

GO-X ARCHITECTURE

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About GOLIA

GOLIA is a project focused on Governing, Optimising and Leveraging Innovation in cities through data-driven and social-optimum led approach. It aims to ensure an adaptive, accessible and just mobility system planned and governed with the help of digital assets, but also with the inclusive and co-creational policy making processes. Through the integration of STEM and SSH expertise and approaches, GOLIA will revolutionize spatial and mobility planning by co-developing and testing vision-led Social Optimum Mobility Index, a metric to assess urban mobility systems based not only on economic variables but also on indicators such as social support, healthy life quality or freedom to make life choices. The index will be location and time dependent to enable dynamic management of transport offer and spaces.

The project will analyse the policy making processes, citizen engagement practices and digital assets of the three Partner cities and with the gained knowledge, it will create an integrated, interdisciplinary and Adaptive Mobility Smart Governance Model. GOLIA aims at understanding to which extent and under which conditions, data generated by Smart Cities supported by AI-based tools novel communication and consultation channels and methodologies to engage citizens and stakeholders might foster the establishment of a new inclusive and adaptive mobility governance. GOLIA's goal is to identify governance models able to deliver policies resilient to political instability, extreme weather events, pandemics or any other more or less disruptive event, as they are co-developed, co-designed, and co-monitored by and for citizens and firms.

1 Deliverable Detailed Information

1.1 Key words

GO-X, Architecture, modules, integration, cloud

1.2 GOLIA Outputs Mapping to GA Commitments

GOLIA GA Item	GOLIA GA Item Description	Document Chapter(s)	Justification
DELIVERABLE			
D2.1	GO-X Architecture	Chapter 3.1.4 – List of deliverables	This document describes the software architecture for the GO-X modules, specifying their means of interaction
TASK			
T2.1	i)The task designs the interactions among the modules developed within the WP ensuring that these modules can work together seamlessly and effectively. ii)The task involves the specification of the interfaces (APIs), that each module will expose. These APIs define the methods and data that are accessible to other modules. iv)In addition to APIs, the task defines the services that each module should offer. These services represent the functionality that each module provides, which could range from simple data processing tasks to more complex computational operations. v)The task identifies the appropriate technologies that will enable the different solutions to operate and scale according to diverse needs (e.g. choosing the right database systems, networking technologies, or cloud platforms).	Chapter 3.1.3 – Detailed Work Package descriptions	This document fulfills the task requirements by establishing the complete GO-X Architectural Blueprint. It defines the Hub-and-Spoke interaction model to ensure seamless modular operation (I), specifies the API strategies (Synchronous REST and Asynchronous Message Broker) for data accessibility (II), outlines the specific services and functions of all four modules (iv), and selects the enabling technologies (AWS, Docker, MongoDB) to ensure scalability and diverse needs coverage (v).

Table 1: Deliverable Adherence to Grant Agreement deliverable and work description

2 Executive summary

This document details the complete technical architecture for the **GO-X platform**, the central technological engine of the **GOLIA (Governing, Optimising and Leveraging Innovations proActively)** project. The GOLIA project, funded by Horizon Europe, aims to establish a new, adaptive, and inclusive governance model for urban mobility, centered on the principles of **Mobility as a Right (MaaR)** and the **Social Optimum Mobility Index (SOMI)**.

The GO-X platform is the tool that enables this vision. It is a cloud-native system designed to ingest complex, heterogeneous data from partner cities and transform it into the unified, actionable intelligence required for data-driven, collaborative decision-making.

The GO-X platform is designed as a **hybrid architecture** that combines the flexibility of **containerized microservices** with the robust control of a **hub-and-spoke** interaction pattern.

This architecture is built on a clear **separation of concerns** by using four distinct modules:

1. **GO-DATA (The Hub):** the foundational data orchestrator. It is the *only* module that interfaces with external data sources (e.g., city OpenData portals, social media). Its primary role is to **abstract and uniformize** all data, making the other modules "source-agnostic." It is for internal use only.
2. **GO-INFO (The Spoke):** the visualization and interaction layer. It provides dashboards and citizen consultation tools, answering the question, "What is happening?"
3. **GO-KNOW (The Spoke):** the analytical engine. It runs models to understand the *why* behind the data (e.g., identifying drivers for the SOMI) and assesses the transferability of solutions.
4. **GO-WISDOM (The Spoke):** the decision-support tool. It leverages insights from the other modules to provide recommendations to policymakers, answering, "What should we do next?"

The system's data flow is circular and centrally managed by GO-DATA:

- **Consumption:** the "spoke" modules (INFO, KNOW, WISDOM) consume clean, standardized data from GO-DATA.
- **Contribution:** these modules then push their results (analyses, models, sentiment scores) *back* to GO-DATA for persistence.
- **Redistribution:** this allows the insights from one module (e.g., GO-KNOW) to be shared and consumed by another (e.g., GO-INFO), creating a powerful, collaborative data economy.

Key principles of this design include:

- **Security & Privacy:** the platform primarily uses **public OpenData portals**, inherently resolving many privacy concerns. Social media scraping is **fully anonymized**, with only aggregated sentiment results being stored. The GO-DATA hub is **completely isolated** from public access.
- **Minimal Data Persistence:** the platform is not a data lake. It operates as a lightweight orchestrator, storing **as little data as possible** (primarily metadata and aggregated results) in its flexible **NoSQL (MongoDB)** database.
- **Dual-Communication Model:** the platform uses two communication methods: a **REST API** for on-demand (pull) data requests and a **RabbitMQ Message Broker** for asynchronous, real-time (push) notifications.

The development of the GO-X platform is the responsibility of **WP2 (led by SUPSI)**, running from **Month 1 to Month 18**. The development of **GO-DATA is front-loaded (M2-M12)**, as it is a critical dependency for all other modules. The platform will be delivered and ready for city testing (WP3) by **M18 (MS3)**. The entire system will be deployed as **containerized (Docker)** services in a unified cloud infrastructure, with each task leader responsible for their module's deployment.

Table of contents

DELIVERABLE ADMINISTRATIVE INFORMATION.....	1
LEGAL DISCLAIMER	2
COPYRIGHT MESSAGE.....	2
ABOUT GOLIA	3
1 DELIVERABLE DETAILED INFORMATION	4
1.1 KEY WORDS	4
1.2 GOLIA OUTPUTS MAPPING TO GA COMMITMENTS	4
2 EXECUTIVE SUMMARY	5
3 LIST OF ABBREVIATIONS AND ACRONYMS	9
4 PURPOSE OF THE DELIVERABLE.....	12
4.1 ATTAINMENT OF THE OBJECTIVES AND EXPLANATION OF DEVIATIONS.....	12
4.2 INTENDED AUDIENCE	12
4.3 LINKS WITH OTHER WORK PACKAGES/DELIVERABLES	12
4.3.1 WP1 - CONTRIBUTOR	12
4.3.2 WP3	12
4.3.3 WP4	13
4.3.4 WP5	13
4.3.5 WP6	13
4.3.6 WP7	13
4.3.7 WP8	13
5 ARCHITECTURAL VISION AND GUIDING PRINCIPLES	14
5.1 THE GOLIA DIKW CONCEPTUAL MODEL.....	14
5.2 DESIGN PRINCIPLES.....	14
5.2.1 DESIGN CORE PRINCIPLES.....	14
5.2.2 FUNCTIONAL BREAKDOWN	15
5.3 HIGH-LEVEL ARCHITECTURE	16
6 DESCRIPTION OF THE GO-X MODULES.....	17
6.1 GO-DATA MODULE	17
6.1.1 GO-DATA: THE CENTRAL DATA MANAGER FOR THE GO-X ARCHITECTURE	17
6.1.2 CENTRALIZED DATA ORCHESTRATION AND INTERACTION	17

6.1.3	DATA CONNECTORS: FLEXIBLE DATA INTEGRATION	17
6.1.4	DATA FETCHING STRATEGY AND DATA STORAGE POLICY	17
6.1.5	COMMUNITIES' SENTIMENT ANALYSIS AND PERSONAS THROUGH A SOCIAL MEDIA CONNECTOR	18
6.1.6	ROBUST, MULTI-LAYERED SECURITY AND SECURE INTERNAL DATA ACCESS	18
6.2	GO-INFO MODULE	19
6.2.1	GO-INFO PURPOSE & ROLE	19
6.2.2	GO-INFO PILOT IN PILSEN CITY	19
6.3	GO-KNOW MODULE	21
6.3.1	GO-KNOW PILOT IN ANTWERP CITY	21
6.4	GO-WISDOM MODULE	23
6.4.1	GO-WISDOM PURPOSE & ROLE	23
6.4.2	GO-WISDOM WORKFLOW CONFIGURATION	23
6.4.3	GO-WISDOM OUTPUT AND RESULTS	23

7 DETAILED TECHNICAL ARCHITECTURE 24

7.1	ARCHITECTURAL STYLE	24
7.2	TECHNOLOGY STACK	25
7.2.1	GO-DATA	25
7.2.2	GO-INFO	26
7.2.3	GO-KNOW	26
7.2.4	GO-WISDOM	26
7.3	DATA MODEL AND INTERFACES (APIs)	27
7.3.1	REST API	27
7.3.2	ASYNCHRONOUS INTERFACE THROUGH THE MESSAGE BROKER	28
7.4	SECURITY AND ACCESS MANAGEMENT	28
7.4.1	GO-DATA	28
7.4.2	GO-INFO	28
7.4.3	GO-WISDOM	28
7.5	DEPLOYMENT AND INFRASTRUCTURE STRATEGY	29
7.5.1	CLOUD INFRASTRUCTURE	29
7.5.2	DEPLOYMENT AND CI/CD WORKFLOW	29
7.5.3	MANAGEMENT AND COORDINATION	30
7.5.4	NETWORK SECURITY AND ACCESS	30
7.5.5	SHARED RESOURCES	30
7.6	PERFORMANCE AND PROCESSING TIME CONSIDERATIONS	31

8 INTEGRATION AND INTEROPERABILITY 32

8.1	INTEGRATION WITH PARTNER CITY SYSTEMS	32
8.1.1	PRIMARY INTEGRATION VIA OPENDATA PORTALS	32
8.1.2	DATA SOURCING POLICY AND THIRD-PARTY DATA	32
8.2	INTEGRATION OF DATA FROM SOCIAL MEDIA	32
8.2.1	PURPOSE: SENTIMENT AND POLICY RECEPTION	33
8.2.2	ANONIMITY AND DATA STORAGE POLICY	33
8.2.3	GOVERNANCE AND COMPLIANCE	33

8.2.4 DATA RELIABILITY AND QUALITY ASSESSMENT	33
9 CONCLUSIONS	35
9.1 SUMMARY OF THE PROPOSED ARCHITECTURE	35
9.2 DEVELOPMENT ROADMAP	35
10 ANNEX A – OBJECTIVES AND ACTORS.....	37
10.1 EXECUTIVE SUMMARY	37
10.1.1 FROM HIGH-LEVEL GOALS TO ACTIONABLE SPECIFIC OBJECTIVES	37
10.1.2 THE PROCESS OF STAKEHOLDER EXTRACTION	38
10.1.3 PRACTICAL EXAMPLE: MAPPING STAKEHOLDERS FOR A SPECIFIC OBJECTIVE.....	38
10.1.4 VALIDATION AND ENGAGEMENT STRATEGY	39
10.2 PURPOSE OF THIS DOCUMENT	40
10.2.1 INTENDED AUDIENCE	40
10.3 INTRODUCTION.....	41
10.3.1 FROM GA USE CASES TO CITIES SPECIFIC OBJECTIVES	41
10.3.2 FROM CITIES’ SPECIFIC OBJECTIVES TO GO-X FUNCTIONAL REQUIREMENTS.....	42
10.4 ACTORS IDENTIFICATION IN CITIES’ OBJECTIVES.....	43
10.4.1 FLORENCE.....	43
10.4.2 ANTWERP.....	49
10.4.3 PLZEN	53

List of figures

Figure 1 - GO-X high level architecture.....	16
Figure 2 - GO-X technical architecture.....	25
Figure 3 - Florence objective 1 UML	44
Figure 4 - Florence objective 2 UML	46
Figure 5 - Florence objective 3 UML	48
Figure 6 - Antwerp objective 1 UML.....	50
Figure 7 - Antwerp objective 2 UML.....	51
Figure 8 - Antwerp objective 3 UML.....	52
Figure 9 - Plzen objective 1 UML	53
Figure 10 - Plzen objective 2 UML	54
Figure 11 - Plzen objective 3 UML	56

List of tables

Table 1: Deliverable Adherence to Grant Agreement deliverable and work description.....	4
Table 2 - WP2 GANTT with milestones	36

3 List of abbreviations and acronyms

Acronym	Meaning
AI	Artificial Intelligence
API	Application Programming Interface
ASAP	As Soon As Possible
B2B	Business-to-business
B2C	Business-to-Consumer
BFF	Backend For Frontend
CCAM	Cooperative, Connected and Automated Mobility
CERTH	CEntre for Research and Technology Hellas
CINEA	European Climate, Infrastructure and Environment Executive Agency
CSV	Comma-Separated Values
DATEX II	Data Exchange
DIKW	Data-Information-Knowledge-Wisdom
EC	European Commission
GA	Grant Agreement
GDPR	General Data Protection Regulation
GraphQL	Graph Query Language
GTFS	General Transit Feed Specification
INLECOM	Innovative Information Learning and Communication Solutions
IT	Information Technology
ITI	Integrated Territorial Investment
JSON	JavaScript Object Notation
KoM	Kick-off Meeting
KPI	Key Performance Indicator

LSP	Logistic Service Provider
MaaS	Mobility as a Right
MaaS	Mobility as a Service
MNO	Mobile Network Operator
MS	Milestone
NoSQL	Not only SQL
OA	Objective for Antwerp
OEM	Original Equipment Manufacturers
OF	Objective for Florence
OP	Objective for Plzen
PU	Public
RE	Real Estate
REST	Representational State Transfer
SINTEF	Stiftelsen for INDustriell og TEknisk Forskning
SIRI	Service Interface for Real Time Information
SOA	Specific Objective for Antwerp
SoC	Separation of Concerns
SOF	Specific Objective for Florence
SOMI	Social Optimum Mobility Index
SOP	Specific Objective for Plzen
SSH	Social Sciences and Humanities
STEM	Science, Technology, Engineering and Mathematics
SUPSI	Scuola Universitaria Professionale della Svizzera Italiana
TT	Transform Transport
UNESCO	United Nations Educational, Scientific and Cultural Organization

V2X	Vehicle-to-Everything
WP	Work Package
XML	eXtensible Markup Language

4 Purpose of the deliverable

4.1 Attainment of the objectives and explanation of deviations

The objectives related to this deliverable have been achieved in full and as scheduled.

