



## IL FUTURO DELLA MOBILITA' INTELLIGENTE E SOSTENIBILE

Digital Twin & Intelligenza Artificiale.  
Innovazione tecnologica “As a Service “  
per la gestione operativa  
e la pianificazione tattico-strategica  
della mobilità urbana sostenibile e interconnessa

Firenze | **Milano** | Roma | Bari



Finanziato  
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Ministero  
dell'Università  
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Italiadomani  
PIANO NAZIONALE  
DI RIFORMA E RESILIENZA

**MOST**  
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

|                              |               |                                                                                                                                                  |
|------------------------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Registrazione</b>         | 10:00 - 10:30 | Registrazione e Welcome Coffee<br>Saluti                                                                                                         |
| <b>Avvio Lavori</b>          | 10:30 - 10:40 | - <b>Prof. Paolo Nesi</b> , UNIFI DISIT Lab/Snap4City<br>- <b>Franco Prampolini</b> , Head of R&D and Innovative Industry Solutions Lutech Group |
| <b>CN MOST SPOKE 8</b>       | 10:40 - 11:00 | Mobility-as-a-Service: tra integrazione e sostenibilità<br>- <b>Prof. Mario Marinelli</b> , Politecnico di Bari                                  |
| <b>Overview OPTIFaaS</b>     | 11:00 - 11:20 | Presentazione generale e obiettivi di <b>OPTIFaaS</b><br>- <b>Mauro Starinieri</b> , Head of Smart City & Mobility Solutions CoE Lutech Group    |
| <b>Strumenti OPTIFaaS</b>    | 11:20 - 11:50 | Presentazione dell'infrastruttura<br>- <b>Prof. Paolo Nesi</b> , UNIFI DISIT Lab/Snap4City                                                       |
| <b>Scenario OPTIFaaS</b>     | 11:50 - 12:10 | Ottimizzazione del Traffico<br>- <b>Prof. Luigi Pariota</b> , Università degli Studi di Napoli                                                   |
| <b>Scenario OPTIFaaS</b>     | 12:10 - 12:40 | Ottimizzazione Semaforica e di Infrastruttura. Ottimizzazione del Trasporto Collettivo<br>- <b>Prof. Paolo Nesi</b> , UNIFI DISIT Lab/Snap4City  |
| <b>Q&amp;A</b>               | 12:40 - 13:00 | Sessione aperta                                                                                                                                  |
| <b>Light Lunch (offered)</b> | 13:00 - 14:00 |                                                                                                                                                  |
| <b>Incontri 1:1</b>          | 14:00 -       | Incontri 1:1 con i referenti di Snap4City/OPTIFaaS (in presenza)                                                                                 |







|                              |               |                                                                                                                                                  |
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## Presentazione dell'infrastruttura

Prof. Paolo Nesi, UNIFI DISIT



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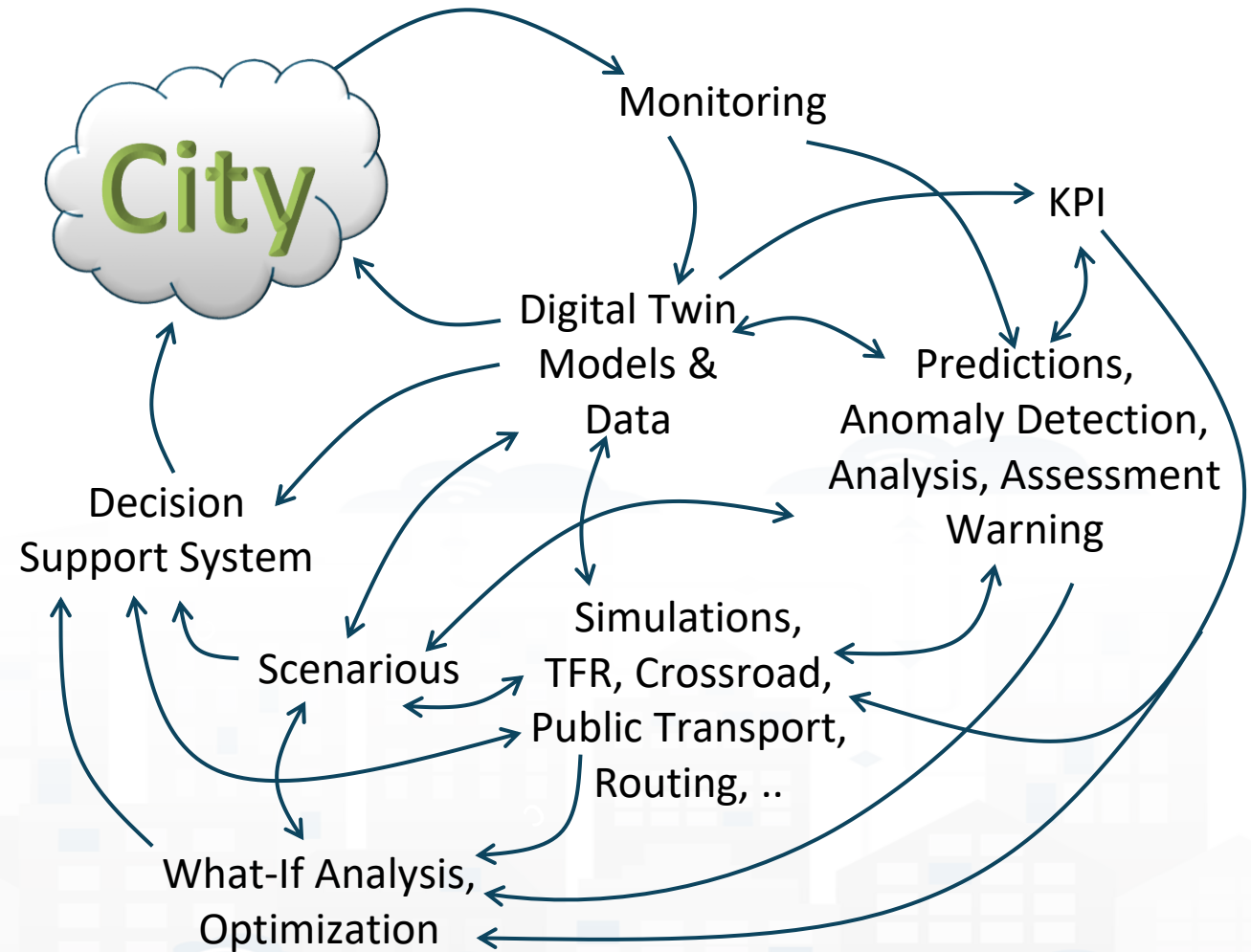


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DI SOSTENIBILITÀ E INNOVAZIONE

**MOST**  
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE



- **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 unknowns
  - What-if analysis wrt scenarios
  - Collaboration with stakeholders







# THE POWER OF ARTIFICIAL INTELLIGENCE AT THE SERVICE OF YOUR OPERATION AND PLAN

[www.snap4city.org](http://www.snap4city.org)



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

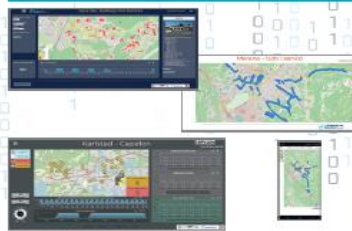
## HORIZONTAL AI PLATFORM



## MOBILITY AND TRANSPORT



## SMART ENERGY AND SMART BUILDING



## ENVIRONMENT AND WASTE MANAGEMENT



## CITY USER'S SERVICES AND TOURISM MANAGEMENT



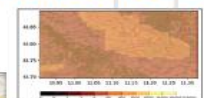
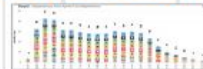
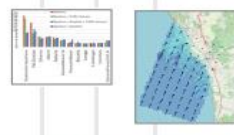
## SNAPADVISOR



