Acumen

D5.5 Digital Twin general platform (interim)

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V0.3	**03/07/2025**	**Emblem and disclaimer update. Introduction, conclusion, and executive summary added**

Abstract

This document provides a summary of the development progress of the ACUMEN Digital Twin, a platform based on a microservices architecture that organizes functionalities into Data Ingestion and Processing, Data Storage, Simulation and Modelling, and Visualization. Significant advancements have been made, including the creation of a data platform that facilitates seamless data upload and download, as well as an API gateway that supports the easy integration of modules from various work packages (WPs).

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Executive Summary

The ACUMEN digital twin architecture organizes services into four key functional domains:

- Data Ingestion & Processing
- Data Storage
- Simulation & Modeling
- Visualization

To date, two foundational components have been successfully implemented:

- A data platform allowing users to upload and download structured datasets
- An API gateway that ensures modular integration across different work packages (WPs 2, 3, and 4)

The four pilot-specific instances of ACUMEN have been deployed, enabling real-time collaboration and testing across cities such as Helsinki, Amsterdam, Luxembourg, and Athens. In terms of visualization, LIST has worked with project partners to standardize a trajectory file format, facilitating uniform input of GPS-based vehicle data. This format will soon be extended to support additional KPI and data analytics visualizations (e.g., heatmaps, charts, matrices).

Ongoing developments include:

- A 2D trajectory visualization module
- A scenario management tool

These components are nearing completion and will enhance user interaction and simulation capabilities. Furthermore, LIST has initiated efforts to integrate modules developed under WPs 2, 3, and 4, for which detailed API specifications have already been distributed to contributors.

1 Introduction

The Luxembourg Institute of Science and Technology (LIST), in partnership with FVH, AIM, NTUA, SLA, NMK, and DAEM, is actively developing the Generic ACUMEN Digital Twin Tool, a robust platform designed to support urban mobility research and operational pilots across Europe. Built on a microservices-based reference architecture (see Figure 1), the Digital Twin facilitates modular, scalable, and flexible integration of data sources, analytics models, and visualization tools. This architecture enables seamless collaboration between technical developers, research partners, and pilot teams.

The objective of this deliverable is to succinctly introduce the development of the ACUMEN Digital Twin performed under Task 5.4, scheduled from month 5 to month 36. This task focuses on the implementation of the Digital Twin in compliance with the reference architecture and by leveraging the software modules developed in Task 5.2 (accessed via APIs) and the simulation models from Task 5.3, tailored to the specific needs of each pilot.

2 Completed developments

The Luxembourg Institute of Science and Technology (LIST) is developing the ACUMEN Digital Twin, which is based on a microservices architecture (Figure 1).