4.2 Intended audience

The primary audience consists of the technical partners, system architects, and software developers within the GOLIA consortium, who will use this document as the definitive blueprint for the development and implementation of the four GO-X modules.

A secondary audience includes the technical staff and IT departments of the partner cities, who need to understand the architecture's specifications to plan for the integration and testing activities in WP3.

Partners involved in WP4, specifically the **Follower Cities**, represent also a strategic audience for the long-term impact and scalability of the project. As these cities aim to replicate the GOLIA approach, this document serves as their primary technical blueprint. It allows them to understand the architectural prerequisites, the modular logic of the GO-X platform, and the integration patterns (APIs and Data Connectors) required to successfully deploy and adopt the solution within their own local IT environments.

4.3 Links with other work packages/deliverables

4.3.1 WP1 - Contributor

WP1 is the main contributor with its deliverables to all GO-X modules development. WP1 output has contributed to the definition of the architecture described in this document with a comprehensive set of specifications and requirements that will serve as the blueprint for all technical development. In detail, the contribution to WP2 from WP1 deliverables is as follows:

- **D1.1 – Concepts and solutions for socially optimized mobility systems:** this report provides the core requirements and guiding principles for the entire architecture, to ensure that it and its components are aligned with the project's social and ethical goals. Expected delivery on M12.
- **D1.2 – ENGAGEMOVE: Roadmap of stakeholder engagement methodologies:** this is a direct input for the GO-INFO module (T2.3). The ENGAGEMOVE roadmap will define the functional requirements for the public-facing components of the platform, such as the citizen survey tools and feedback mechanisms. Expected delivery on M12.
- **D1.3 – Mobility as a Right (MaaR) legal definition:** this is an input for the GO-DATA module (T2.2), setting strict requirements for data privacy, anonymization and GDPR compliance, and for the GO-WISDOM module (T2.5), ensuring that its policy recommendations do not inadvertently violate the principles of equity and access defined as “Mobility as a Right” (MaaR). Expected delivery on M9.
- **D1.4 – SOMI and atlas of Accessibility:** this deliverable provides the precise formula, parameters and data requirements for calculating the Social Optimum Mobility Index (SOMI). This is an input for GO-DATA (T2.2), GO-KNOW (T2.4) and GO-WISDOM (T2.5) modules. Expected delivery on M13.

4.3.2 WP3

WP3 relies on D2.2, D2.3, D2.4 and D2.5 of the WP2 deliverables to test the GO-X platform with partner cities. WP2 contributes also with technical support during the testing phase.

4.3.3 WP4

WP4 relies on all deliverables from WP2, analysing the results from the use of the GO-X modules to create strategic documents that ensure the project's long-term impact and transferability to other cities.

4.3.4 WP5

WP5 relies on all deliverables from WP2. GO-X platform is the central subject of all training activities they must do. WP2 will participate in their activities as technical trainers.

4.3.5 WP6

WP6 relies on all deliverables from WP2. WP6 will exploit GO-X platform as a tangible product of the project, including its usage in articles, live demonstrations etc...

4.3.6 WP7

WP7 relies on all deliverables from WP2. WP7 will exploit GO-X platform in the definition of sustainable future business models, to keep GOLIA legacy alive after the end of the project.

4.3.7 WP8

WP8 relies on the final deliverables from WP2, controlling the technical work performance and overall project execution to manage the periodic reporting process and ensure the project concludes successfully.

5 Architectural vision and guiding principles

5.1 The GOLIA DIKW conceptual model

The GOLIA project's technological platform is conceptually structured around the Data-Information-Knowledge-Wisdom (DIKW) model. This framework provides a virtuous decision-making process by creating a logical flow that transforms raw data into actionable policy insights. Instead of developing entirely new tools, GOLIA adopts this modular approach to systematize and build upon the digital assets already available in partner cities. The four GO-X software modules can be mapped to the stages of the DIKW pyramid: GO-DATA manages the collection of raw data; GO-INFO processes and visualizes this data as accessible information; GO-KNOW uses data and can leverage this information to build transferable knowledge and assess solutions; and finally, GO-WISDOM uses data and can leverage information and knowledge to support high-level, socially optimal policy decisions.

5.2 Design principles

5.2.1 Design core principles

The GO-X architecture is guided by several key principles derived from modern software engineering and data platform design:

1. **Separation of Concerns (SoC):** this is the primary driver for the modular split. Each of the four modules has a single, well-defined responsibility within the data-to-action pipeline. This prevents the creation of a complex, unmanageable "god module," simplifies development, and allows for specialized technologies to be used for each specific task.
2. **Centralized Data Orchestration:** the entire platform operates on a "hub-and-spoke" model with GO-DATA as the central hub. No module interacts directly with another for data; all communication, data requests, and persistence of results are brokered exclusively through GO-DATA. This simplifies data governance, enforces security, and ensures a single source of truth.
3. **Loose Coupling and Interoperability:** the modules are designed to be loosely coupled. They communicate through standardized, well-defined interfaces—primarily synchronous REST APIs for on-demand requests and an asynchronous message broker (RabbitMQ) for real-time event notifications. This means any module can be updated, redeployed, or even replaced without breaking the others, as long as it adheres to the established API contract.
4. **Scalability and Resilience:** by containerizing each module as a separate microservice, the GO-X platform achieves high scalability and resilience. Each component (e.g., data ingestion in GO-DATA, analytics in GO-KNOW) can be scaled independently based on its specific workload, optimizing resource use. If one module fails, it does not inherently bring down the entire system.

5.2.2 Functional breakdown

The division into four modules creates a logical flow that mirrors the process of decision-making: from raw data to informed action. Each module answers a different fundamental question.

GO-DATA (The Foundation - The “How”)

Manage how data is collected, stored, and provided.

Data management is a highly specialized and complex task. By isolating all data-facing operations into GO-DATA, we centralize the handling of connectors, database interactions (MongoDB), security, API provision, and data compliance (e.g., licensing, GDPR). The other modules do not need to know how to connect to a GTFS feed or a social network; they simply ask GO-DATA for the information they need.

GO-INFO (The Interface - The “What”)

Answer on what is happening.

This module is the human-computer interface of the platform. Its sole focus is on presentation and interaction. It consumes processed data from GO-DATA and transforms it into intuitive dashboards, maps, and citizen consultation tools. Separating this "view" logic from the "data" logic (GO-DATA) or the "analysis" logic (GO-KNOW) allows for the frontend (ReactJS) to be developed and iterated upon independently, focusing purely on user experience.

GO-KNOW (The Analyst - The “Why”)

Understand why things are happening.

This module is the analytical engine. Its responsibility is to move beyond simple data display and generate deeper knowledge and insights. It runs analytical models, identifies the key determinants of the Social Optimum Mobility Index (SOMI), and assesses the transferability and scalability of policies. This requires specialized analytical tools and skills. Isolating it ensures that these heavy computational tasks do not interfere with the real-time data delivery of GO-DATA or the user-facing responsiveness of GO-INFO.

GO-WISDOM (The Advisor - The “Now What?”)

Advise on what to do next.

This is the final step: decision support. The GO-WISDOM module leverages the "what" from GO-INFO and the "why" from GO-KNOW to provide actionable recommendations. It is the bridge between analysis and policy. By simulating the impact of potential decisions and identifying optimal solutions to maximize the SOMI, it directly supports the governance and implementation process. This function is distinct from pure analysis (GO-KNOW) as it is forward-looking and prescriptive.

5.3 High-level architecture

The GO-X platform is designed as a decoupled, service-oriented architecture built around a central data hub. The entire system operates on a "hub-and-spoke" model, with GO-DATA serving as the mandatory central hub and the other modules (GO-INFO, GO-KNOW, GO-WISDOM) acting as specialized "spoke" services.

This design ensures a clean separation of concerns, scalability, and flexibility, where the flow of data - not the applications themselves - defines the system's interactions.

The primary architectural role of the GO-DATA module is to function as an **abstraction and uniformization layer**. It is designed to ingest data from a multitude of complex, heterogeneous, and disconnected sources—ranging from real-time GTFS feeds and DATEX II XML streams to static CSV files, social media APIs, and third-party REST services.

GO-DATA's specialized connectors handle all the complexity of interfacing with these sources. The module's core task is to process, clean, and transform this raw data into a single, consistent, and predictable format (JSON) exposed via its internal REST API.

This architectural choice makes all other consumer modules completely source-agnostic.

The GO-KNOW, GO-INFO, and GO-WISDOM modules do not need to know - nor do they care - whether mobility data originated from a city's legacy database or a modern GraphQL endpoint. They simply make a standardized request to GO-DATA (e.g., "Get parking availability for Zone A") and receive a clean, uniform JSON response. This massively simplifies the development of the analytical and visualization modules, allowing them to focus entirely on their specific business logic rather than on data ingestion and parsing.

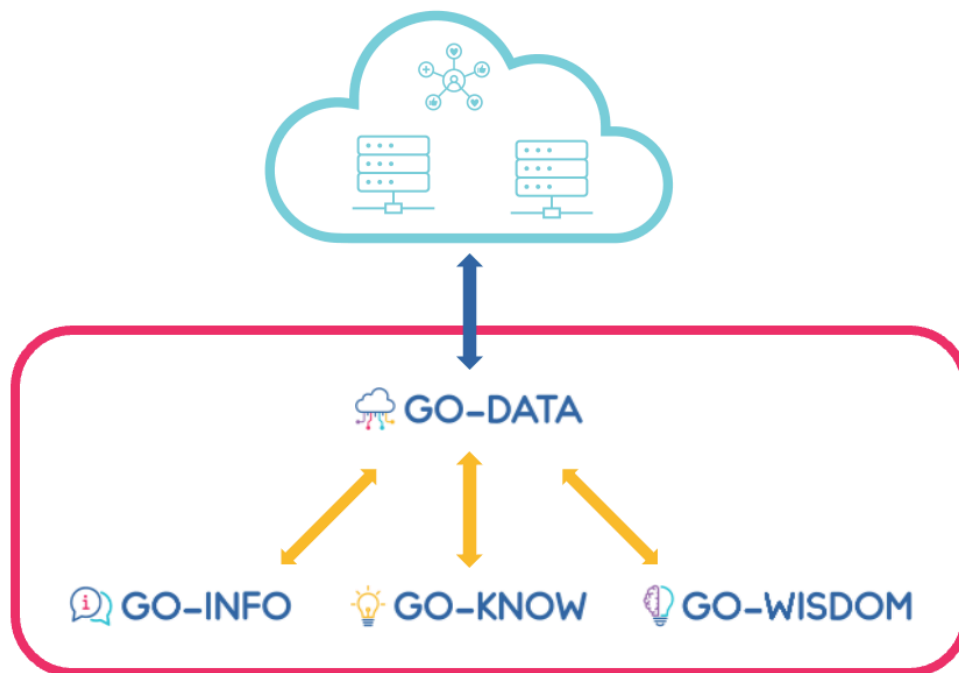


Figure 1 - GO-X high level architecture

6 Description of the GO-X modules

6.1 GO-DATA module

6.1.1 GO-DATA: the central data manager for the GO-X architecture



The GO-DATA module serves as the foundational data hub for the entire GOLIA ecosystem. Its primary purpose is to centralize and manage all data flows, guaranteeing trust, security, and seamless interoperability between disparate data sources and the project's analytical modules. It operates as the single source of truth and the exclusive data broker for all other functional components.

6.1.2 Centralized data orchestration and interaction

GO-DATA's architecture is built on a principle of centralized control. The other modules—GO-INFO, GO-KNOW, and GO-WISDOM—do not communicate directly with data sources or with each other for data exchange. Instead, they interact bidirectionally only through GO-DATA. This design ensures that GO-DATA orchestrates all data ingestion and also persists any elaborations, analytical models, or insights generated by the other modules. Such a centralized model is critical for preventing data silos, maintaining data consistency, and enforcing a unified governance strategy across the system.

6.1.3 Data connectors: flexible data integration

To interface with a wide array of public and private data sources, GO-DATA utilizes a sophisticated system of specialized connectors. Each connector is specifically developed to adapt to a given source, employing standard protocols promoted by OpenData initiatives (such as GTFS, DATEX II, and SIRI), as well as modern APIs like REST and GraphQL. This adaptable, protocol-agnostic approach ensures that GOLIA can seamlessly integrate with the diverse and often complex existing data platforms of the partner cities.

6.1.4 Data fetching strategy and data storage policy

The module implements an intelligent and legally compliant data fetching strategy to optimize resource usage and adhere to data usage constraints.

- **Siloed or static data** is retrieved strictly *on-demand*, meaning it is fetched only when another GO-X module explicitly requests it.
- **Real-time data streams**, conversely, are fetched *cyclically* to ensure that time-sensitive information is always current. A notification system then alerts any subscribed modules whenever new data is received.

Critically, GO-DATA is designed as a lightweight orchestrator and does not, in principle, store raw data from external sources. The underlying assumption is that source data remains temporally available from its provider and can be re-fetched if needed. At most, the module will persist statistics, aggregations, and other processed results. This approach has significant legal and compliance implications. Some third-party data sources require specific usage licenses that may impose strict constraints on data persistence and storage. The GOLIA project's partner cities have committed to providing the necessary third-party data sources for the project's duration. GO-DATA will dynamically adapt its behavior based on the licensing terms of each source, ensuring full compliance and avoiding unauthorized data storage.