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



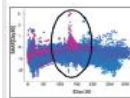
DASHBOARDS, WIDGETS  
TEMPLATES



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

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

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

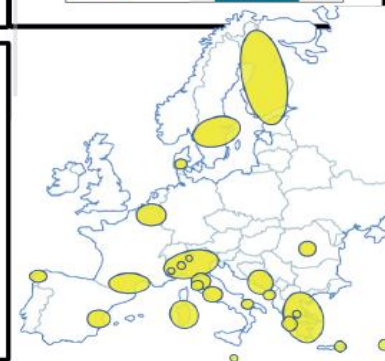


VISUAL PROGRAMMING, ADAPTERS  
DATA FLOWS, WORKFLOWS  
PARALLEL DISTRIBUTED PROCESSING  
DATA DRIVEN

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

NATIVE AND EXTERNAL  
APPLICATIONS

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



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

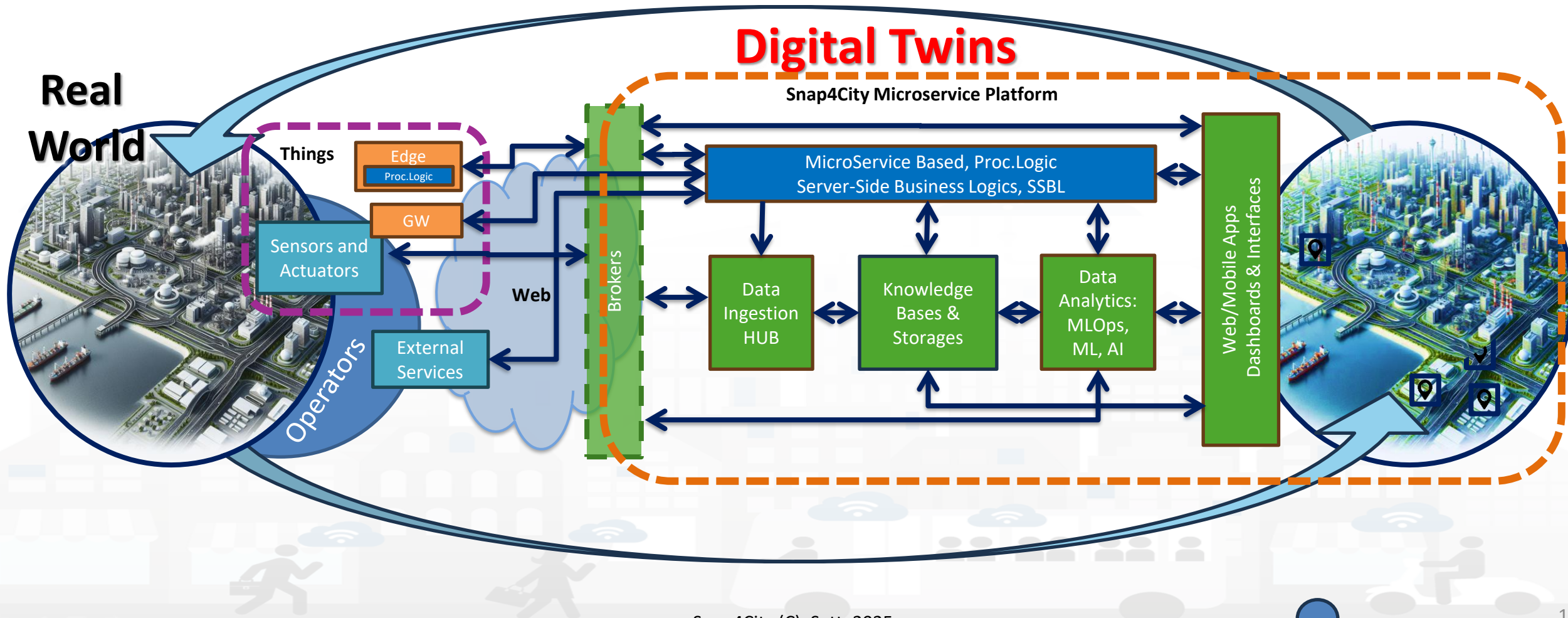


NVIDIA

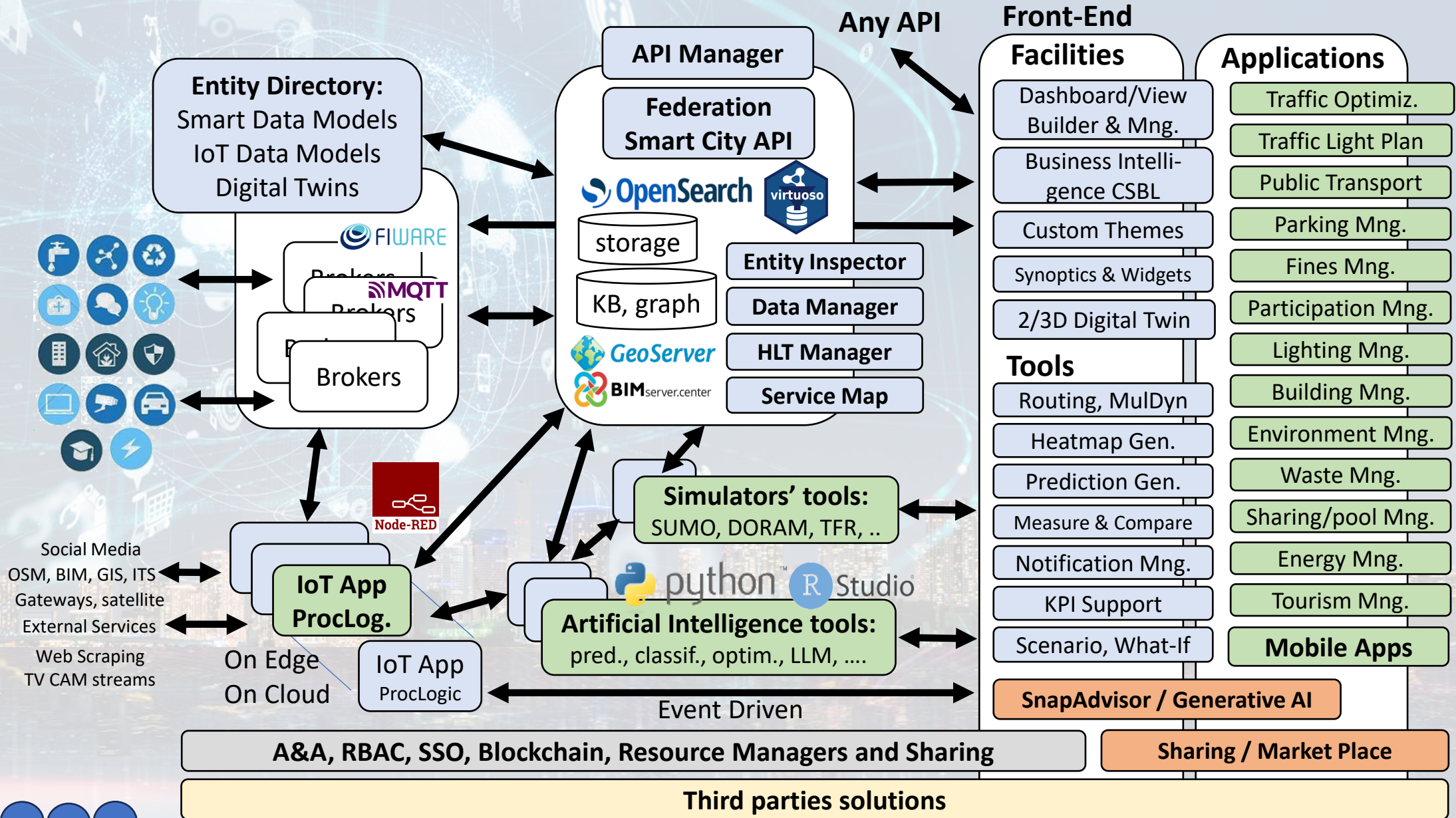




# Digital Twin Development Platform



# Technical Architecture

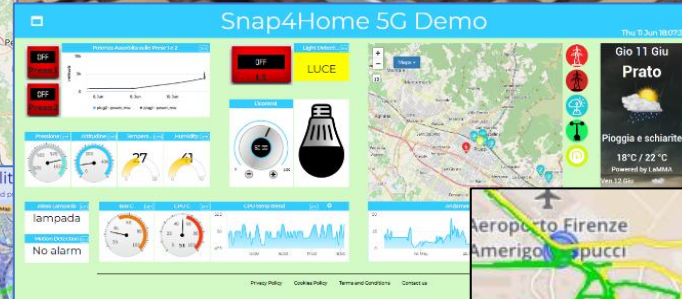
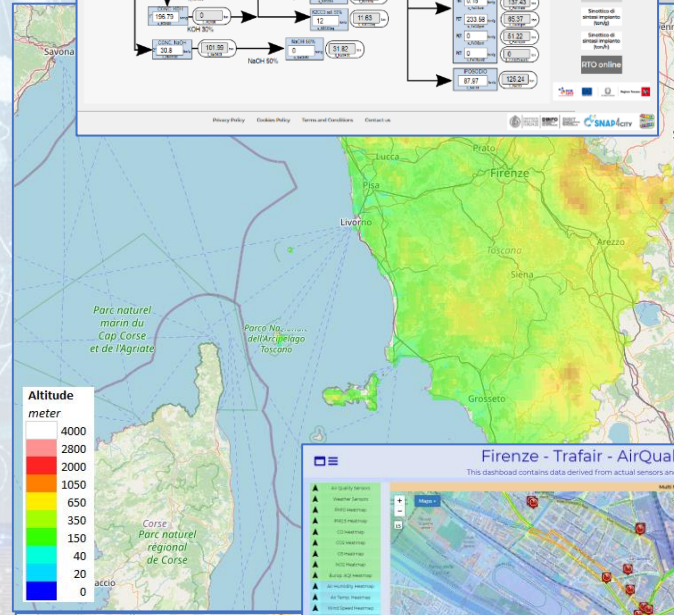
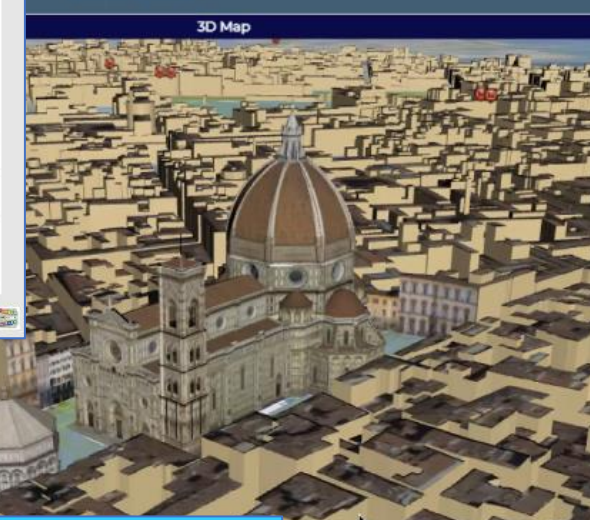
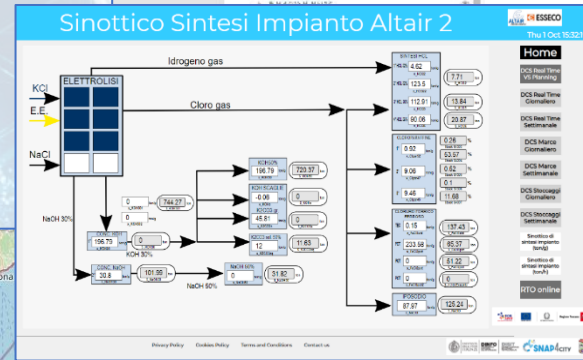
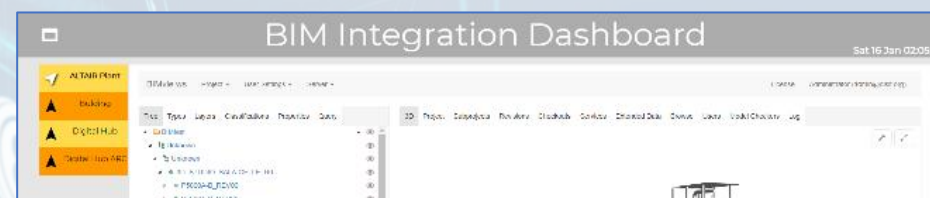




# High Level Types

Snap4City (C), Sett. 2025

- 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.



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# Standards and Interoperability



## Compliant with:

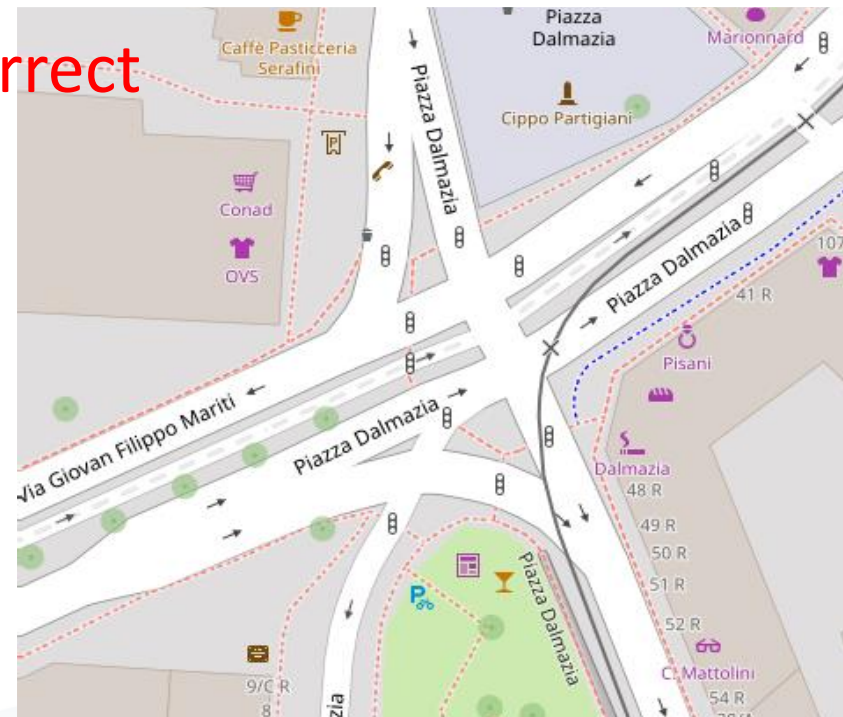
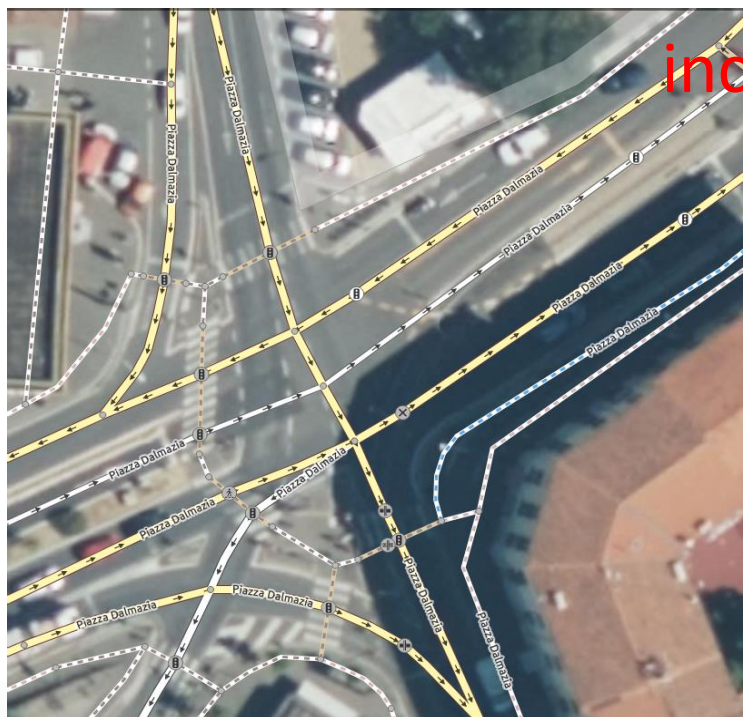
- **IoT:** NGSI V2/LD, LoRa, LoRaWan, MQTT, AMQP, COAP, OneM2M, TheThingsNetwork, SigFOX, Libelium, IBIMET/IBE, EnOcean, Zigbee, DALI, ISEMC, Alexa, Sonoff, HUE Philips, Tplink, BACnet, TALQ, Protocol Buffer, KNX, OBD2, Proximus, ..
- **IoT model:** FIWARE Smart Data Model, Snap4City IoT Device Models
- **General:** HTTP, HTTPS, TLS, Rest Call, SNMP, TCP, UDP, SOAP, WSDL, FTP, FTPS, WebSocket, WebSocket Secure, GML, WFS, WMS, WCS, RTSP, ONVIF, AXIS TVCam, CISCO Meraki, OSM, Copernicus, The Weather Channel, Open Weather, OLAP, VMS Milestone, TIM, HERE, OGC, ....
- **Formats:** JSON, GeoJSON, XML, CSV, GeoTIFF, OWL, WKT, KML, SHP, db, XLS, XLSX, TXT, HTML, CSS, SVG, IFC, XPD, OSM, Enfuser FMI, Lidar, glTF, GLB, DTM, GDAL, Satellite, D3 JSON, ...
- **Database:** Open Search, MySQL, Mongo, HBASE, SOLR, SPARQL, ODBC, JDBC, Elastic Search, Phoenix, PostGres, MS Azure, ..
- **Industry:** OPC/OPC-UA, OLAP, ModBUS, RS485, RS232, ..
- **Mobility:** DATEX, GTFS, Transmodel, ETSI, NeTEx, ..
- **Social:** Twitter, FaceBook, Telegram, ..
- **Events:** SMS, EMAIL, CAP, RSS Feed, ..
- **OS:** Linux, Windows, Android, Raspberry Pi, Local File System, AXIS, ESP32, etc.

