SNAP4CITY

www.snap4city.org
www.snap4solutions.org

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION
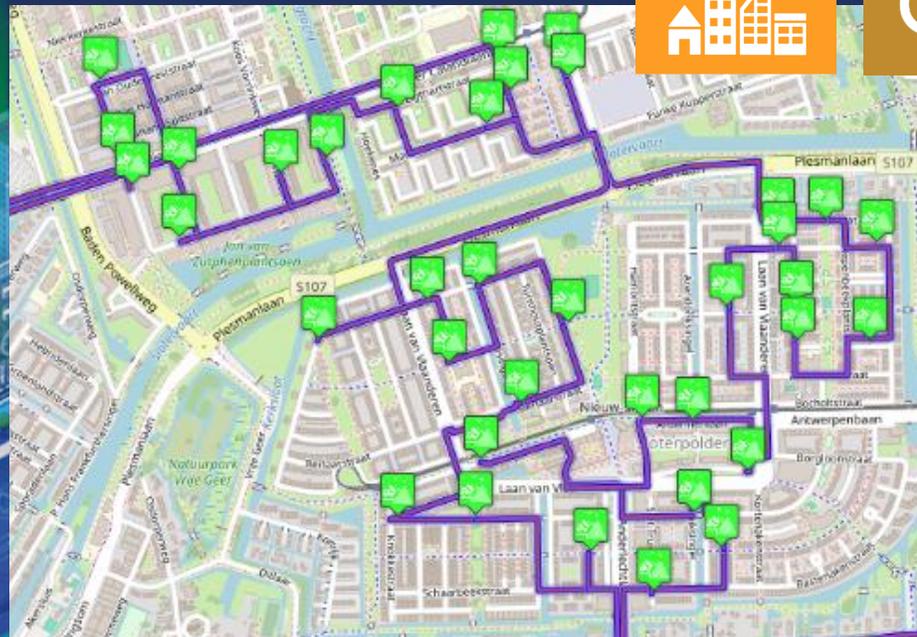
Snap4Waste
Smart Waste

#snap4city
#km4city
#disitlab
@snap4city

DIGITAL TWIN SOLUTIONS TO SETUP SUSTAINABLE DECISON SUPPORT SYSTEMS AND BUSINESS INTELLIGENCE

Environment and Waste

- **Goals:**
  - Reduction of emissions and EC taxations
  - Cost reduction for waste collection,
  - reduction of waste collection impact on mobility
- **AIR quality (Indexes) monitoring and warning**
- **Environment Management & producing predictions/prescriptions:**
  - Monitoring, long and short-term predictions, warning for:
    - GHG, emissions, pollutants, aerosol, chemical plants analysis
  - Traffic Flow impact emissions, predictions
  - Sea conditions, UV conditions, etc.
- **Land slide prediction warning**
- **Coastal erosion monitoring and analysis**
- **Smart Waste Management and Optimisation:**
  - costs reduction, optimal routing production, pay as you throw,
  - avoiding out of bins, predictions of waste production on bins, alarms
- **KPI:** SDG, 15MinCityIndex, QOS, costs, Km, colleting time, EC KPI, emissions
- **Mobile App**: final users services/informing and operators
  - Info Waste for operators, participation, optimal routing, RAEE Collection, ..
- **Participatory**: problem reporting, ticketing, etc.
- **Integration of any kind: env/weather, mobility, ticketing, presences, POI, ..**

THE POWER OF ARTIFICIAL INTELLIGENCE
AT THE SERVICE OF YOUR OPERATION AND PLAN
www.snap4city.org

SNAP4CITY — KM4CITY — UNIVERSITÀ DEGLI STUDI FIRENZE — DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE — DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

100% OPEN SOURCE

Powered by FIWARE

FREE TRIAL

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
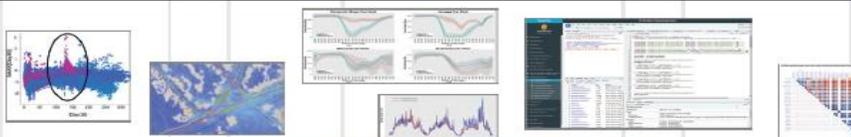
DASHBOARDS, WIDGETS TEMPLATES

**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

SMART CITY LIVING LAB

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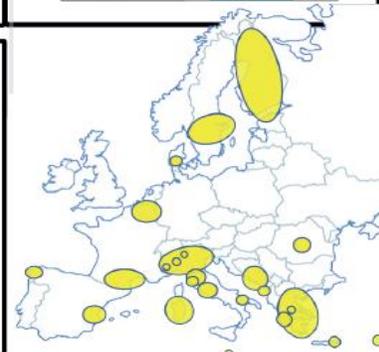SMART DATA MODEL
IOT DEVICE MODELS, DATA SPACES**

**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
- ...

INDUSTRY4.0 - SHARING - PARKING - LIGHT - ENVIRONMENT - AGRICOLTURE - ENERGY - SHOPPING - MOBILE - WASTE - SECURITY - CONTROL ROOM - BUILDING - SATELLITE - TRANSPORT - TOURISM