However, while the "fetch-on-demand" policy is central to the lightweight design and some potential licensing issues of GO-DATA, strict adherence to this rule can introduce performance risks. Repeated real-

time fetching of data—especially from external sources with variable bandwidth or rate limits—may cause significant ingestion latencies that negatively impact the responsiveness of dependent modules.

Consider, for example, a scenario where a user triggers a complex analysis requiring the download of a large historical dataset (e.g., a high-resolution traffic log). If the user subsequently requests multiple distinct post-elaborations or queries on this same data, re-downloading the entire dataset for every single operation would create an unacceptable bottleneck.

To control these situations, GO-DATA will implement an intelligent temporary caching mechanism. This solution creates a "middle ground" between persistence and real-time fetching. When a large dataset is requested, it is stored in a temporary, high-speed cache with a defined Time-To-Live (TTL). Subsequent queries within this window are served instantly from the local cache. Once the TTL expires, the data is purged, thereby maintaining performance without violating the principle of minimal data persistence.

6.1.5 Communities' sentiment analysis and Personas through a social media connector

A key feature of GO-DATA is its specialized connector for scraping and analyzing data from social networks. This tool is essential for conducting sentiment analysis on new mobility policies, creating data-driven user personas, and measuring public engagement with urban initiatives. This process is conducted with a strict focus on ethical and legal compliance. All data is collected and processed in a fully anonymized manner, ensuring that the focus remains on collective trends and public sentiment, not on individuals.

This approach is in full accordance with European data protection regulations, most notably the General Data Protection Regulation (GDPR), which mandates the protection of personal data and privacy.

The interest is pointed at the community, not the single person.

6.1.6 Robust, multi-layered security and secure internal data access

Security and privacy are foundational principles of the module's design. GO-DATA does not expose any service, API, or data directly to the outside world. All processed and aggregated data is made available *exclusively* to the other GO-X modules through a secure, internal-facing standard REST API. This guarantees that all data operations remain within the controlled, trusted, and secure GOLIA environment.

6.2 GO-INFO module

6.2.1 GO-INFO purpose & role



The GO-INFO module, developed under Task 2.3 - GO-INFO, assets and data consultation and visualization services and led by INLECOM, acts as the main interface between the GOLIA

technological framework and its end users, comprised by policymakers, city authorities, mobility stakeholders, and citizens. Its purpose is to translate the complex data and analyses produced by the GO-DATA module and other technical components into accessible, valuable, and actionable information.

GO-INFO, a key component of the GOLIA ecosystem, incorporates various data sources and analytical results to generate interactive dashboards and visualization tools. These tools enable users to understand and study indicators such as the Social Optimum Mobility Index (SOMI) and other performance metrics, resulting in a deeper comprehension of social, environmental, and economic implications. In this way, the module promotes informed and evidence-based decision-making and transparency in mobility policy evaluation.

In addition to data visualization, GO-INFO offers citizen engagement features such as an interactive and GDPR-compliant survey tool for collecting comments, perceptions, and behavioral insights from citizens and stakeholders. This interactive layer ensures that knowledge flows both ways, from the system to society and back again, promoting inclusivity, accountability, and public trust.

In essence, the GO-INFO module serves as the GOLIA architecture's communication, visualization, and interaction hub. It bridges the technical data backbone (GO-DATA) with citizens, stakeholders, and policymakers through the integration of dynamic dashboards, engagement tools, and clear visual communication, empowering decision-makers and communities to contribute to more sustainable and socially driven mobility advancements.

6.2.2 GO-INFO pilot in Pilsen city

The City of Pilsen (UKEP) is GO-INFO's test location. The data from GO-INFO is fed by GO-DATA with an emphasis on city-specific use cases that transform harmonized datasets into customizable dashboards, reports, and an interactive public-engagement survey tool.

The Pilsen use case will demonstrate GO-INFO's ability to

- visualize indicators such as SOMI and its causes,
- collect citizen and stakeholder feedback using GDPR-compliant questionnaires, and
- feed insights back into discussions about policy and co-monitoring efforts.

As per project's Grant Agreement, this pilot represents the "Pilsen use case: application of GO-INFO for vision building" and further expands on how survey input can be paired with Digital Twin simulations to help Pilsen evaluate policy options before implementation and promote collaborative, data-driven decision-making.

Inputs:

- Data and analytical results are generated via the GO-DATA module.
- Outputs from Digital Twin simulations illustrating the effects of policy measures.
- Citizen insights and survey responses are collected using the GO-INFO engagement tools.

Outputs:

- Visualisation of SOMI and related metrics through interactive dashboards.
- Survey-based feedback on citizen perceptions and mobility experiences.
- Support for vision development and policy assessment, facilitating ex ante evaluation of measures.
- Increased awareness and transparency in municipal mobility governance.

Stakeholder groups

- The City of Pilsen officials will be testing and certifying the module in real-life conditions.
- Citizens and members of the administration will participate in surveys and engagement activities.
- Technical partners in charge of GO-DATA and Digital Twin integration, ensuring efficient data flow and interoperability.

In conclusion, the Pilsen city pilot will validate GO-INFO's ability to promote open, inclusive, and data-informed mobility governance, highlighting its importance as an essential element of the GOLIA framework for socially driven urban mobility shift.

6.3 GO-KNOW module



GO-KNOW is a digital dashboard aimed at evaluating the maturity of technical MaaS (Mobility as a Service) implementations across European cities. The ambition is to

enable cities to assess their readiness by providing data for a set of region-specific criteria. Based on this input, the dashboard will generate two indicative scores:

- **Data Maturity Score:** reflecting the completeness and quality of the city's mobility-related data.
- **SOMI Impact Score:** estimating the potential improvement in the Social Optimum Mobility Index (SOMI) through MaaS integration.

In addition to these scores, the dashboard will offer guidance on how cities can plan to meet the necessary data requirements to advance their MaaS implementation.

The dashboard is a frontend application, with only a thin backend component. It will be developed using best practices in accessibility and user experience, and the design will be based on the GOLIA design principles. Communication with the other modules will be done through GO-DATA, in accordance with the overall architecture of the project. All data will be stored in GO-DATA.

6.3.1 GO-KNOW pilot in Antwerp city

GO-KNOW is designed to support the upscale of the existing digital open asset, a trip planner, already developed by the City of Antwerp: “Smart Ways to Antwerp” to the level of the Functional Urban Area, i.e. beyond city limits. The main challenges that Antwerp are facing are the lack of engagement from minorities (e.g. disabled, elderly, youth, migrants) in the use of the travel planner, and the lack of cooperation between mobility actors to offer an integrated, seamless, and equitable mobility system.

GO-KNOW aims to address both mobility inclusion and governance coordination by improving how data is used, shared, and adapted across the transport region. On one side, GO-KNOW will assess the data sources to ensure they include all diverse user needs and behaviours, warranting an equitable and inclusive access in line with mobility as a right. On the other, GO-KNOW will assess the computational requirements for scaling digital tools across the Functional Urban Area, and provide the guidelines for standardizing and adapting data across urban and regional levels, ensuring consistent quality and interoperability.

The open and transparent digital dashboard will also support better cooperation between public and private actors by enabling decision support for policymakers through integrated insights, helping align regional strategies with urban mobility goals.

Inputs:

- Metadata used in Antwerp's trip planner
- Data and analytical results are generated via the GO-DATA module.
- Citizen insights and survey responses are collected using the GO-INFO engagement tools.

Outputs:

- Visualisation of the Data Maturity Score and the SOMI Impact Score through an interactive dashboard.
- Guidelines to support the upscale of the existing travel planner in terms of spatial expansion, and functionalities.
- Guidelines to ensure all citizens needs are covered by the travel planner, supporting equitable transport in line with mobility as a right.
- Increased collaboration in municipal mobility governance.

Stakeholder groups

- The City of Antwerp will be testing the dashboard.
- Citizens and companies that want to build digital services within the existing travel planner will also test the dashboard.
- Technical partners in charge of the other GO-models, ensuring efficient data flow and interoperability.

6.4 GO-WISDOM module

6.4.1 GO-WISDOM purpose & role



GO-WISDOM

GO-WISDOM is the decision-support module of GOLIA for city mobility planners and policymakers, designed to evaluate “what-if” measures against the Social

Optimum Mobility Index (SOMI). A guided workflow captures the planning objective and candidate measure with geographic/constraint context, specifies the impacted personas and their local relevance, and loads MaaR-aligned pillar weights (e.g., Sustainability, Efficiency, Equity/Inclusion, Affordability and Resilience) derived from WP1 consultations.

6.4.2 GO-WISDOM workflow configuration

A curated KPI library is then applied, with heterogeneous indicators normalized to common scales. The module orchestrates a Python agent-based simulation, covering mode choice, operator capacity allocation, business location dynamics, rent/accessibility interactions and emergency routing, to generate quantitative KPI inputs such as modal split, travel times, emissions, rent burden and response times. For each persona, a Persona-SOMI is computed as the weighted aggregation of normalized KPIs across pillars. Persona significance weights are subsequently applied to aggregate Persona-SOMIs into a City-SOMI, yielding transparent trade-off and co-benefit breakdowns.

6.4.3 GO-WISDOM output and results

Scenarios can be versioned and compared over time for authenticated users, while an interactive dashboard presents persona and city results to support selection of socially optimal measures. The full SOMI chain, calculation, decision, behavior/system response and recalculation, will be tested and validated in the Florence use case and will feed SUMP/SULP monitoring.

7 Detailed technical architecture

7.1 Architectural style

The GO-X platform is designed using a hybrid architectural style that combines the principles of a Microservice Architecture with a Hub-and-Spoke interaction pattern. This model, illustrated in the diagram below, was explicitly chosen to meet the project's requirements for scalability, resilience, and a clear separation of concerns.

Each of the four GO-X modules (GO-DATA, GO-INFO, GO-KNOW, GO-WISDOM) is a distinct, containerized microservice. This ensures that each module can be developed, deployed, and scaled independently. For example, the analytical workloads of GO-KNOW can be scaled without impacting the real-time data ingestion performance of GO-DATA.

The interaction between these services is strictly defined by the hub-and-spoke model, which the diagram clearly visualizes:

1. **The Hub:** the GO-DATA module acts as the central, mandatory hub. It is the single point of entry for all external Data Sources (Open Data, Private Data, Social Networks, etc.). Its internal Connectors process and uniformize this data, making it available via a REST API and a Message Broker.
2. **The Spokes:** GO-INFO, GO-KNOW, and GO-WISDOM are the "spoke" services. As the diagram shows, they only communicate with GO-DATA and not directly with each other.

This architecture creates a powerful, bi-directional flow. The spokes consume data from the hub and, crucially, contribute their own processed insights (analyses, models, statistics) back to GO-DATA's Data Storage. This allows the insights from one module (e.g., GO-KNOW) to be persisted and then served to another module (e.g., GO-INFO) via the central hub.

Communication within this architecture is managed through two primary mechanisms to support different use cases:

1. **Synchronous communication (Pull):** for on-demand data retrieval, modules use the REST API provided by GO-DATA to "pull" information as needed.
2. **Asynchronous communication (Push):** for real-time updates, the architecture employs an event-driven pattern using the RabbitMQ Message Broker. GO-DATA can "push" notifications to any subscribed spoke as new data arrives.

This combined architectural style provides the ideal balance: the robust governance and data control of the hub-and-spoke model, with the scalability, flexibility, and resilience of a modern microservice ecosystem.

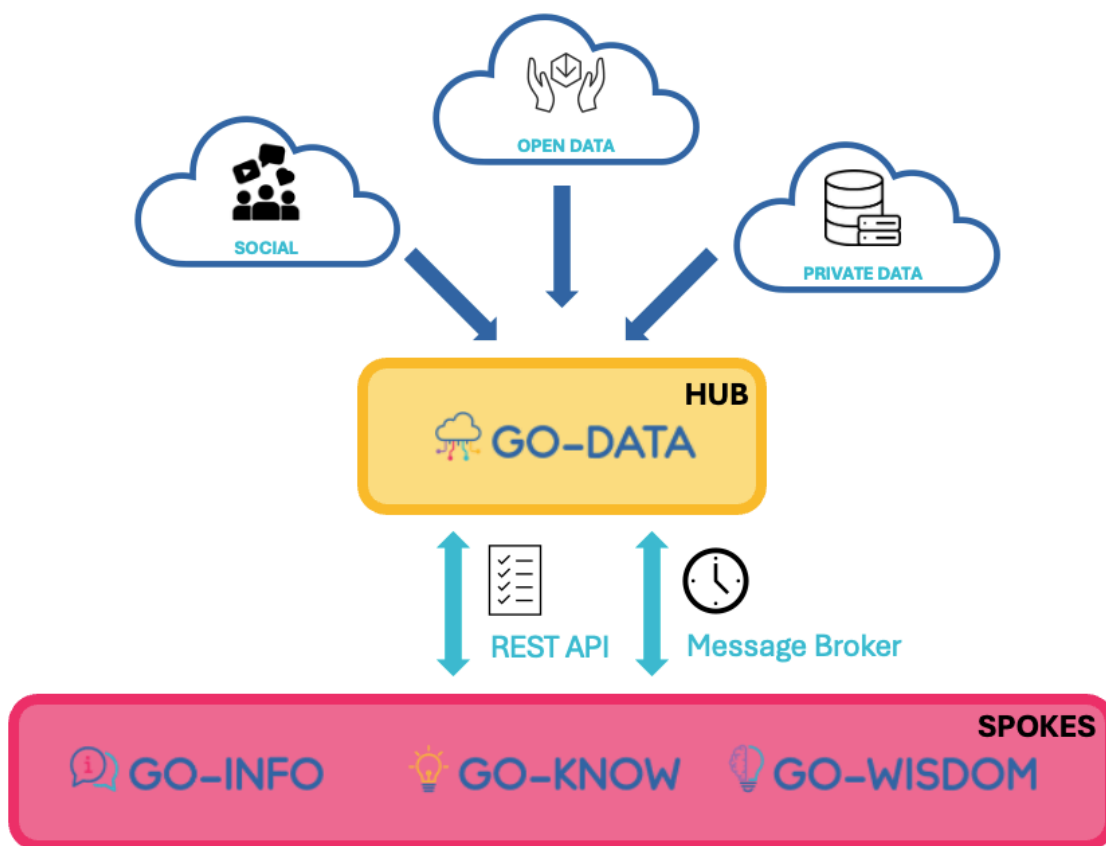


Figure 2 - GO-X technical architecture

7.2 Technology stack

7.2.1 GO-DATA

Module core development

GO-DATA will be developed as an independent, **containerized service** within the overall GO-X architecture.

