.5.8.1 Tools and Products (Software/Hardware)

Tools are therefore considered e-scooters, roller skates, skateboards, & vehicles used for crowd shipping.

Concerning the e-scooters there are 3 modes of operation:

a. ECO is economic mode with maximum speed 6mph/10km/h, which is for new riders:
b. D is standard mode with maximum speed 12mph/20km/h;
c. S is sport mode with speed up to 15.5mph/25km/h

Software is considered the operating information and the programs used by any kind of computer regardless of its size (e.g., desktop, laptop or hand-held).

Hardware is considered any device other than tools which is used to enforce the tools' efficient remote control & tracking (e.g., smartphone only, GPS only or both, depending on the robustness necessary to efficiently carry out the delivery mission assigned to the tool's operators).

EV4[44] Cargo Scooter is a mini scooter designed in two versions – standing and seated – intended for transporting small packages and cargo weighing up to 40 kg. In standard version, the vehicles are equipped with a 250W brushless electric motor, powered by a 36-volt lithium-ion battery with a capacity of 10 amp-hours. The riveted construction made from aviation grade aluminium ensures high strength at a low weight, thanks to which the range of scooters is up to 30km at a maximum speed of 20km/h. The seated version is equipped with a folding handlebar and a removable seat. A more powerful version of the vehicle is also available, equipped with a 500W brushless electric motor, powered by a 48-volt, 21 amp-hour lithium-ion battery. Optionally, the scooters can also be equipped with LED lights and a solar panel mounted on top of the cargo crate.

1.5.9 Sensors (cameras, proximity, location, …)

This section explores the various types of sensors that are essential for the development and deployment of modern technological systems in the context of smart logistics and automated mobility. This section delves into the different sensor technologies, such as cameras, proximity sensors, and GPS-based location sensors, which play a crucial role in capturing and transmitting data necessary for monitoring, tracking, and navigating within complex environments. The subsections will cover the technical specifications and

[44] https://www.ev4.pl/en/cargo-scooter.html

capabilities of each sensor type, illustrating their importance in ensuring operational efficiency, safety, and accuracy.

1.5.9.1 Cameras

Technical specs:

- **Resolution:** Measured in megapixels (MP). Determines the clarity and detail of the captured image. Common resolutions include 1080p (Full HD), 4K (Ultra HD), and more.
- **Sensor Size and Type:** The physical size and type of the image sensor. A larger sensor can generally capture more light, leading to better image quality, especially in low-light conditions.
- **Frame Rate:** Measured in frames per second (fps). Determines how many images the camera captures each second. Common rates include 30fps and 60fps.
- **Field of View (FoV):** The observable area the camera can capture, often given in degrees. A wider FoV captures more area but can lead to more distorted images.
- **Zoom Capability:** Optical zoom refers to the true zoom achieved by the camera's lens. Digital zoom is software-based and can reduce image quality.
- **Low-Light Performance:** The camera's ability to capture clear images in dimly lit environments. This might be specified by a minimum illumination value (often in lux).
- **Infrared (IR) Capability:** Allows the camera to capture images in complete darkness using infrared light. Often accompanied by a specification for the IR range (e.g., 30m).
- **Connectivity:** How the camera connects to other systems, e.g., Wi-Fi, Ethernet, 4G/5G, or proprietary connections.
- **Storage:** Onboard storage options (like SD card slots) and compatibility with external storage or cloud services.
- **Power Source:** Can be wired (plugged into an electrical outlet) or wireless (battery-powered).
- **Audio: Some** cameras come with built-in microphones or speakers, allowing for two-way communication or audio recording.
- **Motion Detection:** The camera's ability to detect movement and possibly trigger alerts or start recording based on detected motion.
- **Lens Type:** Fixed, varifocal, or zoom. Determines the camera's flexibility in adjusting focus and zoom.
- **Image Stabilization:** Reduces blurriness caused by small camera movements, especially useful for cameras mounted in places with vibrations.
- **Video Compression:** Technologies used to compress video files to use less storage and bandwidth without significantly compromising quality.

1.5.9.2 GPS Sensors

Technical specs:

- **Accuracy:** Precision of the location data, often measured in meters.
- **Update Rate:** How frequently the GPS updates its location data.
- **Channels:** Number of satellite channels the GPS can track simultaneously.
- **Sensitivity:** Ability to maintain a satellite lock in challenging conditions, like urban canyons or dense foliage.

- **Assisted GPS (A-GPS):** Uses data from cellular networks to improve satellite lock times.
- **Power Consumption:** Important for battery-operated devices.
- **Connectivity:** How the GPS device communicates with other systems, e.g., Wi-Fi, 4G/5G, or satellite.

1.5.9.3 Accelerometers

Technical specs:

- **Sensitivity:** Minimum amount of motion the sensor can detect.
- **Axis Detection:** Single-axis, dual-axis, or tri-axis (3D) measurement.
- **Measurement Range:** Maximum acceleration the sensor can measure in terms of "g-forces."
- **Frequency Response:** Range of frequencies over which the accelerometer is accurate.
- **Output Type:** Analog or digital output.
- **Temperature Range:** Operational range of temperatures without loss of function.

1.5.9.4 Barcode Scanners

Technical specs:

- **Scan Type:** Laser, linear imager, or 2D area imager.
- **Scan Rate:** Number of scans per second, often ranging from 100 to 500 scans/second.
- **Reading Distance:** The distance from which a scanner can effectively read a barcode.
- **Interface:** Connectivity options like USB, Bluetooth, Wi-Fi, etc.
- **Memory:** Storage capacity, relevant for batch mode operations where scanned data is stored and later transferred.
- **Durability:** Often rated for drops (e.g., survives drops from 1.5m), dust and water resistance (often given an IP rating).
- **Battery Life:** Relevant for wireless models, indicating how long the scanner operates on a full charge.
- **Weight and Dimensions:** Size and weight, which can affect user fatigue in scan-intensive environments.

1.5.9.5 Telematics Systems

Technical specs:

- **Data Collection Capabilities:** GPS location, vehicle speed, fuel consumption, engine temperature, driver behavior (e.g., hard braking), etc.
- **Connectivity:** How the system sends and receives data, e.g., cellular (4G/5G), satellite, or Wi-Fi.
- **Integration:** Compatibility with other systems, such as fleet management software or enterprise resource planning (ERP) systems.
- **User Interface:** Dashboard or software through which data is accessed and analysed.
- **Storage Capacity:** How much data the system can store onboard before transmitting or offloading.
- **Security Features:** Encryption, secure access, and other features ensuring data privacy and protection.

- **Alerts & Notifications:** Real-time alerts for pre-defined events (e.g., geofencing breaches, maintenance requirements).
- **Power Source:** Wired into the vehicle's electrical system, battery-operated, or a combination of both.

1.5.10 Supply chain management

Supply Chains management key factors:

1. Transport management
2. Fleet management
3. Stock management

1.5.10.1 Transport management

Transport management seeks to deliver goods in the most environmentally friendly way, trying to reduce its impact on traffic congestion. To achieve this, companies use a ***Transport Management Systems*** (TMS) which is a software that enables operators to plan and manage their vehicles fleet.

Examples of TMS: ***Oracle Transportation Management***[45] ***(OTM),*** Uber Freight Transportation Management System.

Probes used for TMS:

1. **GPS and GNSS (Global Navigation Satellite System)**: These systems provide precise location data for vehicles and drones, allowing them to navigate and plan delivery routes accurately.
2. **LiDAR (Light Detection and Ranging)**: LiDAR sensors use laser beams to measure distances and create 3D maps of the surroundings. They are crucial for detecting obstacles and ensuring safe navigation for autonomous vehicles and drones.
3. **Ultrasonic Sensors**: Ultrasonic sensors emit sound waves and measure their reflection to detect nearby objects. They are often used for close-range obstacle detection.

Last Mile delivery is also important in transport management. In today's world, internet purchases account for a significant proportion of total purchases. This means that delivery lorries are extremely busy on our roads, creating a lot of traffic jams and pollution. To counter this, different means of transport are being used/developed to take up less space, be less polluting and be more flexible. The use of autonomous vehicles is such a case (e.g., Waymo (Phoenix)) which are cheaper (no human driver to pay) and more climate friendly (less CO_2 emissions). This case concerns mostly the transport of small packages. An example is the case of Starship[46] Technologies in Singapore where you can use one robot per house which is large enough to carry up to three bags of groceries without having to send a van with a human driver.

[45] https://www.oracle.com/scm/logistics/transportation-management/
[46] https://www.starship.xyz/

Other examples are the use of drones[47] as in the city of Hangzhou in China and the Walmart Drone[48] delivery (USA – areas of Texas, Arizona and Florida.)

1.5.10.2 Fleet management

Fleet management is a term used to describe the use of data analytics and technology (such as IoT sensors) in order to reduce costs, increase efficiency and improve customer satisfaction. By using IoT sensors to monitor vehicle performance and condition, fleet management can provide predictive analysis that allows fleets to keep up with demand changes before they happen. Also, by reducing the number of accidents due to low-maintenance engines or faulty tires, from lack of proper monitoring, these technologies significantly impact safety and cost savings for companies at any size.

Example of fleet management software: Verizon Connect Reveal

Fleet management refers to the comprehensive coordination, supervision, and optimization of a company's vehicle fleet. This includes various types of vehicles such as trucks, cars, vans, and for business operations. The main goal of fleet management is to enhance efficiency, reduce costs, and improve fleet productivity.

- Tracking and Optimization: Using GPS and telematics for real-time vehicle tracking, optimizing routes, and ensuring efficient scheduling.
- Maintenance Planning: Implementing proactive schedules for vehicle maintenance, including health monitoring, regular inspections, and prompt repairs to extend fleet lifespan.
- Fuel Efficiency: Monitoring and managing fuel usage through analysis, promoting efficient driving practices, and exploring sustainable fuel options to reduce costs.
- Driver Oversight: Overseeing driver behavior, safety, and compliance by monitoring habits, securing adherence to laws, and implementing training programs.
- Resource Maximization: Maximizing vehicle utilization through strategic planning to minimize downtime, idle time, and optimize routes for enhanced productivity.
- Regulatory Compliance: Ensuring fleet compliance with local, state, and federal regulations, including managing paperwork and licenses.
- Data-driven Analytics: Utilizing data and analytics tools to gain insights into fleet performance, identify areas for improvement, and make informed decisions for optimizing routes and reducing costs.

List of fleet management tools:

- BigChange[49]: Offers end-to-end solutions, including job management, vehicle tracking, and mobile workforce management.

[47] https://www.antwork.link/

[48] https://corporate.walmart.com/news/2022/05/24/were-bringing-the-convenience-of-drone-delivery-to-4-million-u-s-households-in-partnership-with-droneup

[49] https://www.bigchange.com/features

- Azuga[50]: Known for its GPS tracking and fleet management features, providing real-time insights to improve overall efficiency.
- TomTom[51]: Offers a comprehensive platform with mapping, navigation, and traffic solutions, essential for fleet route optimization.
- Intellishift[52]: Focuses on telematics and fleet management solutions, helping businesses enhance safety, compliance, and efficiency.
- GroundCloud[53]: Provides tools for dispatching, routing, and real-time tracking, facilitating smoother operations.
- BulkdataPro[54]: Specializes in data management for bulk commodities, ensuring effective logistics and supply chain operations.
- Linxio[55]: Offers GPS tracking and fleet management solutions with features like geofencing and driver behavior monitoring.
- TSO Mobile[56]: Provides a range of fleet tracking and management tools, including real-time location tracking and reporting.
- Civica[57]: Known for its fleet and asset management solutions, assisting organizations in optimizing resources and reducing costs.
- Wialon[58]: A versatile platform offering GPS tracking, fleet management, and asset tracking capabilities.
- Salesforce Maps[59]: Integrates with Salesforce to enhance field operations, route planning, and customer relationship management.
- Whip Around[60]: Focuses on vehicle inspection and maintenance management, ensuring compliance and safety.
- ClearPathGPS[61]: Offers real-time tracking, reports, and analytics to streamline fleet operations and improve productivity.
- Route4Me[62]: Specializes in route optimization, helping businesses plan the most efficient routes for their fleets.
- Fleet Complete[63]: A comprehensive solution covering GPS tracking, asset management, and field service automation.

[50] https://www.azuga.com/
[51] https://www.tomtom.com/solutions/fleet-management-logistics/
[52] https://intellishift.com/
[53] https://groundcloud.com/
[54] https://www.bulkdatapro.com/
[55] https://linxio.com/
[56] https://www.tsomobile.com/
[57] https://www.civica.com/en-gb/product-pages/transend-fleet-management-software/
[58] https://wialon.com/
[59] https://www.salesforce.com/products/sales-mapping-software/
[60] https://whiparound.com/
[61] https://www.clearpathgps.com/solutions/gps-fleet-management-solutions
[62] https://route4me.com/platform/route-optimization
[63] https://www.fleetcomplete.gr/

- PCS TMS[64]: Provides transportation management solutions, optimizing the planning and execution of freight movements.
- Motive[65]: Is a single, easy-to-use platform which include GPS Tracking, Smart Dashcams, ELD Compliance, Dispatch, Maintenance. It tracks vehicles, trailers, and equipment in real-time. Also, it identifies dangerous driving with AI detection and exonerate drivers with the Smart Dashcam.
- Track-POD[66]: Offers a delivery management platform with real-time tracking, proof of delivery, and route optimization.
- LogiNext Mile[67]: specializes in last-mile delivery optimization with features such as route planning and real-time tracking.
- Tookan[68]: offers a versatile delivery and field workforce management platform, allowing efficient task assignment and tracking across various industries.
- CalAmp[69]: Telematics solutions for fleet tracking, asset management, and supply chain visibility.
- The COSMOTE Fleet Tracker[70] service offers BSK, a prominent distribution and transport service provider, a robust solution for managing its corporate vehicle fleet. By leveraging Internet of Things (IoT) technology, BSK can track 360 of its vehicles in real-time. Telematics devices installed in the fleet provide information on vehicle location, speed, direction, and routes, accessible through a web interface or mobile app. BSK utilizes the integration with Power BI, enabling real-time analysis of data and informed decision-making. The system provides a comprehensive history of routes, aggregated data, and detailed reports on vehicle condition and driver behavior. This data-driven approach enhances efficiency, productivity, and safety for BSK, ultimately leading to reduced operating and transportation costs. The COSMOTE Fleet Tracker platform not only monitors location and movement but also records driving behavior, including speed, braking, and acceleration habits. Depending on the chosen financial plan, additional vehicle condition data, such as engine operation and battery voltage, can be accessed. The system further ensures driver and vehicle safety by automatically sending alerts in case of accidents or emergencies. Overall, the implementation of the COSMOTE Fleet Tracker service significantly contributes to BSK's operational excellence in fleet management.

Example of company using fleet management: UPS

Probes used for Fleet management**:**

1. **OBD-II (On-Board Diagnostics) Sensors**: OBD-II sensors can monitor a vehicle's performance, including engine health, fuel consumption, and emissions. They are often used for diagnostics and preventive maintenance.
2. **IoT Sensors**: Internet of Things (IoT) sensors can be used to monitor various aspects of the vehicle, such as engine performance, emissions, and vehicle health

[64] https://pcssoft.com/
[65] https://gomotive.com/products/#software
[66] https://www.track-pod.com/
[67] https://www.loginextsolutions.com/products/mile
[68] https://jungleworks.com/tookan/solutions/
[69] https://www.calamp.com/
[70] https://www.cosmote.gr/cs/otegroup/gr/bsk_fleet_tracker.html

3. **GPS, camera and RFID**

1.5.10.3 Stock management

Inventory management is important. Stocking goods is expensive. So you need software that can predict future demand, so you can respond better to demand.

Example of software:

1. Warehouse Management System (WMS): It is a category of software packages designed to manage warehouse operations. The primary purpose of the WMS is not to take orders, but to take them into account and optimize their preparation (spacefill, coglass). IoT data is transmitted to the WMS system from a multitude of locations, including handling equipment such as conveyor belts, smartphones and mobile terminals, passive radio beacons, RFID devices and so on.
   Example of WMS: Spacefill[71], Coglass[72]
   - Pulpo WMS[73]: Pulpo WMS is a German WMS that has expanded into the rest of Europe and the United States. It offers fast implementation and personalized pricing according to your requirements.
   - Peoplevox[74]: The British company Peoplevox is a well-known WMS software provider. Peoplevox provides customized software and therefore targets larger retailers with more complex warehouses. Peoplevox focuses on omnichannel retail and offers personalized solutions across different systems.
   - Boxwise[75]: Boxwise is a WMS that integrates very easily with ERP, Exact Globe or AFAS Profit. It ensures warehouse workers pick, pack and scan with confidence, and deliveries arrive at customers complete and on time.
   - iPacky[76]: iPacky is a WMS that helps speed up the fulfilment process. Warehouse workers spend less time picking and packing.
   - Descartes Pixi[77]: It automates internal and logistics processes, and optimizes omnichannel backend processes with the Descartes Pixi WMS. Pixi connects to existing webshop systems, ERP solutions and other IT system landscapes through API Web Services and standard interfaces.
   - Shiphero[78]: Shiphero's WMS simplifies the picking, packing and shipping processes in the warehouse. Also, it increases customer satisfaction and integrates easily with the best-known e-commerce systems.

[71] https://spacefill.eu/
[72] https://www.coglas.com/en/
[73] https://www.pulpowms.com/
[74] https://www.peoplevox.com/
[75] https://www.boxwise.nl/
[76] https://ipacky.com/
[77] https://www.descartes.com/about/investor-relations/acquisitions/descartes-pixi-ecommerce-wms
[78] https://shiphero.com/software/3pl-wms/

- Exact WMS[79]: Exact WMS is the Dutch market leader in business software. The Exact WMS digitizes physical flow of goods and optimizes logistics processes. Their WMS solution integrates seamlessly with their ERP and administrative programs.
- SAP WMS[80]: SAP WMS is a well-known international organization with extensive experience in supply chain management. Their WMS solution is comprehensive ERP software with special features for warehousing. It is dynamic and flexible, working with only essential dashboards and built-in KPIs.
- WebStock[81]: WebStock has more than 10 years of experience in warehouse automation. Their WMS is easy to use and has different modules for all kinds of businesses. WebStock helps companies track their stock locations and levels, and order placement and picking. The costs consist of a one-time purchase fee and an annual license. The license agreement includes support, updates and bug fixes.
- Increff WMS[82]: Increff offers a simple and efficient web-based multi-channel WMS, and 133 warehouses currently use it for their operations worldwide.
- BlueYonder[83]: Blue Yonder, now known as JDA Software after a merger, is a leading provider of end-to-end, AI-driven supply chain and retail solutions.
- Oracle Fusion Cloud Warehouse Management[84]: Oracle was also named a market leader in the 2022 Gartner Magic Quadrant for WMSs. Their Warehouse Management solution makes it easy to combine the benefits of the cloud with warehouse management functionality.
- WMS Manhattan[85]: It is best known for its supply chain and omnichannel e-commerce solutions, which combine information from across the entire organization. Their WMS is customized and used by major players such as Wehkamp, among others.
- Locus by Centric[86]: Centric's WMS is ideal for medium to large enterprises with warehouses operating in retail, wholesale, e-commerce, 3PL and manufacturing. Centric also focuses on other IT solutions, including cyber security, HR, risk management, implementations and migrations.
- Boltrics[87]: Boltrics is another major and well-known name. With many years of experience, they offer various customized solutions, with comprehensive solutions for stock keeping, receiving and shipping, and features for customs, production, scanning and transportation.

[79] https://www.exact.com/products/wholesale-distribution
[80] https://www.sap.com/products/scm/extended-warehouse-management.html
[81] https://www.webstock.ro/
[82] https://www.increff.com/omni-solution/warehouse-management-system/
[83] https://blueyonder.com/solutions/luminate-logistics
[84] https://www.oracle.com/scm/logistics/warehouse-management/
[85] https://www.manh.com/solutions/supply-chain-management-software/warehouse-management-system
[86] https://www.centric.eu/en/what-we-do/locus-wms-enriches-its-functionality-for-simon-loos-benefiting-the-entire-3pl-sector/
[87] https://www.boltrics.com/en/

- Picqer[88]: Dutch company Picqer captured a large market share in the Netherlands within a short period of time, and currently processes 8% of all the country's online orders. Their solution is cloud-based and focuses specifically on webshops. Picqer believes in easy-to-use software and therefore benefits from a very intuitive user interface and features.
- Goed Gepickt[89]: GoedGepickt is a cloud-based software from the Netherlands aimed at online retailers who run their own warehouse(s). The company is committed to a user-friendly product with a modern look and feel. In addition to processing orders, creating purchase orders, configure automatic actions to further automate workflow, and easily process returns.
- BizBloqs[90]: BizBloqz is an all-inclusive WMS solution specifically for SMEs. This Dutch provider uses a platform that allows any logistics scenario to be realized without coding.
- Sherpaan[91]: Sherpaan has been helping ambitious Dutch e-commerce companies to set up and optimize their webshop back offices for more than 14 years already. Their software allows you to set up a warehouse efficiently, work error-free and ship more orders in much less time. It is also accessible for specific customized and more challenging applications.
- Ceyenne WMS – Diract[92]: The Ceyenne WMS solution from Dutch company Diract is particularly suitable for larger webshops offering multiple shipping options or working with multiple carriers. Their software is fully customized, flexible and scalable, and can be deployed in a variety of industries.
- Microsoft Dynamics 365 Supply Chain Management[93]: It is an integrated suite of applications within the broader Microsoft Dynamics 365 platform, specifically tailored to meet the needs of supply chain and manufacturing operations.
- Körber's Supply Chain[94]: Gives software and automation solutions and the necessary expertise for seamless process and system integration of software components, equipment and agents along the complete supply chain.

2. Demand Forecasting Software: Software that can predict future demand of goods.
   Example: SAS[95] Forecasting, Blue Yonder[96]
3. Inventory Optimization: Inventory Management Software for setting optimal stock levels and reorder points.
   Example: SAP Inventory Management, Cin7[97]

[88] https://picqer.com/en
[89] https://www.goedgepickt.nl/
[90] https://www.bizbloqs.com/
[91] https://sherpaan.nl/
[92] https://www.diract-it.com/ceyenne-suite/
[93] https://www.microsoft.com/en-us/dynamics-365/products/supply-chain-management
[94] https://www.koerber.com/en/supply-chain
[95] https://www.sas.com/
[96] https://blueyonder.com/
[97] https://www.cin7.com/

Supply Chain Planning (SCP) Systems: End-to-end supply chain planning solutions that include inventory optimization modules.

Example: Kinaxis[98] RapidResponse

1.5.11 Onboard software components (sensors & transport means- e.g., on-board data collection, fusion, image processing, event management etc.)

Tracking the location of your fleet and monitoring a driver's behavior is a must in modern fleet management platform solutions. The vehicle's OBD port provides the best place to connect an OBD telematics vehicle tracker to provide location data for each vehicle, capturing driver behavior metrics and vehicle metrics.

1.5.11.1 Tools and Products (Software/Hardware)

Telematics and GPS Tracking Systems:

- **Geotab[38]:** is an open platform for fleet management. It connects and manages assets via the Geotab GO[39] tracking device. Geotab GO device is plugged into the vehicles' OBD II port. With its ability to use GPS fleet tracking, vehicle locations can be viewed in near real time along with a complete trip's history. Geotab platform security provides end-to-end data protection. Security methods include authentication, encryption, message integrity verification, unique ID and non-static security keys, over-the-air updates that use digitally-signed firmware to verify that updates come from a trusted source. Device security features are implemented using a FIPS 140-2 validated cryptographic module.
- **Samsara[40]:** is a complete platform for fleet management and logistics. It connects and manages assets via the Vehicle Gateway device. The Vehicle Gateway[41] provides live GPS tracking, FMCSA-registered ELD capabilities, engine diagnostics, a built-in WiFi hotspot, driver workflows, advanced analytics, and more.
- **Teletrac Navman[42]:** is a fleet management software (TN360). It uses a wide range of tracking devices[43] based on the use (internal or external to the vehicle) and the category of the vehicle (truck, cars, heavy equipment, etc).
- **Fleet Management Software:** apart from the above other fleet management software are Fleet Complete, Verizon Connect and KeepTruckin.
- **Electronic Logging Devices (ELDs):** digitally record a driver's Record of Duty Status (RODS), replacing paper logbooks. These are software that a driver uses in order to log it's routing, it's physical situation and it's duty status. Indicative examples are Omnitracs[44], Garmin[45] and EROAD[46].
- **Load Management Software:** In order to provide the best load planning in transportation fleet there are software for this to perform the optimal cargo loading. Indicative example of such software is Cargo Planner.
- **Maintenance and Diagnostics Tools:** OBD-II diagnostic tools and platforms like Fleet Complete's Maintenance Management[47].

[98] https://www.kinaxis.com/en/solutions/platform

1.5.12 Onboard communications

Based on the architecture of vehicular networks there are two mandatory components; smart vehicles and infrastructures. Communication in vehicular networks is executed either Vehicle-to-Vehicle (V2V) or Vehicle-to-Infrastructure (V2I) (Salwani Mohd Daud et al., 2021)[48]. For the vehicles, there is a need to include onboard units (OBU) to communicate with each other and with any assistive roadside units (RSU).

1.5.12.1 Tools and Products (Software/Hardware)

The equipment for performing a V2V or V2I communication includes an on-board unit (an embedded device such raspberry pi or jetson nano or even a mobile handset) or a roadside unit (an embedded device) which should be connected with a communication module (i.e., DSRC module). In the case of using an embedded platform as an embedded device then through its Wi-Fi access point the data can be displayed to a mobile handset. A dedicated software should translate the messages received from the DSRC module and an application should visualize the results to the driver.

Dedicated Short-Range Communications (DSRC) is a wireless communication technology that enables vehicles to communicate with each other directly, without involving cellular or other infrastructure. DSRC is based on WiFi technology. DSRC is used for Vehicle-to-Vehicle and Vehicle-to-Infrastructure communications, and it provides support for various Intelligent Transportation System applications and services such as road safety applications, infotainment services, messaging, and road-weather information (Sherali Zeadally et al., 2020)[49]. DSRC has been designed in the form of maximal cyber security as the receiving vehicle validates the authenticity of the received messages. Messages sent through DSRC do not reveal the identity of the vehicle, thus ensuring the protection of the driver's privacy. Key features of DSRC are the use in a Non-Line-Of-Sight, support speeds 250km/h and communication range 300m.

However, DSRC is not the only option. C-V2X cellular communication is another contender that it allows both direct and indirect communication. In direct C-V2X, vehicles communicate directly in V2V and V2I in the same way as DSRC. In indirect C-V2X, vehicles communicate with other entities indirectly via the cellular network (V2N), which is something DSRC cannot do.

LACROIX[50] provides a complete series of equipment to support V2V and V2I communication. The V2V unit supports a variety of hardware interfaces such as DSRC V2X double channel, C-V2X 5G, GNSS, Cellular 3G/4G, Wifi (optional) and Bluetooth (optional).

Huawei also has equipment for the V2I communication for roadside units as LTE-V RSU5201[51].

1.5.13 Cybersecurity

Data on inventory, delivery and arrival times, and locations can be characterized as valuable in the chain of transportation and logistics. The digitization of these operational data exposes them to cyber-attacks. Transportation services rely on cyber technologies that include positioning, navigation, tracking, shipment routing, access controls and signalling communications. Consequently, transportation companies being increasingly dependent on cyber systems may allow malicious users to be involved in the chain of their operations.

1.5.13.1 Tools and Products (Software/Hardware)

To strengthen the network communication between devices the use of a machine-to-machine network protocol for message queuing is needed. Some representative technologies are as follows:

- **HiveMQ**[52]: is a complete enterprise Message Queuing Telemetry Transport (MQTT) platform that connects devices via open-source MQTT clients. It uses HiveMQ Edge[53] to convert proprietary industrial protocols to MQTT, and integrate data with existing streaming services, databases and IT systems. MQTT is an extremely simple and lightweight messaging protocol (subscribe and publish) designed for limited devices and networks with high latency, low bandwidth or unreliable networks. It is designed for connections with remote locations that have devices with resource constraints or limited network bandwidth, such as in the Internet of Things (IoT). To install HiveMQ MQTT Broker, you need Windows, Linux, or Mac OS X with Java Runtime Environment 11. Minimal hardware requirements are: at least 4 GB of RAM, 4 or more CPUs and 100 GB or more free disk space.
- **Eclipse Mosquitto**[54]**:** is an open source message broker that implements the MQTT protocol. Mosquitto is lightweight and is suitable for use on all devices from low power single board computers to full servers. Mosquitto is highly portable and available for a wide range of platforms (i.e, Linux, Windows and MAC).
- **RabbitMQ**[55]**:** is an open-source message-broker software that originally implemented the Advanced Message Queuing Protocol (AMQP) and supports streaming protocols as the Streaming Text Oriented Messaging Protocol (STOMP) and the MQ Telemetry Transport (MQTT).

1.5.14 VR-based and other types of GUIs and remote-support for transportation (e.g., for drivers, remote control of vehicles)

There are several ways to monitor and support different means of cargo transportation nowadays. Usually, the use of a Transport Management Systems (TMS), which is software based, enables operators to plan and manage their vehicle fleet. Another way to monitor and support a vehicle is Virtual Reality (VR), which is a simulation on a three-dimensional environment and behaves similarly to a real environment through electronic equipment. VR is being applied today in many different sectors such as health, education, content creation, entertainment, culture, scientific research etc.

In the transportation sector VR is being used for training drivers of trucks and trains from a transportation company (i.e., UPS[56]). Furthermore, VR can be used for increasing the safety and efficiency for path planning of an unmanned vehicle as stated by J Paterson[57] or even the supervision of robotic systems aimed at a stock warehouse for automated inventory management as presented by I. Kalinov[58].

To achieve the above applications, the use of specific hardware and software is needed to build the desired virtual environment in the sense of view and feeling from a person.

1.5.14.1 Tools and Products (Software/Hardware)

For the creation of a VR environment there are two major and well-known real-time development platforms being used: Unity[59] and Unreal Engine[60].

Unity is a cross-platform game engine developed by Unity Technologies. It is based on C# (C sharp) language and used for 2D and 3D rendering, simulations etc. It is not open source. It is easy to learn with

an intuitive interface. Unity provides support for many gaming platforms such as PCs (Windows, macOS, Linux), game consoles (Xbox, PlayStation), mobile devices, as well as VR platforms like PlayStation VR and Oculus.

Unreal Engine is a series of 3D computer graphics game engines developed by Epic Games. It is based in C++ language and used for 3D rendering. It is an open-source and supports Augmented Reality (AR), Mixed Reality (MR), and VR.

The rendered application in one of the above engines should be rendered on a head-mounted display. Examples of such displays are Oculus quest 2 and htc vive pro.

- **Oculus quest 2 specs:** LCD Screen with 1832 x 1920 Resolution Per Eye, 90Hz refresh rate, tracking system 6 degrees of freedom (6DOF) with 2 x Front-Facing with Pass-Through and 2 x Side-Facing cameras, Bluetooth is supported, and headset includes Processor, RAM and internal storage for making the use of a PC optional.
- **htc vive pro specs:** Dual AMOLED 3.5" diagonal Screen with 1440 x 1600 pixels per eye, 90Hz refresh rate, Sensors (SteamVR Tracking, G-sensor, gyroscope, proximity, Eye Comfort Setting), USB-C & Bluetooth for peripherals. Needs a connection to a PC to operate.

Depth sensors: Several depth sensors exist for capturing motion tracking and spatial mapping. The quality and accuracy of depth maps from Azure kinects[61] and ORBBEC[62] are considered as the best in the market.

Azure kinects is a cutting-edge spatial computing developer kit with sophisticated computer vision and speech models, advanced AI sensors, and a range of powerful SDKs that can be connected to Azure AI Services.

ORBBEC family camera sensors leverage depth perception, spatial mapping, motion tracking, volumetric data capture, and real-time depth sensing to create immersive experiences, precise measurements, and advanced visualizations.

1.5.15 Relevant Standards

The most relevant standards in transport logistics operations, including **data** and **storage** standards, are as follows: EN 13011: 2000, CEN/TR 14310: 2002, EN 13876:2002, EN 12507: 2005, EN ISO 9001:2000, EN 12798:2006, EN 15696:2007, ISO/AWI 20850, EN 12834:2003 EN 12795:2003 and EN 12253:2004

EN 13011: 2000. This European Standard outlines the requirements for making declarations regarding the quality of performance in goods transport services. It aims to provide a framework for service providers to present specific data on the performance criteria relevant to the service being offered. This information will enable shippers and packers to plan their needs effectively and fulfil their obligations under the Packaging Waste Directive. However, this European Standard does not set specific performance standards. Annex A provides an example of a suitable form of declaration. [63]

CEN/TR 14310:2002. This European Pre-standard is a guideline for preparing environmental declarations and reporting. The guideline recommends the content and structure for documenting and evaluating

environmental performance in **freight transportation**. The guideline is applicable to freight transport purchasers and freight transport operators. Reliability and trustworthiness are essential to the use and acceptance of eco-reporting. When specific data is not available, it is therefore paramount to use commonly acknowledged data. The calculations and results should be presented in a transparent and true way that aids the evaluation of the environmental performance of a given freight transport. As a rule of thumb, it can be said that when the method used for calculating the energy consumption and emissions for one customer is extended to all the customers of a transport company, then all transport-related energy consumption and emissions from that transport company should be accounted for.[64]

EN 13876:2002. This European Standard specifies in the form of a "Code of Practice" the management controls and key performance indicators necessary for the effective and efficient management of customer's cargo throughout the transport process. It is intended for use by the providers of the service and as general guidance by purchasers of such services (customers) and it defines the principles, best practices and obligations of the provider as well for the client as providing advice with regard to contribution by the customer that will facilitate the most effective outcome. In addition, this Code of Practice strongly recommends that the service provider carry out regular self-assessment of performance against defined criteria with the objective of continually improving the quality of services provided and is prepared in a manner which facilitates independent audit of the service provider's performance in order to give confidence to customers that the integrity of performance measurement is maintained. Annex A contains a recommended procedure for "Self Assessment"[65].

EN ISO 9001:2000. This standard specifies the requirements for a quality management system that enables an organization to demonstrate its ability to consistently provide products that meet customer and applicable regulatory requirements. It also aims to enhance customer satisfaction through the effective implementation of the system, including processes for continual improvement and ensuring conformity to customer and regulatory requirements. The requirements of this International Standard are generic and intended to be applicable to all organizations, regardless of their type, size, or the products they provide.[66]

EN 12507: 2005. This European Standard provides guidelines for applying EN ISO 9001, Quality management system, to the provision of freight transportation services by road and rail, including storage and distribution activities.[67]

SSH EN 12798:2006. This European Standard specifies quality system requirements, supplementary to those of EN ISO 9002, for the management of safety in the field of the transport of dangerous goods by road, rail and inland navigation. Its application covers, and is limited by, the range of transport-related services that the company claims to provide in compliance with this European Standard.[68]

SSH EN 12798:2007. This European Standard specifies quality management system requirements, supplementary to those of EN ISO 9001:2000, for the management of safety in the field of the transport of dangerous goods by road, rail and inland navigation. Application of this document covers, and is limited to, the range of transport-related services that a company claims to provide in compliance with this European Standard.[69]

EN 15696:2007. This European Standard specifies requirements for the provision of self-storage facilities and related services, for both personal and business purposes.[70]

CSN EN 16258. Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers) [71].

ISO/AWI 20850. This standard specifies the supply chain interoperability and integration coping with strategic sourcing concepts, principles, and data requirements.

- *In scope*: terminology required to describe the workflow and data used in the strategic sourcing process;
- *stages:* Stages of the strategic sourcing process;
- data required to support the strategic sourcing process;
- metadata and reference data required to support the strategic sourcing process.

EN 12834:2003 EN 12795:2003 and EN 12253:2004

Standards for road transport and traffic telematics based on the Dedicated short-range communication (DSRC) Standards (EN 12253, EN 12795 and EN 12834) which together form a three-layered architecture for DSRC, are designed to encompass a wide range of services for different purposes to make the basic DSRC architecture suited for many different applications and for a wide range of possible products and systems. This standard:

- Specifies a physical layer at 5,8 GHz for DSRC as applicable in the field of Road Transport and Traffic Telematics (RTTT).[72]
- Provides requirements for the communication medium to be used for the exchange of information between **road-side units** (RSU) and **on-board units** (OBU).[73]
- Caters for communication means to be used by several applications in the RTTT sector.[74]

Communication Standards [COSMOTE]

Communications play a crucial role in the support of data collection in the field. Some representative protocols are as follows:

TS 22.185	Service requirements for V2X services - 22.185[99]
TS 22.186	Service requirements for enhanced V2X scenarios - 22.186[100]
TR 22.885	Study on LTE support for Vehicle-to-Everything (V2X) services – 22.885[101]
TR 22.886	Study on enhancement of 3GPP support for 5G V2X services – 22.886[102]

KPIs defined by SDOs & Industry Initiatives for V2X/ CAM/ logistics use cases.

3GPP defines V2X KPIs in TS22.185 & V2X Services in TR 22.885. V2X application categories:

- Vehicles Platooning
- Advanced Driving (semi-automated or fully automated driving)
- Extended Sensors enabling vehicles obtain awareness of local situation
- Remote Driving
- Vehicle Quality of Service Support (adaptability of service depending on network conditions)

[99] https://www.3gpp.org/dynareport/22185.htm
[100] https://www.3gpp.org/dynareport/22186.htm
[101] https://www.3gpp.org/dynareport/22885.htm
[102] https://www.3gpp.org/dynareport/22886.htm

5G Automotive Association (5GAA[103]) is a global, cross-industry organization of companies from the automotive, technology, and telecommunications industries (ICT). 5GAA V2X Use Cases categories:

- Safety
- Vehicle Operations Management
- Convenience
- Autonomous Driving
- Platooning
- Traffic Efficiency and Environmental Friendliness
- Society and Community

5GAA analyses an all-encompassing set of V2X UCs, considering 5G not only for V2N but also for V2V and V2I reliable message exchanging. There is correspondence between 5GAA & 3GPP categories.[75]

BEREC, the Body of European Regulators for Electronic Communications, has identified 5G as a strategic priority acknowledging in the Annual 2021 Report that all urban areas and all major terrestrial transport paths are to have uninterrupted 5G coverage towards the 2030 Digital Compass, aiming for coverage of the entire populated areas by 2030.

We also consider the following references - standards:

1. 3GPP TS 23.286 version 16.4.0 Release 16, Application layer support for Vehicle-to-Everything (V2X) services; Functional architecture and information flows.[76]
2. 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to Vehicle-to-Everything (V2X) services", [77]
3. 3GPP Release 17 Description; Summary of Rel-17 Work Items, [78]
4. TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3", [79]
5. 3GPP TS 23.434: "Service Enabler Architecture Layer for Verticals; Functional architecture and information flows"
6. 3GPP TS 24.486 version 16.1.0 Release 16 Vehicle-to-Everything (V2X) Application Enabler (VAE) layer, [80]
7. 3GPP TS 29.486: "V2X Application Enabler (VAE) Services; Stage 3", [81]
8. 3GPP TS 22.185 version 14.3.0 Release 14 Service requirements for V2X services, [82]
9. 3GPP TS 22.186 version 16.2.0 Release 16 Service requirements for enhanced V2X scenarios [83]
10. 3GPP TR 22.885 V14.0.0 (2015-12), Study on LTE support for Vehicle to Everything (V2X) services (Release 14)
11. 3GPP TR 22.886 V16.2.0 (2018-12), Study on enhancement of 3GPP Support for 5G V2X Services (Release 16)
12. TRIALS AND PILOTS FOR CONNECTED AND AUTOMATED MOBILITY, [84]
13. A visionary roadmap for advanced driving use cases, connectivity technologies and radio spectrum needs, November 2022,[85]

1.6 Relevant Projects

In this paragraph, 20 EU projects are selected on the basis of the potential synergies with the main TRACE topics.

