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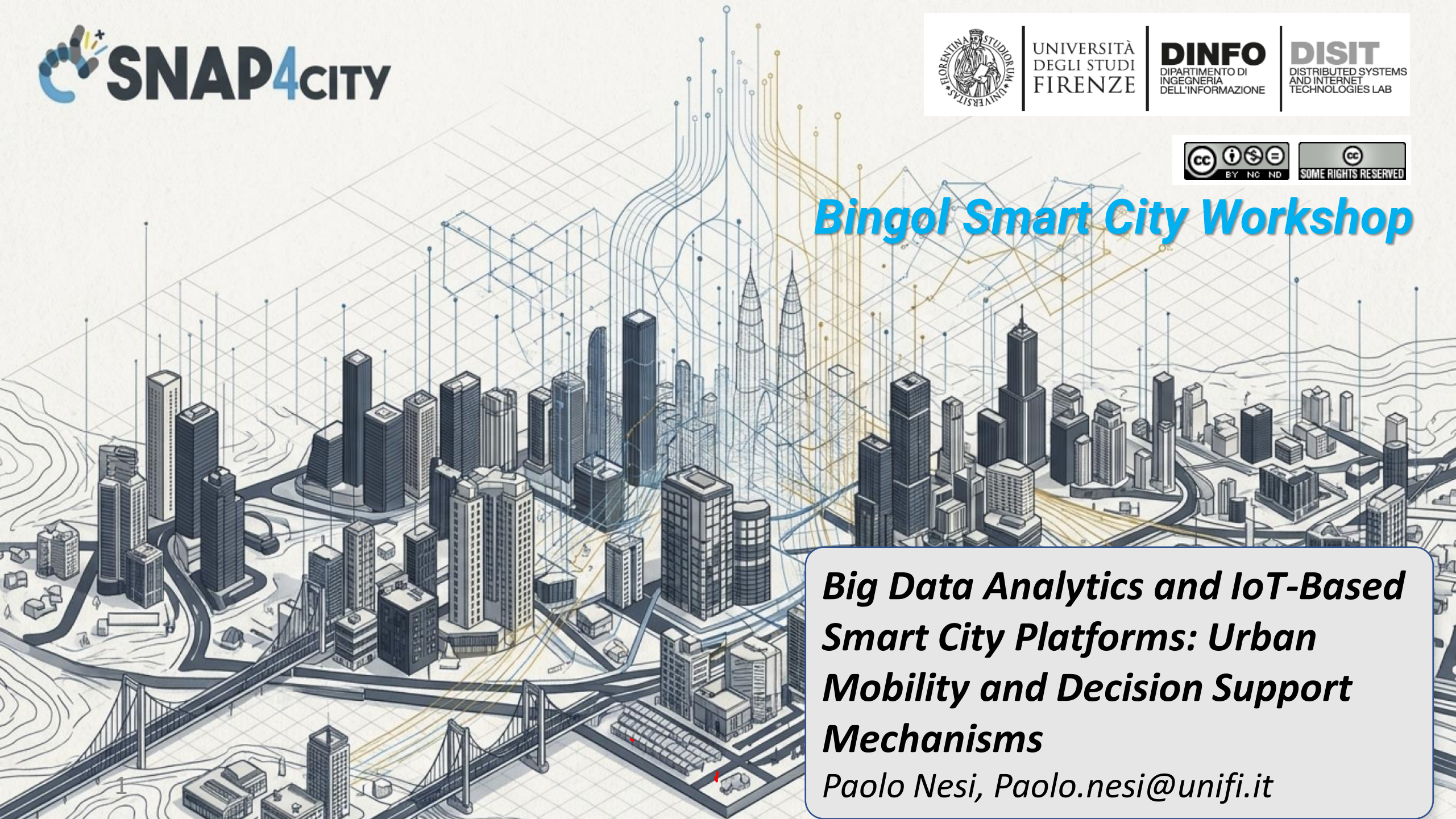


Bingol Smart City Workshop

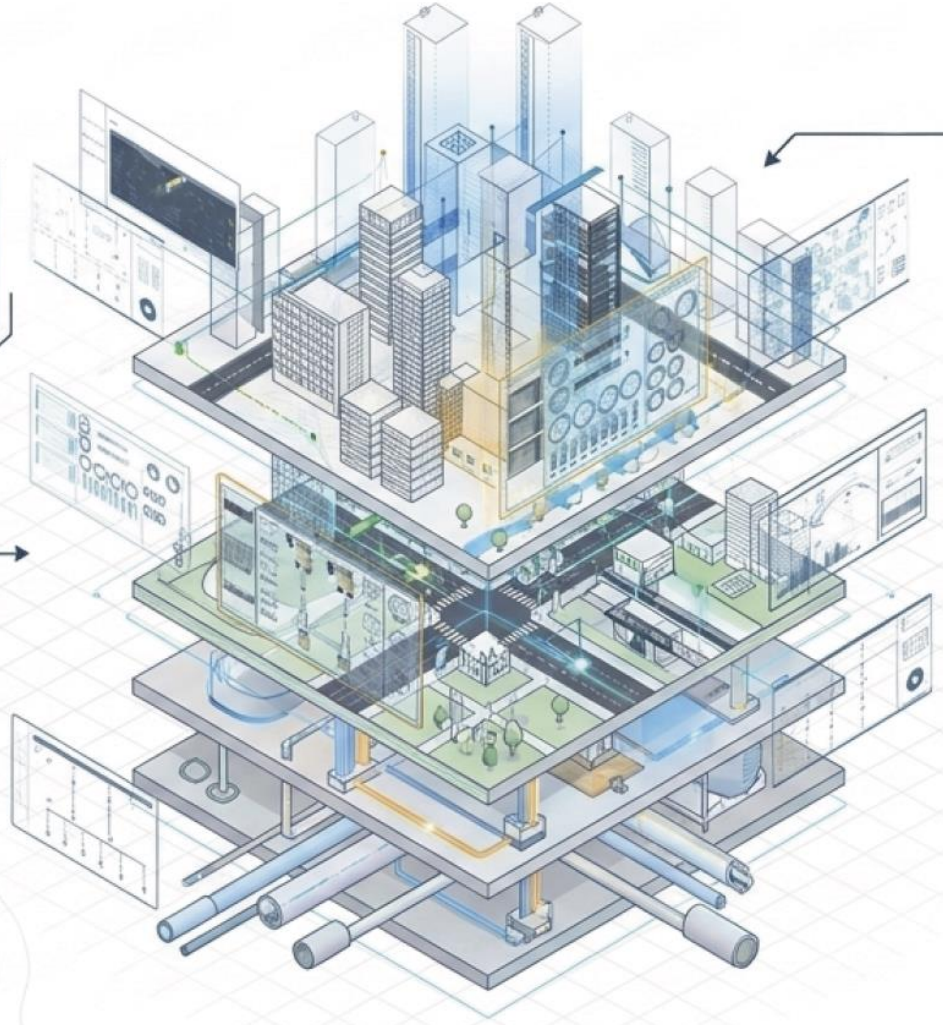
Big Data Analytics and IoT-Based Smart City Platforms: Urban Mobility and Decision Support Mechanisms

Paolo Nesi, Paolo.nesi@unifi.it

Shattering Silos with Global 3D Digital Twins

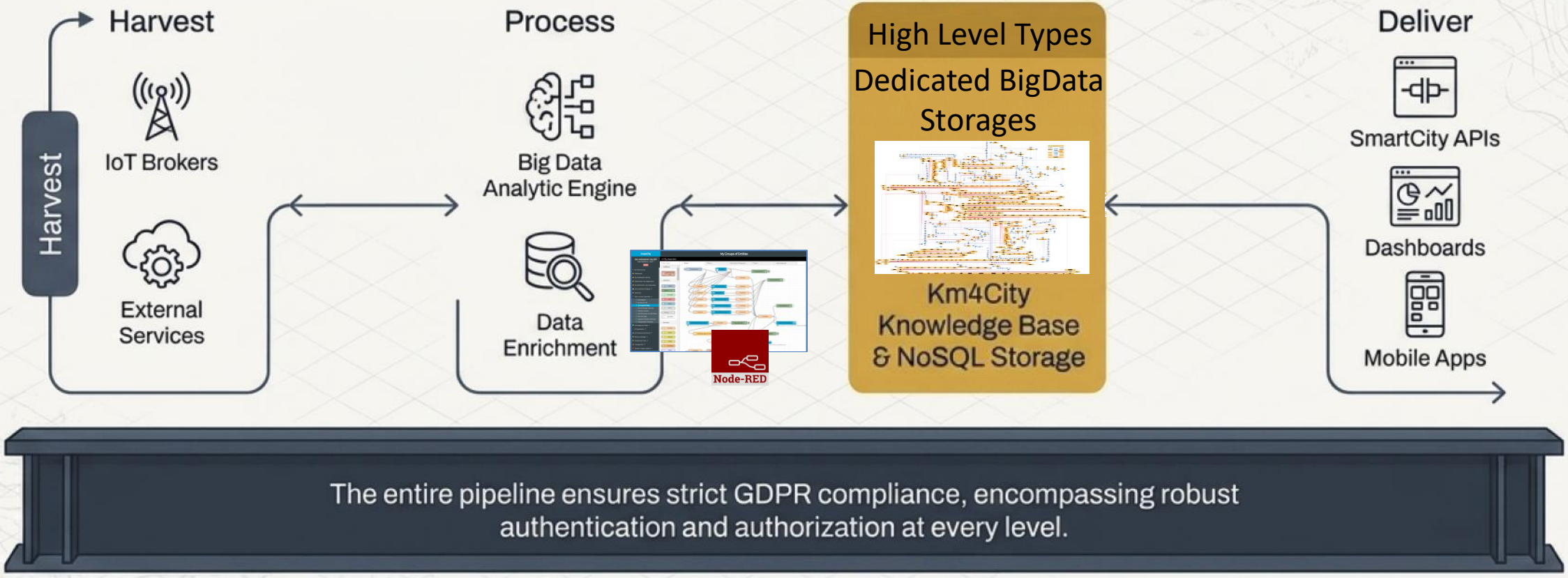
A multi-domain, multi-tenant platform designed to ingest any data type while respecting its original semantic meaning.

Transitions urban management from reactive, event-driven monitoring to proactive, holistic 3D simulation.



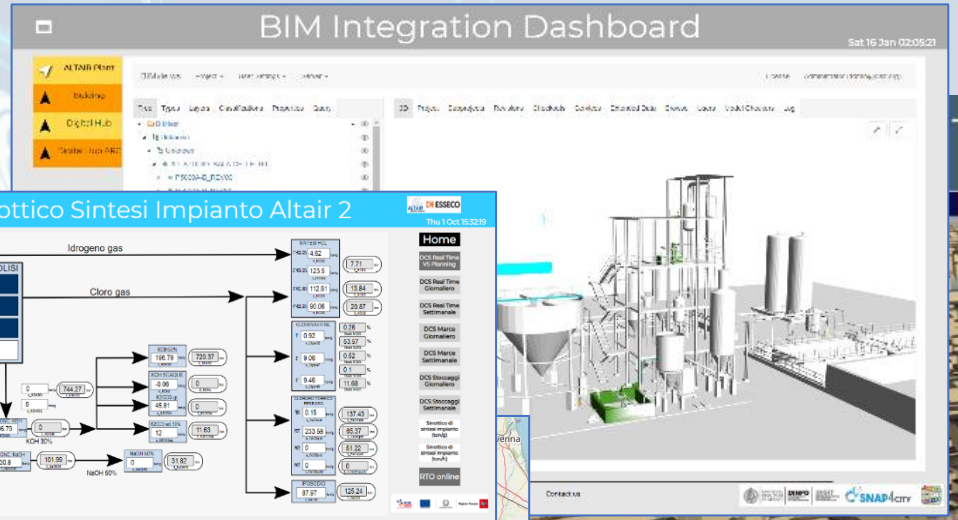
Unifies the fragmented city into a single, highly searchable and actionable Knowledge Base.

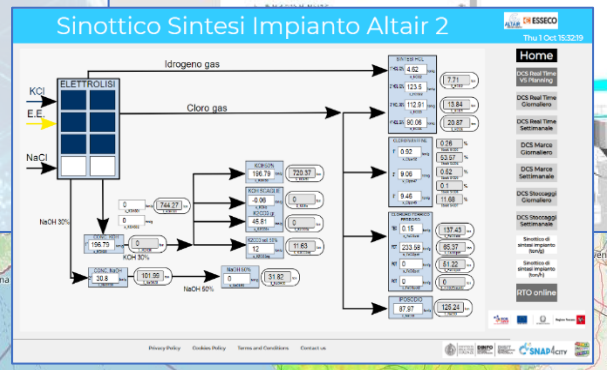
End-to-End Intelligence Architecture

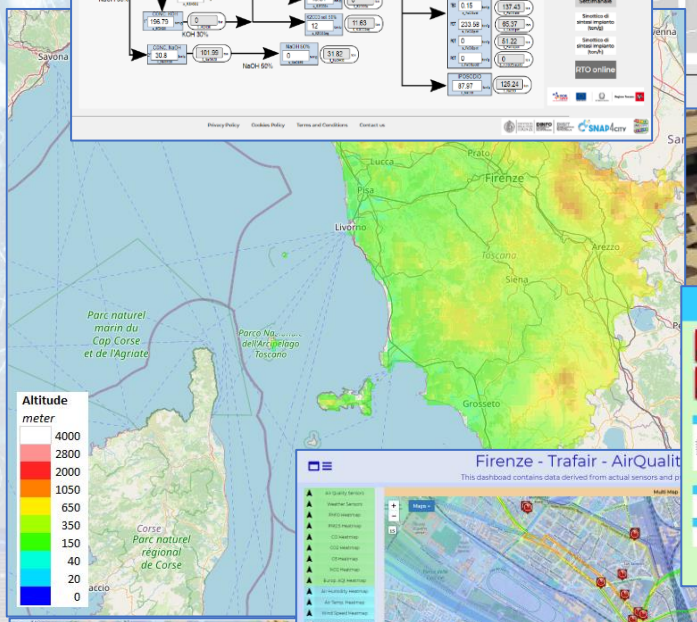


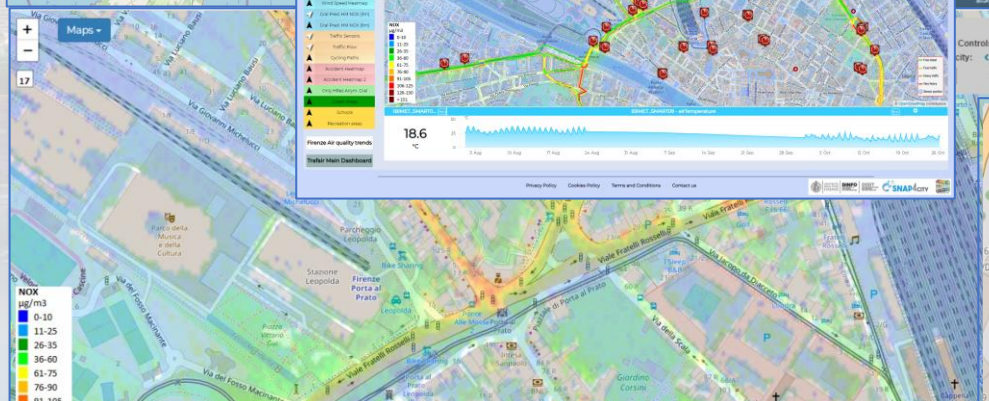
High Level Types

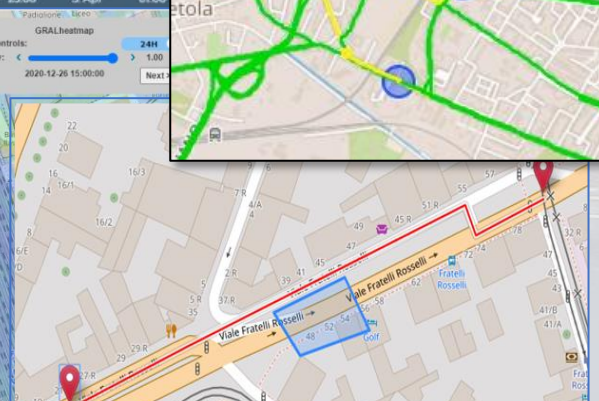
- POI, IOT Devices, shapes,..
  - FIWARE Smart Data Models,
  - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ..
- Satellite data, any kind..
- traffic flow, typical trends, ..
- Vector fields + heatmaps, ..
- trajectories, events, workflow, ..
- 3D Models, BIM, Digital Twins, ..
- OD Matrices of several kinds, ..
- Dynamic icons/pins, ..
- Synoptics, animations, ..
- KPI, personal KPI,..
- social media data, TV Stream,
- routing, multimodal, constraints, ..
- scenarios, ….
- etc.











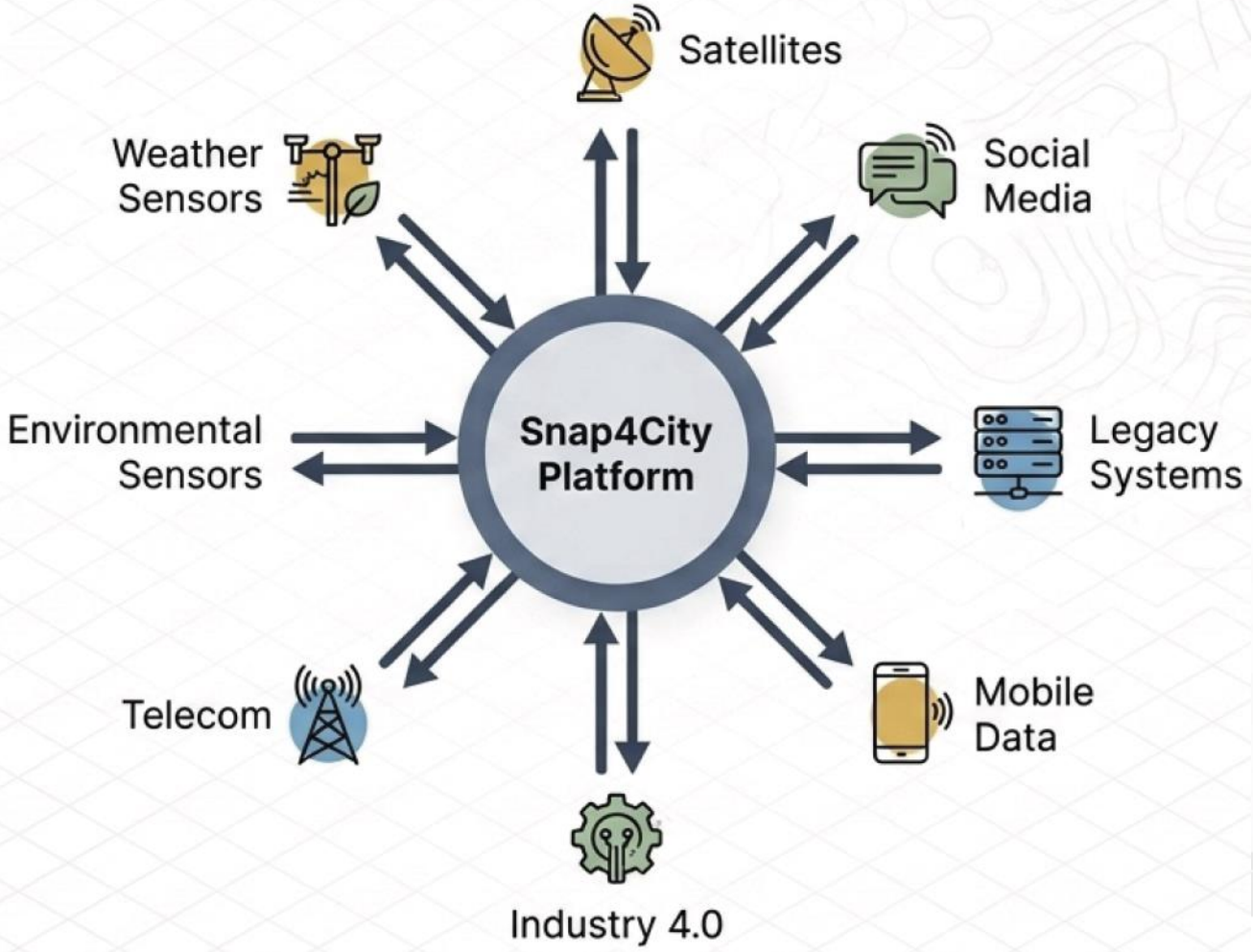
Universal, Bidirectional Data Ingestion

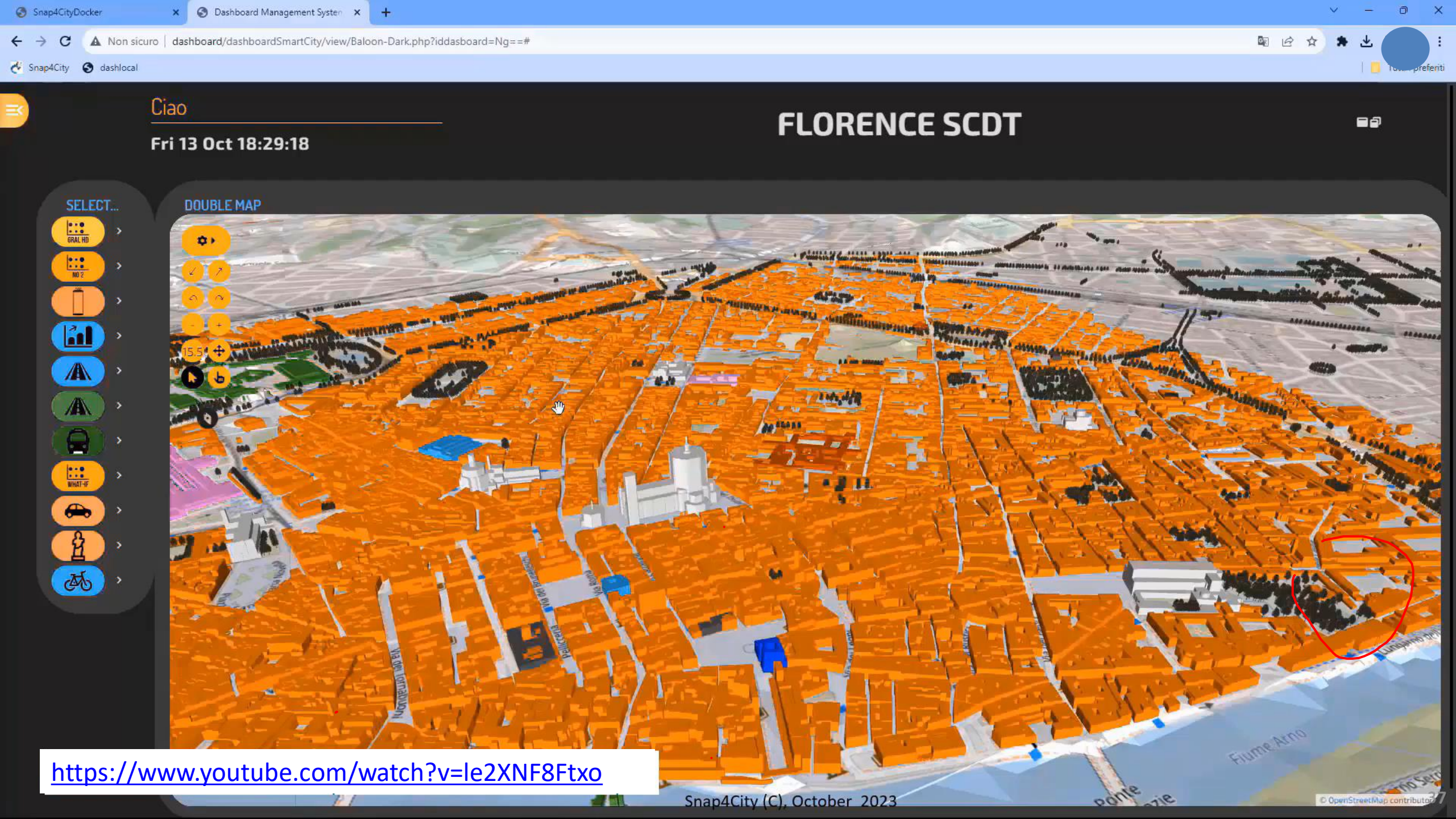
Protocol Agnostic

Seamlessly adapts to existing IoT networks, legacy databases, proprietary vendor solutions, and Open Data portals.