The core of the service will be implemented using the **Spring Framework**, specifically **Spring Boot**. This choice is driven by its robustness, extensive community support, and its ability to accelerate the development of production-ready applications. The connectors for the various data sources will be implemented directly within the service itself, structured as dedicated services and controllers. Each connector will be a modular component, making it easy to maintain and add new data sources in the future without modifying the application's core logic.

For data persistence (aggregations, statistics, and configuration metadata), the NoSQL database **MongoDB** will be used. This is an ideal choice for the GOLIA context, as MongoDB excels at managing unstructured or semi-structured data from heterogeneous sources.

Communication with other modules

The GO-DATA module will expose its functionalities and data to the other GO-X modules exclusively through **REST APIs**. Dedicated and secure interfaces will be defined for each consuming module (GO-INFO, GO-KNOW, GO-WISDOM), ensuring controlled and granular access to resources. All API responses will be standardized in JSON format, guaranteeing maximum interoperability.

To enable an efficient, real-time notification system, a message broker such as **RabbitMQ** will be introduced. When GO-DATA receives new data from real-time sources (e.g., traffic data or parking availability), it will publish a message to a specific queue. Modules interested in that data can subscribe to these queues and will be notified instantly, allowing for near-immediate system reactivity to events. This pattern decouples the services and improves the overall resilience of the architecture.

Administration frontend

A small administration frontend is planned to facilitate the management of the GO-DATA module. This web-based interface, developed using the **ReactJS** JavaScript framework, will allow system administrators to:

- Monitor the status of the service and its individual connectors.
- Configure and manage data sources, particularly the parameters for the dedicated social network connector (e.g., keywords to track, scraping frequency).
- View logs and statistics on data usage.

7.2.2 GO-INFO

For the development of the GOLIA Dashboard application, we plan to use a modern web technology stack that combines flexibility, scalability, and security. The goal is to build a responsive web interface where different user roles (such as administrators and standard users) can create, manage, and answer surveys. The system will be based on the following main components:

- Frontend: The user interface will be developed using React 19, which provides high performance and a dynamic experience for users. It allows the creation of reusable components and smooth interaction with backend APIs.
- Backend: The server-side logic will be implemented in Python, using the FastAPI framework. This choice ensures fast API development, automatic documentation, and easy integration with authentication and database services.
- Database: The application will use MongoDB as its main database. MongoDB's flexible schema design is ideal for storing dynamic survey structures, questions, and user responses without the need for complex migrations.
- Deployment & Infrastructure: All services will be containerized using Docker to simplify deployment and ensure consistency between development and production environments.

7.2.3 GO-KNOW

The dashboard will be developed as a **NextJS** application, run in a **docker container**. Data will be fetched from the GO-DATA module REST-API, and we don't expect to store any data ourselves. (If needed, data will be stored in a **Postgres** or **MongoDB** database.) If a more complex backend than the server-side functionality NextJS provides is needed, a containerised backend with **Python Fast API** or **Spring Boot** will be used. All communication with the other modules will go through the GO-DATA module, and if live data updates are needed, we will subscribe to the message broker implemented by GO-DATA.

7.2.4 GO-WISDOM

GO-WISDOM is developed at HIT/CERTH, with all services containerized in Docker in line with the project's modular GO-X architecture. Python backend services handle data ingestion, KPI normalization, SOMI computation, persona and city aggregation, and scenario/version management, while also orchestrating



simulation runs and applying optimization where necessary for responsive feedback. The simulation core is a Python agent-based model with sub-modules for multinomial-logit mode choice, transit operator capacity allocation under budget and social priorities, business location choice, rent dynamics as a function of accessibility and walkability, and emergency routing under restricted links; its outputs are mapped to SOMI via a dedicated metrics-mapping layer. The frontend is a web application for data entry aligned to GO-WISDOM determinants, scenario configuration, analytics and dashboard visualization. The specific framework (e.g., React, Angular or Vue) will be selected to best meet partner-city dashboarding needs. A database persists pillar weights, KPI definitions, normalized values, simulation outputs, scenarios and results with full audit and versioning support.

7.3 Data model and interfaces (APIs)

The GO-X platform architecture is built to be a flexible and non-intrusive orchestrator. This philosophy is directly reflected in its approach to data modelling and its communication interfaces, which prioritize flexibility and real-time responsiveness over rigid structures.

There will be no single, specific data model enforced across the GO-X platform. A rigid, predefined relational schema would be impractical and counter-productive given the vast and unpredictable variety of data sources—from static GeoJSON files to dynamic real-time APIs.

Instead, the platform adopts a "meta-data organization" strategy. The GO-DATA module's primary responsibility is not to force all incoming data into a uniform structure, but rather to *understand and catalogue* the structure of the data it ingests.

This approach is supported by the use of a NoSQL Document Database (MongoDB). This technology is perfectly suited for the task as it allows for the storage of flexible, JSON-like documents, accommodating different data structures side-by-side.

A core principle of this architecture is to store and persist as little data as possible. GO-X modules, GO-DATA in particular, are not data lakes or a warehouses. They are designed to be a lightweight orchestrators. GO-DATA in particular will only persist aggregated results from other modules (e.g., insights from GO-KNOW) or configuration metadata. Raw data from external sources is, in principle, fetched on-demand and passed directly to the requesting module, adhering to all data persistence licenses and privacy requirements.

7.3.1 REST API

The primary interface for *on-demand* data retrieval (pulling data) is a set of internal REST APIs provided by GO-DATA. These APIs will be the exclusive communication channel for synchronous requests from the other GO-X modules.

To ensure clarity and ease of use, the API endpoints will be logically organized, likely divided by city and/or data type. For example, endpoints might be structured as:

- `/api/v1/florence/parking/availability`
- `/api/v1/antwerp/traffic/incidents`
- `/api/v1/sentiment/keywords`

While these APIs are logically segmented for manageability, they are all generally available to every other module within the secure GO-X environment. GO-INFO, GO-KNOW, and GO-WISDOM can all access any endpoint, provided they are authenticated. This allows data from one use case to be easily combined with data from another, fostering cross-modular analysis.

7.3.2 Asynchronous interface through the Message Broker

For real-time data feeds, a synchronous "pull" model is inefficient. To solve this, the platform will implement an asynchronous "push" mechanism using a **message broker (RabbitMQ)**.

This system works on a publish-subscribe model:

1. **Subscription:** a GO-X module (e.g., the GO-INFO dashboard) can "subscribe" to a specific topic it cares about, such as `antwerp.traffic.updates` or `florence.parking.new_data`.
2. **Notification:** when the GO-DATA module receives new data from a real-time source that matches this topic, it instantly publishes a small notification message to the broker.
3. **Delivery:** the message broker immediately pushes this notification to all subscribed modules.

This allows the GO-INFO module to update its dashboards in real-time or the GO-KNOW module to run an analysis the moment new data is available, all without resorting to inefficient, continuous polling of the REST API.

7.4 Security and access management

The GOLIA platform's hybrid architecture necessitates a multi-layered security approach. Access control is managed differently for the central hub (GO-DATA) versus the user-facing "spoke" modules (GO-INFO, GO-KNOW, GO-WISDOM).

7.4.1 GO-DATA

The GO-DATA module is the most critical component in terms of security, as it manages all data ingestion and orchestration. Its security posture is one of complete isolation.

- **Network access:** the module is for internal use only and will not expose any public-facing endpoints. It is only accessible from within the platform's private cloud network via its internal REST API and message broker.
- **Admin portal access:** the module will feature a small administration portal (the ReactJS frontend) for monitoring connectors and managing sources. Access to this portal will be secured using a strong local authentication mechanism (i.e., managing its own encrypted user credentials) rather than a federated system, ensuring it remains self-contained and decoupled from other services.

7.4.2 GO-INFO

As the primary user-facing module (providing dashboards and citizen consultation tools), GO-INFO requires a robust system for managing different user types, such as policymakers, researchers, and citizens.

- **Identity and Access Management (IAM):** user authentication and access management in the GOLIA GO-INFO Dashboard will be handled using **Keycloak**, an open-source IAM system.
- **Role-Based Access Control (RBAC):** keycloak will be configured to manage all user accounts, roles (e.g., 'admin', 'researcher', 'public_user'), and fine-grained access permissions. This ensures that only authorized users can perform sensitive actions, such as creating or editing citizen surveys or accessing specific protected datasets.

7.4.3 GO-WISDOM

The GO-WISDOM module is going to employ a hybrid access model that balances ease of use with responsible data persistence. This means that public, anonymous users may perform one-off, non-persistent SOMI assessments through the web interface, while authenticated users can save inputs and

results, resume incomplete scenarios and compare longitudinal “self-SOMI” runs. When it comes to authentication, this is enforced at the interface layer only, and no user, regardless of their role, can access the simulation environment directly. The interface validates and securely transmits inputs to backend services, which execute the ABM/SOMI pipeline and return results. The platform will be deployed exclusively on Golia GO-X infrastructure, which will have as a result that the system will make sure encrypted transport and storage, role-based access to saved scenarios, GDPR-compliant processing of any personal or city-specific data, and versioned records to support reproducibility and auditing.

7.5 Deployment and Infrastructure Strategy

The GO-X platform is designed as a cloud-native system, leveraging modern infrastructure and deployment practices to ensure scalability, manageability, and a rapid development lifecycle. The strategy is centered on containerization, automated continuous deployment, and a clear separation of responsibilities.

7.5.1 Cloud infrastructure

The entire GO-X platform, including all four modules and their supporting services, will be deployed within a single, unified cloud infrastructure. This approach simplifies network management, security, and resource monitoring.

Every component of the platform (GO-DATA, GO-INFO, GO-KNOW, GO-WISDOM) will be built and deployed as a Docker container. This containerized approach guarantees consistency between development and production environments, isolates dependencies, and allows for granular, independent scaling of each service.

7.5.2 Deployment and CI/CD WorkFlow

To facilitate a modern, agile workflow, the platform will utilize a Continuous Integration/Continuous Deployment (CI/CD) pipeline. For each of the four modules, a managed container orchestration service (similar to Amazon ECS or Google Cloud Run) will be configured.

This service will be linked directly to its corresponding Docker image repository. This configuration enables automated deployments:

1. A developer pushes a new, tested version of a module (e.g., `go-know:v1.2`) to its image repository.
2. The cloud service automatically detects the new image.
3. It then provisions a new task or service revision, seamlessly updating the running application with zero downtime.

This automated process removes manual deployment steps, reduces human error, and allows for rapid iteration.

7.5.3 Management and coordination

While the deployment process is automated, responsibility is clearly defined:

- **Task Leader Responsibility:** Each designated Task Leader (e.g., SINTEF for GO-KNOW) is responsible for the development, maintenance, and successful containerized deployment of their specific module.
- **Infrastructure Coordination:** The overall coordination of the infrastructure, including setting up the cloud environment, networking, shared resources, and CI/CD pipelines, will be managed by the Work Package 2 Leader, SUPSI. SUPSI will ensure all modules integrate correctly and adhere to the project's architectural standards.

7.5.4 Network security and access

The platform's network will be configured with two distinct security zones:

- **Internal Network:** Within the private cloud environment, the GO-X modules can communicate internally with each other without restrictions. This open internal communication is essential for the high-speed data exchange required by the hub-and-spoke model (e.g., for GO-INFO to query GO-DATA).
- **Public Access:** Of the four modules, only GO-DATA won't be accessible from the public internet. The GO-INFO, GO-KNOW, and GO-WISDOM modules may expose public-facing interfaces (e.g., the GO-INFO dashboards for citizens or the admin panels). GO-DATA, as the secure data hub, will only be accessible from within the private network, shielding all data sources and internal APIs from external threats.

7.5.5 Shared resources

To optimize and simplify management, several services will be provisioned as **shared resources** for all modules. These common resources will be managed centrally and will include:

- **NoSQL Database:** A managed MongoDB instance, used primarily by GO-DATA for storing unstructured metadata, aggregations, and results from other modules.
- **Relational Database:** A managed relational DB instance (e.g., PostgreSQL) for services that require structured, transactional data, such as the admin panel's user management.
- **Message Broker:** The central RabbitMQ service used for asynchronous communication.

7.6 Performance and processing time considerations

The GO-X architecture is designed to support a wide variety of use cases, each with different performance requirements. The definition of an "acceptable processing time" is not static; it depends entirely on the function being performed. For example, loading an analytical dashboard (via GO-INFO) may have an "acceptable" latency of several seconds, while a real-time traffic alert has an "acceptable" latency of near-zero.

To meet these varied needs, the platform's interface is intentionally split into two mechanisms:

- **High-Latency (Pull) Operations:** For on-demand requests, such as loading historical data for GO-KNOW or populating a dashboard for GO-INFO, the synchronous REST API is used. This "pull" model is ideal for user-initiated actions where a response time measured in hundreds of milliseconds or a few seconds is considered acceptable.
- **Low-Latency (Push) Operations:** For critical, time-sensitive events (e.g., real-time public transport updates), a "pull" model based on polling would be highly inefficient and slow. The architecture therefore uses an asynchronous Message Broker (RabbitMQ). This "push" model guarantees minimal latency (near-instant processing) by immediately notifying subscribed modules (like GO-INFO) the moment new data is available.