SUSTAINABLE DEVELOPMENT GOALS

SNAP4CITY

KM 4 CITY

1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION

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

7 AFFORDABLE AND CLEAN ENERGY

- 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

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

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

11 SUSTAINABLE CITIES AND COMMUNITIES

- 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

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

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

13 CLIMATE ACTION
15 LIFE ON LAND

- 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

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

- 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

Environment and Quality of Life
Air Quality Predictions

Cities of:
Firenze, Pisa, Livorno

reference

SNAP4CITY

KM4CITY

- **Multiple Domain Data**
  - Traffic Flow data, Pollutant: NOX, CO2, PM10, PM2.5, O3, ….
  - 3D City structure, weather, …

- **Multiple Decision Makers**
  - Pollutant Predictions: NOX, NO2, ..
  - City officers, energy industries
  - Dashboards, What-IF analysis
  - Traffic Flow Reconstruction

- **Historical and Real Time data**
  - Billions of Data

- **Services Exploited on:**
  - Dashboards, Mobile App

- **Since 2020**
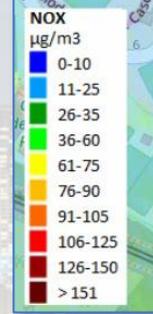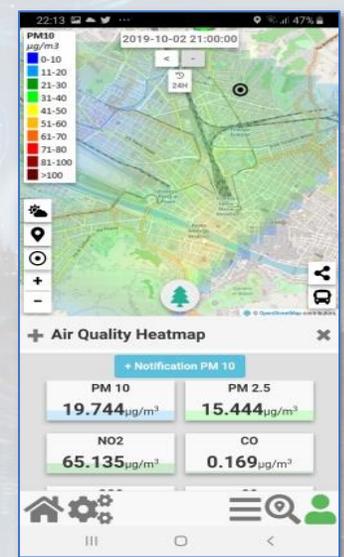
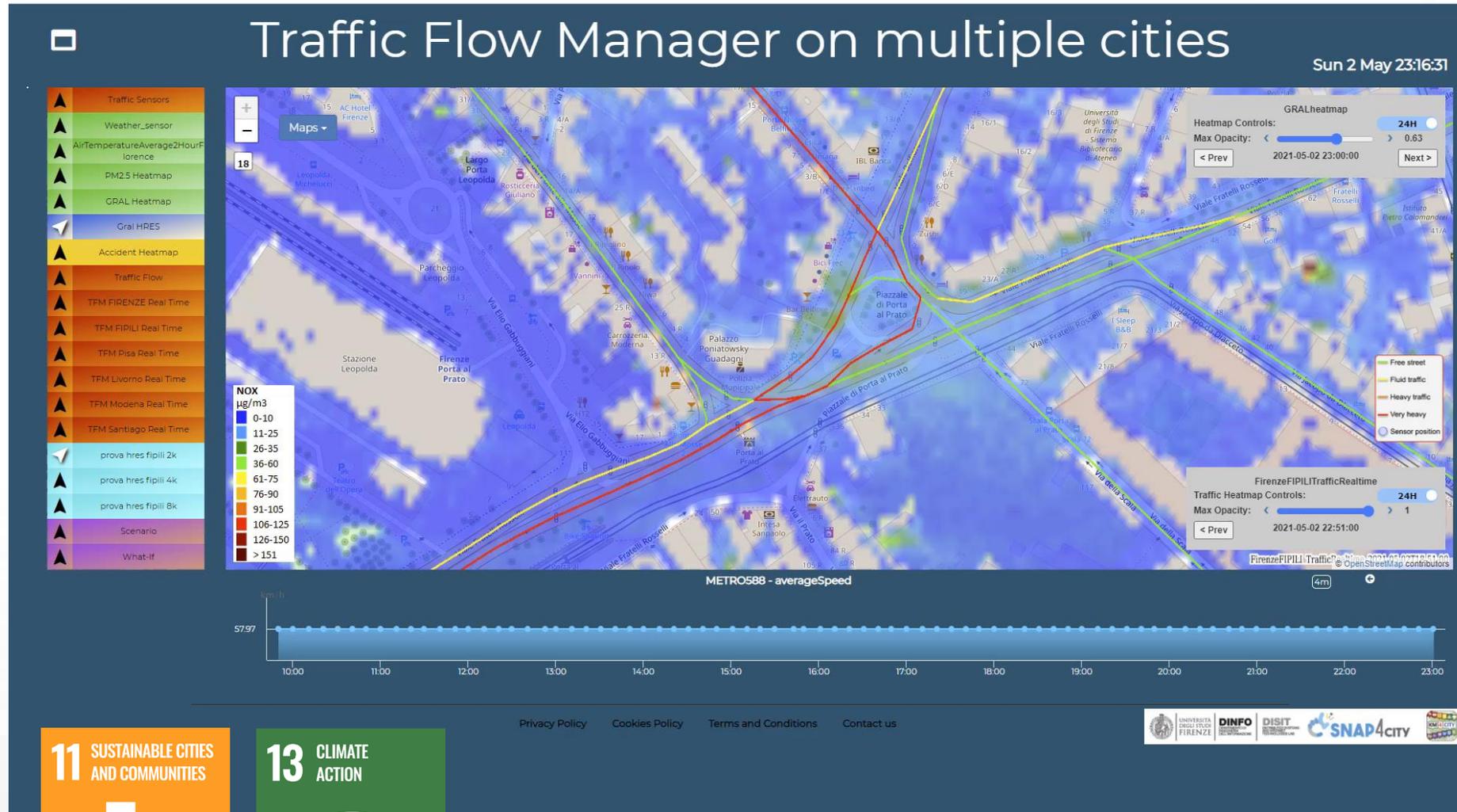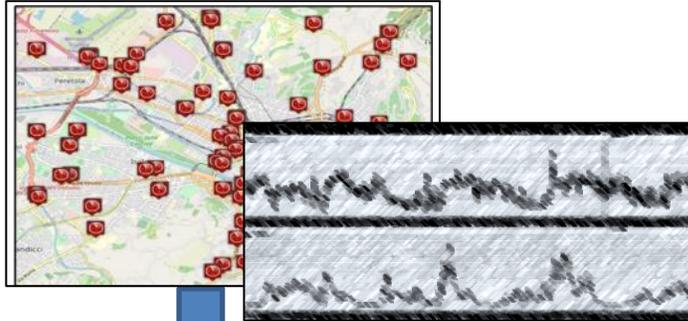|		Air Quality Directive		WHO guidelines	
Pollutant	**Averaging period**	**Objective and legal nature and concentration**	**Comments**	**Concentration**	**Comments**
$PM_{2.5}$	One day			25 µg/m³ (*)	99th percentile (3 days/year)
$PM_{2.5}$	Calendar year	Target value, 25 µg/m³	The target value become a limit value re 1 January 2015	10 µg/m³	
PM_{10}	One day	Limit value, 50 µg	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	