<https://www.snap4city.org/65>

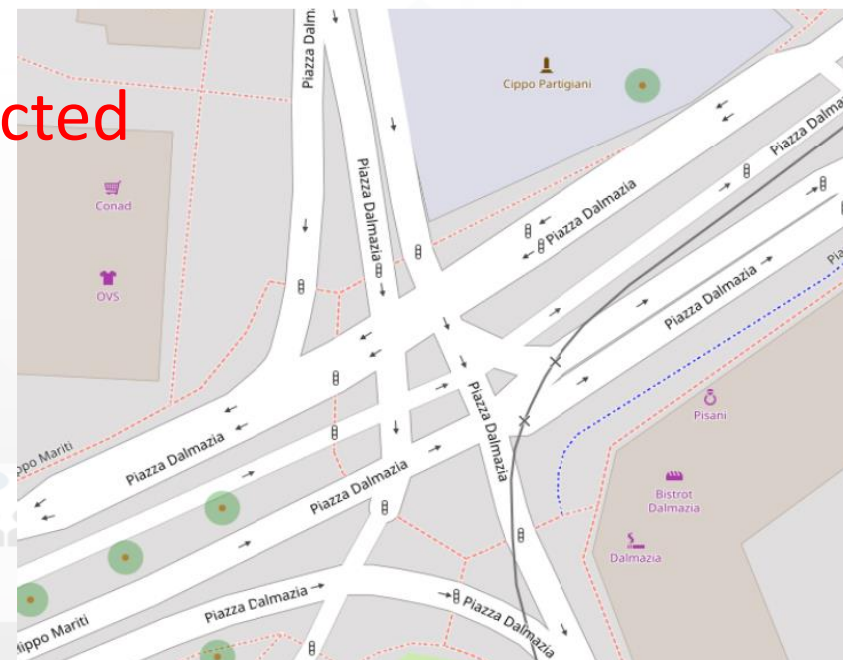
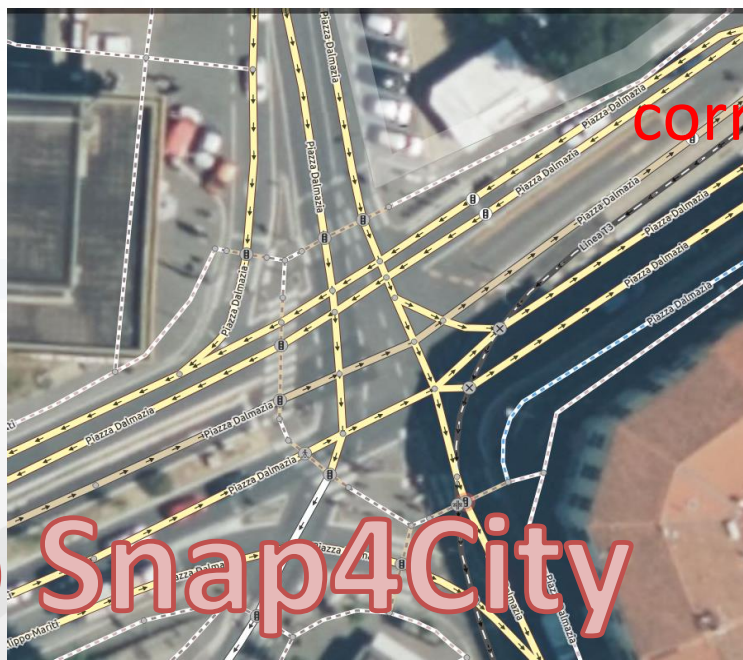




OSM data with non  
correct viability in Piazza  
Dalmazia, Firenze



After Correction of OSM  
data defining a correct  
viability of Piazza Dalmazia,  
Florence. Regeneration of  
the TILES for the maps



From OSM to Snap4City



# Scenario Editor

Select map

Zoom

New Scenario

Editing  
Drag & drop  
Split & Join  
Delete  
Do and Undo

Edit Road  
Segment

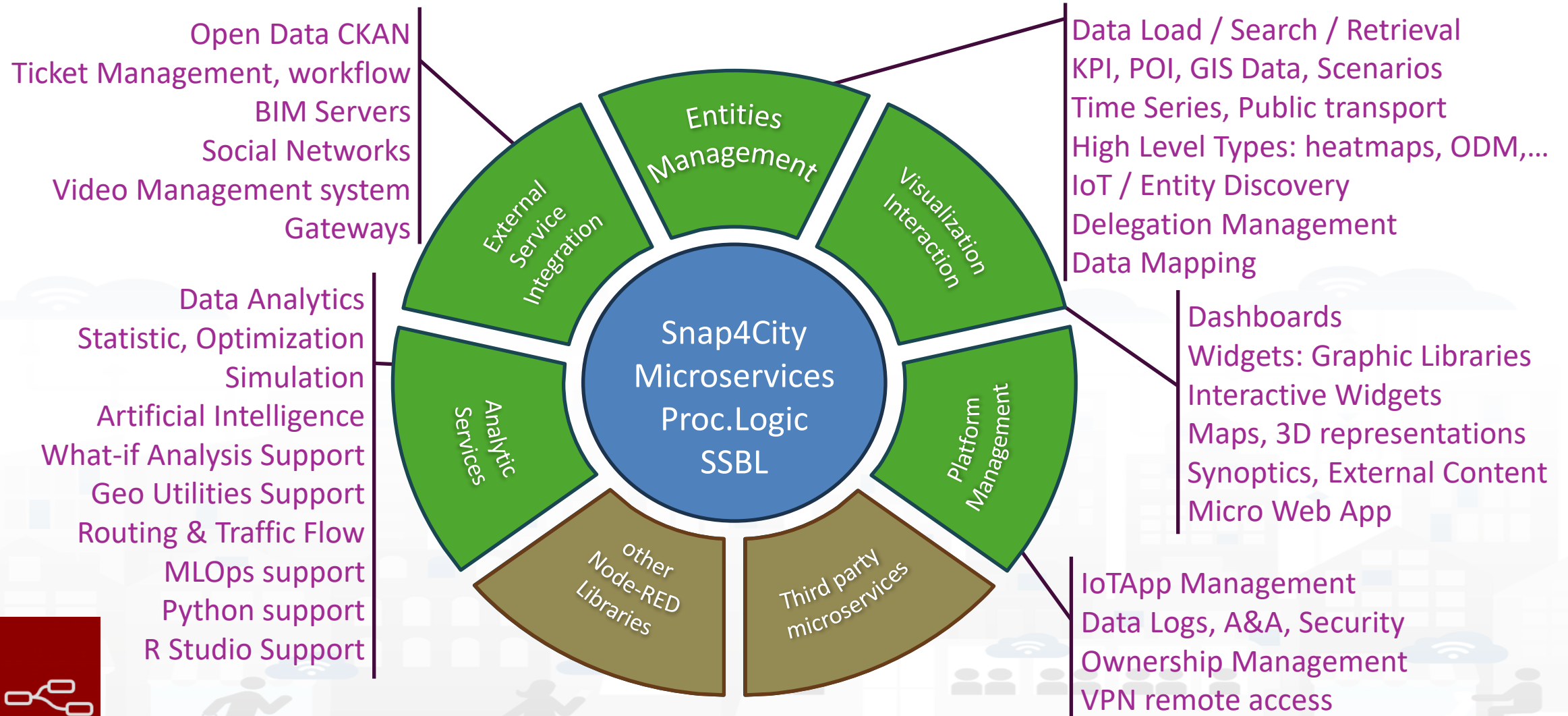
| identifier      |
|-----------------|
| composition     |
| elemLocation    |
| elementClass    |
| elementType     |
| length          |
| operatingStatus |
| speedLimit      |
| trafficDir      |
| width           |
| highwayType     |
| route           |





> 60.000 downloads (up to 2024)

## Areas

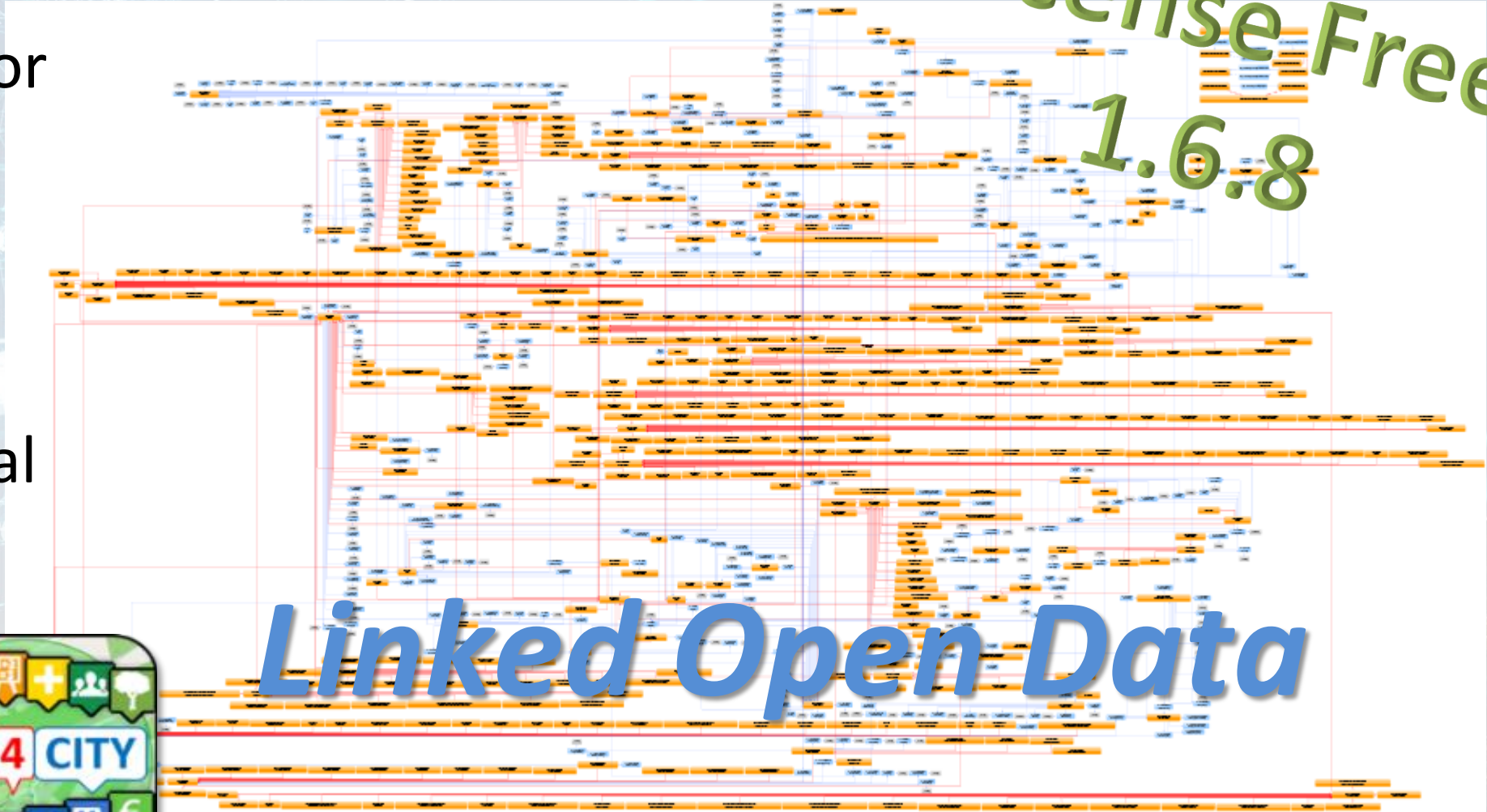




# Expert System *semantic queries*



- via:
- **Smart City API** for Apps and third party
- **MicroServices** data driven develop via visual language Node-RED