This dual-architecture ensures that acceptable performance is delivered for each specific use case. Furthermore, the containerized microservice strategy is the mechanism by which these performance levels will be *maintained* under load. If analytical processing in GO-KNOW, for example, becomes a bottleneck and exceeds acceptable time limits, the platform can be configured to scale *only* that module horizontally to meet the demand, without impacting the real-time performance of the other services.

8 Integration and interoperability

8.1 Integration with partner city systems

The GOLIA project's goal is fundamentally tied to its deep integration with the existing digital and data ecosystems of its partner cities. The GO-X platform is not designed to replace these systems, but rather to connect to them, acting as an intelligent layer that enhances their value. This integration is managed entirely by the GO-DATA module.

8.1.1 Primary integration via OpenData portals

The primary and preferred method for data acquisition is through the official OpenData portals maintained by the partner cities. These portals are the designated and preferred source of truth for public-available data. By interfacing as much as possible with publicly published datasets, the GOLIA platform inherently resolves many significant privacy and security concerns. This approach ensures that the project does not access, ingest, or process any sensitive, non-public, or personally identifiable information (PII). All data handled from these portals is, by definition, already cleared for public consumption, allowing the project to focus on analysis rather than on complex data anonymization or privacy-preserving procedures.

The GO-DATA connectors are being designed to handle the diverse nature of data found on these portals, which typically includes:

- **Static Data:** files that are updated infrequently, such as administrative boundaries (e.g., GeoJSON or Shapefiles), public transport network maps, and historical mobility statistics (often in CSV or Excel formats).
- **Dynamic Data:** data sources that are updated in near real-time, providing a live snapshot of the city's mobility. This is usually exposed via APIs and includes information like public transport vehicle positions, parking availability, or traffic congestion levels.

8.1.2 Data sourcing policy and third-party data

The project will operate on a "city-first" data policy. Development will prioritize the use of first-party data provided directly by the cities' portals or internal systems. This approach minimizes complexity, reduces dependency on external entities, and avoids the legal and financial overhead associated with third-party data.

However, in specific cases where crucial data is only available from a third-party commercial provider, the project will rely on the partner cities to facilitate access. The cities have committed to providing the necessary support for these scenarios: cities will be responsible for procuring and providing any required licenses for third-party data sources that are deemed essential for achieving the project's objectives. The GOLIA platform itself will not be responsible for licensing external data.

8.2 Integration of data from social media

In addition to quantitative data from city portals, the GOLIA platform will integrate qualitative data from social media to gain a deeper, human-centric understanding of public opinion. This capability is managed by a specialized connector within the GO-DATA module.



8.2.1 Purpose: sentiment and policy reception

The primary purpose of this integration is to conduct sentiment analysis. The system will be configured to scrape public social media platforms for a defined period, specifically tracking public discourse related to mobility. This process will not be a continuous, broad surveillance; rather, it will be a targeted tool used to:

1. Search for specific, pre-defined keywords relevant to the project's use cases (e.g., "Florence new tramline," "Antwerp smart parking").
2. Analyze the public's reception and perception of mobility policy changes or new services introduced in the partner cities.
3. Gather qualitative insights that are impossible to obtain from structured mobility data, such as citizen concerns, user-reported issues, and general public opinion.

8.2.2 Anonymity and data storage policy

The platform's design adheres to a strict "privacy-by-design" principle, especially concerning social media. The GO-DATA module will not store any raw scraped data.

Absolutely no data that can identify individuals - such as usernames, personal profiles, or full, unedited comments - will be persisted by GO-DATA.

Instead, the social media connector will perform its analysis in-memory or in a temporary cache. Once the sentiment analysis is complete, the module will:

- **Store only the results of the analysis** (e.g., "70% positive sentiment" for a specific keyword).
- **Store aggregated information** (e.g., a count of keywords, a trend-line of sentiment over time).

This ensures that the platform benefits from the collective insights of public discourse without compromising the privacy of any individual, in full alignment with the project's ethical and privacy-respecting commitments.

8.2.3 Governance and compliance

This entire process is strictly governed by the project's formal management and ethics frameworks. All data collection and processing activities are defined within the Data Management and Ethics Plan (D7.3), which is managed under WP7 (Project Management). This document outlines the complete lifecycle for all data collected, processed, and generated by the project.

Furthermore, all activities are subject to the project's ethics supervision (also part of WP7) and the Quality assurance and Risks Management plan (D7.2) to ensure full compliance with all legal and ethical requirements, most notably the GDPR (General Data Protection Regulation).

8.2.4 Data reliability and Quality Assessment

A core requirement for the GOLIA platform, especially given its intended use in public consultation, is transparency regarding the quality and timeliness of its data. The GO-X architecture addresses this by treating data reliability as a key metric to be managed and exposed.

This is not a manual process but a design feature of the GO-DATA module. The module's connectors are being engineered to do more than just fetch data; they are designed to introspect and assess the data at the point of ingestion.

This assessment is achieved by automatically capturing critical metadata from the source, such as:

- **last_updated** timestamps provided by the API.
- ETag headers to determine if a data file has changed.
- HTTP cache-control headers.

This qualitative metadata is not discarded. It is treated as an integral part of the dataset and is persisted in the NoSQL database alongside the data itself.

This information is then explicitly exposed via the GO-DATA API to all consumer modules. This allows the GO-INFO module, for example, to transparently communicate the data's limitations to the end-user. Instead of presenting stale data as "live," GO-INFO can use this metadata to display a clear message on the dashboard, such as "Data shown was last updated at the source on [Date/Time]," ensuring that both policymakers and citizens are fully aware of the context and reliability of the information they are viewing.

9 Conclusions

9.1 Summary of the proposed architecture

The architecture detailed in this document provides the technical blueprint for the GOLIA project's GO-X platform. The design is a carefully considered **hybrid model**, blending the flexibility of a **containerized microservice architecture** with the clear, robust governance of a **hub-and-spoke** interaction pattern.

This architecture is built on three core pillars:

1. **Separation of Concerns:** the platform is functionally decomposed into four distinct modules: GO-DATA (the *how* of data), GO-INFO (the *what* of visualization), GO-KNOW (the *why* of analysis), and GO-WISDOM (the *now what?* of decision support).
2. **Centralized Data Orchestration:** GO-DATA acts as the mandatory central hub and single source of truth. It is the only component that interfaces with external data sources, abstracting all complexity away from the other modules. This makes the "spoke" modules (INFO, KNOW, WISDOM) completely source-agnostic.
3. **Circular Data Flow:** the modules engage in a bi-directional data economy. Spokes consume uniform data from GO-DATA and, crucially, contribute their own generated insights (analyses, models, sentiment scores) back to GO-DATA for persistence, allowing those insights to be shared and consumed by the other modules.

This entire ecosystem is designed to be cloud-native, deployed as a series of containerized services in a single cloud infrastructure. This ensures scalability, resilience, and an automated CI/CD workflow, with infrastructure coordination managed by the WP2 leader, SUPSI.

By design, this architecture is secure, prioritizing the use of public OpenData and anonymized social media metrics while isolating the entire data-hub (GO-DATA) from public access. It is also lightweight, adhering to a "minimal persistence" policy by acting as an orchestrator, not a data lake.

In summary, this robust, scalable, and flexible architecture directly enables the GOLIA project's goals. It provides a clear technical pathway to transform diverse, complex city data into the unified, actionable intelligence required to co-create and govern a more equitable and optimal mobility future.

9.2 Development roadmap

The development of the GO-X platform is encapsulated within **Work Package 2 (WP2)**, which begins at **Month 1 (M1)** and concludes at **Month 18 (M18)**. The roadmap is structured as a series of sequential and parallel tasks, with key milestones ensuring the platform is developed in alignment with the project's evolving requirements, particularly from WP1.

The development is broken into five core tasks, with a clear dependency on the foundational GO-DATA module.

- **T2.1: Design of GOLIA modules architecture and interoperability (M1 – M6)** This initial task, which ran from M1 to M6, focused on defining the complete technical architecture, data flow models, and interoperability protocols for the entire GO-X platform. This deliverable document is the primary result of this task.
- **T2.2: GO-DATA, qualitative and quantitative knowledge base and data space (M2 – M12)** Starting early in the project at M2, this task is responsible for building the central data hub. Development of **GO-DATA** is **strategically front-loaded** in the roadmap, as it must be in an advanced development state *before* the other modules, which depend on it for all data. This task will produce the first functional module.

- *Deliverable: D2.2: GO-DATA module and data connectors (M12)*
- **T2.3: GO-INFO, assets and data consultation and visualization services (M7 – M18)** Once the foundational architecture (T2.1) is complete, work begins on the user-facing visualization module. This task will run in parallel with GO-KNOW.
 - *Deliverable: D2.3: GO-INFO module and citizen consultation platform (M18)*
- **T2.4: GO-KNOW, target driven synergic solution exploration (M7 – M18)** Also beginning at M7, this task focuses on the analytical engine of the platform, developing the models to understand and transfer mobility solutions.
 - *Deliverable: D2.4: GO-KNOW module for social optimum index exploration (M18)*
- **T2.5: GO-WISDOM, decision support for collaborative mobility planning (M14 – M18)** This is the final module to be developed, starting at M14. It logically builds upon the data hub (GO-DATA) and the analytical models (GO-KNOW) to provide its final decision-support recommendations.
 - *Deliverable: D2.5: GO-WISDOM module for collaborative mobility planning (M18)*

The 18-month development roadmap is punctuated by three critical milestones that serve as quality gates and integration points for the project:

- **MS1: City Objectives and Actors Identification (M3)** Delivered at M3, this milestone was a joint effort between WP1 and WP2 leaders. It finalized the initial architectural requirements by formally defining the city-specific objectives and identifying the key actors, ensuring the GO-X design was aligned with real-world needs from the start.
- **MS2: Modularization and Initial Architecture Alignment (M12)** Due at M12 (coinciding with the delivery of GO-DATA), this milestone is a major integration point. The focus is on the modularization of the partner cities' strategic digital assets, enabling the virtuous Data-Information-Knowledge-Wisdom (DIKW) decision-making process. This milestone will demonstrate the overall architecture and focus on the alignment of one module per city to enable the first data-led and social optimum-driven consultation activities in WP3.
- **MS3: GO-X Platform Ready for Testing (M18)** At the conclusion of WP2, this final milestone marks the completion of the fully integrated GO-X platform (D2.3, D2.4, D2.5). The platform will be formally handed over and ready to be used by WP3 for the comprehensive city test plans.

	MS1											MS2					MS3	
Tasks	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M16	M16	M17	M18
T2.1												D2.1						
T2.2												D2.2						
T2.3																		D2.3
T2.4																		D2.4
T2.5																		D2.5

Table 2 - WP2 GANTT with milestones

10 Annex A – Objectives and actors

10.1 Executive summary

The GOLIA project is fundamentally designed to improve the quality, sustainability, and resilience of urban mobility systems in the partner cities. A challenge inherent in this ambition is the vast and complex ecosystem of actors whose interests, needs, and actions intersect within the urban environment. Successfully navigating this complexity requires engaging with an exceptionally high number of diverse stakeholders. These actors span across all sectors of society and are essential to creating mobility solutions that are not only effective but also equitable and widely accepted.

This diverse group of stakeholders can be broadly categorized into three main pillars. Firstly, the **public administration**, which includes various municipal departments (from Mobility and Urban Planning to Environment and Social Services) and other governmental or regulatory bodies that define policies and manage public infrastructure.

Secondly, the world of **industry and private enterprise**, a wide-ranging group that encompasses everything from large logistics corporations and public transport operators to local businesses, shared mobility startups, and technology providers.

Finally, and most importantly, is the **civil society** in all its facets. This pillar includes the entire population that lives, moves, and interacts with the city: **citizens**, both **residents and non-residents** (like "city users"), the community of **workers and commuters** who depend on the urban network daily, and **tourists**, whose travel patterns create unique demands on the system. Each of these subgroups has distinct needs, perspectives, and priorities that must be understood and integrated into the planning process.

Given this intricate web of relationships and interests, a simple or informal approach to stakeholder engagement would be insufficient. For this reason, a cornerstone of the GOLIA project is its inclusive and collaborative approach, which relies on a precise and systematic methodology to identify and map all relevant stakeholders. To streamline the process, Golia identifies a mobility vision for each of the three cities. Each vision is broken down into high-level objectives, which to the operational level are translated into targeted specific objectives, each advancing the high-level objectives (which in turn advance the vision). This process helps defining actions and the actors responsible for (or impacted by) these specific objectives. Thanks to the active collaboration of the cities of Antwerp, Florence, and Pilsen, these high-level objectives are further refined and translated into concrete, context-specific goals that reflect the realities and priorities of each urban environment.

This detailed mapping is fundamental for several reasons: it ensures that the solutions developed with the GO-X modules are practical and grounded in reality, facilitates co-design and participatory processes, and anticipates potential barriers or conflicts, allowing for the development of effective mitigation strategies.

10.1.1 From High-Level Goals to Actionable Specific Objectives

The high-level objectives, while essential for defining the strategic vision for each city, are too broad to be directly actionable. To bridge the gap between strategy and implementation, each high-level objective was deconstructed into a series of more granular **Specific Objectives**.

These specific objectives are more targeted and actionable ambitions to achieve the broader strategic goal. For example, the high-level objective for Florence, "Promote Innovative Logistics Policies and Strategies for the UNESCO Area Of the City Centre," was broken down into specific objectives such as:

- *Specific Objective 1.1:* "Optimise the use of public space, including road space re-allocation, greening and dynamic solutions for sustainable urban logistics"
- *Specific Objective 1.2:* "Reduce the distance between origin and destination (improve proximity planning), promote the adoption of micro-hubs."
- *Specific Objective 1.3:* "Promote sustainable urban logistics modes and models, considering the constraints of a UNESCO protected city centre."