[103] https://5gaa.org/about-us/

Table 2: List of relevant research projects

Project	Eu Programme	Year	Brief description	Link
Synchro-modal Supply Chain Eco-Net	Horizon 2020	2015-2018	The core of the SYNCHRO-NET solution will be an integrated optimisation and simulation eco-net, incorporating: real-time synchro-modal logistics optimisation (e-Freight-enabled); slow steaming ship simulation and control systems; synchro-modal risk/benefit analysis statistical modelling; dynamic stakeholder impact assessment solution and a synchro-operability communications and governance architecture.	https://cordis.europa.eu/project/id/636354
ePIcenter	Horizon 2020	2020-2023	The ePIcenter project intends to develop and test AI driven logistic software solutions, new transport technologies and supporting methodologies to increase the efficiency of global supply chains and reduce their environmental impact. On focus is dedicated to optimisation, using new data and emerging technologies in a smart way, developing AI algorithms and simulation techniques that can optimise the real-life logistics and synchromodal planning processes end users are facing daily.	https://epicenterproject.eu/about-the-project
Disco	Horizon Europe	2023-2026	DISCO will develop and demonstrate - in real-life conditions - a federated European urban freight (UF) data space as one stop shop of data sharing on digital urban logistics solutions and smart tools for ambitious decision making. It will be a continental Ten-T – oriented and distributed real-life ecosystem to prove its value via demonstrated and replicable Use Cases (UCs), build upon innovation drivers to code concrete transformation of urban planning and land use by an open and collaborative UF Data Space with a smart governance model.	https://cordis.europa.eu/project/id/101103954
ReMuNet	Horizon Europe	2023-2026	ReMuNet has the mission to revolutionize European freight transport through synchromodal relay-transportation. ReMuNet identifies and signals disruptive events and assesses their impact on multimodal transport corridors. It reacts quickly and seamlessly upon disruptive events in real-time. It supports TMS-	https://cordis.europa.eu/project/id/101104072

Project	Eu Programme	Year	Brief description	Link
			providers to improve route planning resilience. ReMuNet communicates alternative, pre-defined, multimodal transport routes to logistics operators and subsequently to truck drivers, locomotive drivers and barge captains. Through this, it enables a faster and adaptive multimodal network response. ReMuNet orchestrates route utilization, suggests transshipment points and optimizes capacity allocation, minimizing damage and shortening the recovery time.	
Logistar	Horizon 2020	2018-2021	Logistar project is aimed at allowing effective planning and optimizing of transport operations in the supply chain by taking advantage of horizontal collaboration relying on the increasingly real-time data gathered from the interconnected environment. For this, a real-time decision-making tool and a real-time visualization tool of freight transport were developed, with the purpose of delivering information and services to the various agents involved in the logistic supply chain.	https://logistar-project.eu/
Selis	Horizon 2020	2016-2019	Selis project worked on delivering a 'platform for pan-European logistics applications' by embracing a wide spectrum of logistics perspectives and creating a unifying operational and strategic business innovation agenda for pan European Green Logistics. The second objective was to establishing an exceptionally strong consortium of logistics stakeholders and ICT providers, that can leverage EU from over 40 projects so as to create proof of concept Common Communication and navigation platforms for pan-European logistics applications deployed in 8 living labs representing the principal logistics communities.	https://selis project.eu/
Cristal	Horizon Europe	2023-2026	The CRISTAL project focuses on the development of inland waterway transport (IWT) and its infrastructure on smaller and commercially undeveloped feedwater routes. They are key to expanding Europe's waterway system. The	http://www.cristal-project.eu/

Project	Eu Programme	Year	Brief description	Link
			project contains an activity related to synchromodal resource planning and cooperative operations preparation integrated to the synchromodal corridor management system.	
MultiRELOAD	Horizon Europe	2022-2025	MultiRELOAD project focusses on the specific role and challenges of inland terminals as multimodal freight nodes in reducing GHG emissions through shifting inland road flows to rail and inland waterways by increasing operational efficiency, safety and reliability of inland infrastructures through digitalization. MultiRELOAD envisions to enhance the collaboration between the intermodal logistics nodes in Europe to test innovations and propose favorable market solutions for strengthening the use of multimodal freight transport. It will enable an increase in operational efficiency through data sharing between actors within and between nodes. The ambition is to reach sustainability and terminal transshipment efficiency at nodes and corridors, by optimizing the use of assets and infrastructures.	https://www.multireload.eu/
SEAMLESS	Horizon Europe	2023-2026	SEAMLESS project aims at developing and adapting missing building blocks and enablers into a fully automated, economically viable, cost-effective, and resilient waterborne freight feeder service for Short Sea Shipping and Inland Waterways Transport. Autonomous systems will be integrated to ensure safe, resilient, efficient, and environmentally friendly operation to shift road freight movements to hinterland waterways. The services will rely on a redesigned logistics system enabling seamless freight flows by minimizing delays at intermodal nodes. A digital bird's-eye view of the supply chain allows the exploitation of real-time information for planning optimization and reconfiguration to support resilient logistics, included digitalized administrative procedures.	https://www.seamless-project.eu/

Project	Eu Programme	Year	Brief description	Link
FRONTIER	Horizon 2020	2021-2024	The FRONTIER project empower a seamless transition to a new era in transport management. Different cutting-edge systems and solutions are being leveraged to create the ultimate integrated network and traffic management systems, that will favour driverless automation, seamless transfer among different modes of transport, better collaboration among different stakeholders, reduction of accidents and transport emissions. A focus was dedicated to the synchromodality and in particular to an analysis of the three-pillar foundation: operational-technical, technological (data sharing in particular), and behavioural-organisational.	https://www.frontier-project.eu/ https://www.frontier-project.eu/blog/synchromodality-how-frontier-can-help-modal-shift-freight-transport
Senator	Horizon 2020	2020-2024	SENATOR aims to create a new urban logistic model for enhancing the sustainability of cities. For this purpose, the project will develop a smart network operator, as a control tower supported on an ICT Platform that will work as a support tool for decision making, integration and planning of all logistics operations. In consequence, it will minimize the negative impacts that this distribution causes in the cities and will constitute an effective means of collaboration between agents (citizens, operators, transporters and administrations).	https://www.senatorproject.eu/
RAD-AUTO-NOM	Funded by German Federal Ministry of Transport and Digital Infrastructure (BMVI)	2019-2022	The aim of the project is to examine the upcoming challenges for cycling in cities in interaction with emerging autonomous vehicles and to develop possible solutions. A holistic perspective is taken, which takes into account urban traffic and technical concerns. The main sub-goals are (1) traffic science methods for identifying and avoiding conflicts between cyclists and autonomous vehicles (2) urban planning concepts for the design of bicycle traffic facilities in urban environments with autonomous vehicles, (3) technical systems for detecting and predicting the movement of	https://www.mobilitaetsforum.bund.de/DE/Themen/Wissenspool/Projekte/Projektbeispiele/Projekte/21510_konzepte_zur_integration_des_ra

Project	Eu Programme	Year	Brief description	Link
			cyclists in autonomous vehicles based on machine learning methods and (4) simulation tools and studies for evaluating the interplay of planning and technical approaches.	dverkehrs.html#vt-sprg-5
SETO	Horizon 2020	2023-2026	SETO creates a digital Platform that collects and integrates data from the broadest possible range of sources, providing easy access to information related to specific regulations. The Platform will ensure data security by implementing the most recent industry standards and utilising blockchain technology. This will result in an innovative, efficient, consistent, and resilient enforcement support system available in multimodal and cross-border contexts. Through the implementation of its solutions, SETO aims at contributing to a competitive and fairer transport market. The goals are optimising the use of human and economic resources and leading to broader impacts. The Platform will be validated in real-life scenarios, with the direct involvement of relevant stakeholders and promoting 'soft enforcement' approaches resulting in a compliant-by-default.	https://setoproject.eu/
SAFE 10 T – Safety of Transport Infrastructure on the TEN-T Network	Horizon 2020	2017-2020	The SAFE-10-T project has developed a Safety Framework to ensure high safety performance while allowing longer life-cycles for critical infrastructure across the road, rail and inland waterway modes. The SAFE-10-T project will provide a means of virtually eradicating sudden failures. This has been achieved by: a) Safety framework incorporates remote monitoring data stored in a BIM model; b) Algorithms incorporate machine learning to train the system to evolve with time using available monitoring data; c) Trans-disciplinary approach; d) Demonstration projects at critical interchanges and nodes of the TEN-T transport network.	https://www.safe10tproject.eu/
Transforming Transport	Horizon 2020	2017-2019	The Transforming Transport (TT) project will demonstrate, in a realistic, measurable, and replicable way the transformations that Big Data	https://cordis.europa.eu/project/id/731932

Project	Eu Programme	Year	Brief description	Link
			will bring to the mobility and logistics market. To this end, TT, validates the technical and economic viability of Big Data to reshape transport processes and services to significantly increase operational efficiency, deliver improved customer experience, and foster new business models. TT will address seven pilot domains of major importance for the mobility and logistics sector in Europe.	
ADMIRAL	Horizon Europe	2023-2026	ADMIRAL project aims to have a systemic socio-technical approach. The vision of ADMIRAL is to change the mindset to take the emission level minimization as the main target by providing tools for companies. The main result is the Admiral marketplace, which manages the whole supply chain infrastructure and related emissions. It also works as a channel for developers to distribute innovative and sustainability-focused solutions in EU. ADMIRAL is focusing on the following objectives: 1) Evolve seamless operation within supply chains; 2) Enable better utilization of current assets and infrastructure to decrease emissions; 3) Embrace systemic change towards sustainability with sustainable sourcing; 4) Develop and pilot solutions that have altogether energy and emission reduction potential. The marketplace will also work as an innovation platform for new services, as software and solution developers have clear guidelines to include the invented services to be available on the platform. The marketplace will improve the value of the B2B logistic platforms.	https://cordis.europa.eu/project/id/101104163
SYNCHROMODE	Horizon Europe	2023-2026	SYNCHROMODE aims to develop data driven ICT tools for improving the management of transport operations from a multimodal perspective and managing the overall transport network as a whole. SYNCHROMODE will provide to transport managers new predictive and network optimization capabilities for	https://cordis.europa.eu/project/id/101104171

Project	Eu Programme	Year	Brief description	Link
			balancing the transport supply and demand, and capable of reacting to different types of events. The project will research in transport network supply& demand modelling, simulation and prediction of future states; optimization techniques for multimodal traffic optimisation, standards for data collection and storage; new governance models in transport management and new approaches for defining KPI for assessing the overall solution. SYNCHROMODE will deliver a suite of services for improving the overall transport network management, fostering the coordination of different agents involved in the provision and control of the transport services.	
UNCHAIN	Horizon Europe	2023-2026	UNCHAIN will implement a standardised and reliable data exchange ecosystem supported by a public-private collaborative framework that will allow the establishment of reliable data sharing agreements, break data silos and make the urban freight data more available and accessible. Driven by the unlocked data, an innovative set of 12 urban logistics services will be implemented to optimise the allocation of urban space, improve the policy-making capacity of local authorities and optimise network management and logistics operation. With UNCHAIN, public authorities will improve their data collection capabilities and have the right tools to achieve sustainability goals. Meanwhile, for operators, having services aligned with their own and society's objectives will unlock mutually beneficial cooperation schemes, a key factor for long-term collaboration and the establishment of sustainable urban freight transport policies and operations.	https://cordis.europa.eu/project/id/101103812
DELPHI	Horizon Europe	2023-2026	DELPHI focuses on the strategic dimension of integrating passenger and freight transport in a single system aiming to deliver the enablers - both on technical and governance/regulatory	https://cordis.europa.eu/project/id/101104263

Project	Eu Programme	Year	Brief description	Link
			level, towards a federated network of platforms for multimodal passenger and freight transport, capable of sharing in a seamless and secure manner, cross-sectoral, multi-modal passenger and freight transport data, as well as traffic management systems information. Moreover, DELPHI will utilise novel and ultra-efficient methodologies for traffic monitoring such as UAS-powered monitoring, multi-/inter-modal optimisation, AI/ML-powered algorithms and frameworks, and will exploit diverse modes for hybrid passenger and freight transport in different ecosystem types. To achieve its maximum potential, utmost interoperability and best optimisation results, DELPHI's digital framework and transversal tools will be validated in the context of 4 pilots with complementary requirements and features.	
ACUMEN	Horizon Europe	2023-2026	Ai-aided deCision tool for seamless mUltiModal nEtwork and traffic managemeNt (ACUMEN) proposes a generic, privacy-preserving, data-driven modular digital paradigm for advanced network management, which aims at enabling efficient and reliable door-to-door journeys for people and goods, increased safety and resilience at the network level. The main concept developed in ACUMEN is a modular, multi-layered Digital Twin (DT), a high-fidelity representation of integrated and interacting real complex systems, ultimately forming a digitised version of seamless and sustainable, connected urban mobility. This is complemented by plug-in modules, or digital tools, which represent the outcomes of the models, data (including that generated via AI/ML approaches using said models), and simulation tools at the disposal of a city/road authority/mobility service provider. AI-powered digital tools supporting mobility management and decision-making, exploiting the modular DT architecture, will be developed.	https://cordis.europa.eu/project/id/101103808

Project	Eu Programme	Year	Brief description	Link
			The DT platform will be demonstrated and validated through a set of comprehensive and carefully selected use cases.	
STORM	Horizon 2020	2021-2023	STORM project aims to study transformation and structural changes in freight and logistics business structures from different perspectives, focusing on the future challenges and needs of the sector by developing new methods and tools to support digitalization, sustainability transition, and future policy needs. STORM output will be a toolbox bringing together tools and methods centring on Big Data, data fusion, and agent-based modelling applied to electrified freight transport concepts and new collaborative, digitised logistics systems. It responds to the emerging needs of transport researchers, planners, and policy makers and it will generate knowledge for the implementation of innovative transport policies.	https://cordis.europa.eu/project/id/101006700
ULaaDS	Horizon 2020	2020-2024	ULaaDS project sets out to offer a new approach to system innovation in urban logistics. Its vision is to develop sustainable and liveable cities through re-localisation of logistics activities and re-configuration of freight flows at different scales. Specifically, ULaaDS will use a combination of innovative technology solutions (vehicles, equipment and infrastructure), new schemes for horizontal collaboration (driven by the sharing economy) and policy measures and interventions as catalysers of a systemic change in urban and peri-urban service infrastructure.	https://cordis.europa.eu/project/id/861833

1.7 Logistics Framework and Associations

The following Table reports on frameworks and associations that are relevant to the TRACE objectives (1: less relevant to 4: highly relevant). Annex A provides a more analytical view on the frameworks/associations.

Table 3: List of associations and relevant frameworks

Association	Association/ Framework	Target Audience	Website	Relevance
ACEA - European Automobile Manufacturers' Association	Association	Manufacturers / Suppliers	https://www.acea.auto/	2
AEDTF - European Association for the Development of the Railway Transport	Association	Carriers and agents	http://www.aedtf.org/	2
AEL - Alliance for European Logistics	Association	Governmental agencies, policy makers and public authorities	https://www.logistics-alliance.eu/	4
AET - Association for European Transport	Association	Service end users (logistics industries)	https://aetransport.org/	4
AGEPOR - Associação dos Agentes de Navegação de Portugal	Association	Governmental agencies, policy makers and public authorities	http://www.agepor.pt/index.php?mig=1	2
ALICE - Alliance for Logistics Innovation through Collaboration in Europe	Association	Academia, research and other projects	https://www.etp-logistics.eu/	4
ASBAC - Association of Shipbrokers and Agents of Croatia	Association	Governmental agencies, policy makers and public authorities	https://www.asbac.hr/	2
ASCM - Association for Supply Chain Management	Association	Service end users (logistics industries)	https://www.ascm.org/	3
ASECOB - Asociación Española de Consignatarios de Buques	Association	Carriers and agents	https://asecob.org/nosotros/	2
ASLOG - Association francaise pour la logistique	Association	Carriers and agents	https://www.francesupplychain.org/en/	3
AUVSI* - Association for Uncrewed Vehicle Systems International	Association	Application developers	https://www.auvsi.org/	3
BASBA - The Bulgarian Association of Ship Brokers and Agents	Association	Carriers and agents	https://www.basba.eu/en/	2
BDVA/DAIRO - Big Data Value Association	Association	Application developers	https://www.bdva.eu/	4
BIMCO - The Baltic and International Maritime Council	Association	Service end users (logistics industries)	https://www.bimco.org/about-us-and-our-members	2
CAD - Connected and Automated Driving	Association	Academia, research and other projects	https://www.connectedautomateddriving.eu/	4
CEDR - Conference of European Directors of Roads	Association	Governmental agencies, policy makers and public authorities	https://www.cedr.eu/	3

Association	Association/ Framework	Target Audience	Website	Relevance
CEL - Centro Espanol de Logistica	Association	Governmental agencies, policy makers and public authorities	https://cel-logistica.org/	4
CER - European Rail Freight Association	Association	Service end users (logistics industries)	https://www.cer.be/about-us/who-we-are#details	2
CILT - Chartered Institute of Logistics and Transport	Association	Service end users (logistics industries)	https://ciltinternational.org/	4
CLA - Česká Logistická Asociace	Association	Carriers and agents	https://czech-logistics.eu/en/homepage-en/	4
CLECAT - European Association for Forwarding, Transport, Logistics and Customs Services	Association	Governmental agencies, policy makers and public authorities	https://www.clecat.org/	3
CLEPA - European Association of Automotive Suppliers	Association	Citizens, customers, wider public	https://clepa.eu/	1
Cluster Mobility and Logistics	Association	ICT providers, systems integrators and vehicles vendors	https://www.mobilitylogistics.de/das-cluster/cluster-mobility-logistics	4
CLUSTERS 2.0	Association	Open source associations, technology clusters	http://www.clusters20.eu/	4
COA - Container Owners Association	Association	Carriers and agents	https://www.containerownersassociation.com/	2
CSA - Cyprus Shipping Association	Association	Carriers and agents	https://www.csa-cy.org/	1
CSCMP - Council of Supply Chain Management Professionals	Association	Academia, research and other projects	https://cscmp.org/	3
CTANW - Community Transportation Association of the Northwest	Association	Academia and research	https://www.ctanw.org/	1
DNE - The International Maritime Union	Association	Service end users (logistics industries)	https://dne.gr/	1
DTLF - Digital Transport and Logistics Forum	Association	Governmental agencies, policy makers and public authorities	https://transport.ec.europa.eu/transport-themes/digital-transport-and-	3

Association	Association/ Framework	Target Audience	Website	Relevance
			logistics-forum-dtlf_en	
EALTH - European Association for Logistics and Transportation in Healthcare	Association	Manufacturers / Suppliers	https://www.ealth.org/	2
EARPA - Association of automotive R&D organisations	Association	Manufacturers / Suppliers	https://www.earpa.eu/earpa/home	2
ECA - Express Carriers Association	Association	Carriers and agents	https://ecadeliveryindustry.org/	1
ECG - Association of European Vehicle Logistics	Association	Governmental agencies, policy makers and public authorities	https://www.ecgassociation.eu/	2
ECSA - European Community Shipowners Association	Association	Service end users (logistics industries)	https://www.ecsa.eu/index.php/	1
ECSLA - European Cold Storage and Logistics Association	Association	Governmental agencies, policy makers and public authorities	https://ecsla.eu/	3
ECTA - EUROPEAN CHEMICAL TRANSPORT ASSOCIATION	Association	Governmental agencies, policy makers and public authorities	https://www.ecta.com/	3
ECTP-CEU - European Council of Spatial Planners	Association	Academia, research and other projects	https://ectp-ceu.eu/about-us/	3
ECTRI - European Conference of Transport Research Institutes	Association	Governmental agencies, policy makers and public authorities	https://www.ectri.org/	3
EFT - Eye For Transport	Association	Service end users (logistics industries)	https://www.reutersevents.com/supplychain/	3
ELA - European Logistics Association	Association	Service end users (logistics industries)	https://www.elalog.eu/	3
ELP - European Logistics Platform	Association	Governmental agencies, policy makers and public authorities	http://www.european-logistics-platform.eu/	3
ERF - European Union Road Federation	Association	Academia, research and other projects	https://erf.be/	2
ERTRAC - European Road Transport Research Advisory Council	Association	Academia, research and other projects	https://www.ertrac.org/	4
ESC - European Shippers' Council	Association	Governmental agencies, policy makers and public authorities	https://europeanshippers.eu/	3

Association	Association/ Framework	Target Audience	Website	Relevance
ESCF - European Supply Chain Forum	Association	Academia and research	https://escf.nl/	4
ESPO - The European Sea Ports Organisation	Association	Infrastructure providers	https://www.espo.be/	1
ETA - European Tugowners Association	Association	Service end users (logistics industries)	https://eurotugowners.com/	1
ETRA - European Transport Research Alliance	Association	Academia and research	http://etrallicance.eu/	3
Eumos - European Safe Logistics Association	Association	Academia, research and other projects	https://eumos.eu/eumos/	2
EUROPLATFORMS	Association	Service end users (logistics industries)	http://europlatforms.eu/index.html	2
F&L - European Freight and Logistics Leaders Forum	Association	Service end users (logistics industries)	https://www.europeanfreightleaders.eu/	4
FEDERAGENTI - Federazione Nazionale Agenti Raccomandatari Marittimi e Mediatori Marittimi	Association	Carriers and agents	https://www.federagenti.it/	1
FEHRL - Forum of European National Highway Research Laboratories	Association	Governmental agencies, policy makers and public authorities	https://www.fehrl.org/	2
FENAMAR - Federação Nacional das Agências de Navegação Marítima	Association	Service end users (logistics industries)	https://www.fenamar.com.br/	1
FERSI - Forum of European Road Safety Research Institutes	Association	Academia, research and other projects	https://fersi.org/	2
FIATA - International Federation of Freight Forwarders Associations	Association	Service end users (logistics industries)	https://fiata.org/	4
FONASBA - The Federation of National Associations of Ship Brokers and Agents	Association	Carriers and agents	https://www.fonasba.com/	1
FTA - Freight Transport Association (Logistics UK)	Association	Carriers and agents	https://logistics.org.uk/	3
GCCA - Global Cold Chain Alliance	Association	Carriers and agents	https://www.gcca.org/	3
GIL - Global Institute of Logistics	Association	Academia, research and other projects	http://www.globeinst.org/	2
Global Shippers Forum	Association	Service end users (logistics industries)	https://globalshippersforum.com/	3
Greek Cold Storage & Logistics Association	Association	Service end users (logistics industries)	http://www.cold.org.gr/default.aspx?lang=en	3

Association	Association/ Framework	Target Audience	Website	Relevance
H-CLOUD, HORIZON CLOUD	Association	Governmental agencies, policy makers and public authorities	https://www.h-cloud.eu/	4
hEART - European Association for Research in Transportation	Association	Manufacturers / Suppliers	https://transp-or.epfl.ch/heart/	2
HIDC - Holland International Distribution Council	Association	Service end users (logistics industries)	https://hollandinternationaldistributioncouncil.com/en/	3
IACS - International Association of Classification Societies	Association	Service end users (logistics industries)	https://iacs.org.uk/	1
IAPH - International Association of Ports and Harbors	Association	Service end users (logistics industries)	https://www.iaphworldports.org/about-iaph/	1
IBS - International Rail Freight Business Association	Association	Service end users (logistics industries)	https://www.ibs-ev.com/	1
ICHCA - International Cargo Handling Coordination Association	Association	Carriers and agents	https://ichca.com/	2
ICS - International Chamber of Shipping	Association	Carriers and agents	https://www.ics-shipping.org/	2
IDA - Independent Distributor Association	Association	Carriers and agents	https://www.idaparts.org/	2
IFA - International Forwarding Association	Association	Manufacturers / Suppliers	https://ifa-forwarding.net/network.php	4
IFWLA - International Federation of Warehousing & Logistics Associations	Association	Service end users (logistics industries)	http://www.ifwl.org/	4
IMCC - Inventory Management Competence Centre - Netherlands	Association	Carriers and agents	https://www.imcc.nl/	3
Intercargo - The International Association of Dry Cargo Shipowners	Association	Service end users (logistics industries)	https://www.intercargo.org/about/	2
Interferry	Association	Carriers and agents	https://interferry.com/	2
InterManager	Association	Service end users (logistics industries)	https://www.intermanager.org/	2
International Organization for Standardization (ISO) 28000	Association	Service end users (logistics industries)	https://www.dnv.com/services/iso-28000-supply-chain-security-	4

Association	Association/ Framework	Target Audience	Website	Relevance
			management-4344	
International Society of City and Regional Planner, Smart Cities and Communities European Innovation Partnership	Association	Academia and research	https://isocarp.org/	3
IOLT - Institute of Logistics and Transport	Association	Service end users (logistics industries)	http://www.iolt.org.uk/	3
IPCSA - The International Port Community Systems Association	Association	Service end users (logistics industries)	https://ipcsa.international/	2
IRU	Association	ICT providers, systems integrators and vehicles vendors	https://www.iru.org/	4
ISF - International Shipping Federation	Association		https://uia.org/s/or/en/1100047687	1
ISM - Institute for Supply Management	Association	Academia, research and other projects	https://www.ismworld.org/	3
ISTA - International Safe Transit Association	Association	Academia and research	https://ista.org/	2
ITSA - International Transportation Safety Association	Association	Governmental agencies, policy makers and public authorities	https://itsasafety.com/about/members/	2
LLA - Lithuanian Logistics Association	Association	Governmental agencies, policy makers and public authorities	https://www.ltlogistics.lt/	2
LMI - Logistics Management Institute	Association	Academia, research and other projects	https://www.lmi.org/	3
NASSTRAC - National Shippers Strategic Transportation Council	Association	Academia and research	https://www.nasstrac.org/	1
NAW - National Association of Wholesaler-Distributors	Association	Manufacturers / Suppliers	https://www.naw.org/	3
NCBFAA - National Customs Brokers/Forwarders	Association	Carriers and agents	https://www.ncbfaa.org/	1
NFTA - National Freight Transportation Association	Association	Carriers and agents	https://nftahq.org/	1
NGIoT - Next Generation Internet of Things	Association	Academia, research and other projects	https://www.ngiot.eu/	4
NITL - Institute for National Transport Logistics	Association	Manufacturers / Suppliers	http://www.nitl.ie/	3
NLA - Nordic Logistics Association	Association	Governmental agencies, policy makers and public authorities	https://nla.eu/	3

Association	Association/ Framework	Target Audience	Website	Relevance
OPEN DEI	Association	Academia and research	https://www.opendei.eu/	4
OpenEnLocc	Association	Academia, research and other projects	https://www.openenlocc.net/	4
PANECO	Association	Governmental agencies, policy makers and public authorities	https://paneco.eu/	2
POLIS	Association	SMEs	https://www.polisnetwork.eu/	2
RIA - Railway Industry Association	Association	SMEs	https://www.riagb.org.uk/	2
RLA - The Reverse Logistics Association	Association	Manufacturers / Suppliers	https://www.rla.org/	3
SCC - Supply Chain Council	Association	Service end users (logistics industries)	https://www.supplychain247.com/company/supply_chain_council	3
SCRA - Specialized Carriers and Rigging Association	Association	Service end users (logistics industries)	https://www.scranet.org/	2
SFFLA - Selangor Freight Forwarders and Logistics Association	Association	Service end users (logistics industries)	https://sffla.com.my/	1
SOLE - International Society of Logistics	Association	Academia and research	http://www.sole.org/	3
TE - European Federation for Transport and Environment	Association	Governmental agencies, policy makers and public authorities	https://www.transportenvironment.org/	3
The Logistics Institute	Association	Academia, research and other projects	https://loginstitute.ca/	3
TIA - Transportation Intermediaries Association	Association	Service end users (logistics industries)	https://www.tianet.org/	3
TLC - Transportation and Logistics Council	Association	Service end users (logistics industries)	https://tlcouncil.org/	3
TRB - Transportation Research Board	Association	Academia, research and other projects	https://www.nationalacademies.org/trb/transportation-research-board	3
UETR	Association	SMEs	https://uetr.eu/	3
UIC - International Union of Railways	Association		https://uic.org/	1

Association	Association/ Framework	Target Audience	Website	Relevance
ULI Europe - Logistics Council	Association	Governmental agencies, policy makers and public authorities	https://europe.uli.org/councils/european-product-councils/logistics-council/	3
Supply Chain Operations Reference (SCOR) model	Framework	Service end users (logistics industries)	https://scor.ascm.org/	4
COREALIS	Framework	Service end users (logistics industries)	https://www.corealis.eu/	3
Lean logistics framework	Framework	Carriers and agents	https://www.researchgate.net/publication/270881185_The_Conceptual_Framework_of_Lean_Sustainable_Logistics	4
TOC - Theory of Constraints	Framework	Carriers and agents	https://www.leanproduction.com/theory-of-constraints/	4
JIT - Just-in-Time logistics framework	Framework	Manufacturers / Suppliers	https://www.researchgate.net/publication/228798768_A_New_Approach_in_Logistics_Management_Just_in_Time-Logistics_JIT-L	4
ILS - Integrated Logistics Support framework	Framework	Service end users (logistics industries)	https://afry.com/en/service/integrated-logistics-support-ils	4
DDMRP - Demand-Driven Material Requirements Planning	Framework	Manufacturers / Suppliers	https://www.demanddriveninstitute.com/ddmrp	4
Green Logistics framework	Framework	Service end users (logistics industries)	https://transportgeography.org/contents/applications/green-logistics/	4

Association	Association/ Framework	Target Audience	Website	Relevance
Risk Management framework for logistics	Framework	Service end users (logistics industries)	https://www.marsh.com/content/dam/marsh/Documents/PDF/asia/en_asia/Logistic_Risk_Management.pdf	4
ITS - Intelligent Transport Systems	Framework	Service end users (logistics industries)	https://link.springer.com/chapter/10.1007/978-981-19-0105-8_10	4
GFE - Green Freight Europe	Framework	Service end users (logistics industries)	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://galileo.cs.telespazio.it/core/12%20Conferenza%20Logistica%20Sostenibilit%E0%20Supply-Chain%20Milan%201%20July%202015/7-barbarino.pdf	4
EMS - European Modular System	Framework	Service end users (logistics industries)	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://www.euroexpress.org/uploads/ELibrary/NEA%20PAPER.pdf	3
DTLF - Digital Transport and Logistics Forum	Framework	Governmental agencies, policy makers and public authorities	https://transport.ec.europa.eu/transport-themes/digital-transport-and-logistics-forum-dtlf_en	4

Association	Association/ Framework	Target Audience	Website	Relevance
European Green Deal	Framework	Governmental agencies, policy makers and public authorities	https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en	4
European Intermodal Transport Strategy	Framework	Academia, research and other projects	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.eca.europa.eu/Lists/ECADocuments/SR-2023-08/SR-2023-08_EN.pdf	3
Agile Logistics	Framework	Service end users (logistics industries)	https://locus.sh/resources/glossary/agile-logistics/	4
MRP - Material Requirements Planning	Framework	Manufacturers / Suppliers	https://www.netsuite.com/portal/resource/articles/inventory-management/material-requirements-planning-mrp.shtml	2
DRP - Distribution Requirements Planning	Framework	Manufacturers / Suppliers	https://www.planettogether.com/blog/distribution-requirements-planning-in-supply-chain	4
SCALE-UP	Framework	Service end users (logistics industries)	https://www.scale-up-project.eu/	4
National Land Transport Strategic Framework 2023-2028	Framework	Academia, research and other projects	https://www.gov.za/sites/default/files/gcis_document/202303/	3

Association	Association/ Framework	Target Audience	Website	Relevance
			48176gon3119.pdf	
IoT - Internet of things	Framework	Manufacturers / Suppliers	https://www.digiteum.com/internet-of-things-logistics/	4
UNCTAD's Framework for Sustainable Freight Transport (SFT Framework)	Framework	Service end users (logistics industries)	https://unctad.org/publication/unctad-framework-sustainable-freight-transport-sft-framework	4
Kofax Transport and Logistics Framework	Framework	Service end users (logistics industries)	https://marketplace.kofax.com/details/kofax-transport-and-logistics-solution-framework	2
Six Sigma	Framework	Service end users (logistics industries)	https://op-scm.com/six-sigma/	3

1.8 EU and National Legislation and Regulations

The following Table reports on the relevant legislations and regulations.

Table 4: List of relevant legislation and regulations

Topic	Legislation / Regulation	Short Description	Target Audience
Safety & Health	European Framework Directive (1989/391/EEC)	Establishes general principles for managing safety and health, such as: responsibility of the employer, rights and duties of the workers, using risk assessments to continuously improve company processes, and workplace health and safety representation. The objective of this Directive	Member states

Topic	Legislation / Regulation	Short Description	Target Audience
		is to introduce measures to encourage improvements in the safety and health of workers at work. It applies to all sectors of activity, both public and private (industrial, agricultural, commercial, administrative, service, educational, cultural, leisure, etc.).	
	European Commission's Strategic Framework on Health and Safety at Work 2021-2027 (EC, 2021)	Defines the key priorities and actions for improving workers' health and safety, addressing rapid changes in the economy, demography, and work patterns.	- EU institutions - Member states Social partners & other stakeholders
Ethics, Data Protection, Artificial Intelligence	Charter of Fundamental Rights of the European Union (EU, 2012)	Gathers the fundamental rights to be shared, fostered, and protected by every Member State of the European Union (EU). The Charter sets the starting point for any research or action conducted within the context of the EU.	- Member states
	European Code of Conduct for Research Integrity (ALLEA, 2023)	Created by the European Federation of Academies of Sciences and Humanities and has been revised and republished in 2023. This document contains rules to self-regulate academic research through European territories and is designed to be used across all scientific fields. It includes the principles to preserve Research Integrity (RI), a list of good practices and guidelines about violations of RI (the	- European Research Community

Topic	Legislation / Regulation	Short Description	Target Audience
		most serious being fabrication, falsification, and plagiarism) and procedures to be followed in the event of those violations.	
	General Data Protection Regulation (GDRP) (EU, 2016)	Key legislative instrument to be followed within the project implementation setting up the data protection principles.	Member states
	Horizon Europe Regulation (Regulation 2021/695) (EU, 2021)	Establishes, in Article 19, para.1 (Ethical principles): "Actions carried out under the Programme shall comply with ethical principles and relevant Union, national and international law, including the Charter and the European Convention for the Protection of Human Rights and Fundamental Freedoms and its Supplementary Protocols."	- European Research Community - Horizon Europe beneficiaries
	Recommendations on shaping technology according to GDPR provisions: An overview on data pseudonymisation (ENISA, 2018 and 2019)	Starting from the definition of pseudonymisation, the report discusses the data protection benefits and addresses some techniques that may be used for pseudonymization. It also includes pseudonymisation use cases and best practices, focusing especially on the area of mobile apps and revisiting some of the earlier discussed techniques.	- European Research Community - Research and Innovation stakeholders and developers
	Data Pseudonymisation: Advanced Techniques	Building on the basic pseudonymisation techniques, the document	- European Research Community

Topic	Legislation / Regulation	Short Description	Target Audience
	and Use Cases (ENISA, 2021)	examines advanced solutions for more complex scenarios. It applies some of these techniques in the field of healthcare to discuss possible pseudonymisation options in different example cases.	- Research and Innovation stakeholders and developers
	Communication on Fostering a European Approach to Artificial Intelligence (April 2021)	In April 2021, the European Commission presented its AI package including: - A Communication on fostering a European approach to Artificial Intelligence (EU AI Strategy): an initial and baseline document in the sphere of regulating AI. This document sets clear definitions, guidelines and principles. The document states that the development of new technologies are based on values defined in the GDPR but not only. The communication acknowledges the facts that some AI applications may raise new ethical and legal questions, for example related to liability or potentially biased decision-making. For this reason, the EU must therefore ensure that AI is developed and applied in an appropriate framework, which	- Member states - European Research Community - Research and Innovation stakeholders and developers

Topic	Legislation / Regulation	Short Description	Target Audience
		promotes innovation and respects the Union's values and fundamental rights as well as ethical principles such as accountability and transparency (EU, 2018). The Communication introduced the AI ethics guidelines as a first step to address ethical concerns. - A review of the Coordinated Plan on Artificial Intelligence (with EU Member States). - A proposal for a regulation laying down harmonised rules on AI (AI Act) and relevant Impact assessment. It is a proposed European law on artificial intelligence (the first ever law on AI by a major regulator). The law assigns applications of AI to 3 different risk categories: applications and systems that create an unacceptable risk, high-risk applications, and applications not explicitly banned or listed as high-risk are largely left unregulated.	
	EU AI Act (EU, 2024)	Regulation (EU) 2024/1689 of the European Parliament and	- Member states

Topic	Legislation / Regulation	Short Description	Target Audience
		of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act). The AI Act is a European regulation on artificial intelligence (AI). It is the first comprehensive regulation on AI ever developed and approved by a major regulator. The document associates the applications of AI to different risk categories. Unacceptable risk: if the AI system falls into the categories prohibited by the AI Act, such as social scoring by governments, exploitation of vulnerabilities, or use in harmful subliminal techniques. High risk: if the AI system is listed in Annex III of the AI Act, which includes systems used in critical infrastructure, education, employment, essential private and public services, law enforcement, migration, asylum, and border control, administration of justice, and democratic processes.	- European Research Community - Research and Innovation stakeholders and developers

Topic	Legislation / Regulation	Short Description	Target Audience
		Limited risk: if the AI system requires transparency obligations under the AI Act, such as those that interact with humans, detect emotions, or use biometric categorisation. Minimal or no risk: if the AI system does not fall into the above categories, it is likely to be classified as having minimal or no risk.	
	Framework Convention on Artificial Intelligence and Human Rights, Democracy and the Rule of Law (Council of Europe, 2024)	The Council of Europe Framework Convention on Artificial Intelligence and Human Rights, Democracy, and the Rule of Law (adopted in May 2024) establishes guidelines to ensure that AI systems are developed and deployed in ways that respect human rights, upholding democratic values, and maintaining the rule of law. The Framework Convention emphasizes the need for transparency, accountability, and safeguards against biases and discrimination, promoting the ethical use of AI across the Council of Europe's member states.	- Member states - European Research Community - Research and Innovation stakeholders and developers - Policymakers
	Ethics Guidelines for trustworthy AI (EU, 2019)	According to the document, trustworthy AI covers three main aspects: 1. Lawfulness: compliance with all applicable laws and regulations. 2. Ethicality: adherence to ethical principles and values. Ethicality	- Member states - European Research Community - Research and Innovation stakeholders and developers

Topic	Legislation / Regulation	Short Description	Target Audience
		in AI development stems from the principle that AI systems should be human centric, allowing individuals and society to perform old and new activities in better and simpler ways, without causing harm or other limitations to individual and collective freedom. 3. Robustness: technically and socially consistent and coherent. The document includes principles and procedures to ensure that AI systems are compliant with the regulations in place at EU level and with the four main principles: respect for human autonomy, prevention of harm, fairness and explicability.	

1.9 Extending State-of-the-Art Technologies and Leveraging Synergies

TRACE is set to advance the state of the art (SOTA) by integrating and extending current methodologies across several key areas. In the domain of shared logistics networks and trust, TRACE enhances existing practices through real-time multi-source data collection, advanced AI/ML-driven optimization, and blockchain-based security measures, thus providing a more holistic and secure approach to logistics management. By leveraging these innovations, TRACE not only optimizes operational efficiency but also introduces novel solutions such as real-time emergency controls and smart contract enforcement. In intelligent planning and ICT technologies, TRACE pushes the envelope with its advanced data lakes, real-time machine learning integration, and comprehensive scheduling and optimization capabilities. This includes automating complex scheduling tasks and dynamically adjusting logistics based on real-world conditions, thereby surpassing conventional methods. For physical infrastructure, TRACE's emphasis on specialized hubs and corridors, alongside robust communication systems, will set new benchmarks for logistics operations and serve as critical case studies for future deployments. In the legal and regulatory framework, TRACE will provide in-depth legal assessments and policy recommendations, integrating blockchain and smart contracts to enhance IPR management and stakeholder trust. Finally, in addressing pricing, cost, and climate neutrality, TRACE will innovate business models to incorporate asset sharing and resource exchange, aiming to drive behavioral shifts towards climate neutrality and cost efficiency. Additionally, TRACE will establish synergies with ongoing and concluded projects by integrating results from prior research, fostering collaboration through shared resources and joint initiatives, and applying lessons learned to optimize and enhance its own framework. This collaborative approach will ensure TRACE not only advances the current state of the art but also maximizes the collective impact of related innovations.

2 TRACE Engagement Framework

The present section aims to provide an overview of the TRACE Engagement Framework, composed by: TRACE Participatory Model (TPM), participation strategy definition and action plan. The TPM will be further developed and described in D2.3 – Ethics and Societal Report at M30 (November 2025).

Within the work of WP2, T2.3 – Ethics and Societal Requirements has a twofold purpose: on one hand it aims to ensure the adoption of the principles for achieving trustworthy AI, thus ensuring compliance with applicable laws and regulations, adherence to ethical principles and values, and robustness of the AI system developed. On the other hand, T2.3 aims to design a Participatory Model and develop methodologies and tools for promoting end-users and stakeholders' involvement in all project phases, thus informing all the WPs dealing with end-users and stakeholders' involvement and ensuring a timely inclusion of end-users and stakeholders in the (co)design, validation and evaluation processes.