*License Free*  
*1.6.8*

*Linked Open Data*



<https://www.snap4city.org/19>





# Available AI Solutions on Snap4City

<https://www.snap4city.org/997>

**More than 80 Available Solutions & 300 AI applic.**

- **Mobility and Transport**
- **Environment, Weather, Waste, Water**
- **City Users Behaviour and Social analysis**
- **Energy and Control**
- **Tourism and People**
- **Security and Safety**
- **High Level Decision Support Solutions**
  - **Asset management**
  - **Resilience and Risks Analysis**
- **Low level Techniques**

<https://www.snap4city.org/download/video/course/p4/>



[https://www.snap4city.org/download/video/DPL\\_SNAP4SOLU.pdf](https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf)





## • 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: NO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub>, 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



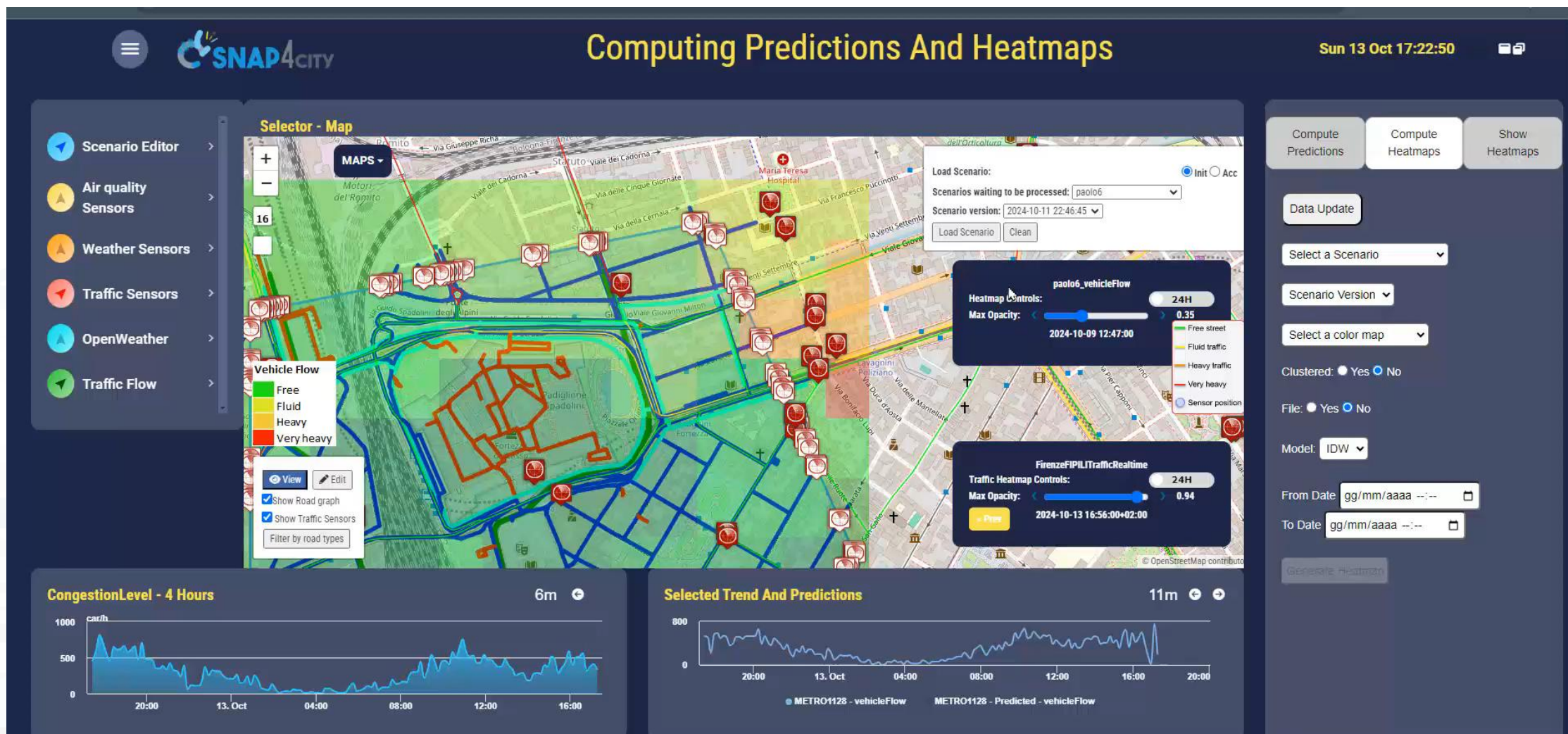
- Optimization of Waste Collection
- business intelligence tools for decision makers
- Reduction production costs
- Monitoring resource consumption
- Advisor for documentation, generative AI



- 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



# Predictions and Heatmaps in Real Time

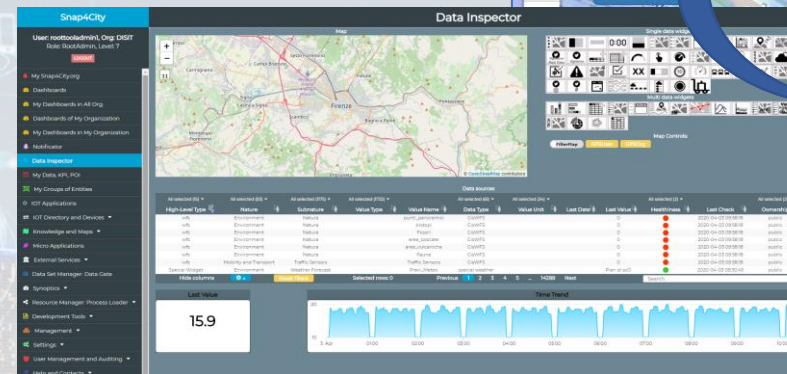
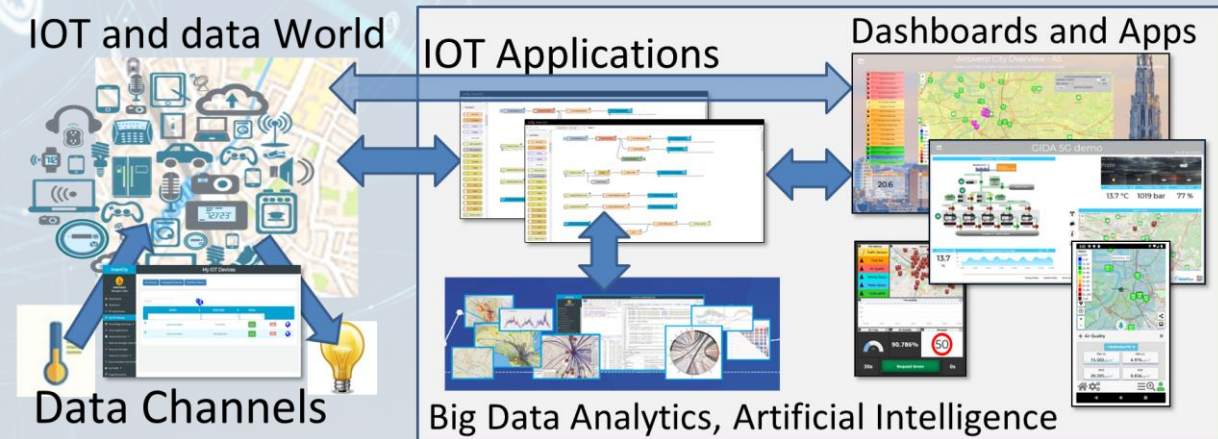




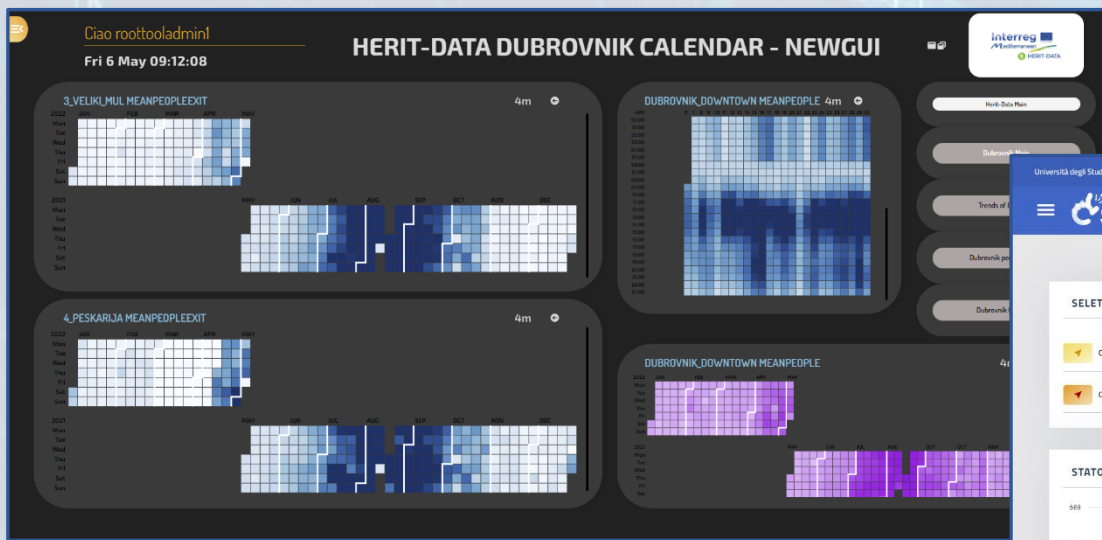
# Solutions: reliable, secure and fast to realize

- Via Snap4City tools
  - Dashboard Wizard
  - Dashboard Builder
  - Data/Visual Analytic