Bidirectional Capability

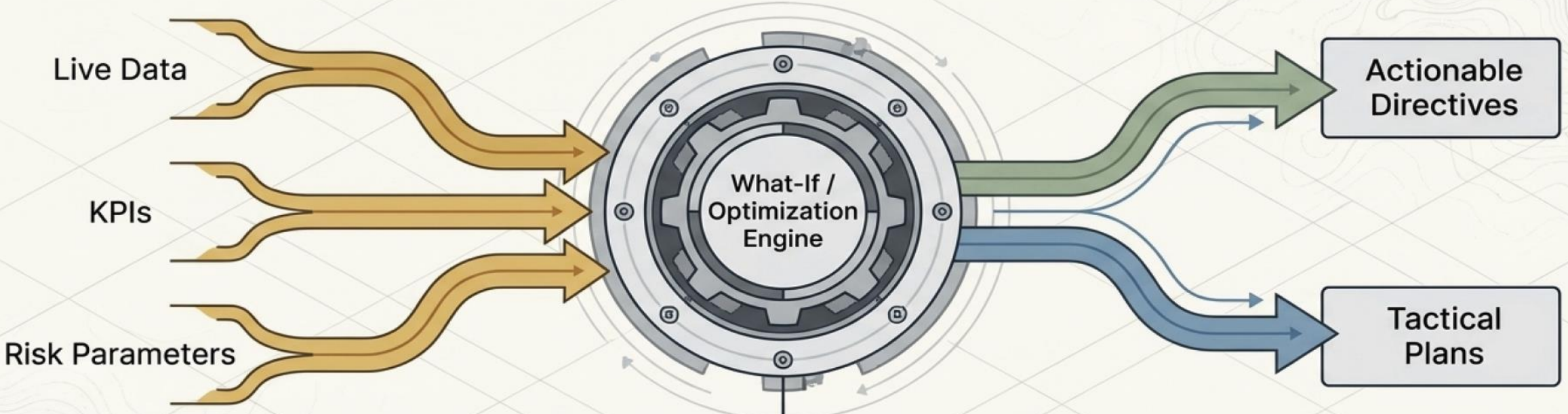
Snap4City does not merely read data; it actively produces and pushes entities, prescriptions, and warnings back through any channel or protocol.





https://www.youtube.com/watch?v=le2XNF8Ftxo

Decision Support Systems

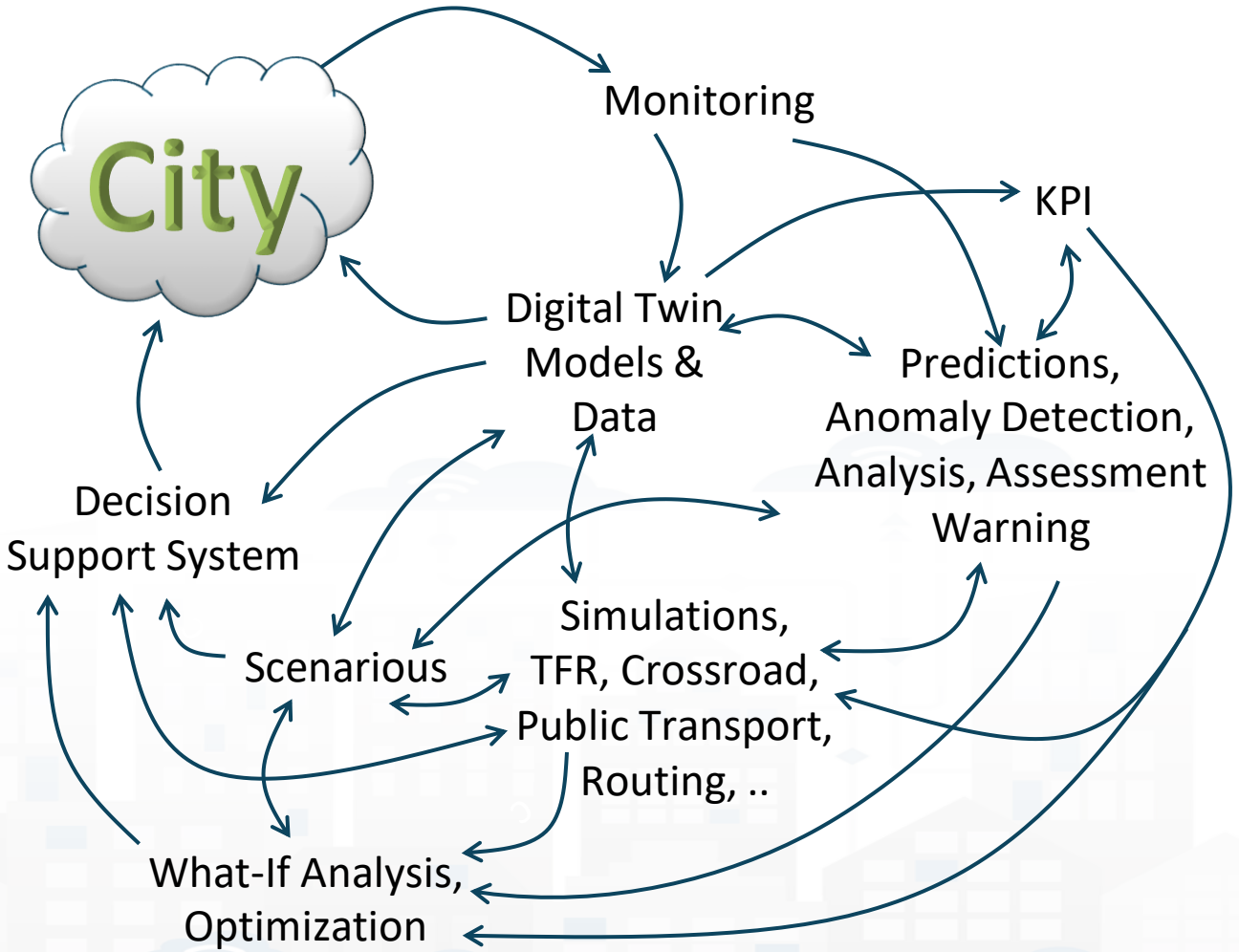


What-If Analysis:
Grounded on robust predictive algorithms and simulations.

Scenario-Based Optimization:
Test traffic light plan optimizations digitally. Evaluate major traffic infrastructure changes. Assess tactical risks and generate prescriptions before spending public funds.

Main tasks

- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Predictions vs KPI
  - Anomaly detection
  - Neuro-Symbolic analysis
  - Risk assessment
  - Early warning on critical conditions
  - Fast What-if analysis
- **Making plan: tactic and strategic, medium and long range, micro/macro**
  - Simulation & optimization
  - Generative AI Prescriptions, scenarios
  - Resilience to Unexpected unknows
  - What-if analysis wrt scenarios
  - Collaboration with stakeholders



Key Performance Indicators, KPI

		Air Quality Directive		WHO guidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
$PM_{2.5}$	One day			25 µg/m³ (*)	99th percentile (3 days/year)
$PM_{2.5}$	Calendar year	Target value, 25 µg/m³	The target value has become a limit value since 1 January 2015	10 µg/m³	
PM_{10}	One day	Limit value, 50 µg/m³	Not to be exceeded on more than 35 days per year.	50 µg/m³ (*)	99th percentile (3 days/year)
PM_{10}	Calendar year	Limit value, 40 µg/m³ (*)		20 µg/m³	
O_3	Maximum daily 8-hour mean	Target value, 120 µg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³	
NO_2	One hour	Limit value, 200 µg/m³ (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m³ (*)	
NO_2	Calendar year	Limit value, 40 µg/m³		40 µg/m³	

- **United Nations Sustainable Development Goals, SDGs** (for which cities can do more to achieve some of the 17 SDGs, https://sdgs.un.org/goals);
- **15 minutes cities** (where primary services must be accessible within 15 minutes on foot);
- **objectives of the European Commission** in terms of pollutant emissions for: NO2, PM10, PM2.5 (https://environment.ec.europa.eu/topics/air_en);
- **SUMI: mobility and transport vs env**
  - **https://www.snap4city.org/951**
- **SUMP/PUMS: mobility and transport vs env.**
- **ISO indicators:** city smartness, digitization, tech level.
- **Low Level/Real Time:** global traffic, quality of service, betweenness, centrality, queue, time to travel, etc.

Global & Local

Periodic & Realtime

SUSTAINABLE DEVELOPMENT GOALS

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KM 4 CITY

- ***15 Minute City Index:***
  - 13 subindexes: energy, slow mobility, fast mobility, housing, economy education, culture and cults, health, entertainment, gov, food, security…

- Optimization of car sharing/pooling
- Monitoring and Prediction of energy consumption
- Stimulating: Bike sharing, e-bikes, car charge, etc.
- Sizing energy plants, Community of energy

- Reduction of emissions, reduction of congestions
- Smart City infrastructure: monitoring and resilience, long terms predictions, optim. operation and plan
- Effective and Low cost smart solutions
- What-if analysis, Simulations, optimization
- Origin Destination matrices computation

- Reduction of emissions, reduction of congestions
- Monitoring and Predicting: NO2, NOX, CO2, Traffic flow, pollutant, landslide, waste, etc.
- Traffic flow reconstruction, optimisation
- Demand vs Offer of Mobility analysis

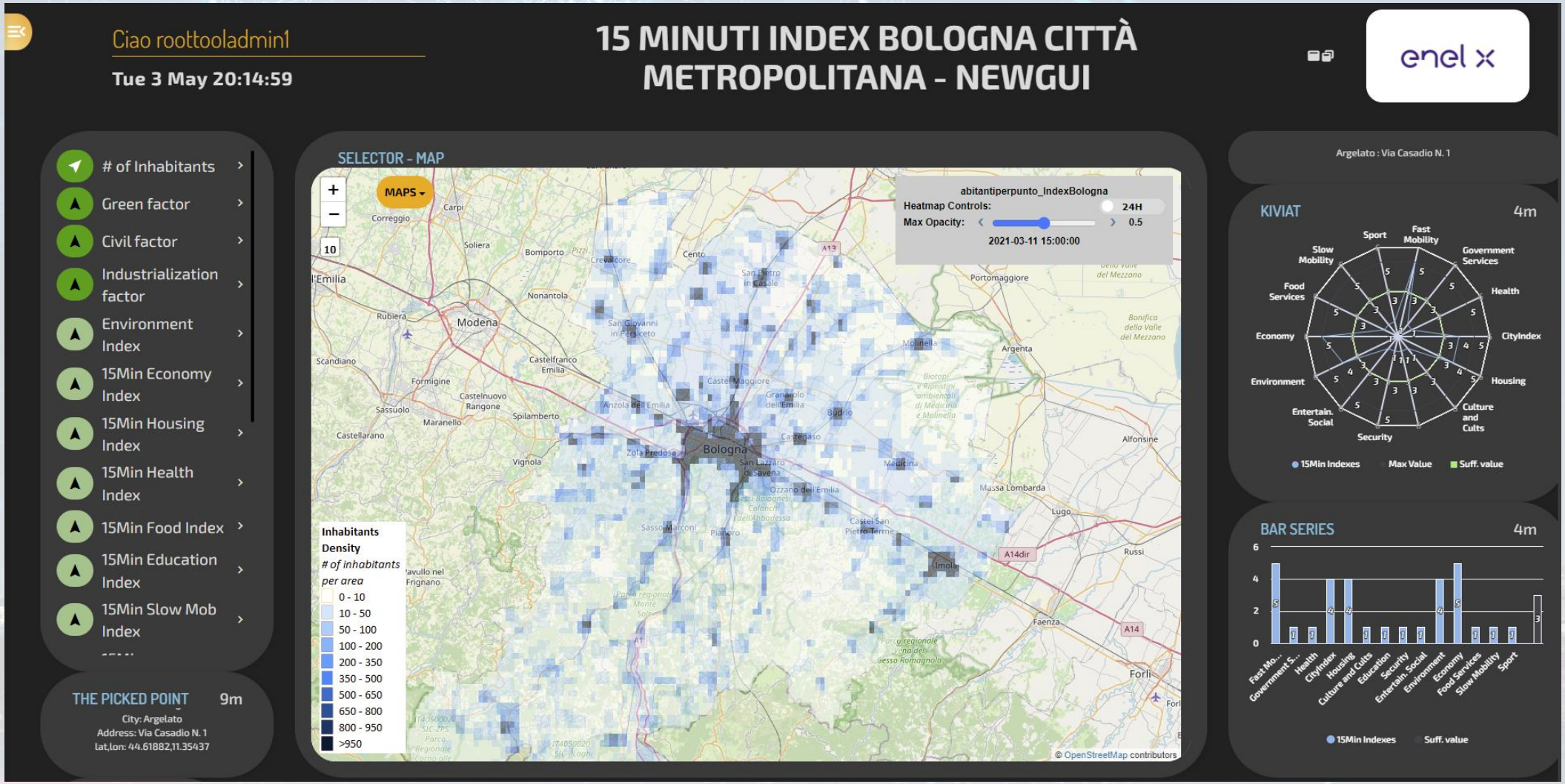
- Predictive maintenance
- Decisions Support Systems
- Process optimization, control
- Industry 4.0 integrated solutions
- AI assistant for commercial activities

- Optimization of Waste Collection
- business intelligence tools for decision makers
- Reduction production costs
- Monitoring resource consumption
- Advisor for documentation, generative AI

- Shortening justice time
- Prediction of mediation proneness
- Assisting institution is taking legal decisions
- Anonymization and indexing legal docs.
- Ethical Explainable Artificial Intelligence
- Advisor for legal documentation, generative AI

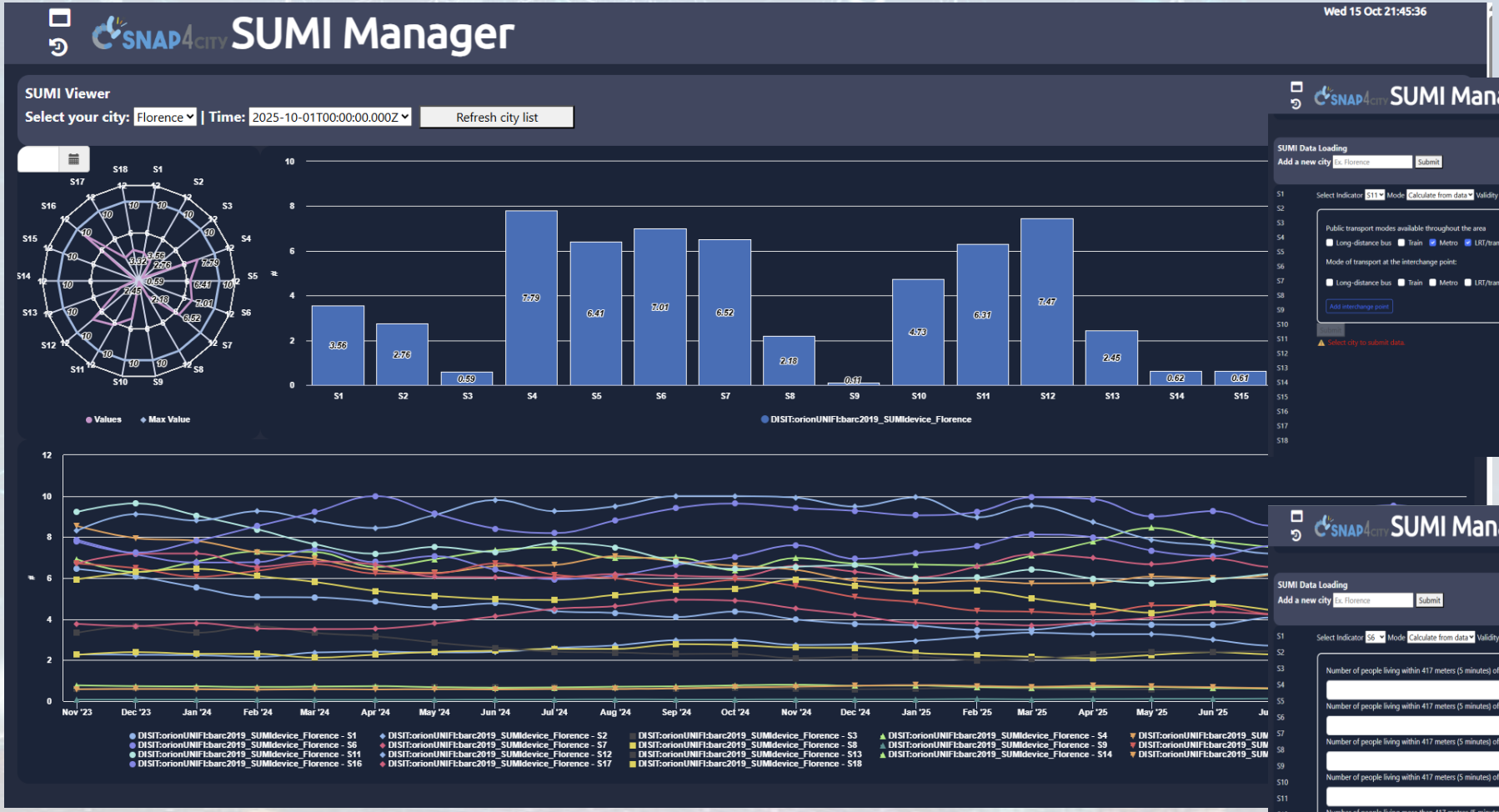
(9/2025)

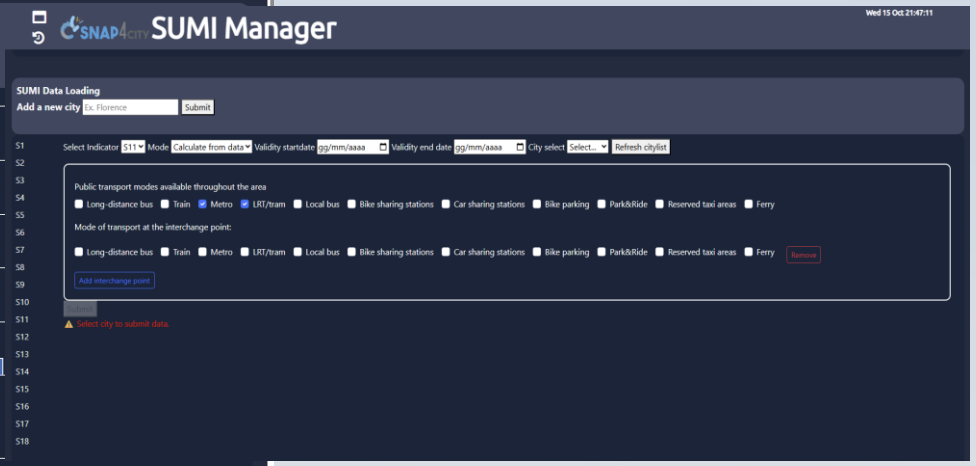
15MinCityIndex on Bologna

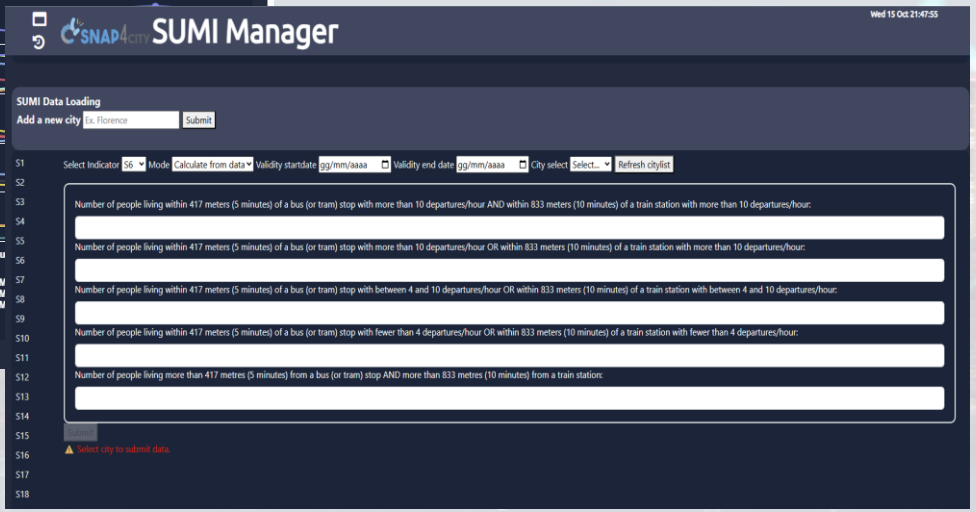


https://www.snap4city.org/dashboardSmartCity/view/Baloon-Dark.php?iddasboard=MzQxMg==

SUMI: Sustainable Urban Mobility Indicators







Mobility and Transport Goals

Decongestion

Safety

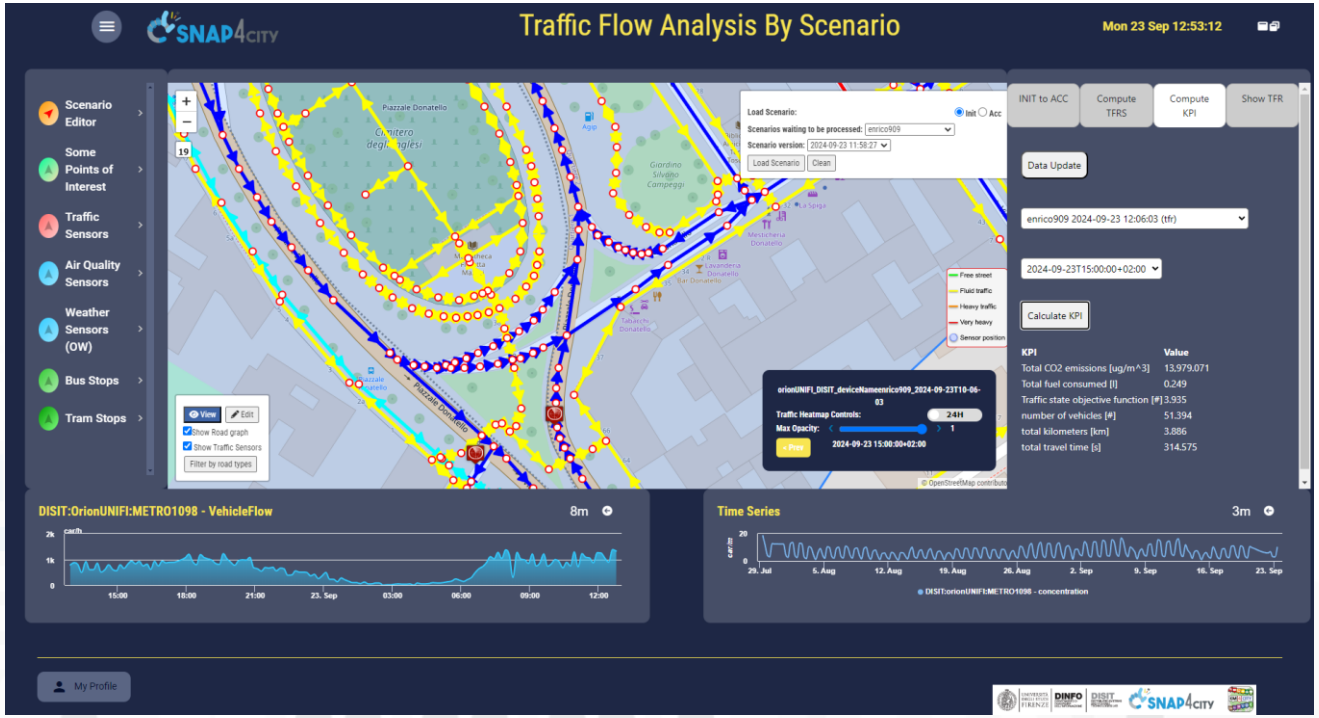
Accessibility

Cost Reduction

Decarbonization

What you can do with advanced tools

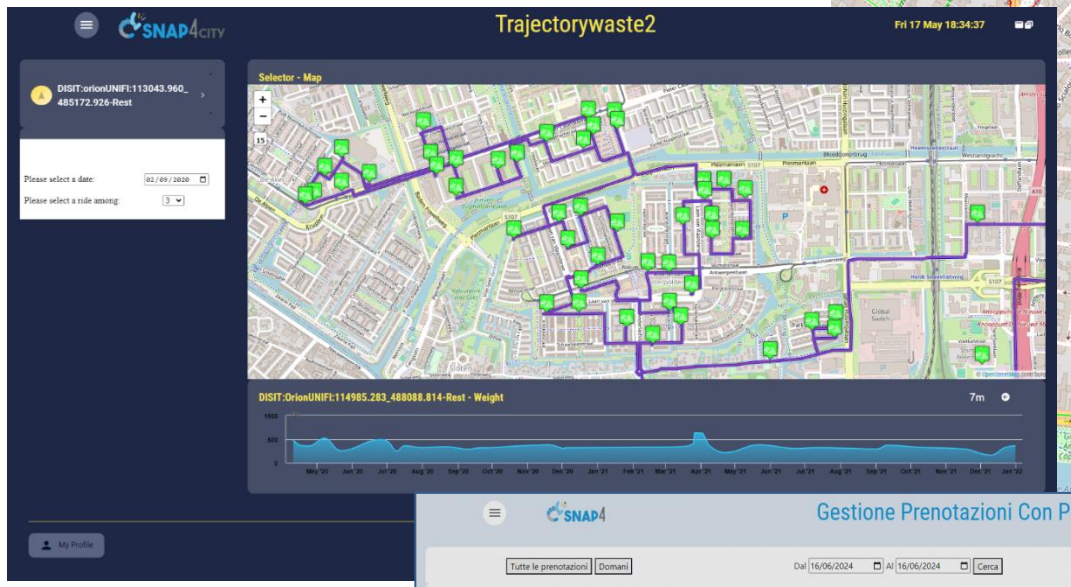
- **Advanced Scenario Editor**
  - Create complex and full detailed scenario, with road graph, sensors, of any kind, even new roads, restrictions, parameters, etc.
  - Exploit these scenarios to create
    - Simulation
    - Business intelligence tools and visual/business analytic tools also working in real time
    - Traffic flow reconstruction
    - Traffic infrastructure optimisation
    - Traffic light plan optimization
    - Pedestrian analysis and simulation
    - Match demand vs Offer, simulation and analysis
    - Computation of SUMI, SUMP, 15 Min City Indexes, etc.
    - Heatmaps computation
    - Etc. etc.