This decomposition provides the necessary level of detail to understand exactly which mobility solutions and practices can be implemented, by whom, and for whom.

10.1.2 The Process of Stakeholder Extraction

Once the specific objectives were clearly formulated, a systematic mapping exercise was conducted to extract the relevant stakeholders for each one. This process ensures a comprehensive and unbiased identification of all actors involved.

10.1.2.1 Stakeholder Analysis per Specific Objective

For every single specific objective, the project team conducted an analysis by asking a structured set of questions:

- **Who is responsible for implementing this action?** (e.g., municipal departments, transport authorities).
- **Who will be directly or indirectly affected by this action?** (e.g., citizens, commuters, tourists, local businesses).
- **Who holds the necessary resources (data, funding, expertise) for this action?** (e.g., technology providers, research institutions, private sector partners).
- **Who has the power to influence or block this action?** (e.g., political bodies, regulatory agencies, influential community groups).

10.1.2.2 Categorization of Stakeholders

The identified actors were then categorized to better understand their roles, interests, and potential influence on the project. The primary categories include:

- **Public Sector Actors:** Municipal departments (e.g., Urban Planning, Mobility, Environment), public transport operators, and other government agencies.
- **Private Sector Actors:** Logistics companies, technology providers, shared mobility operators, local retailers, and business associations.
- **Civil Society and Academia:** Citizen associations, NGOs (e.g., environmental or cycling advocacy groups), universities, and research centers.
- **End-Users:** The general public, categorized into relevant segments such as residents, commuters, students, tourists, and vulnerable user groups (e.g., the elderly, persons with disabilities).

10.1.3 Practical Example: Mapping Stakeholders for a Specific Objective

Let's consider the specific objective for Florence: *"Install 500 new secure bicycle parking stations near key public transport hubs and public offices."*

Applying the methodology, the following stakeholders would be identified:

- **Implementers:**
 - *City of Florence, Department of Mobility:* Responsible for planning, authorizing, and overseeing the installation.
 - *Public Works Department:* Responsible for the physical installation.

- **Beneficiaries (End-Users):**
 - *Cyclists (Commuters and Residents):* Direct users of the new infrastructure.
 - *Public Transport Users:* Who may adopt a bike-plus-transit commuting model.
- **Affected Parties:**
 - *Pedestrians:* As the installation might affect sidewalk space.
 - *Local Businesses:* Whose storefronts or access might be impacted by the placement of the stations.
- **Resource Holders / Partners:**
 - *Public Transport Operator (e.g., Autolinee Toscane):* To coordinate placement at transport hubs.
 - *Hardware/Technology Suppliers:* The company providing the parking stations.
- **Influencers:**
 - *District Councils (Consigli di Quartiere):* Whose approval or consultation may be required for local placement.
 - *Cycling Advocacy Groups (e.g., FIAB):* Who can provide input on ideal locations and features.

10.1.4 Validation and Engagement Strategy

The resulting stakeholder map is not a static document. It was first validated through workshops and interviews with key representatives from each partner city to confirm its accuracy and completeness. This validated map now serves as the foundation for the project's engagement strategy, ensuring that the right actors are involved at the right time in the co-design and implementation phases of the GOLIA project.

10.2 Purpose of this document

The purpose of this document is to bridge the gap between the high-level strategic goals of the GOLIA project and the concrete requirements needed for technical development. It systematically breaks down each partner city's broad ambitions into granular, actionable "Specific Objectives". For each of these specific objectives, the document provides a detailed mapping of all relevant actors and stakeholders, categorizing them into public, private, and civil society groups. This formalization of objectives and actors serves as the foundational input for the technical teams in WP2, providing them with the necessary use cases to design and build a GO-X architecture that is practical, grounded in reality, and tailored to the specific needs of each city.

10.2.1 Intended audience

The primary audience for this document is internal to the GOLIA project, with a specific focus on the technical partners of WP2. As the document formalizes the architectural requirements and use cases derived from WP1, it serves as a direct and essential guide for the development of the GO-X platform modules. It is also relevant for all consortium members who need to understand the concrete objectives and stakeholder landscape that will shape the project's technological tools and pilot activities.

10.3 Introduction

The GOLIA project was born from the ambitious vision of transforming urban mobility governance, making it more inclusive, resilient, and data-driven. In an increasingly complex urban context, characterized by a large number of stakeholders—from public administration and industry to civil society in all its forms (residents, commuters, tourists)—making effective decisions requires innovative tools and a collaborative approach.

The technological core of the project is the GO-X suite of digital modules, designed to support local administrations throughout the entire lifecycle of mobility policies: from data collection (GO-DATA) and analysis (GO-KNOW) to visualization (GO-INFO) and advanced decision support (GO-WISDOM).

This document represents a cornerstone of the project, as it outlines the strategic framework that will guide all subsequent activities. Here, the High-Level Objectives are defined, established in close collaboration with the partner cities of Florence, Pilsen, and Antwerp. These objectives are not mere statements of intent, but rather the strategic "guiding stars," specific to the context of each city, that will direct the application of the GO-X modules and the measurement of their impact.

10.3.1 From GA use cases to cities specific objectives

The three partner cities participating to the Golia project aim at achieving a more user-centric, inclusive and resilient transport planning approach, aligning with Golia's final objective. Starting from the challenges these three cities face in their mobility planning, Golia aims at building a comprehensive mobility and stakeholders' analysis that could other cities achieving the same improved and user-centric approach to mobility planning approach.

To kickstart this activity, Bax collected all the challenges and concerns the three cities brought to the attention of the consortium. Starting from this input, together with the WP1 and WP2 partners, Bax produced the **framework for the minimum requirements**. This framework translated cities challenges into specific objectives that would help the cities achieving a more user-centric and inclusive mobility planning. More specifically, the framework identifies (1) one vision per each city (2) three high-level objectives that addressed the vision and (3) multiple actionable specific objectives that advance the achievement of their respective specific objectives (and in turn, the vision of the city).

The framework the minimum requirements will provide the content ground on which a large part of WP1 and WP2 work will be based.

The three-dimensional ecosystem analysis (T1.1) will select mobility solutions and practices based on the specific objectives defined in the framework. The choice will be based on their potential to address one or more of these specific objectives. The user personas developed by Panteia will be guided by those same specific objectives. Moreover, as the personas will feed into the definition of the SOMI, the indicator will also be dependent on the minimum requirements. WP2 will also base the analysis of the stakeholders starting from the same framework, as better explained in the following chapters.



10.3.2 From cities' specific objectives to GO-X functional requirements

The process of converting a city's strategic vision into concrete software functionalities for the GO-X modules is a structured process. By applying an agile framework, it is possible to ensure that every technical development is directly aligned with real-world needs. This transformation moves from the highest strategic level down to the most granular technical detail.

- **Objectives as Epics:** Objectives are defined as broad, strategic goals defined by each city. In agile development, a goal is called an Epic. An Epic represents a large body of work or a significant strategic objective that is too complex to be completed in a single development cycle. It serves as a container for all the related features and functionalities that contribute to achieving its vision.
- **Specific objectives as Features:** A feature represents a distinct service or outcome that delivers value and contributes to the completion of the Epic. The specific objectives defined for each high-level objective can be considered features, within which different actors interact to reach a common goal.
- **Features breakdown in User Stories:** To generate related User Stories, the Feature is deconstructed by considering all the different actors who will interact with it and their unique goals. Each distinct interaction or need becomes its own user story, considering the point of view of each involved actor.
- **User Stories are the basis of Functional Requirements:** User stories are used in discussions to fully understand the actor's needs, and from that, it is possible to derive one or more specific Functional Requirements that will deliver the value described in the story.

10.4 Actors identification in Cities' objectives

10.4.1 Florence

10.4.1.1 OF1 – Promote innovative logistics policies and strategies for the UNESCO area of the city centre.

- **Government**
 - **Municipal:** this includes urban planning, transportation and heritage departments. Responsible for creating policies, re-allocating road spaces, leading proximity planning and engaging with the public, identify locations for innovative urban logistics solutions (e.g. micro hubs, white-label parcel lockers, consolidation centres), facilitate the implementation of innovative urban logistics solutions (providing permits, etc.). Involved in SOF1.1, SOF 1.2, SOF1.3 and SOF 1.4.
 - **Supranational body (UNESCO) :** set specific constraint for the protected city centre. Involved in SOF1.3
- **Commercial and private sector**
 - **Logistic companies :** businesses that will implement the new sustainable logistics models. Involved in SOF1.2 and SOF 1.3
 - **Local businesses :** primary receivers of goods in city centre. Involved in adopting more sustainable practices. Involved in SOF1.4
 - **Technology providers:** responsible to provide technological instruments for the dynamic optimization solutions. Involved in SOF 1.1
 - **RE owners and Developers :** provide or create new infrastructure needed for logistics infrastructure. Involved in SOF1.2
- **Civil Society**
 - **Citizens :** People directly affected by new policies. Actively involved in SOF1.4
 - **Tourists :** Their experience is impacted by logistics operations. May be actively involved in SOF1.4

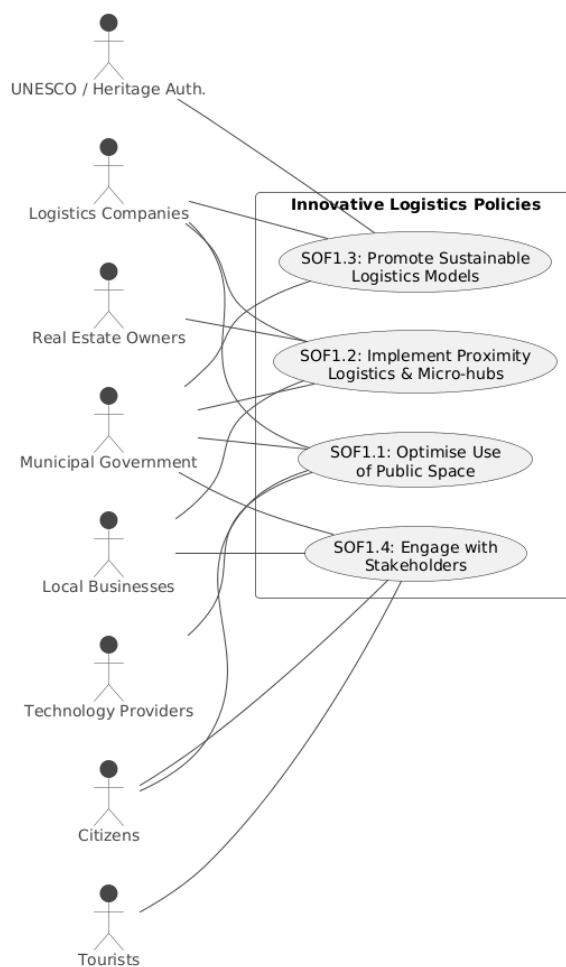


Figure 3 - Florence objective 1 UML

10.4.1.2 OF2 – Improve road safety, aiming at reducing the number of road injuries in line with EU Vision Zero

- **Government**
 - **Municipal:** this includes transportation, public works, urban planning. Responsible for the legal and physical implementation of the objectives. Involved in SOF2.1, SOF2.2, SOF2.3 and SOF2.4
 - **Police/Law enforcement :** Enforcement of traffic laws. Involved in SOF2.1 (speed limit) and SOF2.4 (safety education campaigns)
- **Commercial and private sector**
 - **Civil Engineers and urban planners :** Involved in designing traffic calming measures in SOF2.2
 - **Construction companies:** build new road designs and install protective interventions. Involved in SOF2.2 and SOF2.3
- **Civil Society**
 - **Drivers :** Target of speed limits and self-explaining roads. Involved in SOF2.1, SOF2.2 and SOF2.4 (as citizens)
 - **Vulnerable road users :** Includes children, elderly, people with reduced mobility, people with sensory impairments. Involved in SOF2.3 and SOF2.4
 - **Community groups:** Involved in co-designing solutions for the needs for special groups. Involved in SOF2.3 and SOF2.4
 - **Educational Institutions:** Involved in promoting road safety education, SOF2.4

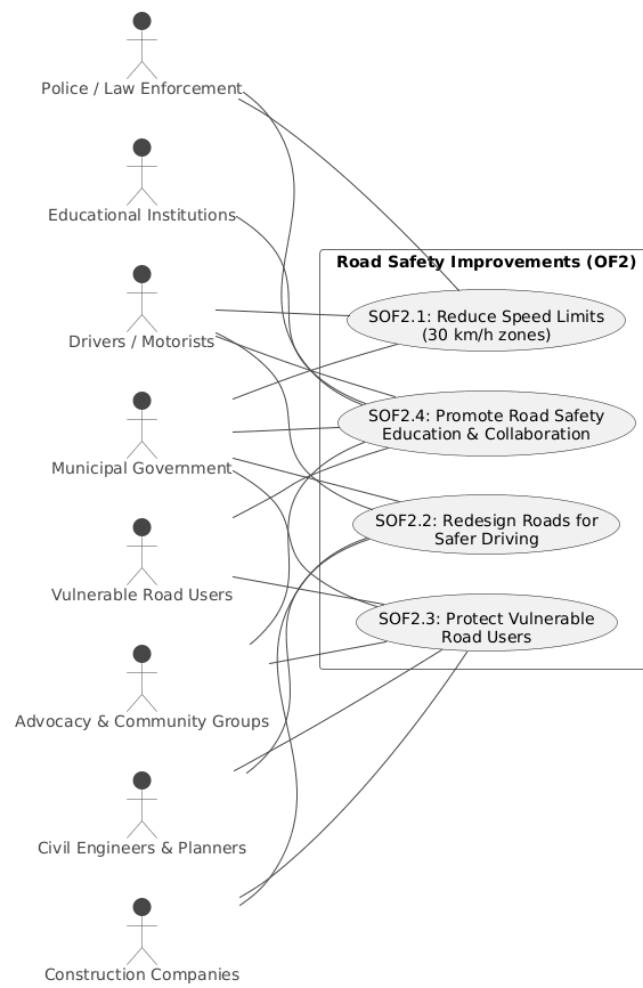


Figure 4 - Florence objective 2 UML

10.4.1.3 OF3 – Promote an interdisciplinary approach and collaboration across different sectors and stakeholders to achieve a sustainable, safe, digital and equitable mobility ecosystem