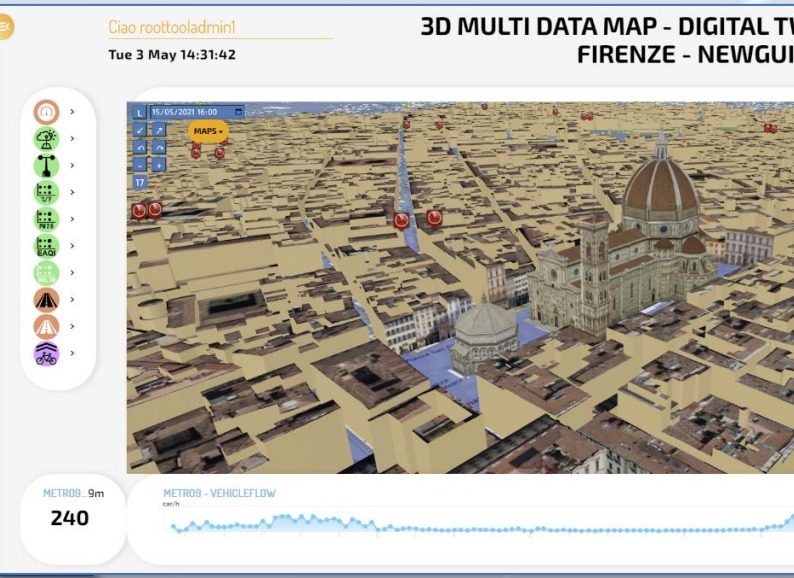
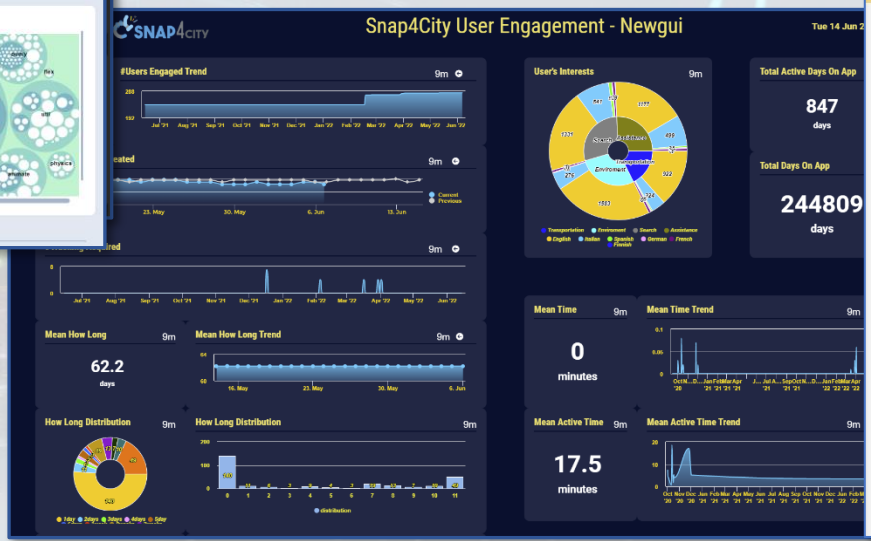
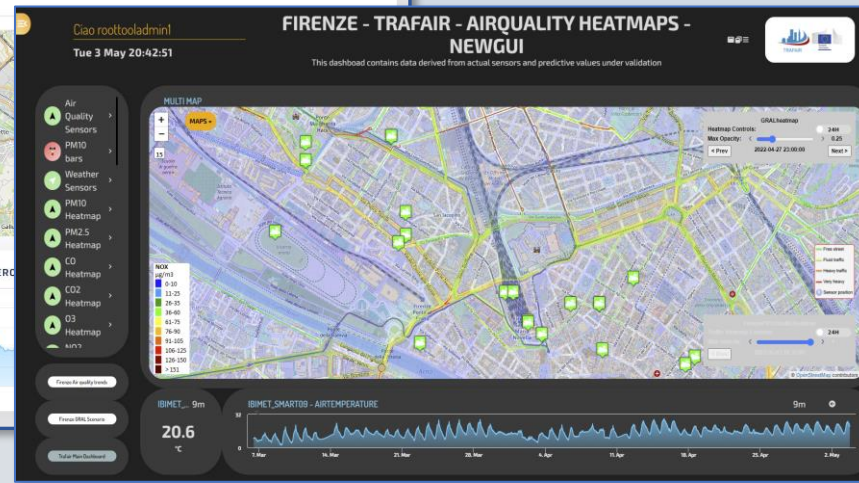
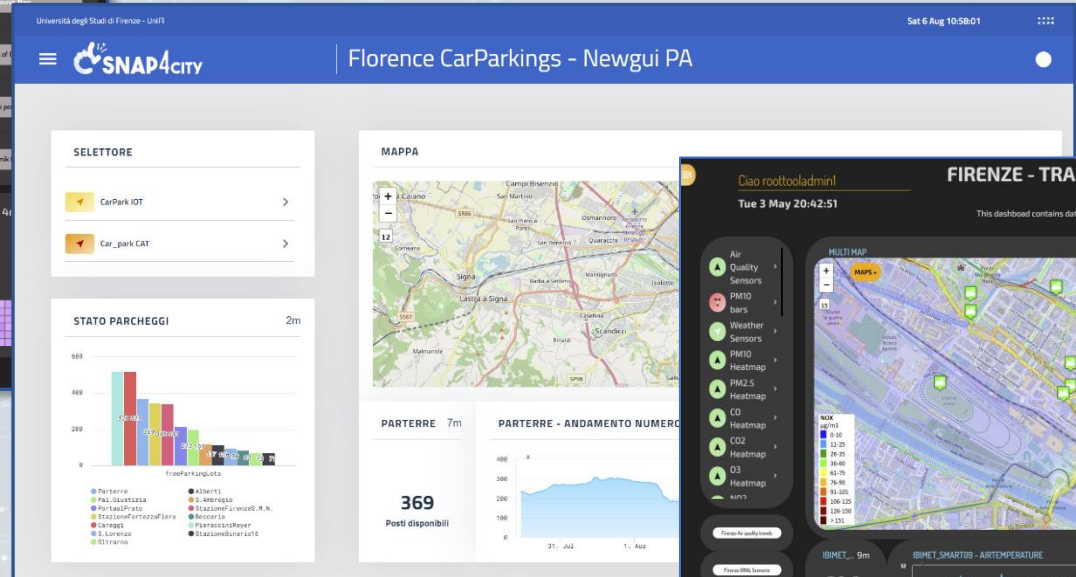
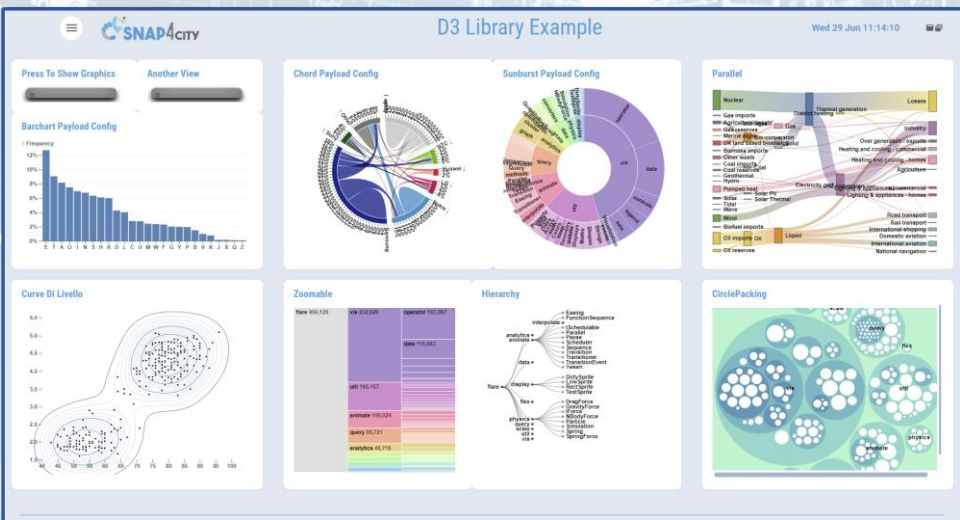
- Smart Solutions results to be
  - Real time data drive
  - Secure end-to-end
  - GDPR compliant
  - Reliable, interoperable
  - Auditable, marketable







# Different Themes

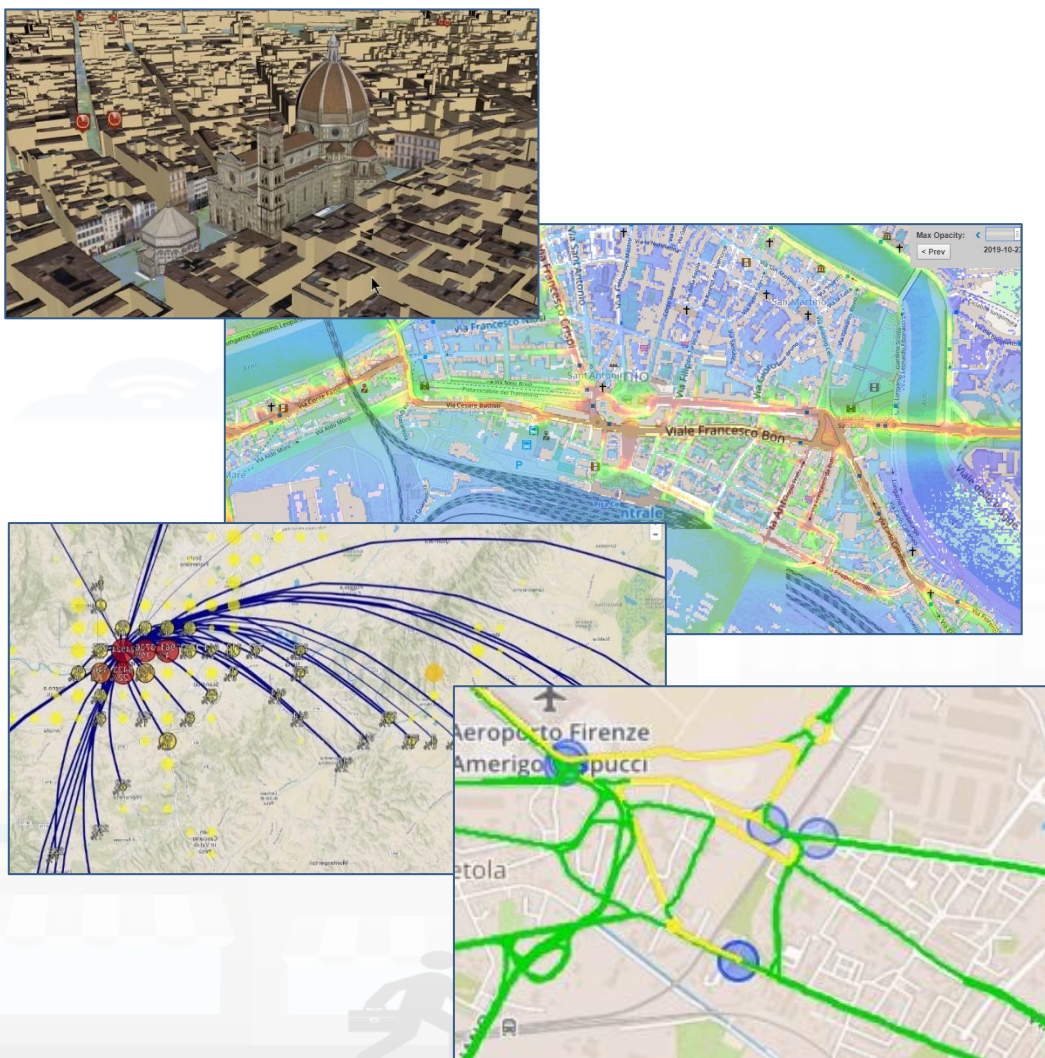


New styles/themes can be developed by specializing a few files from open source

<https://www.snap4city.org/793>



# Smart City Digital Twin



## City Digital Model with...

- Intuitive platform
- Any Data TYPE, any data source, any protocol
- Data storage seamless
- Data analytics → artificial intelligence, AI/XAI
- Data Ethics, AI Ethics, GDPR
- Interactive Data Representation, any kind
- Key Performance Indicators, any kind
- What-IF analysis – Simulation, prediction, 2D/3D
- Micro, Meso e macro scales
- Operation, planning tactic and strategic / optimization
- Collaborative and shared representation
- Sustainable, shared, open source 100%



## Complex and heterogeneous information, interoperability

- GIS, ITS, AVM, IoT, BIM, CKAN, etc.
- Satellite services
- MaaS, last-mile delivery HUBs
- etc.





Ciao roottooladmin!

Fri 2 Sep 19:13:07

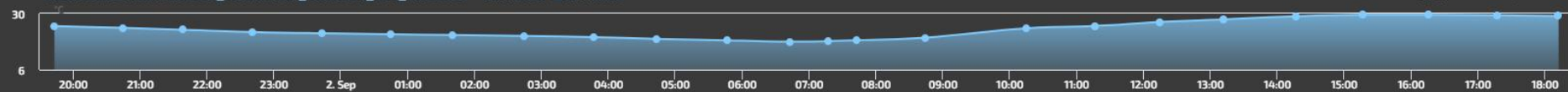
## 3D MAP GLOBAL DIGITAL TWIN - NEWGUI



3D MAP



DISIT:ORIONUNIFI:TUSC\_WEATHER\_SENSOR\_OW\_3176959 - AIRTEMPERATURE







Ciao

Fri 13 Oct 18:29:18

# FLORENCE SCDT



SELECT...