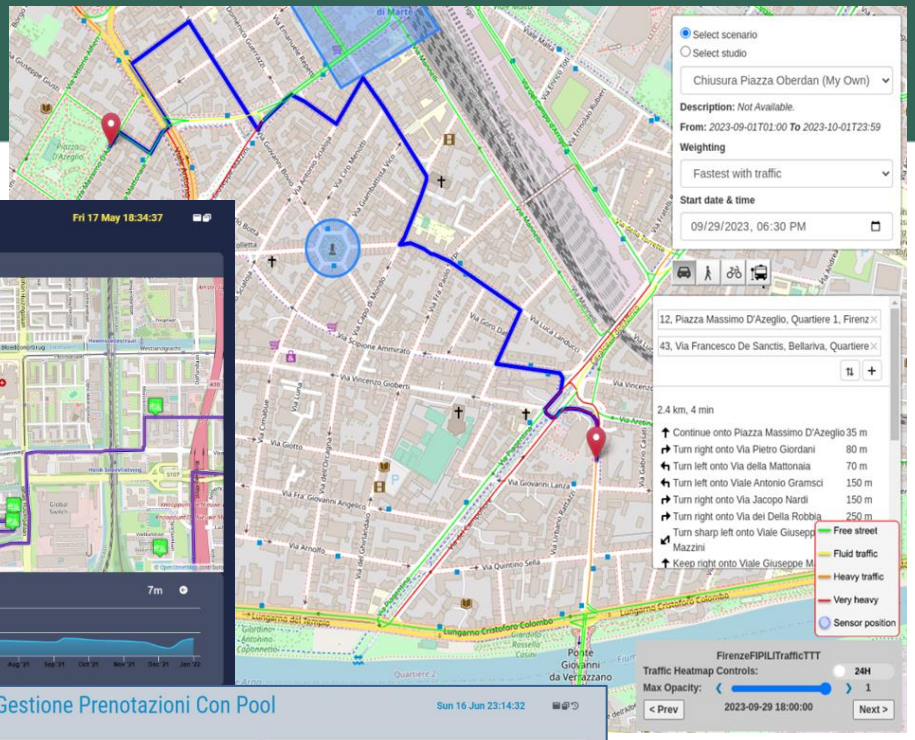


Routing Optimization

Goals on planning:

- Reduction **of costs on plan**
- **waste collection** optimization, Reduction of Km
- **car pooling trajectories** optimization for maximize the pool usage
- **delivering optimization**, reduction of travel time, reduction of Km
- etc.





Dynamic Routing on operation:

- React in operation to define immediate routing solutions: rescue teams, ambulance, etc.
- Recovery from failure

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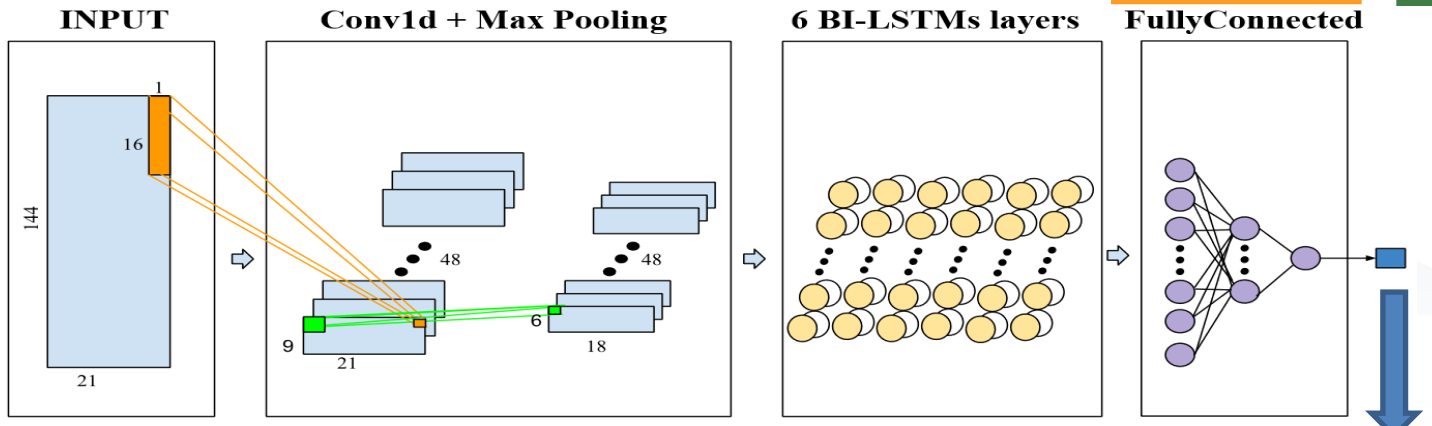
Short-Term Prediction of City Traffic Flow via Convolutional Deep Learning

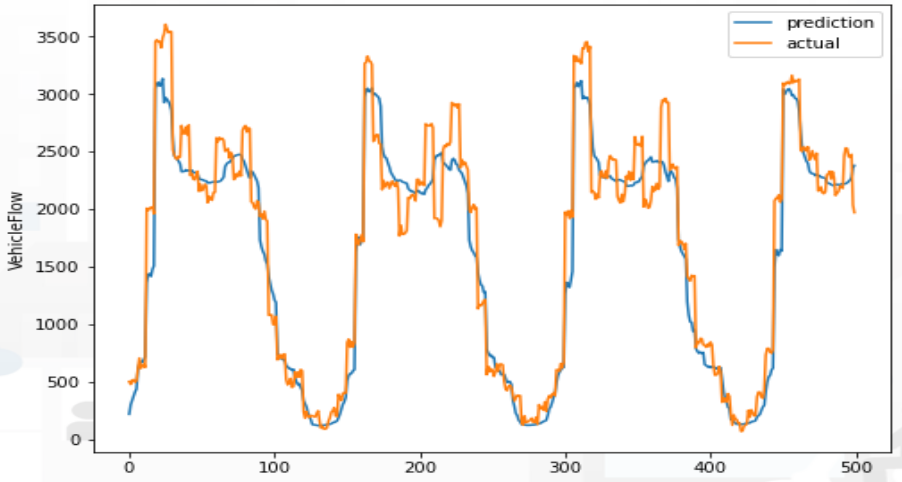


Urban data:

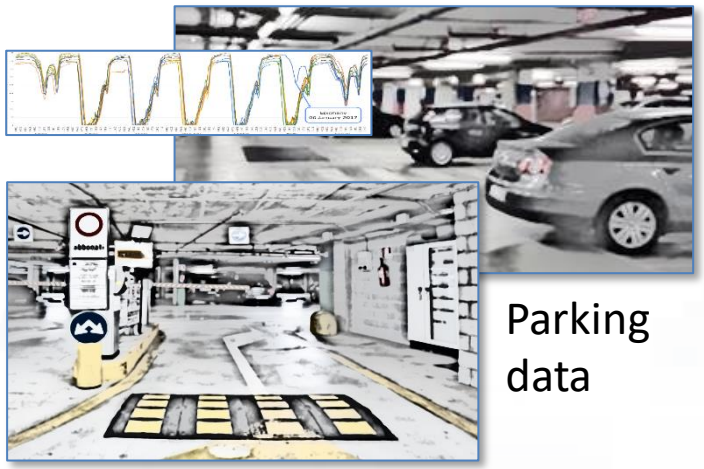
- Date-time
- Traffic
- Temporal
- Seasonality
- Pollution
- Weather

RF
XGBOOST
DNN
LSTM
BI-LSTM
Autoencoder BI-LSTM
Attention CONV-LSTM
CONV-BI-LSTM

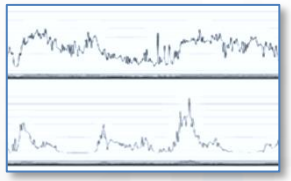
CONV-BI-LSTM



Deep Learning AI to surely Park!

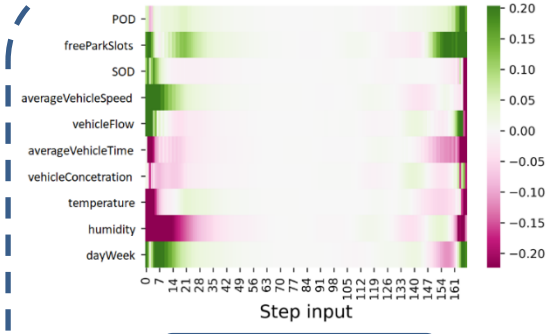


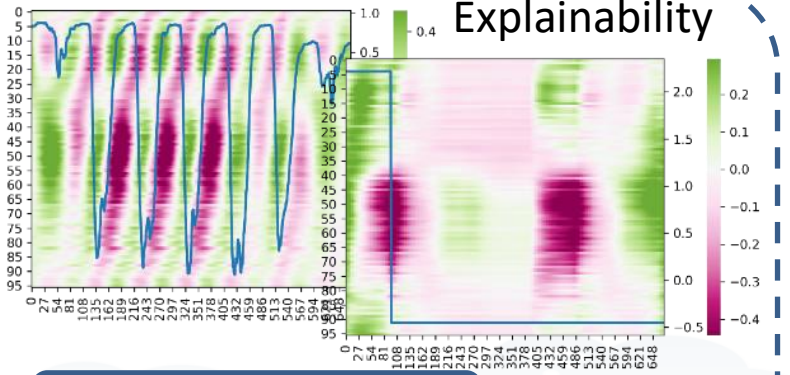
Parking data



Traffic sensors data

Weather Features

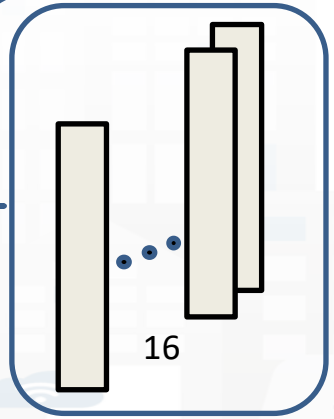


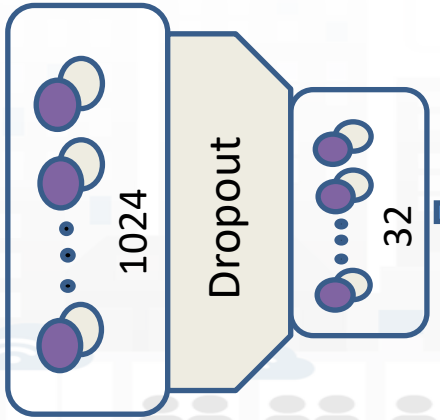


Explainability

Gradient

Integrated Gradient

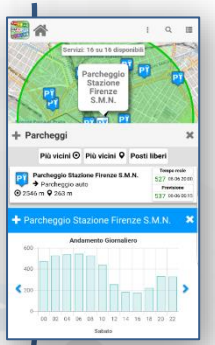




Dropout

Multi-step

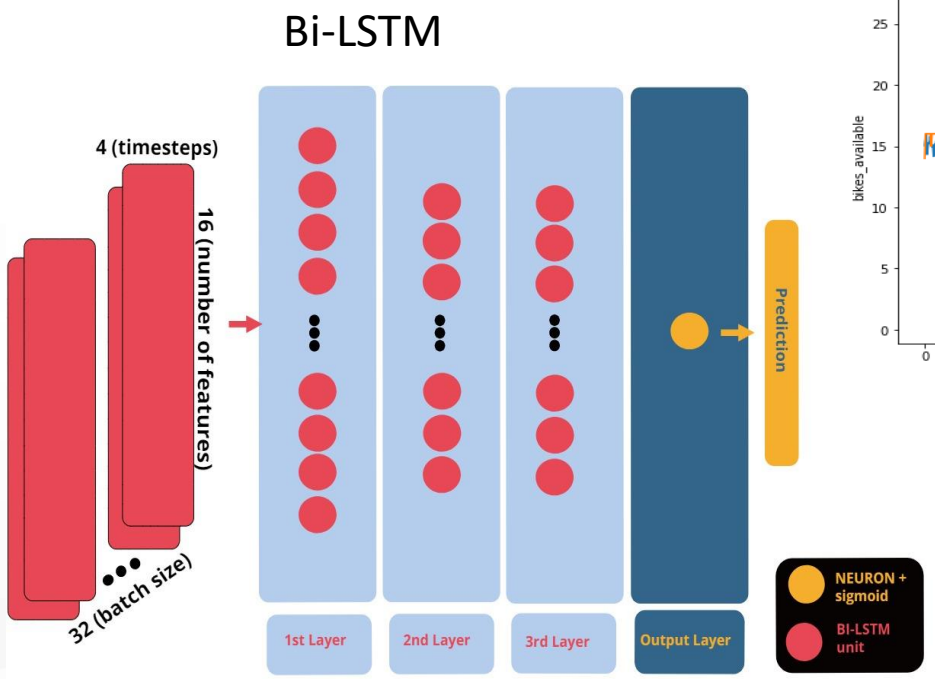
Predictions

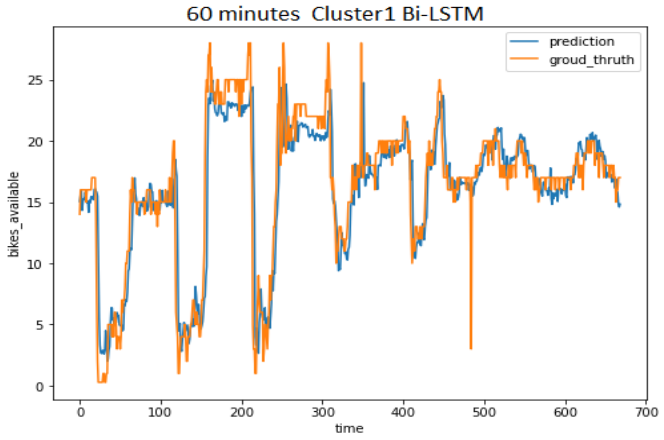


Conv1D+AvPooling1D BI-LSTM BI-LSTM Dense

Compared with: BRANN, RNN, CNN-GRU, CNN-LSTM

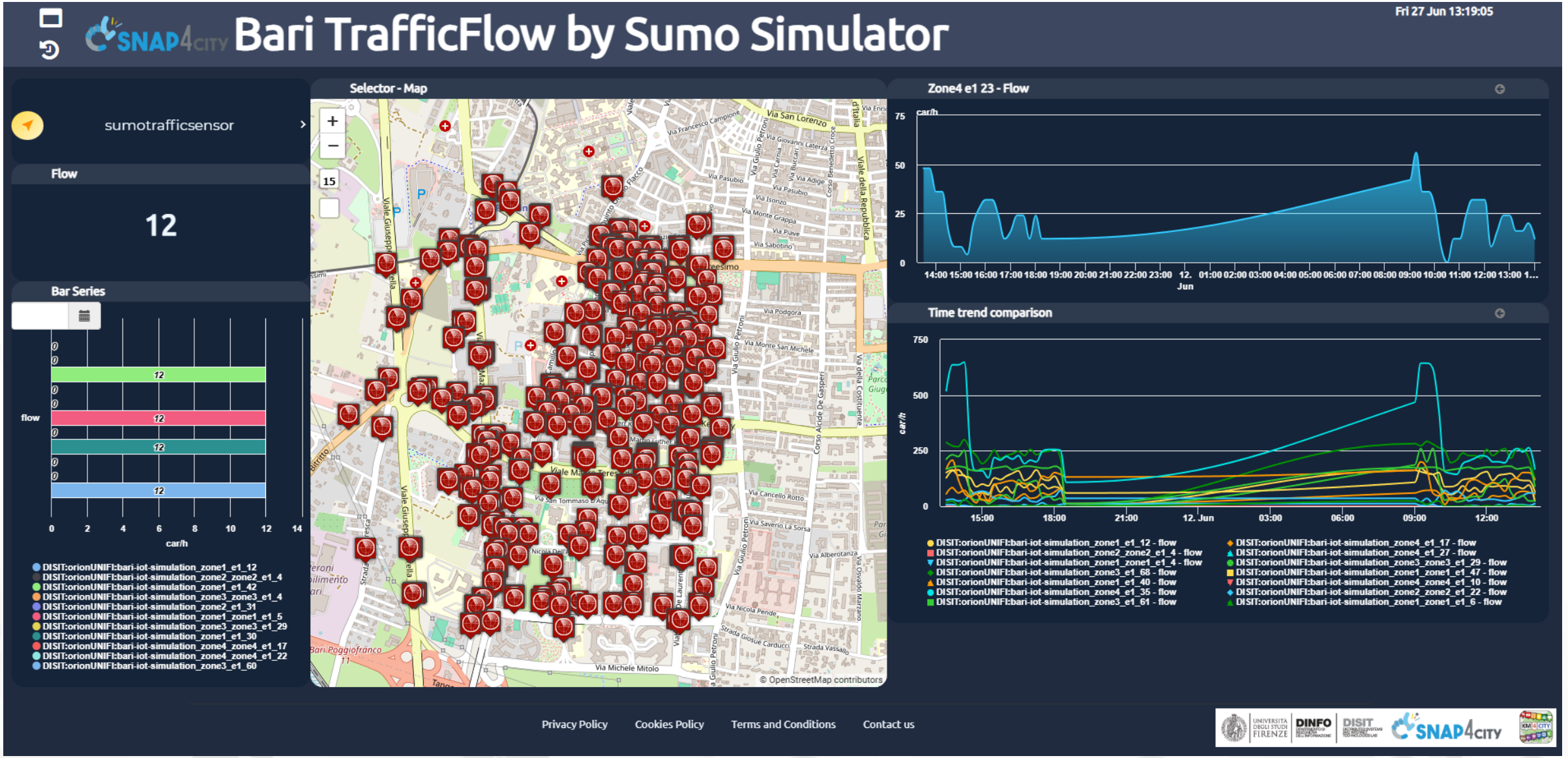
Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations





E. Collini, P. Nesi and G. Pantaleo, "Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations," in *IEEE Access*, vol. 9, pp. 124337-124347, 2021, doi: 10.1109/ACCESS.2021.3110794.
https://ieeexplore.ieee.org/abstract/document/9530580

Comp: RF, XGBoost, DNN, LSTM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Fri 27 Jun 13:19:05
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Flow
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Bar Series
flow
car/h
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Selector - Map
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Zone4 e1 23 - Flow
car/h
Jun
Time trend comparison
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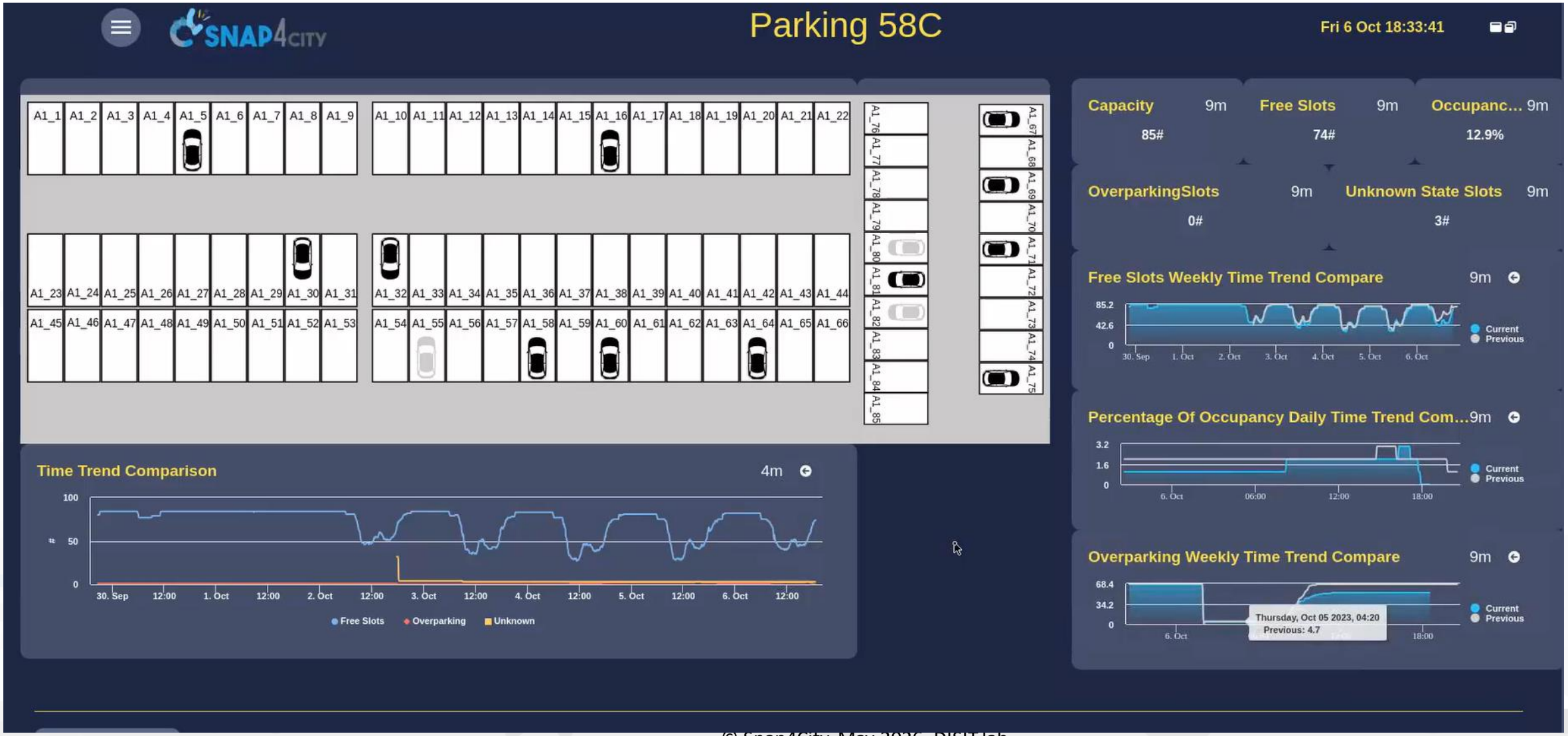
Snap4ISPRA Parking: ISPRA JRC