The TRACE Participatory Model (TPM) will establish an inclusive process to promote stakeholders' and citizens' engagement and the definition of targeted participation strategies and action plan.

While the participatory model and its theoretical and operational framework are presented in this document, the engagement activities and their results will be reported in D2.3 – Ethics and Societal Report at M30 (November 2025).

In collaboration among WP2 partners, a preliminary stakeholders' mapping process was carried out to identify relevant existing logistics frameworks and associations. The results of such activity are reported in section 1.7 of the present document.

This section introduces the framework for stakeholders' engagement in TRACE. The framework will support partners in identifying key stakeholders for engagement during project activities, integrating efforts across various project tasks. To support this process, a data collection tool will be designed to facilitate stakeholder analysis. The data collected will help identify and analyse relevant stakeholders, ensuring they align with TRACE goals. The outcomes of this mapping will result in a list of stakeholders to be engaged at different stages and through various methods throughout the project's implementation.

2.1 Overall theoretical framework

The TRACE engagement framework builds on the methodology proposed by the by the Civil Participation in Decision-making Toolkit (CoE/ISIG; 2017/2020)[104], allowing for the elaboration and implementation of context-based strategies to increase the level of a community's participation/engagement on specific policy topics.

The TRACE participatory model will be developed and implemented in all pilot sites (Slovenia, Italy and Greece), ensuring the testing different engagement approaches based on the specific characteristics of a given community. This will imply the assessment of several variables to identify the overall propensity of a community towards participation, the level of awareness and perception regarding smart delivery

[104] ISIG/CoE, Civil Participation in Decision-Making Toolkit, 2017, 2020.

systems, and the stakeholders to engage in the process based on the relevance and interest towards the topic at stake.

The framework consists of 3 components:

1. **TRACE Participatory Model**: describing the methodology establishing the framework and defining targets and methods of engagement.
2. **TRACE Participation Strategy**: defines the goals of engagement.
3. **TRACE Participation Action Plan**: setting the operational steps and tools towards the engagement of stakeholders.

2.2 TRACE Participatory Model

2.2.1 Identifying targets

The following list provides a preliminary and provisional overview of some of the categories of stakeholders which might be of interest for the development of TRACE project and products.

- **Local community as a whole**. Local community as a whole represents the widest target group, as well as the less defined in relation with transport operations issues.
- **Transportation and logistics operators**. This specific group of operators, active in the field of transport, supply chain, and logistics, are those directly impacted by the development and implementation of TRACE solutions. They can be considered both as single companies and as consortiums or professional associations representing enterprises and freelances.
- **Economic operators**. Economic operators, taken into consideration as a broader spectrum of individuals and companies using transportation and logistics services to deliver their goods, are indirectly impacted by the development and implementation of TRACE solutions. Similarly to the previous group, they can be taken into consideration both as professional associations representing the economic sector, as well as private investors and entrepreneurs.
- **Civil Society Organisations (CSOs).** They represent the interests of social groups, such as, for instance, workers (working unions), or local inhabitants affected by the impacts deriving from the presence of critical infrastructures (environmentalist groups). CSOs are also particularly significant to collect and represent needs and interests of minority and disadvantaged groups. To engage with CSOs across the project may constitute a key element in communication activities, to promote the construction of networks of trust and enforce the use of the identified solutions in a soft and smart way.
- **Infrastructure's managers**. Public, private or public-private partnership entities managing networks and infrastructure – especially those related with transportation flows – are particularly relevant for the development and application of TRACE solutions.
- **Public authorities**. Bodies which are responsible, at several administrative levels, of both the definition of rules and policies related with the fields in which TRACE solutions will be implemented, and their enforcement. Local policy makers constitute also key actors in

transforming and implementing local, national, and international policies taking into consideration future TRACE recommendations and the needs expressed by other stakeholders.

The implementation of TRACE Participation Model will propose a taxonomy for identifying targets of involvement (e.g., different subjects such as citizens, stakeholders, etc.). The participation model proposes a Taxonomy for identifying targets of involvement (e.g., different subjects such as citizens, stakeholders, etc.) that considers two types of dimensions. By analysing targets based on these dimensions, it will be possible to highlight their potential relevance in the involvement process, specifically in terms of the type of information/feedback/ insights that will have to be collected. The two types of dimensions are described, as follows:

- **Impact**– What type of impact will the final results have on the target? In this sense, the impact is articulated in two dimensions:
  - Direct impact – the target directly relates to the products/end-results, such as the direct utilization of the product or direct exposure to the product.
  - Indirect impact – the target has an indirect relation with the products/end-results of the development process. The target is not exposed to the product.
- **Acceptance** – What type of acceptance is expected from the target concerning the development process results? What kind of feedback is thus envisaged from the target? In this sense acceptance is articulated in two dimensions:
  - Technical acceptance – the target expresses its acceptance levels with the product's deployment, thus with the product's usability and performance.
  - Societal acceptance – the target expresses its levels of acceptance with the perceived effects of the product's deployment in a specific (societal) context.

Ultimately, the Taxonomy for Targets identification allows for depicting four main profiles of Targets of involvement: Citizens, Stakeholders, Actors and End-users.

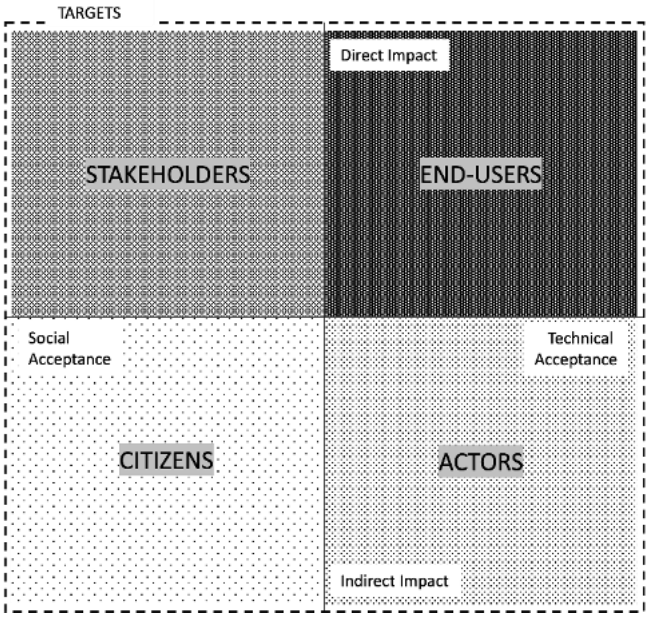

Figure 1: Taxonomy for targets' identification

The four Target profiles defined by the taxonomy may be described as follows:

1. **Citizens** – this profile of involvement target is characterized through Societal acceptance and Indirect Impact variables. The end-result of the development process indirectly impacts the target insofar as the target is not necessarily exposed to the product and does not deploy it directly. Similarly, the target may express its levels of acceptance with the product in terms of the perceived effects of the potential deployment of the product generally, in society and not regarding a specific case (example → International Organizations, NGOs, youth associations, associations representing the interests of minority groups, associations representing the interests of disadvantaged groups, volunteering associations, awareness-raising associations, entrepreneurs from different fields, private foundations, etc.).
2. **Stakeholders** – this profile of involvement target is characterized through Societal acceptance and Direct impact variables. The end-result of the development process directly impacts the target insofar as the target is directly exposed to the product. Furthermore, the target may express its levels of acceptance with the product in terms of the perceived effects of the potential deployment of the product in a specific (societal) context (example → Local Authorities in pilot areas, CSOs and associations operating in pilot areas, etc.).
3. **Actors** – this profile of involvement target is characterized through Technical Acceptance and Indirect Impact variables. The end-result of the development process indirectly impacts the target insofar as the target is not necessarily exposed to the product and does not deploy it directly. However, the target may express feedback/insights related to the deployment of the products (example → National Authorities, experts from the Academia, Research Institutions, etc.).

4. **End-users** – this profile of involvement target is characterized through Technical Acceptance and Direct Impact variables. The end-result of the development process directly impacts the target insofar as the target deploys the products. Furthermore, the target may express its levels of acceptance with the product in terms of usability.

2.2.2 Identifying the Action Situations for the TRACE Participation Model

The TRACE participation model proposes a taxonomy that considers two types of dimensions that ultimately describe the potential interaction of the identified target and the development process itself: Capacity and Interest.

The two types of dimensions are described thus, as follows:

- The capacity of the target concerning the development process – **Capacity** is understood as the type/level of knowledge of the target vis-à-vis the development process. What kind of knowledge or expertise does the target have? What type of feedback/info/insights can be requested from the target? Ultimately what is the target's relevance for the development process? In this sense capacity is articulated in two dimensions:
    - Context capacity – defining a high level of awareness/knowledge on the specific (societal) context at stake.
    - Technical capacity – defining a high/expert level of technical knowledge.
- The interest of the target towards the development process – **Interest** is understood as the level of willingness of the targets to engage in the interaction. What is the incentive that motivates the target to engage? In this sense, interest is articulated in two dimensions:
    - Direct interest – targets that show a high willingness to engage in/feedback on the development process.
    - Indirect interest – targets with low willingness to engage in/feedback on the development process.

Ultimately, the Taxonomy of Action Situations allows for depicting four main interaction patterns: Information, Consultation, Dialogue and Partnership.

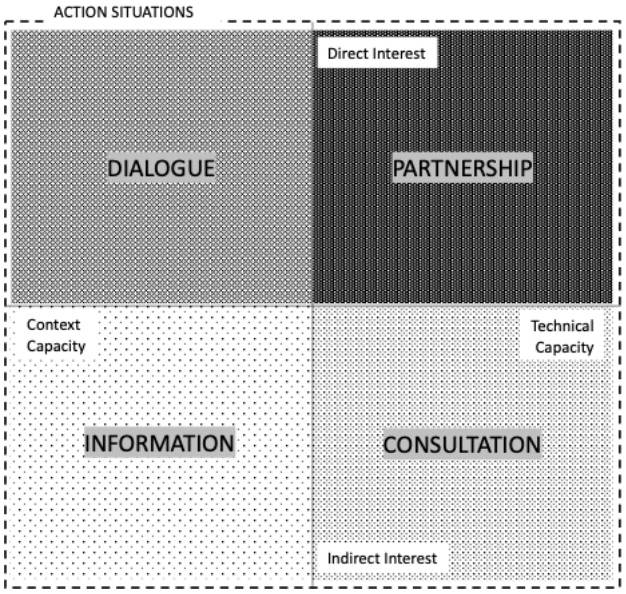

Figure 2: Taxonomy of action situations

1. **Information** – this action situation considers targets characterised by Context Capacity and Indirect Interest variables. Targets do not play an active role in the involvement process, but instead, they are regarded as recipients of general information regarding the development process at stake. Thus, this pattern of interaction aims to ensure overall visibility and provide general information to the public (i.e., understood as the representatives of a specific community where an involvement process is foreseen).
2. **Consultation** – this action situation considers targets characterised by Technical Capacity and Indirect Interest variables. However, this action situation considers targets, with expert/technical knowledge, that do not have a direct stake/interest in being involved. For this purpose, such action will be characterized mainly by targeted/sporadic consultation activities, focused mostly on the context.
3. **Dialogue** – this action situation considers targets characterised by Direct interest and Context capacity variables. This pattern of interaction is characterized by structured exchanges with targets mainly focused on context-related aspects.
4. **Partnership** – this action situation considers targets characterised by direct interest and technical capacity variables. This pattern of interaction is described thus by structured exchanges focused mainly on technical aspects.

2.3 The TRACE Participation Strategy

The TRACE Participation Strategy aims to ensure a coherent framework within which different relevant targets (i.e., citizens and communities, stakeholders, actors, and end-users) are efficiently and effectively involved in TRACE technologies' development process across the project cycle. The TRACE Participation Strategy aims to define the goals and specific objectives of involvement for particular activities (e.g., pilots) and contexts (e.g., TRACE pilot communities). The Participation Strategy will also include vision, values and mission.

2.4 The TRACE Participation Action Plan

The TRACE Participation Action Plan consists in the operationalisation of the participatory model. The action plan will provide the operational steps and tools to support partners in the engagement of stakeholders. For each engagement activity, the action plan defines: Responsibilities, Objectives, Outputs, Timeline.

2.5 The Plan for Stakeholders' Engagement in TRACE

1. The TRACE Engagement Framework will be developed into a booklet/ guidelines and shared with partners by December 2024.
2. The guidelines will include a **data collection tool** to integrate the preliminary **stakeholders mapping** performed to identify all relevant stakeholders to be involved in the project. (January 2025)
3. A **stakeholders' analysis** will be performed to understand stakeholders needs, influence and relationships to determine their level of participation. (January 2025)
4. Definition of the **TRACE Participation Strategy** to effectively engage stakeholders throughout project activities. (February-March 2025)

2.6 Ethical and societal aspects to be considered in TRACE engagement activities

In TRACE, several ethical and societal dimensions must be carefully evaluated to ensure responsible and inclusive outcomes. This section analyses key dimensions (technological, social, economic, and environmental) encompassing specific topics that are critical to the project's success. The aim of this exercise is to identify relevant target groups and appropriate data collection tools that will guide the project's efforts in addressing these aspects. By considering these dimensions systematically, TRACE will make sure to ethically navigate the complex connection between technology, society, economy, and environment, fostering a holistic approach to innovation in the logistics sector.

2.6.1 Dimensions and topics

Table 5: Dimensions and Topics considering ethics and societal aspects

Dimension	Topic	Target group	Data collection tools
Technological Dimension	Technology Legal Framework	Transportation and logistics operators Infrastructure's managers	Workshops (T2.1) Survey (T2.1)
	Relationship Between Logistics Flows and Infrastructures	Transportation and logistics operators Infrastructure's managers	Workshops (T2.1) Survey (T2.1)

Dimension	Topic	Target group	Data collection tools
	Artificial Intelligence Impact in the Logistic Sector	Transportation and logistics operators Infrastructure's managers	Workshops (T2.1) Survey (T2.1)
Social Dimension	Safety and Health	Local community as a whole Civil Society Organisations (CSOs)	Survey on Citizens' perceptions and awareness of automated mobility (T2.3) Workshops (T2.3; T5.4)
	Social Protection and Labour Regulation	Local community as a whole Civil Society Organisations (CSOs)	Survey on Citizens' perceptions and awareness of automated mobility (T2.3) Workshops (T2.3; T5.4)
	Issues of Inequality and Underrepresentation (self-employed and foreign drivers, women, SMEs)	Local community as a whole Civil Society Organisations (CSOs)	Survey on Citizens' perceptions and awareness of automated mobility (T2.3) Workshops (T2.3; T5.4)
	Ethics and Data Protection	Local community as a whole Civil Society Organisations (CSOs)	Survey on Citizens' perceptions and awareness of automated mobility (T2.3) Workshops (T2.3; T5.4)
	Trust and acceptance of technologies	Local community as a whole Civil Society Organisations (CSOs)	Survey on Citizens' perceptions and awareness of automated mobility (T2.3) Workshops (T2.3; T5.4)
Economic Dimension	Market Regulations	Transportation and logistics operators	
	Supply Chain Dynamics	Transportation and logistics operators	
	Competition and Fair Markets	Transportation and logistics operators	Survey developed by the University of Maribor T5.5)
	Job displacement	Transportation and logistics operators	

Dimension	Topic	Target group	Data collection tools
Environmental Dimension	Environmental sustainability and awareness	Local community as a whole Civil Society Organisations (CSOs) Infrastructure's managers Public authorities	Survey on Citizens' perceptions and awareness of automated mobility (T2.3) Workshops (T2.3; T5.4)
	Access to Urban Areas: Congestion and Regulations	Local community as a whole Civil Society Organisations (CSOs) Infrastructure's managers Public authorities	Survey on Citizens' perceptions and awareness of automated mobility (T2.3) Workshops (T2.3; T5.4)

ISIG/CoE, Civil Participation in Decision-Making Toolkit, 2017, 2020[105].

2.6.2 Engagement of citizens

The primary focus of the TRACE project is on business-to-business (B2B) logistic models, where direct involvement of citizens in demonstrations, such as receiving shipments via autonomous vehicles, is not a primary objective. However, the potential social impacts of these demonstrations are recognized and will be carefully monitored.

Even though direct citizens participation will be limited, project partners are already considering impacts to local community and businesses though workshops and consultations.

Additionally, citizens and communities will be more directly involved in other work packages, such as WP5 and WP6, as this document focuses on the platform conceptual framework. As the TRACE project is focused on business models and coordination of delivery, we will not perform demonstrations with citizens (such as delivery with robot or drones directly to citizens) but will involve citizen indirectly.

2.7 TRACE Local Network for Smart Delivery (LNSD)

Stemming from the information collected through the interactive activities and questionnaires under WP2 and WP5, a strong lack of cooperation among logistics operators was manifested by interviewed stakeholders to TRACE partners. To this end, among the outcomes of T2.3, the task aims to develop guidelines on how to set up and pilot TRACE Local Network for Smart Delivery (LNSD), a participatory mechanism to strengthen collaboration among logistics operators, public administrations, citizens, and other relevant stakeholders at local level. LNSDs aim to address several challenges identified throughout the study phase of the TRACE project, including lack of collaboration between logistics stakeholders, poor awareness and trust towards automated mobility systems, and poor inclusion of communities in the policy development processes when it comes to logistics and mobility.

[105] https://rm.coe.int/civil-participation-in-decision-making-toolkit-/168075c1a5

The LNSDs aim to create a collaborative framework involving stakeholders at local level, including citizens, local businesses, logistics providers, municipal authorities to optimize last-mile delivery processes. These networks will be created at pilot sites level and will:

- In a first phase: support the TRACE piloting activities in pilot areas.
- In a second phase: become a consultative mechanism to facilitate interaction with the public authorities and enhance cooperation among different stakeholders.

LNSD are local informal networks established among stakeholders acting as local project multipliers. Such participatory mechanism will contribute to the activities related to the pilot organisation and implementation, evaluation and validation (WP6), as well as awareness raising and engagement activities (WP7).

The LNSDs will include, among others: community leaders, logistics operators and experts, local authority representatives, civil society representatives, business partners (i.e., local retailers, e-commerce, delivery service providers), academia, technological companies, citizens, regional transport authorities.

By establishing Local Networks for Smart Delivery (LNSD), TRACE aims to effectively engage local communities in optimising last-mile delivery processes, fostering a collaborative environment where innovative, efficient, and sustainable delivery solutions can be developed and implemented, enhancing overall urban logistics and community well-being.

While this activity extends beyond the original foreseen activities at pilot site level, D2.3 will include guidelines on how to establish LNSDs at pilot areas, enabling the creation of such platforms for participation with the collaboration of local TRACE partners.

2.8 Survey on citizens' perception and awareness of automated mobility

Within the activities of T2.3 – Ethics and Societal Requirements a "Survey on Citizens' perceptions and awareness of automated mobility" was developed by ISIG. The survey intends to investigate on citizens' perception, awareness and acceptance of autonomous systems in the logistics operations. The data collected will allow the TRACE team to further develop its analysis on the level of perception, awareness, acceptance of autonomous systems and technologies and their perceived impact and effectiveness. The survey will contribute to the integration of citizens' inputs and concerns into TRACE activities, design, and products. The survey is provided in Annex B at the end of the present document.

2.8.1 Target

The survey aims to target:

- Citizens in project countries, especially Pilot Sites (Greece, Italy, Slovenia), and citizens in other areas in Europe.
- Citizens living in EU countries (including EU citizens and citizens from non-EU countries living in EU).

For each country (Greece, Italy, Slovenia), the sample (quota sampling) should:

- Aim at collecting a minimum of 200 (valid) responses.
- Provide a balanced representation among the demographic variables identified by the survey: Age, Gender, Occupation, Educational level.

2.8.2 Methodological Note

The survey combines two types of questions, namely multiple-choice questions and rating scale questions (except for two demographic questions, Age and Place/Country of residence, which are kept as open-ended). Most of the questions are not mandatory, meaning that respondents could opt for not filling in the answer in the cases in which all the answers were not applicable and/or when they were not able to provide an answer because they could not understand the question.

A glossary proposing the definition of three key concepts for the development of the survey: automated mobility, unmanned transportation, and unmanned autonomous vehicles, so to ensure that all participants elaborate their answers starting from a minimum shared understanding of the topic.

The survey is developed around 4 sections, whose rationale is explained below:

1. **General perception related to unmanned transportation systems.**

The section is composed of four questions, covering the following topics:

- previous experience/exposure to automated mobility and unmanned transportation systems
- initial associations with automated mobility
- perception about the current level of maturity of the technology
- main emotional response in relation to automated mobility technologies

The common rationale behind these questions is to assess the respondent's awareness, perception, and sentiment toward automated mobility and unmanned transportation systems. Each question is designed to gather specific insights, helping to paint a comprehensive picture of how people relate to, understand, and feel about the emerging field of automated mobility.

2. **Perceived impact.**

The section is composed of four questions, covering the following topics:

- general expected impact of unmanned transportation systems on several areas
- expected impact on city centres
- main concerns related to the risk connected to the development of unmanned vehicles
- expected impact in terms of reduction of carbon emissions

The common rationale behind these questions is to evaluate the respondent's perception, concerns, and expectations regarding the impact of unmanned transportation systems, particularly in the context of goods delivery. Each question focuses on a different aspect of this impact. Together, the above-mentioned questions are aimed at collecting meaningful information so to inform about public sentiment related to unmanned transportation systems and to guide the development, regulation, and communication strategies for these technologies.

3. **Unmanned transportation future expectations.**

The section is composed of two questions, covering the following topics:

- perception about the most relevant actors involved in the development of automated mobility technologies for good delivering
- desired changes in the use of unmanned vehicles

The common rationale behind these questions is to identify the respondent's perception of the key stakeholders involved in the development of automated mobility technologies for goods delivery and their priorities for future advancements in this field. This is particularly relevant in designing co-creation and co-production processes, being aware of who to involve, when, and how.

4. **Demographics.**

The section is composed of six questions, covering the following aspects:

- age
- gender
- occupation
- education level
- place/Country of residence
- place of residence

The questions are meant to segment the survey audience according to socio-demographic characteristics, so to analyse the results in a deeper way.

The survey is expected to take approximately 8 minutes to complete.

The results will be analysed in aggregate form and presented in a public report “D2.3 – Ethics and Societal report” and associated documents at M30 (December 2025).

2.8.3 Data Collection

The survey has been developed in 4 languages, reflecting the need to target Pilot Sites involved in the project and citizens across EU: English, Greek, Italian, Slovene.

The survey is being promoted via various means:

- Online: through the SurveyMonkey platform (EU based), both through direct link or with QR code.
- On hard copy: upon partners’ request, a printable version of the survey (word or PDF) can be provided.

To ensure an efficient dissemination and monitoring process, a task force composed by responsible partners has been identified for each survey language. Survey dissemination guidelines have been prepared and provided to all project partners, to support the consortium in the distribution of the survey.

1. English: INC, EPS

2. Greek: UTH, NKUA, CERTH, ACS SMSA, TUC, COSM, HT, UNISYSTEMS
3. Italian: UNIMORE, MOD, ISIG, DIFLY, OLV, URBICO, ITL
4. Slovene: AVLL, UM, PS

The survey is supported by the Information Sheet and Informed Consent Form, to comply with GDPR and the TRACE Ethical framework.

ISIG will periodically monitor the answers collected, inform relevant partners about the progress, and advise the Consortium on the need to increase dissemination actions. The following timeline has been defined for data collection and analysis of results.

- Data collection: from 01 July 2024 – to 30 September 2024.
- Results will be analysed and reported in Deliverable 2.3 at M30 (December 2025).

2.9 Next steps

A set of engagement activities are foreseen to take place in the upcoming months and are being planned at the time of writing. Such activities will support the analysis of aspects linked to citizens' needs in term mobility and logistics, with a particular focus on the levels of perception, acceptance, awareness and trust of synchromodal and automated solutions and on the identification of users' mobility profile and of differences in mobility patterns (i.e., age, gender, disability and other socio-economic factors).

Among these activities, the collection of answers to the survey will be promoted through different means and events:

- **52nd World Folklore Festival – Gorizia** (23-25 August 2024): an information booth promoting TRACE project objectives, activities, achievements and the survey on Citizens' perceptions and awareness of automated mobility will be set up during the World Folklore Festival in Gorizia. The festival has an international dimension, and it is attended by a high number of people of the cross-border area and tourists. Such activity will be coordinated and promoted by ISIG.
- **Smart Life Festival (SLF) – Modena** (26-29 September 2024): the city of Modena will host the Smart Life Festival, focusing on digital innovation and its relation with society. TRACE Italian partners (MOD, ISIG, UNIMORE, URBICO, ITL, OLV, DIFLY) have proposed and organised several activities during the festival. The activities can be summarised as follows and are further described below:
    - Promotion of **Survey** on Citizens' perceptions and awareness of automated mobility.
    - Collect relevant **information** regarding: the analysis of citizens' needs and perception (i.e., trust and knowledge) related to mobility and logistics; identification of differences in mobility patterns in relation with gender, age, disabilities, and other socio-economic factors; identification of challenges related with the use of AI and AV systems (including ethical and societal challenges). This will be done through a workshop.
    - Promotion of the **Italian Demonstrator** through the use of cargo bike and drone prototypes.

- Communicating project objectives and disseminating achievements and results through the organisation of a panel discussion on ethics, privacy, security and AI for mobility and logistics.

Table 6: Engagement activities at Smart Life Festival

Event	Description
Panel discussion: Ethics, privacy, security and AI for mobility and logistics: from Horizon Europe to Modena. 27 September 2024	*In a rapidly changing world, technology is redefining the boundaries of mobility and logistics. Technological innovation poses complex challenges in terms of ethics, privacy and security. How can we ensure that the use of AI is responsible and safe? An in-depth analysis and open dialogue to explore the legal and social implications and challenges of emerging technologies, building on from the experience of the TRACE project, funded by the Horizon Europe programme to develop and test innovative functionalities for optimizing urban logistics operations.*
Workshop: Future mobility: between perception, trust and technological innovation. 28 September 2024	*The workshop aims to explore how technological innovation is transforming mobility and its impact on everyday life, creating a bridge between technical and social standards. Starting from a reflection on the objectives, activities and results of the TRACE project, and on the case study of Modena, the workshop aims at:* *1. Investigating on the issues related to industrialisation and standardisation of autonomous driving technologies.* *2. Analysing the level of knowledge, perception, acceptance and trust towards autonomous driving technologies.* *3. Identify the mobility needs and challenges related to the application of autonomous driving systems through a participatory approach.* *An opportunity to analyse and discuss current challenges and the future prospects of mobility, with a participatory and interactive approach.*

All partners involved in the organisation of the Italian demonstrator (MOD, UNIMORE, ISIG, URBICO, ITL, OLV, DIFLY) will contribute to the Smart Life Festival, by showcasing the prototypes of cargo bikes and drones that will be used during the demonstrator. Moreover, the survey will be further disseminated through the distribution of flyers and posters with QR codes to easily access the survey online.

The SLF will be an important occasion to disseminate TRACE objectives, results and plan, paving the way for the implementation of the activities related to the demonstration, that will take place in 2025.

3 Stakeholders Engagement

To provide relevant feedback for the development of the platform, several stakeholder groups have been identified during the project preparation phase. These groups include manufacturers and suppliers, citizens and society, government agencies, end-users of services, carriers and agents, public authorities, logistics companies, edge service providers, unmanned vehicle manufacturers, telecommunications, application developers, infrastructure providers, ICT providers and vehicle manufacturers, SMEs and academia.

Through a collaborative process, we identified that the key stakeholders to define industry needs and platform requirements are all companies involved in any type of logistics processes - end-users of services, carriers and agents, and logistics companies.

To further identify the needs of key stakeholders, two types of data collection and analysis were conducted:

- Qualitative, in the form of workshops with relevant stakeholders at each pilot site to either gather inputs for the TRACE platform as a whole or pilot use case concretization.
- Quantitative, in the form of an online questionnaire addressed to logistic companies in Europe.

3.1 Qualitative analysis – workshops

The project partners organised workshops in Greece, Italy and Slovenia to gather input for the development of the TRACE platform and to define more precisely the specific of each pilot and use cases. They addressed all relevant or potential project partners who will/might participate in the pilot project under WP6.

The workshops were conducted in a semi-structured interview format and in the local languages (Greek, Italian and Slovenian) to make the interviews more natural and to adapt to local specificities and needs.

Effective stakeholder engagement is critical to the success of any project, especially in areas that require collaboration across different sectors, such as logistics and sustainability. In the TRACE project, stakeholder engagement was carefully carried out from November 2023 to April 2024, with multiple touch points to ensure comprehensive participation and feedback.

3.1.1 Slovenian workshops

In November 2023, the Slovenian pilot partners organised a workshop with logistics operators and end-users of logistics processes, including telecommunication companies and a retail chain. The project partners initially presented the TRACE project, after which a semi-structured interview and discussion were held regarding the challenges and opportunities presented by the new TRACE platform.

In general, logistics companies are interested in optimising their operations and reducing their carbon footprint, despite concerns regarding confidentiality and issues related to the handling of competitors' goods. Based on the feedback received, it can be concluded that the platform has the potential to optimise

operations, provided that issues related to confidentiality and business secrets are properly addressed. It is therefore imperative that the platform addresses the issues of security and data protection, and that it is aligned with EU regulations on cybersecurity. In addition, the platform must support the requirements related to authentication, robust security features, controlled access, and encryption.

Labour shortages represent a significant challenge for the industry, as evidenced by feedback from logistics companies. This is a key factor driving the adoption of new automation technologies. However, the high cost of automation and the relatively recent emergence of these technologies can present implementation challenges. Consequently, the TRACE platform must be scalable and future-proof, with a proven track record of working with automated logistics solutions.

The feedback from logistics companies and retailers indicates that end customers desire more flexible delivery options, such as wider time windows and personal collection and parcel lockers. Subsequent discussions with the Slovenian Ministry of Infrastructure and the City of Ljubljana revealed the necessity of considering potential future limitations on last-mile delivery, which may be imposed at the national, regional, or city/district level.

Blockchain technology is not widely understood and is often perceived as complex and costly. It is believed that there is a lack of adoption due to a lack of expertise and experts. This supports the decision to provide a comprehensive platform that exploits the beneficial aspects of blockchain technology, while end users are not required to possess expertise in implementation.

In the context of the forthcoming autonomous delivery pilot in Slovenia, stakeholders have identified a number of potential benefits associated with robotic delivery, particularly in terms of flexibility and efficiency. These factors are highly valued by customers. For instance, evening deliveries have a higher success rate, making robotic delivery an attractive option for increasing delivery rates and user satisfaction while simultaneously reducing costs and energy consumption.

Furthermore, they addressed the issue of labour shortages, supporting automatization of last-mile delivery and other logistic processes as a viable option.

Furthermore, participants emphasised the significance of delivery tracking and carbon footprint assessment, which are fundamental aspects of the TRACE platform development. They also suggested that the integration of robots and on-board/mobile parcel lockers can significantly enhance the efficiency of delivery robots, which is offered as an additional requirement for Slovenian pilot.

In the context of autonomous delivery options with delivery robots, two key issues have been identified by logistics operators. These are the security concerns related to high-value parcels and the complexity of coordinating multiple logistics providers.

Regarding the security challenges, logistics companies have emphasised the importance of tracking parcels in real time and the necessity of reliable parcel collection confirmation. A robot operator should have a have real-time access to delivery robot telematics and live sensors, such as cameras and LIDARs, as well as robot remote control.

Additionally, participants generally highlighted the importance of informing customers of exceptional events, monitoring delivery quality through KPIs, and the potential to optimise small business deliveries to reduce empty runs. The workshop highlighted the shared focus on optimising logistics through

technology, addressing labour and cost challenges, and ensuring flexible, secure, and transparent delivery solutions for end customers.

Consolidation warehouses were only considered if they reduced costs, even though some cities might implement them to increase load factor and consequently lover carbon footprint, energy consumption and congestions, caused by last-mile delivery. Real-time updates and AI integration were highlighted as critical to customer satisfaction and operational visibility.

3.1.2 Italian workshops

The engagement process began with an initial outreach via email, followed by subsequent meetings by phone or telephone, and culminated in several face-to-face meetings. This multi-phased approach aimed to build trust, facilitate in-depth discussions and gather valuable insights from stakeholders.

In the first phase, introductory emails were sent to selected stakeholders, mainly large companies and logistics providers. These emails introduced the TRACE project, highlighting its objectives, potential benefits and the tools it could offer to improve their daily operations, optimisation and sustainability efforts.

The second phase consisted of follow-up meetings, which were held via telephone or telephone calls. These meetings allowed for more in-depth discussions and provided a platform for stakeholders to ask questions and express their initial thoughts and concerns.

The final phase involved several face-to-face meetings. These face-to-face interactions were crucial for building stronger relationships and gaining a deeper understanding of stakeholders' needs and expectations.

Stakeholders were selected on the basis of their industrial relevance, ensuring that the project engaged with organisations that could significantly influence and benefit from the TRACE project. Stakeholders selected included major corporations and logistics providers whose feedback would be instrumental in shaping the project's direction and implementation strategies.

Stakeholders co-created the pilot and platform requirements, set in D2.1 and D2.4 and expressed a willingness to follow up and remain engaged, demonstrating a strong interest in the project's potential to revolutionise logistics operations through improved traceability and sustainability.

3.1.3 Greek workshops

In Greece, partners performed two physical meetings with pilot stakeholders, one in September 2023 at ACS premises and another one in January 2024 at HT premises. Additionally, they performed two online meetings in June and July 2024.

The pilot shareholders were selected from partners within the consortium, specifically ACS Postal Services S.M.S.A., part of Quest Group, Greece's leading courier company, with over 750 service points and 3,700 employees, and Hellenic Train S.A., Greece's primary private railway company, operating passenger and freight services.

During the discussion meetings, they focused on analysis of Greek pilots with detailed examination of pilot projects, definition of steps, when they established a clear roadmap and defined steps for the successful execution of the project, defined KPIs to measure success and impact of pilot scenarios and presented internal processes to measure success and impact of the pilot scenarios.

Additionally, both ACS and HT presented their internal processes to provide a comprehensive understanding of their operational frameworks and how they align with the TRACE project objectives.

The discussion with the stakeholders related to their internal processes and how their routes can be matched using the TRACE platform. They also mentioned the needs from their perspective in terms of shipment transfer and possible restrictions based on their business operations.

Inputs of stakeholders were implemented in D2.1 and D2.4.

3.1.4 Outcomes and use of results

Insights and data gathered from stakeholders during qualitative workshops were vital in preparing User requirements analysis for the development of the TRACE platform. The outcomes were used for pilot development and user requirement definition, focusing on optimisation of the platform, security measures, scalability, and flexibility. Additionally, future-proof automation with autonomous delivery options was defined.

Stakeholder engagement played a pivotal role in the TRACE project, ensuring that the platform and pilots will be aligned with the needs and expectations of key industry players and pilot stakeholders. The collaborative approach with industry stakeholders is instrumental to successful development and implementation of the TRACE platform and TRACE pilots as well. Workshops, held in Greece, Italy, and Slovenia, provided also a place of discussion to better refine and define pilot use cases. By addressing key requirements from stakeholders, the project established a strong foundation for optimization of logistic operations and enabling coopetition between different logistic providers.

3.2 Quantitative analysis – questionnaire

3.2.1 Methodology

To ensure the effectiveness and relevance of the questionnaire used for the analysis of industry needs for the development of TRACE platform, we followed several steps to ensure comprehensive data collection.

In the first step, we defined objectives of the questionnaire – to understand current challenges of the logistic industry, identify key features and functionalities and to gather additional insights on adoption of new technologies and constrains related to it. In the process, all project partners were involved to submit potential questions and areas of interest to check and test.

In the following step, we have designed a questionnaire (Annex C) based on defined objectives and feedback from project partners. This involved careful selection of question types, making questions clear

and precise with logical sequence. Before sending it to external stakeholders, questionnaire was tested internally to identify potential issues and refine the questions accordingly.

We have decided to use online tools, developed by University of Ljubljana's Faculty of Social Sciences, enabling easy user interface with additional layers of GDPR-compliance.

3.2.2 Mapping and engagement

The project partners started by compiling a comprehensive list of contacts from logistics companies in 21 European countries: Austria, Belgium, Croatia, Cyprus, Czech Republic, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Sweden and Switzerland. The list of contacts was obtained from the online databases of FIATA (International Federation of Freight Forwarders Associations) and ELALOG (European Logistics Association). These contacts were strategically selected to represent a diverse cross-section of the logistics sector in the target European countries.

To ensure an organised and efficient approach, we divided the roles between our project partners. Each partner was assigned specific countries for which they were responsible for overseeing the distribution and monitoring of the questionnaire, using cold outreach.

The questionnaire was distributed to a total of 377 logistics companies and 27 national logistics associations. The national logistics associations were asked to distribute the questionnaire to their members. After the initial distribution, a follow-up was carried out to remind respondents of the survey in order to increase the response rate and ensure a balanced representative sample.

Of the 404 emails sent, 28 were no longer active, leaving 376 emails reaching recipients. The questionnaire landing page was accessed 156 times and 32 contacts from 13 countries completed the questionnaire in full, achieving a response rate of 8.5%, which is above the usual response rates for a cold outreach.

3.2.3 Analysis of answers

Company size: The respondents were evenly distributed among large, medium, and small companies, ensuring a balanced representation of the industry.

In terms of **industry representation**, the questionnaire was directed to the logistics and transportation industry, from which we received 91% responses. The remaining 9% of stakeholders included representatives from the retail, e-commerce, ICT and technology sectors.

Shipping volume was evenly distributed among the respondents as well, reflecting a diverse range of operational activity.

Delivery Frequency: A significant 68% of the companies reported making deliveries at least six times per week, indicating a high level of operational activity.

Delivery Methods: 76% of the respondents managed their deliveries internally, while 55 % used outsourced delivery services. Multiple responses were allowed, indicating some companies use both in-house and outsourced delivery methods.

High percentage of either in-house delivery and outsourced delivery indicate a need of combining different optimizations.

Partner Selection Criteria: The top five criteria for selecting partners in shipments and logistics were Cost-effectiveness, Operational efficiency, Speed of delivery, Reliability and reputation, Customer service and support, while the least important criterion was value-added services.

With rising operational costs and high competition, cost-efficiency and operational efficiency is key to staying competitive, combined with common demands from the customers, such as speed of delivery, reliability, and support. TRACE platform should ensure to follow were top criterions.

Outsourcing of mid- and last-mile delivery: Companies were evenly distributed in their use mid-mile logistics between Third-party logistics providers, a combination of in-house fleet and third-party providers or In-house fleet alone. The distribution of responses regarding last-mile logistics was similar.

Existing Challenges: The top five challenges faced by the companies were Workforce challenges, Green transition, Inefficiencies or redundancies, Lack of automation, and Scalability limitations. The least pressing challenges were regulatory compliance, lack of transparency, and cybersecurity risks.

The low results for cybersecurity risk mean that logistic companies may underestimate cybersecurity as a significant threat compared to other immediate and more visible challenges, possibly also due to low awareness levels and no past incidents. Nevertheless, the TRACE platform should simplify cybersecurity management to minimize potential future vulnerabilities and threats.

Reasons for delayed delivery: The primary causes of delayed deliveries were identified as traffic conditions (63%), inefficient routing (56%) and workforce challenges (53%). These findings support the necessity for additional route optimisation based on real-time data and the optimisation of deliveries to reduce workforce challenges.

Possible improvements: Potential improvements identified by respondents include investment in staff (79%), automation (71%) and operational streamlining (58%) as key strategies for enhancing future performance. In contrast, investment in hardware (29%) and software (42%) is perceived as less crucial, despite its potential to facilitate more efficient operations.

Fleet Composition: The survey findings revealed that 96% of companies utilise internal combustion engine trucks, with 83% using internal combustion engine vans. However, electric vans are present in only 33% of responding companies, while electric trucks are even less common. Micromobility is used by only 13% of companies. Additionally, all respondents reported utilising a heterogeneous mix of vehicles, with no current usage of autonomous vehicles, which is to be expected.

Load factor: The most prevalent load factor among the surveyed companies fell within the range of 60% to 89%. It is interesting to note that one-third of the respondents reported a load factor exceeding 89%.

Sensor Data Collection: Regarding the collection of sensor data, 67% of companies or their subcontractors have already adopted the use of various types of sensors, while an additional 17% have expressed interest

in doing so in the future. Only 4% of respondents indicated that they do not collect data and are not interested in doing so in the future, which further supports the need to implement a range of sensor data types into the TRACE platform.

Fuel Consumption data: Most companies (79%) already collect fuel consumption and/or emissions data.