- ORAL HD
- NO 2
- 
- 
- 
- 
- 
- 
- WHAT-IF
- 
- 

DOUBLE MAP



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





- Snap4City at OSAKA with OPTIFaaS and CN MOST
- SMART3R-FLITS: SMART Transport for Travellers and Freight Logistics Integration Towards Sustainability
- SOLUTION: Security, Smart City Asset Management for Cuneo, Italy [PDF](#)
- ENERGIA: R&S di autoclave a mandrini multipli nel curing di serbatoi in composito per storage di H2 mediante ottimizzazione energetica machine learning.
- UrbanDT4TF: Urban Digital Twin for Traffic Flow
- ELLIE: On the Use of Internet of Senses for the Cultural Heritage
- Snap4Rhodes: The "Single Smart City & Cyber Security Monitoring Platform" for the Municipality of Rhodes
- SADI-MIAC: Integrated Decision Support System with Digital Twin Models and Artificial Intelligence for Business
- SADI-MIAC: Sistema di Assistenza alle Decisioni Integrato con Modelli Digital Twin e Intelligenza Artificiale per le attività commerciali
- SCENARIO: City Users' Participation and Engagement with Snap4City, [PDF](#)
- OPTIFaaS: Operation and Plan, Transport Infrastructure and Facilities Support as a Service
- SOLUTION: 15MinCityIndex: understanding city areas by means of 13 different aspects, [PDF](#)
- SOLUTION: Energy Management and Control, [PDF](#)
- SOLUTION: Environment Control, Predictions & Prescriptions, [PDF](#)
- SOLUTION: Smart Light Control and Light Adaptive with Traffic Density [PDF](#)
- SOLUTION: Smart Tourism Management with Snap4City [PDF](#)
- SOLUTION: Traffic Infrastructure Optimisation: reducing travel time and emissions [PDF](#)
- SOLUTION: Traffic Light Plan Optimisation: reducing travel time, number of stops for vehicles and tramway lines: [PDF](#)
- SOLUTION: Snap4Building: monitoring, managing, controlling infrastructures [PDF](#)
- SOLUTION: Snap4City integration with Milestone X Protect, VMS, Video Management System [PDF](#)
- SOLUTION: Snap4City Digital Twin, [PDF](#)
- SOLUTION: eShare in a Snap - The innovative car sharing and car pooling service, [PDF](#)
- SOLUTION: Snap4City Smart Parking Manager and mobile App supports [PDF](#)
- SOLUTION: Exploit Snap4City in different Smart Waste use cases, waste manager, [PDF](#)
- eShare in a Snap - The innovative car sharing and car pooling service
- Digital Twin Cityverse FAQ to Snap4City
- AMMIRARE: make the beach system more resilient to climate change risks through the implementation of natural based solutions
- TOURISMO: TOURism Innovative and Sustainable Management of flows
- CAI4DSA: Collaborative explainable neuro-symbolic AI for Decision Support Assistant
- SASUAM: Solutions for Safe, Sustainable and Accessible Urban Mobility
- SCENARIO: Exploit Snap4City in different Smart Waste use cases
- SCENARIO: Smart City Asset Management for Cuneo, Italy
- Digital Data Analytics (D2A) Models and Digital Twin (ITA)
- Smart Light Control and Light Adaptive to Traffic Density (the actual case of Merano) [PDF](#)
- Key performance indicators (KPI) for smart mobility e trasporti, MaaS, parcheggi, inquinamento (ITA)
- [Snap4City integration with Milestone X Protect, VMS, Video Management System](#) [PDF](#)
- SCENARIO: Smart Light Control, 2023, CAPELON, [PDF](#)
- Florence HeritData FactSheet: <https://www.snap4city.org/drupal/sites/default/files/files/FACTSHEET%20FLORENCE.pdf>
- SCENARIO: Smart City Living Lab in Romania, [PDF](#)
- Snap4PVenergy: Online Photovoltaic System Simulator
- SCENARIO: Fashion Retail Recommendation System via Multiple Clustering Approach
- SCENARIO: Energy Community, CER, SELFUSER
- SCENARIO: Supporting Decision Makers in Real Time about Quality Lab Analyses on the production process, [PDF](#)
- Herit-Data and Snap4City: to better manage tourism flows, [PDF](#)
- Digital Twin Local and Global, [PDF](#)
- Social Media Analysis: Twitter Vigilance, [PDF](#)
- GDPR Compliant People Detection and Counting using Thermal Cameras, [PDF](#)
- Artificial Intelligence Predicts Landslides in Florence Area, [PDF](#)
- Available Parking Slots Prediction, [PDF](#)
- Available Bikes and Free Slots Prediction On Bike Sharing Stations, [PDF](#)
- Long Term Prediction of NO2 KPI of European Commission reference values, [PDF](#)
- Inventory of transferable digital applications and solutions for the tourism ecosystem
- Scenario: AMPERE Operator Manual
- Scenario: IMPETUS Intelligent Management of Processes, Ethics and Technology for Urban Safety (Oslo and Padova)

<https://www.snap4city.org/4>





2020



Contract



- Smart Tourism
- 6 Pilots
- Data Analytics
- Extended platform



- Smart Mobility
- PISA, PUMS
- Living lab



Km4City 1.6.7

Smart Ambulance (2021-22)

Enterprise (2021-22) Industry 4.0



enel x Contract



Contract

2021

PC4City (2020-21) Monitoring Terrain

Winner of Open Data Challenge of enel x

CAPELON

- Smart Light
- Sweden

Almafluida Industry 4.0 (2021-22)

AMPERE (2021-22) Industry 4.0

SYN-RG-AI SmartCity



Industry 4.0

uni.systems

SmartCity, 2021-23



AXIS collab SmartCity

2022



Asymmetrica Smart City, 2022-23

Contract, 2022-23



2023



Contract, 2022-23



2022-2023

enel x Contract, 15min



Security and Risk

Smartea



Italferr, Smart City



CN MOST, 2022-26



EI THE, 2022-26

G. Agile, 2021-23



2023-26



Merano, smart light

OceanRace, Genova, AWS

Cuneo, smart city

2024

Km4City 1.6.8

TOURISMO



ELLIE IA 2025-2027



UrbanDT4TF



Contract, 2024-25

CAI4DSA



OPTIFaaS



Rhodes, smart city

eShare

UNIFI TUSS



AMMIRARE



- **UrbanDT4TF**, CN HPC: Digital Twin mobility, <https://www.snap4city.org/drupal/node/1057>
  - **DI-DTPlatform**, CN HPC: Digital Twin, mobility, environment, <https://www.snap4city.org/drupal/node/1097>
  - **Sasuum**, CN MOST, PNRR: AI, mobility, <https://www.snap4city.org/drupal/node/999>
  - **OPTIFaaS**, CN MOST, PNRR: AI, mobility, DSS, <https://www.snap4city.org/drupal/node/1008>
  - **LeverageOPTIFaaS**, CN MOST: PNRR, mobility, <https://www.snap4city.org/drupal/node/1064>
  - **TOURISMO**, Interreg, EC: Tourism, NLP, DSS, <https://www.snap4city.org/drupal/node/1001>
  - **ELLIE**, Horizon Europe, EC: AI, VR, <https://www.snap4city.org/drupal/node/1056>
  - **CN MOST**, PNRR: sustainable mobility, platform, <https://www.snap4city.org/drupal/node/1050>
  - **ISPRA JRC contract**, EC: DSS, SOC, control room, energy, <https://www.snap4city.org/drupal/node/970>
  - **AMMIRARE**, Interreg, EC: AI, environment, Big Data, <https://www.snap4city.org/drupal/node/1002>
  - **CAI4DSA**, FAIR PE1, PNRR: AI, Neuro-Symbolic, PINN, NG-DSS, <https://www.snap4city.org/drupal/node/1016>
  - **SADI-MIAC**, RT, partner: AI, Tourism, Retail, Computer Vision, <https://www.snap4city.org/drupal/node/1055>
  - **SMART3R**, PRIN UNICagliari: mobility, DSS, <https://www.snap4city.org/drupal/node/1087>
  - **Tuscany X.0, EDIH**, TestBeforeInvest, Training on AI, Big Data, Security, HPC: <https://www.tuscanyx.eu/>
  - **Reg4IA**, AI for regional public administration, A project of presidency of national council
  - **SmartCyprus**, a project of Cyprus Ministry of Digital Innovation and Policy
  - **The IE**, PNRR: AI, NLP, LLM, Legal Aspects
  - **BullVIT**, RT, conv: AI, NLP, LLM on commercial phases
  - **Energia**, RT, conv: AI, PINN, DSS, on manufacturing
  - **RFI contract**: mobility, AI, DSS
  - **Salerno Port**: AI for container ID recognition and tracking
  - **Talent Hub**, ECRF, conv: NLP, match demand vs offer
- + currently: Merano, Salerno, Cuneo, Rhodes, Reverberi, Florence, IDTS, ALTAIR, etc.

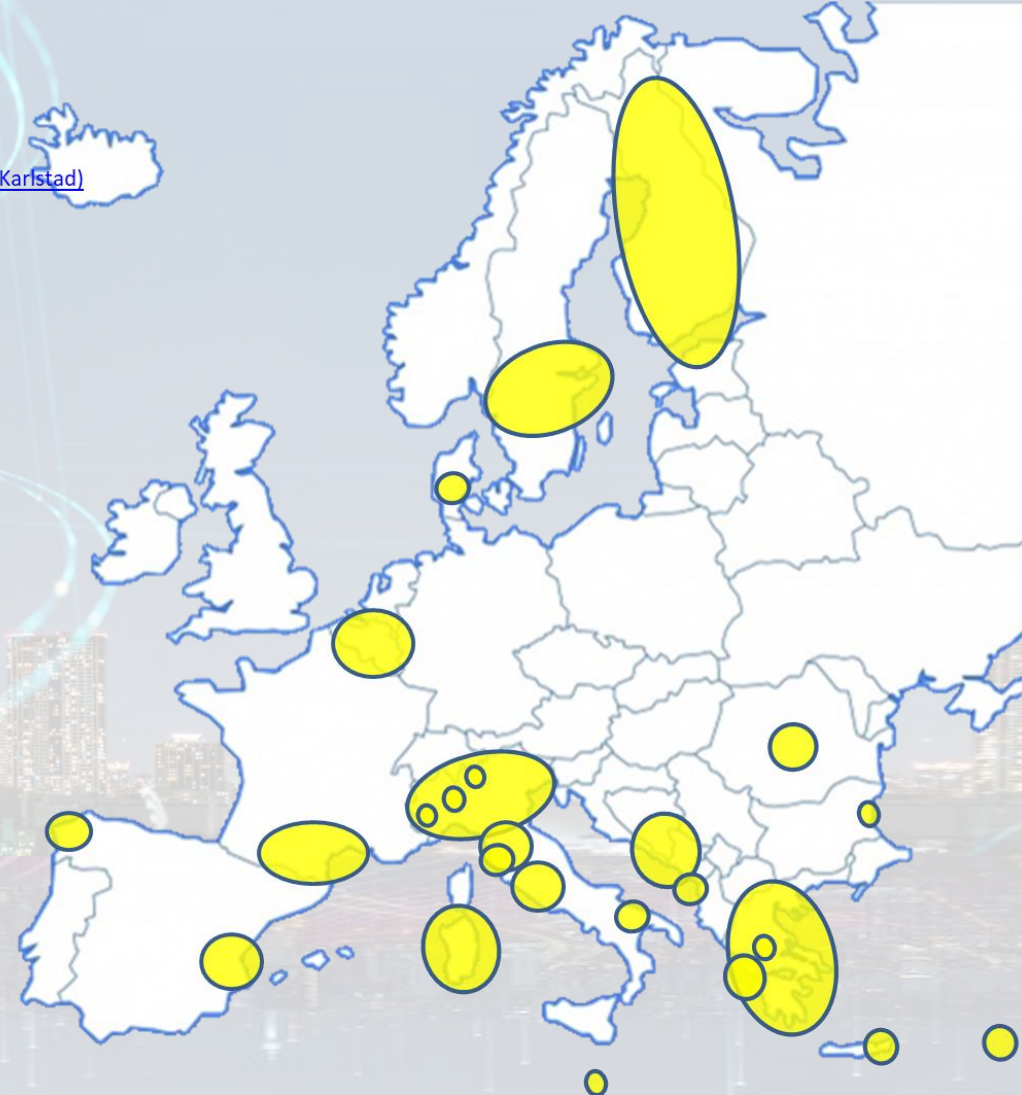




- 11 running installations in Europe
  - Snap4city.org, Greece, Merano, Cuneo, ...
  - Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
  - Altair, Italmatic, M4F, Romania, ....
- 20 projects, 12 pilots on 10 Countries
  - >40 cities/area
- **Widest MULTI-tenant deploy has**
  - 26 Organizations / tenant
  - > 8850 users on
  - > 1800 Dashboards
  - > 17 mobile Apps
  - > **2.2 Million of structured data per day**
  - > 580 IoT Applications/node-RED
  - > 850 web pages with training
  - > 85 videos, training videos

#### Main Organizations/areas

- [Antwerp area \(Be\)](#)
- [Bari \(I\)](#)
- [Bisevo, Croatia](#)
- [Bologna \(I\)](#)
- [Brasov \(Ro\)](#), by ICEBERG
- [Capelon \(Sweden: Västerås, Eskilstuna, Karlstad\)](#)
- [Cuneo \(I\)](#)
- [DISIT demo \(multiple\)](#)
- [Dubrovnik, Croatia](#)
- [Firenze area \(I\)](#)
- [Garda Lake area \(I\)](#)
- [Greece \(Gr\)](#)
- [Helsinki area \(Fin\)](#)
- [Limassol \(Cy\)](#)
- [Livorno area \(I\)](#)
- [Lonato del Garda \(I\)](#)
- [Malta \(Malta\)](#)
- [Merano \(I\)](#)
- [Modena \(I\)](#)
- [Mostar, Bosnia-Herzegovina](#)
- [Oslo & Padova \(Impetus\)](#)
- [Pisa area \(I\)](#)
- [Pistoia \(I\)](#)
- [Pont du Gard, Occitanie \(Fr\)](#)
- [Prato \(I\)](#)
- [Rhodes \(Gr\)](#)
- [Roma \(I\)](#)
- [Santiago de Compostela \(S\)](#)
- [Sardegna Region \(I\)](#)
- [Siena \(I\)](#)
- [SmartBed \(multiple\)](#)
- [Toscana Region \(I\), SM](#)
- [Valencia \(S\)](#)
- [Varna \(Bulgaria\)](#)
- [Venezia area \(I\)](#)
- [WestGreece area \(Gr\)](#)



- + Israel, Colombia, Brasile, Australia, India, China, etc.