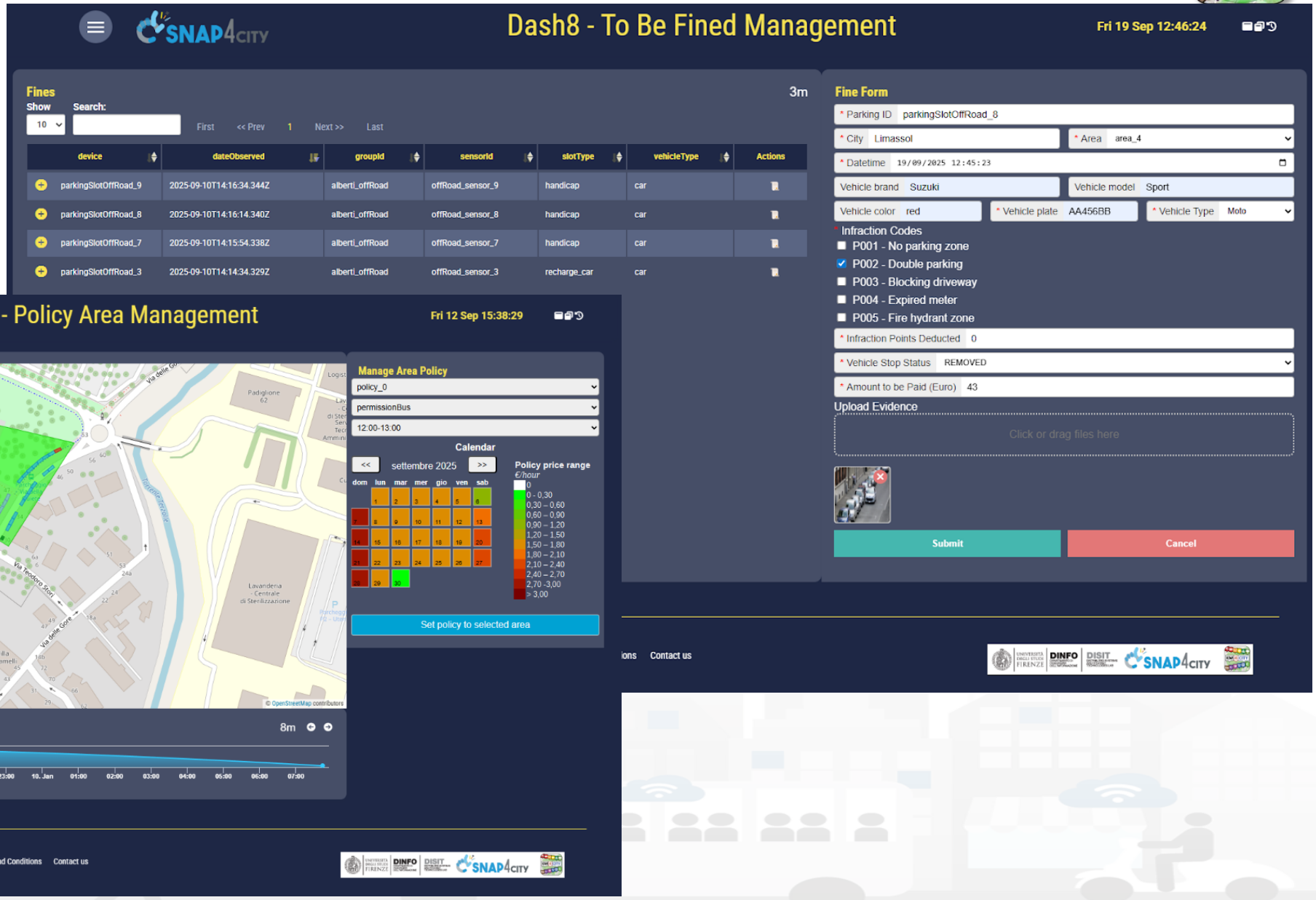
Snap4Parking

Smart Parking

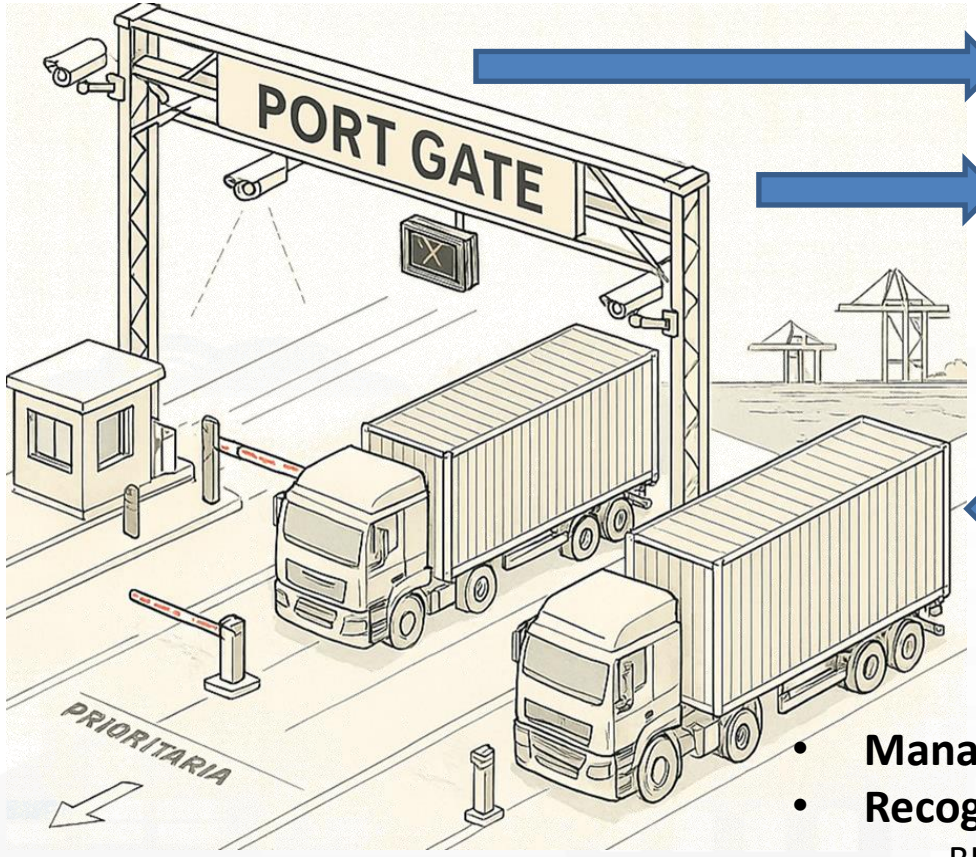
-- payments, profiles

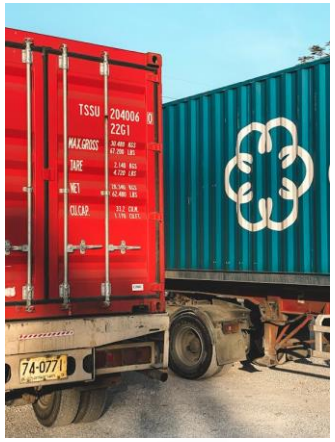
-- Fines

-- mobile for parking



Trucks' Plates and Container ID Recognition





Interoperability

Snap4City Platform

Signage/Control

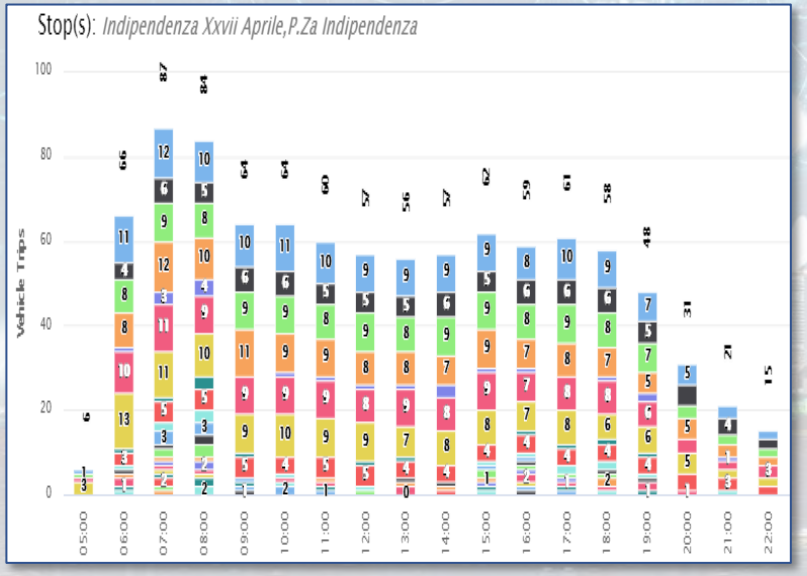
- **Managing Gates** in/out
- **Recognition and decoding**
  - BIC code: FCIU 964484 8
  - ISO code: 45G1
  - Seal status: on/off
  - Multi-national Plates: EX 398AE

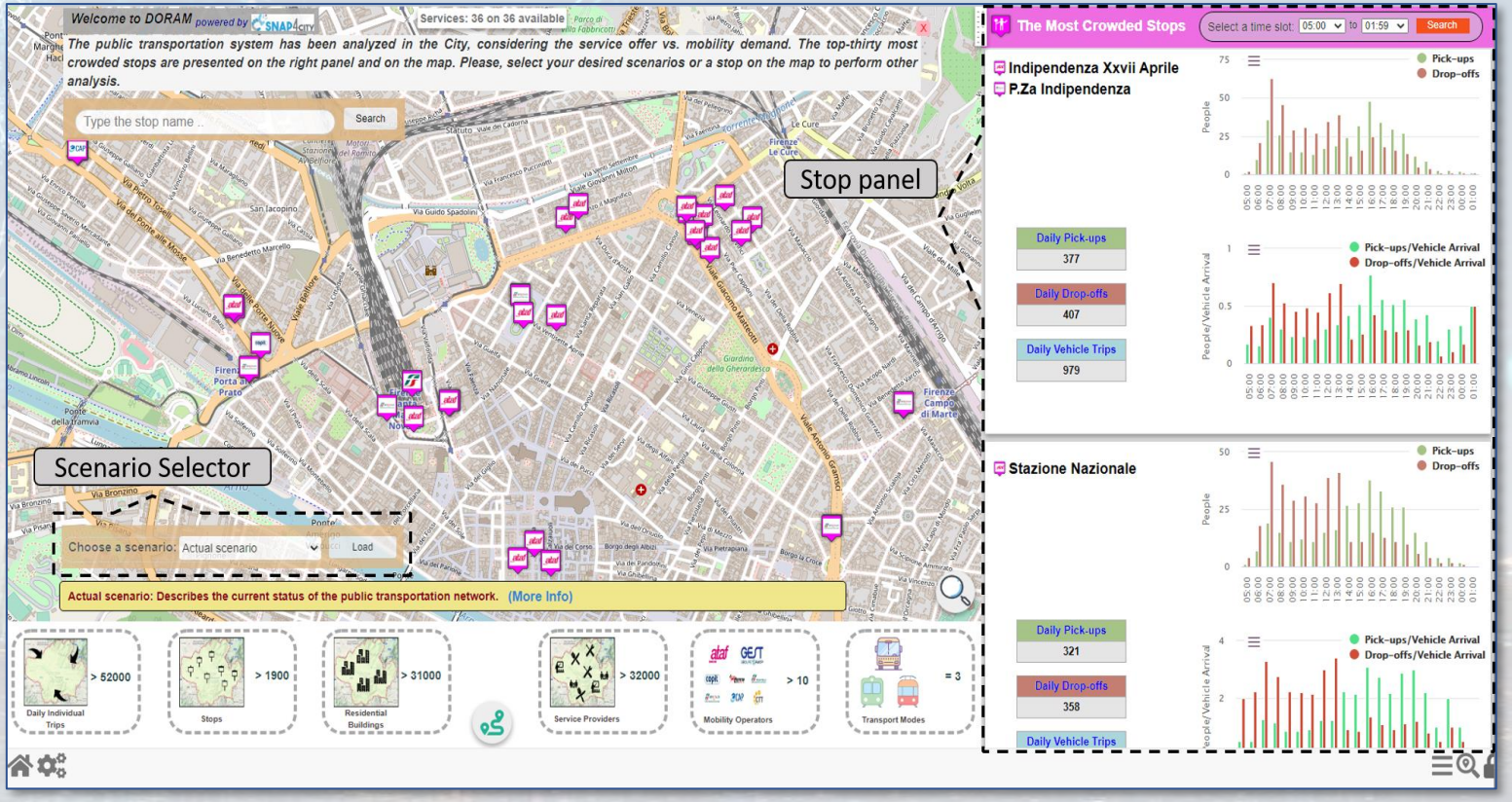
Mobility Demand vs Transportation Offer

What-if Analysis on Collective Transport: DORAM

- Simulation / analysis of Mobility Demand wrt Transportation Offer
  - **GTFS/TranSmodel vs ODM**, taking into account road graph and services
- Definition of scenarios impact on
  - Traffic, Pollutant, parking, public transport, private flows, etc.
  - KPI analysis

Public Services





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DORAM

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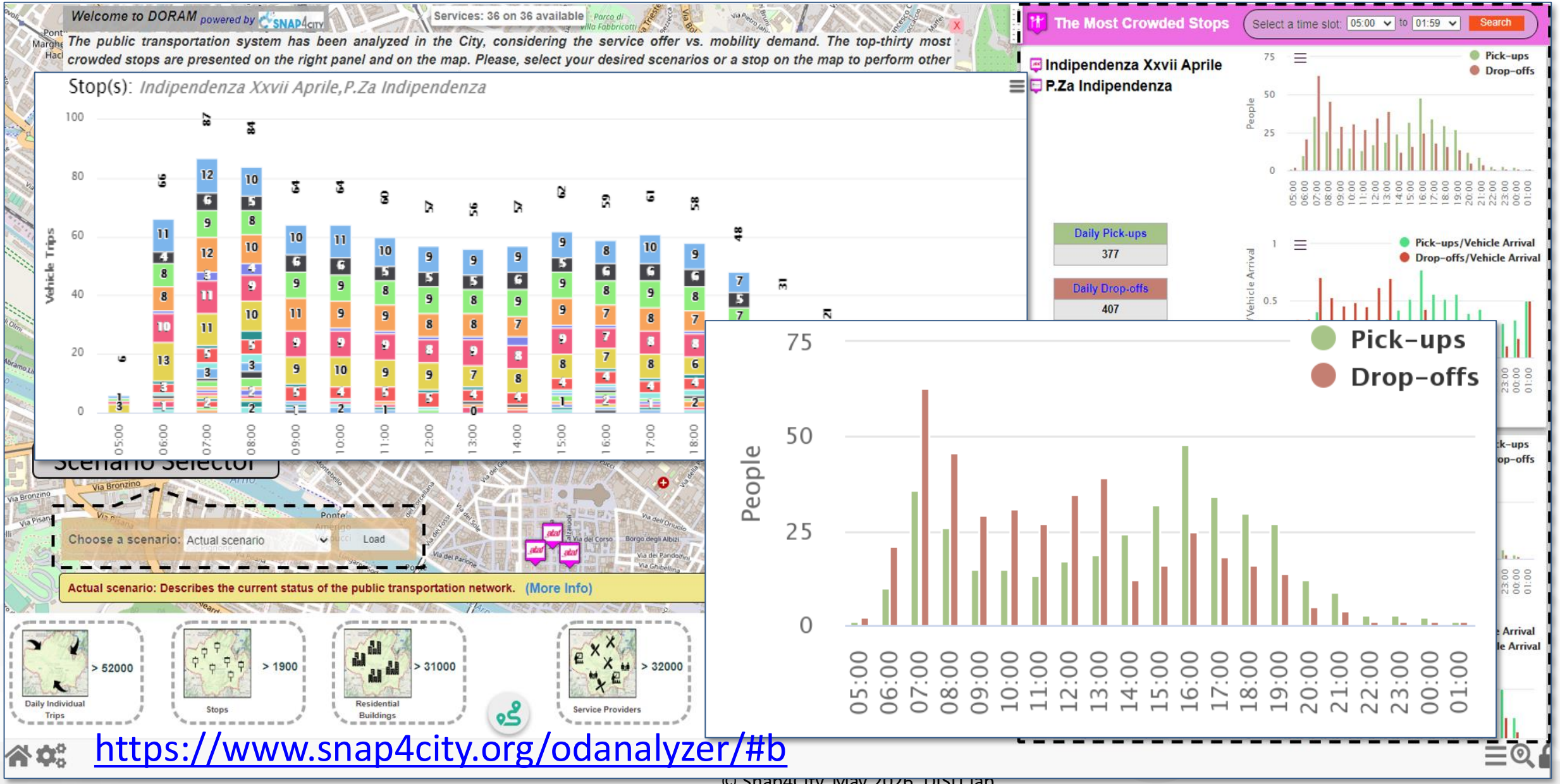

https://www.snap4city.org/odanalyzer/#b

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SNAP4CITY KM4CITY

SNAP4CITY

Traffic Simulation-K8S

Sun 22 Jun 11:53:30

Ext

STOP PAUSE HELP

slow fast

Delay: 30.0 ms

Stats

time: 0.000 s
payload: 0.0 KB
simulate: 0.00 ms
snapshot: 0.00 ms

Vehicle Summary

Quick Find

ID Edge / Lat, Long (float, float) / X,Y (int, int)

SEARCH

CAR BIKE TRAIN TRAM PERSON BUS LIGHT

Wid

Prepare Simulation | Execute Simulation | KPI Simulation

Simulation:

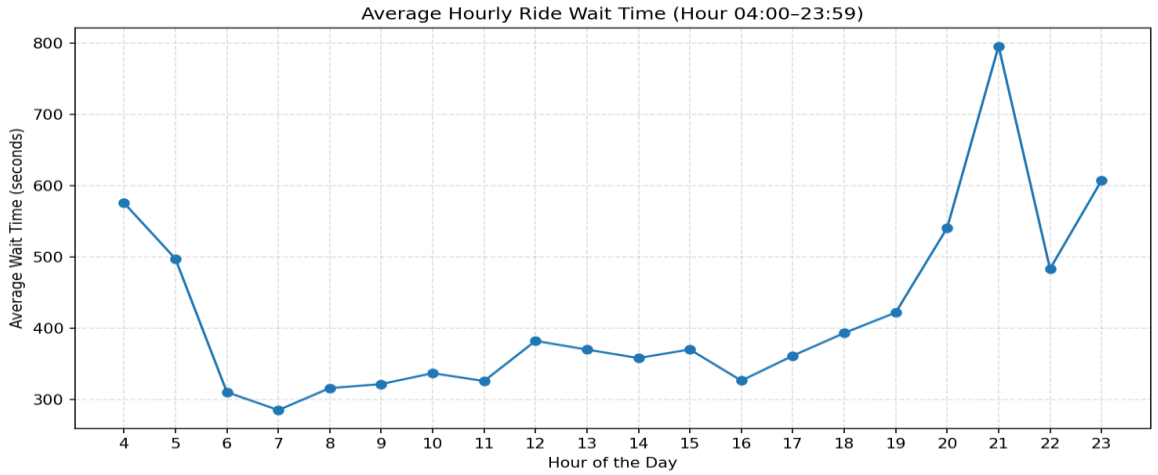
firenzeodbus

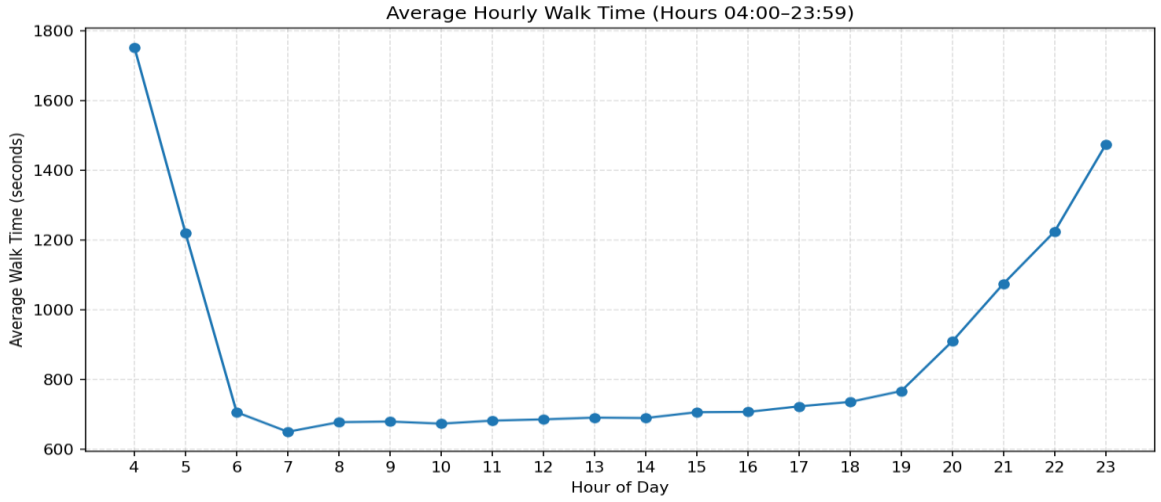
Execute

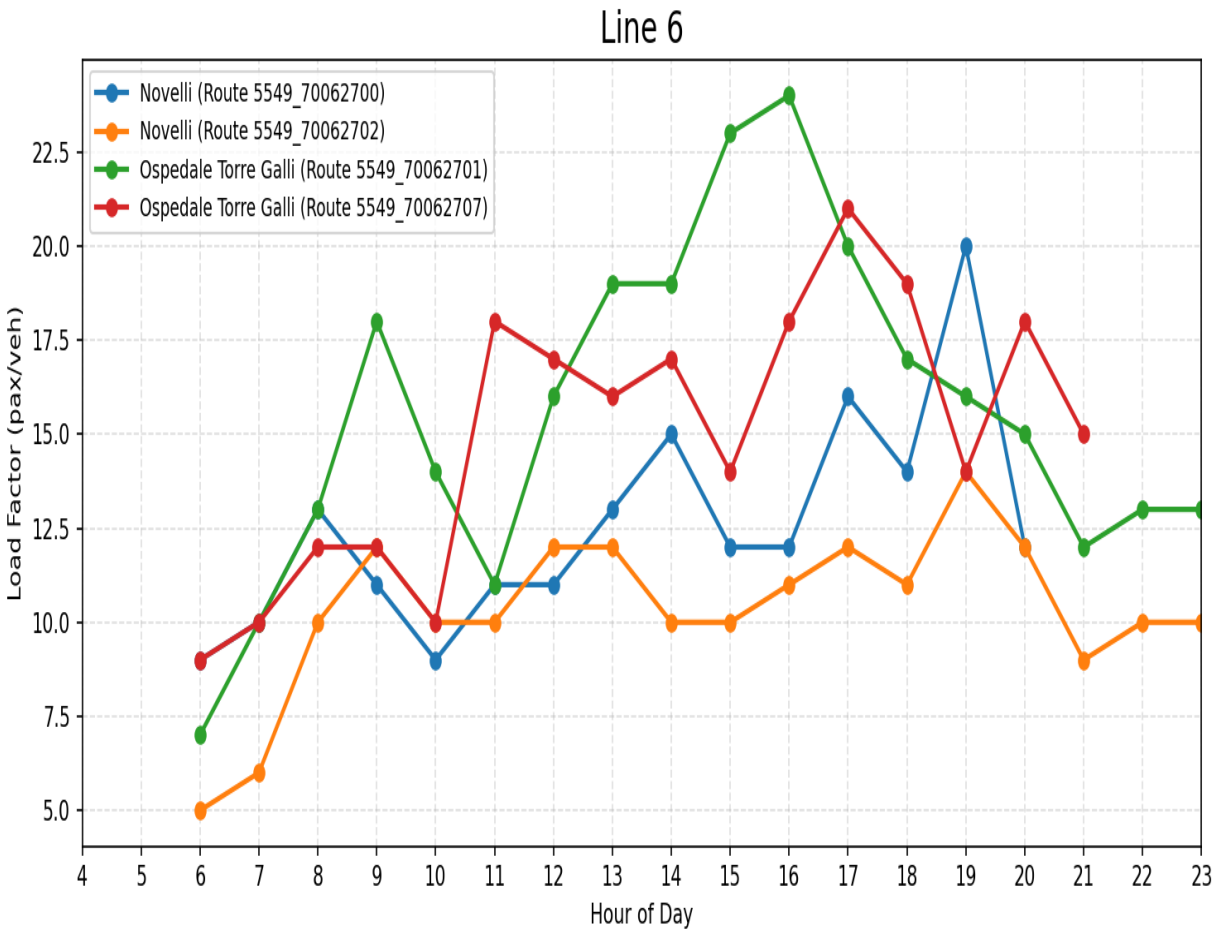
Simulation: 2025/06/22 11:53:27

My Profile

The typical working day







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Traffic Light Plan Optimization

MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

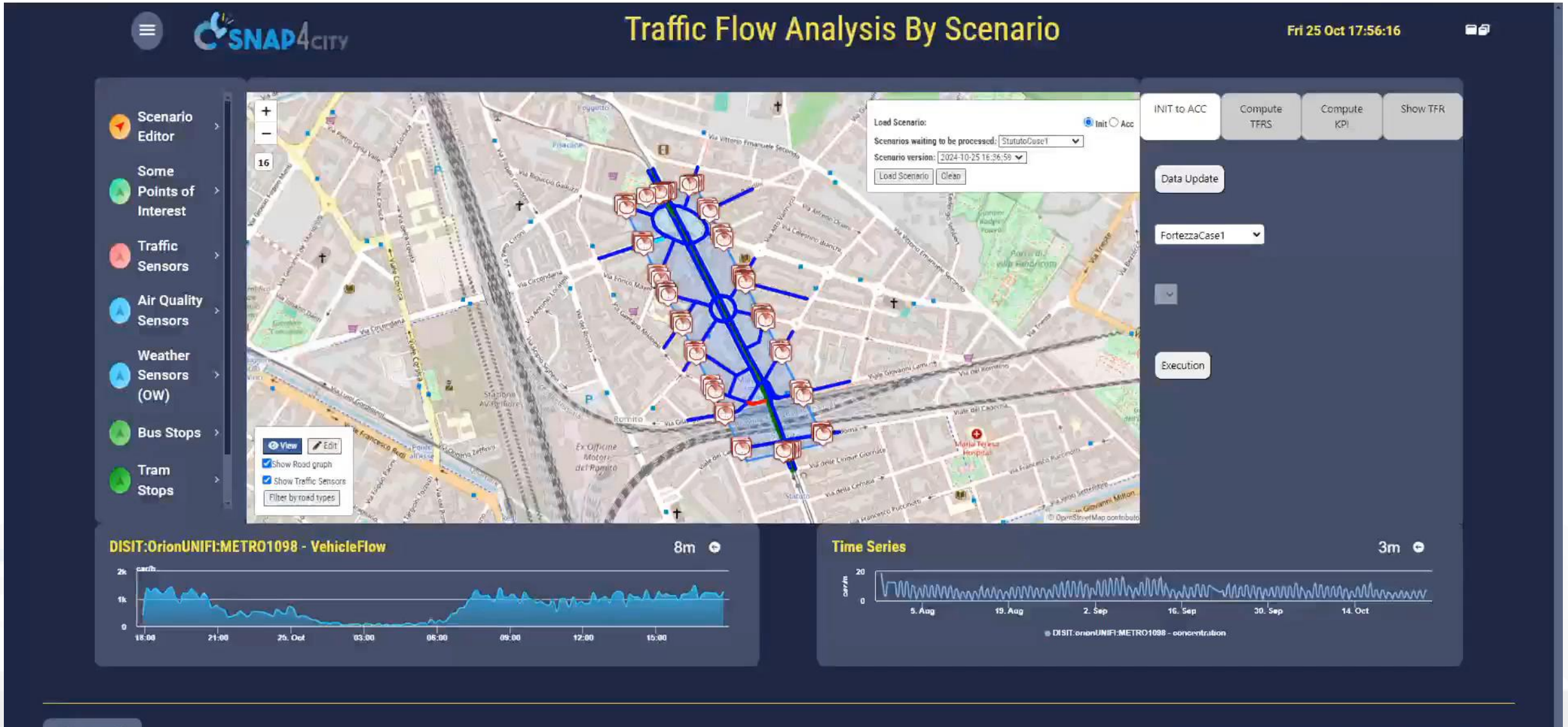
11 SUSTAINABLE CITIES AND COMMUNITIES

https://www.snap4city.org/1015

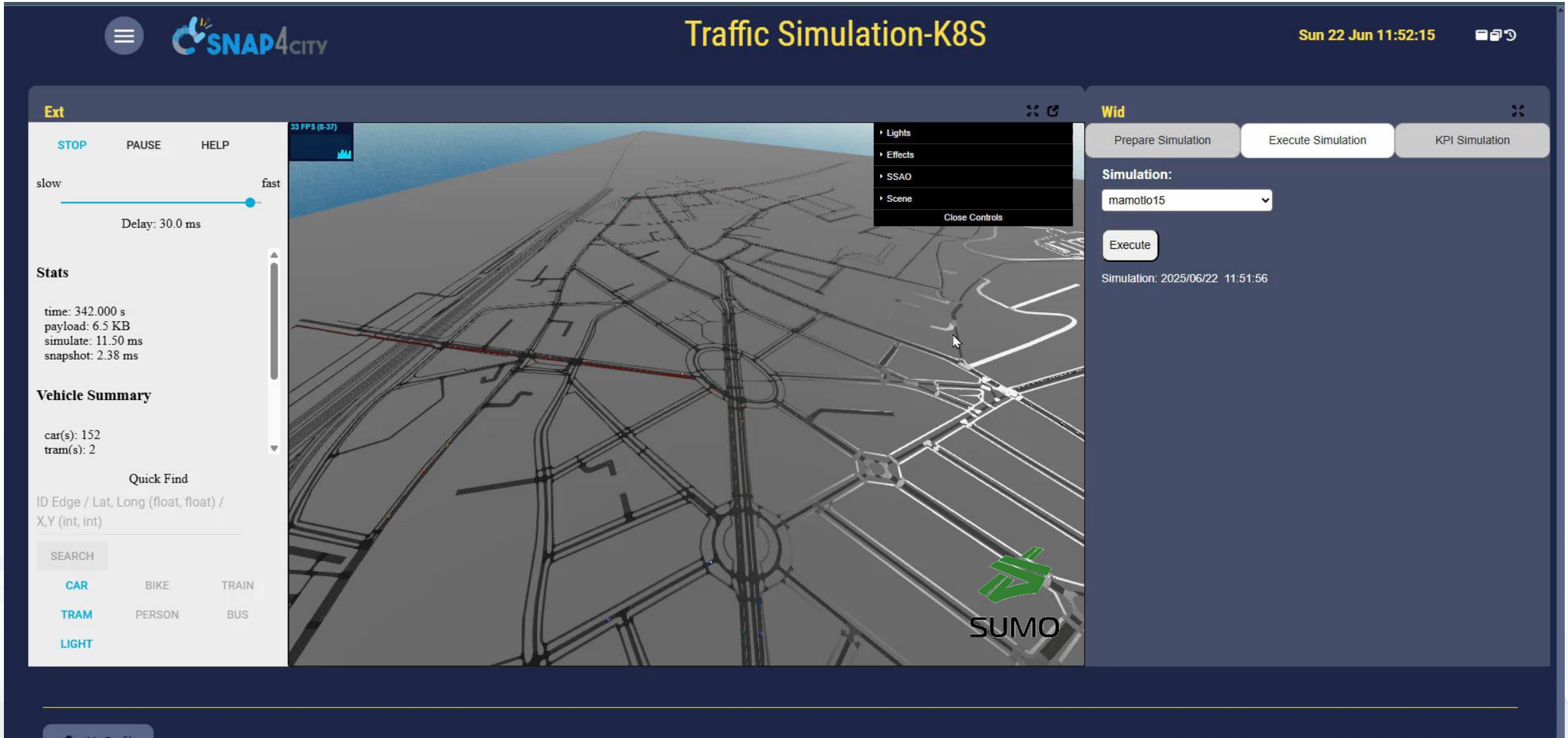
Traffic Light Optimisation

- **Traffic Light Plan:**
  - General construction of Traffic Light Plans for the area
  - TLP are loaded on the basis of the expected conditions: football game, ferial and festive, school period, morning and afternoon, etc.
  - Single Junction TLP can be:
    - adjusted exploiting local data, on demand signals, etc.
    - Actuated on the basis of the measures of traffic
- **Issues:**
  - Making multijunction synchronization to keep under control of quality of Service for TRAMWAYS and/or Busses Rapid Transit, BRT/HRB

Optimization of Traffic Light Plan



S. Bilotta, Z. Fereidooni, L.A. Ipsaro Palesi, P. Nesi, "Macroscopic GA-based Multi-Objective Traffic Light Optimization Prioritizing Tramways", Applied Soft Comp. Journal, Elsevier, 2025.



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SNAP4CITY | KM 4 CITY

Traffic Infrastructure Optimization

MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

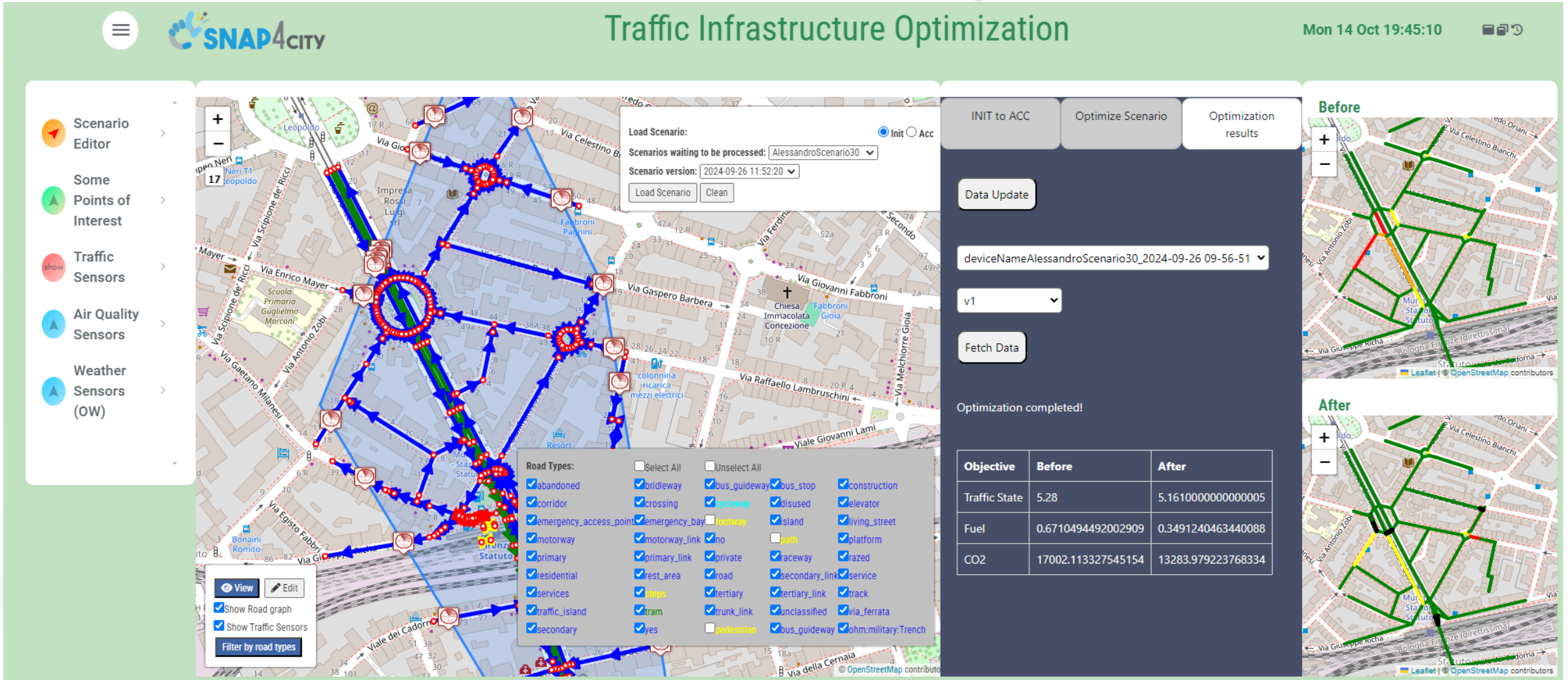
FROM CITY DASHBOARD TO APPLICATIONS

SNAP4CITY THE VIEW OF THE ADMINISTRATORS

11 SUSTAINABLE CITIES AND COMMUNITIES

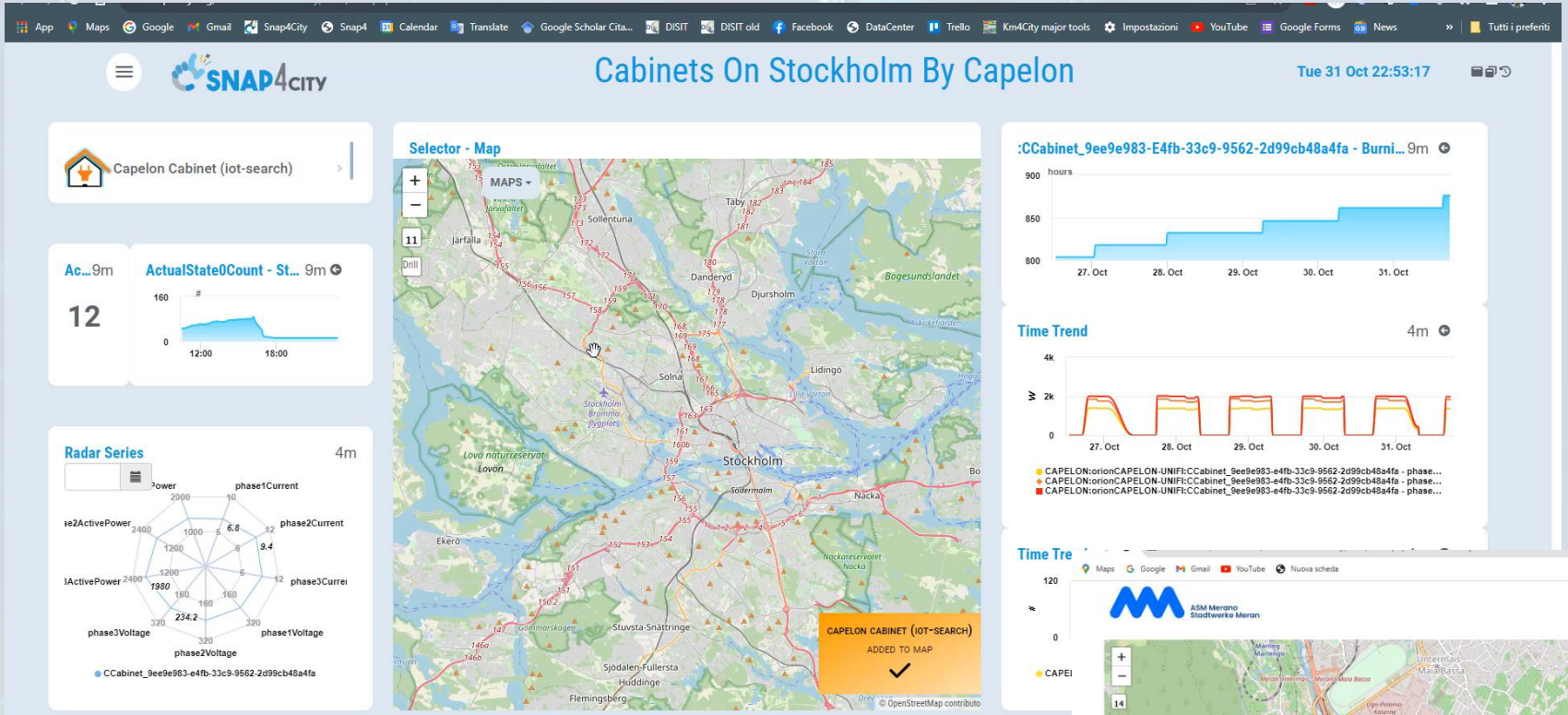
https://www.snap4city.org/1014

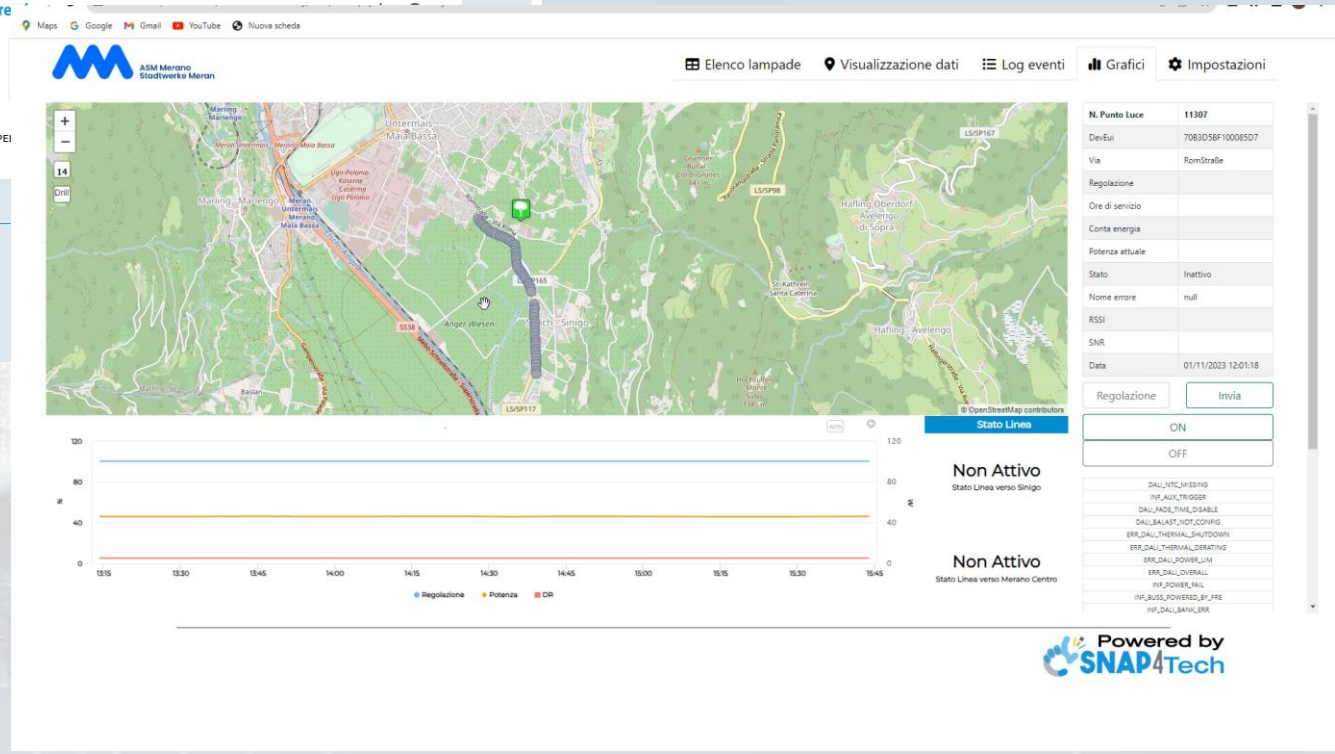
Traffic Infrastructure Optimization



Smart Energy and Smart Building

- Energy consumption reduction,
- increment of efficiency,
- Areas and building sustainability
- Improve accessibility to services,
- security and safety

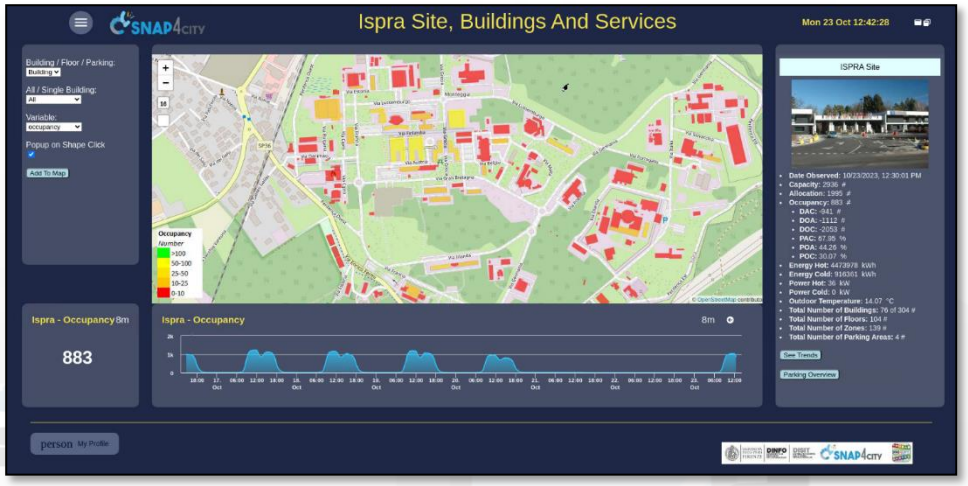




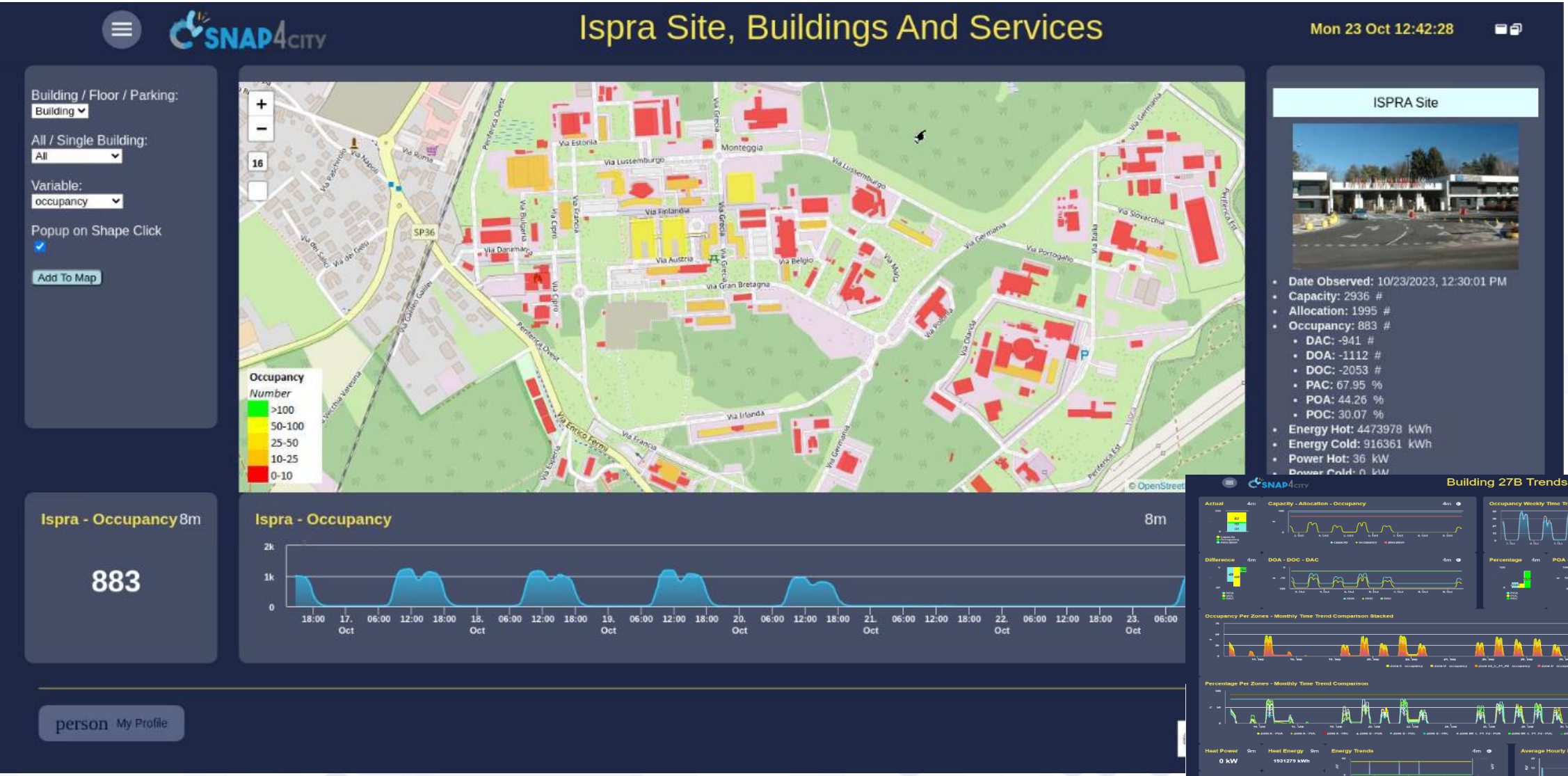
Smart Light Management

Snap4Building Domain (2024/8)

- Goals:
  - increase efficiency, cost reduction, sustainability
  - Accessibility to services, Security/Safety
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring: usage, energy, environmental conditions, people flows, services, etc.
  - Early detection/warning, alarm, of critical conditions, notifications, decision support
  - Production of suggestions/prescriptions, nudging
  - Managing smart services: cabinets, dispenser, lockers, etc.
  - Global and local 3D/2D representations of area and buildings
  - Integration with Video Management Systems
  - Computing predictions of any kind
- Solutions for Planning (optimization and what-if analysis)
  - Reduction of energy costs via optimization
- Algorithms and computational solutions, see next slide