KPI of EC

- **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

Traffic Flow Manager on multiple cities

11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

Estimating City Local CO2 from Traffic Flow Data

Traffic Flow data

Computing Traffic Flow into CO2 sensor area

Computing CO2 on the basis of 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**
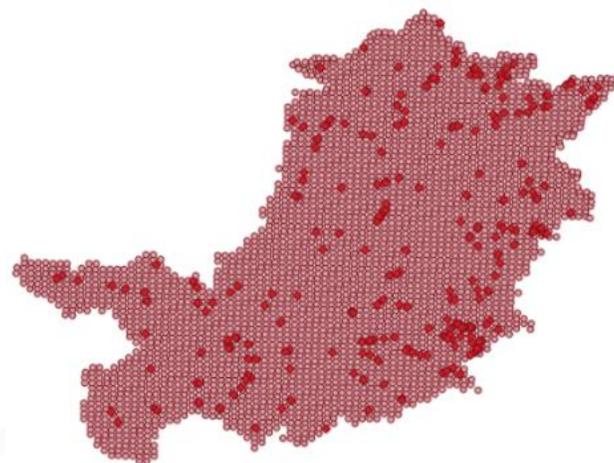- **Dense estimation of CO2 into the city** is very useful to know to target EC's KPIs

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/

Predicting Land slides
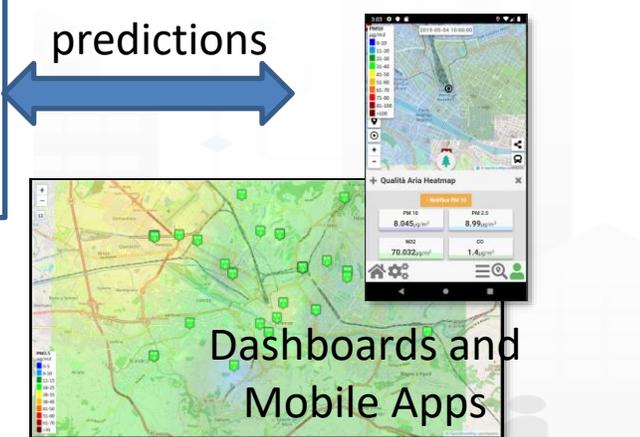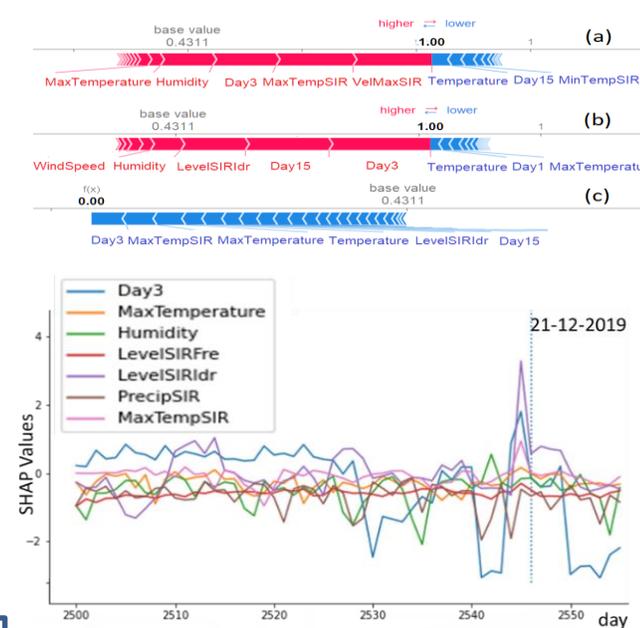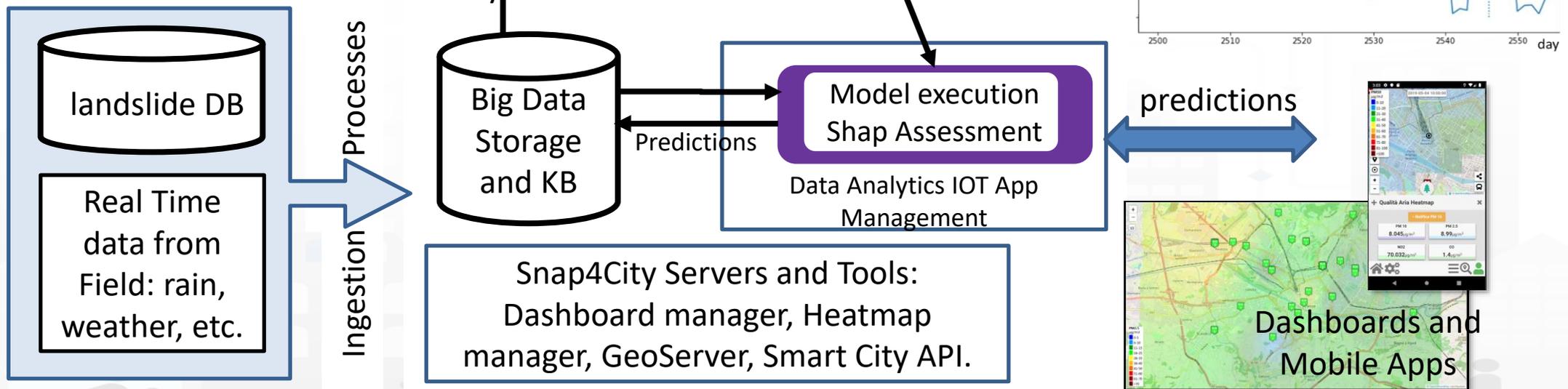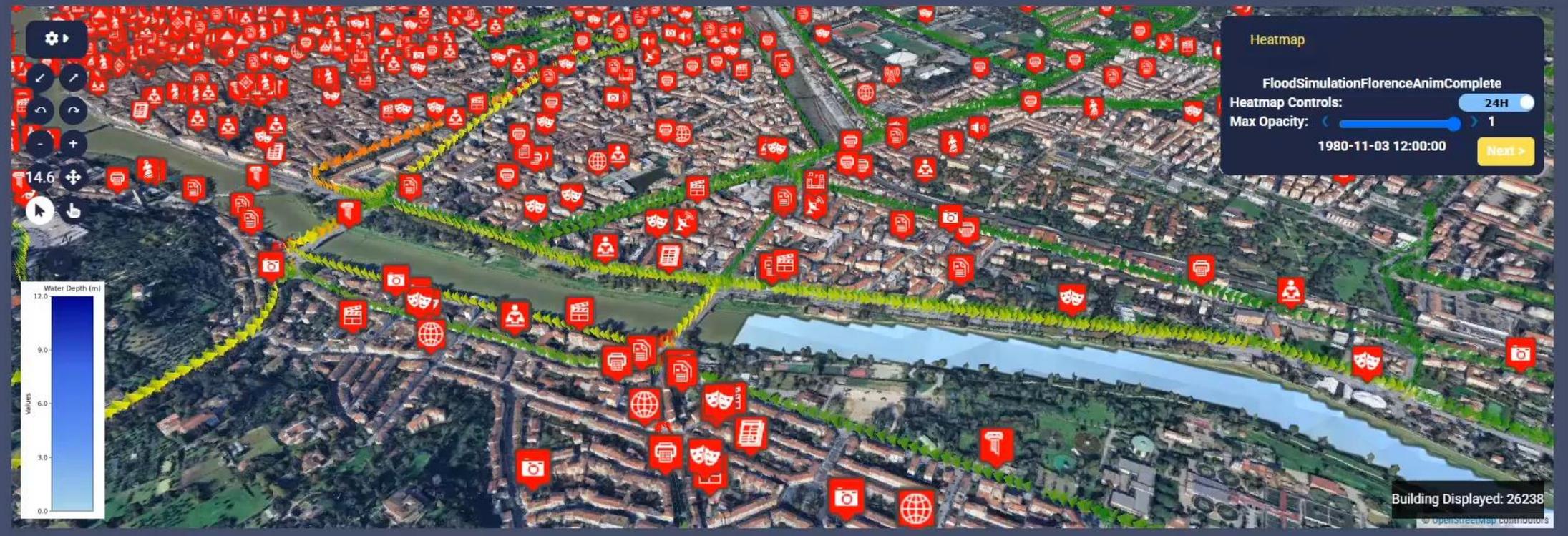
Dataset Construction

Previsional Model

Dataset Construction → Model training And validation

Model

Data

SNAP4City Advanced APIs

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.