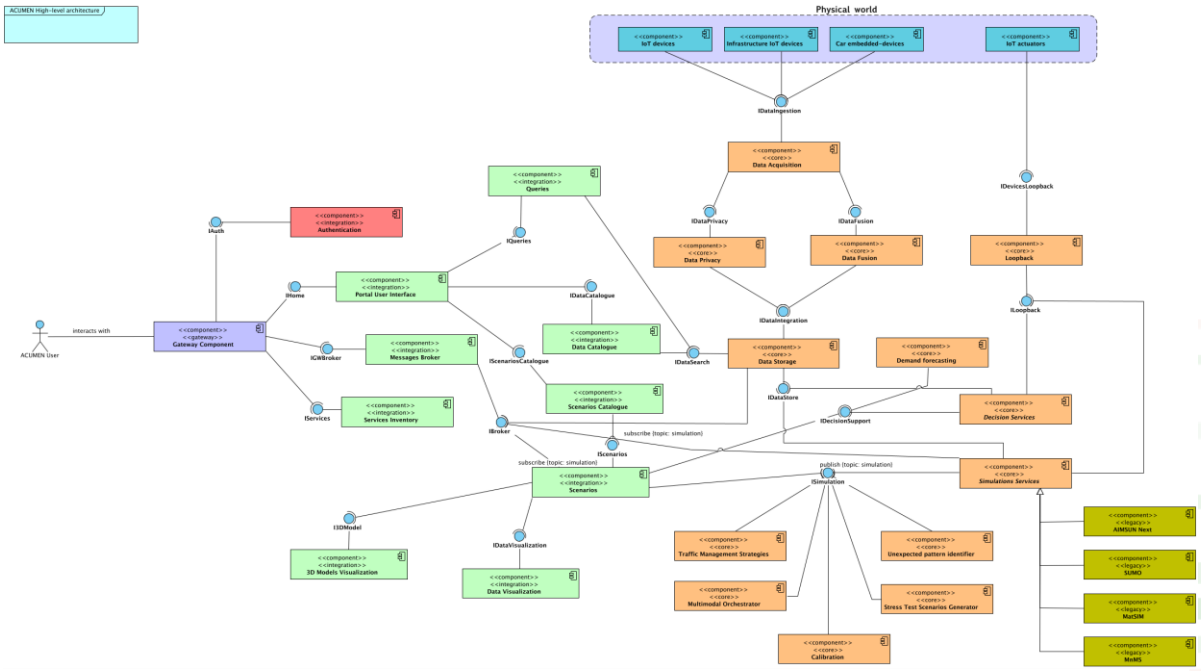

Figure 1: ACUMEN Reference Architecture overview

This architecture divides services into key functional categories: Data Ingestion and Processing, Data Storage, Simulation and Modeling, and Visualization.

As of now, LIST has successfully completed two essential components of the Digital Twin: the data platform and the API gateway. The data platform enables straightforward uploading and downloading of data, providing a seamless user experience. The API gateway, meanwhile, facilitates the integration of mobility tools (e.g. Traffic management tool, Decision tool, Multimodal management orchestrator) from WPs 2, 3, and 4 into the Digital Twin through API development. With these two components in place, both pilot teams and tools owners (i.e. the partner having develop the tool) can now connect their tools and upload data to the Digital Twin.

Below are some screenshots of the developments completed so far:

1. Figure 2 - Login page
2. Figure 3 - Access Control Management page
3. Figure 4 - Service Inventory (i.e. the service delivered by tools developped in WPs 2, 3, 4 and 5)
4. Figure 5 - Data Manager page

The code associated with this platform is available at the following internal link: https://git.list.lu/acumen