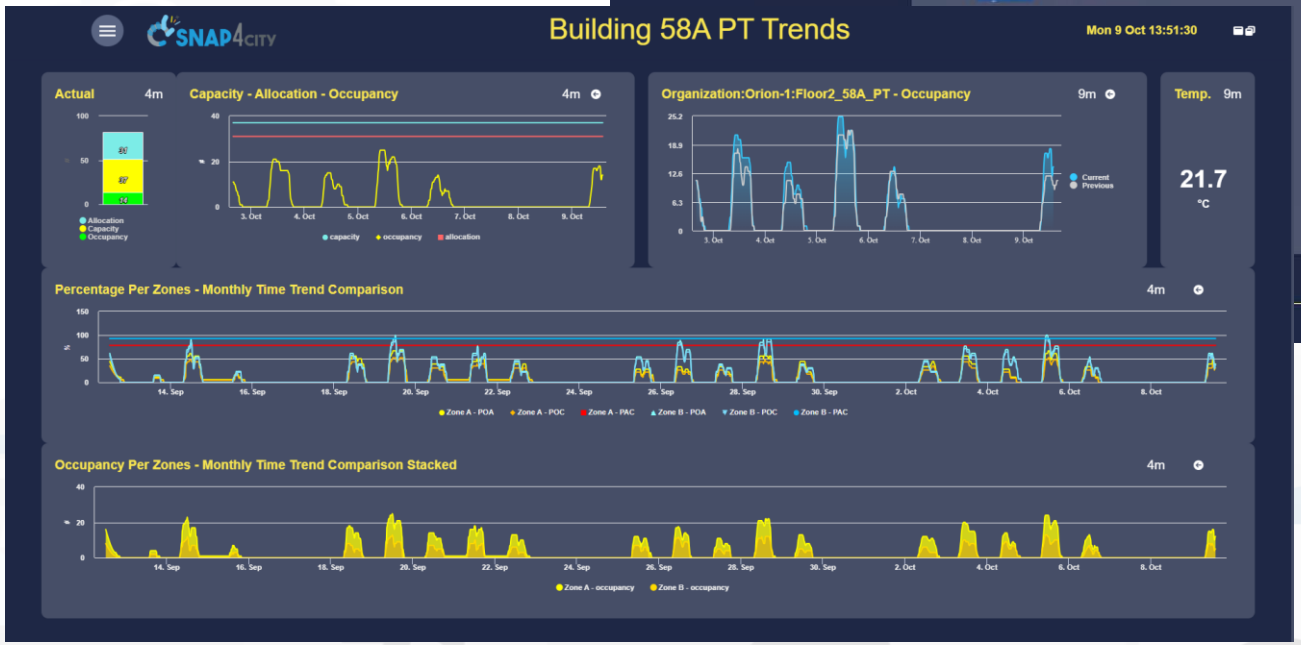


ISPRA JRC Site



Floor Details

ISPRA JRC Site

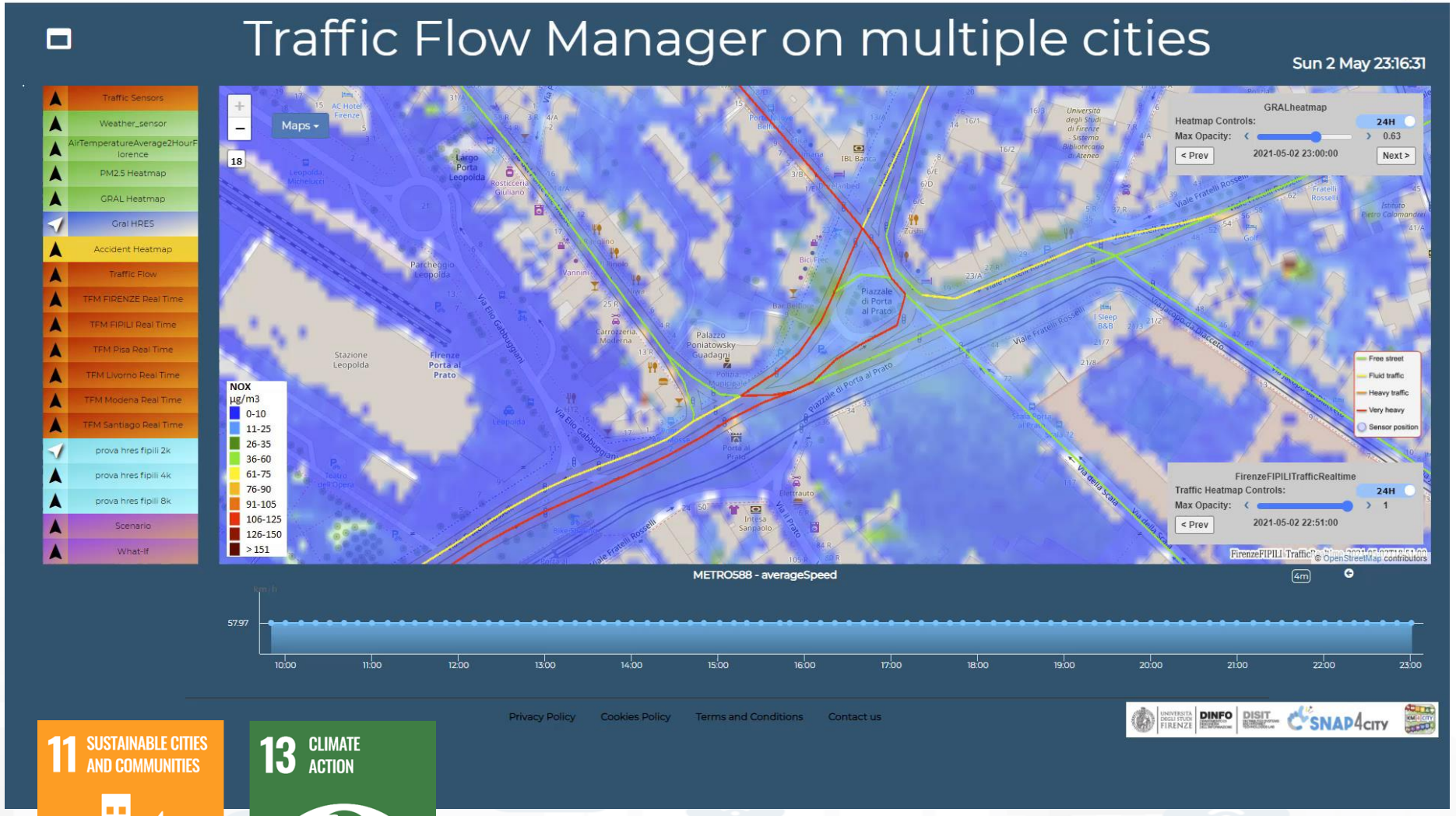


Environment and Waste Management goals

- *Control of emissions*
- *Reduction of emissions*
- *Early warning*
- *Meet the EC targets*
- *Reduction of EC taxation*

Environment

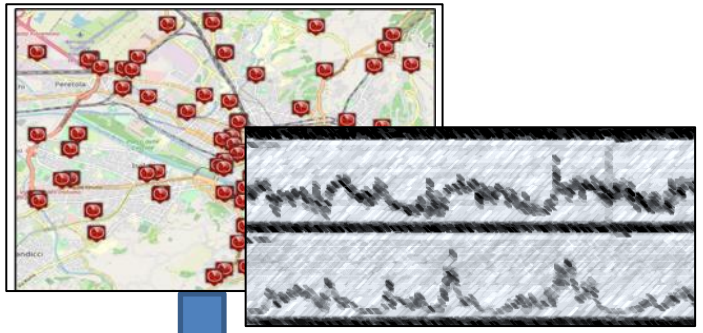
- **Prediction**
  - **NOX Pollutant** diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
  - **NO2 progressive average** (Long term)
- **Project:**
  - **Trafair** CEF EC
  - Mixed solutions of Fluidinamics modeling and AI



11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

Estimating City Local CO2 from Traffic Flow Data



Computing Traffic Flow into CO2 sensor area

Traffic Flow data

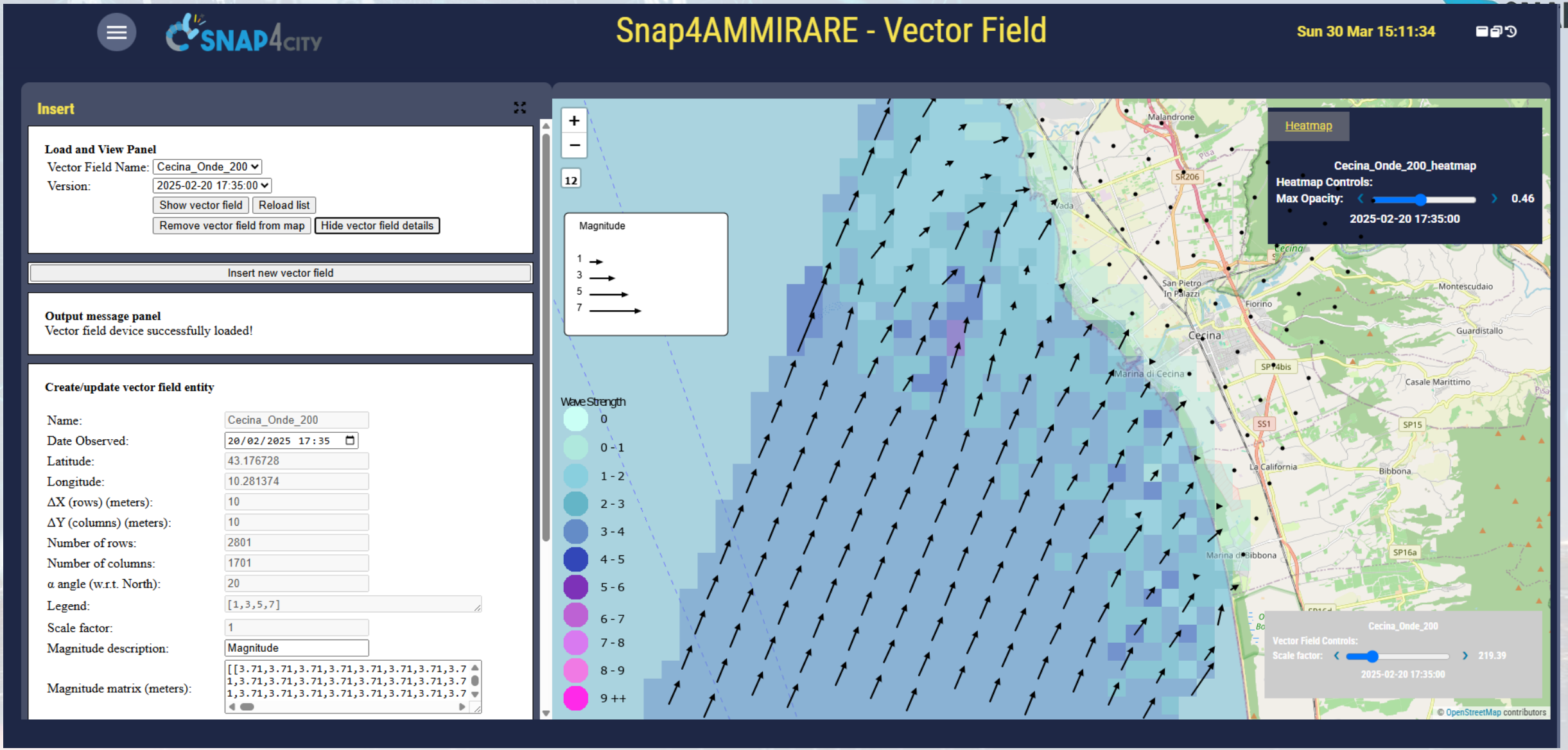
- Traffic Flow is one the main source of CO2 **(ton of CO2 x Km x Vehicle)**
  - **K1: Fluid Flow**
  - **K2: Stop and Go**
- **Dense estimation of CO2 into the city** is very useful to know to target EC's KPIs

Computing CO2 on the basis of traffic flow data

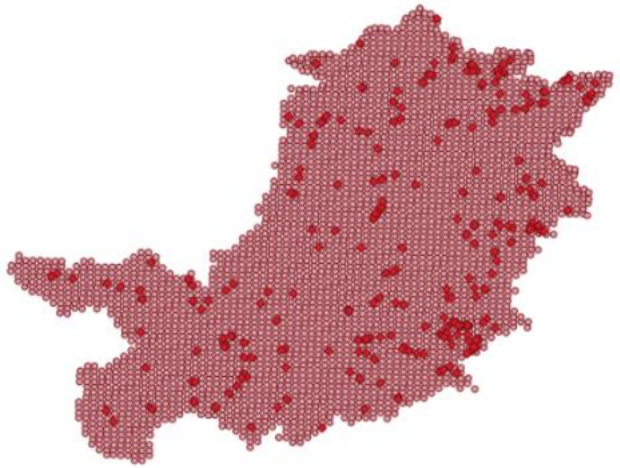
CO2 estimation

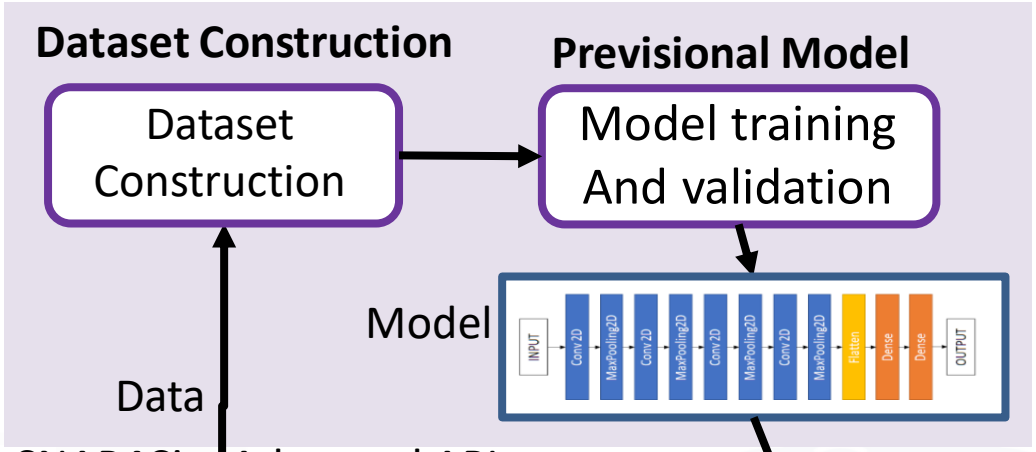
S. Bilotta, P. Nesi, "Estimating CO2 Emissions from IoT Traffic Flow Sensors and Reconstruction", Sensors, MDPI, 2022. https://www.mdpi.com/1424-8220/22/9/3382/

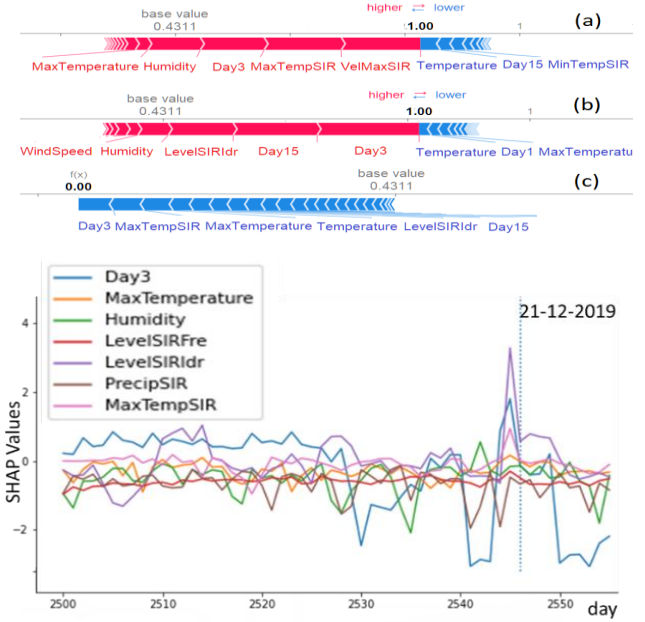
Monitoring Costal Bathymetry and Waves



Predicting Land slides







landslide DB

Real Time data from Field: rain, weather, etc.

Processes

Ingestion

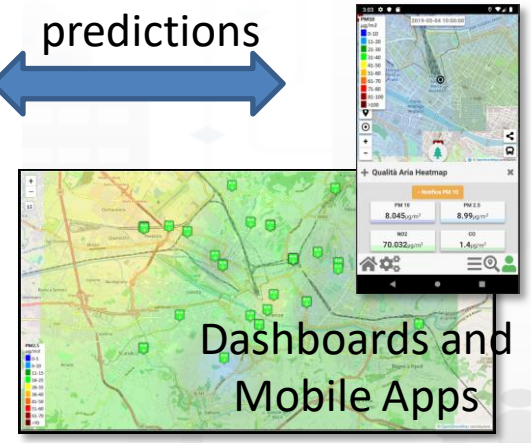
Big Data Storage and KB

Predictions

Model execution Shap Assessment

Data Analytics IOT App Management

predictions



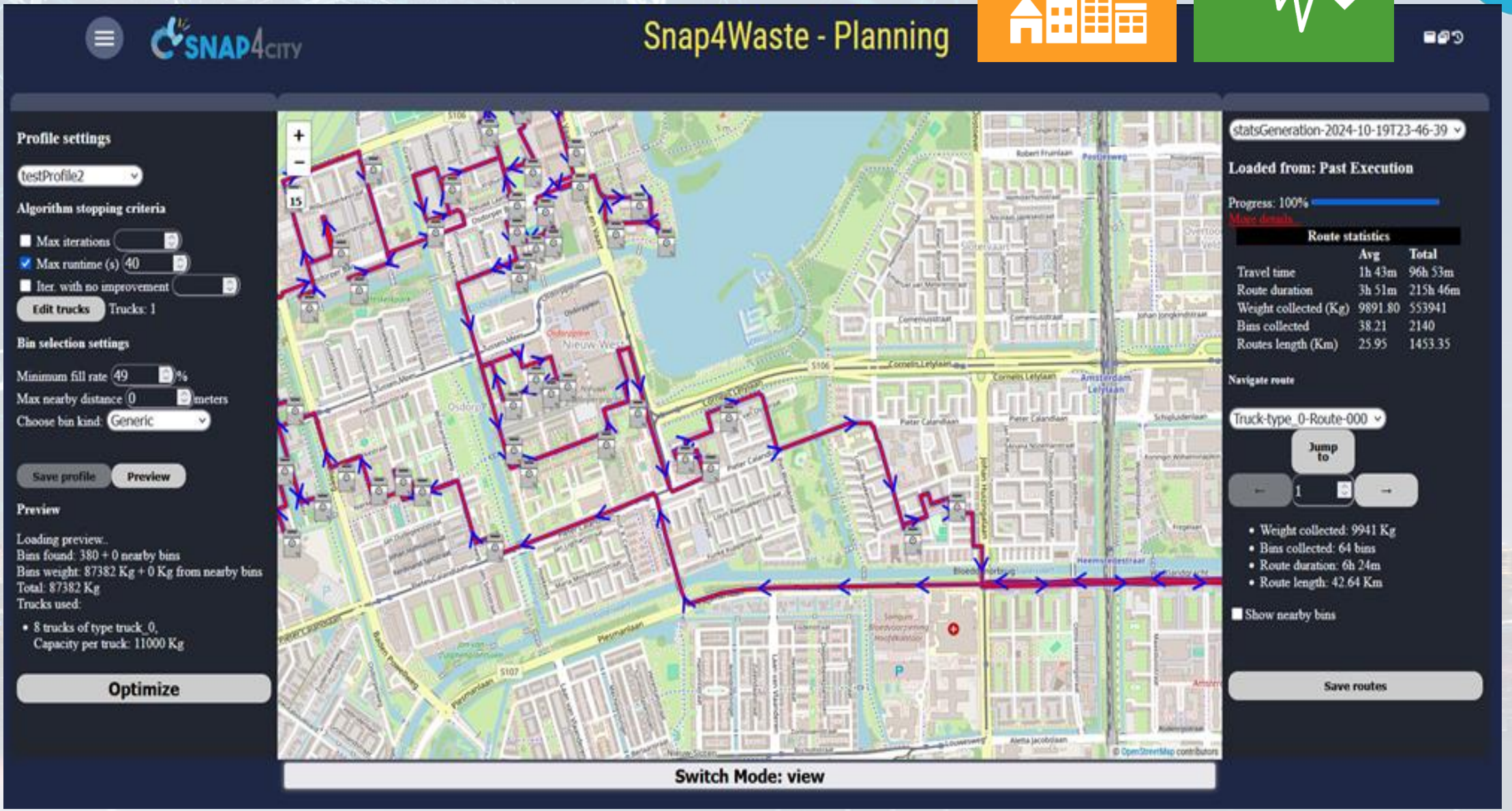
Snap4City Servers and Tools: Dashboard manager, Heatmap manager, GeoServer, Smart City API.

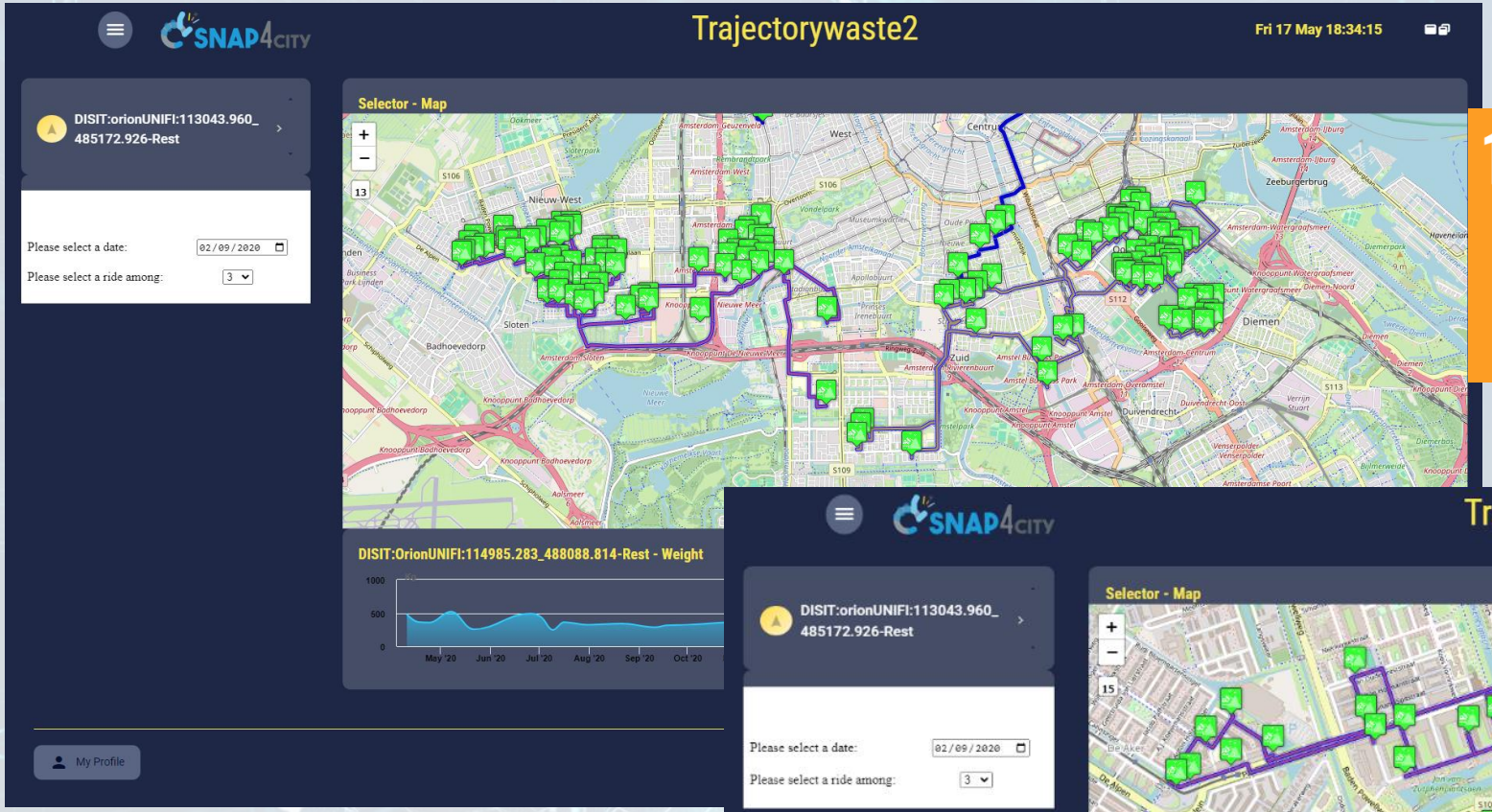
E. Collini, L. A. I. Palesi, P. Nesi, G. Pantaleo, N. Nocentini and A. Rosi, "Predicting and Understanding Landslide Events with Explainable AI," in *IEEE Access*, doi: 10.1109/ACCESS.2022.3158328.
https://ieeexplore.ieee.org/abstract/document/9732490

Waste Collection Optimization

11 SUSTAINABLE CITIES AND COMMUNITIES

3 GOOD HEALTH AND WELL-BEING





11 SUSTAINABLE CITIES AND COMMUNITIES

3 GOOD HEALTH AND WELL-BEING

Optimal Routing Collection

City Users' Services and Tourism Management

- Improve Quality of Life and quality of services,
- Over tourism mitigation, sustainability
- Costs reduction of services
- Improve accessibility to services: citizens, Tourists, commuters, etc.
- Improve Security/Safety of city users

Improve Quality of Life and quality of services

Over tourism mitigation, sustainability

Costs reduction of services

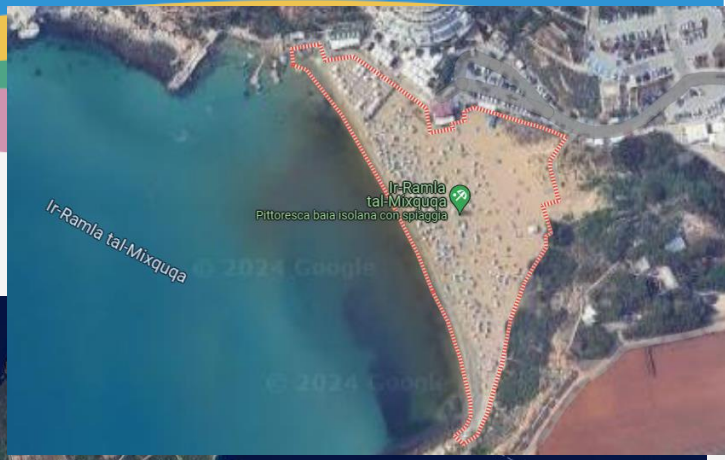
Improve accessibility to services: citizens, Tourists, commuters,

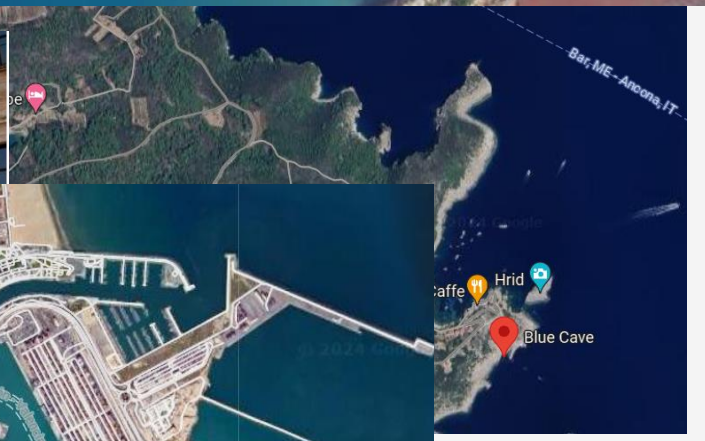
Improve Security/Safety of city users

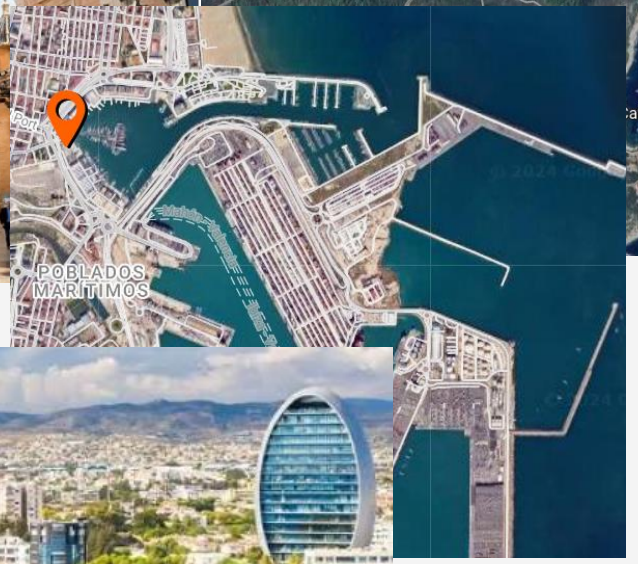
SMART CITIES. BETTER SERVICES. HIGHER QUALITY OF LIFE.