Dashboards and Mobile Apps

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

Monitoring Costal Bathymetry and Waves

Smart Waste Management

https://www.snap4city.org/982
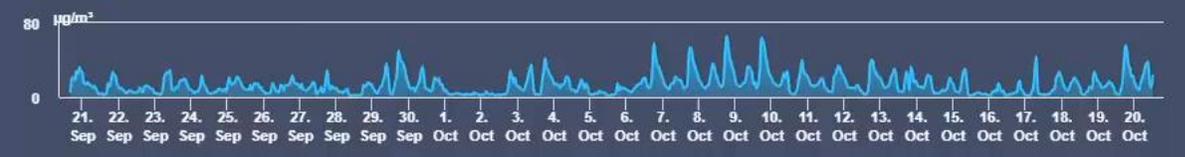
Key Benefits

- **Lower OPEX**: fewer km, better truck utilization, targeted maintenance

- **Higher service quality**: fewer overflows, faster reaction to alarms

- **Supports stakeholder engagement** and transparency

- **Optimization** based on Typical and/or Real time

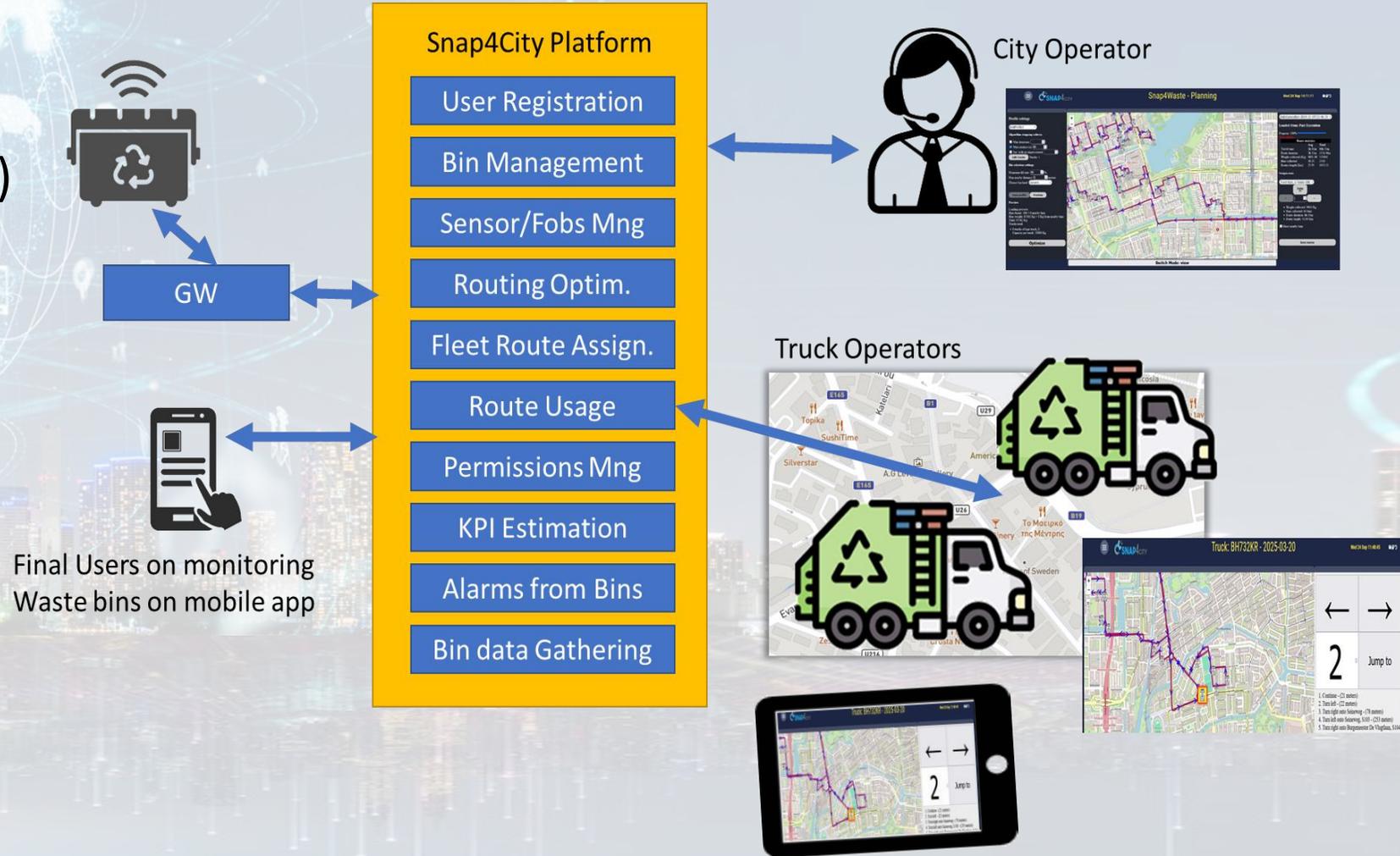- **Optional**: PAYT, telematics, predictions