Geofencing and delivery disruption alerts: With regard to geofencing alerts, 42% of companies have already adopted this technology, while a further 54% are currently evaluating its potential future application. Similarly, delivery disruption alerts are currently in use by slightly more than half of the respondents, while the remaining half has expressed interest in implementing such alerts in the future.

Delivery Challenges: The respondents identified traffic congestion (4.6 out of 5) and delivery time windows (4.4) as the most significant challenges during the delivery process. In contrast, vehicle breakdowns (3.0) were perceived as a relatively less problematic issue.

Last-mile Route Efficiency: In line with the responses provided by respondents, it is reasonable that a significant proportion of them (79%) would benefit from more efficient routes in the context of their operations. This may be a key expectation of a new platform.

Technologies: The most prevalent functionalities, already in use by logistics companies, are static route planning (91%), real-time monitoring of shipments/tracking (75%), and capacity planning for vehicles (70%). These are regarded as the essential functionalities for logistics. Currently, there is a low utilisation of AI-driven dynamic route planning, data visualisation, and multi-carrier operations. However, the majority of respondents expressed interest in the potential use of these functionalities. It is noteworthy that 70% of respondents expressed interest in multi-carrier operations, which aligns with the development of the TRACE platform. Currently, only 9% utilise blockchain technology in any form, yet 61% indicated interest in its future implementation. Furthermore, 78% of respondents either intend to implement automated last-mile delivery or are interested in this technology.

Parcel Data Availability: Two-thirds of companies have data on the precise content of shipments, while one-third have data on the approximate content. Furthermore, 88% have data on the exact size of shipments, and all have data on the exact weight. While knowledge of the shipment's content category is sufficient for safe automated delivery and special care, knowledge of the shipment's exact size would enable even greater optimisation of deliveries.

Internal KPIs: Total cost of logistics and 75% track total delivery time. Other KPIs that are frequently employed include total delays (75%), capacity utilisation (67%), on-time delivery rate (63%), energy/fuel consumption (61%), order accuracy rate (58%), inventory turnover rate (54%), and customer satisfaction scores (50%). However, only 33% of respondents indicated that they currently track their carbon footprint, with another 54% reporting that they plan to do so or expressing interest in doing so. This suggests significant potential for this KPI on the TRACE platform.

Customer-Facing Functionalities: Many companies (63%) provide customers with shipment and delivery alerts, and the real-time tracking of deliveries is also a common offering. Other functionalities, such as return management services, packing and warehousing solutions, automated booking/scheduling, self-service portals, and flexible delivery options, are less prevalent, with a presence in approximately 20% to 25% of cases. A quarter of respondents have indicated that they intend to implement automated booking

and scheduling, self-service portals, sustainable options, flexible delivery, and customised reporting in the near future. Furthermore, additional functionalities that have yet to be planned but are of interest include consolidation of goods/consolidation centres (47%), automated booking/scheduling (28%), sustainable options (31%), and flexible delivery (25%). It is evident that automation, digitalisation, and flexibility are key trends in the logistics industry, which TRACE must also follow. Furthermore, the selection of sustainable options is important. Consolidation centres are particularly interesting as they are currently underutilised (9%) but hold high potential. This highlights the need to test these solutions for economic viability, especially when combined with autonomous delivery.

IT and Software Use: A third of companies utilise custom-developed software, 58% employ on-premises software, and slightly more than one third utilise cloud software as a service. However, one-third of companies still rely on pen and paper for some processes. This versatility supports the need to adopt different connection mechanisms to coexist with the TRACE platform.

Barriers to technology adoption: The most significant barriers to the adoption of technology include the preference for waiting for mature solutions (58%), cost concerns (54%), and a lack of resources and expertise (42%). It is anticipated that, due to the high level of investment and the lack of resources and expertise, logistics companies are less willing to adopt new technologies quickly.

Reasons for New Functionalities: Due to the logistics industry's low net profit margins, challenging market conditions, green transition-related requirements and intense competition, cost optimisation and reduction is the main reason for implementing new functionalities, with 96% of responses, followed by operational efficiency (74%), competitive advantage and customer satisfaction (70%). Sustainability (35%) and security (13%) are not among the industry's top concerns, despite the fact that logistics is a major contributor to CO2 emissions and cybersecurity threats are widespread.

Current Limitations and Expansion Plans: Space constraints are an issue for 45% of companies, while 41% report no current constraints. Reducing warehouse space by consolidating shipments is important to 38% and very important to 21%. In terms of expansion, 50% are planning to increase their warehouse space and 46% are considering consolidating shipments.

Optimization Potential: When asked which steps in the logistics process have the greatest potential for optimisation, respondents could choose between routing, sorting and scheduling. Routing was chosen by two-thirds of respondents and delivery scheduling by almost one-third. The remaining 4% chose sorting as the step with the greatest potential for optimisation.

Crucial elements for event management: When it comes to event logistics and supply chain management, 96% of respondents cited the coordination of suppliers and deliveries as fundamental to event management needs, while 39% cited the timely delivery of materials and products.

Safety measures: Monitoring vehicle movements is viewed as a key measure for enhancing safety and security by 91% of companies, while responding to security breaches/incidents (35%) and ensuring compliance with safety regulation (30%) is seen as less essential.

Alerts integration: When it comes to event scheduling and timelines, respondents believe that integrating alerts with event schedules is critical (79%), as well as supporting the response to event delays/disruptions (75%) and optimising event timelines (63%).

Communication Preferences: When it comes to alert communication, 71% of respondents prefer dashboards and 54% prefer mobile apps, while a fifth suggest API connectivity to other existing platforms.

Blockchain and Smart Contracts: Blockchain usage is currently low, with only a few planning to implement it, but there is interest in smart contracts for payment settlement and customer contracts (both at 50%). In addition, 24% are interested in tokenising physical assets such as real estate or machinery.

3.2.4 Conclusions

The results of our survey demonstrate the dynamic and diverse nature of the logistics industry. The balanced representation of different countries and company sizes ensures that our findings reflect the diversity of the industry, although we are cautious about generalising conclusions to the whole industry in the EU.

One of the key findings is the high frequency of both in-house and outsourced delivery. This points to a clear need for optimisation strategies that can seamlessly combine both delivery models. The TRACE platform should focus on providing solutions that increase cost effectiveness, operational efficiency, speed of delivery and reliability, which are the key criteria for partner selection, while adding solutions to make the green transition easier for logistic companies.

The survey also highlighted key challenges such as workforce issues, green transition, inefficiencies, lack of automation and scalability constraints. The TRACE platform should address these challenges by focusing on real-time data for route optimisation and workforce management. It should also address these issues while simplifying cybersecurity management and reducing the carbon footprint.

The composition of the fleet is still heavily reliant on internal combustion engines, and interest in electric and micro-mobility options is growing. The prevalence of a heterogeneous mix of vehicles suggests that TRACE needs to support a variety of fleet management capabilities, while encouraging the adoption of greener alternatives and preparing for automated delivery in the near future.

Sensor data collection and fuel consumption tracking are areas in which many companies are already investing, indicating a willingness to use data to improve performance. The TRACE platform should build on this by providing advanced data analysis and real-time monitoring capabilities.

Delivery challenges such as traffic congestion and delivery windows require more efficient routing solutions, which is a key expectation for a new platform such as TRACE. Interest in technologies such as dynamic route planning based on artificial intelligence, data visualisation and multi-carrier operations reinforces the need for TRACE to include these advanced functionalities.

Despite the low current adoption of blockchain, there is considerable interest in its future implementation, particularly for smart contracts and the tokenisation of physical assets. TRACE should explore these areas in order to offer state-of-the-art solutions that increase the transparency and efficiency of logistics operations.

In terms of internal KPIs, there is a notable gap in the monitoring of carbon footprint, suggesting an opportunity for TRACE to introduce sustainability metrics. Most companies already provide shipment and delivery alerts, but there is growing interest in more sophisticated customer functionality such as automated booking, scheduling and flexible delivery options.

Barriers to technology adoption, such as cost issues, the need for mature solutions and a lack of resources and expertise, highlight the importance of TRACE providing cost-effective, easy-to-use and scalable solutions that are easy to implement.

The importance of optimising routing and scheduling, improving safety through vehicle monitoring and integrating alerts into event management processes are key functionalities that TRACE needs to address as a priority. The preference for dashboards and mobile apps for alert messaging also suggests that TRACE should focus on intuitive and accessible interfaces.

3.2.5 Outcomes and use of results

The quantitative data obtained from the analysis of the questionnaires was utilised to prioritise the TRACE requirements identified by the project partners, the pilot definitions and the qualitative stakeholder contributions. For each platform requirement, we made a comparison between the requirement and the responses obtained from the quantitative analysis. In accordance with the TRACE requirements methodology, each requirement was assigned a score according to its criticality. A score of 3 was allocated to 'shall' requirements, indicating essential features, a score of 2 was allocated to 'should' requirements, indicating important but non-essential features, and a score of 1 was allocated to 'may' requirements, indicating optional features. If a particular requirement was not supported by the answers to the questionnaire, no points were awarded for this type of evaluation. Described system enabled the effective prioritisation of the development of TRACE platform requirements, based on industry needs, ensuring that the most critical and widely supported features were prioritised. This approach ensured that the needs of industry stakeholders were systematically integrated into the platform development process.

4 Methodology of Requirements analysis

4.1 Activities and process

TRACE prescribes the use of two iterations during platform development. The development life cycle process is particularly well suited to this context. During each iteration, a requirement specification is provided that can be used for the delivery or evolution of certain operational capabilities of the final platform, which can then be put into operation.

Feedback will be provided that may result in the modification or extension of requirements in subsequent iterations. Each delivery in this model represents a full development cycle, including requirements analysis.

The appropriate requirement management tools will be employed to facilitate the definition of requirements using certain patterns or wordings (often based on predefined vocabulary or a domain-specific ontology). This enables the creation of well-formed requirements (semi-formal or formal) which can be further supported by formal languages.

4.1.1 Requirements elicitation

The objective of this phase is to identify relevant stakeholders, their needs and potential constraints. In the process, project partners have methodically gathered a comprehensive set of requirements that reflect project needs. The outcome is a set of raw requirements.

4.1.2 Requirement analysis

After the first step of requirements elicitation, we focused on analysing the collected requirements. This phase was dedicated to resolving ambiguities, inconsistencies and conflicts within the requirements. The result of this phase is a set of well-documented, measurable, testable and traceable requirements that form a solid foundation for the next project deliverables.

4.1.3 Requirement specification

After the requirements have been analysed, they were documented in a formal requirements specification, serving as an official record of the validated requirements. They were structured in a format, aligned with project standards and stakeholder expectations as well.

4.1.4 Requirement verification and validation

The final phase involved verification and validation of the requirement specification, ensuring it is an accurate, correct, and complete representation of stakeholders' needs. This process guarantees that only accepted and validated requirements are included in this deliverable.

4.2 Requirements specification template

In the context of the TRACE project, we have adopted the general principles of functional requirements syntax as set forth in ISO/IEC/IEEE 29148:2018. This approach has enabled us to contribute to the validation of requirements with the relevant stakeholders and to guarantee that the requirements themselves accurately reflect the needs of those stakeholders.

4.2.1 TRACE Requirement card

The VOLERE requirements specification template[2] was chosen as a start point, adapting it to the particularities and needs of the TRACE project. Volere is a straightforward methodology that does not require a complex analysis and guarantees the participation of all relevant actors, who are further involved in the design and development that have to fulfil the requirements defined.

The proposed methodology builds around the gathering process and the shell to register the requirements, classified in 27 categories in 5 main groups:

- **Project drivers**, the business-related forces, e.g., the purpose of the project is a project driver, as are all of the stakeholders.
- **Project constraints**, restrictions on how the product must be designed.
- **Functional requirements**, the fundamental or essential subject matter of the product. They describe what the product has to do or what processing actions it is to take.
- **Non-functional requirements**, the properties that the functions must have, such as performance, security and usability. These requirements should be considered of equal important as the functional requirements for the product's success.
- **Project issues**, the conditions under which the project will be done. The reason for including them as part of the requirements is to present a coherent picture of all factors that contribute to the success or failure of the project and to illustrate how managers can use requirements as input when managing a project.

The Volere methodology adopts a template that prescribes description of a particular requirement with following characteristic:

- **Requirement Numbering**. We provide to each requirement a unique identifier to make it traceable throughout the development process. The numbering scheme suggested in the requirement shell is a simple scheme and defined as follows:
- Requirement **#** is the next unique requirement number;
- Requirement **Type** is the section number from the template for this type of requirement. The inclusion of the section number serves as a reminder of what this requirement relates to and helps to remind why the requirement is considered important. Also, the ability to compare requirements of the same type makes it easier to identify contradictions and duplications.

- **Event/use case #** is the identifier of a business event or use case that contains this requirement. There might be several Event/use case #'s for one requirement because the same requirement might relate to a number of events. The terms event and use case are already widely used in the systems development world.
- **Customer Value** is a measure of how much your client cares about each requirement. Customer should grade each requirement for **Customer Satisfaction** or **Customer Dissatisfaction**. The point of having a satisfaction and a dissatisfaction rating is that it guides clients to think of the requirement from two different perspectives and helps to uncover what they care about most deeply.
- **Dependencies** keep track of other requirements that have an impact on this requirement. If the dependency exists because requirements use the same information, then use of standard naming conventions and definitions will implement this dependency.
- **Other dependencies** exist because a solution to this requirement has a positive or negative effect on solutions to other requirements. Some requirements, especially project drivers and project constraints, have an impact on all the other requirements.
- **Conflicts** keep track of other requirements that disagree with this one.

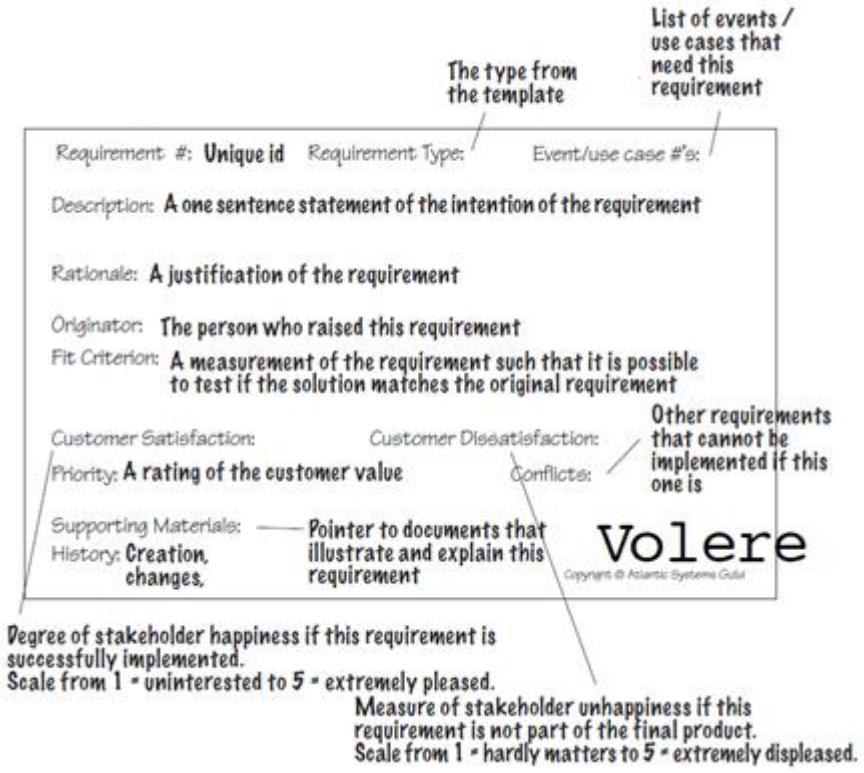

Figure 3: Requirement card template based on Volere

For the purpose of TRACE, a more simplified card is proposed compared to the one presented in Figure 3. This is presented below.

Table 5: TRACE requirement card

Id	*{ClassId}-{XX}*	**Type**	*XX*[3]	**Priority**	*XX*[4]	**Source**	*XX*[5]	**Ver**	*X*
Title		*Requirement title/name*							
Description		*More detailed description of particular requirement (textual form only).* *If Requirement title is sufficient enough to understand the requirement, this filed can remain empty.*							
Rationale		*Indicate the reason behind the requirement. Why the requirement is important and how it contributes to the system's purpose.*							
Dependencies		*Indicate if the requirement depends on another requirement. Relations between two or more requirements should be noted and separated by comma(s).*							
Conflict		*It implies that there are contradictions upon system implementation, or a requirement makes the implementation of another requirement less feasible. Potential values: Default "(None)" or requirement number(s), separated by comma(s).*							
Additional Info (comments)		*Any additional info to better clarify or illustrate concepts (pictures may be possible).*							
Related Scenario(s)		*ID of the Use case / scenario if relevant*							

Table 6: List of categories for requirements

Functional	Functional	FUNC
	Data	DATA
	Look and Feel Requirements	L&F
	Usability Requirements	USE
	Performance Requirements	PERF
Non-functional	Operational - Environmental Requirements	ENV
	Maintainability and Support Requirements	SUP
	Security & safety Requirements	SEC
	Other	OTH

4.2.2 UML Tools of modelling

In the course of the project, a number of tools for modelling were identified. Amongst these, the web-based, free tool Draw.io was selected for use on the grounds of its suitability.

5 Functional requirements

5.1 Platform Requirements

5.1.1 Platform Related Requirements

Id	PLT-FUN-001	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title		**Omnichannel integration (Empty trip and container optimization should integrate with horeca, micromobility, and food delivery)**							
Description		The optimization of empty trips and containers should integrate with HoReCa, micromobility, food delivery, and real-time deliveries on a consolidation basis, considering all different channels (possible clients) present in the operational area							
Rationale		Enables efficient transportation							
Dependencies		None							
Conflict		None							
Additional Info (comments)		None							
Related Scenario(s)		Italian pilot							

Id	PLT-FUN-002	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title		**Productivity – Operational Harmonization(Optimization of loading per cargo bike or platoon shall be based on productivity KPIs and working shifts)**							
Description		The optimization of loading (number of parcels) per cargo bike or platoon shall be based on productivity KPIs and working shifts							
Rationale		Enables more efficient transportation and work force organization							
Dependencies		None							
Conflict		None							
Additional Info (comments)		None							
Related Scenario(s)		Greek, Italian and Slovenian pilot							

Id	PLT-FUN-003	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title		**Platform shall consider delivery constraints such as time, vehicle type, and emissions**							
Description		The platform shall take into consideration various constraints related to the deliveries in specific areas or addresses (e.g., restrictions based on time, vehicle types, vehicle fuel, total weight, total length, maximum time in delivery area, emission standards, city entry points, etc.)							

Rationale	Given the increasing restrictions or additional fees imposed by national or local authorities on urban logistics, it is crucial that the platform respects these constraints. By incorporating these factors, the platform will ensure compliance with local regulations, optimize delivery activities, and increase overall efficiency.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**PLT-FUN-004**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**The platform should enable defining these variables if/when needed.**								
Description	Types of constraints: • time restriction (hour, day in the week, bank holidays), • temporary restrictions (due to events, infrastructure limitations, emissions, weather conditions …), • noise restrictions • parking restrictions for delivery vehicles, such as designated (un)loading zones • vehicle fuel type and/or emissions class (for green/emission zones, varies by country), • vehicle type (such as (cargo)bike, light truck, heavy truck, autonomous delivery robot …), • vehicle total weight, • vehicle height restriction (low bridges and tunnels), • vehicle length restriction (in case of very sharp turns), • vehicle width restriction (applies in narrow streets), • maximum time in delivery area (if such restriction applies), • entry/exit points (if such restriction applies), • special permits to enter delivery area (based on vehicle type, weight, cargo-type), • prohibited materials Beside constrains, additional costs may apply, such as congestion charges or parking fees.								
Rationale	The platform should enable defining these variables to ensure flexible, efficient, and compliant logistics operations by adapting to various constraints and additional costs that affect routing, scheduling, and overall service quality.								
Dependencies	None								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**PLT-FUN-005**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Flexible time window for package pickup availability (System should select a 1-2 hour time window for package picker availability for B2B and B2C deliveries)**								
Description	The system should select a wider time window for the availability of the package picker (1-2 hour time window) within which the delivery is made, for both B2B and B2C deliveries.								
Rationale	Tighter time windows are more difficult to achieve, due to last mile operational complexity. With wider time windows we can achieve better KPI's related performance								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	**PLT-FUN-006**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Standards	**Ver**	1
Title	**TRACE platform should enable the planning of necessary measures to prevent or mitigate the negative impacts of future events**								
Description	The TRACE platform collects data on events and disruptions along transportation routes, enabling risk analysis for route selection. TRACE provides valuable insights into route reliability and safety by recording incidents such as traffic delays and other potential disruptions.								
Rationale	The platform should choose reliable vehicles and routes to minimize the risk of unforeseen events								
Dependencies	PLT-FUN-003, PLT-FUN-007, VS-FUN-002, VS-PRM-002, COM-PRM-036, EVT-FUN-003, SRY-FUN-004								
Conflict	PLT-FUN-004								
Additional Info (comments)	None								
Related Scenario(s)	Greek and Slovenian pilot								

Id	PLT-FUN-007	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**TRACE platform may integrate seamlessly with scheduling, routing, and tracking systems**								
Description	TRACE platform may integrate seamlessly with other systems and modules within the transportation ecosystem, such as scheduling, routing, and tracking systems								
Rationale	Enables more efficient vehicle usage to reduce CO2								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian cargo bike demonstrator								

Id	PLT-FUN-008	Type	FUNC	Priority	HIGH	Source	Consortium Know - how	Ver	1
Title	**TRACE platform shall dynamically adjust resource allocations, based on real-time performance data and predictive insights to optimize efficiency and responsiveness**								
Description	The TRACE platform offers dynamic resource allocation by updating schedules with each new request to ensure optimal vehicle and route assignments. With every incoming request, TRACE recalculates the most efficient allocations, allowing the platform to keep pace with ongoing demands. This continuous updating process ensures that resource allocation remains optimal over time, adapting to changing conditions and requirements in real-time.								
Rationale	Optimal use of resources such as vehicles, drivers, time, fuel								
Dependencies	PLT-FUN-001, PLT-FUN-007, RA-FUN-001, VS-FUN-002, VS-FUN-007, VS-FUN-013, VS-FUN-016, VS-PRM-010, EVT-FUN-005, EVT-PRM-001, MON-FUN-005, MON-FUN-006, BLK-FUN-007								
Conflict	PLT-FUN-004, COM-PRM-020, SRY-FUN-004								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-FUN-009	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Platform shall have CO2 reporting for customers, auditors, and regulators**								

Description	The platform shall have a CO2 reporting system for customers, auditors and regulation agencies in the field of logistics
Rationale	The platform shall have a reporting CO2 system due to rissing regulatory and market pressures for more transparency on CO2 emissions in the logistics sector. A lot of logistic companies are already complying with ISO standard 50001 and are currently moving towards the adoption of ISO standard 14083. The GLEC Framework provides the basis for legitimate CO2 calculation
Dependencies	None
Conflict	None
Additional Info (comments)	In order to establish a legitimate CO2 reporting system it has to be in line with the prescriptions of the GLEC Framework and ISO standard 14083. This setting is being developed with sister EU project ADMIRAL. We should acquire deeper knowledge about the reporting system from said project.
Related Scenario(s)	Greek pilot

Id	**PLT-FUN-010**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title		**TRACE platform shall include tools for automated testing and component quality**							
Description		TRACE platform shall include tools and frameworks for automated testing, ensuring component quality and compatibility							
Rationale		Ensures that all components of the TRACE platform are tested for quality and compatibility, reducing bugs and increasing reliability							
Dependencies		PLT-FUN-012							
Conflict		None							
Additional Info (comments)		This requirement emphasizes the need for robust testing frameworks and tools that can automate the testing process, thereby ensuring continuous integration and continuous deployment (CI/CD) practices are upheld							
Related Scenario(s)		Greek, Italian and Slovenian pilot							

Id	**PLT-FUN-011**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title		**TRACE platform shall include tools for automated testing and component quality**							
Description		TRACE platform shall offer well-documented APIs for integration with other applications and services, enabling custom development and automation							
Rationale		Facilitates the integration of the TRACE platform with external systems and services, enhancing extensibility and customization.							
Dependencies		None							
Conflict		None							
Additional Info (comments)		Documentation should include clear examples and use cases. The APIs specifications will follow well known standards.							
Related Scenario(s)		Greek, Italian and Slovenian pilot							

Id	PLT-FUN-012	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**TRACE platform shall support interoperability with hardware, software, and external APIs**								
Description	TRACE platform shall support interoperability with various hardware devices, software systems, and external APIs to facilitate seamless integration								
Rationale	Ensures that the TRACE platform can operate effectively with a diverse range of systems and devices								
Dependencies	PLT-FUN-010, PLT-FUN-011								
Conflict	None								
Additional Info (comments)	Interoperability should be considered during all phases of development to ensure compatibility and functional integrity across different systems and platforms. Testing for interoperability should include scenarios that reflect real-world usage to identify and address potential issues early in the development process								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-FUN-013	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Integration of KPIs for Performance Measurement in TRACE Platform**								
Description	TRACE platform shoud accomodate KPIs for emasuting the performance of the functionalities								
Rationale	KPIs are essential for tracking and optimizing the performance of the TRACE platform's functionalities.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-FUN-014	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Support for Notifications and Alerts in TRACE Platform**								
Description	TRACE platform should accomodate notifications and alerts (e.g., SMS, etc)								
Rationale	Notifications and alerts are crucial for ensuring that users are promptly informed about important events on the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Slovenian pilot								

Id	PLT-FUN-015	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Integration of Reporting and Analytics in TRACE Platform**								
Description	TRACE platform should accommodate reporting and analytics functionalities								
Rationale	Reporting and analytics functionalities are vital for users to monitor performance and make informed decisions on the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-FUN-016	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Implementation of Route Optimization in TRACE Platform**								
Description	TRACE platform should accommodate route optimization functionalities								
Rationale	Route optimization is essential for improving operational efficiency and reducing costs on the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-FUN-017	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Support for User Authentication and Authorization in TRACE Platform**								
Description	TRACE platform should accommodate user authentication and authorization								
Rationale	User authentication and authorization are critical for ensuring secure access and protecting sensitive data on the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-FUN-018	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**TRACE platform should allow easy configuration and customization of individual components**								

Description	TRACE platform should allow for easy configuration and customization of individual components without affecting the entire platform
Rationale	Provides flexibility to users needing to tailor components to specific needs without impacting overall platform integrity
Dependencies	PLT-FUN-010, PLT-FUN-011
Conflict	None
Additional Info (comments)	This requirement highlights the importance of a modular design and the availability of intuitive user interfaces that support non-technical users in customizing functionalities according to their preferences
Related Scenario(s)	Italian and Slovenian pilot

5.1.2 Data Management Requirements

Id	**DM-FUN-001**	**Type**	FUNC	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title		**TRACE platform shall integrate data from various sources for a unified view**							
Description		TRACE platform shall integrate data from different sources and formats to provide a unified view of the transportation system							
Rationale		Trace platform will use a common Information model to handle data from different sources and to support Synchromodality. In the interoperability layer of Trace platform one connector per each operational DB will be implemented for data sharing and transforming the source data to a common information model.							
Dependencies		None							
Conflict		None							
Additional Info (comments)		None							
Related Scenario(s)		Greek pilot							

Id	**DM-FUN-002**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title		**Data types**							
Description		TRACE platform should support both structured and unstructured data							
Rationale		Trace platform should store both structured data (i.e., vehicle data info, shipment info and sensor readings) and unstructured data (i.e., shipment images, pdf files (contracts))							
Dependencies		None							
Conflict		None							

Additional Info (comments)	None
Related Scenario(s)	Greek pilot

5.1.3 Reporting & Analytics Requirements

Id	**RA-FUN-001**	**Type**	FUNC	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title		**TRACE platform may include predictive analytics capabilities to forecast future transportation demand, resource utilization, and potential disruptions**							
Description		By analysing historical data collected by the platform and leveraging machine learning algorithms, TRACE may predict trends and identify patterns, allowing users to anticipate changes in demand and optimize resource allocation accordingly.							
Rationale		Use the collected data throughout the platform's lifespan to improve its performance.							
45Dependencies		PLT-FUN-008, INT-FUN-001, INT-FUN-010, DM-PRM-001, EVT-FUN-008							
Conflict		ETH-PRM-013							
Additional Info (comments)		None							
Related Scenario(s)		Greek, Italian and Slovenian pilot							

Id	**RA-FUN-002**	**Type**	FUNC	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title		**TRACE Platform may Leverage Geospatial Analysis for Optimized Route Calculation**							
Description		TRACE platform may incorporate geospatial analysis capabilities to analyze transportation data based on geographic location, such as route optimization, traffic patterns, and spatial distribution of demand							
Rationale		Including traffic data guarantees efficient decisions regarding cost, delivery time, fuel consumption and emissions.							
Dependencies		PLT-FUN-008, PLT-FUN-016, VS-FUN-017							
Conflict		VS-PRM-002							
Additional Info (comments)		None							
Related Scenario(s)		Greek, Italian and Slovenian pilot							

Id	RA-FUN-003	Type	DATA	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**TRACE platform should enforce data governance for integrity, accuracy, and compliance**								
Description	TRACE platform should enforce data governance policies to ensure data integrity, accuracy, and compliance with regulatory requirements, including data privacy and security regulations								
Rationale	This requirement is essential to maintain trust and adherence to legal standards, safeguarding user data and ensuring the high quality and reliability of data processed and stored by the platform								
Dependencies	RA-PRM-001								
Conflict	None								
Additional Info (comments)	The implementation should consider current and future regulatory landscapes, potentially involving GDPR compliance for European data.								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	RA-FUN-004	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**TRACE platform should support real-time reporting for up-to-date transportation insights**								
Description	TRACE platform should support real-time reporting capabilities to provide up-to-date insights into the performance and status of the transportation system								
Rationale	Enables timely decision-making and immediate response to operational changes, which is crucial for managing dynamic and complex transportation environments								
Dependencies	RA-FUN-003, RA-PRM-006								
Conflict	None								
Additional Info (comments)	The implementation of this feature should consider the high volume of data processed and the need for efficient data handling and visualization techniques to ensure that reports are generated and displayed without delays								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	RA-FUN-005	Type	USE	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**TRACE platform should use APIs for reporting and analytics integration**								
Description	TRACE platform should be able to use API for reporting and analytics purposes to integrate with existing internal systems and platforms								
Rationale	To facilitate the integration of TRACE platform analytics with other enterprise systems, enhancing data accessibility and decision-making processes								
Dependencies	PLT-FUN-011								
Conflict	None								
Additional Info (comments)	Ensure that APIs are secure and comply with data governance standards to protect sensitive information								
Related Scenario(s)	Greek pilot								

5.1.4 Security and Data Protection Requirements

Id	SEC-FUN-001	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**TRACE system shall provide secure authentication for vehicle devices**								
Description	The TRACE system shall provide secure authentication of vehicle devices that connect to the TRACE platform.								
Rationale	The integration of secure authentication for vehicle devices connecting to the TRACE platform is essential for 1) protection against unauthorized access, 2) data integrity and security, 3) operational reliability.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian pilot								

Id	SEC-FUN-002	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**TRACE platform shall provide robust security features: RBAC, encryption, and MFA**								
Description	TRACE platform shall provide robust security features, such as role-based access control (RBAC), encryption (at rest and in transit), and multi-factor authentication.								
Rationale	Ensuring the security of a platform is paramount to protect sensitive data and maintain user trust.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	SEC-FUN-003	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Access control mechanisms for data integrity and unauthorized access prevention**								
Description	TRACE system shall perform access control mechanisms to protect data integrity and prevent unauthorized access.								
Rationale	Implementing robust access control mechanisms in the TRACE system is critical for 1) data integrity protection, 2) risk mitigation, 3) compliance with regulatory standards, 4) incident response, 5) trust.								
Dependencies	None								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Italian pilot

5.1.5 Blockchain Infrastructure Requirements

Id	**BLK-FUN-001**	**Type**	FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**dNFT Smart Contract**								
Description	TRACE will implement an NFT module to generate a unique ID for each parcel and a flexible smart contract ecosystem to dynamically update the values of the NFT in accordance with real-time values. The NFT smart contract will also be updated based on changes in the terms of the collaboration agreement (CA) between the partners.								
Rationale	TRACE will update the status of the shipment using smart contracts and dNFTs, ensuring up-to-date and accurate tracking information.								
Dependencies	Data Management Module, Events Module. To store new record and update existing record there is the dependency on Data Management Module.								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**BLK-FUN-002**	**Type**	FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**User Authentication on Blockchain**								
Description	TRACE should automatically initiate a blockchain transaction using the Algorand network whenever login credentials are successfully submitted by the logistics company								
Rationale	TRACE will seamlessly trigger blockchain transactions upon successful login, enhancing automation and security in logistics operations.								
Dependencies	This component depends upon the GUI module as the user needs an interface to login.								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-FUN-003	Type	FUNC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Transaction ID Capture and Verification**								
Description	TRACE should capture and retrieve the transaction ID from the Algorand blockchain once a transaction has been processed, facilitating tracking and verification								
Rationale	TRACE will facilitate precise tracking and verification by capturing transaction IDs directly from the blockchain.								
Dependencies	This component depends on the Data management Module. This component will query the database to compare the Tnx Id to facilitate secure session permission for user authentication.								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-FUN-004	Type	FUNC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Secure Storage of Public Keys**								
Description	TRACE should enhance security by securely storing public keys associated with logistics companies offline, used for verifying transactions								
Rationale	TRACE will enhance security by storing public keys offline, protecting the integrity of logistics transactions.								
Dependencies	This component will store the new user's public address to the database. The component depends upon Data management module.								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-FUN-005	Type	FUNC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**dNFT Generation for Logistics Assets**								
Description	TRACE should generate a unique dNFT for each shipment/parcel, allowing digital tracking and management of logistic assets								
Rationale	TRACE will create unique dNFTs for each parcel, enabling efficient digital tracking and asset management.								

Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**BLK-FUN-006**	**Type**	FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**Immutable Transaction Records**								
Description	TRACE should maintain a transparent and immutable record's transactions Id in centralized storage which is accessible via the platform interface								
Rationale	TRACE will maintain a transparent and immutable record of all transactions, accessible through the platform interface.								
Dependencies	Data management module, Security and Data protection Module.								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**BLK-FUN-007**	**Type**	FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**Blockchain-Based Scheduling Management**								
Description	TRACE should manage and store optimized and collaborative scheduling agreements for shipping goods on the Trace Database from where the collaboration agreement's hash will be taken and stored on blockchain.								
Rationale	TRACE will automate and secure logistics operations by managing collaborative scheduling agreements on the blockchain.								
Dependencies	Data Management and Cloud Infrastructure Modules								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-FUN-008	Type	FUNC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Delivery Process Completion on Blockchain**								
Description	TRACE should mark the completion of delivery processes on the blockchain, finalizing the status of logistic tasks								
Rationale	TRACE will finalize the status of logistic tasks by marking the completion of delivery processes on the blockchain.								
Dependencies	Data Management & Cloud Infrastructure								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-FUN-009	Type	FUNC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Logging Significant Events on Blockchain**								
Description	TRACE may log all significant events related to the delivery process on the blockchain, ensuring that all actions are transparent and immutable								
Rationale	TRACE will ensure transparency and immutability by logging all significant delivery-related events on the blockchain.								
Dependencies	Data Management & Cloud Infrastructure								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-FUN-010	Type	FUNC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Comprehensive Delivery Details Recording**								
Description	The TRACE may record comprehensive delivery details such as the delivery medium, personnel involved, pickup times, and other relevant data on the blockchain for enhanced traceability								
Rationale	TRACE will enhance traceability by recording detailed delivery information on the blockchain, including personnel and timing data.								

Dependencies	Data Management, Cloud Infrastructure
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**BLK-FUN-011**	**Type**	FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**Integration of Algorand Wallets for Authentication**								
Description	The TRACE should integrate Algorand wallets into the authentication process to enhance security by leveraging blockchain-based transaction authentication								
Rationale	TRACE will enhance security by integrating Algorand wallets, leveraging blockchain for secure transaction authentication.								
Dependencies	Cloud Infrastructure, GUI								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

5.1.6 Event Management Requirements

Id	**EVT-FUN-001**	**Type**	FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**Events should be generated when a) a shipment is loaded to a vehicle, b) when the shipment is delivered at the platform and/or the logistic company's system in real-time**								
Description	Logistic companies track the shipments by events created in several points of the process. To be seamlessly connected with the TRACE platform, it is important to keep tracking the shipments, so events should be generated and sent to the platform and eventually to the logistic company.								
Rationale	Transparency through the process. Real time information for the companies and the clients								
Dependencies	None								
Conflict	None								
Additional Info (comments)	These events should be in real time. Example of event: When a parcel is allocated to the autonomous vehicle, an event of this action must be generated.								