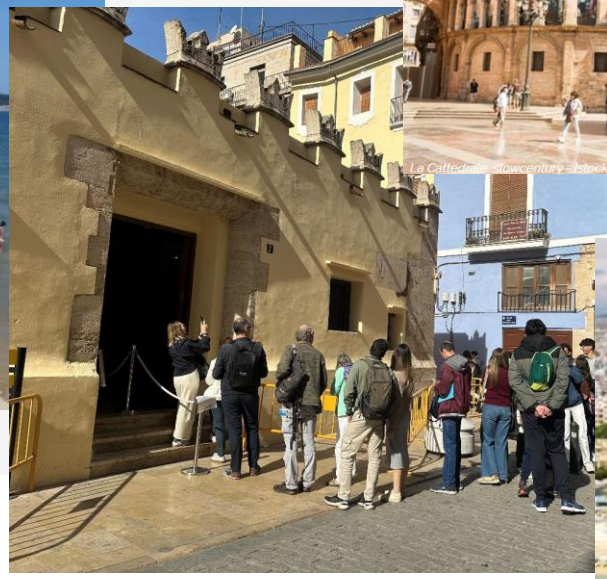
• Pilots of Snap4City on:

- Greece - READ S.A.: Rodi
- Italy – FRI, UNIFI: Firenze
- Spain – FV, FSMLR: Valencia
- Cyprus – ANELEM: Limassol
- Bulgaria – VEDA: Varna
- Croatia – RERA SD: Splitsko-dalmatinska županija
- Malta – MRDDF: La Valletta



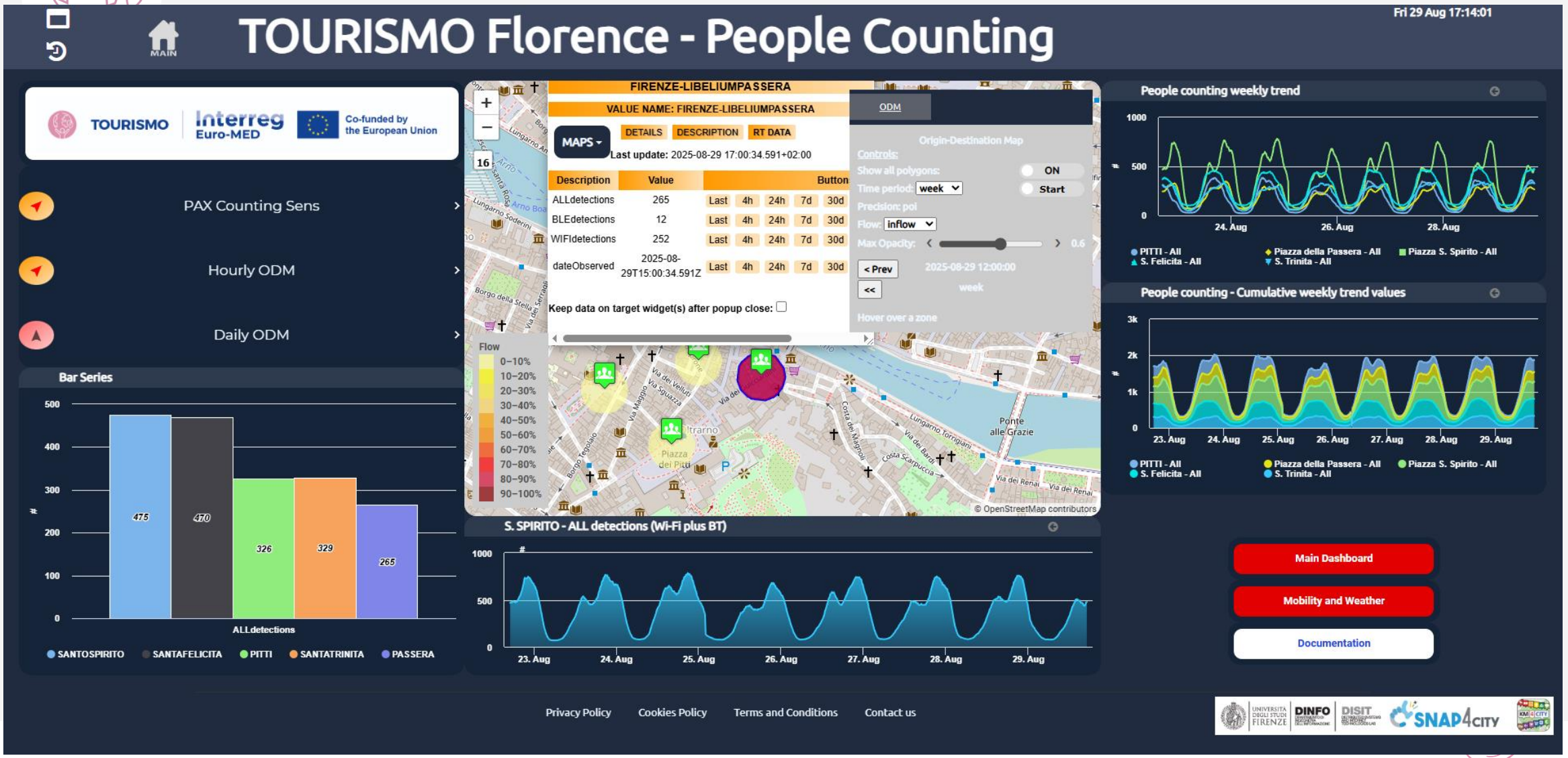




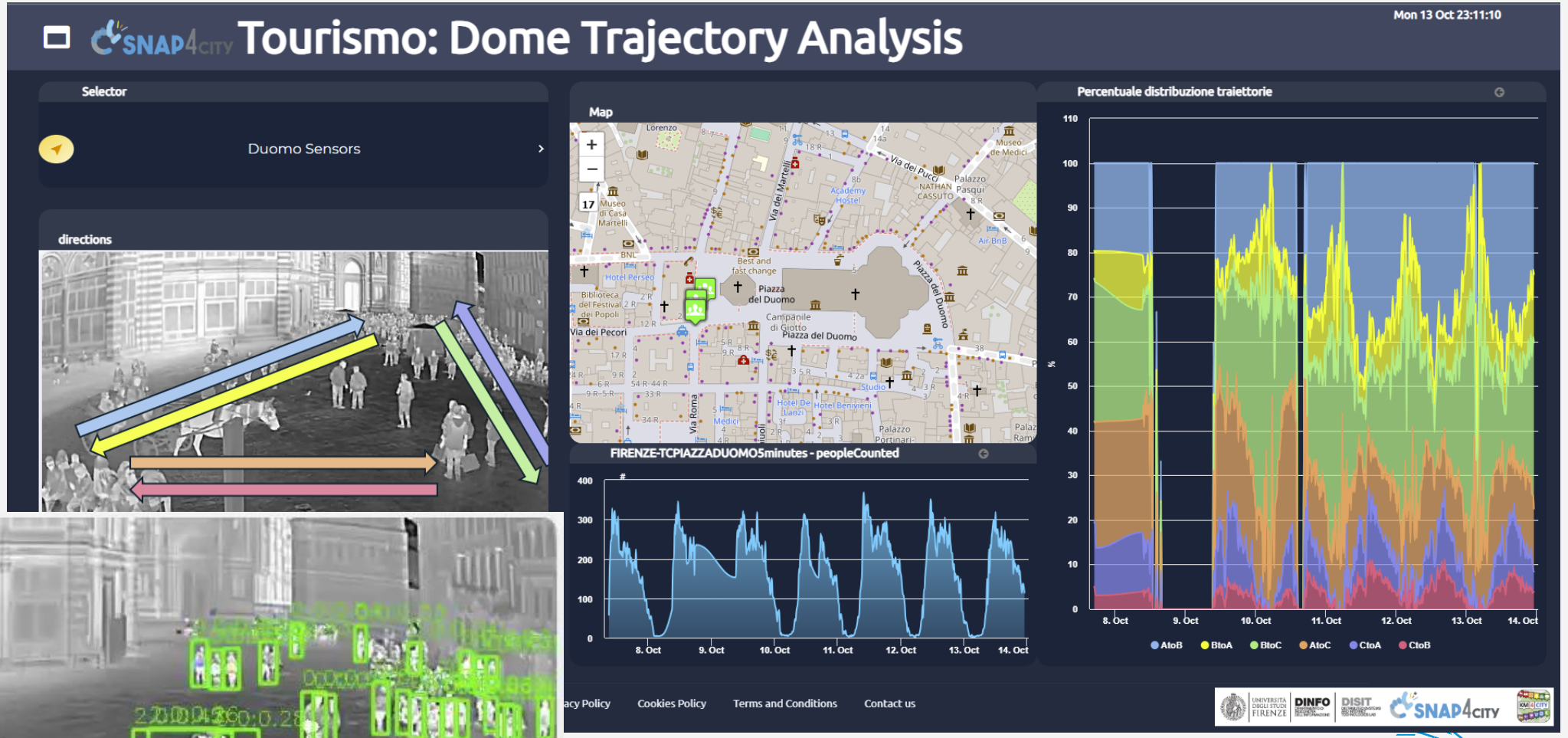


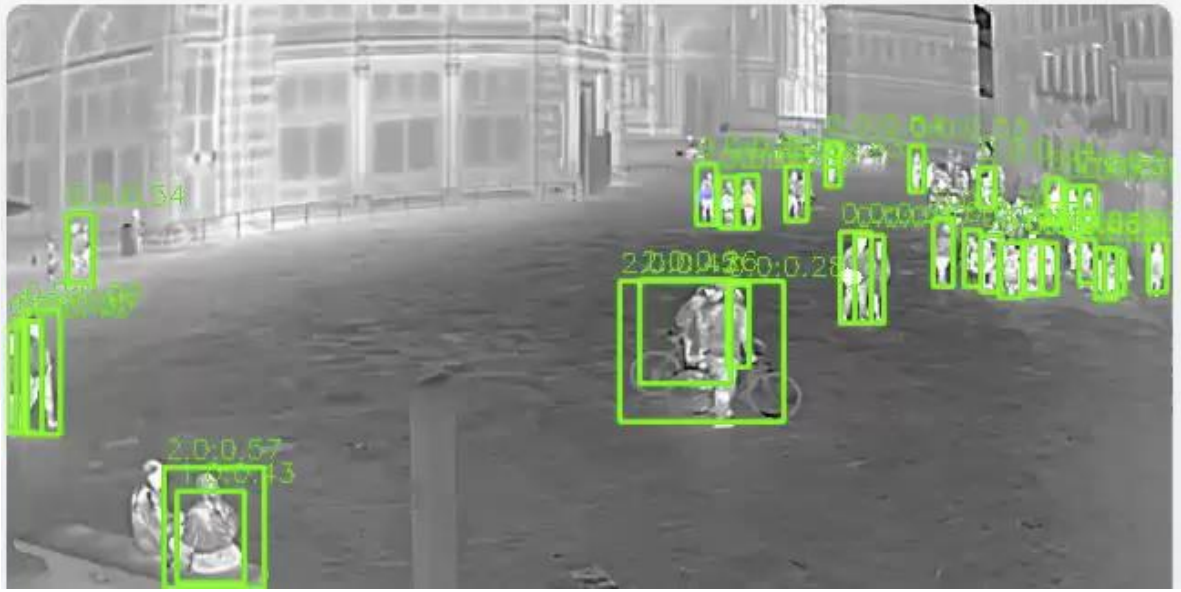
Interreg Euro-MED
Co-funded by the European Union

https://www.snap4city.org/dashboardSmartCity/view/newTheme.php?iddasboard=NDYzNQ==



https://www.snap4city.org/dashboardSmartCity/view/newTheme.php?iddasboard=NDcyMQ==





Assistants on taking decision and for training/development

Logged in as:
edoardo_tester

Your Profile

Logout

New Chat

EdoChat1

EdoChat2

EdoChat3

EdoChat4

prova

chatNuova

chatTest1LLAMA

chatTest2LLAMA

testGianniLLAMA

testTastoInvioPreChanges

ChatTestPostPSWINVIO

https://www.snap4city.org/1116

SnapAdvisor

Current chat: debug0

Visualize references

Personal Advisor LLM

Come creo una dashboard?

Per creare una dashboard, puoi utilizzare la piattaforma Snap4City. La dashboard si compone di un insieme di widget grafici che possono essere impostati separatamente assegnando una serie di parametri, come origine dati, dimensioni, colori, forma, font, allarmi, relazioni con altri, ecc. (SOURCE: Snap4 City per la creazione di Smart City Control Room, SCCR). Inoltre, la piattaforma offre la possibilità di creare vere e proprie applicazioni interattive, multipagina/multidashboard, e non semplici storie monopagina da scrollare. Puoi anche condividere la dashboard con altri utenti anche fuori dalla Smart City Control Room tramite canali autenticati e protetti in HTTPS, in accordo al GDPR (SOURCE: Snap4 City per la creazione di Smart City Control Room, SCCR). Per vedere alcuni esempi di dashboard, puoi visitare il sito https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjU0Mg== (SOURCE: Snap4 City 1st Overview v4 8 annot). Tuttavia, non ho trovato informazioni dettagliate sulla procedura di creazione di una dashboard. Se hai bisogno di ulteriore assistenza, ti consiglio di contattare direttamente il team di supporto di Snap4City. Non so dirti altro in merito.

Write a message...

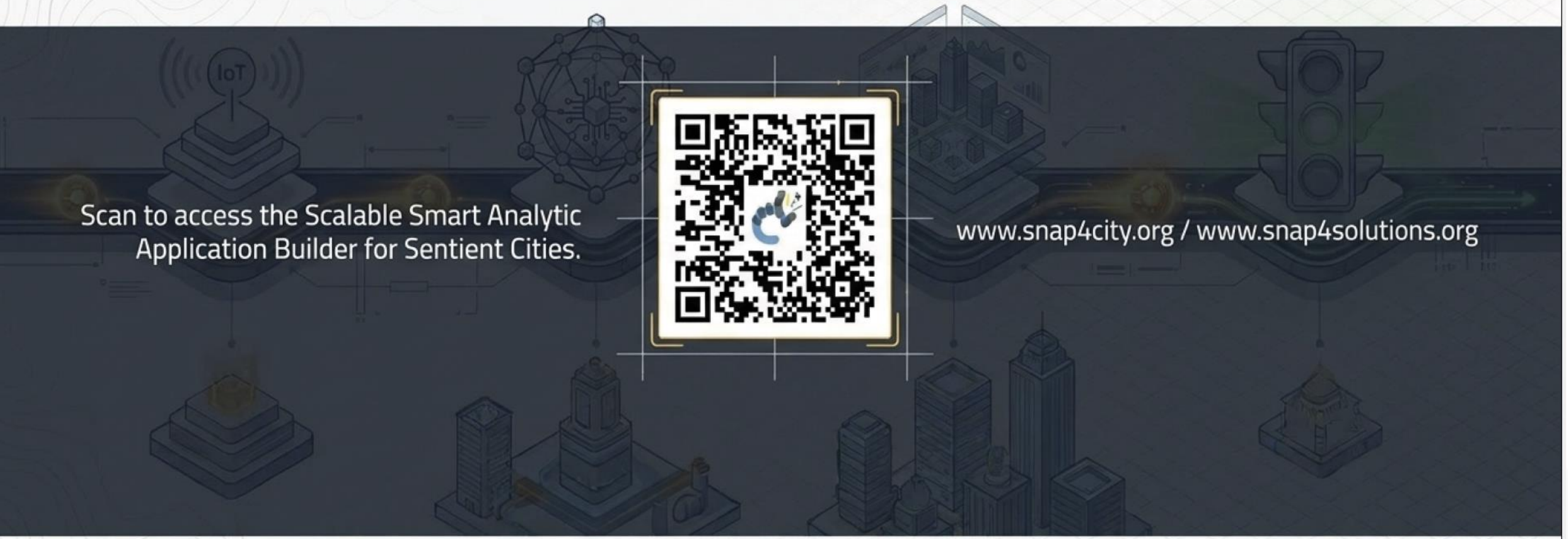
SnapAdvisor

- **working on your private content** and thus producing answers.
  - Select a subset of documents
- **domain control**: you can decide the knowledge base (internal wikis, PDFs, APIs),
- **explainability** capability, provide references to your documents
- **multilingual via content**
- **modularity**: it is possible to pass from one collection of documents to another, and multiple users can work on the advisor asking for different topic on different collections/domains at the same time, independently as needs change, without any interferences among them.
- **lower hallucinations**

https://www.snap4city.org/1116

Build the Future of Your City

SNAP4CITY



Scan to access the Scalable Smart Analytic Application Builder for Sentient Cities.

www.snap4city.org / www.snap4solutions.org

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PEN Test Passed

EU GDPR COMPLIANT

SNAP4 Appliances and Dockers Installations

EUROPEAN OPEN SCIENCE CLOUD

Node-RED

JS Foundation

E015 digital ecosystem

NVIDIA

OPERATION AND PLAN - CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS - OPTIMIZATION - APPLICATIONS

HORIZONTAL AI PLATFORM

MOBILITY AND TRANSPORT

SMART ENERGY AND SMART BUILDING

ENVIRONMENT AND WASTE MANAGEMENT

CITY USER'S SERVICES AND TOURISM MANAGEMENT

SNAPADVISOR

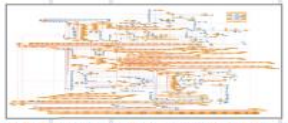
BUSINESS INTELLIGENCE - SIMULATIONS - VISUAL ANALYTICS - SYNOPTICS - GRAPHICAL WIDGETS - ANALYTICS

DASHBOARDS, WIDGETS
TEMPLATES

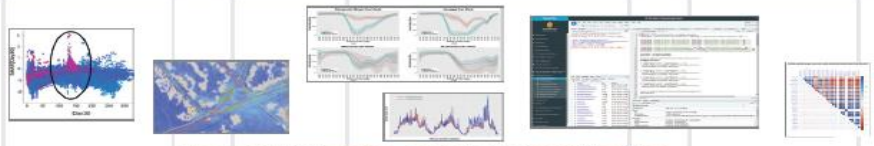
PREDICTION - ANOMALY DETECTION - CLUSTERING - ROUTING - SENTIMENT NLP - TRAFFIC FLOW - PEOPLE FLOWS - SDG
15 MIN CITY INDEX - KPI - HEATMAPS - ORIGIN DESTINATION - MAPS - VECTOR FIELD - ETC...

API - MICROSERVICES - GIS - BPM
VIDEO - REPORTS - MAPS - 3D ...

- DEVELOMENT ENVIRONMENT AND METHODOLOGY
- VISUAL PROGRAMMING, ML, AI, HPC
- TRAINING COURSES



EXPERT SYSTEM, KNOWLEDGE BASE
SEMANTIC REASONING
SMART DATA MODEL
IOT DEVICE MODELS, DATA SPACES



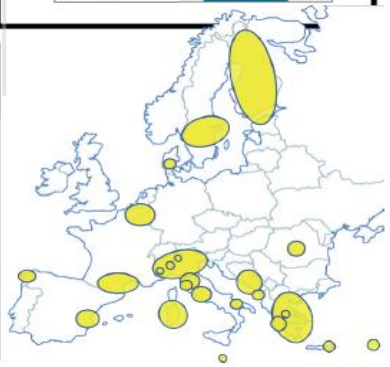
BIG DATA ANALYTICS, ARTIFICIAL INTELLIGENCE
EXPLAINABLE AI, MACHINE LEARNING, GENERATIVE AI
OPERATIVE RESEARCH, STATISTICS

VISUAL PROGRAMMING, ADAPTERS
DATA FLOWS, WORKFLOWS
PARALLEL DISTRIBUTED PROCESSING
DATA DRIVEN

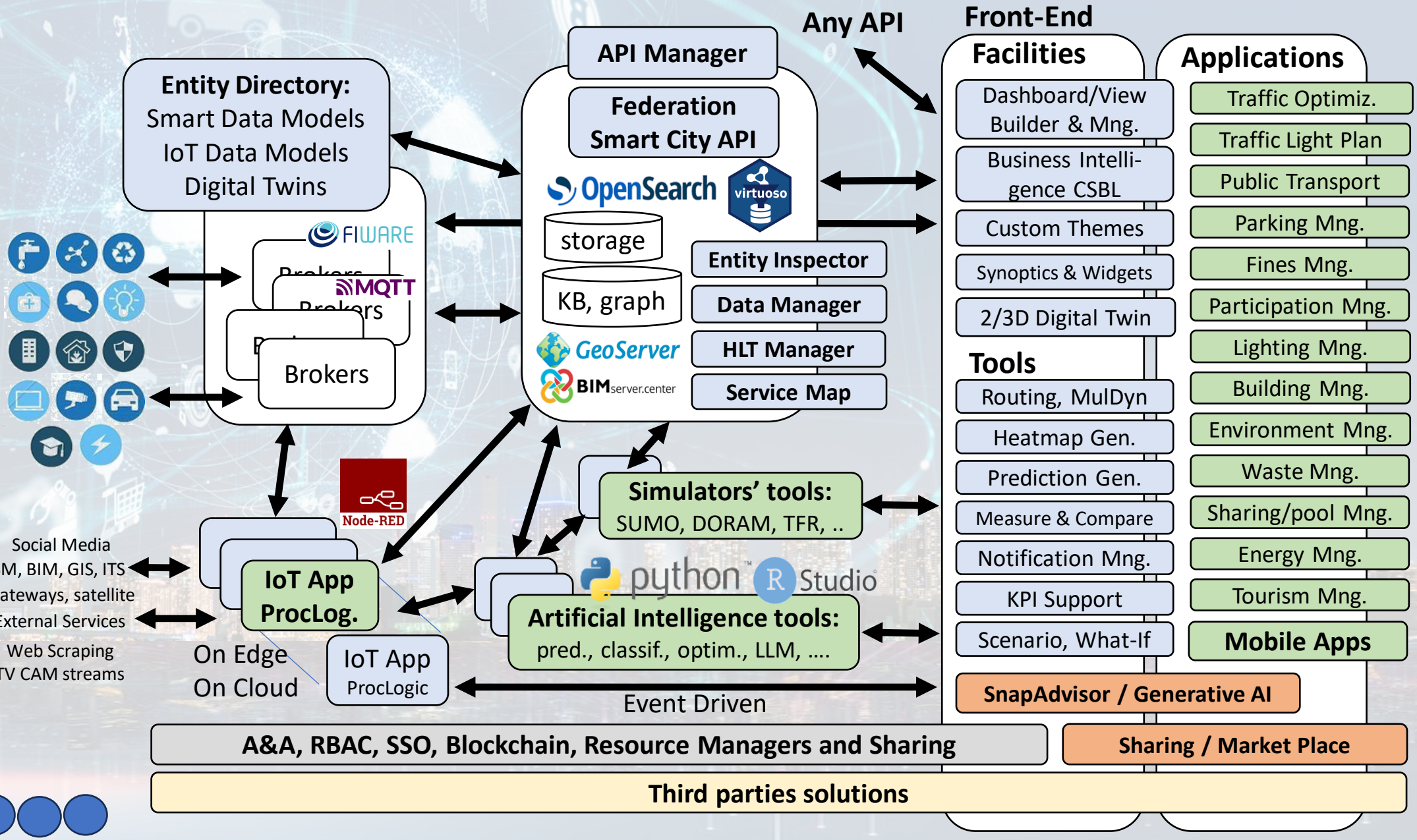
FULL INTEROPERABILITY, ANY: DATA, BROKERS, NETWORKS AND VERTICALS

NATIVE AND EXTERNAL APPLICATIONS

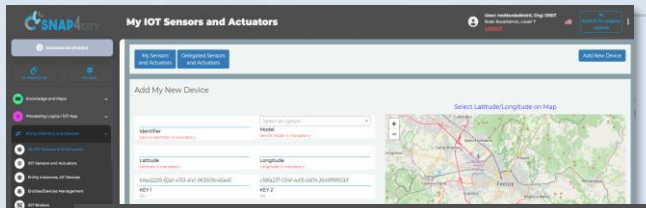
- Smart Parking
- Smart Light
- Smart Waste
- Smart Energy
- Smart Building
- Smart Tourism
- ...