Vision & Objectives

- **May monitor bins and/or trucks** in near real time

- **Optimize collection** to reduce km, time, and costs

- **Progressive adoption**:
    - start basic → go advanced

- **Integrate with city services** and sensors

- **Support** FOBS/NFC/RFID if available and PAYT

Architecture Highlights

- **Device-agnostic** ingestion: fill level, temperature, alarms
  - periodic + push (real-time) data
  - City data for bins, trucks, depots, constraints
- **Routing** engine based on Snap4City / OSM
- **Dashboards** for operators, planners, and drivers

GW

Final Users on monitoring Waste bins on mobile app

Snap4City Platform

- User Registration
- Bin Management
- Sensor/Fobs Mng
- Routing Optim.
- Fleet Route Assign.
- Route Usage
- Permissions Mng
- KPI Estimation
- Alarms from Bins
- Bin data Gathering

City Operator

Truck Operators

Core Monitoring (Overview Dashboard)

- **Map of bins** with color/icon by fill, temperature, alarm

- **Time-series of average** fill by waste type and date

- **Filters by bin kind, thresholds, alarm conditions**

- **Customizable** UI/ branding per municipality
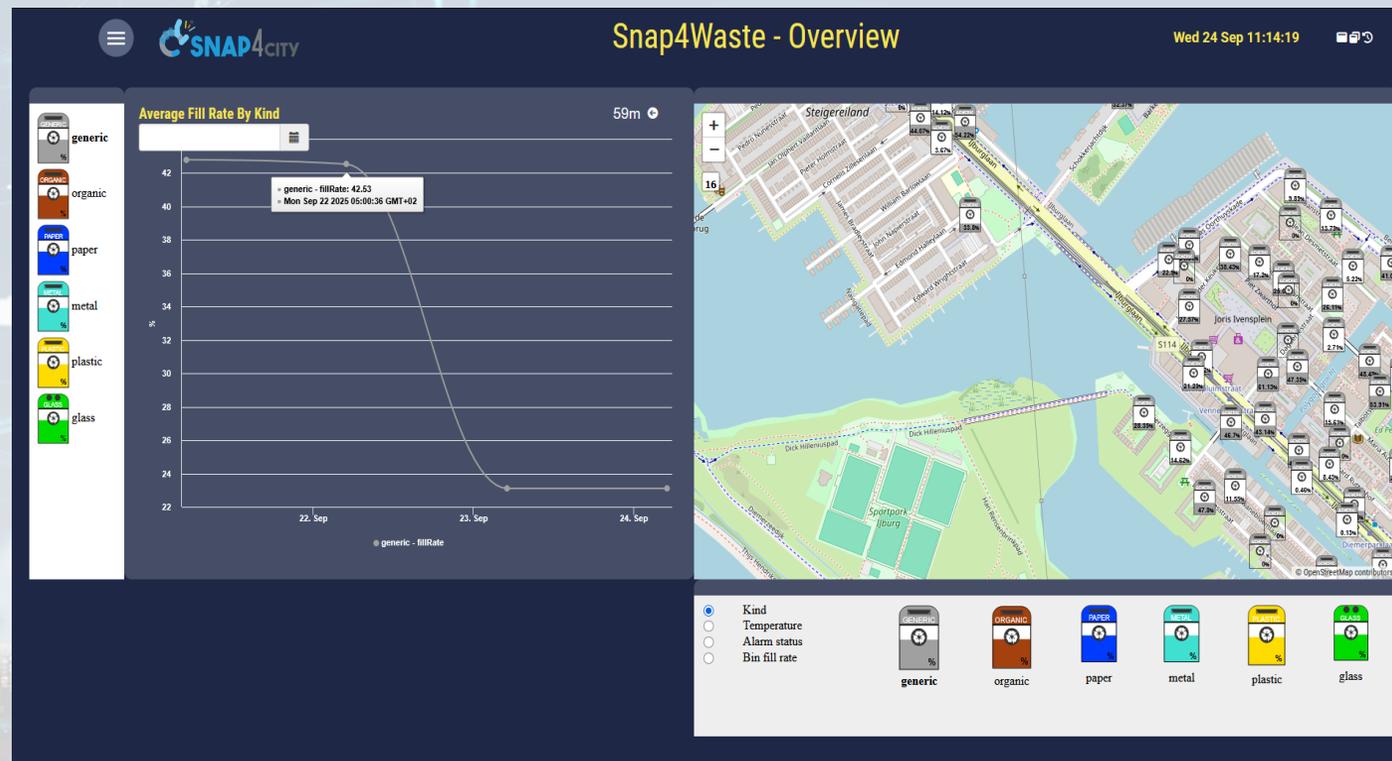
Alarms & Maintenance

- **Central table** of device/bin alarms (battery, GPS, locker, accelerometer)