	This info should be immediately available to the TRACE platform and at the Logistic Company's systems.
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**EVT-FUN-002**	**Type**	FUNC	**Priority**	HIGH	**Source**	Standards	**Ver**	1
Title		**Event Management Module shall integrate with other Modules**							
Description		TRACE event management module shall integrate seamlessly with other modules, such as the Fleet Monitoring Manager and Mitigation Manager, to facilitate event-driven actions and decision-making.							
Rationale		Ensures interoperability and cohesive functionality across different modules, improving overall efficiency and decision-making.							
Dependencies		EVT-FUN-003, EVT-FUN-004, PLT-FUN-007, CLD-FUN-002, DM-FUN-001, SRY-FUN-001, INT-PRM-003, SEC-FUN-001, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-005, RA-PRM-008							
Conflict		PLT-FUN-007, CLD-FUN-002, DM-PRM-001, ETH-PRM-003, SEC-PRM-002, VR-FUN-005, EVT-FUN-005, EVT-FUN-006, PLT-FUN-007, CLD-FUN-002, DM-PRM-001, ETH-PRM-003, SEC-PRM-002, VR-FUN-005, EVT-FUN-005, EVT-FUN-006							
Additional Info (comments)		None							
Related Scenario(s)		Greek, Italian and Slovenian pilot							

Id	**EVT-FUN-003**	**Type**	FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title		**Platform may impact the assessment of events**							
Description		TRACE platform may allow for the assessment of the impact of events on various aspects of logistic processes, including operational costs, time delays, and customer satisfaction.							
Rationale		Enables a comprehensive understanding of how events affect logistics, aiding in better planning and resource allocation.							
Dependencies		EVT-FUN-002, EVT-FUN-005, PLT-FUN-008, CLD-FUN-004, DM-PRM-001, ETH-PRM-004, INT-PRM-005, INT-FUN-005, ETH-PRM-007, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-PRM-001, RA-PRM-002, RA-PRM-005, RA-PRM-006							
Conflict		PLT-FUN-015, DM-PRM-005, BLK-PRM-009, ETH-PRM-007, SEC-PRM-003							
Additional Info (comments)		None							
Related Scenario(s)		Greek and Slovenian pilot							

Id	**EVT-FUN-004**	**Type**	PERF	**Priority**	HIGH	**Source**	Technical	**Ver**	1

Title	**Platform shall detect real-time events**
Description	TRACE platform shall be capable of detecting various types of events, such as delays, disruptions, or anomalies, in real-time.
Rationale	Ensures prompt identification of issues, allowing for immediate corrective actions to minimize impact.
Dependencies	EVT-FUN-002, EVT-FUN-007, PLT-FUN-008, CLD-FUN-001, DM-PRM-003, SRY-FUN-004, BLK-PRM-007, INT-PRM-005, ETH-PRM-014, MON-FUN-006, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-001, RA-PRM-003, RA-PRM-004, RA-PRM-008, COM-FUN-013
Conflict	PLT-FUN-016, DM-PRM-002, BLK-PRM-007, ETH-PRM-005, SEC-FUN-003, EVT-FUN-001, EVT-FUN-009, EVT-FUN-010
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**EVT-FUN-005**	**Type**	FUNC	**Priority**	HIGH	**Source**	Business Logic	**Ver**	1
Title	**Platform shall prioritize events**								
Description	TRACE platform shall prioritize events based on predefined criteria to ensure appropriate response and resource allocation.								
Rationale	Helps manage resources effectively and respond to the most critical events promptly.								
Dependencies	EVT-FUN-004, EVT-FUN-003, PLT-FUN-013, CLD-FUN-006, DM-PRM-002, RA-PRM-003, COM-FUN-013								
Conflict	PLT-FUN-008, DM-PRM-003, BLK-PRM-005, ETH-PRM-011, SEC-PRM-002, EVT-FUN- 002, EVT-FUN-006, EVT-FUN-009								
Additional Info comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**EVT-FUN-006**	**Type**	FUNC	**Priority**	HIGH	**Source**	Comm and Reporting	**Ver**	1
Title	**Platform shall support notification and alerting capabilities**								
Description	TRACE platform shall provide notification and alerting capabilities to inform users about important events, updates, or changes in transportation operations, ensuring timely awareness and response.								
Rationale	Enhances user awareness and enables timely reactions to changes or disruptions in transportation operations.								
Dependencies	EVT-FUN-005, PLT-FUN-014, CLD-FUN-001, INT-PRM-005, INT-FUN-004, SEC-PRM-001, VR-FUN-001, ETH-PRM-010, RA-FUN-004, RA-FUN-005, RA-PRM-001, RA-PRM-003, RA-PRM-005, RA-PRM-008, COM-FUN-013, COM-FUN-016								
Conflict	PLT-FUN-014, DM-PRM-001, ETH-PRM-013, SEC-PRM-005, EVT-FUN-005, EVT-FUN-007								

Additional Info (comments)	None
Related Scenario(s)	Greek and Slovenian pilot

Id	**EVT-FUN-007**	**Type**	DATA	**Priority**	HIGH	**Source**	Data Management	**Ver**	1
Title	**Platform shall store action tracking and machine learning enhancement**								
Description	TRACE platform shall store actions taken in response to specific events (e.g., assessing the effectiveness of the action and the timeframe for its execution). This confirms the suitability of each action for a particular event, enabling the platform's machine learning capabilities to improve future actions for similar events.								
Rationale	Supports continuous improvement through machine learning by analyzing past actions and outcomes.								
Dependencies	EVT-FUN-004, EVT-FUN-008, PLT-FUN-006, SRY-FUN-005, INT-FUN-001, ETH-PRM-014, RA-FUN-005, RA-PRM-001, RA-PRM-004, RA-PRM-005								
Conflict	PLT-FUN-015, DM-PRM-004, BLK-PRM-011, ETH-PRM-014, SEC-PRM-001, EVT-FUN-006, EVT-FUN-008								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**EVT-FUN-008**	**Type**	DATA	**Priority**	HIGH	**Source**	Data Management	**Ver**	1
Title	**Platform shall store historical event data**								
Description	TRACE platform shall store historical event data for analysis, reporting, and future reference.								
Rationale	Facilitates data-driven decision-making and analysis for improving future operations.								
Dependencies	EVT-FUN-007,PLT-FUN-006,CLD-PRM-003,DM-PRM-005,SRY-FUN-005,BLK-FUN-006, INT-FUN-001, SEC-PRM-001,ETH-PRM-006,RA-FUN-001,RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-001, RA-PRM-003, RA-PRM-004, RA-PRM-005, COM-FUN-013								
Conflict	PLT-FUN-015, DM-PRM-001, ETH-PRM-015, SEC-PRM-003, EVT-FUN-007, EVT-FUN-009								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**EVT-FUN-009**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Performance Metrics	**Ver**	1
Title	**TRACE platform should have real-time track and trace for events**								

Description	TRACE platform should have an adequate track and trace system of events available in real time
Rationale	Ensures continuous monitoring, accountability, and prompt issue detection by providing real-time visibility and traceability of all events on the TRACE platform.
Dependencies	EVT-FUN-001
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**EVT-FUN-010**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Advanced Analytics and AI	**Ver**	1
Title	**Platform should use machine learning for event pattern identification**								
Description	TRACE platform should use machine learning algorithms to identify patterns in event occurrences.								
Rationale	Leverages advanced analytics to improve event prediction and response strategies.								
Dependencies	EVT-FUN-007, EVT-FUN-008, PLT-FUN-006, CLD-FUN-002, ETH-PRM-009, RA-FUN-004, RA-PRM-005, RA-PRM-008, COM-FUN-016, COM-FUN-013								
Conflict	PLT-FUN-012, DM-PRM-002, BLK-PRM-002, ETH-PRM-016, SEC-PRM-004, EVT-FUN-004, EVT-FUN-009								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**EVT-FUN-011**	**Type**	FUNC	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE should direct unmanned vehicles to return to the consolidation center for low-battery alerts**								
Description	When an low-battery alert event is arised from an unmanned vehicle, TRACE should forced to return to consollidation center for a battery charging or switching								
Rationale	Enables operational flow								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	EVT-FUN-012	Type	FUNC	Priority	HIGH	Source	Monitoring	Ver	1
Title	**TRACE shall operating area limit warning**								
Description	When an unmanned vehicle approaches the limits of its authorized operating area, TRACE shall trigger a warning event.								
Rationale	Prevents unmanned vehicles from straying beyond their designated areas, ensuring compliance and safety.								
Dependencies	EVT-FUN-014, PLT-FUN-014, CLD-FUN-001, DM-PRM-003, SRY-PRM-001, BLK-FUN-003, INT-FUN-009, VR-FUN-001, VR-FUN-002, VR-FUN-003, ETH-PRM-015, RA-FUN-002, RA-FUN-005, RA-PRM-005, RA-PRM-008, COM-FUN-013, COM-FUN-016, COM-PRM-002, COM-PRM-005, COM-PRM-006, COM-PRM-007, COM-PRM-008, COM-PRM-012, COM-PRM-016, COM-PRM-020								
Conflict	PLT-FUN-006, DM-PRM-003, ETH-PRM-001, SEC-FUN-001								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	EVT-FUN-013	Type	FUNC	Priority	LOW	Source	Consortium Know-how	Ver	1
Title	**TRACE shall trigger a fault event for unmanned vehicle breakdowns**								
Description	When an unmanned vehicle has a mechanical or electronic breakdown, TRACE shall trigger a fault event								
Rationale	Enables operational flow and assistance-recovery								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	EVT-FUN-014	Type	FUNC	Priority	HIGH	Source	Boundary Enforcement	Ver	1
Title	**TRACE shall operating area limit fault event**								
Description	When an unmanned vehicle leaves the limits of its authorized operating area, TRACE shall trigger a fault event.								
Rationale	Ensures that unauthorized movements are quickly identified and addressed.								
Dependencies	EVT-FUN-012, PLT-FUN-014, CLD-FUN-001, SRY-PRM-001, BLK-FUN-003, VR-PRM-002, VR-PRM-003, RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-005, RA-PRM-008, COM-FUN-013, COM-FUN-016, COM-PRM-002, COM-PRM-005, COM-PRM-006, COM-PRM-007, COM-PRM-008, COM-PRM-012, COM-PRM-016, COM-PRM-020								
Conflict	PLT-FUN-006, DM-PRM-004, BLK-PRM-009, ETH-PRM-002, SEC-PRM-003								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

5.1.7 Monitoring and Optimization Requirements

Id	**MON-FUN-001**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Platform should have live data on status of consolidation center**								
Description	Platform should have data on status of consolidation center, both static and dynamic/operational. Static data should include: location (address and coordinates), working hours (workdays, weekends, public holidays), facility layout (detailed map for autonomous vehicles, loading/unloading zones and docks and vehicle types), cargo (cargo storage types, maximum capacity), available equipment (such as forklifts), additional services (repacking, value-added services …), regulatory compliance (such as HACCP, ISO …) Dynamic/operational data should include: real-time updates of storage availability, queue times for loading/unloading, average processing times and on-time delivery rates, customer satisfaction rates								
Rationale	A consolidation center is an intermediate delivery hub where goods are sorted/consolidated before being dispatched to their final last-mile destinations. In the direction towards the recipients, consolidation hubs dispatch last-mile deliveries. The platform enables the most (time/cost/emissions) efficient way to perform the last-mile delivery. To optimize delivery, the platform should have both static and live status of the consolidation center available.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**MON-FUN-002**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Performance Metrics	**Ver**	1
Title	**Enable Proof of Delivery via TRACE Platform**								
Description	The Proof of delivery should be possible by using TRACE platform								
Rationale	Proof of delivery is essential for verifying that goods or services have been successfully delivered, enhancing accountability and trust within the TRACE platform.								
Dependencies	None								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**MON-FUN-003**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Performance Metrics	**Ver**	1
Title	**Shipment ETA calculation using optimization algorithm**								
Description	The Trace System should calculate the shipment ETA for the recipient based on the optimization algorithm								
Rationale	Enables extra services for recipients								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**MON-FUN-004**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE system should optimize payload based on cargo bike capacity (1.5m³)**								
Description	The TRACE system should optimize the payload based on the load capacity of the cargo bike (1.5m³ per cargo bike)								
Rationale	Enables load optimization for cargo bikes								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**MON-FUN-005**	**Type**	ENV	**Priority**	LOW	**Source**	Maintenance Integration	**Ver**	1
Title	**Platform may integrate with maintenance management systems**								
Description	TRACE platform may integrate with maintenance management systems to monitor vehicle health and maintenance schedules, optimizing fleet availability and reliability.								
Rationale	This requirement is important to ensure that vehicle health is continuously monitored, allowing for timely maintenance and maximizing fleet uptime.								

Dependencies	VR-PRM-003, PLT-FUN-007, CLD-FUN-001, DM-FUN-001, SRY-FUN-001, BLK-FUN-006, ETH-PRM-015, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-005, RA-PRM-008, COM-PRM-036
Conflict	PLT-FUN-001, PLT-FUN-002, PLT-FUN-003, PLT-FUN-007, PLT-FUN-008, PLT-PRM-007, INT-FUN-005, INT-PRM-008, RA-FUN-004, VS-FUN-014, VS-PRM-005, CLD-FUN-001, CLD-FUN-004
Additional Info (comments)	None
Related Scenario(s)	Greek and Slovenian pilot

Id	**MON-FUN-006**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Optimization	**Ver**	1
Title		**Platform should incorporate predictive analytics models**							
Description		TRACE platform should incorporate predictive analytics models to forecast future performance trends, anticipate potential bottlenecks or disruptions, and optimize resource allocation and scheduling accordingly.							
Rationale		Improves resource management and anticipates potential issues.							
Dependencies		INT-FUN-001, PLT-FUN-015, CLD-FUN-002, DM-PRM-005, ETH-PRM-016, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-PRM-001, RA-PRM-003, RA-PRM-005, RA-PRM-008							
Conflict		PLT-FUN-003, PLT-FUN-004, PLT-FUN-007, PLT-FUN-008, PLT-FUN-016, PLT-PRM-011, INT-FUN-001, INT-PRM-001, RA-FUN-001, VS-FUN-017, VS-FUN-024, CLD-FUN-002, CLD-FUN-005, CLD-PRM-004							
Additional Info (comments)		None							
Related Scenario(s)		Greek and Slovenian pilot							

Id	**MON-FUN-007**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Performance Metrics	**Ver**	1
Title		**TRACE shall enable recipients to book real-time/same-day deliveries to reduce vehicle numbers**							
Description		TRACE shall implement a feature for recipients to book on the designated area (operational) the possibility for real time/same day deliveries on a consolidation approach in order to reduce numbers of vehicles on the designated area							
Rationale		Enables costs and environmental optimization							
Dependencies		None							

Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**MON-FUN-008**	**Type**	FUNC	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE system may allow the progressive introduction of increasingly autonomous operations - from constant vehicle monitoring, remote monitoring, to fully automated or driverless**								
Description	Starting with constant vehicle monitoring, TRACE supports the transition to remote monitoring and eventually to fully automated or driverless operations. The TRACE system will facilitate the gradual adoption of increasingly autonomous operations within the logistics industry. As self-driving technologies advance and become more reliable and common, TRACE will be able to support these innovations, ensuring both reliability and safety.								
Rationale	The platform should support future technologies and autonomous systems								
Dependencies	PLT-FUN-004, PLT-PRM-003, MON-FUN-010, VS-FUN-002, VS-FUN-004, VS-FUN-006, VS-FUN-007, VS-FUN-008, VS-FUN-012, VS-FUN-013, VS-FUN-020, VS-FUN-028, VS-FUN-018, VS-PRM-002, COM-FUN-003, COM-PRM-002, EVT-FUN-011, EVT-FUN-013, SRY-FUN-001, SRY-FUN-004, SRY-FUN-006								
Conflict	ETH-PRM-016								
Additional Info (comments)	None								
Related Scenario(s)	Greek and Slovenian pilot								

Id	**MON-FUN-009**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE shall avoid low-density areas when generating cargo bike delivery routes**								
Description	When generating delivery routes, TRACE shall consider avoidance of low density areas for cargo bikes delivery								
Rationale	Enables load and costs optimization								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	MON-FUN-010	Type	FUNC	Priority	HIGH	Source	Law Regulation	Ver	1
Title	**When generating trajectories and paths for unmanned vehicles, TRACE shall generate trajectories and paths crossing exclusively the authorized operating areas**								
Description	When generating trajectories and paths for unmanned vehicles, the TRACE system ensures that these routes exclusively cross authorized operating areas. This strict adherence to designated zones guarantees compliance with regulations and enhances the safety and reliability of autonomous logistics operations. TRACE meticulously plans and adjusts paths to maintain operational integrity within the approved boundaries.								
Rationale	The platform shall respect the rules of the areas of operation and shall ensure the safety of the people and the vehicles.								
Dependencies	COM-PRM-001, COM-PRM-003, COM-PRM-005, COM-PRM-007, COM-PRM-008, COM-PRM-016, COM-PRM-021, COM-PRM-033, EVT-FUN-012, EVT-FUN-014, MON-FUN-009								
Conflict	VS-FUN-017, EVT-FUN-011								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

5.1.8 Interfaces Requirements

Id	INT-FUN-001	Type	FUNC	Priority	MEDIUM	Source	Visualization	Ver	1
Title	**GUI should incorporate predictive analytics capabilities**								
Description	GUI should incorporate predictive analytics capabilities to forecast future trends, demand, or system performance based on historical data, aiding in proactive decision-making.								
Rationale	Helps in making informed decisions by anticipating future scenarios.								
Dependencies	INT-FUN-005, PLT-FUN-015, PLT-FUN-006, BLK-FUN-006, SEC-PRM-001, VR-PRM-003, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-PRM-001, RA-PRM-003, RA-PRM-005, RA-PRM-008, COM-FUN-013, COM-FUN-016								
Conflict	PLT-FUN-012, DM-PRM-005, BLK-PRM-005, ETH-PRM-006, SEC-PRM-002, RA-FUN-001, INT-FUN-005, INT-FUN-009								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	INT-FUN-002	Type	FUNC	Priority	LOW	Source	Collaboration	Ver	1
Title	**GUI may incorporate collaborative features**								

Description	GUI may incorporate collaborative features such as shared workspaces, comments, and notifications to facilitate teamwork and communication among users.
Rationale	Enhances user collaboration and communication, improving teamwork.
Dependencies	INT-PRM-012, PLT-FUN-014, CLD-FUN-001, SRY-PRM-003, BLK-PRM-006, SEC-PRM-003, ETH-PRM-012, RA-FUN-003, RA-PRM-006, RA-PRM-007, COM-PRM-036, COM-PRM-019, COM-PRM-018, COM-PRM-017, COM-FUN-016, COM-FUN-013
Conflict	PLT-FUN-007, DM-PRM-001, ETH-PRM-012, SEC-PRM-006
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**INT-FUN-003**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Establish smart contracts**								
Description	GUI should allow concerned parties to sign (digital acceptance) the smart contract								
Rationale	Trace platform should provide a GUI where two parties can interact within a cooperative network and establish and sign a smart contract to switch in real-time between transport modes tailored to available resources.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**INT-FUN-004**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Route Optimization	**Ver**	1
Title	**GUI should have presentation of optimal routes**								
Description	GUI should present the calculated optimal routes to the drivers with the capability to recalculate manually with the tap of a button or automatically if a disruption occurs.								
Rationale	Provides flexibility and efficiency in route management.								
Dependencies	INT-FUN-009, PLT-FUN-008, CLD-FUN-004, DM-PRM-003, BLK-FUN-007, VR-PRM-002, RA-FUN-002, RA-FUN-004, RA-PRM-005, RA-PRM-008, COM-FUN-013, COM-FUN-016, COM-PRM-014, COM-PRM-015, COM-PRM-017, COM-PRM-018, COM-PRM-030, COM-PRM-031								
Conflict	PLT-FUN-016, DM-PRM-002, BLK-PRM-007, ETH-PRM-004, SEC-FUN-002, INT-FUN-001, INT-FUN-005								
Additional Info (comments)	None								

Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**INT-FUN-005**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Data Interoperability	**Ver**	1
Title	**GUI should integrate with external systems**								
Description	GUI should seamlessly integrate with external systems and APIs to fetch real-time data such as weather updates, traffic conditions, and inventory levels.								
Rationale	Ensures access to real-time data, enhancing decision-making and operational efficiency.								
Dependencies	INT-FUN-001,PLT-FUN-007,PLT-FUN-011,CLD-FUN-006,DM-FUN-001,,SRY-FUN-004,ETH-PRM-014, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-001, RA-PRM-005, RA-PRM-008, COM-FUN-016, COM-FUN-009, COM-PRM-017, COM-PRM-018, COM-PRM-019, COM-PRM-035								
Conflict	PLT-FUN-012, DM-PRM-003, BLK-PRM-009, ETH-PRM-015, SEC-PRM-003, INT-FUN-001, INT-FUN-004, INT-FUN-009								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**INT-FUN-006**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**GUI should support different level of users (e.g., driver, manager, admin, etc)**								
Description	In general, there should be at least 3 roles **Requestor** of the services with access to statistical data and other info **Executor** of the services **Admin** with full access, and the ability to create roles within the organization, that he represents								
Rationale	Different kind of users can be identified. there are different operational needs and different data access needs for the users. For example, the driver (courier) should know the schedule and the itinerary scheduled for him, with limited access to other info. A manager (scheduler, supervisor) should have access to more data, and statistics generated form the use of the platform. Also, this is the role of the one asking for the services of the TRACE platform								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	INT-FUN-007	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**GUI should support one master account per company and functionalities to give access and permissions to other users of the same company**								
Description	The master account would have the access and the role of the admin as described the INT-FUN-006 requirement. The first registration of a company/organization at the platform should create the master account. Then the master user can give access/rights and roles at users within the organization.								
Rationale	Ensures centralized control within each company, allowing the master account to efficiently manage user access and permissions, thereby enhancing security and maintaining organizational hierarchy.								
Dependencies	INT-FUN-006								
Conflict	None								
Additional Info (comments)	After the master account registration, other users within the same organization, should not be required to register. They will get an invite to log in with the role and access appointed by the admin (master user) They can alter personal info though (such as name, telephone, picture, if supported by the platform, password, etc). An organization can be uniquely identified by Tax identification number, or the master email (the one of the first registration by the master user)								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	INT-FUN-008	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**User wallet integration and payment options in the GUI (GUI should enable seamless integration of cryptocurrency wallets and credit card details for transactions)**								
Description	The GUI should offer to the users the capability to seamlessly integrate a cryptocurrency wallet into their user profiles, along with the option to add credit card details, facilitating transactions for return shipments or other services								
Rationale	This feature enhances user convenience by providing integrated payment options, allowing for seamless transactions involving return shipments or other services. It also broadens the payment flexibility by accommodating both cryptocurrency wallets and credit cards, catering to diverse user preferences and streamlining the overall transaction process.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	INT-FUN-009	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**The GUI should show the location of the vehicle (AV) and the ETA for the delivery of the consignment**								
Description	There should be a connection between the autonomous vehicle software and the TRACE platform. The autonomous vehicle will transmit location info. An estimated time of arrival at recipient's site must be calculated based on that info.								
Rationale	ETA is important, so as the recipient of the package is on site at the time needed.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	INT-FUN-010	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**TRACE platform shall be scalable for growing data volumes and user loads**								
Description	TRACE platform shall be scalable to accommodate increasing data volumes and user loads as the system grows								
Rationale	Ensures that the platform can handle growth without performance degradation, supporting an expanding user base and increasing data processing needs								
Dependencies	CLD-FUN-005, PLT-FUN-012								
Conflict	None								
Additional Info (comments)	The scalability should be tested under various simulated conditions to ensure the platform can handle projected growth scenarios. Considerations should include not only technical scalability but also cost-effectiveness and operational efficiency								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	INT-FUN-011	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**TRACE shall allow recipients to book real-time/same-day deliveries to reduce vehicle numbers**								
Description	TRACE shall implement a feature for recipients to book on the designated area (operational) the possibility for real time/same day deliveries on a consolidation approach to reduce numbers of vehicles on the designated area.								
Rationale	Enables more efficient movement of parcels and vehicles to reduce CO2								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VR-FUN-001	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Event-based notification mechanism**								
Description	Virtual Cockpit shall provide alerting mechanisms to notify the user about detected events and their implications								
Rationale	The user must be guided with notifications to be able to handle the incoming information.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek and Italian pilots								

Id	VR-FUN-002	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Video stream compression**								
Description	Virtual Cockpit should receive compressed video streams from visual sensors placed on the vehicles that will be used for real-time visualization								
Rationale	Securing real-time monitoring requires efficient handling of the available bandwidth								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VR-FUN-003	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Geolocation parameters reception**								
Description	Virtual Cockpit should receive geolocation parameters (GPS) from the vehicles that will be used for real-time visualization								
Rationale	Knowing the exact location of the monitored vehicle provides implicit information to the user								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VR-FUN-004	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1

Title	**Setup predefined actions for emergency conditions**
Description	Virtual Cockpit should transmit scalar signals to the TRACE platform that will interact with the vehicles to perform predefined actions in the context of the package delivery (e.g. return to base)
Rationale	Predefined actions during an emergency help the user avoid mixing his/her emotions into the decision-making process.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

5.2 Vehicles and Sensors Requirements

Id	**VS-FUN-001**	**Type**	FUNC	**Priority**	LOW	**Source**	Standards	**Ver**	1
Title	**Battery powered vehicles may reduce the location transmission frequency and/or accuracy when battery level is less than 20% of a fully charged battery.**								
Description	The vehicles will send their location at a different frequency when the vehicles have low battery level.								
Rationale	Support power saving at low charge conditions								
Dependencies	VS-FUN-002								
Conflict	VS-PRM-004 the maximum time the maximum time elapsing between two transmissions computed as the minimum between the time to travel 100 meters at the current speed and 1 minute. VS-PRM-005 Each vehicle shall transmit to TRACE its location once every 5 seconds VS-FUN-001 Battery powered vehicles may reduce the location transmission frequency and/or accuracy when battery level is less than 20% of a fully charged battery.								
Additional Info (comments)	Not having a real impact on the battery life time, the power consumption of this task is not significant. Unmanned robots will need this data internally to navigate.								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-FUN-002**	**Type**	FUNC	**Priority**	HIGH	**Source**	Standards	**Ver**	1
Title	**A battery management system should monitor the battery of the vehicles that base their movement on electricity**								

Description	The batteries mounted on the vehicles will include a BMS and monitor the provided data.
Rationale	Monitor battery consumption and remaining vehicle operating time
Dependencies	None
Conflict	None
Additional Info (comments)	Battery life varies depending on use. Idle mode offers significantly longer runtime than active movement.
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-FUN-003**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE platform shall require all payload devices to provide position and status, like autonomous vehicles.**								
Description	Any payload carrying device (e.g. secondary/tertiary medical container) integrated in TRACE platform, even if it is not a vehicle, shall provide its position and status as mentioned for autonomous vehicles.								
Rationale	All payload-carrying devices, regardless of whether they are vehicles, maintain consistent tracking and status reporting within the TRACE platform. This uniformity is crucial for maintaining the integrity, security, and visibility of shipments, especially in sensitive applications like medical logistics, where real-time monitoring of location and condition is critical for compliance and operational efficiency.								
Dependencies	INT-FUN-009								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-FUN-004**	**Type**	FUNC	**Priority**	HIGH	**Source**	Standards	**Ver**	1

Title	**Autonomous vehicles shall have obstacle sensors; aerial vehicles may avoid obstacles via trajectory planning.**
Description	Autonomous vehicles shall be equipped with obstacle sensors to avoid any obstacles; Aerial vehicles may avoid obstacles based on detailed trajectory planning and validation.
Rationale	Due to obstacles on pavements, streets and roads it is imperative to instal sensors that can detect obstacles and enable incident free operations.
Dependencies	None
Conflict	None
Additional Info (comments)	Since there a plethora of commercially proven UGVs on the delivery market it might be useful to check what are the industry standards in this field.
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-FUN-005**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Attachment of Barcodes to Shipments in TRACE Platform**								
Description	Barcodes shall be attached to shipments								
Rationale	Attaching barcodes to shipments is crucial for accurate tracking and management, improving the efficiency and reliability of the shipping process on the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek and Slovenian pilot								

Id	**VS-FUN-006**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Each unmanned vehicle shall use a dedicated GPS receiver to measure its position**								
Description	Each unmanned vehicle shall measure its own position using a dedicated GPS receiver device mounted on it.								
Rationale	GPS sensor is a key component for locating in real time either a vehicle or a shipment. This is significant for the Trace system in the case of locating alternative means of transportation and for performing the route optimization. Use GPS to meet the accuracy requirement.								
Dependencies	None								

Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-FUN-007**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Each vehicle shall transmit its real-time operational status to TRACE**								
Description	Each vehicle shall transmit to TRACE its operational status in real-time (e.g., offline, online, operative, idle, etc.).								
Rationale	The position of the vehicles shall be known in real-time to provide the service and ensure QoS and availability.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-FUN-008**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Shipments shall be mounted onto UGVs in designated parcel lockers**								
Description	Shipments shall be mounted onto the UGV within specially designated parcel lockers.								
Rationale	Due to safety risks and regulatory demands, it is necessary to provide a closed compartment for the shipment. The customer must easily access the shipment once the delivery is being performed.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	There are multiple ways how to enable this functionality. Many logistics/postal operators view UGV as moving parcel lockers. The customer should easily access the parcel upon delivery. It can be via specially designated security number or NFC technology. Stemming from this we also have to design a system for user validation and opening mechanism.								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-FUN-009**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1

Title	**Inertial measurement unit (IMU) s, a barometric pressure sensor and a real-time 3D attitude solution that is continuous over the complete 360 degrees of motion shall support an unmanned vehicle**
Description	Unmanned vehicles as drones shall support inertial measurement unit (IMU) combining 3-axis accelerometers, gyroscope, and magnetometers, a barometric pressure sensor, calibrated IMU data and a real-time 3D altitude solution that is continuous over the complete 360 degrees of motion.
Rationale	Monitor the unmanned vehicle pose and movement.
Dependencies	None
Conflict	More than one component in the same requirement
Additional Info (comments)	Not clear Title. • Movement monitoring, installation and usage sensors that allow odometry in the required DOF (degrees of freedom). Description (if all vehicles will be included, not only drones) • Unmanned vehicles shall support the sensors needed to implement odometry techniques, as inertial measurement unit (IMU), a barometric pressure sensor, …. The odometry will provide an estimation of the pose and the speeds in the vehicle axes.
Related Scenario(s)	Italian pilot

Id	**VS-FUN-010**	**Type**	FUNC	**Priority**	HIGH	**Source**	Standards	**Ver**	1
Title		**Load capacity of a vehicle in terms of volume (e.g., length, width, and height) shall be known for tracking a suitable vehicle (e.g., type of a truck)**							
Description		It is necessary to know the load capacity of a vehicle in terms of volume (e.g., length, width, and height) for tracking a suitable vehicle (e.g., type of a truck).							
Rationale		Select the suitable vehicle to transport a defined delivery package							
Dependencies		None							
Conflict		None							

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-FUN-011**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Integration of Barcode Scanners at Delivery Checkpoints in TRACE Platform**								
Description	Scanner readers for Barcodes shall be available at various checkpoints along a delivery route to update the system with location and status data								
Rationale	Barcode scanners at checkpoints are essential for providing real-time updates on shipment location and status, enhancing the accuracy and reliability of the TRACE platform's tracking capabilities.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek and Slovenian pilot								

Id	**VS-FUN-012**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Bike loading-operativity**								
Description	System should allow remote operation of autonomous vehicles								
Rationale	Enables more efficient movement of parcels to reduce CO2								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian cargo bike demonstrator								

Id	**VS-FUN-013**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1

Title	**UGV shall display parcel locker info to aid in shipment loading and route planning**
Description	The UGV shall display information about the number, size, and availability of parcel lockers. This information aids in planning the loading of shipments for specific delivery routes.
Rationale	To enable efficient planning of pickup and delivery operations the platform/system must have knowledge about the availability/quality (number, size) of vacant parcel lockers on the UGV.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-FUN-014**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title		**Integration functionality**							
Description		The platform should be able to integrate with existing vehicle-tracking/telematics solutions.							
Rationale		Enables scalability							
Dependencies		None							
Conflict		None							
Additional Info (comments)		None							
Related Scenario(s)		Greek, Italian and Slovenian pilot							

Id	**VS-FUN-015**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title		**Indirect Calculation of Fuel Consumption in TRACE Platform**							
Description		The platform should enable indirect calculation of fuel consumption for vehicles where this data is not available							
Rationale		Indirect calculation of fuel consumption is crucial for estimating fuel usage when direct data is unavailable, aiding in efficient fleet management and cost control on the TRACE platform.							

Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Slovenian pilot

Id	**VS-FUN-016**	**Type**	FUNC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Capacity of Bikes**								
Description	The platform should know the number of vehicles are expected to be available								
Rationale	Enables more efficient workflow optimization								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian cargo bike demonstrator								

Id	**VS-FUN-017**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Bikes and drones' safety guidelines**								
Description	The System should optimize routes and/or vehicle selection to avoid heavy traffic roads for cargo bikes.								
Rationale	Enables compliance with safety standards								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian pilot								

Id	**VS-FUN-018**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Immobilize a terrestrial unmanned vehicle while exceeding the limit of a distance through an authorized operational area.**								
Description	When navigating in full autonomy outside the authorised operating area and exceeding the buffer distance from the authorised operating area boundary, the terrestrial unmanned vehicle shall stop navigation.								
Rationale	If too distant from the authorised operating area a terrestrial unmanned vehicle shall not go further for safety reasons.								
Dependencies	None								

Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-FUN-019**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Failure Alert**								
Description	The TRACE System should provide a breakage push button for the operator in case of mechanical failure of the cargo bike								
Rationale	Enables service flow and assistance to operators and vehicles								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-FUN-020**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Notification for upcoming UGV delivery**								
Description	There shall be a notification system (for upcoming delivery) for customers in order to achieve maximum rates of successful deliveries.								
Rationale	Recipients have to have information about the upcoming delivery (performed by UGV) because the UGVs cannot summon recipients to the door as current delivery personnel.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	The current industry standard for UGVs to notify the recipients about the upcoming delivery is based on time slot oriented route optimization. In this scenario, the recipient has to choose a specific 15 minute (it can be less or more) time slot on the planned day of delivery. The recipient is notified about the upcoming delivery the day before through a business UI. Within this notification, the recipient is required to submit a 15 minute time slot. With this time preference for delivery we have a more controlled environment for a successful delivery. The alternative option for notifying recipients is to establish a notification system which informs you in designated time intervals (1 hour before, 30 mins before, 15 mins before)								
Related Scenario(s)	Greek and Italian pilot								

Id	**VS-FUN-021**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Changing point of leaders**								
Description	TRACE platform should know the 'changing point of leaders' during the platooning delivery.								
Rationale	Enables connectivity, and interaction with the Trace platform								

Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Italian pilot

Id	**VS-FUN-022**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Vehicle selection-optimization**								
Description	TRACE should know the exact types of unmanned vehicles								
Rationale	Enables connectivity, optimization and safety								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-FUN-023**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**UAV operative boundaries**								
Description	UAVs shall have a specific take off / landing points								
Rationale	Enables connectivity, and safety								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-FUN-024**	**Type**	FUNC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**More detailed description of particular requirement (textual form only).**								
Description	Vehicles shall support communication hardware and software to transmit and receive data over wireless networks to/from TRACE system or perform coordination tasks with other vehicles (V2V communication) or any centralized control systems.								
Rationale	In order to enable harmonized and synchronized logistics operations it is imperative to interconnect all delivery means and systems.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								

Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	VS-FUN-025	Type	FUNC	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Last mile delivery optimization**								
Description	When a manned cargo bike finishes its delivery round, the TRACE System should initiate platoon transhipment								
Rationale	Enables optimization								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian pilot								

Id	VS-FUN-026	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Non-GPS enabled manned vehicle**								
Description	When a manned vehicle is not equipped with a dedicated GPS receiver device, TRACE shall approximate the vehicle location with the location of the GPS-enabled mobile phone/tablet of the vehicle operator.								
Rationale	The position of the vehicle still shall be known.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VS-FUN-027	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**GPS enabled manned vehicle**								
Description	When equipped with a dedicated GPS receiver device, each manned vehicle shall measure its own position using such dedicated GPS receiver device.								
Rationale	Manned vehicles are not strictly required to have a GPS.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VS-FUN-028	Type	FUNC	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Re-calculate the trajectory of an unmanned vehicle while leaving from an authorized operation area**								
Description	When navigating in full autonomy and crossing the outside of the authorised operating area, the unmanned vehicle shall change trajectory to re-enter the authorised operating area.								
Rationale	Try re-entering the authorised operating area for safety reasons.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

6 Non-Functional Requirements

6.1 Platform Requirement

6.1.1 Platform Related Requirements

Id	PLT-PRM-001	Type	PERF	Priority	LOW	Source	Consortium Know-how	Ver	1
Title	**Support and Training Provisions for TRACE Platform**								
Description	TRACE may include provisions for support and training for staff, users, and technical personnel								
Rationale	Support and training are essential for ensuring that all users and technical personnel can effectively utilize and maintain the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-PRM-002	Type	PERF	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Cloud-based infrastructure**								
Description	TRACE platform shall be compatible with cloud infrastructure to leverage scalability, flexibility, and cost-effectiveness.								
Rationale	The use of cloud infrastructure has the advantage to fit and scale the computer needs of the Trace platform in terms of applications and resources and optimize the speed and quality of platforms' functions. Furthermore, a cloud-infra could cost less for the Trace project than purchase, retain and support its own infrastructure.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-PRM-003	Type	PERF	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Trace Platform Openness**								
Description	TRACE platform shall be extensible to easily incorporate new features, modules, or functionalities in the future.								

Rationale	Trace platform will be based on a modular design and implementation to be easily extensible to any new features and functionalities will arise in the future.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**PLT-PRM-004**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Common data exchange and integration**								
Description	TRACE platform should be compatible with other tools, databases, and cloud services to support seamless data exchange and integration.								
Rationale	Trace platform involves the exchange of data with logistic companies through different services and interfaces. Exchanging data in a structured format, typically using standardized protocols and interfaces enables seamless data integration and interoperability between disparate systems.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian pilot								

Id	**PLT-PRM-005**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Fault tolerance mechanisms**								
Description	TRACE platform should be designed with fault tolerance mechanisms to handle failures decently and ensure system resilience.								
Rationale	Trace platform should support fault tolerance mechanisms in terms of: (a) hardware (i.e., by deploying an identical server that runs in parallel to the productive server and mirrors all its operations), (b) software (i.e., by backing software modules with other replica software modules) and (c) power sources (i.e., use of alternative power sources in case of power interruption such as power generators).								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-PRM-006	Type	PERF	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**TRACE platform should support Limited sharing of business-sensitive data.**								
Description	Business sensitive data are for example shipment data and relevant statistics. Such info cannot be openly shared with the competition, or other users. Especially, shipment data contain sensitive information such as names, telephone number and addresses.								
Rationale	Sharing data openly, is a constraint for individual companies. There are also GDPR restrictions in place								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-PRM-007	Type	PERF	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Availability, Load Balancing, and Failure Resilience**								
Description	TRACE shall consider availability, including load balancing and designing for single/multiple points of failure								
Rationale	Ensuring high availability and resilience through load balancing and failure management is crucial for maintaining reliable and uninterrupted service on the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	PLT-PRM-008	Type	PERF	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Maintainability Considerations**								
Description	TRACE shall consider maintainability, making sure that updates are easy to perform and documentation is easily retrievable								
Rationale	Designing for maintainability ensures that updates and support are straightforward, enhancing the platform's long-term usability and reducing operational overhead.								
Dependencies	None								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**PLT-PRM-009**	**Type**	PERF	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Compliance with Industry Standards and Audit Preparedness**								
Description	TRACE shall ensure compliance with industry standards, such as ISO, and be prepared for audits								
Rationale	Ensuring compliance with industry standards and being prepared for audits is crucial for maintaining trust and meeting regulatory requirements for the TRACE platform.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**PLT-PRM-010**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**High Reliability and Uptime**								
Description	TRACE should aim for high reliability, such as maintaining a high uptime								
Rationale	High reliability and uptime are essential for ensuring that the TRACE platform remains consistently available and dependable for users.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**PLT-PRM-011**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**System Performance and Optimization**								
Description	TRACE should consider system performance and its optimization								
Rationale	Optimizing system performance is crucial for maintaining a fast and efficient TRACE platform, improving user experience and operational efficiency.								
Dependencies	None								

Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

6.1.2 Data Management Requirements

Id	**DM-PRM-001**	**Type**	PERF	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**Data retention and regulatory policies**								
Description	TRACE platform shall define data retention policies to manage the lifespan of data and comply with regulatory requirements								
Rationale	Trace should establish a comprehensive data retention policy ensuring regulatory compliance and efficient data management. This policy should meet or exceed any applicable data retention laws. Such a policy should include: (a) identification of data types, (b) retention timeframes, (c) access and security protocols, (d) procedures for data disposal, (e) regular policy reviews and (f) compliance and auditing procedures. Furthermore, processes or stores of personal information about citizens must comply with the General Data Protection Regulation (GDPR).								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**DM-PRM-002**	**Type**	PERF	**Priority**	LOW	**Source**	ConsortiumKnow-how	**Ver**	1
Title	**TRACE data consistency**								
Description	TRACE platform shall ensure data quality by implementing validation, cleansing, and normalization processes to remove inconsistencies and errors.								
Rationale	TRACE platform shall use methods to filter, map and validate data types based on the common information model through data exchange with operational DBs to ensure data consistency and integrity.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	DM-PRM-003	Type	PERF	Priority	LOW	Source	Consortium Know-how	Ver	1
Title	Data processing								
Description	TRACE platform shall ensure low latency and high throughput for data processing and retrieval								
Rationale	Trace platform shall be implemented in a cloud-based infrastructure using a dockerized environment where an automated CI/CD development will improve the software procedures in terms of speed and quality. This type of integration of Trace platform will ensure high throughput and low latency in the data processing.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	DM-PRM-004	Type	PERF	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	Data backup and Recovery mechanisms								
Description	TRACE platform should implement backup and recovery mechanisms to protect against data loss and ensure data integrity in case of system failures.								
Rationale	Trace should implement replica data stores in case of data loss or failure of any of the primary data storages.								
Dependencies	PLT-PRM-005								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	DM-PRM-005	Type	PERF	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	Data Integrity								
Description	TRACE should ensure data integrity by maintaining accuracy, consistency, and minimizing errors								
Rationale	Maintaining data integrity is essential for ensuring the accuracy and reliability of information within the TRACE platform.								
Dependencies	None								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Greek, italian and Slovenian pilot

6.1.3 Reporting & Analytics Requirements

Id	**RA-PRM-001**	**Type**	USE	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE should provide comprehensive performance tracking**								
Description	The system shall track the total cost of delivery, total cost of logistics, total time of delivery, total delays, delays per route, capacity utilization, on-time delivery rate, order accuracy rate, carbon footprint, and emission measurement (linkage with Admiral project), customer satisfaction, and return shipments (unclaimed, damaged, etc.).								
Rationale	Finding an optimal schedule and route is a multi-objective problem, by reporting, the total cost of delivery, the total cost of logistics, total time of delivery, total delays, delays per route, capacity utilization, on-time delivery rate, order accuracy rate, carbon footprint, and emission measurement (linkage with Admiral project), customer satisfaction, and return shipments ensures the effectiveness of the platform.								
Dependencies	PLT-FUN-002, PLT-FUN-009, PLT-FUN-013, PLT-FUN-015, INT-FUN-010, VS-FUN-005, VS-FUN-015, EVT-FUN-009, BLK-FUN-009, BLK-FUN-011								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**RA-PRM-002**	**Type**	USE	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE may allow benchmarking and performance comparison**								
Description	The TRACE platform enables users to compare the performance of different transportation routes, vehicles, and operators against industry benchmarks or predefined standards. This powerful feature provides users with valuable insights into how the logistics operations measure up to established norms. By evaluating key metrics such as delivery times, costs, fuel efficiency, and on-time delivery rates, users can identify areas for improvement and adopt best practices. This comparative analysis allows for informed decision-making regarding route planning, vehicle selection, and operator performance. By highlighting discrepancies and pinpointing inefficiencies, TRACE helps users optimize resource allocation, enhance operational efficiency, and achieve higher standards of service quality.								
Rationale	Compare TRACE's tailored approach to benchmark and predefined standards								
Dependencies	PLT-FUN-007, PLT-FUN-015, INT-PRM-009, RA-PRM-004, MON-PRM-001								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**RA-PRM-003**	**Type**	USE	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**Historical Data Analysis Capability**								
Description	TRACE platform may enable users to analyse historical data trends, patterns, and performance metrics to identify areas for improvement and make data-driven decisions.								
Rationale	This capability is crucial for continuous improvement and strategic planning. By understanding historical trends and performance metrics, stakeholders can identify operational inefficiencies and opportunities for cost savings and service enhancements.								
Dependencies	RA-PRM-001, RA-FUN-004								
Conflict	None								
Additional Info (comments)	The platform should ensure that data analysis tools are user-friendly and provide actionable insights, not just raw data. Consideration for data privacy and compliance with relevant regulations is mandatory.								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**RA-PRM-004**	**Type**	**SUP**	**Priority**	**LOW**	**Source**	**Consortium Know-how**	**Ver**	**1**
Title	**Reporting generation**								
Description	TRACE platform may generate reports to highlight the improvements from using the architecture compared to what the company did in the past or to show how, on certain days in the past, the company's solution was not optimal.								
Rationale	Enables scalability								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Italian pilot								

Id	**RA-PRM-005**	**Type**	USE	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**Ad Hoc Queries and Exploratory Analysis Capability**								
Description	TRACE platform may have the ability to perform ad hoc queries and exploratory analysis to investigate specific questions or scenarios using the available data.								
Rationale	This capability enables stakeholders to dive deeper into data for custom analysis, supporting dynamic decision-making processes and providing insights that are not covered by standard reports.								