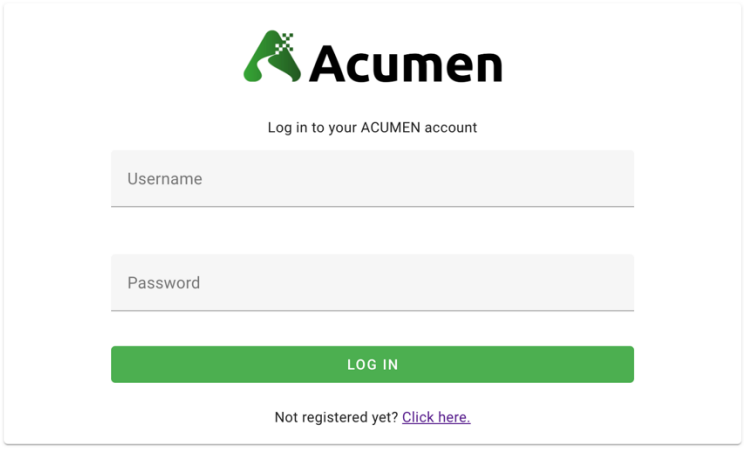

Figure 2: Login page

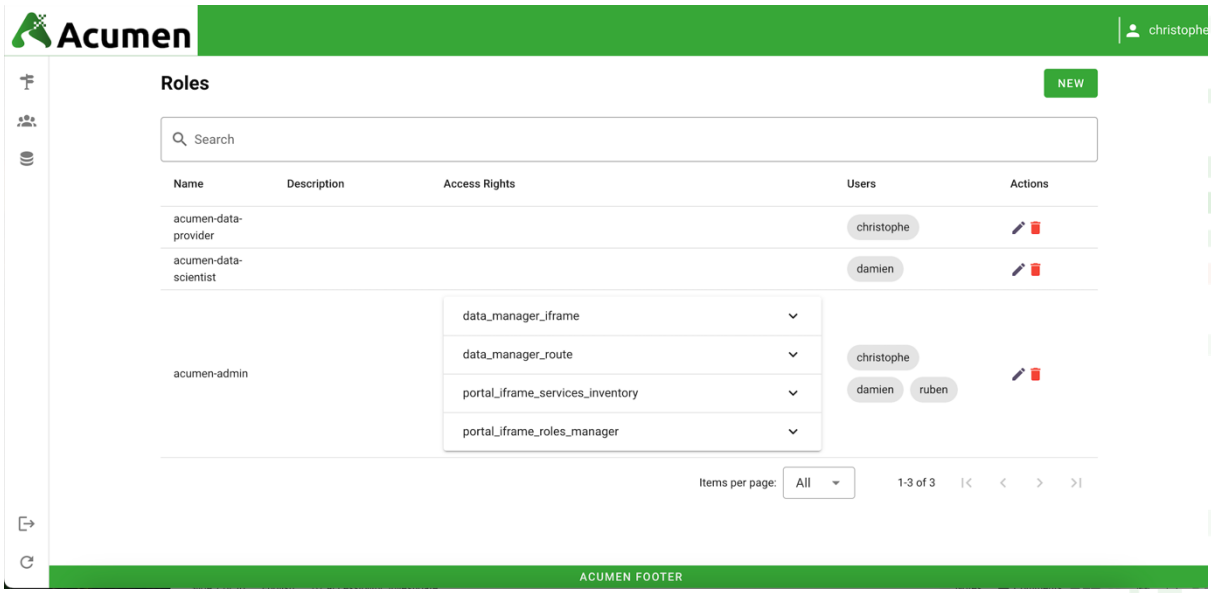

Figure 3: Access Control Management page

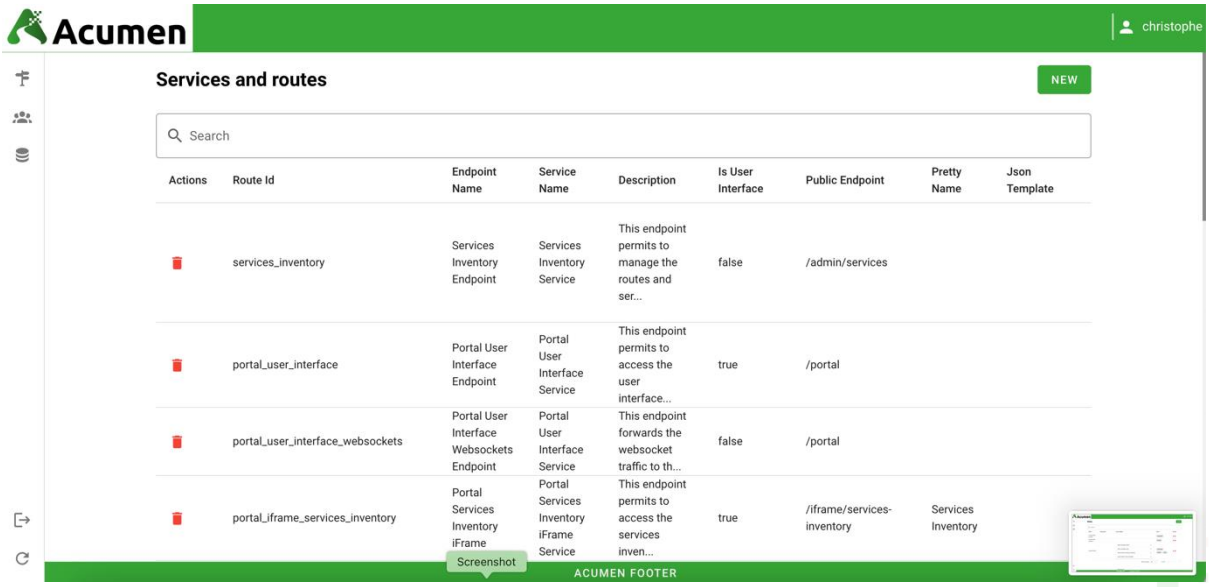

Figure 4: Service Inventory

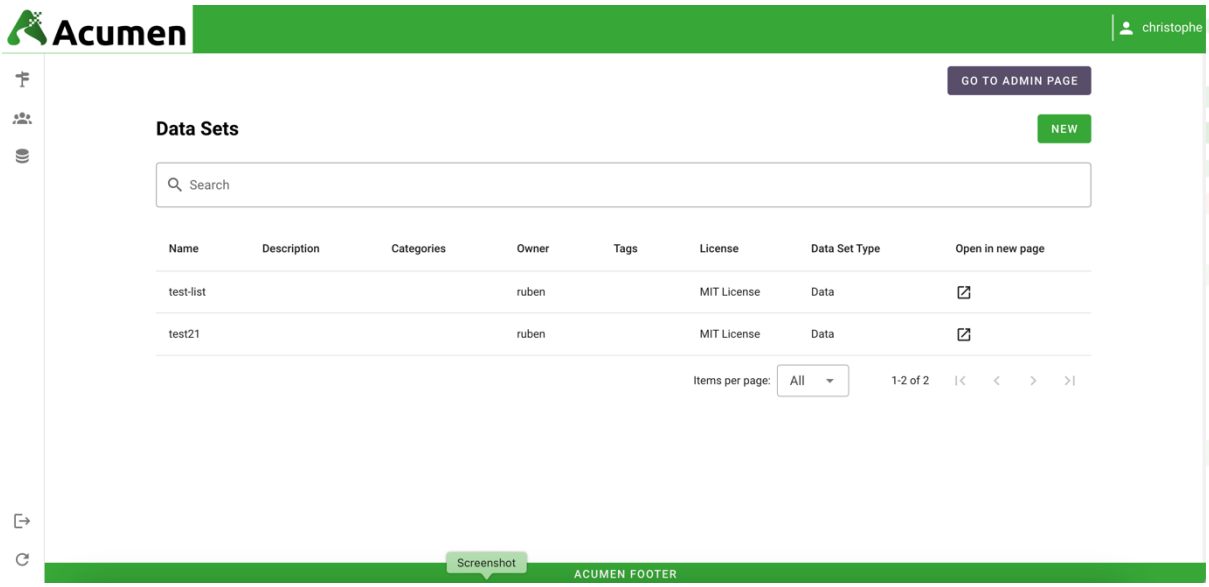

Figure 5: Data management platform

3 Ongoing developments

Current development efforts are focused on completing the 2D trajectory visualization module and the scenario management module (Figure 6), both of which are anticipated to be finalized in the coming weeks.

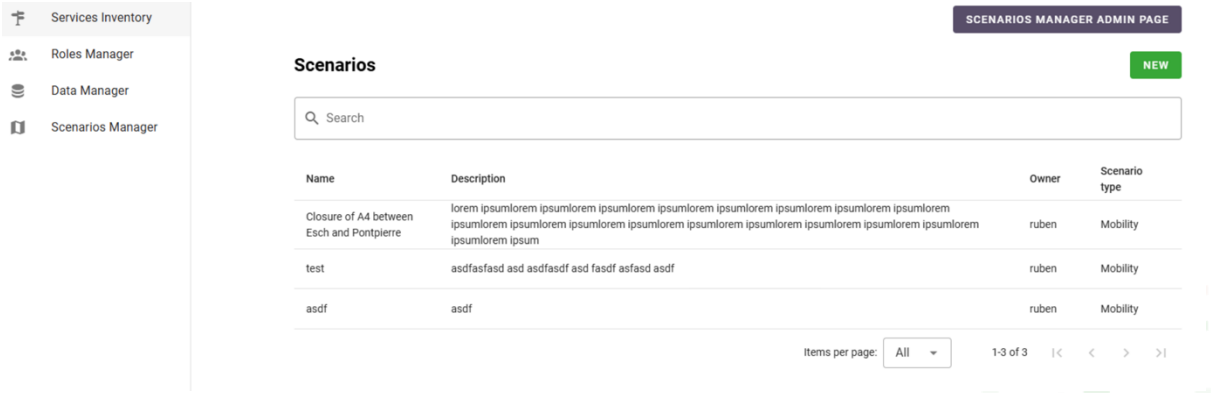

Figure 6: Initial development of the scenario manager.

In terms of visualization, LIST, in collaboration with AIMSUN, UGE, Mobilisys, has established a standardized format for trajectory files, ensuring consistent data input across platforms. This fields of this format are :

- The veh_id, unique veh_id, in the case of agent base this will be user/person
- time, time with the following format YYYY-MM-DD hh:mm:ss. As per LIST requirement the file needs to be sorted in ascending order by this field.
- lat, latitude in GPS coordinates
- lon, longitude in GPS coordinates
- (optional) speed, moving speed at the current time in km/h
- (optional) veh_type, a string indicating the type of vehicle like: 'car', 'motorbike', 'bus', 'bicycle', 'pedestrian', etc. If you need to have a vehicle type show different than the ones before, please let us know so we can standarize the names for all use cases
- (optional) veh_width, vehicle width (in meters).
- (optional) veh_len, vehicle length (in meters).