- **Per-bin priority** score to triage interventions

- **Actions**: locate on map, view details, push updated states

- **Operators** can force an alarm to flag bins for maintenance

Analytics & KPIs

- **Stats** per bin kind/date range: bins, trucks, weight, km, time, CO_2

- **Drill-down** to single bin: weekly collections + map centering

- **Planned vs actual** when truck data is available

- Identify outliers and adjust collection frequency
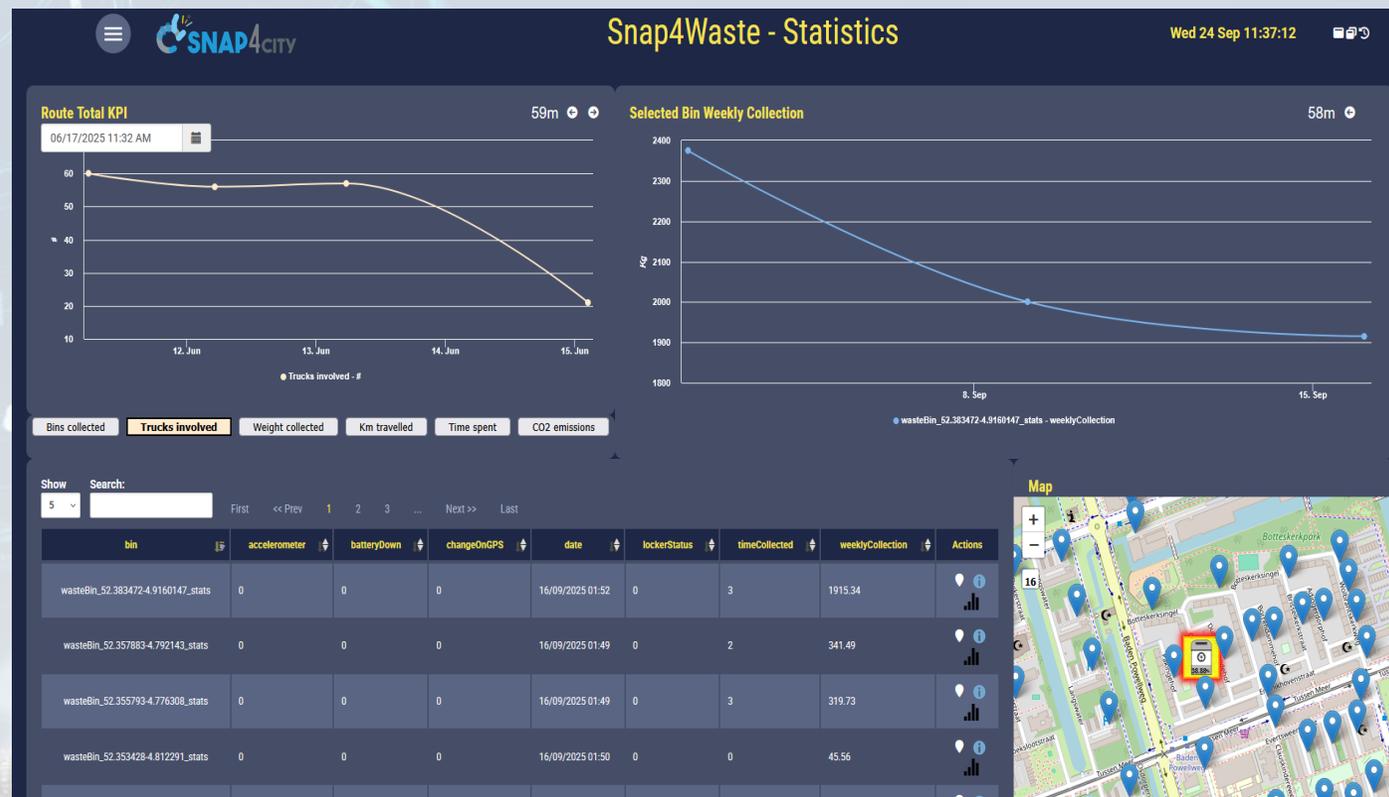
Planning & Routing (Operator View)

- **Define optimization** profiles (iterations, runtime, min fill, max distance, fill time, daily or typical)

- **Preview to estimate** required trucks and loads

- **Considers**
  - Differentiated waste collection
  - Different bin capacity
  - Different trucks kinds/size on fleets
  - depots, road graph
  - Mix of fleet of trucks