Dependencies	RA-PRM-001, RA-FUN-004
Conflict	None
Additional Info (comments)	The implementation of this feature should include considerations for data security and user access controls to ensure that sensitive data is protected during ad hoc analysis.
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**RA-PRM-006**	**Type**	USE	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Customized Reporting Capability**								
Description	TRACE platform should be able to create customized reports per company, tailored to specific requirements, including selecting relevant data fields, applying filters, and choosing display formats.								
Rationale	This feature allows stakeholders to generate reports that are specifically aligned with their operational needs and preferences, enhancing the usability and applicability of the platform's data analytics.								
Dependencies	RA-PRM-001, RA-FUN-004								
Conflict	None								
Additional Info (comments)	The system should ensure that the report generation process is user-friendly and accommodates various levels of technical expertise among users.								
Related Scenario(s)	Greek and Slovenian pilot								

Id	**RA-PRM-007**	**Type**	USE	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Export and Sharing of Reports and Analytics**								
Description	TRACE platform should be able to export reports and analytics results in various formats, such as PDF, Excel, or CSV, and share them with other stakeholders within the organization.								
Rationale	This feature supports the dissemination and broader utilization of generated data and analytics, facilitating better communication and decision-making across different departments or stakeholder groups.								
Dependencies	RA-PRM-006, RA-FUN-004								
Conflict	None								
Additional Info (comments)	Ensure that the export functionality supports large data sets efficiently, and incorporates features for secure sharing to maintain data integrity and confidentiality.								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**RA-PRM-008**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Optimization of Reporting and Analytics Performance**								
Description	TRACE platform should optimize the performance of reporting and analytics queries to ensure fast response times, especially when dealing with large volumes of data.								

Rationale	Fast and efficient data processing is critical for maintaining the usability of the platform, particularly under conditions of high data volume and complex query requirements. This ensures that stakeholders can access insights and reports in a timely manner, supporting effective decision-making.
Dependencies	RA-PRM-001, RA-FUN-004
Conflict	None
Additional Info (comments)	Consideration should be given to the scalability of data storage and processing architectures to accommodate future increases in data volume and complexity.
Related Scenario(s)	Greek, Italian and Slovenian pilot

6.1.4 Security and Data Protection Requirements

Id	**SEC-PRM-001**	**Type**	SEC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Data Security**								
Description	TRACE platform shall implement encryption algorithms to secure personal data and business-sensitive data.								
Rationale	Strong data protection to protect business-critical functions and for a privacy-by-design approach.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	Related to SEC-PRM-003. Covered by SEC-PRM-006.								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**SEC-PRM-002**	**Type**	SEC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Personal authentication and authorization**								
Description	TRACE platform shall implement robust authentication and authorization mechanisms.								
Rationale	First line of defence against remote attacks.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	Covered by SEC-PRM-006.								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**SEC-PRM-003**	**Type**	SEC	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE shall implementing Technical Security Measures for Personal Data Protection**								

Description	TRACE shall implement sufficient technical security measures to ensure protection of personal data, in compliance with the GDPR.
Rationale	Compliance with European data protection legislature.
Dependencies	None
Conflict	None
Additional Info (comments)	Related to SEC-PRM-006.
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**SEC-PRM-004**	**Type**	SEC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE should Compliance with Directive (EU) 2022/2555: Establishing a High Common Level of Cybersecurity Across the Union**								
Description	TRACE should comply with the requirements laid down in Directive (EU) 2022/2555 on measures for a high common level of cybersecurity across the Union								
Rationale	Align with EU-wide cybersecurity standards.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	May not be applicable to TRACE, legal interpretation needed								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**SEC-PRM-005**	**Type**	SEC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE should ensure Compliance with Directive (EU) 2022/2557: Enhancing the Resilience of Critical Entities**								
Description	TRACE should comply with the requirements laid down in Directive (EU) 2022/2557 on the resilience of critical entities								
Rationale	Comply with EU directive for cybersecurity for critical entities.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	May not apply to TRACE (is TRACE or its adopters critical entities? Legal interpretation needed).								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**SEC-PRM-006**	**Type**	SEC	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE should Compliance with EU Regulation on Horizontal Cybersecurity Requirements for Products with Digital Elements**								

Description	TRACE should comply with the requirements laid down in the Regulation of the EU Parliament and of the Council on horizontal cybersecurity requirements for products with digital elements.
Rationale	Comply with EU cyber resilience act.
Dependencies	None
Conflict	None
Additional Info (comments)	The legislature only applies to products on the European market, developments instances and demonstrators are exempt.
Related Scenario(s)	Greek, Italian and Slovenian pilot

6.1.5 Blockchain Infrastructure Requirements

Id	**BLK-PRM-001**	**Type**	SEC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**Blockchain Network Performance Optimization**								
Description	The system shall optimize the performance of the blockchain network to ensure timely execution of transactions and smart contracts.								
Rationale	Ensuring timely execution of transactions and smart contracts through optimized blockchain performance.								
Dependencies	Cloud Infrastructure								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**BLK-PRM-002**	**Type**	NON-FUNC	**Priority**	LOW	**Source**	Performance Metrics	**Ver**	1
Title	**Adherence to Regulatory Standards**								
Description	The TRACE shall adhere to relevant regulatory requirements and standards governing blockchain technology and authentication processes.								
Rationale	Complying with all relevant regulatory requirements to ensure secure and legitimate blockchain operations.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-003	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Regulatory Compliance for Blockchain in Logistics**								
Description	The TRACE shall ensure compliance with relevant regulations and standards governing blockchain technology and logistics operations, providing legal assurance.								
Rationale	Providing legal assurance by ensuring compliance with blockchain and logistics standards.								
Dependencies	Ethics								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-004	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Scalability of Blockchain Network**								
Description	The TRACE shall ensure the blockchain network can handle a growing number of transactions as the logistics operations expand.								
Rationale	Guaranteeing the network's ability to handle increased transaction volumes as operations expand.								
Dependencies	Cloud Infrastructure								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-005	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Integrity and Consensus in Blockchain Transactions**								
Description	The TRACE shall ensure the integrity and consensus of transactions recorded on the blockchain, providing trust in the system.								
Rationale	Maintaining trust in the system by ensuring transaction integrity and consensus.								
Dependencies	Ethics								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-006	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Seamless Integration with Stakeholder Systems**								
Description	The TRACE should facilitate integration with other systems or platforms used by stakeholders, ensuring seamless data exchange and communication.								
Rationale	Facilitating data exchange by integrating TRACE with other platforms and systems used by stakeholders.								
Dependencies	External System Collaboration Module.								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-007	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Timely Processing of Blockchain Transactions**								
Description	The TRACE should ensure timely processing of transactions on the Algorand blockchain to minimize authentication delays.								
Rationale	Minimizing authentication delays by ensuring quick and efficient processing of blockchain transactions.								
Dependencies	Cloud Infrastructure								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-008	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Performance Optimization for Quick Verification**								
Description	The TRACE should optimize the performance of the blockchain network to ensure quick transaction processing and verification.								
Rationale	Optimizing blockchain performance to ensure fast transaction processing and verification.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-009	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**Enhancing Authentication Security with Blockchain**								
Description	The TRACE should utilize the immutability and decentralized nature of the Algorand blockchain to enhance the security of the authentication process.								
Rationale	Leveraging blockchain's immutability and decentralized nature to improve the security of the authentication process.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	BLK-PRM-010	Type	SEC	Priority	LOW	Source	Performance Metrics	Ver	1
Title	**High Availability of Blockchain Network**								
Description	The TRACE shall ensure high availability and reliability of the Algorand blockchain network to prevent disruptions in the authentication process.								
Rationale	Ensuring uninterrupted operations by maintaining high availability and reliability of the blockchain network.								
Dependencies	Cloud Infrastructure								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

6.1.6 Event Management Requirements

Id	EVT-PRM-001	Type	ENV	Priority	HIGH	Source	Workflow Orchestration	Ver	1
Title	**Platform shall support automated event response**								
Description	TRACE platform shall support automated responses to certain types of events, such as triggering re-allocations or updating schedules.								
Rationale	Enhances the platform's efficiency and responsiveness by automating routine responses to predictable events.								
Dependencies	EVT-FUN-005, EVT-FUN-006, PLT-FUN-008, CLD-FUN-002, SRY-FUN-005, BLK-PRM-009, ETH-PRM-010, ETH-PRM-016, RA-FUN-004, RA-FUN-005, RA-PRM-005, RA-PRM-008, COM-FUN-013, COM-FUN-016								
Conflict	PLT-FUN-011, DM-PRM-001, BLK-PRM-003, ETH-PRM-010, EVT-FUN-005, EVT-FUN-006								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

6.1.7 Monitoring and Optimization Requirements

Id	**MON-PRM-001**	**Type**	USE	**Priority**	LOW	**Source**	Decision Support	**Ver**	1
Title	**Platform may support scenario modelling and What-If analysis**								
Description	TRACE platform may support scenario modelling and what-if analysis to evaluate the impact of different operational strategies, route optimizations, or resource allocations on performance metrics.								
Rationale	Scenario modelling aids in understanding potential outcomes of various strategies, helping in better decision-making and planning.								
Dependencies	PLT-FUN-008, CLD-FUN-004, DM-PRM-002, RA-FUN-002, RA-FUN-004, RA-PRM-001, RA-PRM-003, RA-PRM-004, RA-PRM-005, RA-PRM-008, VS-FUN-017								
Conflict	PLT-FUN-001, PLT-FUN-004, PLT-FUN-007, PLT-FUN-013, PLT-PRM-002, PLT-PRM-011, INT-PRM-001, RA-PRM-003, VS-FUN-017, VS-PRM-003, CLD-PRM-001, CLD-PRM-002								
Additional Info (comments)	None								
Related Scenario(s)	Greek and Slovenian pilot								

Id	**MON-PRM-002**	**Type**	PERF	**Priority**	HIGH	**Source**	Consortium Know - how	**Ver**	1
Title	**TRACE platform shall consider cost optimization objectives alongside performance metrics, balancing operational efficiency with cost-effectiveness to maximize overall value and profitability**								
Description	In synchromodal logistics, performance metrics are critical for evaluating and optimizing the efficiency and effectiveness of logistics operations. Performance metrics include delivery time, operational cost, resource utilization, and carbon footprint. TRACE will effectively balance performance metrics with cost efficiency to ensure that efficiency aligns with cost-effectiveness. By integrating these critical aspects, TRACE optimizes logistics operations to maximize value and profitability.								
Rationale	The platform shall minimize the cost of deliveries and reduce emissions and waste of energy at the same time.								
Dependencies	PLT-FUN-003, PLT-FUN-013								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**MON-PRM-003**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**TRACE platform should allow users to define performance thresholds and alerting rules to notify them when performance metrics exceed or fall below acceptable levels, triggering proactive intervention.**								
Description	Due to multi-objective optimization in logistics operations, the TRACE platform enables users to define performance thresholds to ensure guaranteed results and predetermine acceptable bounds for less-than-optimal conditions. This feature allows users to set specific criteria for key performance metrics, ensuring that operations remain within acceptable limits even when compromises are necessary. If a disruption occurs, which may affect the performance to be less than the desired threshold, an event alert will trigger proactive measures.								
Rationale	The platform should offer to the users the choice to transfer their goods under sub-optimal conditions.								
Dependencies	RA-PRM-003, EVT-FUN-003								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

6.1.8 Interface Requirements

Id	**INT-PRM-001**	**Type**	USE	**Priority**	LOW	**Source**	User Interface	**Ver**	1
Title	**GUI may allow customizable interfaces**								
Description	GUI may allow users to customize their interface preferences, layouts, and views based on their specific roles and requirements.								
Rationale	Enhances user experience by providing a personalized interface.								
Dependencies	PLT-FUN-018, CLD-PRM-002, SRY-PRM-002, SEC-PRM-002, RA-FUN-003								
Conflict	PLT-PRM-001, DM-PRM-005, BLK-PRM-005, ETH-PRM-009, SEC-PRM-001, VR-PRM-002								
Additional Info (comments)	None								
Related Scenario(s)	Slovenian pilot								

Id	INT-PRM-002	Type	USE	Priority	LOW	Source	Data Exploration	Ver	1
Title	**GUI may include interactive features**								
Description	The GUI may include interactive features such as filtering, sorting, and drill-down capabilities to facilitate data exploration and analysis.								
Rationale	Interactive features in the GUI enhance user experience and efficiency by allowing users to easily navigate, explore, and analyse data.								
Dependencies	PLT-FUN-015, CLD-FUN-001, DM-PRM-003, RA-FUN-001, RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-001, RA-PRM-002, RA-PRM-003, RA-PRM-005, RA-PRM-007, COM-FUN-016								
Conflict	PLT-FUN-017, DM-PRM-003, BLK-PRM-008, ETH-PRM-016, SEC-PRM-005								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	INT-PRM-003	Type	SEC	Priority	HIGH	Source	Security and Access	Ver	1
Title	**GUI shall enforce security measures**								
Description	GUI shall enforce security measures such as user authentication, role-based access control, and data encryption to protect sensitive information.								
Rationale	Security measures are crucial to protect sensitive data and ensure that only authorized users have access to specific functionalities and data, maintaining the integrity and confidentiality of the system.								
Dependencies	PLT-FUN-017, CLD-FUN-003, DM-PRM-002, SRY-PRM-002, SEC-PRM-003, SEC-FUN-003, SEC-PRM-002, ETH-PRM-015, RA-FUN-003								
Conflict	PLT-PRM-007, DM-PRM-001, BLK-PRM-010, ETH-PRM-014, SEC-PRM-006								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	INT-PRM-004	Type	USE	Priority	HIGH	Source	User Experience	Ver	1
Title	**GUI shall have intuitive design**								
Description	GUI shall have an intuitive design that is easy to navigate and understand for users with varying levels of technical expertise.								
Rationale	Improves usability and reduces the learning curve for new users.								
Dependencies	PLT-PRM-008, CLD-PRM-004, VR-PRM-002, COM-FUN-016								
Conflict	PLT-PRM-008, DM-PRM-002, BLK-PRM-006, ETH-PRM-008, SEC-PRM-002								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**INT-PRM-005**	**Type**	PERF	**Priority**	HIGH	**Source**	Monitoring	**Ver**	1
Title	**GUI shall provide real-time data visualization**								
Description	GUI shall provide real-time visualization of data, events, and system status to enable quick decision-making.								
Rationale	Facilitates timely and informed decision-making by presenting real-time data.								
Dependencies	PLT-FUN-015, SEC-PRM-001, VR-FUN-002, ETH-PRM-016, RA-FUN-002, RA-FUN-004, RA-FUN-005, RA-PRM-001, RA-PRM-003, RA-PRM-005, RA-PRM-006, RA-PRM-007, RA-PRM-008, COM-FUN-013, COM-FUN-016								
Conflict	PLT-FUN-015, DM-PRM-003, BLK-PRM-008, ETH-PRM-015, SEC-PRM-004, VR-PRM-003, INT-FUN-001, INT-FUN-005, INT-FUN-009								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**INT-PRM-006**	**Type**	USE	**Priority**	MEDIUM	**Source**	Responsive Design	**Ver**	1
Title	**GUI should have responsive design**								
Description	GUI should be responsive and compatible with different devices and screen sizes, including desktops, tablets, and smartphones.								
Rationale	Ensures a consistent user experience across various devices.								
Dependencies	PLT-PRM-004, CLD-FUN-005, DM-PRM-003, BLK-PRM-006								
Conflict	PLT-FUN-007, DM-PRM-002, ETH-PRM-013, SEC-PRM-003								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**INT-PRM-007**	**Type**	ENV	**Priority**	MEDIUM	**Source**	Data Synchronization	**Ver**	1
Title	**GUI should support offline mode functionality**								
Description	GUI should have an offline mode functionality, allowing users to access and interact with essential features and data even when internet connectivity is intermittent or unavailable.								

Rationale	Ensures continuity of operations during connectivity issues.
Dependencies	PLT-PRM-010, CLD-PRM-006, DM-PRM-004, SRY-FUN-005, RA-FUN-003, COM-FUN-016
Conflict	PLT-PRM-005, DM-PRM-004, BLK-PRM-009, ETH-PRM-003, SEC-PRM-001
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**INT-PRM-008**	**Type**	PERF	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**High Availability to Minimize Downtime**								
Description	TRACE platform shall ensure high availability to minimize downtime and maintain system functionality								
Rationale	Ensures continuous operation and reliability of the TRACE platform, critical for maintaining user trust and operational integrity								
Dependencies	INT-FUN-010								
Conflict	None								
Additional Info (comments)	Implement failover mechanisms, load balancing, and redundant systems								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**INT-PRM-009**	**Type**	L&F	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Interactive and Appealing Data Visualizations**								
Description	TRACE platform shall provide interactive and visually appealing data visualizations, such as charts, graphs, and maps, to help users understand complex transportation data.								
Rationale	Enhances user engagement and comprehension of data, facilitating informed decision-making and analysis.								
Dependencies	RA-FUN-002, RA-FUN-004								
Conflict	None								
Additional Info (comments)	The implementation of this requirement should focus on usability and accessibility, ensuring that visualizations are not only informative but also easy to interact with across various devices and platforms								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**INT-PRM-010**	**Type**	L&F	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Usability and User Interface Standards**								

Description	TRACE should prioritize usability, ensuring easy navigation and adherence to user interface standards
Rationale	Prioritizing usability ensures that the TRACE platform is user-friendly and accessible, leading to improved user satisfaction and efficiency.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**INT-PRM-011**	**Type**	L&F	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	**Interoperability and Developer Interface**								
Description	TRACE should support interoperability with systems like ERP, CRM, and provide a developer interface								
Rationale	Supporting interoperability and providing a developer interface are crucial for seamless integration with existing systems and enabling extended functionality through custom development.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Slovenian pilot								

Id	**INT-PRM-012**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Members	**Ver**	1
Title	**Users should be able to access communication and collaboration features from mobile devices, such as smartphones and tablets, to stay connected while on the go**								
Description	The use of the TRACE platform should be supported by TRACE apps, to be used by all kind of devices.								
Rationale	Drivers don't have access to desktops or laptop during their workday. The use mobile phone, PDAs, or tablets.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VR-PRM-001	Type	PRM	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Real-time overall vehicle status monitoring**								
Description	Virtual Cockpit shall provide real-time visualization of data, events, and vehicle status to enable instant decision-making.								
Rationale	Provides a summary about all vehicles, simplifying the monitoring process.								
Dependencies	VR-FUN-001, VR-FUN-002, VR-FUN-003, VR-FUN-004								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VR-PRM-002	Type	PRM	Priority	HIGH	Source	Consortium Know-how	Ver	1
Title	**Intuitive UI/UX**								
Description	Virtual Cockpit shall have an intuitive UI/UX that is easy to understand and use for users with varying levels of technical expertise.								
Rationale	Helps towards the familiarisation of the user with the application.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	VR-PRM-003	Type	PRM	Priority	MEDIUM	Source	Consortium Know-how	Ver	1
Title	**Real-time quality feedback of the streamed information**								
Description	Cameras feeds in the Virtual Cockpit should be aligned with the real-time information (e.g., highlighting green background if the delivering is going smoothly, red if there are difficulties).								
Rationale	Enables more efficient movement of parcels and vehicles to reduce CO2.								
Dependencies	VR-FUN-002								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek pilot								

Id	VR-PRM-004	Type	PRM	Priority	MEDIUM	Source	Consortium Know-how	Ver	1

Title	**Transportation analytics**
Description	Virtual Cockpit should collect and aggregate performance data from various sources, including sensors and GPS trackers, to provide a comprehensive view of transportation performance and security.
Rationale	Provides critical live and history data for analysis.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VR-PRM-005**	**Type**	PRM	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title		**Integration with any TRACE UI module**							
Description		Virtual Cockpit should integrate seamlessly with other user interface modules within the TRACE platform.							
Rationale		Boosts interoperability and accessibility of the monitoring process.							
Dependencies		None							
Conflict		None							
Additional Info (comments)		None							
Related Scenario(s)		Greek pilot							

Id	**VR-PRM-006**	**Type**	PRM	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title		**Non-immersive variant**							
Description		Virtual Cockpit should provide a non-immersive alternative for HMD malfunctioning scenarios with seamless transition to ordinary monitors.							
Rationale		Boosts application's accessibility.							
Dependencies		None							
Conflict		None							
Additional Info (comments)		None							
Related Scenario(s)		Greek pilot							

6.2 Vehicles and Sensors Requirements

Id	VS-PRM-001	Type	PERF	Priority	Medium	Source	Consortium Know-how	Ver	1
Title	**2D/3D LiDAR, camera sensor or 360 cameras should perform the mapping of the environment (e.g., for ground unmanned vehicles)**								
Description	The vehicles should use these sensors for autonomous navigation.								
Rationale	Get a map of the environment for navigation								
Dependencies	None								
Conflict	Multiple sensors in one requirement								
Additional Info (comments)	It could be interesting to merge all autonomous vehicles in only one requirement. VS-PRM-001, VS-PRM-006 Title: Autonomous navigation and obstacle detection (unmanned vehicles). Description: Integration of sensors that allow the correct navigation and obstacle detection. Rationale: Localization of the vehicle for navigation								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VS-PRM-002	Type	NF	Priority	LOW	Source	Consortium Know-how	Ver	1
Title	**UAV RANGE**								
Description	Autonomous vehicles should have a operational limitation range/time								
Rationale	Enables operational area definition								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	VS-PRM-003	Type	PERF	Priority	High	Source	Consortium Know-how	Ver	1
Title	**Dimensions (e.g., length, width, and height) of vehicles performing in a bounded pathway (e.g., cycle lanes) should be considered**								
Description	Dimensions are needed to get the optimized route.								

Rationale	Be sure that the vehicle can circulate
Dependencies	None
Conflict	None
Additional Info (comments)	Size of vehicles can be found in Annex D of this document. Size of infrastructure used can be examined further in the Suitability framework analysis (*see TRACE Deliverable 2.4*).
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-PRM-004**	**Type**	PERF	**Priority**	HIGH	**Source**	Standards	**Ver**	1
Title	**Each vehicle shall transmit to TRACE**								
Description	Each vehicle shall transmit its location to TRACE regularly, with the maximum time elapsing between two transmissions computed as the minimum between the time to travel 100 meters at the current speed and 1 minute								
Rationale	Avoid DoS attack to TRACE from vehicles								
Dependencies	VS-FUN-006, VS-FUN-026, VS-FUN-027								
Conflict	VS-PRM-004 the maximum time elapsing between two transmissions computed as the minimum between the time to travel 100 meters at the current speed and 1 minute. VS-FUN-001 Battery powered vehicles may reduce the location transmission frequency and/or accuracy when battery level is less than 20% of a fully charged battery.								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-PRM-005**	**Type**	PERF	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**Estimate the average fuel consumption**								
Description	When in operation, fuel-powered vehicles shall calculate the average fuel consumption.								
Rationale	Support the assessment of KPIs related to the fuel consumption gain based on optimization provided by the TRACE platform.								
Dependencies	None								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Slovenian pilot

Id	**VS-PRM-006**	**Type**	PERF	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	Integration of Image Sensors for Autonomous Functionality								
Description	Image sensors (e.g, a 2D camera, RGB-D cameras, 6-DOF tracking camera sensor, depth sensor cameras) shall enable unmanned vehicles to capture images of the surroundings, detect an object, autonomous navigation and route planning								
Rationale	Utilizing image sensors is essential for enabling unmanned vehicles to accurately perceive their environment, detect objects, and navigate autonomously, improving operational efficiency and safety.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Slovenian pilot								

Id	**VS-PRM-007**	**Type**	PERF	**Priority**	MEDIUM	**Source**	Consortium Know-how	**Ver**	1
Title	Temperature and Humidity Sensors for Shipment Environment Monitoring								
Description	Temperature and humidity sensors should provide insight into the shipment's environment (e.g., an RFID-sensor tag could provide real-time cold chain data such as temperature, humidity, moisture, tampering, etc.)								
Rationale	Monitoring temperature and humidity is crucial for maintaining the quality and integrity of shipments, particularly in cold chain logistics, ensuring that environmental conditions are within acceptable ranges.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-PRM-008**	**Type**	PERF	**Priority**	LOW	**Source**	Consortium Know-how	**Ver**	1
Title	**Vehicle Location information - not required data**								
Description	The location information transmitted by each vehicle may provide additional fields, such as measured vs estimated flag, accuracy, altitude, and velocity.								

Rationale	Additional information not essential for operations.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**VS-PRM-009**	**Type**	PERF	**Priority**	HIGH	**Source**	Consortium Know-how	**Ver**	1
Title	**Vehicle Location information - required data**								
Description	The location information transmitted by each vehicle shall provide, at a minimum, the following fields: latitude, longitude, and timestamp with locale.								
Rationale	Minimum information to qualitatively assess the position of the vehicle								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**VS-PRM-010**	**Type**	PERF	**Priority**	MID	**Source**	Consortium Know-how	**Ver**	1
Title	**Delivery means should be considered upon weather conditions**								
Description	Certain weather conditions inhibit certain dellivery means. It is hard to deploy UGV if there are severe snowy conditions for example								
Rationale	Some delivery means are adapted to all weather conditions while some can be used only in mild weather conditions. These limitations should be taken into account once delivery planning is being performed.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek and Italian pilot								

6.3 Ethics Requirements

Id	**ETH-PRM-001**	**Type**	OTH	**Priority**	HIGH	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1

Title	**Ethics self-assessment sheet for research activities shall be completed and sent to Privacy and Ethics manager before the event**
Description	Researchers and staff engaged in the development, planning, and execution of project activities are required to adhere to the project's ethical and data protection principles. To ensure their compliance with these principles, it is necessary for them to conduct regular self-assessments, before and during the implementation of research activities. To support project partners in this process, a Self-assessment sheet has been prepared and is provided in Annex 3 of D1.2.
Rationale	The Ethics self-assessment sheet is a tool developed to ensure compliance with TRACE Ethics and Data Protection Framework.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-002**	**Type**	OTH	**Priority**	HIGH	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**Recruitment procedures for participation in testing events shall be clear and recruitment checklist completed before the event and sent to Privacy and Ethics manager.**								
Description	Partners are required to fill in the checklist for recruitment of participants prior to involving human participants in the project activities. The Checklist must be reviewed and approved by the Partner's Data Protection Officer (PDPO). The Checklist is provided in Annex 4 of D1.2.								
Rationale	The process of recruitment in the project follows several considerations. The project considers whether the selection of the participants: Is impartial and justifiable. Minimises the potential for bias. Protect individual rights to privacy. Is free from coercion and influence. Allows sufficient time for prospective participants to consider whether they are interested in proceeding to the consent process or not. Is gender balanced. The concerns listed above are addressed through performed self-assessment procedures (presented in Section 6.6.2 of Deliverable 1.2) and consultations performed with the TRACE Ethics Board (EB). Participants are able to withdraw consent at any time.								

	Key considerations in terms of human participation and recruitment within project activities are in the following areas: recruitment settings, recruitment timeframe, recruitments methods and procedures.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-003**	**Type**	OTH	**Priority**	HIGH	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**Completed Informed consent shall be stored securely by the project partner(s) distributing and collecting them.**								
Description	Participation to research activities is on a voluntary basis. Nobody should be forced to participate in project activities. Main tools applied to ensure voluntary participation are Informed Consent Forms and Information Sheets. Moreover, the project ensures voluntary participation by providing: clear and sufficient information on the participation, and information regarding the possibility to stop participation at any time. **All partners responsible for data collection should collect and securely store completed Informed Consent Forms, as per the procedures described in D1.2 - Data Management Plan (a).**								
Rationale	The **right to physical and mental integrity of a person** is foreseen within right to the integrity of a person underlined in Art. 3 of the Charter of Fundamental Rights of the European Union. The article states that everyone has a right to respect for his or her physical and mental integrity, which comprises free and informed consent; the prohibition of eugenic practices, those aiming at the selection of persons; the prohibition of making the human body and its parts as such a source of financial gain; the prohibition of the reproductive cloning of human beings. Moreover, consent is also inextricably linked to the right to data protection under Art. 8 of the Charter of Fundamental Rights of the European Union, which states that everyone has the right to the protection of personal data, and in line with the concept of consent described by the GDPR.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	ETH-PRM-004	Type	OTH	Priority	HIGH	Source	TRACE Ethics and Data Protection Framework	Ver	1
Title	**Informed consent shall be sent and completed by participants before the start of the event**								
Description	**All Informed Consent Forms should be sent and completed by participants before the start of the events.** Informed consent form templates have been developed and are available in Annex 5 of D1.2. Templates must be adapted to the specific needs and language of the research activity.								
Rationale	The **right to physical and mental integrity of a person** is foreseen within right to the integrity of a person underlined in Art. 3 of the Charter of Fundamental Rights of the European Union. The article states that everyone has a right to respect for his or her physical and mental integrity, which comprises free and informed consent; the prohibition of eugenic practices, those aiming at the selection of persons; the prohibition of making the human body and its parts as such a source of financial gain; the prohibition of the reproductive cloning of human beings. Moreover, consent is also inextricably linked to the right to data protection under Art. 8 of the Charter of Fundamental Rights of the European Union, which states that everyone has the right to the protection of personal data, and in line with the concept of consent described by the GDPR.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	ETH-PRM-005	Type	OTH	Priority	MEDIUM	Source	TRACE Ethics and Data Protection Framework	Ver	1
Title	**TRACE AI components may be certified for cybersecurity**								
Description	All AI components integrated within the system must undergo a comprehensive cybersecurity certification process. This certification ensures that the AI components adhere to the highest standards of cybersecurity, protecting them against vulnerabilities and threats that could compromise the safety, privacy, and reliability of the entire mobility system.								

Rationale	• **System Integrity**: certification mitigates vulnerabilities, ensuring the CCAM system's overall integrity and protection against malicious attacks. • **Data Protection**: it secures sensitive user data, maintaining privacy and trust (authorized access only, use of encryption). • **Regulatory Compliance**: ensures adherence to legal standards and avoids penalties related to data protection and cybersecurity. • **Public Trust**: enhances reliability and safety perception, fostering public confidence and acceptance. • **Operational Continuity**: reduces the risk of cyber-attacks that could disrupt operations, ensuring continuous service. • **Interoperability**: meets standardised protocols, facilitating seamless interaction with other systems and infrastructure. • **Risk Management System:** Implement a comprehensive risk management system that assesses and mitigates risks throughout the AI system's lifecycle, regularly update and review the risk management procedures. • **Robustness, Accuracy, and Security:** Design the AI system to achieve a high level of accuracy, robustness, and security, especially concerning potential misuse or adversarial attacks; Implement technical measures to minimize errors, inaccuracies, and system failures.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-006**	**Type**	OTH	**Priority**	LOW	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE should evaluate if there are any negative impacts of the AI components on environment**								
Description	Assessment of any potential negative environmental impacts caused by the AI components used in the system. This involves examining the lifecycle of AI components, from development and deployment to operation and disposal, to ensure they align with environmental sustainability goals.								
Rationale	Evaluating the environmental impacts of AI components is essential for protecting ecosystems, supporting sustainable development, ensuring regulatory compliance, enhancing public trust, and securing the long-term viability of CCAM systems.								
Dependencies	None								
Conflict	None								

Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-007**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE should evaluate if there are any negative impacts of the AI components on human work and work arrangements**								
Description	Assessment of any potential negative impacts of the AI components on human work and work arrangements. This involves assessing potential changes in job roles, displacement of workers, alterations in work conditions, and effects on job satisfaction and security.								
Rationale	The impact evaluation of TRACE solutions on human work and work arrangements is essential for the protection of the workforce, to ensure fair work practices and positive societal impacts, ultimately building public trust and acceptance.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**ETH-PRM-008**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE should set up procedures to avoid creating or reinforcing unfair bias of the AI components, both regarding the use of input data as well as for the algorithm design**								
Description	TRACE should establish robust procedures to prevent the creation or reinforcement of unfair biases within AI components used in the system. This includes implementing protocols for the selection and use of input data and ensuring fairness in the design and development of AI algorithms. TRACE should also prevent biases in the implementation of the AI (foreseen in ETH-PRM-012).								
Rationale	Setting up procedures to avoid unfair bias in AI components is essential for promoting fairness and equity, preventing discrimination, improving accuracy and reliability, enhancing public trust, ensuring regulatory compliance								
Dependencies	None								

Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-009**	**Type**	OTH	**Priority**	HIGH	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE shall clearly explain the decision of the AI components to the users**								
Description	TRACE should implement mechanisms to ensure that the decisions made by AI components within the system are transparent and easily understandable by users. This involves providing clear, concise, and accessible explanations of how and why certain decisions were made by the AI.								
Rationale	Clearly explaining the decisions of AI components to users is essential for promoting transparency, accountability, user trust, regulatory compliance, ethical responsibility, improved user interaction, error correction, and effective dispute resolution within the CCAM system.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**ETH-PRM-010**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE should consider including the participation of the widest range of possible stakeholders in the AI components' design and development**								
Description	TRACE should ensure the inclusion of a broad and diverse range of stakeholders in the design and development processes of AI components for the system. This involves engaging various groups such as end-users, industry experts, regulatory bodies, community organizations, and other relevant parties.								
Rationale	Including the participation of the widest range of possible stakeholders in the design and development of AI components ensures comprehensive perspectives, user-centric design, consideration of ethical and societal issues, enhanced innovation, improved trust								

	and acceptance, regulatory alignment, risk mitigation, sustainable development, and inclusive decision-making.
Dependencies	None
Conflict	Exclusion criteria
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-011**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE should make sure that the AI components correspond to the variety of preferences and abilities in society**								
Description	TRACE should ensure that AI components used in the system are designed to accommodate the diverse preferences and abilities of all segments of society. This involves developing inclusive AI solutions that respond to different user needs, capabilities, and preferences, ensuring accessibility and usability for everyone.								
Rationale	Ensuring that AI components correspond to the variety of preferences and abilities in society is crucial for inclusivity, enhanced user experience, social equity, regulatory compliance, market reach, ethical responsibility, user trust and acceptance, innovation, and long-term sustainability.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**ETH-PRM-012**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE should define procedures to avoid end-users over-relying on the AI components developed**								
Description	TRACE should establish procedures to ensure that end-users do not become overly dependent on the AI components within the system. These procedures will involve								

	setting clear guidelines, providing adequate training, and implementing features that encourage active user engagement and situational awareness.
Rationale	Defining procedures to avoid end-users over-relying on AI components is essential for promoting vigilance, enhancing safety, fostering responsible use, preventing skill degradation, building trust.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-013**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title	**TRACE should place measures to continuously assess the quality of the input data to the AI components**								
Description	TRACE should adopt measures to continuously evaluate and ensure the quality of the input data used by AI components within the system. These measures will involve monitoring data accuracy, consistency, completeness, and relevance to maintain the integrity and performance of AI-driven processes.								
Rationale	Placing measures to continuously assess the quality of input data to AI components is vital for ensuring accuracy, maintaining consistency, improving completeness, enhancing relevance, supporting performance optimisation, facilitating compliance, mitigating risks, building trust, and enhancing transparency within the system.								
Dependencies	None								
Conflict	None								
Additional Info (comments)	None								
Related Scenario(s)	Greek, Italian and Slovenian pilot								

Id	**ETH-PRM-014**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1

Title	**TRACE should prevent any adversarial, critical or damaging effect (to humans or society) in case of risks or threat (in design, technical faults, defects, attacks, misuse, inappropriate or malicious use)**
Description	TRACE should implement robust measures and safeguards to prevent any adversarial, critical, or damaging effects on humans or society due to risks or threats associated with AI components within the system. This includes proactive strategies to address potential issues in design, technical faults, defects, cyber-attacks, misuse, and malicious or inappropriate use of AI technology.
Rationale	Preventing adversarial, critical, or damaging effects from risks or threats associated with AI components is essential for ensuring safety, mitigating risks, fulfilling ethical responsibilities, complying with regulations, maintaining trust, enhancing cybersecurity resilience, promoting continuous improvement, assuring public safety, and preparing for emergencies within the system.
Dependencies	None
Conflict	None
Additional Info (comments)	None
Related Scenario(s)	Greek, Italian and Slovenian pilot

Id	**ETH-PRM-015**	**Type**	OTH	**Priority**	MEDIUM	**Source**	TRACE Ethics and Data Protection Framework	**Ver**	1
Title		**TRACE should support human autonomy and decision making (user agency and human oversight)**							
Description		TRACE should ensure that AI components within the system support and enhance human autonomy and decision-making. This involves empowering users with the ability to exercise control, make informed choices, and maintain oversight over AI-driven functionalities and decisions.							
Rationale		Supporting human autonomy and decision-making in AI components is crucial for respecting user rights, promoting user-centric design, adhering to ethical standards, fostering transparency and trust, mitigating risks, ensuring legal compliance, enabling adaptability, empowering user confidence, and enhancing the safety and reliability of the system.							
Dependencies		None							
Conflict		None							
Additional Info (comments)		None							

Related Scenario(s)	Greek, Italian and Slovenian pilot

6.3.1 Legal and regulatory framework

This sub-section intends to provide an overview of the legal and regulatory framework to be considered within TRACE development process. The procedures to be followed and the monitoring tools to be adopted in order to ensure the application of TRACE Ethics Framework have been developed within WP1 and WP2 tasks and are presented in Deliverable 1.2 – Data Management Plan (submitted at M6 – November 2023). The present section is intended as complementary to D1.2, providing an overview of principles related to ethics, data protection, AI development and involvement of human participants.

6.3.1.1 Research and ethics

6.3.1.1.1 Charter for fundamental rights of the European Union

The Charter of Fundamental Rights of the European Union[106] gathers the fundamental rights to be shared, fostered, and protected by every Member State of the European Union (EU). The Charter sets the starting point for any research or action conducted within the context of the EU. When developing a methodology for conducting a research, specific articles need to be considered, such as Article 8, para. 2 on Protection of personal data, stress that: "*Everyone has the right to the protection of personal data concerning him or her. Such data must be processed fairly for specified purposes and based on the consent of the person concerned or some other legitimate basis laid down by law. Everyone has the right to access data that has been collected concerning him or her and the right to have it rectified*".

Within the TRACE project, the protection of personal data will be ensured in several ways. The project will follow the rules underlined in the General Data Protection Regulation (GDPR) for all personal data collected and processed during research activities. The right to privacy and protection of personal data within the project is ensured by several key actions, namely:

Clear procedures on humans' involvement before every research activity, including privacy and data protection aspects.

Clear procedures on data processing for all research activities involving humans and personal data.

Clear instructions for the research results' delivery/report, which follow privacy and data protection requirements.

[106]EU, *Charter of Fundamental Rights of the European Union*, Official Journal of the European Union , 2012.