# booklets

- Smart City



[https://www.snap4city.org/download/video/DPL\\_SNAP4CITY.pdf](https://www.snap4city.org/download/video/DPL_SNAP4CITY.pdf)

- Industry



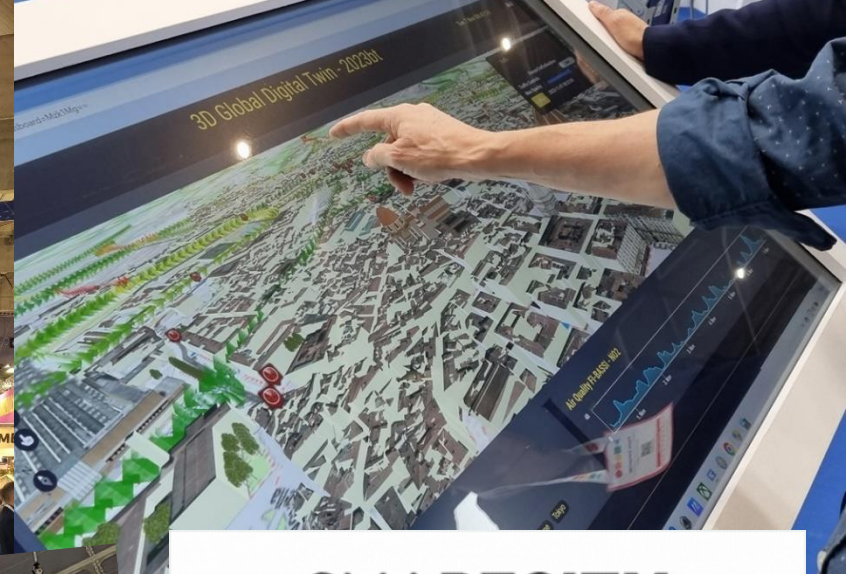
[https://www.snap4city.org/download/video/DPL\\_SNAP4INDUSTRY.pdf](https://www.snap4city.org/download/video/DPL_SNAP4INDUSTRY.pdf)

- Artificial Intelligence



[https://www.snap4city.org/download/video/DPL\\_SNAP4SOLU.pdf](https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf)







# Control Planning

# Goals

## Control

**Management and Operational**  
(monitoring, KPI, anomaly detection, early warning)

## Planning

**Tactic and strategic, medium and long range, micro/macro**  
(simulations and predictions, what-if analysis)





# THE POWER OF ARTIFICIAL INTELLIGENCE AT THE SERVICE OF YOUR OPERATION AND PLAN

[www.snap4city.org](http://www.snap4city.org)



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

DINFO  
DIPARTIMENTO DI  
INGEGNERIA  
DELL'INFORMAZIONE

DISIT  
DISTRIBUTED SYSTEMS  
TECHNOLOGIES LAB

Powered by  
**FIWARE**

**FREE  
TRIAL**



**SNAP4**  
Appliances and Dockers  
**Installations**



**JS Foundation**

**E015**  
digital ecosystem



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

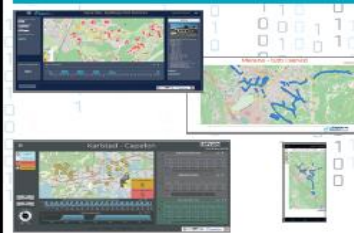
## HORIZONTAL AI PLATFORM



## MOBILITY AND TRANSPORT



## SMART ENERGY AND SMART BUILDING



## ENVIRONMENT AND WASTE MANAGEMENT



## CITY USER'S SERVICES AND TOURISM MANAGEMENT



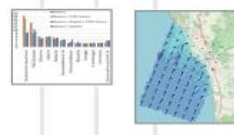
## SNAPADVISOR



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...



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

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

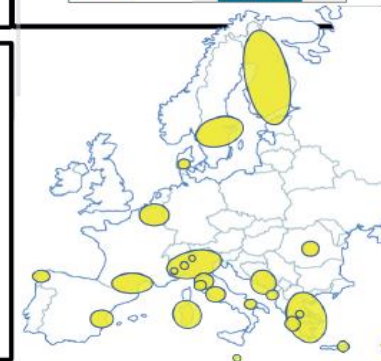
FULL INTEROPERABILITY, ANY: DATA, BROKERS, NETWORKS AND VERTICALS

• DEVELOPMENT ENVIRONMENT  
AND METHODOLOGY  
• VISUAL PROGRAMMING, ML, AI, HPC  
• TRAINING COURSES



NATIVE AND EXTERNAL  
APPLICATIONS

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





# Key Performance Indicators, KPI



| Air Quality Directive |                           |                                              |                                                                             | WHO guidelines            |                                           |
|-----------------------|---------------------------|----------------------------------------------|-----------------------------------------------------------------------------|---------------------------|-------------------------------------------|
| Pollutant             | Averaging period          | Objective and legal nature and concentration | Comments                                                                    | Concentration             | Comments                                  |
| PM <sub>2.5</sub>     | One day                   |                                              |                                                                             | 25 µg/m <sup>3</sup> (*)  | 99 <sup>th</sup> percentile (3 days/year) |
| PM <sub>2.5</sub>     | Calendar year             | Target value, 25 µg/m <sup>3</sup>           | The target value has become a limit value since 1 January 2015              | 10 µg/m <sup>3</sup>      |                                           |
| PM <sub>10</sub>      | One day                   | Limit value, 50 µg/m <sup>3</sup>            | Not to be exceeded on more than 35 days per year.                           | 50 µg/m <sup>3</sup> (*)  | 99 <sup>th</sup> percentile (3 days/year) |
| PM <sub>10</sub>      | Calendar year             | Limit value, 40 µg/m <sup>3</sup> (*)        |                                                                             | 20 µg/m <sup>3</sup>      |                                           |
| O <sub>3</sub>        | Maximum daily 8-hour mean | Target value, 120 µg/m <sup>3</sup>          | Not to be exceeded on more than 25 days per year, averaged over three years | 100 µg/m <sup>3</sup>     |                                           |
| NO <sub>2</sub>       | One hour                  | Limit value, 200 µg/m <sup>3</sup> (*)       | Not to be exceeded more than 18 times a calendar year                       | 200 µg/m <sup>3</sup> (*) |                                           |
| NO <sub>2</sub>       | Calendar year             | Limit value, 40 µg/m <sup>3</sup>            |                                                                             | 40 µg/m <sup>3</sup>      |                                           |

- **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: NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub> ([https://environment.ec.europa.eu/topics/air\\_en](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**



# 15MinCityIndex

*What would support my neighborhood to become a 15-Minute City?*

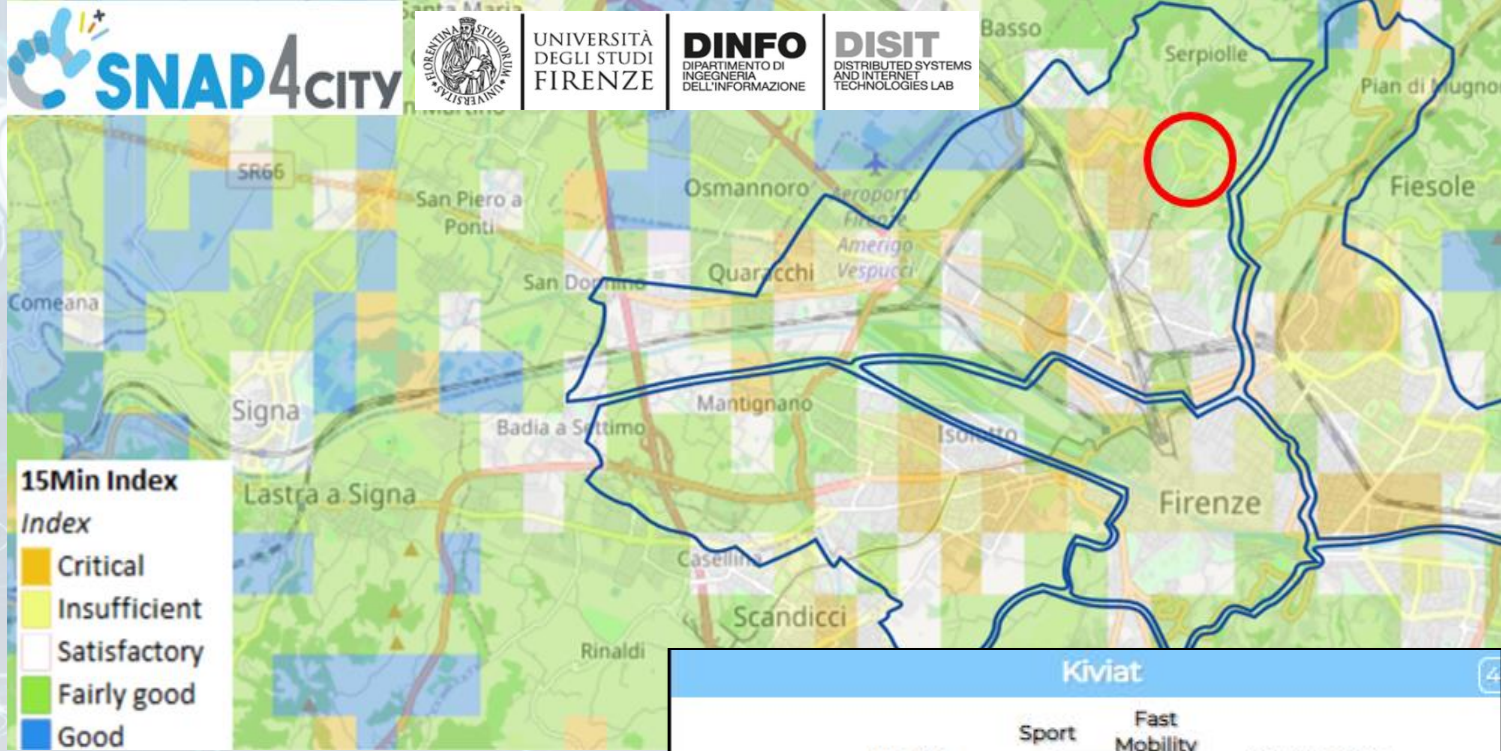
## Using the Open Data:

We developed a data analytic tool based on municipal and national open data to assess services adequacy for people living in each 15 minutes areas of the city.

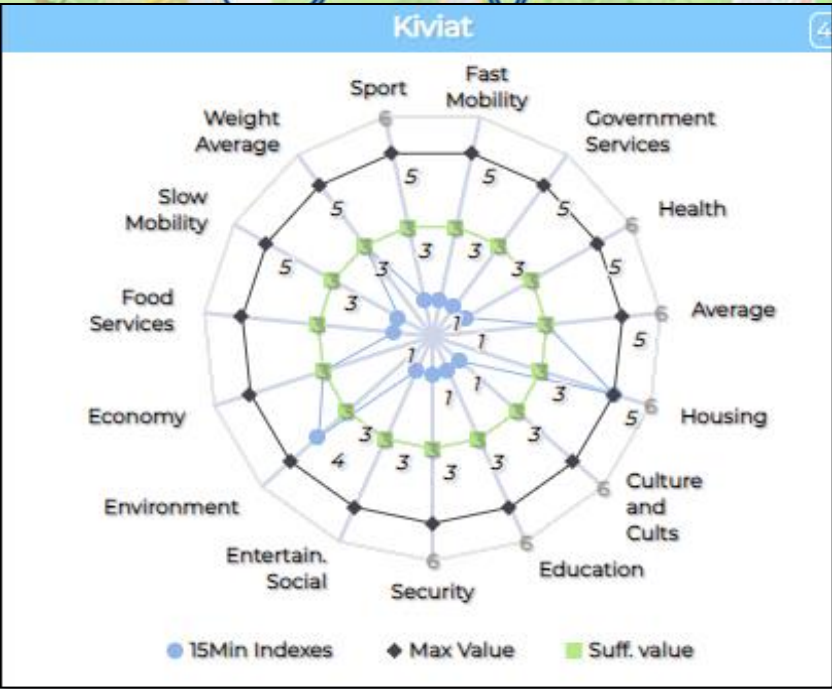
Good public transport services: bus, new tram line, train stations, cycle paths.