- **Outputs** routes with distance, duration, bins, weight

Waste Collection Optimization

Execution & Driver Support

- **Dashboard to view routes** for a given day and assign trucks

- **Driver web/app** with route on map, next bin, counters

- **Drivers can** mark routes as interrupted for rescheduling

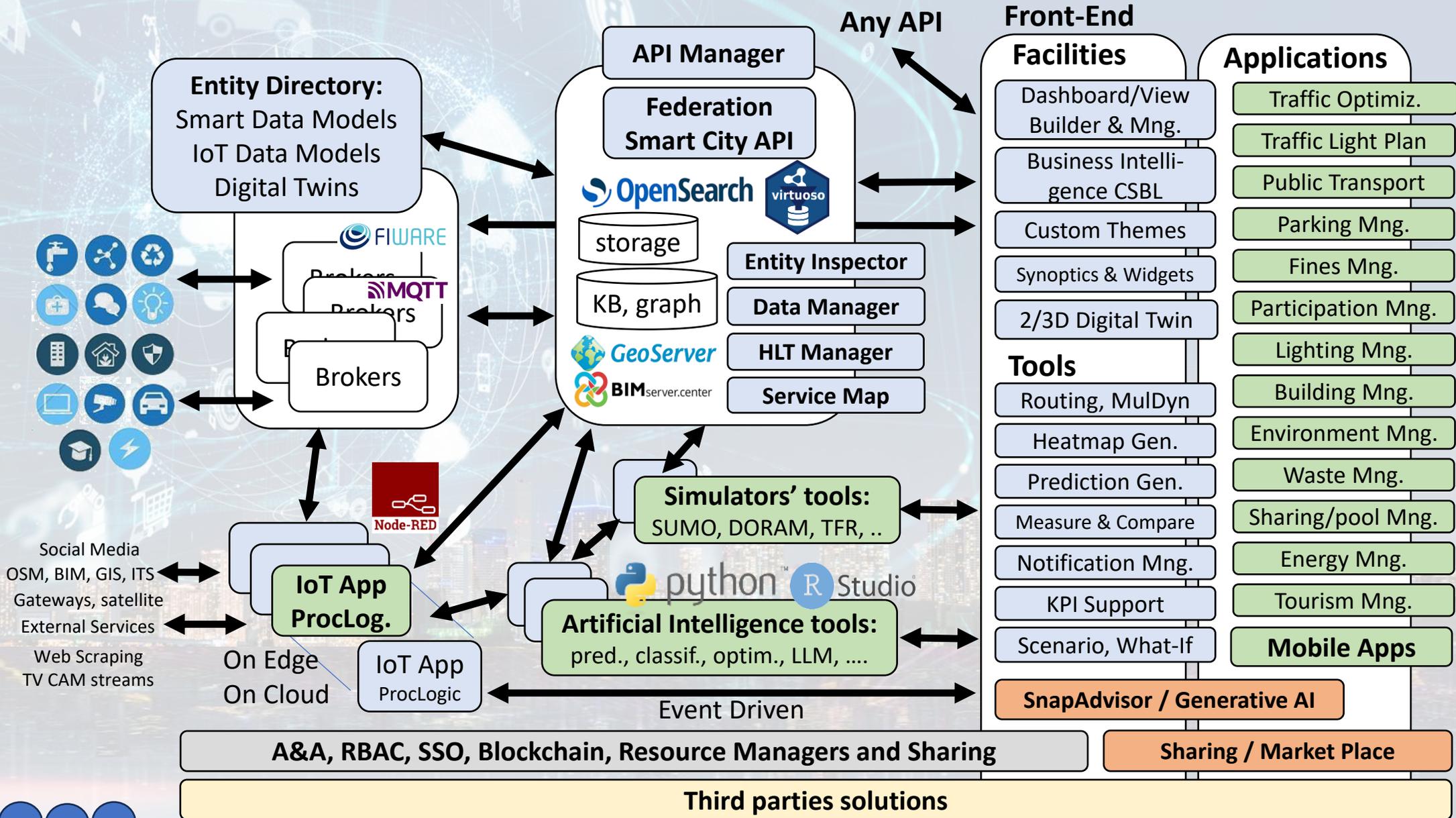- **Routing links** can be shared after assignment

Technical Architecture

SNAP4CITY
KM4CITY

Any API

Front-End

API Manager

Federation Smart City API

Entity Directory:
Smart Data Models
IoT Data Models
Digital Twins

FIWARE

Brokers

MQTT

Brokers

Brokers

OpenSearch
virtuoso

storage

KB, graph

GeoServer

BIMserver.center

Entity Inspector

Data Manager

HLT Manager

Service Map

Facilities

Dashboard/View Builder & Mng.

Business Intelligence CSBL

Custom Themes

Synoptics & Widgets

2/3D Digital Twin

Tools

Routing, MulDyn

Heatmap Gen.

Prediction Gen.

Measure & Compare

Notification Mng.

KPI Support

Scenario, What-If

Applications

Traffic Optimiz.

Traffic Light Plan

Public Transport

Parking Mng.

Fines Mng.

Participation Mng.

Lighting Mng.

Building Mng.

Environment Mng.

Waste Mng.

Sharing/pool Mng.

Energy Mng.

Tourism Mng.

Mobile Apps

Node-RED

Simulators' tools:
SUMO, DORAM, TFR, ..

Social Media
OSM, BIM, GIS, ITS
Gateways, satellite
External Services
Web Scraping
TV CAM streams

IoT App ProcLog.

python R Studio

Artificial Intelligence tools:
pred., classif., optim., LLM, ...

On Edge
On Cloud

IoT App
ProcLogic

Event Driven

SnapAdvisor / Generative AI

A&A, RBAC, SSO, Blockchain, Resource Managers and Sharing

Sharing / Market Place

Third parties solutions

8/25

booklets

- Smart City
- Industry
- Artificial Intelligence

https://www.snap4city.org/download/video/DPL_SNAP4CITY.pdf

https://www.snap4city.org/download/video/DPL_SNAP4INDUSTRY.pdf

https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf

Be smart in a SNAP!

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SMART**CITY** EXPO WORLD CONGRESS

SNAP4 Appliances and Dockers **Installations**

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