- **Government**
 - **Municipal** : decision-making for strategies concerning public spaces, urban planning and local transport. Involved in SOF3.1, SOF3.4 and SOF3.5.
 - **Regional and metropolitan authorities** : Coordination beyond city's borders, necessary for aligning transport and land use strategies at a larger scale. Involved in SOF3.5.
 - **Urban and land use planning departments**: Development of the master plan and zone regulation in the city. Involved in SOF3.1 (Public spaces quality) and SOF3.4 (Transport strategies).
 - **Transport and mobility departments**: Managers of the city's transport network. Involved in SOF3.3.
 - **Environmental agencies**: expertise and set regulation on greening, sustainability and environmental impact, involved in SOF3.1.
 - **Communications and Public Engagement Departments** : Creating campaigns for awareness and public engagement. Involved in SOF3.2.
- **Commercial and private sector**
 - **Urban Planners, Architects and Landscape Designers** : Professionals (hired by public institutions) to help develop public spaces. Involved in SOF3.1.
 - **RE Developers and Construction Companies** : physically build city elements. Involved in SOF3.4.
 - **Mobility service providers** : bike/scooter/car sharing companies. Involved in SOF3.3.
 - **Technology Companies (MaaS Providers)**: multi-modal transport system to plan routes. Involved in SOF3.3.
 - **Local businesses and retailers** : Impacted by mobility decisions. Involved in SOF3.1.
- **Civil society**
 - **Citizens** : Includes both residents and city users (commuters, tourists). Feedback and participating in awareness campaigns. Involved in SOF3.2.
 - **Community groups** : Can represent specific area groups of citizens (city center, suburbs etc...). Involved in SOF3.2.
 - **Advocacy groups** : Organizations that represent user groups with special needs. Involved in SOF3.3.
 - **Non-Governmental Organizations** : Environmental sustainability, social equity, public health. Involved for sure in SOF3.1, SOF3.2, SOF3.3, can be helpful in SOF3.4 and SOF3.5.

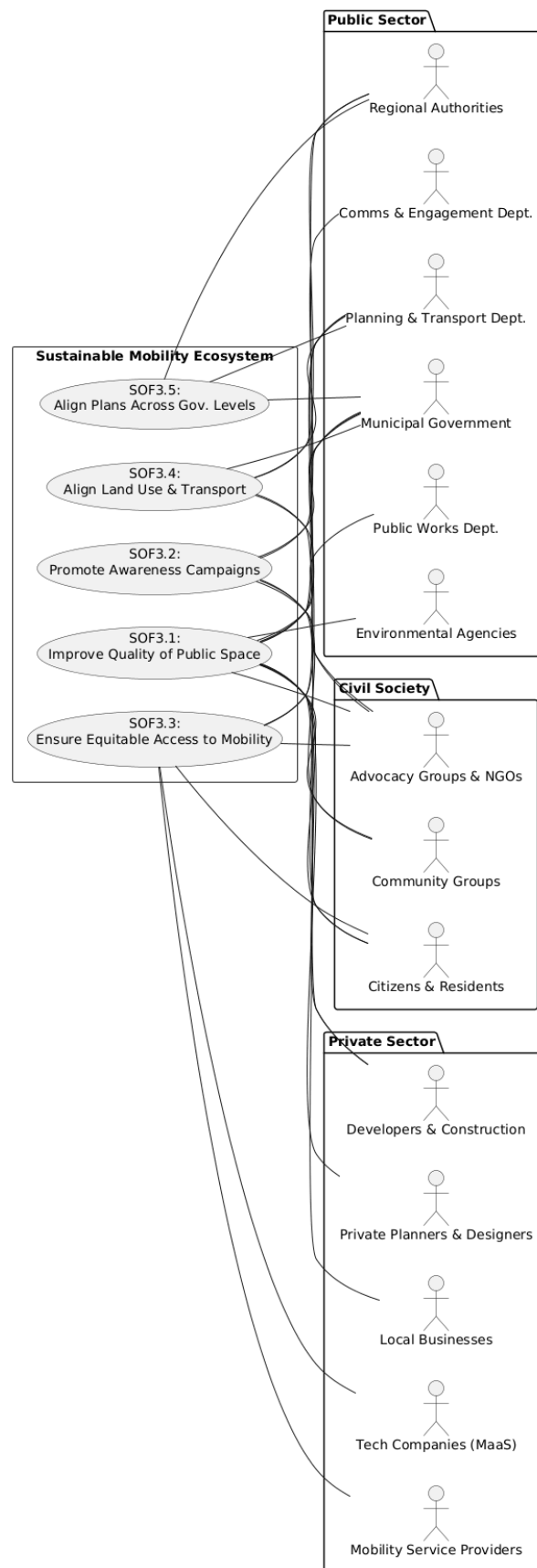


Figure 5 - Florence objective 3 UML

10.4.2 Antwerp

10.4.2.1 OA1 – Decrease car dependency in the whole transport region

- **Government**
 - **Municipal:** Strategic planning, funding and implementation. Involved in all SOA (from 1.1 to 1.7)
 - **Regulatory bodies:** Create legal and policy frameworks. Involved in SOA1.2, SOA1.5 and SOA1.6.
 - **Public works departments:** Physical construction and maintenance of infrastructure. Involved in SOA1.1, SOA1.3, SOA1.4 and SOA1.5.
- **Commercial and private sector**
 - **Mobility Service Providers :** Provide alternative to cars (bike/e-scooter sharing). Involved in SOA1.6 and SOA1.7.
 - **Logistics and Delivery Companies:** Adapt their way to operate in city centers. Involved in SOA1.2
 - **Public Transport Operators:** day-by-day management of public transport services and implementation of measures to enhance operational reliability. Involved in SOA1.5.
 - **Employers and Businesses :** use sustainable logistic, promote employee alternative mobility (public, sharing), contribute to a broader engagement. Involved in all SOA (from 1.1 to 1.7)
 - **RE Developers :** Design and build developments more pedestrian-friendly, cycling infrastructure and help integrate public transport networks. Involved in SOA1.1, SOA1.3, SOA1.4 and SOA1.5
- **Civil society**
 - **Citizens :** Target of citizen engagement and final consumers of the more liveable areas. Involved in all SOA (from 1.1 to 1.7)
 - **Advocacy and Community Groups :** Public interest representation. Involved in SAO1.1, SOA1.3, SOA1.4, SOA1.5, SOA1.7.
 - **Non-Governmental Organizations (NGOs):** Focus on broader environmental or social goals, running public awareness campaigns. Involved in SOA 1.6 and SOA 1.7.
 - **Educational Institutions:** Influence on students' mobility. Involved in SOA1.3, SOA1.4, SOA1.5 and SOA1.7.

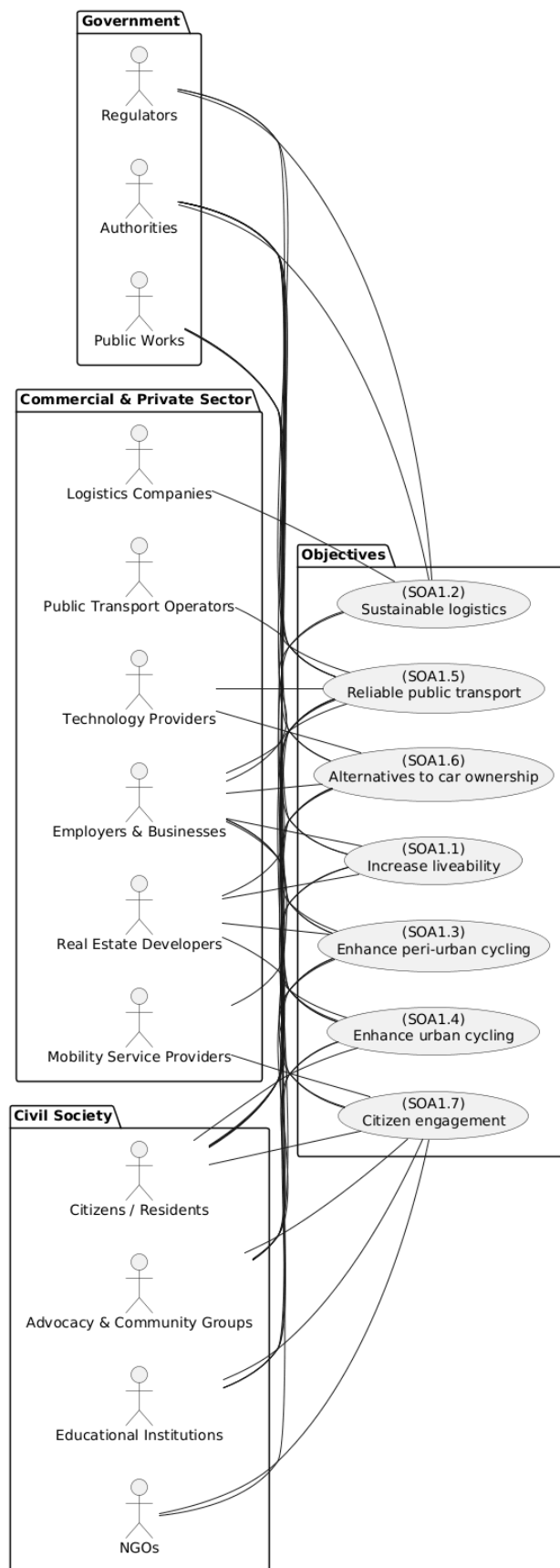


Figure 6 - Antwerp objective 1 UML

10.4.2.2 OA2 – Improve the adoption, functionalities and coverage of smart ways through Antwerp

- **Government**
 - **Metropolitan area administration:** Plan for a coherent citizen experience, data sharing to improve services. Involved in SOA2.1 and SOA2.2.
 - **City/Project planners:** Communicate new mobility solutions and promote sustainable behaviours. Involved in SOA2.3 and SOA 2.4.
- **Commercial and private sector**
 - **MaaS (Mobility as a Service) App Provider:** Benefits from data sharing to improve services and extend the app's reach. Involved in SOA2.2.
 - **Mobility Service Providers (Including Public Transport):** All their mobility options will be made available through the mobility marketplace. Involved in SOA2.4.
- **Civil society**
 - **Citizens:** Commuters, MaaS app final users, target audience for communication campaigns. Involved in all SOA (from 2.1 to 2.4)

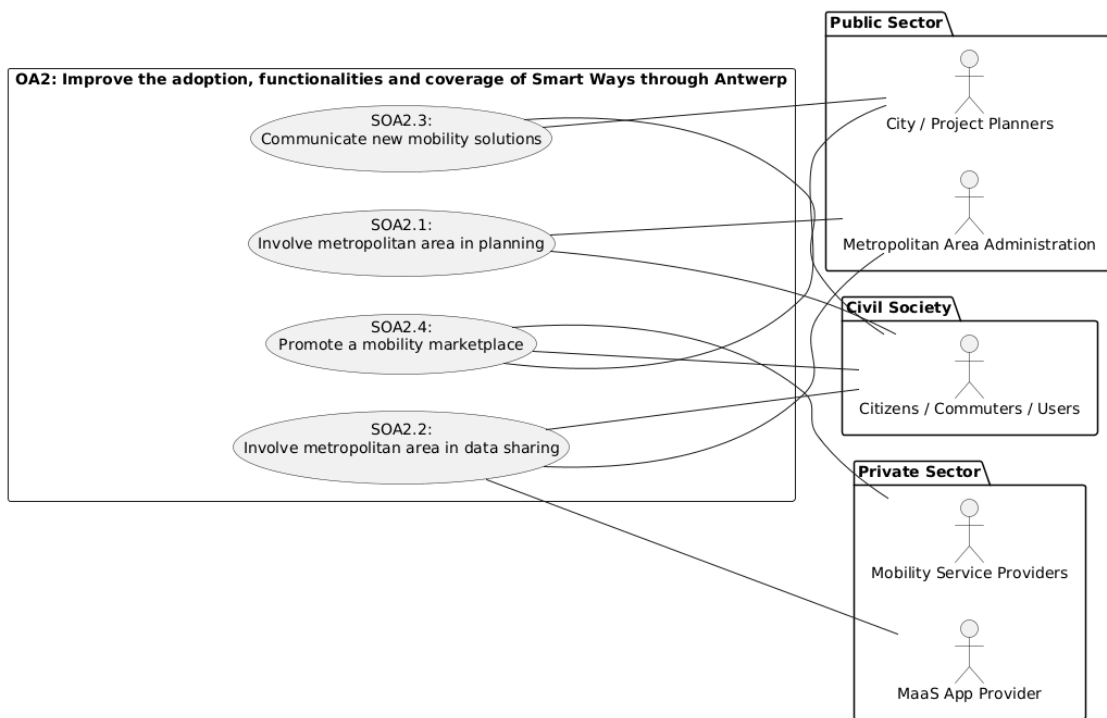


Figure 7 - Antwerp objective 2 UML

10.4.2.3 OA3 – Reach an inclusive policy making approach

- **Government**
 - **City/Project planners:** Responsible for planning mobility solutions, engaging residents, promoting their involvement. Involved in all SOA (from 3.1 to 3.4)
- **Commercial and private sector**
 - **Local businesses:** Evaluate new sustainable logistics policies and practices. Involved in SOA3.4.
 - **Logistics Service Providers:** Evaluate and implement new sustainable logistics planning. Involved in SOA3.4.
- **Civil society**
 - **Citizens:** Including different backgrounds such as residents of low-income neighbourhoods, minorities, elderly, hard-to-reach-groups, children, people with reduced mobility. Involved in SOA3.2 and SOA 3.3