In the near future, additional file formats will be made available to partners to support visualization of key performance indicators (KPIs), charts, matrices, heatmaps, and other analytical views.

4 Deployments for the pilots

For deployment, a dedicated instance has been established for each pilot, enabling pilot team members to conduct tests and exchange data as needed.

The stable pilot-specific instances of ACUMEN that can be used by all the partners are:

- https://acumen-helsinki.list.lu/portal
- https://acumen-amsterdam.list.lu/portal
- https://acumen-luxembourg.list.lu/portal
- https://acumen-athens.list.lu/portal

5 Future developments

The next phase in the Digital Twin's development will concentrate on integrating the bulk of modules created under WPs 2, 3, and 4 to make them fully accessible to pilot teams. To facilitate this process, API specifications have been distributed to module owners, who are responsible for developing the necessary APIs on their side to enable smooth integration.

6 Conclusion

The ACUMEN Digital Twin represents a major step forward in urban mobility analysis, offering a highly modular and interoperable architecture that empowers pilot teams and researchers alike. With core infrastructure in place and additional modules nearing completion, the platform is now ready to scale its capabilities through collaborative integration. The coming months will focus on finalizing visualization features, enhancing scenario management, and ensuring seamless API-based integration of analytical components, setting the stage for data-driven decision-making and impactful pilot outcomes.