6.3.1.1.2 European Code of Conduct for research integrity

The Code of Conduct for Research Integrity[107], developed by the European Federation of Academies of Sciences and Humanities, has been recently revised and republished in 2023. This document contains rules for a (self) regulation of academic research through European territories and is designed to be used across all scientific fields without distinction. It includes the principles to preserve Research Integrity (RI), a list of good practices and guidelines about violations of RI (the most serious being fabrication, falsification, and plagiarism) and procedures to be followed in the event of those violations. According to the Code, the principles to preserve RI are the following:

- **Reliability**: ensuring the quality of the research in design, methodology, analysis, and use of resources.
- **Honesty**: developing, undertaking, reviewing, reporting, and communicating research in a transparent, fair, complete, and unbiased way.
- **Respect**: among colleagues, research participants, society, ecosystems, cultural heritage, and the environment.
- **Accountability** for the research from idea to publication, for its management and organization, for training, supervision, and mentoring, and for its broader impacts.

TRACE project adopts a specific list of principles to ensure that the above-mentioned principles, aimed at preserving RI, are covered and included in every step of project implementation. Section 6.2 of D1.2 contains a description of TRACE ethics principles.

6.3.1.1.3 Horizon Europe Regulation

Ethical compliance is a fundamental aspect to be considered in research projects funded by the EU. Ethics is dealt with at various levels within the Horizon Europe Regulation (Regulation 2021/695)[108], which establishes, in Article 19, para.1 (Ethical principles) that: "*Actions carried out under the Programme shall comply with ethical principles and relevant Union, national and international law, including the Charter and the European Convention for the Protection of Human Rights and Fundamental Freedoms and its Supplementary Protocols*".

[107] ALLEA, *The European Code of Conduct for Research Integrity*, 2023.

[108] EU, *REGULATION (EU) 2021/695 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation*, Official Journal of the European Union, 2021.

This Regulation explicitly points out the need to address and clearly follow the key principles listed in the table below:

Table 7: Horizon Europe Regulation Ethics Principles

Principle	Description
Proportionality	The principle of **proportionality** implies that the research activity should not go beyond what is necessary to achieve the established research aims and objectives. Another aspect of this principle implies that responses/results should be proportional to the good that can be achieved with the research activities and the research aim and the harm that might be caused. This principle is used in many different contexts and scientific fields (i.e., from medical science to social sciences, humanities and technical sciences). Scholars examining the importance of this principle have highlighted four of its main aspects[109]: • The importance of objective. • The relevance of means. • The most favourable option. • Non-excessiveness.
Right to Privacy	The **right to privacy** can be defined a legal right, rather than a principle per se. As a right, it aims at safeguarding and honouring personal dignity. It comprises data protection 'stricto sensu' and the right concerning choices and preferences that human beings do and express in their lifetime (e.g., how to conduct their family life; religious, political, or other preferences and choices they make; interception of communications, use of hidden cameras; genetic testing, etc.). This right is embodied in a legal order with the sole purpose to ensure respect for personal dignity.
Right to Protection of Personal Data	The **right to protection of personal data** implies that data protection is an element of the right to privacy. It is directed towards protecting personal data against any misuse or unauthorised access. The GDPR (i.e., General Data Protection Regulation), in Art. 5, clearly presents several principles which cover this general right to protection of personal data: "lawfulness, fairness

[109] G. Hermerén, «The principle of proportionality revisited: interpretations and applications,» *Medicine, health case, and phylosophy,* vol. 15, n. 4, pp. 373-382, 2012.

	and transparency, purpose limitation, data minimisation, accuracy, storage limitation, integrity and confidentiality, accountability".
Right to physical and mental integrity of a person	The **right to physical and mental integrity of a person** is foreseen within right to the integrity of a person underlined in Art. 3 of the Charter of Fundamental Rights of the European Union. The article states that everyone has a right to respect for his or her physical and mental integrity, which comprises free and informed consent; the prohibition of eugenic practices, those aiming at the selection of persons; the prohibition of making the human body and its parts as such a source of financial gain; the prohibition of the reproductive cloning of human beings.
Right to non-discrimination	The **right to non-discrimination**, seen in Art. 21 of the Charter of Fundamental Rights of the European Union, where it is forbidden, any discrimination based on any ground such as sex, race, colour, ethnic or social origin, genetic features, language, religion, or belief, political or any other opinion, membership of a national minority, property, birth, disability, age or sexual orientation. In the scope of research projects, this implies that during the research activity, no discrimination is allowed.
High level of Human Health Protection	The principle of **high level of human health protection** implies that human health needs to be fully respected and protected during research activities.

The list of TRACE ethics principles, linked with the related Horizon Europe Principles, is reported in table 2 in section 6.2 of D1.2.

6.3.1.2 Privacy and Data Protection Regulation

The General Data Protection Regulation (GDRP)[110] is the fundamental legislative instrument to be followed within TRACE so to ensure the protection of personal data.

In order to establish the project ethical principle, TRACE has been strictly guided by the data protection principles in the GDPR (section 6.3 of D1.2). According to Art. 5 of the Regulation, the principles are:

[110] EU, Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC, 2016.

Lawfulness, fairness and transparency.

Purpose limitation.

Data minimisation.

Accuracy.

Storage limitation.

Integrity and confidentiality.

Accountability.

Furthermore, in accordance with Art. 35 of the GDPR, TRACE will conduct a Data Protection Impact Assessment (DPIA), to evaluate any risk to individuals. The DPIA will consist of several assessment stages described in section 6.1 of D1.2. A DPIA survey has been developed within the first year of project implementation and it has been completed by partners. Results will be analysed and reported in D1.3 – Data Management Plan (B) at M18 (November 2024).

6.3.1.3 Policy and regulatory framework on Artificial Intelligence in the EU

In 2018, the Communication from the European Commission Artificial Intelligence (AI) for Europe provided a definition of AI as follows: "Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g., voice assistants, image analysis software, search engines, speech and image recognition systems) or AI can be embedded in hardware devices (e.g., advanced robots, autonomous cars, drones or Internet of Things applications). We are using AI on a daily basis, e.g., to translate languages, generate subtitles in videos or to block email spam. Many AI technologies require data to improve their performance. Once they perform well, they can help improve and automate decision making in the same domain. For example, an AI system will be trained and then used to spot cyberattacks on the basis of data from the concerned network or system".[111]

Ethical and societal principles are embedded in this definition. The document clearly states that the development of new technologies is based on values defined in the GDPR but not only, acknowledging the facts that some AI applications may raise new ethical and legal questions, for example related to liability or potentially biased decision-making.

[111] EC, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Artificial Intelligence for Europe, COM(2018) 237 final, Brussels, 2018.

In April 2021, the European Commission presented the Artificial Intelligence package, which included a Communication on fostering a European approach to AI, a review of the Coordinated Plan on Artificial Intelligence (with EU Member States) and its proposal for a regulation laying down harmonised rules on AI (AI Act) and relevant Impact assessment.

The Communication Fostering a European approach to artificial intelligence is a key document, which opens the door to a new regulatory process. Starting with the launch of the European AI strategy in April 2018, the Commission's two-pronged policy has been to make the EU a world-class hub for AI, while ensuring that AI is human-centric and trustworthy. Published in February 2020, the Commission's White Paper on AI set out a clear vision for AI in Europe: an ecosystem of excellence and an ecosystem of trust for AI. The communication as part of the EU AI package represents a key milestone in both policy dimensions: promoting the development of AI and addressing the potential high risks it poses to safety and fundamental rights equally[112].

6.3.1.3.1 Ethics guidelines for Trustworthy AI

In 2019, the Hight-Level Expert Group in Artificial Intelligence (AI HLEG) released the Ethics Guidelines for Trustworthy AI [113]. According to the document, trustworthy AI covers three main aspects:

- **Lawfulness**, i.e., compliance with all applicable laws and regulations.
- **Ethicality**, i.e., adherence to ethical principles and values.
- **Robustness**, i.e., technically and socially consistent and coherent.

Ethicality in AI development stems from the principle that AI systems should be human-centric, allowing individuals and society to perform old and new activities in better and simpler ways, without causing harm or other limitations to individual and collective freedom. AI systems raise several ethical challenges, summarised by the AI HLEG through four main principles that AI systems must comply with. The EU Treaties constitute the foundation of the four principles, the EU Charter and international human rights law, which state, among other principles: respect for human dignity; freedom of the individual; respect for democracy, justice and the rule of law; equality, non-discrimination and solidarity; citizens' rights.

The four principles selected by the AI HLEG are:

Table 8: Principles for trustworthy AI

Principle	Description

[112] EC, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Fostering a European approach to Artificial Intelligence COM(2021) 205 final, Brussels, 2021.

[113] AI HLEG, Ethics guidelines for trustworthy AI, 2019.

Respect for human autonomy	The development, implementation and use of AI systems must safeguard the full and effective self-determination of humans, without any manipulation of individual will, i.e., the possibility of human choice and human oversight. AI systems should, on the other way, «augment, complement and empower human cognitive, social and cultural skills» (ivi, p. 12).
Prevention of harm	AI systems must avoid adverse effects on human beings and, more generally, any living being. They must preserve human dignity and integrity – both physical and mental – and should be designed to avoid malicious and unintended uses, especially when dealing with vulnerable persons or in an environment characterised by asymmetries of power or information.
Fairness	AI system scope, design, and use must ensure a fair distribution of benefits and costs and a coherence between means and ends, as well as prevention of unfair bias, discrimination and stigmatisation, which could derive from the use of such technology. Procedural fairness pertains to the possibility to «contest and seek effective redress against decisions made by AI systems and by the humans operating them» (ivi, p. 13), implying the need for transparency in terms of positions of responsibility and decision-making processes.
Explicability	AI systems need to be transparent as much as possible, through open communication of the purpose of implemented systems, especially to those involved in implementing AI systems (end-users, target groups). Procedural transparency may encounter obstacles, requiring thus other explicability measures (e.g., traceability, auditability and transparent communication on system capabilities).

The AI HLEG underlines that tensions may arise among these principles, for instance, when the principle of prevention of harm and the principle of human autonomy may conflict. Conflict may also emerge between the goal of the implemented technology (e.g., preventing crime) and the overall fundamental rights (for instance, the right to individual liberty and privacy). AI HLEG suggests addressing ethical dilemmas and trade-offs through reasoned and evidence-based reflection.

Drawing from the abovementioned principles, the document then presents seven concrete requirements to achieve Trustworthy AI:

Table 9: Requirements for Trustworthy AI

Requirement	Description
Human agency and oversight	Fundamental rights: implies the need to undertake a fundamental rights impact assessment where the risk to hamper fundamental rights exist. Human agency: implies the need to give the users the necessary knowledge and tools to comprehend and interact with AI systems, making informed decisions. Human oversight: must be achieved through governance mechanisms such as human-in-the-loop (HITL), human-on-the-loop (HOTL), or human-in-command (HIC).
Technical robustness and safety	Resilience to attack and security: AI systems should be protected against attacks that may exploit system vulnerabilities.

	Fallback plan and general safety: AI systems must provide for a fallback plan, for instance, asking for a human operator before continuing their process when encountering errors. Accuracy: AI systems should be able to correctly perform their actions through classifications, predictions, recommendations, decisions. This includes the capability to indicate the error probability when this is unavoidable. Reliability and reproducibility: these features are requested to scrutinise AI systems, i.e., for testing and reproducing results.
Privacy and data governance	Privacy and data protection: AI systems must guarantee privacy and data protection throughout the entire system's cycle, also ensuring that data collected will not be unlawfully or unfairly used against users. Quality and integrity of data: AI systems must ensure the integrity of collected data and their quality, especially when dealing with self-learning systems. Access to data: data protocols outlining who can access data under which circumstances are needed when the AI systems deal with individuals' data.
Transparency	Traceability: all the processes characterising the AI system procedures must be documented as much as possible to increase transparency. Explainability: this principle involves both the technical process itself and the human-made decisions characterising it; making an AI system understandable may encounter a trade-off with the increasement of its accuracy. Communication: humans have the right to be informed when they are interacting with an AI system instead of another human being; they also have the right to opt-out from AI interaction in favour of human interaction.
Diversity, non-discrimination and fairness	Avoidance of unfair bias: AI systems should address biases deriving from incompleteness, wrong governance models or other imperfections of previous systems. Accessibility and universal design: AI systems should be user-centric and accessible regardless of their users' age, gender, abilities, or characteristics. Stakeholder participation: the development of AI systems should be characterised by the consultation of stakeholders who may be directly or indirectly affected by the system itself; stakeholders may also provide feedbacks during the entire AI system lifecycle.
Societal and environmental wellbeing	Sustainable and environmentally friendly AI: AI systems should be developed, taking care of the resource and energy consumption along the whole AI lifecycle. Social impact: AI systems' development in key areas, such as education, work, care or entertainment, may negatively affect social agency and relationships; such risks must be adequately considered. Society and democracy: AI systems' effects should also be assessed on a societal scale, rather than only from an individual perspective, considering effects on institutions, democracy and society at large.
Accountability	Auditability: AI systems should be able to be independently audited when impacting fundamental rights; in other cases, the assessment of algorithms, data and design processes should be balanced with existing intellectual property rights. Minimisation and reporting of negative impacts: a secure way to report concerns about the development and implementation of an AI system should be ensured, also through the development of impact assessment along the whole AI lifecycle. Trade-offs: trade-offs among ethical principles should be addressed in a rational, methodological and documented manner, taking into account all the possible variables; when no suitable solution to trade-off conflicts can be reached with the

	available technology, the development of AI systems must be interrupted in that form. Redress: AI systems must provide a way to redress when adverse impacts occur, paying particular attention to vulnerable persons or groups.

The above-mentioned requirements should be implemented in the use, analysis, re-design and development of AI systems, through technical and non-technical methodologies, as:

- Technical methodologies
  - Development of specific architectures
  - Ethics and rule of law-by-design
  - Explanation methods
  - Testing and validating
  - Quality of service indicators
- Non-technical methodologies
  - Regulation
  - Codes of conduct
  - Standardisation
  - Certification
  - Accountability via governance frameworks
  - Education and awareness to foster an ethical mind-set
  - Stakeholder participation and social dialogue
  - Diversity and inclusive design teams

The abovementioned requirements constitute the basis on which the AI HLEG drafted a Trustworthy AI assessment list, which are to be adopted within TRACE. To this end, a self-assessment for trustworthy AI has been foreseen by the Consortium and has been embedded in the ethical procedures set out in D1.2. More specifically, 2 phases have been described in section 6.6.3 of D1.2.

6.3.1.3.2 EU AI Act

Recently the European Union has made relevant efforts to regulate artificial intelligence (AI) in order to ensure better conditions for the development and use of this innovative technology. As part of this efforts the new EU AI Act was adopted on 13 March 2024112.

The act establishes obligations for providers and users depending on the level of risk of artificial intelligence. While many AI systems pose minimal risk, they still need to be assessed. Several levels of risks are defined within the act as follows:

Prohibited AI practices

Article 5 describes Prohibited Artificial Intelligence Practices:

(d) the placing on the market, the putting into service for this specific purpose, or the use of an AI system for making risk assessments of natural persons in order to assess or predict the risk of a natural person committing a criminal offence, based solely on the profiling of a natural person or on assessing their personality traits and characteristics; this prohibition shall not apply to AI systems used to support the

human assessment of the involvement of a person in a criminal activity, which is already based on objective and verifiable facts directly linked to a criminal activity;

High risk

The Act regulates high-risk AI systems in Article 6, and define them as those:

used as a safety component or a product covered by EU laws in Annex II and required to undergo a third-party conformity assessment under those Annex II laws; or those under Annex III use cases (below), except if: the AI system performs a narrow procedural task; improves the result of a previously completed human activity; detects decision-making patterns or deviations from prior decision-making patterns and is not meant to replace or influence the previously completed human assessment without proper human review; or performs a preparatory task to an assessment relevant for the purpose of the use cases listed in Annex III.

AI systems are always considered high-risk if it profiles individuals, i.e. automated processing of personal data to assess various aspects of a person's life, such as work performance, economic situation, health, preferences, interests, reliability, behaviour, location or movement.

Providers that believe their AI system, which fails under Annex III, is not high-risk, must document such an assessment before placing it on the market or putting it into service.

6.3.1.1.3.3 Framework Convention on Artificial Intelligence and Human Rights, Democracy, and the Rule of Law

On May 17th 2024 the Council of Europe adopted the Framework Convention on Artificial Intelligence and Human Rights, Democracy, and the Rule of Law113. The convention is an international legally binding treaty on artificial intelligence, human rights, democracy, and the rule of law. Although binding only in member states, it can be considered a global treaty that received contributions from stakeholders also from outside the member states. The Convention aims to establish a global minimum standard for the protection of human rights from the risks associated with artificial intelligence (AI). Its core principles and key obligations closely align with those of the EU AI Act, including a risk-based approach and considerations across the entire AI system life cycle. However, while the EU AI Act provides detailed regulations for the development, deployment, and use of AI systems within the EU internal market, the AI Convention focuses primarily on safeguarding the universal human rights of individuals affected by AI systems. As an international treaty, the Convention does not require immediate compliance, but rather serves as a policy framework that sets the scene for future regulations and seeks to harmonize practices at the international level.

6.3.1.3.4 TRACE action plan towards the analysis of its technologies

Stemming from the approval of the EU AI Act, and consultation with the Ethics Board external experts, the project proposes the following steps for the assessment of its technologies:

1. **Identification of the AI system**: definition of the AI system, purposes and functionalities; definition of the context in which the AI system will be deployed.
2. **Categorisation of risk level** (according to the AI Act).
3. **Risk assessment** for all technological components (ALTAI assessment).
4. **Implementation of compliance** measures.
5. **Continuous monitoring**.

6.3.2 Ethics and data protection principles

In line with the key principles outlined in Art. 19 of the Horizon Europe Regulation, the project has identified several key ethical principles to be adopted within the project. Principles aimed at ensuring research integrity (from the Code of Conduct for Research Integrity) are seen as horizontal and applied throughout the project. TRACE principles and their link with HEU principles are presented in section 6.2 of D1.2.

TRACE also adopts a set of data protection principles identified under the GDPR principles and relating to personal data processing.

Art. 5 of GDPR defines several principles ensuring the right to personal data protection, namely: “lawfulness, fairness and transparency; purpose limitation; data minimisation; accuracy; storage limitation; integrity and confidentiality; accountability”. TRACE data protection principles are presented in section 6.3 of D1.2.

6.3.3 Ethical Research with Human Participants

When conducting research with human participants it is of outmost importance to set clear rules of ethical conduct when conducting the research and to ensure transparency during research activities. Ethical and privacy related measures should ensure that human participants are protected, their voluntary participation to research activities ensured and their wellbeing is respected throughout the whole period of their participation.

For demonstrations that will involve human participants, a Guidelines for ethically sound pilot implementation will apply and will be prepared in 2024 and included in either D1.3 or D6.1.

6.3.4 Recruitment criteria and procedures

6.3.4.1 Recruitment criteria

The project foresees several different research activities where human participants will be involved. For this reason, the project sets the inclusion and exclusion criteria. In the project the following criteria are defined:

- Exclusion criteria to be considered throughout the project; and
- Possible inclusion criteria explained for specific research events to the type of activity performed.

TRACE sets clear criteria to determine who will be excluded from taking part in the project and single research activities. The following criteria will apply to all project research activities:

Table 10: TRACE exclusion criteria

Exclusion criteria	Description
Individuals who are under 18 years old.	The project goals and objectives do not foresee the need for the participation of minors.
Individuals who are above 75 years old	The project will ask the participant to provide their expertise and feedback on several aspects, technologies and instruments developed in the project. Those participants could also be people retired and above a certain threshold for retirement. The limit of 75 years old is set not to disturb individuals in their elderly life and avoid intrusion and any impact that some of the research activities might have on them. By disturbance, we emphasise for elderly individuals above 75: long duration of the activity; brainstorming activities; participating in online activities which require a certain amount of time in front of a computer which might be harmful to their sight; participating in on-site activities which will require travel and could have an impact on their health.
Individuals who do not wish to participate	Voluntary participation is one of the TRACE principles, which is strongly respected and followed. In this respect, if someone does not want to participate, they will be excluded from the research activities by default. Individuals who signed an informed consent form, but wish to step out during the activity and no longer participate will also be excluded by default. Participants in the project are advised to leave at any time if they no longer wish to participate.
Individuals who do not sign an informed consent form.	Linked with the voluntary participation principle, individuals who do not express their will to participate by not signing the informed consent form given to them prior to any research activity will not participate in the activity by default.
Individuals who are not in good physical and mental health.	In line with the TRACE principles protecting the volunteer participant, honouring trust, and anticipating harm, the project will not include individuals who are not in a good health condition to avoid any disturbance that could worsen their mental and physical health. Potential participants with sensory impairment, namely deafness, blindness, visual impairment, and hearing impairment, are excluded since they would have limited ability to assess the tests/demos.

	Moreover, they also have limited ability to receive warning and alerts that might occur during piloting activities. Potential participants are not directly asked about their health, but they are rather informed that if they have these conditions they cannot participate.

The following table presents possible inclusion criteria to be adopted within the project.

Table 11: Project selection criteria

Target Group	Selection Criteria
Project partners	• Official persons assigned (employed) by the partner institution to the project
Technology providers outside project consortium	• Geographical location • Personal experience in the required field
Stakeholders	• Geographical location • Personal experience in the required field
Civil society representatives	• Geographical location • Personal experience in the required field
Public (for survey on perception)	• Geographical location • Age (18-75)

6.3.4.1.1 Recruitment procedures

The process of recruitment in the project follows several considerations. The project considers whether the selection of the participants:

Is impartial and justifiable.

Minimises the potential for bias.

Protects individual rights to privacy.

Is free from coercion and influence.

Allows sufficient time for prospective participants to consider whether they are interested in proceeding to the consent process or not.

The concerns listed above are addressed through performed self-assessment procedures (presented in Section 6.6.2 of Deliverable 1.2) and consultations performed with the TRACE Ethics Board (EB). Key considerations in terms of human participation and recruitment within project activities are in the following areas: recruitment settings, recruitment timeframe, recruitments methods and procedures.

6.3.4.1.2 Recruitment Setting

In general, the project will put effort not to carry out the recruitment in a stressful location (e.g., workplace of the participants at the beginning of the working day, during daily operations, etc.). The setting/place of recruitment is carefully planned to ensure that the potential participants are lucid and capable of making independent decisions (when warranted). Generally, recruitments are not carried out in public settings. They are carefully planned, and each participant should foresee a dedicated time in a private location where only the recruiter and the participant are present.

6.3.4.1.3 Recruitment timeframe

Potential participants are informed well in advance of the upcoming research activities, and they are given sufficient time to read and agree to take part or not in the project research activities. The amount of time given to potential participants prior to the planned research activities is calculated proportionally with the risks and effort associated with their participation.

6.3.4.1.4 Recruitment methods

Project partners researchers knowledgeable of the particular study or activity and assigned by their institution to perform recruitment are eligible to perform the recruitment procedure because they will know how to answer potential questions about the research within the project and the single activities during the organised research activity.

The following are the project's standard recruitment methods:

Invitation by e-mails or official letters to public/private institutions. Project partners' researchers wishing to use e-mails obtained from private organisations must obtain permission and abide by the holder's requirements of the e-mail distribution list. Researchers will use e-mails obtained from public sources with no additional permissions.

Recruitment within the project will not occur by sending group emails/messages. Recruitment will follow a person-to-person approach. Official correspondence/official letters to public and private institutions will be made following a previous consultation with project coordinator, so to ensure coordination of the activities performed by the project partners.

Use of direct Person-to-person contact with potential participants. Project researchers will use standardised person-to-person recruitment and carefully choose the setting, venue, and time and ensure that the potential participant's individual privacy is protected.

Use of snowball sampling. Snowball/network sampling is foreseen for research activities regarding primary data collection, such as interviews and surveys. This non-probability sampling method implies selecting a random sample from a given population, recruiting a limited number of research participants within the sample in an initial stage, and rely on recruited research participants in identifying additional ones in later stages.

Use of existing records (recruitment lists, databases, and repositories). Project researchers will use existing internal records, databases, and repositories for recruitment. Using the records of other project partners within the consortium will be made on need-to-know basis. The access to the existing internal records follows an internal organization policy of access to private information. Each researcher is responsible and obliged to follow internal policies of the organisation.

6.3.4.2 Ensuring voluntary participation

Following the TRACE principle of ensuring voluntary participation, within the project, it is not allowed to force nobody to take part in any research or management activity. In order to ensure voluntary participation, informed consent will be used for participation of humans. Persons who do not wish to sign the informed consent thus not wishing to take part in the activity will not be considered as participants (see exclusion criteria of recruitment above).

The informed consent is an obligatory element of the voluntary participation of humans in the project. Therefore, TRACE covers this element in its various types informed consents. When preparing and delivering information sheets and consent forms, the project's researchers make use of a checklist to cover all relevant aspects of participation, ethics, personal data processing, and participants' privacy (the checklist for recruitment of research participants is provided in Annex 4 of D1.2). Depending on the research activity, different types of informed consents are used. Informed consent procedures and templated are provided in D1.2 (Section 6.4.2 and Annex 5).

6.4 Health and Safety policies

6.4.1 European Union

European Directives set out minimum requirements and fundamental principles, such as the principle of prevention and risk assessment, as well as the responsibilities of employers and employees. The fundamental legal act regulating health and safety procedures at workplace is the European Framework Directive (1989/391/EEC), which establishes general principles for managing safety and health, such as responsibility of the employer, rights and duties of the workers, using risk assessments to continuously improve company processes, and workplace health and safety representation[114]. The objective of this Directive is to introduce measures to encourage improvements in the safety and health of workers at work. It applies to all sectors of activity, both public and private (industrial, agricultural, commercial, administrative, service, educational, cultural, leisure, etc.) (Art. 2).

EU, Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work, 1989.

[114] EU, Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work, 1989.

The general principles prescribed in the framework directive, and these are to be followed also in the case of TRACE. The directive establishes the following principles:

- Avoiding risks.
- Evaluating the risks which cannot be avoided.
- Combating the risks at source.

Adapting the work to the individual, especially as regards the design of workplaces, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effects on health.

- Adapting the technical progress.
- Replacing the dangerous by the non-dangerous or the less dangerous.

Developing a coherent overall prevention policy which various technology, organization of work, working conditions, social relationships and the influence of the factors related to the working environment.

- Giving collective protective measures priority over individual protective measures.
- Giving appropriate instructions to the workers.

The European Commission's Strategic Framework on Health and Safety at Work 2021-2027 defines the key priorities and actions for improving workers' health and safety, addressing rapid changes in the economy, demography, and work patterns[115].

6.4.2 TRACE Health and safety framework

Health and safety principles and policies are to be applied in the TRACE project, as it involves not only participations of humans but also the development and use of technologies. Within the project, the Health and Safety Policy is managed by the project partners individually and based on their individual internal health and safety policies.

As a guidance for project partners, the following aspects are to be taken into account:

Table 12: TRACE Health and safety framework indications

Management	• Project main bodies responsible for Ethics and Data Protection are in charge of ensuring the enforcement and consideration of health and safety measures, as well as ethics and data protection.

[115] EC, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EU strategic framework on health and safety at work 2021-2027, 2021.

	• Project partners bear the responsibility for implementing health and safety measures and respecting ethical and data protection standards. • All involved actors should demonstrate a strong commitment towards continuous improvement in health and safety and set project expectations and responsibilities.
Active participation of researchers	• Active participation by all individuals appointed and involved in project activities is necessary to make sure that safety and health is tackled properly. • All individuals should take active participation in all aspects of identification hazards and incidents and track them properly. • All project partners need to organize (if deemed necessary) informative sessions on periodical basis before each research activity, if possible hazards or incidents are foreseen. • Researchers/project staff are encouraged and have means to communicate openly with their respective organisation management and project coordinator and to report safety and health concerns without fear of retaliation. Any potential barriers or obstacles to worker participation in the project and single research activities (such as language, lack of information or disincentives) are removed and addressed properly.
Identification and assessment of hazards	• All project partners need to make sure that procedures for identification and assessment of hazards are applied and include: identification of the source; Identification of the effects and impact; identification of risks to the project; identification of responsible person/authority to address and combat the risks; identification of control measures; reporting.
Prevention and control of hazards	• Researchers/project staff need to cooperate to identity and select methods for eliminating, preventing, or controlling project hazards that might affect health and safety of themselves as well as research participants. • Controls are selected according to a hierarchy that uses engineering solutions first, followed by safe work practices, administrative controls, and finally personal protective equipment. • A plan should be developed to ensure that controls are implemented, interim protection is provided, progress is tracked, and the effectiveness of controls is verified.

Education and training of involved staff	• All researchers/project staff should be trained to understand how the project works and how to carry out the responsibilities assigned to them under the project. • Project partners organizations are responsible for providing specific training on safety principles and their responsibilities for protecting researchers/project staff rights and responding to researchers/project staff reports and concerns. • All researchers/project staff are to be trained to recognise project hazards and to understand the control measures that have been implemented.
Evaluation and improvement of overall policies	• Processes for monitoring the performance, verifying that safety and health measures are implemented, and identification of shortcomings and opportunities for improvement need to be applied.
Communication and coordination	• All companies/institutions/organisations working with the project partners commit to providing the same level of safety and health protection to all involved. • All staff involved communicate the hazards present at the worksite and the hazards that work has caused on site and in the premises of the project partners and their collaborators. • Before any beginning of the activities, project partners researchers and staff as well as any external collaborators coordinate on work planning and scheduling to identify and resolve any conflict that could affect safety or health.

6.4.3 Use of Unmanned Vehicles

Within TRACE it is foreseen the use of Unmanned Vehicles, both unmanned ground vehicles (UGV) and unmanned aerial vehicles (UAV), within the framework of pilots and demonstration activities. It is thus essential to consider several ethical and legal aspect to ensure the compliance of project activities and outputs with ethical and legal requirements. Aspects to be considered include privacy, considering the possibility that unmanned vehicles capture images and personal data, data security, to prevent unauthorised access, ensuring that data transfers are made on encrypted channels with the adoption of appropriate standards, environmental impact of vehicles, in terms of energy consumption and potential harm to humans and to the ecosystem, safety and accountability of operations. It is fundamental to ensure compliance of TRACE operations with all relevant European and national regulations and laws in the field of unmanned vehicles.

The following sub-sections present on overview of the regulatory framework governing the operation of civil drones and automated cars at the EU level.

6.4.4 Civil drones

The European Union Aviation Safety Agency (EASA) plays a key role in the regulation of civil drones in the EU. EASA introduced a set of rules and guidelines (Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and 2019/945), known as the EU Drone Regulation and applicable since December 31, 2020, aiming to ensure the safe operation of drones across EU member states[116]. By adopting a risk-based the EU Drone Regulation, defines three categories of civil drones' operations, based on their level of risk and operational characteristics:

- **'Open' category**: lower-risk operations, typically for recreational and non-commercial use, for which no operational authorization is required before starting the flight.
- **'Specific' category**: for riskier operations, for which an authorization from the national competent authority is required before starting the operation. In order to obtain the operational authorization, the drone operator should conduct a risk assessment.
- **'Certified' category**: for operation with the highest risk, a certification for the drone and its operator is required as well as licensing for the remote pilot.

Key requirements under the EU Drone Regulation include drone registration and identification, remote pilot competency certificates, liability insurance to cover potential damages, operational limitations and no-fly zones, and the use of geofencing technology to restrict drones from flying in certain areas. Compliance with data privacy and data protection laws must be ensured and consent may be required in case of operations envisaging data capture.

Member States may introduce additional rules and regulations for operations within their territories, including specific requirements or restrictions.

The U-space Regulation, adopted in April 2021, ensures the management of drone traffic, establishing a set of requirements for both manned and unmanned aircrafts operations in order to prevent collisions and mitigate risks[117].

6.4.5 Automated cars/vehicles

The new Vehicle General Safety Regulation by the EU, applicable since July 2022[118], establishes the legal framework, harmonised rules and technical requirements for automated and fully automated vehicles systems in the EU. The implementing acts of the Regulation set the technical specification relating to:

EASA, Easy Access Rules for Unmanned Aircraft Systems, 2022.

[116] EASA, Easy Access Rules for Unmanned Aircraft Systems, 2022.

[117] EASA, «Civil drones (unmanned aircraft),» [Online]. Avalable: https://www.easa.europa.eu/en/domains/civil-drones.

[118] EU, *REGULATION (EU) 2019/2144 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL,* 2019.

- Systems to replace the driver's control of the vehicle, including signalling, steering, accelerating and braking.
- Systems to provide the vehicle with real-time information on the state of the vehicle and the surrounding area.
- Driver availability monitoring systems.
- Event data recorders for automated vehicles.
- Harmonised format for the exchange of data for instance for multi-brand vehicle platooning.

7 Validation of Requirements

The validation of requirements within the TRACE project and this deliverable is conducted in accordance with a structured approach set forth in the Methodology of Requirements Analysis chapter.

A dual validation process was conducted, encompassing both the project and demonstration specifications, as well as a selected subset of requirements, which were validated with external stakeholders.

The rating assigned to the demonstration validation is based on an internal evaluation of the criticality of implementation for each requirement.

A rating of "shall" (3) indicates a mandatory requirement, that is, an essential component of the platform's ability to achieve its objectives. It is therefore imperative that this requirement is fully implemented. A rating of "should" (2) indicates a desired, but not mandatory, requirement. While not essential, these requirements are important for the optimal performance and usability of the platform. A rating of "may" (1) indicates optimal requirements or, alternatively, non-binding functionalities that are recommended for consideration.

The evaluation was conducted in accordance with the needs of the demonstrator activities and the coordinators of each specific requirement. However, these requirements will undergo a further evaluation during the testing phase to adapt them to meet the needs of the stakeholders, the objectives of the project, and real-world conditions.

The Stakeholder validation is explained in Stakeholders Engagement chapter and bases on analysis of how local governments limit logistics and traffic, questionnaires, and focus groups/workshops.

Ethical and Social considerations will be taken into account in other WPs (WP1, WP5 and WP6) to identify potential societal impacts, prepare guidelines for authorities, implementation of feedback loops and engagement, and implementation of ethical guidelines.

7.1 Platform requirements

ID	Demonstration validation rating	Stakeholder evaluation
PLT-FUN-001	1	
PLT-FUN-002	1	
PLT-FUN-003	3	This requirement in based on analysis on how local governments limit logistics and traffic. To align with green transition/carbon neutral goals, cities are imposing various restrictions, which are listed in the requirement
PLT-FUN-004	2	
PLT-FUN-005	2	
PLT-FUN-006	3	
PLT-FUN-007	2	
PLT-FUN-008	3	

ID	Demonstration validation rating	Stakeholder evaluation
PLT-FUN-009	3	Based on the T2.2 questionnaire, the majority of logistic companies, who haven't implemented carbon footprint calculation, are eather planning or are interested in this solution.
PLT-FUN-010	3	
PLT-FUN-011	3	Based on T2.2 questionnaire, the majority (63 %) of respondents use custom developed software. This supports the need of easy integration
PLT-FUN-012	3	
PLT-FUN-013	3	
PLT-FUN-014	2	Based on the T2.2 questionnaire, the most desired communication channel is web dashboard (71 %), followed by mobile app (54 %), email (38 %), and SMS (33 %). 17 % responded API.
PLT-FUN-015	3	
PLT-FUN-016	3	Based on T2.2 questionnaire, traffic congestion (4.6/5) and delivery time windows (4.4/5) are a highly-ranked challanges during delivery. Additionaly, 67 % of respondends believe routing has the highest potential for optimization of resources.
PLT-FUN-017	3	
PLT-FUN-018	3	
PLT-PRM-001	3	
PLT-PRM-002	3	
PLT-PRM-003	3	
PLT-PRM-004	2	Based on T2.2 questionnaire, 38 % of the respondents use Cloud software as a service solution, supporting the need for easy integration.
PLT-PRM-005	3	
PLT-PRM-006	1	
PLT-PRM-007	3	
PLT-PRM-008	3	
PLT-PRM-009	3	
PLT-PRM-010	3	
PLT-PRM-011	3	

7.2 Interfaces requirements

ID	Demonstration validation rating	Stakeholder evaluation
INT-FUN-001	2	Based on pilots' workshops feedback, end users and logistic companies are open to use new technologies, including AI-based prediction.
INT-FUN-002	3	
INT-FUN-003	3	
INT-FUN-004	3	
INT-FUN-005	3	
INT-FUN-006	3	

ID	Demonstration validation rating	Stakeholder evaluation
INT-FUN-007	3	
INT-FUN-008	3	
INT-FUN-009	3	
INT-FUN-010	3	
INT-FUN-011	3	
INT-PRM-001	1	
INT-PRM-002	2	Based on T2.2. questionnaire, just 16 % of respondents use customized reporting, while 28% are planning and 16 % are interested in this functionality, opening a potential for new uses.
INT-PRM-003	3	
INT-PRM-004	3	
INT-PRM-005	3	
INT-PRM-006	3	
INT-PRM-007	3	
INT-PRM-008	3	
INT-PRM-009	3	
INT-PRM-010	3	
INT-PRM-011	2	
INT-PRM-012	3	

7.3 Reporting and Analytics requirements

ID	Demonstration validation rating	Stakeholder evaluation
RA-FUN-001	3	Based on T2.2 Questionnaire, 28 % of respondents are planning to implement customized reporting, while 16 % are interested to implement in near future. Only 16 % are not interested.
RA-FUN-002	3	
RA-FUN-003	3	
RA-FUN-004	3	
RA-FUN-005	2	
RA-PRM-001	3	
RA-PRM-002	3	
RA-PRM-003	3	
RA-PRM-004	3	
RA-PRM-005	3	
RA-PRM-006	3	
RA-PRM-007	3	
RA-PRM-008	3	

7.4 Vehicles and Sensors Requirements

ID	Demonstration validation rating	Stakeholder evaluation
VS-FUN-001	3	
VS-FUN-002	3	
VS-FUN-003	3	Based on T2.2 questionnaire, 3/4 of respondents are already using real-time monitoring of shipments, while the remaining 1/4 is either planning or considering to implement in near future.