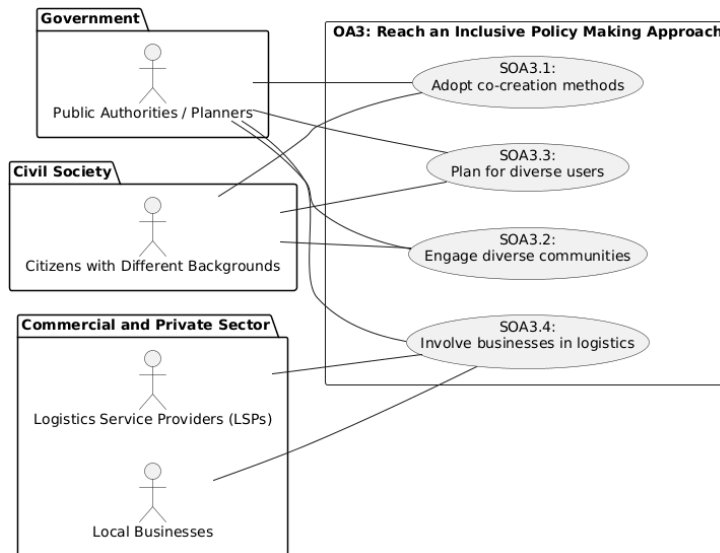


Figure 8 - Antwerp objective 3 UML

10.4.3 Plzen

10.4.3.1 OP1 – Extend Smart City initiatives and reach

- **Government**
 - **Municipal:** Build a mobility management approach. Involved in SOP1.2.
 - **Neighbouring Communities:** partnering in the mobility management approach. Involved in SOP1.2.
 - **ITI Plzen agglomeration:** Partner in elaborating a smart city and data federation strategies, consumer of the open data outputs from the digital twin. Involved in SOP1.5 and SOP1.6.
- **Commercial and private sector**
 - **Data contributors:** This actor includes commercial activities, logistic partners, city businesses in general that own and manage digital assets and mobility data, as data contributors. Involved in SOP1.3.
 - **Mobility solutions providers:** Provide sustainable mobility solutions (bike/e-scooter/car sharing), including public transport. Involved in SOP 1.1, SOP1.4, SOP1.5.
- **Civil society**
 - **Citizen:** Receiver of the value of improved data sharing and mobility management, target of promotion. Involved in SOP1.1 and SOP1.3.

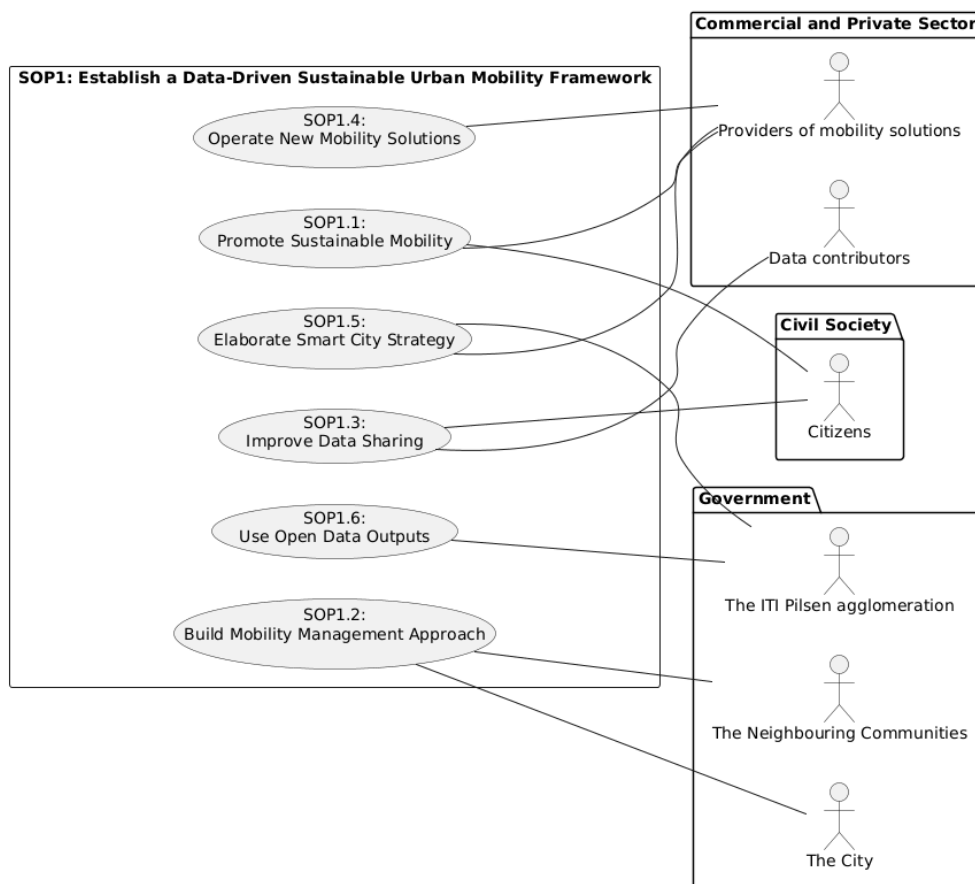


Figure 9 - Plzen objective 1 UML

10.4.3.2 OP2 – Improve liveability of the city given: peculiar city topology, changes in source of employment of citizens and diversity considerations

- **Government**
 - **Municipal:** Responsible of planning, creating frameworks, promoting initiatives, enhancing infrastructure. Involved in all SOP (from 2.1 to 2.5)
- **Commercial and private sector**
 - **Big Employers/Companies:** Collaborate in mobility planning, participate in the communication framework. Involved in SOP2.1 and SOP2.3.
 - **Transport operators:** Operational side of the transport network. Involved in SOP2.5.
- **Civil society**
 - **Citizen:** Provide feedback, primary beneficiary of city's initiatives. Involved in SOP2.3, SOP2.4, SOP2.5.
 - **Employees:** specific target for their daily commuting pattern. Involved in SOP2.1 and SOP2.3.
 - **Community groups:** focus on social integration efforts, representing diverse cultural and local interests. Involved in SOP2.2.

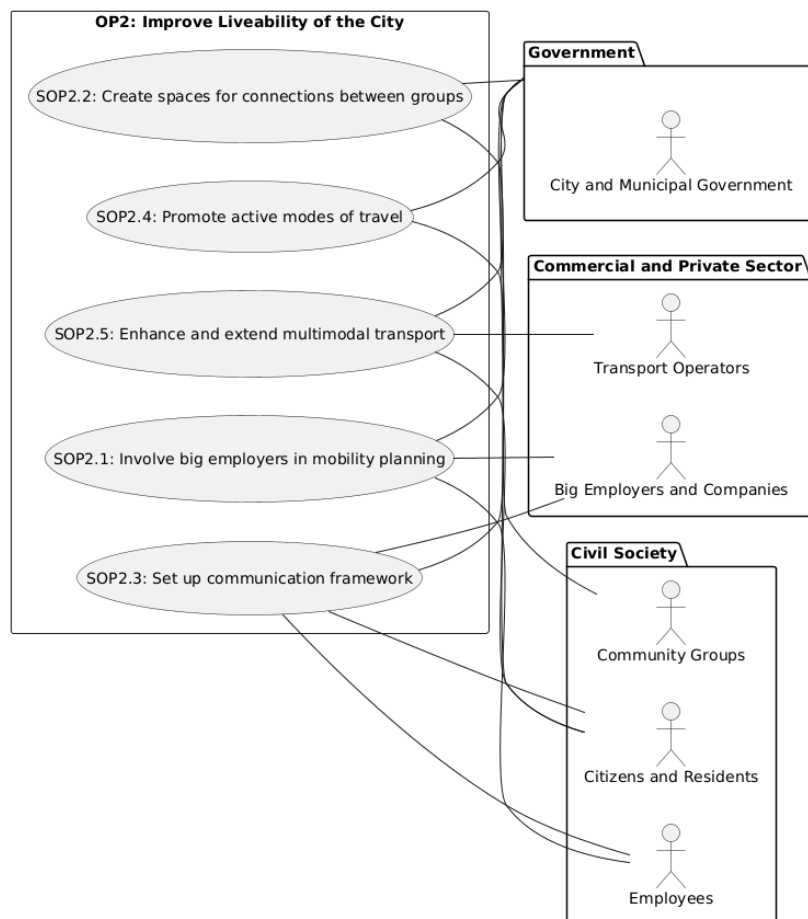


Figure 10 - Plzen objective 2 UML

10.4.3.3 OP3 – Make Plzen a CCAM-Ready city

- **Government**
 - **Municipal:** responsible for the overall strategy and policy-making. Involved in SOP3.3 and SOP3.5.
 - **Public Transport Authority:** Integrate new on-demand services. Involved in SOP3.1 and SOP3.2.
 - **Road and Transport Infrastructure Authority:** maintain and upgrade physical infrastructure. Involved in SOP3.3.
 - **Digital and IT Department:** municipal digital backbone. Involved in SOP3.4.
- **Commercial and private sector**
 - **CCAM Technology Developers and Vehicle Manufacturers (OEMs):** Responsible for vehicles, technologies and sensors. Involved in SOP3.2, SOP3.3 and SOP3.4.
 - **Telecommunication Companies (MNO):** provide data connection (4G-5G) for V2X communication and connected vehicles. Involved in SOP3.4.
 - **On-Demand mobility service providers:** bike/e-scooter sharing services. Involved in SOP3.1.
 - **Logistics and Freight Companies:** Automated delivery vehicles and platooning trucks. Involved in SOP3.2.
 - **Infrastructure and Engineering firms:** Help govt. to upgrade road infrastructure to make it V2X-capable. Involved in SOP3.3.
- **Civil society**
 - **Citizen:** target of promotional campaigns, source of feedback and end-users of the new transport system. Involved in SOP3.1 and SOP3.2.
 - **Universities and Research Institutions:** Research, data analysis, technical expertise. Involved in SOP3.2 and SOP3.5.
 - **Community and advocacy groups:** this includes lobbying for various users' groups, such as pedestrians, cyclists, elderly, people with reduced mobility. Involved in SOP3.2.

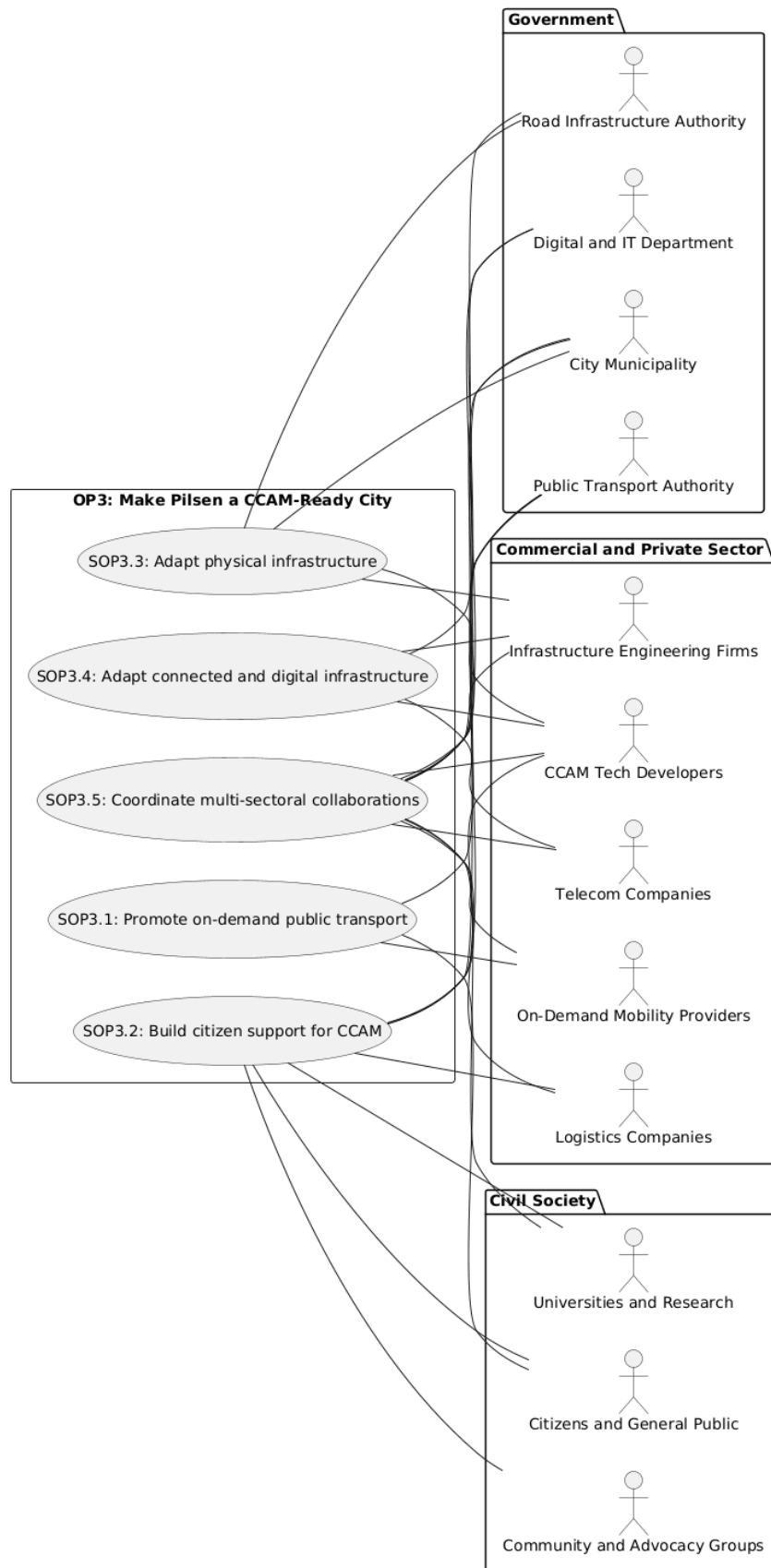


Figure 11 - Plzen objective 3 UML