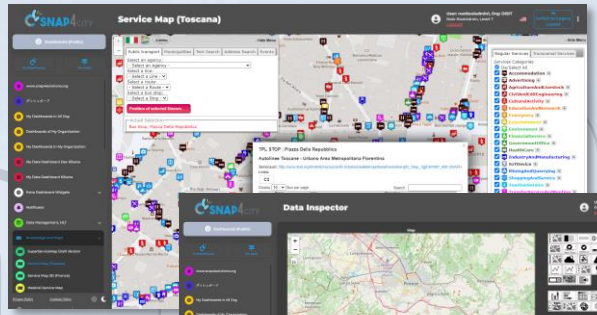


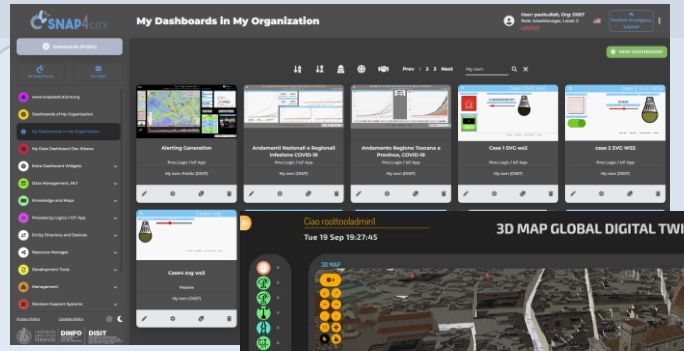
Technical Architecture

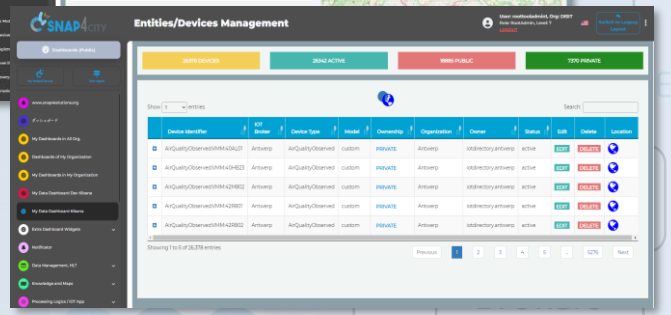


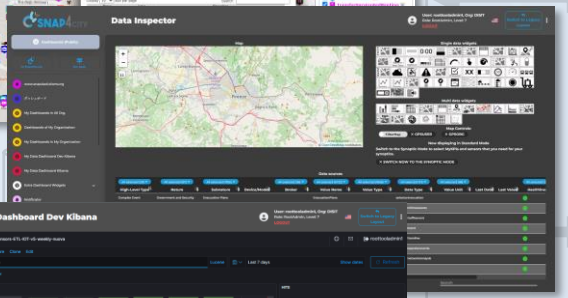
Visual Development Tools

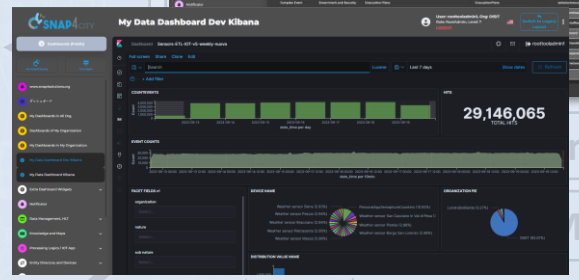


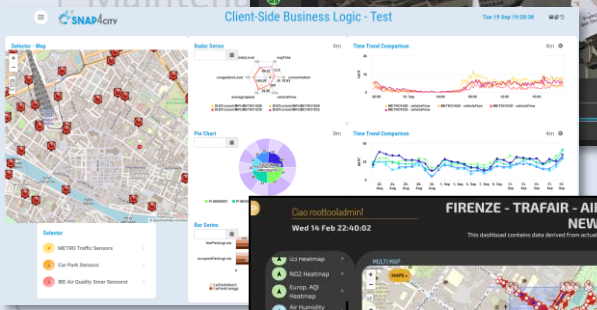


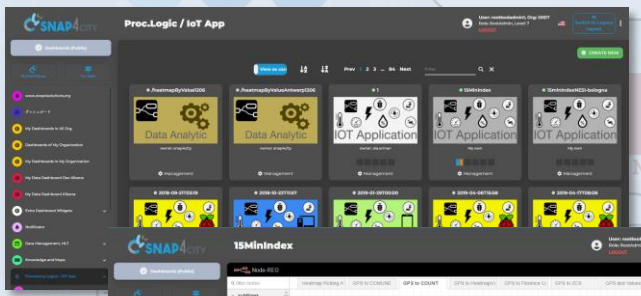


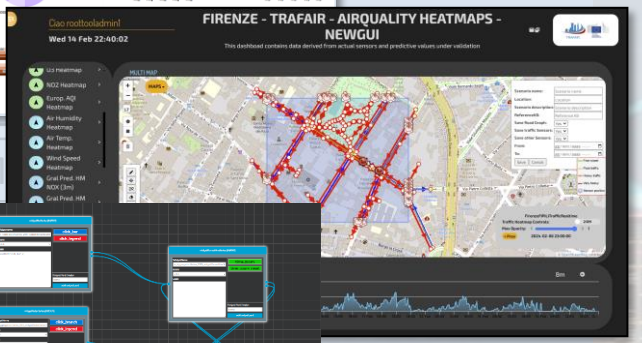


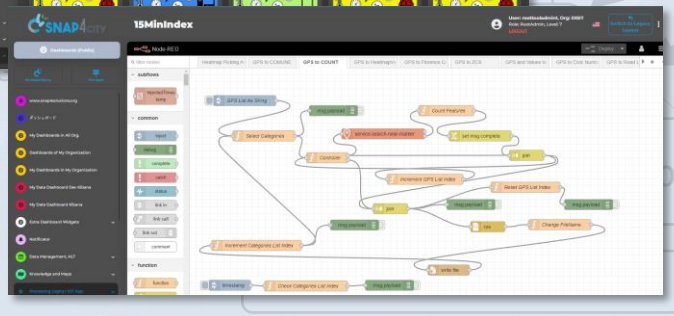


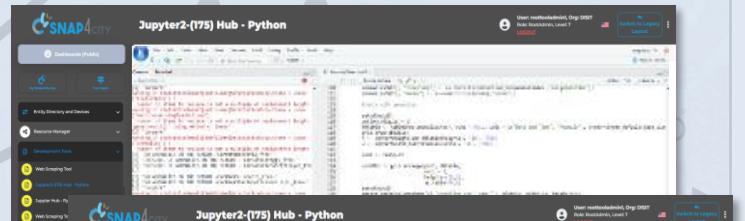


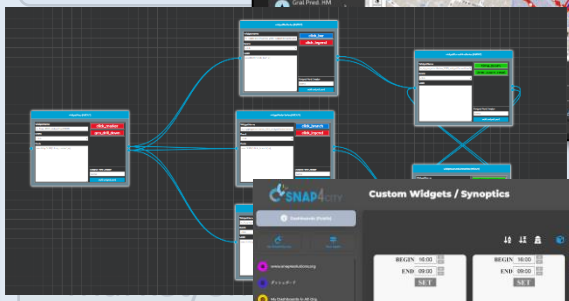


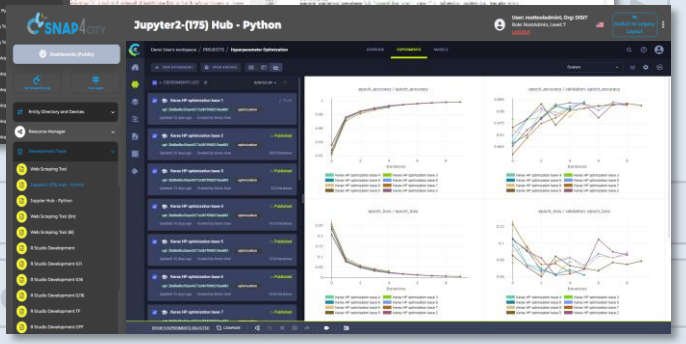




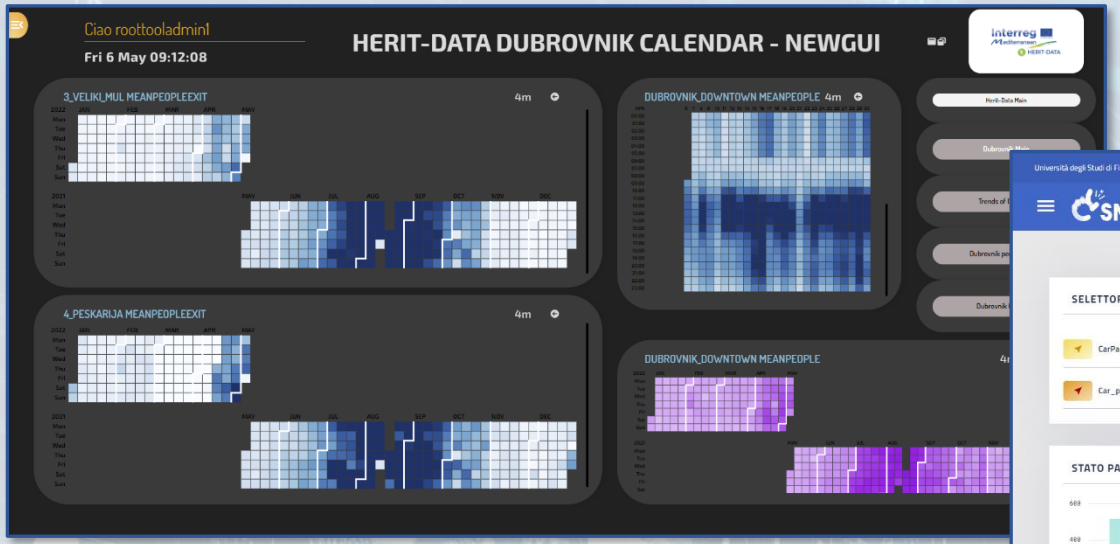


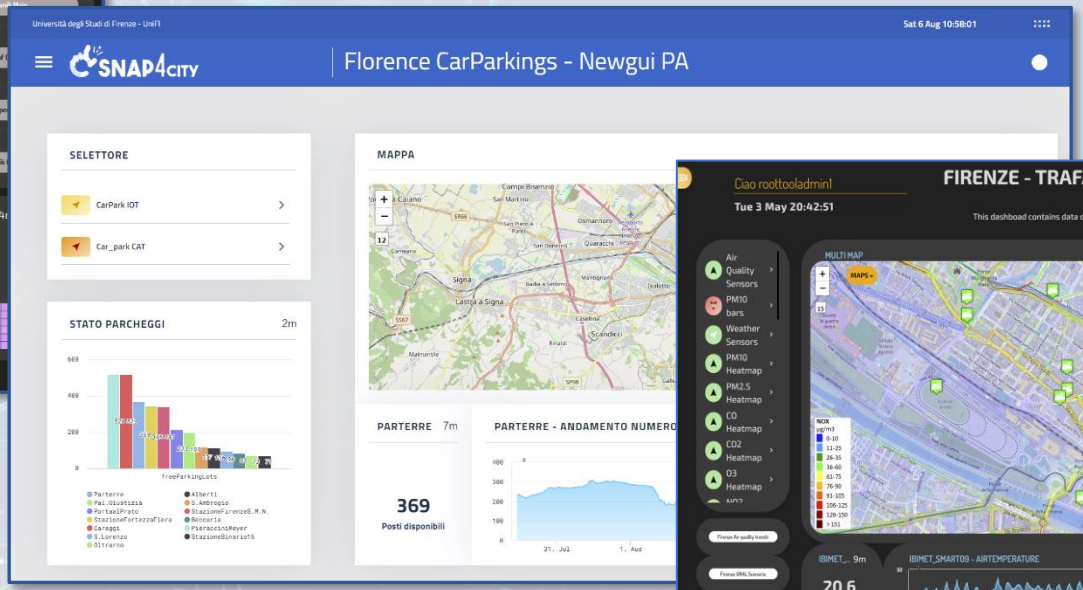


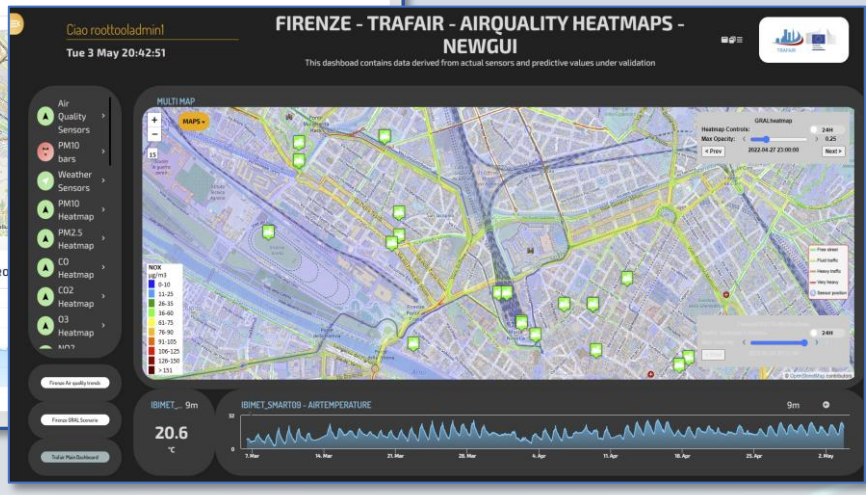


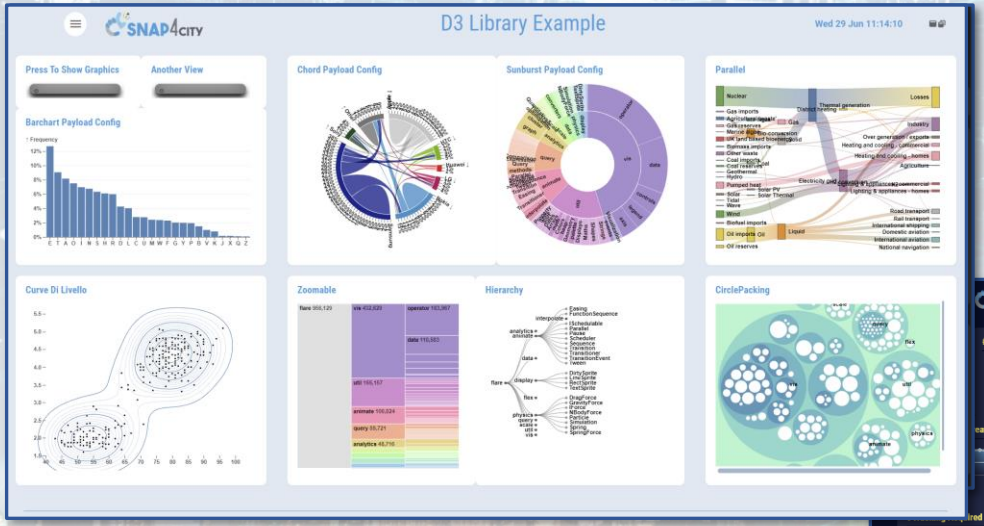


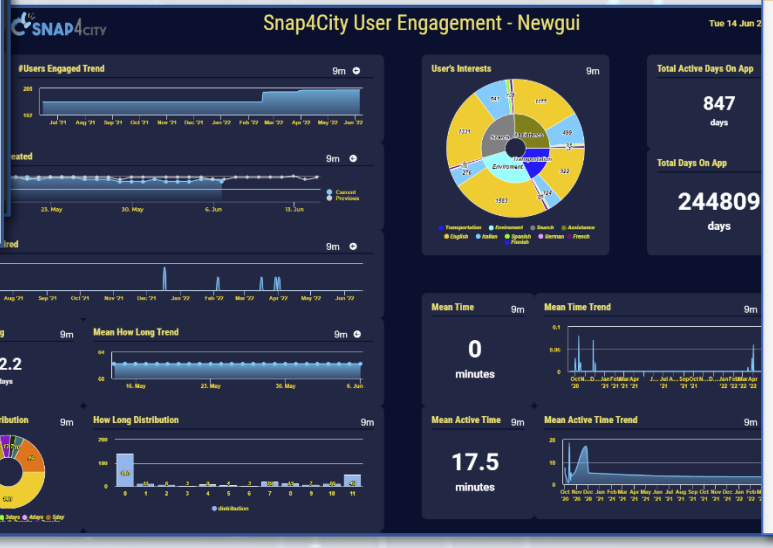
Different Themes

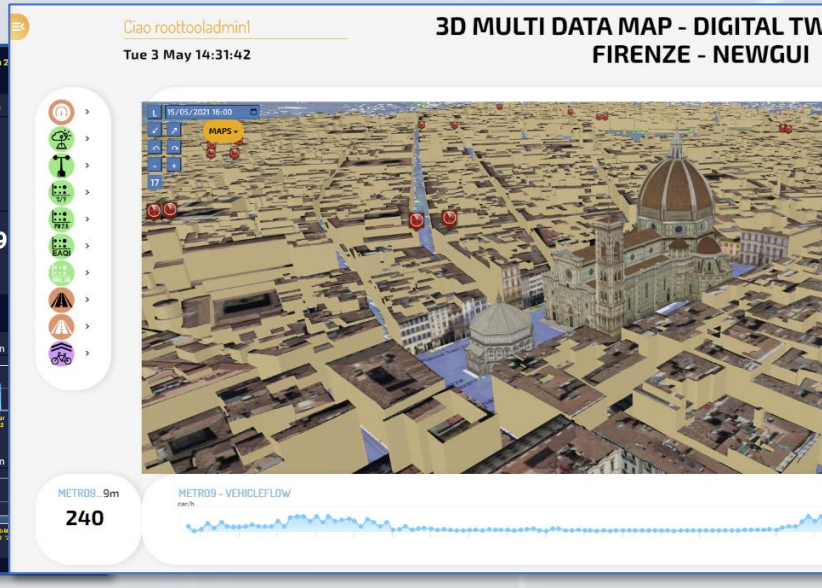












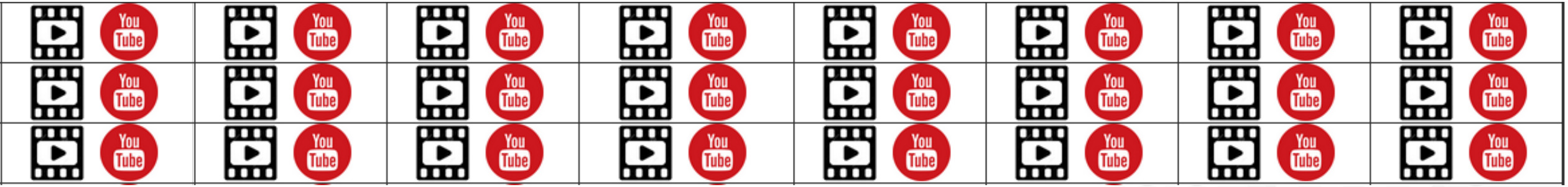
New styles/themes can be developed by specializing a few files from open source

https://www.snap4city.org/793

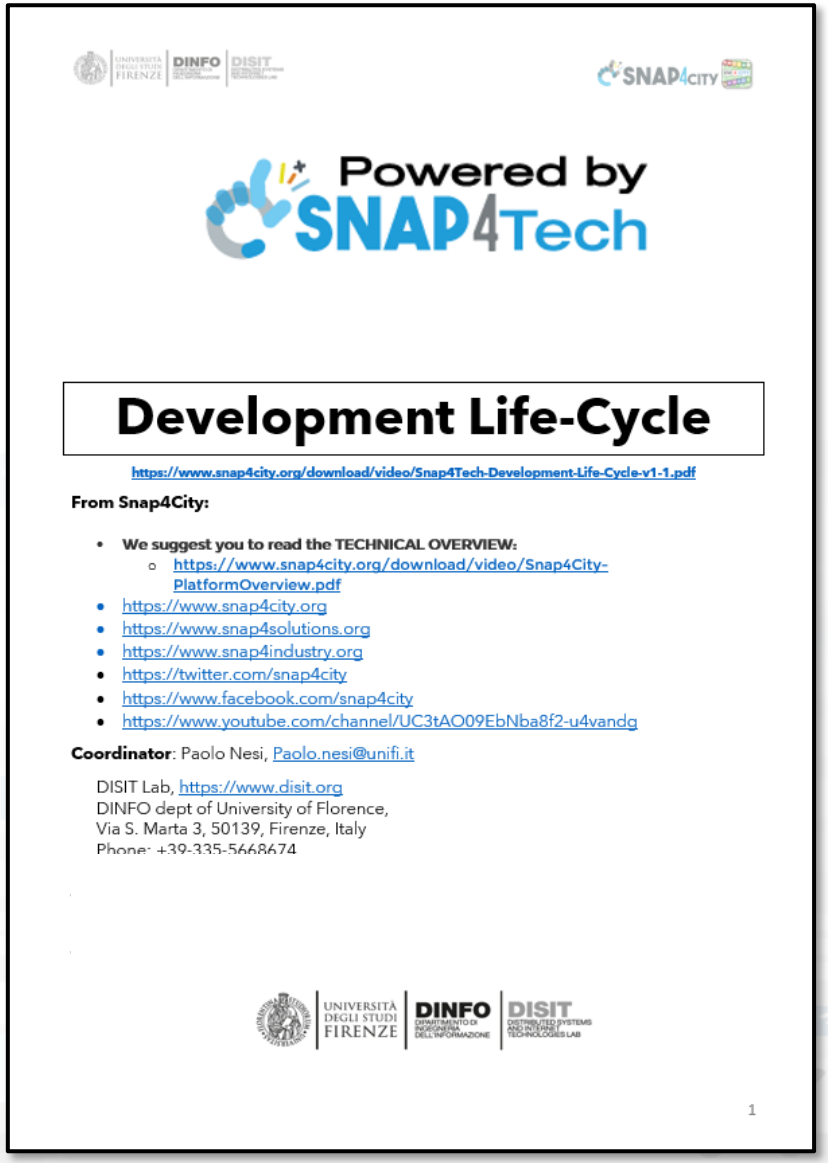
https://www.snap4city.org/944

On Line Training Material (free of charge)

1st part	2nd part	3rd part	4th part	5th part	6th part	7th part	8th
Overview	Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App	Design and Develop Smart Solutions
							
							



Development



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Development Life-Cycle

https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle-v1-1.pdf

From Snap4City:

- **We suggest you to read the TECHNICAL OVERVIEW:**
  - https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf
- https://www.snap4city.org
- https://www.snap4solutions.org
- https://www.snap4industry.org
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