ID	Demonstration validation rating	Stakeholder evaluation
VS-FUN-004	3	
VS-FUN-005	3	
VS-FUN-006	3	System design
VS-FUN-007	3	System design
VS-FUN-008	3	
VS-FUN-009	2	
VS-FUN-010	3	
VS-FUN-011	3	
VS-FUN-012	2	
VS-FUN-013	2	
VS-FUN-014	1	
VS-FUN-015	2	
VS-FUN-016	2	
VS-FUN-017	1	
VS-FUN-018	3	
VS-FUN-019	1	
VS-FUN-020	3	Based on feedback of workshops, where stakeholders discussed the optimization of autonomous delivery options.
VS-FUN-021	1	
VS-FUN-022	2	
VS-FUN-023	1	
VS-FUN-024	3	
VS-FUN-025	1	
VS-FUN-026	3	System design
VS-FUN-027	3	System design
VS-FUN-028	3	System design
VS-PRM-001	3	
VS-PRM-002	2	
VS-PRM-003	3	
VS-PRM-004	3	Timing respected 97% of times under no failure conditions
VS-PRM-005	3	
VS-PRM-006	2	
VS-PRM-007	1	
VS-PRM-008	3	System design
VS-PRM-009	3	System design
VS-PRM-010	3	

7.5 Security and Data Protection requirements

ID	Demonstration validation rating	Stakeholder evaluation
SEC-FUN-001	2	
SEC-FUN-002	2	
SEC-FUN-003	2	
SEC-PRM-001	3	

ID	Demonstration validation rating	Stakeholder evaluation
SEC-PRM-002	3	
SEC-PRM-003	3	
SEC-PRM-004	3	
SEC-PRM-005	3	
SEC-PRM-006	3	

7.6 Communications and Physical Infrastructure

ID	Demonstration validation rating	Stakeholder evaluation
COM-FUN-001	2	
COM-FUN-002	2	
COM-FUN-003	2	
COM-FUN-004	1	
COM-FUN-005	2	
COM-FUN-006	2	
COM-FUN-007	2	
COM-FUN-008	2	
COM-FUN-009	2	
COM-FUN-010	2	
COM-FUN-011	2	
COM-FUN-012	2	
COM-FUN-013	2	
COM-FUN-014	2	
COM-FUN-015	3	
COM-FUN-016	3	
COM-PRM-001	2	
COM-PRM-002	2	
COM-PRM-003	2	
COM-PRM-004	2	
COM-PRM-005	2	
COM-PRM-006	2	
COM-PRM-007	2	
COM-PRM-008	2	
COM-PRM-009	3	
COM-PRM-010	3	
COM-PRM-011	2	
COM-PRM-012	2	
COM-PRM-013	3	
COM-PRM-014	2	
COM-PRM-015	3	
COM-PRM-016	2	
COM-PRM-017	3	
COM-PRM-018	3	
COM-PRM-019	3	
COM-PRM-020	2	
COM-PRM-021	3	
COM-PRM-022	2	

ID	Demonstration validation rating	Stakeholder evaluation
COM-PRM-023	3	
COM-PRM-024	3	
COM-PRM-025	3	
COM-PRM-026	3	
COM-PRM-027	3	
COM-PRM-028	2	
COM-PRM-029	2	
COM-PRM-030	2	
COM-PRM-031	3	
COM-PRM-032	2	
COM-PRM-033	3	
COM-PRM-034	3	
COM-PRM-035	3	
COM-PRM-036	3	
COM-PRM-037	3	

7.7 Data Management requirements

ID	Demonstration validation rating	Stakeholder evaluation
DM-FUN-001	2	
DM-FUN-002	2	
DM-PRM-001	3	
DM-PRM-002	2	
DM-PRM-003	2	
DM-PRM-004	2	
DM-PRM-005	3	

7.8 Events requirements

ID	Demonstration validation rating	Stakeholder evaluation
EVT-FUN-001	3	
EVT-FUN-002	3	
EVT-FUN-003	3	
EVT-FUN-004	3	T2.2 Questionnaire: slightly more than half of respondents are already using delivery disruption alerts, white everyone else would like to receive these types of alerts.
EVT-FUN-005	3	
EVT-FUN-006	3	
EVT-FUN-007	3	
EVT-FUN-008	3	
EVT-FUN-009	3	
EVT-FUN-010	3	Based on focus group discussions with stakeholders, they are generally willing to use AI and similar technologies for these purposes.
EVT-FUN-011	2	
EVT-FUN-012	3	

ID	Demonstration validation rating	Stakeholder evaluation
EVT-FUN-013	2	
EVT-FUN-014	3	
EVT-PRM-001	3	

7.9 Monitoring and Optimisation

ID	Demonstration validation rating	Stakeholder evaluation
MON-FUN-001	2	
MON-FUN-002	2	
MON-FUN-003	2	
MON-FUN-004	2	
MON-FUN-005	3	
MON-FUN-006	3	
MON-FUN-007	2	
MON-FUN-008	3	
MON-FUN-009	1	
MON-FUN-010	3	System design
MON-PRM-001	3	
MON-PRM-002	2	
MON-PRM-003	3	

7.10 Blockchain

ID	Demonstration validation rating	Stakeholder evaluation
BLK-FUN-001	3	T2.2 Questionnaire: General feedback on blockchain and smart contracts: just a small percentage (6%) of respondents are using blockchain technologies, while none are using smart contacts. Based on feedback during workshop discussions, companies either don't have knowledge about the BC/Smart contact solutions, or they are more complex and expensive to implement and use due to lack of experts in this field.
BLK-FUN-002	3	
BLK-FUN-003	3	
BLK-FUN-004	3	
BLK-FUN-005	3	
BLK-FUN-006	3	
BLK-FUN-007	3	
BLK-FUN-008	3	
BLK-FUN-009	3	
BLK-FUN-010	3	
BLK-FUN-011	3	
BLK-PRM-001	3	
BLK-PRM-002	3	
BLK-PRM-003	3	
BLK-PRM-004	3	
BLK-PRM-005	3	
BLK-PRM-006	3	
BLK-PRM-007	3	
BLK-PRM-008	3	
BLK-PRM-009	3	
BLK-PRM-010	3	

7.11 Safety and Reliability requirements

ID	Demonstration validation rating	Stakeholder evaluation
SRY-FUN-001	3	
SRY-FUN-002	2	
SRY-FUN-003	3	
SRY-FUN-004	3	
SRY-FUN-005	3	
SRY-FUN-006	3	
SRY-PRM-001	3	System design
SRY-PRM-002	3	
SRY-PRM-003	3	

7.12 Virtual Cockpit requirements

ID	Demonstration validation rating	Stakeholder evaluation
VR-FUN-001	2	
VR-FUN-002	3	
VR-FUN-003	3	
VR-FUN-004	3	
VR-PRM-001	2	
VR-PRM-002	3	
VR-PRM-003	3	
VR-PRM-004	3	
VR-PRM-005	1	
VR-PRM-006	3	

7.13 Ethics

ID	Demonstration validation rating	Stakeholder evaluation
ETH-PRM-001	3	
ETH-PRM-002	3	
ETH-PRM-003	3	
ETH-PRM-004	3	
ETH-PRM-005	2	
ETH-PRM-006	1	
ETH-PRM-007	1	
ETH-PRM-008	2	
ETH-PRM-009	1	
ETH-PRM-010	3	
ETH-PRM-011	2	
ETH-PRM-012	2	
ETH-PRM-013	2	
ETH-PRM-014	2	
ETH-PRM-015	2	
ETH-PRM-016	2	
ETH-PRM-001	3	

ID	Demonstration validation rating	Stakeholder evaluation
ETH-PRM-002	3	
ETH-PRM-003	3	
ETH-PRM-004	3	
ETH-PRM-005	2	
ETH-PRM-006	1	
ETH-PRM-007	1	
ETH-PRM-008	2	
ETH-PRM-009	1	
ETH-PRM-010	3	
ETH-PRM-011	2	
ETH-PRM-012	2	
ETH-PRM-013	2	
ETH-PRM-014	2	
ETH-PRM-015	2	
ETH-PRM-016	2	

8 Conclusions

The primary objective of this TRACE Technical Requirements deliverable was to guarantee comprehensive integration between diverse logistic operators. This integration is critical for streamlining operations and enabling seamless cooperation and coordination. By fostering interoperability, the TRACE platform will ensure optimization of logistic workflows, reduce redundancies, and improve overall operational efficiency. This increased efficiency will directly contribute to reach sustainability goals reducing fuel and energy consumption and therefore minimizing CO2 emissions.

Though implementation of a participatory model and active engagement, we successfully involved different stakeholders. This included both internal partners and demonstration stakeholders, and external stakeholders from national and local governments, end users, and logistic operators. By using different means of involvement, such as qualitative questionnaires and quantitative focus groups and workshops, we ensured that their feedback was integrated in the requirements analysis. This approach proved advantageous in two ways: firstly, it enhanced the relevance of the requirements and usability in future real-world scenarios, as it incorporated diverse perspectives, and secondly, it fostered greater commitment from stakeholders to participate in the demonstration activities.

In the process of defining and validating technical requirements, our objective was to emphasise the adoption of cutting-edge technologies, challenging the conventional boundaries of traditional logistics and implementing innovative solutions for synchromodal operations, including autonomous delivery systems, blockchain technology, and the application of artificial intelligence. Blockchain technology can be leveraged to enhance the security, transparency, and traceability of logistics operations, ensuring that all transactions and data exchanges across the supply chain are recorded and stored in an immutable manner. This level of trust and security is crucial for fostering collaboration among diverse logistic operators. Furthermore, the use of dynamic NFTs (dNFTs) is proving to be a game-changer in asset management within logistics. dNFTs allow for real-time updates of asset status, ensuring that the traceability and authenticity of goods are maintained throughout their lifecycle. Additionally, blockchain-based authentication mechanisms are enhancing the security of the TRACE platform by providing decentralized and tamper-proof verification of identities and transactions, further solidifying trust among stakeholders and reducing the risk of fraud. The implementation of autonomous delivery systems into last-mile deliveries has the potential to enhance efficiency and reduce the costs and resources required for this segment of the delivery process, particularly in urban environments. In addition, blockchain technology can guarantee secure and transparent operations, thereby fostering trust in synchromodal operations. Artificial intelligence plays a pivotal role in optimisation tasks, which can further enhance efficiency, reduce costs and emissions. The combination of all these cutting-edge technologies can ensure the preparation of a platform capable of addressing current and future logistic challenges and fostering the desired synchromodality.

The design of the TRACE platform has been designed with scalability and flexibility at its core. Even though testing and validation of the platform will first occur withing controlled demonstration sites, the requirements were prepared and evaluated from the viewpoint of broader scale use. This means that the TRACE platform will be capable to adapt to more complex logistics networks, integrate emerging technologies and empower the cooperation of various logistic providers. The future-proof layout of the

platform will ensure that it is ready to meet diverse needs of stakeholders, improving logistic efficiency and sustainability.

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Annex A – Logistics Associations and Frameworks

Name	Association / Framework	Relevance	Academia and research	Application developers	Carriers and agents	Citizens, customers, wider public	Governmental agencies, policy makers and public authorities	ICT providers, systems integrators and vehicles vendors	Infrastructure providers	Manufacturers / Suppliers	Open-source associations, technology clusters	Service end users (logistics industries)	SMEs
ACEA - European Automobile Manufacturers' Association	Association	2					x	x		x			x
AEDTF - European Association for the Development of the Railway Transport	Association	2	x		x		x		x		x		
AEL - Alliance for European Logistics	Association	4			x			x	x			x	x
AET - Association for European Transport	Association	4	x				x				x		
AGEPOR - Associação dos Agentes de Navegação de Portugal	Association	2			x				x			x	x
ALICE - Alliance for Logistics Innovation through Collaboration in Europe	Association	4	x				x			x			x

ASBAC - Association of Shipbrokers and Agents of Croatia	Association	2			x		x				x	
ASCM - Association for Supply Chain Management	Association	3	x				x			x	x	x
ASECOB - Asociación Española de Consignatarios de Buques	Association	2			x		x					x
ASLOG - Association francaise pour la logistique	Association	3		x			x	x			x	x
AUVSI* - Association for Uncrewed Vehicle Systems International	Association	3	x	x					x		x	x	
BASBA - The Bulgarian Association of Ship Brokers and Agents	Association	2			x		x					x	
BDVA/DAIRO - Big Data Value Association	Association	4	x	x			x				x	x	
BIMCO - The Baltic and International Maritime Council	Association	2	x									x	x
CAD - Connected and Automated Driving	Association	4	x				x	x	x		x	x	x
CEDR - Conference of European Directors of Roads	Association	3	x				x		x			x	
CEL - Centro Espanol de Logistica	Association	4	x				x			x	x	x	

CER - European Rail Freight Association	Association	2				x	x		x			x	
CILT - Chartered Institute of Logistics and Transport	Association	4	x		x			x	x			x	
CLA - Česká Logistická Asociace	Association	4	x		x						x		x
CLECAT - European Association for Forwarding, Transport, Logistics and Customs Services	Association	3			x		x						x
CLEPA - European Association of Automotive Suppliers	Association	1				x	x	x		x			
Cluster Mobility and Logistics	Association	4	x	x				x	x		x	x	x
CLUSTERS 2.0	Association	4	x								x	x	x
COA - Container Owners Association	Association	2	x		x							x	
CSA - Cyprus Shipping Association	Association	1			x				x			x	
CSCMP - Council of Supply Chain Management Professionals	Association	3	x	x							x		
CTANW - Community Transportation Association of the Northwest	Association	1	x				x			x	x		x

DNE - The International Maritime Union	Association	1			x				x			x	x
DTLF - Digital Transport and Logistics Forum	Association	3			x		x		x			x	x
EALTH - European Association for Logistics and Transportation in Healthcare	Association	2	x							x	x	x	
EARPA - Association of automotive R&D organisations	Association	2	x					x		x	x		
ECA - Express Carriers Association	Association	1	x		x			x				x	
ECG - Association of European Vehicle Logistics	Association	2			x		x	x		x		x	
ECSA - European Community Shipowners Association	Association	1			x		x					x	
ECSLA - European Cold Storage and Logistics Association	Association	3	x		x		x			x	x	x	
ECTA - EUROPEAN CHEMICAL TRANSPORT ASSOCIATION	Association	3			x		x		x			x	
ECTP-CEU - European Council of Spatial Planners	Association	3	x								x		
ECTRI - European Conference of	Association	3	x				x				x		

Transport Research Institutes													
EFT - Eye For Transport	Association	3	x									x	
ELA - European Logistics Association	Association	3	x				x					x	
ELP - European Logistics Platform	Association	3	x				x					x	x
ERF - European Union Road Federation	Association	2	x				x		x		x		
ERTRAC - European Road Transport Research Advisory Council	Association	4	x					x			x	x	
ESC - European Shippers' Council	Association	3			x		x			x		x	
ESCF - European Supply Chain Forum	Association	4	x								x		
ESPO - The European Sea Ports Organisation	Association	1					x		x				
ETA - European Tugowners Association	Association	1					x					x	
ETRA - European Transport Research Alliance	Association	3	x								x	x	
Eumos - European Safe Logistics Association	Association	2	x						x			x	
EUROPLATFORMS	Association	2	x		x				x			x	
F&L - European Freight and	Association	4	x		x				x		x	x	

Logistics Leaders Forum													
FEDERAGENTI - Federazione Nazionale Agenti Raccomandatari Marittimi e Mediatori Marittimi	Association	1			x				x			x	
FEHRL - Forum of European National Highway Research Laboratories	Association	2	x				x				x		
FENAMAR - Federação Nacional das Agências de Navegação Marítima	Association	1					x					x	
FERSI - Forum of European Road Safety Research Institutes	Association	2	x						x		x		
FIATA - International Federation of Freight Forwarders Associations	Association	4			x		x					x	
FONASBA - The Federation of National Associations of Ship Brokers and Agents	Association	1			x		x					x	
FTA - Freight Transport Association (Logistics UK)	Association	3			x				x	x		x	
GCCA - Global Cold Chain Alliance	Association	3			x				x	x		x	x

GIL - Global Institute of Logistics	Association	2	x									x	x
Global Shippers Forum	Association	3			x		x					x	x
Greek Cold Storage & Logistics Association	Association	3			x				x			x	
H-CLOUD, HORIZON CLOUD	Association	4	x	x			x		x		x	x	
hEART - European Association for Research in Transportation	Association	2	x								x		
HIDC - Holland International Distribution Council	Association	3			x			x	x	x		x	
IACS - International Association of Classification Societies	Association	1			x							x	
IAPH - International Association of Ports and Harbors	Association	1			x				x			x	
IBS - International Rail Freight Business Association	Association	1							x	x		x	
ICHCA - International Cargo Handling Coordination Association	Association	2	x		x						x	x	
ICS - International Chamber of Shipping	Association	2			x							x	

IDA - Independent Distributor Association	Association	2			x					x		x	
IFA - International Forwarding Association	Association	4			x					x		x	
IFWLA - International Federation of Warehousing & Logistics Associations	Association	4					x		x			x	
IMCC - Inventory Management Competence Centre - Netherlands	Association	3			x						x	x	
Intercargo - The International Association of Dry Cargo Shipowners	Association	2			x				x			x	
Interferry	Association	2	x	x	x			x	x	x	x	x	
InterManager	Association	2			x				x	x	x	x	
International Organization for Standardization (ISO) 28000	Association	4			x							x	x
International Society of City and Regional Planner, Smart Cities and Communities European Innovation Partnership	Association	3	x								x		

IOLT - Institute of Logistics and Transport	Association	3			x						x	x
IPCSA - The International Port Community Systems Association	Association	2			x						x	
IRU	Association	4	x				x	x			x	x
ISF - International Shipping Federation	Association	1			x		x				x	
ISM - Institute for Supply Management	Association	3	x							x		
ISTA - International Safe Transit Association	Association	2	x								x	
ITSA - International Transportation Safety Association	Association	2					x					
LLA - Lithuanian Logistics Association	Association	2					x				x	
LMI - Logistics Management Institute	Association	3	x	x				x		x		
NASSTRAC - National Shippers Strategic Transportation Council	Association	1	x		x						x	
NAW - National Association of Wholesaler-Distributors	Association	3			x					x	x	x

NCBFAA - National Customs Brokers/Forwarders	Association	1			x				x			x	x
NFTA - National Freight Transportation Association	Association	1			x					x		x	x
NGIoT - Next Generation Internet of Things	Association	4	x	x							x		
NITL - Institute for National Transport Logistics	Association	3			x					x		x	x
NLA - Nordic Logistics Association	Association	3			x		x					x	
OPEN DEI	Association	4	x										
OpenEnLocc	Association	4	x				x						
PANECO	Association	2			x		x				x	x	x
POLIS	Association	2	x				x				x		x
RIA - Railway Industry Association	Association	2								x		x	x
RLA - The Reverse Logistics Association	Association	3	x							x			x
SCC - Supply Chain Council	Association	3			x							x	
SCRA - Specialized Carriers and Rigging Association	Association	2										x	x
SFFLA - Selangor Freight Forwarders and Logistics Association	Association	1			x							x	x

SOLE - International Society of Logistics	Association	3	x		x							x	
TE - European Federation for Transport and Environment	Association	3	x				x						
The Logistics Institute	Association	3	x									x	x
TIA - Transportation Intermediaries Association	Association	3			x							x	x
TLC - Transportation and Logistics Council	Association	3	x		x							x	
TRB - Transportation Research Board	Association	3	x									x	x
UETR	Association	3					x		x				x
UIC - International Union of Railways	Association	1			x							x	
ULI Europe - Logistics Council	Association	3	x				x					x	
Supply Chain Operations Reference (SCOR) model	Framework	4										x	x
COREALIS	Framework	3							x	x		x	
Lean logistics framework	Framework	4			x					x		x	x
TOC - Theory of Constraints	Framework	4			x					x		x	x
JIT - Just-in-Time logistics framework	Framework	4								x		x	x
ILS - Integrated Logistics Support framework	Framework	4			x							x	x

DDMRP - Demand-Driven Material Requirements Planning	Framework	4			x					x		x	
Green Logistics framework	Framework	4			x							x	x
Risk Management framework for logistics	Framework	4			x							x	x
ITS - Intelligent Transport Systems	Framework	4	x	x	x						x	x	x
GFE - Green Freight Europe	Framework	4			x							x	x
EMS - European Modular System	Framework	3						x				x	x
DTLF - Digital Transport and Logistics Forum	Framework	4		x			x					x	x
European Green Deal	Framework	4					x	x	x	x		x	x
European Intermodal Transport Strategy	Framework	3	x					x	x			x	
Agile Logistics	Framework	4								x		x	x
MRP - Material Requirements Planning	Framework	2			x					x		x	x
DRP - Distribution Requirements Planning	Framework	4	x		x					x		x	x
SCALE-UP	Framework	4	x			x					x	x	
National Land Transport Strategic Framework 2023-2028	Framework	3	x									x	x

IoT - Internet of things	Framework	4		x						x	x	x	x
UNCTAD's Framework for Sustainable Freight Transport (SFT Framework)	Framework	4			x							x	x
Kofax Transport and Logistics Framework	Framework	2										x	x
Six Sigma	Framework	3			x							x	x

Annex B – Mobility and logistics: Survey on Citizens' perceptions and awareness of automated mobility

Privacy notice and Informed Consent Form

1. Brief information about the research within the TRACE project

TRACE is a project funded by the Horizon Europe Programme, the European Union (EU) Framework Programme for Research and Innovation for the period 2021-2027 (Grant Agreement n. 101104278). The project aims to offer a universal platform with functionalities related to planning, scheduling, optimisation and events management in the logistics operations. TRACE will perform studies related to the barriers towards the new logistics era, new business opportunities, requirements for the legislation and regulatory frameworks and expose the benefits of the proposed approach in terms of the reduction for energy demand and emissions while limiting the operational costs for logistics stakeholders.

2. The Survey

As output, the present survey intends to provide information on citizens' perception, awareness and acceptance of autonomous systems in the logistics operations. This data will allow the TRACE team to further develop its analysis on the level of perception, awareness, acceptance of autonomous systems and technologies and their perceived impact and effectiveness. This allows TRACE to integrate these inputs and concerns in its activities, design, and products.

Your answers will be anonymous and will not be used for any purpose other than that needed for this analysis.

You are invited to voluntary participate in TRACE Mobility and Logistics: Survey on citizens' perceptions and awareness on automated mobility. Your responses to this survey will help us to gather information on the level of perception towards unmanned transportation systems, their impact and privacy implications.

You will be asked to provide answers to the survey questionnaire that consists of 4 sections:

1. General perception related to unmanned transportation systems.
2. Perceived impact.
3. Unmanned transportation future expectations.
4. Demographics.

If you think that some parts of the survey do not concern you, please click on the "I don't know" or "N/A (Not Applicable)" choice. This option applies not only for the case of being Not Applicable, but also in the case that you are Not Able to answer because you don't understand all or part of the question.

The answers provided in the survey will be analysed in an aggregate form and will be Published/presented in a public report (i.e., TRACE deliverable 2.3 outlining the results of this research activity).

We thank you in advance for your contribution to TRACE research activities.

The TRACE team

3. Duration – time estimated to complete the survey

The survey is expected to take approximately 8 minutes to complete.

4. Information about the data collected within the survey

4.1. For how long will data be processed (stored and used)

Information will be stored for the duration of the project. The information will be kept by TRACE project partners/researchers and stored in secure servers.

4.2. What type of personal data will be collected and used
No personal data (e.g., name, surname, IP address) will be collected within this survey.

4.3 What special categories of personal data will be collected and used
No special categories of data will be collected.

4.4. Transfer of data to non-EU/EEC country or international organisation, and safeguards
The data will be kept inside TRACE project partners/researchers. None of the information you give will be transferred to non-EU/EEC countries.

4.5 Automated decision making
No automated decision making is used.

4.6 Your rights

- Your participation in the TRACE project is completely voluntary, and you can choose to stop participating at any time without any consequences.
- You have a right to ask for correction or deletion of the personal information you reveal during the completion of this survey.
- You have a right to ask for restriction of your data processing.

4.7 Competent Data Protection Authority
Garante per la protezione dei dati personali (GPDP) Italian Data Protection Authority
Garante per la protezione dei dati Personali Website: https://www.garanteprivacy.it/
E-mail: urp@gpdp.it

5. How to contact us (for further information or any queries)
For further information or any queries please contact the TRACE partner responsible for this survey:
ISIG - Istituto di Sociologia Internazionale di Gorizia (ISIG)
ISIG researcher: Paola Lorenzoni (lorenzoni@isig.it)
ISIG Data Protection Officer: Marina Andeva (andeva@isig.it)

At this stage, to participate in the TRACE survey you need to consent to the following questions:
Are you at least 18 years old?

- o Yes
- o No

Have you read the Information Sheet and understood the procedures described therein?

- o Yes
- o No

Do you voluntarily agree to participate in this survey?

- o Yes
- o No

Do you consent for the data you provide to be used for the TRACE project for the purposes specified above?

- o Yes
- o No

Glossary

Automated mobility refers to transportation systems where vehicles operate using advanced technologies like sensors, artificial intelligence, and machine learning to navigate and make decisions without human intervention, enhancing efficiency and safety in travel and logistics.

Unmanned transportation systems encompass a wide range of transport services and networks that operate without any onboard human presence, utilising remote control or automation technologies to move goods and passengers.

Unmanned autonomous vehicles are specific types of self-operating machines, such as drones, driverless cars, or robots, that navigate and perform tasks independently using AI, sensors, and GPS; among other functions, they are also used for delivery purposes.

Section 1 – General perception related to unmanned transportation systems

1. Do you have any experience or exposure to automated mobility and unmanned transportation systems?

Yes

No
I don't know

2. When you think about automated mobility, what comes to your mind first?

	Yes	*No*	*N/A*
Self-driving cars			
Automated public transportation (e.g., buses, trains)			
Delivery drones			
Ride-sharing services with autonomous vehicles			
Automated delivery robots			
Other (Please specify)			

3. Which do you think is the current level of maturity of these technologies?

(Early stage) "Automated mobility technologies are in the early stages of development and not widely available
(Public Awareness) Automated mobility technologies are becoming known but are not yet widely understood

(Public Interest) There is growing public interest in automated mobility technologies, with increasing curiosity about their potential
(Public Evaluation) Automated mobility technologies are being actively evaluated, with consideration of their benefits and drawbacks
(Public Trial) Automated mobility technologies are being tested and experienced in real-world scenarios
(Public Adoption) Automated mobility technologies are widely adopted and regularly used in daily life

4. What is your prevailing sensation in relation to automated mobility technologies?
(only one option)
Excitement
Concern
Curiosity
Scepticism
Fear
Indifference
I don't know

Section 2 – Perceived impact

5. How do you think unmanned transportation systems deployed to deliver goods generally impact on the following aspects?
(Please provide an answer from 1 to 5, where 1 means "very negative impact" while 5 "very positive impact")
Transportation efficiency
Working conditions
Job availability
Security of workers
Security of goods
Overall road safety
Road congestions and traffic
Quality of public spaces
Environment
Security of public spaces

6. When focusing on **city centres**, how do you think unmanned transportation systems deployed to deliver goods impact on the following aspects? *(Please provide an answer from 1 to 5, where 1 means "very negative impact" while 5 "very positive impact"*)

Transportation efficiency
Working conditions
Job availability
Security of workers
Security of goods
Overall road safety
Road congestions and traffic
Quality of public spaces

Environment
Security of public spaces

7. How concerned are you about the following aspects related to the use of unmanned vehicles: *(Please provide an answer from 1 to 5, where 1 means "not concerned at all" while 5 "extremely concerned")*

Accidents or collisions involving unmanned vehicles and pedestrians, cyclists, or other vehicles
Privacy issues related to the use of unmanned vehicles for goods transportation, such as data collection, surveillance, or intrusion of privacy
Security risks, including hacking or unauthorized control of unmanned vehicles
Reliability and safety of the technology in various weather and road conditions
Environmental impact of unmanned vehicles, such as energy consumption and emissions
Impact on traffic congestion and urban infrastructure
Trust in the decision-making capabilities of unmanned vehicles, including their ability to respond to emergencies and unexpected situations

8. Do you think the use of unmanned vehicles for goods transportation could contribute to reducing carbon emissions and improving air quality?

Strongly agree
Agree
Neutral
Disagree
Strongly disagree
I don't know

Section 3 – Unmanned transportation future expectations

9. Which do you deem as the most relevant actors involved in the development of automated mobility technologies for goods delivery? *(Please provide an answer from 1 to 5, where 1 means "Not relevant at all" while 5 "extremely relevant")*

Transport operators
Big enterprises
Small-medium enterprises
Start ups
Shop owners and managers
Workers
Consumers
Local authorities
National authorities
International authorities

10. What changes or developments would you like to see regarding the use of unmanned vehicles for goods transportation in the future? *(Please provide an answer from 1 to 5, where 1 means "Not important" while 5 "extremely important")*

Increased safety measures and regulations

Improved technology for better navigation and efficiency
Integration with existing transportation infrastructure
Greater consideration for environmental impact
Enhanced accessibility for all communities
More research and development into potential uses and limitations]

Section 4 – Demographics

11. Age: _____
12. Gender
    Woman
    Man
    Genderqueer
    Non-binary
    Prefer not to disclose
    Prefer to self-describe: _____

13. Occupation
    Student
    Homemaker
    Not employed
    Employed
    Civil servant
    Self employed
    Retired
    Prefer not to disclose

14. Education level
    No degree
    Elementary school degree
    Middle school degree
    High-school degree
    Bachelor's degree or equivalent
    Master's degree or equivalent
    PhD
    Prefer not to disclose

15. Place/Country of residence: _____

16. Place of residence (countryside, small town, medium city, metropolitan area)
    Metropolitan area (>1.000.000)
    City (500.000-1.000.000)
    Town (50.000-500.000)
    Provincial town (10.000-50.000)
    Rural area
    I prefer not to disclose

Annex C – Stakeholder questionnaire

Q1: What is your country of operation?

Possible answers: List of countries (e.g., Albania, Andorra, Austria, etc.)

Q2: What is the size of your company as per EU classification?

Possible answers: Micro, Small, Medium, Large

Q3: In which industry is your company primarily operating?

Possible answers: Logistics and transportation, Manufacturing/Supplier, Retail/e-commerce, ICT/Technology providers, Other

Q4: Which logistic services does your company offer?

Possible answers: Transport/delivery, Warehousing, Packaging, Inventory management, IT services for logistics processes

Q5: Approximately how many EUR pallets do you ship per year?

Possible answers: 0-100k, 100-300k, 300-500k, more than 500k

Q6: How often do you make deliveries/ship or receive items?

Possible answers: At least 6 times per week, At least 3 times per week, At least once per week, Less than once per week

Q7: How are you currently delivering to your customers?

Possible answers: In-house delivery, Outsourced delivery

Q8: What are your criteria when selecting partners for shipments/logistics? (1 – not important, 5 – extremely important for each category)

Sustainability, Technology integration, Regulatory compliance, Customer service and support, Security measures, Cost-effectiveness, Reliability and reputation, Geographical coverage, Operational efficiency, Speed of delivery, Value-added services

Q9: How do you currently handle your company's mid-mile/extra-urban logistics operations?

Possible answers: 1 (Not using logistics services at mid-mile / extra-urban level), 2 (In-house fleet only), 3 (Third-party logistics providers (3PL)), 4 (Combination of in-house fleet and 3PL)

Q10: How do you currently handle your company's last mile logistics operations?

Possible answers: 1 (Not using logistics services at last-mile level), 2 (In-house fleet only), 3 (Third-party logistics providers (3PL)), 4 (Combination of in-house fleet and 3PL)

Q11: Please, provide the average shipping time for your shipments.

Q12: What are your primary challenges or issues with the existing system or processes? (multiple answers possible)

Possible answers: Lack of automation, Inefficiencies or redundancies, Data management issues, Regulatory/compliance challenges, Scalability limitations, Cybersecurity risks, Lack of transparency, Partnership difficulties, Total shipment cost estimation difficulties, Shipping label creation difficulties, Package pick-up/drop-off difficulties, Package tracking difficulties, Green transition, Workforce challenges

Q13: What are the main reasons for delayed deliveries (if there are any)? (multiple answers possible)

Possible answers: Traffic conditions, Inefficient routing, Weather conditions, Vehicle breakdowns, Workforce challenges, Other

Q14: What are your suggestions for possible improvements of your logistic processes?

Possible answers: Streamlining operations, Investing in hardware, Investing in software, Investing in automation, Investing in staff, Optimizing routes, Other

Q15: What types of vehicles are you (or your subcontractors) using for deliveries? (multiple answers possible)

Possible answers: Electric vans, Internal Combustion Engine (ICE) vans, Electric trucks, Internal Combustion Engine (ICE) trucks, Bikes and similar micro-mobility, Drones, Autonomous ground vehicles, Other vehicles with ICE engine, Other electric and sustainable vehicles

Q16: Are you using heterogeneous or homogeneous vehicles for last-mile delivery?

Possible answers: Homogeneous - all vehicles are with the same spaces and characteristics, Heterogeneous - diverse vehicles, Not providing last-mile delivery services

Q18: How full are your vehicles (load factor)?

Possible answers: 90-100%, 89-60%, 30-59%, Less than 30%

Q19: Are you or your subcontractors collecting/do you want to collect sensor information data for your vehicle?

Possible answers: Yes, we are already collecting sensor data; Yes, we want to collect sensor data in near future; No

Q20: At the moment, do you have data related to fuel consumption and/or emissions?

Possible answers: Yes, No

Q21: Would you like the ability to set up geofencing alerts to monitor when vehicles deviate from their planned routes?

Possible answers: Yes, No

Q22: Would you like to receive alerts when a delivery is disrupted?

Possible answers: Yes, No

Q23: How relevant is each of the challenges you are facing during delivery? (1 – not significant, 5 – very significant)

Traffic congestion, Delivery time windows, Vehicle breakdowns

Q24: Would it be useful for you to have more efficient routes for your vehicles in the last-mile deliveries?

Possible answers: Yes, No

Q25: What functionalities are you currently using or considering using in your operations? (using/planning, interested, not interested)

Real-time monitoring of shipment/tracking, Event-triggered tracking, Static route planning, Dynamic route planning (changing within the day based on weather, traffic, demand-based), AI-driven dynamic route planning, Multi-carrier operations, Electronic documents services, Visualization of data, Management of the entire supply chain, Capacity planning for warehouses, Capacity planning for vehicles, Shared resource transport with other (logistic) companies, Automated last-mile delivery solutions, Blockchain solutions, Smart contracts for automated billing and payments

Q26: What kind of data do you have available for delivery? (exact/range/no data)

Content, Size, Weight

Q27: Which KPIs are you currently using to measure your logistics and supply-chain performance? (using/planning/interested in near future/not interested)

Total cost of logistics, Total cost per delivery, Total time of delivery, Total delays, Order accuracy rate, Inventory turnover rate, Customer satisfaction scores, Carbon footprint of logistics, Capacity utilization, On-time delivery rate, Energy or fuel consumption of logistic operations

Q28: What functionalities do you offer or plan to provide to your customers? (using/planning/interested in near future/not interested)

Alerting on shipments and deliveries, Real-time tracking, Automated booking and scheduling, Customized reporting, Self-service portals, Flexible delivery options, Return management services, Sustainable options, Packaging/warehousing solutions, Consolidation of goods/Consolidation centers

Q29: What are the existing IT systems and databases you use for logistics operations? (multiple answers possible)

Possible answers: On-premises software, Cloud software as a service, Custom developed software, Pen and paper, Other

Q30: Which of the following technologies is your company currently using? (multiple answers possible)

Possible answers: Blockchain technologies, Smart contracts, AI for supply chain optimization or/and route optimization, IoT devices for real-time tracking/optimization, Automated last-mile delivery solution, Automated warehousing solutions

Q31: Why have you not already implemented technologies you considered as interesting? (multiple answers possible)

Possible answers: Lack of resources, Technological challenges, Regulatory and compliance issues, Lack of expertise, Risk aversion, Cost concerns, Stakeholder resistance, Waiting for more mature solutions, Other

Q32: What is the primary reason for your interest in adopting these new functionalities? (multiple answers possible)

Possible answers: Cost-optimization/reduction, Faster transactions, Enhanced security, Increased transparency to stakeholders, Operational efficiency, Competitive advantage, Customer satisfaction, Regulatory compliance, Sustainability, Scalability, Innovation, Risk management

Q33: What is your current business space/storage limitations? (multiple answers possible)

Possible answers: Space constraints, Storage capacity, No current limitations, Other

Q34: How important would you rate reducing warehouse space at the expense of shipment consolidation?

Possible answers: Very important, Important, Not important

Q35: What are your needs/plans for expansion? (multiple answers possible)

Possible answers: Expand warehouse space, Consolidate shipments, No current plans for expansion

Q36: Which step in the process has the highest potential for optimization of resources?

Possible answers: Sorting, Routing, Delivery scheduling, Other

Q37: In event logistics and supply chain management, which elements are crucial for your event management needs? (multiple answers possible)

Possible answers: Timely material/product deliveries, Managing inventory and stock, Coordinating suppliers and deliveries, Other

Q38: For enhancing safety and security during your events, what measures and notifications are essential for you? (multiple answers possible)

Possible answers: Monitoring vehicle movements, Ensuring compliance with safety regulations, Responding to security breaches or incidents, Other

Q39: When it comes to event scheduling and timelines, how should alerts and responses be integrated into your event management process? (multiple answers possible)

Possible answers: Integrating alerts with event schedules, Responding to event delays or disruptions, Optimizing event timelines, Other

Q40: Regarding communication and notification systems, please select your preferences and requirements. (multiple answers possible)

Possible answers: Email, SMS, Mobile App, Web dashboard, Other

Q41: Is it desirable or required to facilitate instant payments to external parties based on the nature of their services or about shipment dimensions? (multiple answers possible)

Possible answers: Specialized services, Urgent or last-minute requests, Dimension-based or weight-based payments, Quality or premium services, Other

Q42: Are you currently using, or have you ever explored implementing the following blockchain technology in your operations? (using/planning/interested in near future/not interested)

Possible answers: Supply chain traceability, Smart contracts for agreements, Tokenization of assets or rewards, Decentralized Identity management

Q43: Would you be interested in using smart contracts to automate certain rule-based processes in your operations? (multiple answers possible)

Possible answers: Payment settlements, Supply agreements, Customer contracts, Dispute resolutions, Other

Q44: Are you considering the option of tokenizing any of your assets, products, or services to leverage the blockchain's ecosystem? (multiple answers possible)

Possible answers: No, Physical assets (e.g., real estate, machinery), Digital assets (e.g., software, digital art), Rewards or loyalty points, Other

Q46: In your opinion, how do logistic operators currently address privacy concerns, discrimination risks, and ensure transparency regarding data handling, especially in the context of evolving technologies and diverse workforce compositions? (1 totally uncompliant, 5 totally compliant)

Transparency is maintained through clear communication channels and disclosure of relevant information, Measures are in place to prevent discrimination in logistics operations, Risk management strategies are employed to identify and mitigate potential risks, Ethical guidelines and codes of conduct are established, Regular audits and assessments are conducted, Logistic operators actively engage with stakeholders, Continuous learning and improvement are prioritized, Logistic operators embrace a culture of accountability and responsibility

Q47: How much do you think the adoption of unmanned/automated vehicles in logistic operations will impact the following aspects? (-2 very negative, 0 neutral, +2 very positive)

Logistic efficiency, Working conditions of transport workers, Security of workers, Overall road safety, Job displacement, Road congestions and traffic, Quality of public spaces, Environmental impact, Privacy and data security of individuals

Annex D – Unmanned Vehicle Characteristics and Technical Specifications

The following information was provided by TRACE vehicle providers in 2023-2024 and includes characteristics and technical data about the UGV's and UAV's to be piloted in the project.

Cargo Bike:

Provider	**Sum Solutions (SUM)**
Vehicle Type	**Cargo Bike**
Pilot Deployment Location(s)	**Modena**
Weight	**55 kg**
Max Travel Distance (e.g., one battery charge) if applicable	**30km**
Load Capacity	**250kg**
Max speed (with driver)	**25km/h**
Max speed (unmanned)	**6km/h**
Max slope	**3%**
Max step size (cm)	**TBD**
Dimensions (Width, length, height)	**W=105cm x L=265cm x H=195cm**
SAE level during operation (e.g. Level 3)	**L3 (L4 for emergency maneuvers and for the parking/detaching from the platoon – this can be omitted, in case of local law restrictions)**
Weather restrictions (e.g., cannot operate with heavy precipitation, wind etc.)	**Cannot operate under rain nor snow.** **The large surface of the box and low weight of the vehicle suggests careful utilization with strong wind.**
Max size requirement for cargo bikes in Italy/EU	**EU: can vary from 5-6m in length (cargo bike + trailer) to 60cm - 130cm in width. Italy: 3.5m length x 1.3m width. Cargo bikes used for Italian pilot are 95cm (min required size) and 2.6m length (min required size).**
Permit required for pilot testing?	**Yes**
If yes, have permits been acquired?	**Not Yet**

Robot:

Provider	**Robotnik (ROB)**
Vehicle Type	**RB-VOGUI robot**
Pilot Deployment Location(s)	**Athens and Ljubljana**
Weight	**165 kg**
Working Time (frequent movement, flat environment, "slow" speed)	**4 hours**
Working Time (stopped)	**8 – 9 hours**
Payload	**150kg**
Max speed	**2.5 m/s**
Max slope	**47%**
Max step size (cm)	**3-8 cm**
Dimensions (Width, Length, Height)	**W=785mm x L=1205mm x H=530mm (529+ parcels Box)**
SAE level during operation (e.g. Level 3)	**3**
Weather restrictions (e.g., cannot operate with heavy precipitation, wind etc.)	**Cannot operate with heavy rain and wind**
Permit required for pilot testing?	**Yes**
If yes, have permits been acquired?	**Not Yet**

Mechanical	***Control***
Dimensions: **1.040 x 650 x 530 mm**	Controller: **Open architecture ROS Integrated PC with Linux**
Environment: **Indoor / Outdoor**	Communication: **Wifi 02.11a/b/g/n/ac Bluetooth 5.1 (5G/4G optional)**
Batteries: **LiFePO4 30Ah@48V**	Connectivity: **USB, RJ45, HDMI, power supply 12 , 24 VDC and batteries**
Max Travel Distance (e.g., one battery charge) if applicable	**14 km**
Traction motors :	**4 x 500W with brake**
Traction system :	**Omnidirectional**
Steering motors :	**4**
Enclousure class :	**IPS50**
Temperature range :	**-10 to +45 C**
Max Slope :	**47 %**

Drone:

Provider	**DIFLY**
Vehicle Type	**Drone**
Pilot Deployment Location(s)	**Bologna, Modena**
Maximum Takeoff Mass (MTOM)	**20 kg**
Payload	**4 kg**
Endurance	**30 min**
Max speed	**13 m/s**
Max Travel Distance (e.g., one battery charge) if applicable	**10 km**
Dimensions (Width, depth, height)	**0.95 m (<1m3)**
Take-off / landing space requirements? (e.g. Designated launch pad with dimensions xyz)	**3m wide area with clear vertical**
Have takeoff/landing sites been confirmed?	**TBD**
Noise level (dB) while operating	**TBD**
SAE level during operation (e.g. Level 3)	**4**
Weather restrictions (e.g., cannot operate with heavy precipitation, wind etc.)	**Heavy rain, icing, wind>20kts**
Permit required for pilot testing?	**Yes**
If yes, have permits been acquired?	**Not yet**