Careggi/Rifredi is a relevant district in Florence because of hosting the main Florence/Tuscany hospitals Careggi and Meyer, but also university headquarters and many other workplaces.



The tool supports the becoming of a 15-Minute city evaluating the service level in various domains.



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjkzOA==>



# 15MinCityIndex on Bologna

enel x



Ciao roottooladmin!

Tue 3 May 20:14:59

## 15 MINUTI INDEX BOLOGNA CITTÀ METROPOLITANA - NEWGUI

enel x

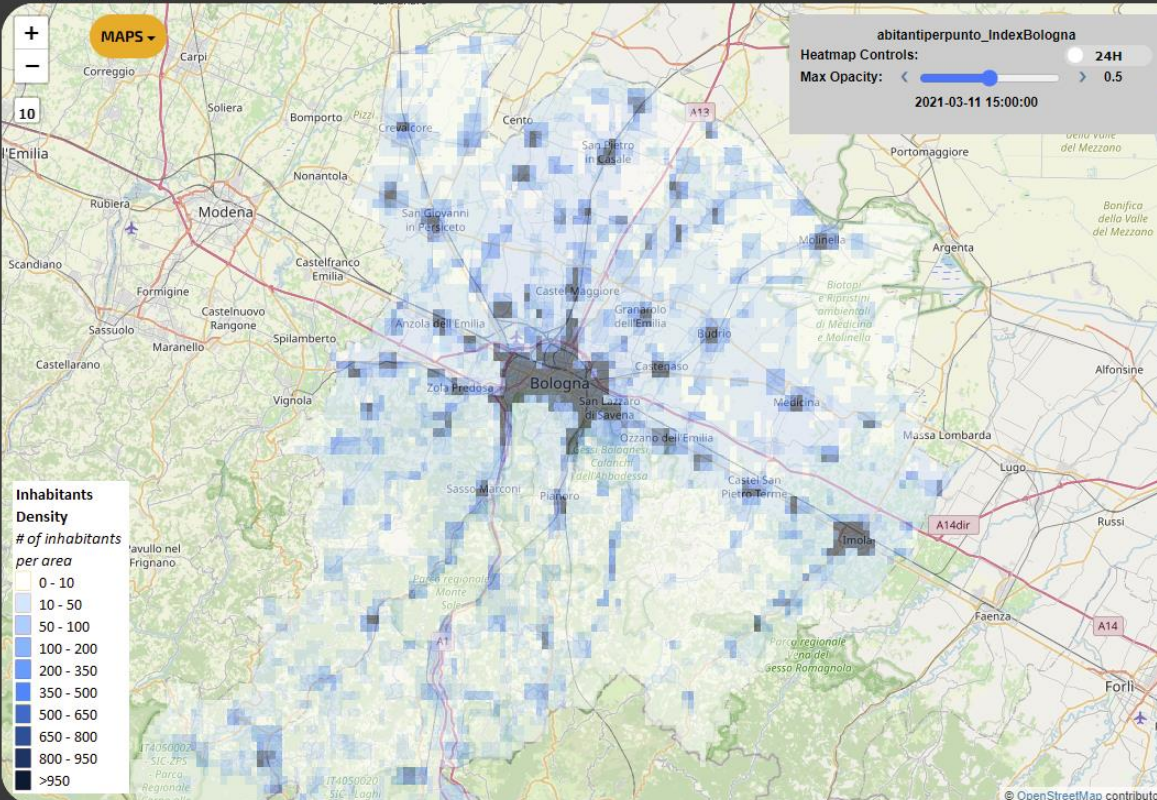
- # of Inhabitants
- Green factor
- Civil factor
- Industrialization factor
- Environment Index
- 15Min Economy Index
- 15Min Housing Index
- 15Min Health Index
- 15Min Food Index
- 15Min Education Index
- 15Min Slow Mob Index

THE PICKED POINT

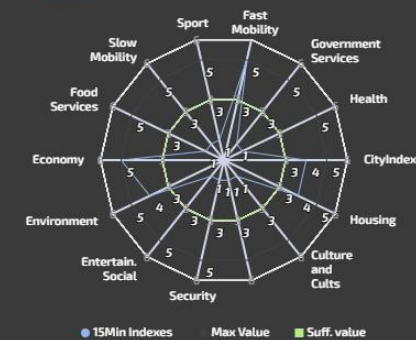
9m

City: Argelato  
Address: Via Casadio N. 1  
lat,lon: 44.61882,11.35437

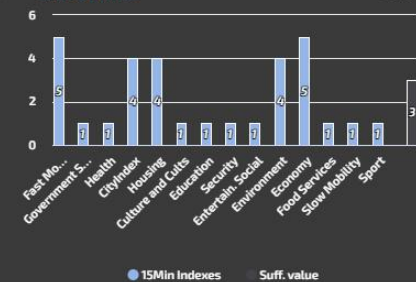
SELECTOR - MAP



KIVIAT



BAR SERIES



1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



7 AFFORDABLE AND CLEAN ENERGY



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



15 LIFE ON LAND







# Control Room



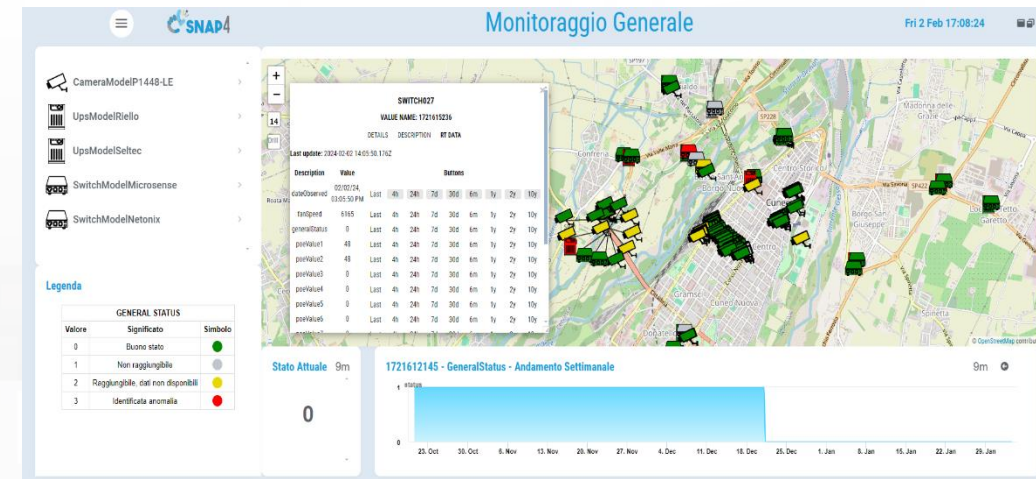
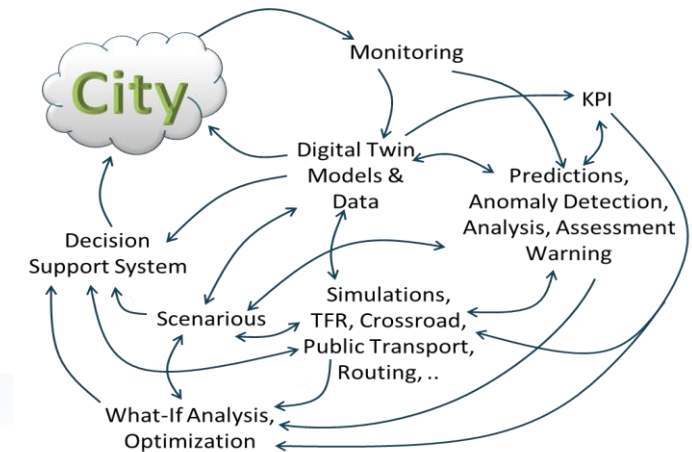






# Assets Control Domain (2024/8)

- Goals:
  - Costs reduction, increase service availability, risk reduction
  - Quality Level
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring :
    - Assets:** switches, Wi-Fi, servers, UPS, sensors, building, TV Cams, etc.
    - Energy:** consumption, operative conditions, UPS continuity, etc.
    - Production:** continuous serviceability analysis
    - Etc.
  - Early detection/warning, alarm, of critical conditions
    - Multichannel** Event reporting, notifications: email, Telegram, mobile apps, SMS, etc.
  - Managing maintenance operation, predictive maintenance
  - Computing predictions of any kind
- Solutions for Planning (optimization and what-if analysis)
  - Reduction maintenance costs, reduction of critical SLA conditions, improve service level
- Algorithms and computational solutions, see next slide





# ICT Assets Control: CUNEO Municipality



Monitoraggio Dettagliato

Mon 4 Dec 10:54:14

Tabella Device

Cerca per Indirizzo, ID o device...

Camera UPS Switch

| ID        | Stato | Tipo device    | Indirizzo                                   | IP            | Azioni |
|-----------|-------|----------------|---------------------------------------------|---------------|--------|
| TC010182  |       | Camera         | Cuneo Sud Palo Angolo Parco Giochi          | 172.16.12.185 |        |
| TC010178  |       | Camera         | Cuneo Sud Palo Alto verso Asilo             | 172.16.12.181 |        |
| TC010181  |       | Camera         | Cuneo Sud Palo davanti Biblioteca           | 172.16.12.184 |        |
| TC010179  |       | Camera         | Biblioteca Cuneo Sud Esterna Sopra Ingresso | 172.16.12.182 |        |
| TC010184  |       | Camera         | Cuneo Sud Angolo verso Parco Giochi         | 172.16.12.187 |        |
| TC010185  |       | Camera         | Cuneo Sud Angolo verso Bar                  | 172.16.12.188 |        |
| TC010183  |       | Camera         | Cuneo Sud Angolo davanti Megafresco         | 172.16.12.186 |        |
| TC010203  |       | Camera         | Rotonda Corso Francia Croce Rossa           | 172.16.12.203 |        |
| TC010204  |       | Camera         | Rotonda Corso Francia Distributore          | 172.16.12.204 |        |
| SWITCH041 |       | Switch Netonix | Rotonda C.so Francia Croce Rossa            | 172.16.15.222 |        |
| TC010202  |       | Camera         | Rotonda Corso Francia Tabaccaio             | 172.16.12.202 |        |

Tabella Dettaglio

TC010185

dateObserved

04/12/2023, 06:01

generalStatus

tempStatus1

1

TEMP STATUS

Valore

1

Significato

Buono stato

- Cabinets, Switches, UPS
- TV Cameras, etc.

Manage the status, tickets, notifications

Conteggi Telecamere

Thu 28 Mar 12:05:32

TC010246 Piazza Audifreddi - Media Ogni 10 Minuti

TC010247 Via Roma-Piazza Galimberti - Media Ogni 10 Minuti

Monitoraggio Generale

CameraModelP1448-LE

UpsModelRiello

UpsModelSeltec

SwitchModelMicrosense

SwitchModelNetonix

Legenda

GENERAL STATUS

Valore

0

1

2

3

Significato

Buono stato

Non raggiungibile

Raggiungibile, dati non disponibili

Identificata anomalia

Simbolo

SWITCH027

VALUE NAME: 1721615234

DETAILS DESCRIPTION RT DATA

Last update: 2024-02-02 14:05:50.176Z

Description

Value

Buttons

dateObserved

02/02/24, 02:05:50 PM

Last

4h

24h

7d

30d

6m

1y

2y

10y

fanSpeed

6185

Last

4h

24h

7d

30d

6m

1y

2y

10y

generalStatus

0

Last

4h

24h

7d

30d

6m

1y

2y

10y

portValue1

48

Last

4h

24h

7d

30d

6m

1y

2y

10y

portValue2

48

Last

4h

24h

7d

30d

6m

1y

2y

10y

portValue3

0

Last

4h

24h

7d

30d

6m

1y

2y

10y

portValue4

0

Last

4h

24h

7d

30d

6m

1y

2y

10y

portValue5

0

Last

4h

24h

7d

30d

6m

1y

2y

10y

portValue6

0

Last

4h

24h

7d

30d

6m

1y

2y

10y

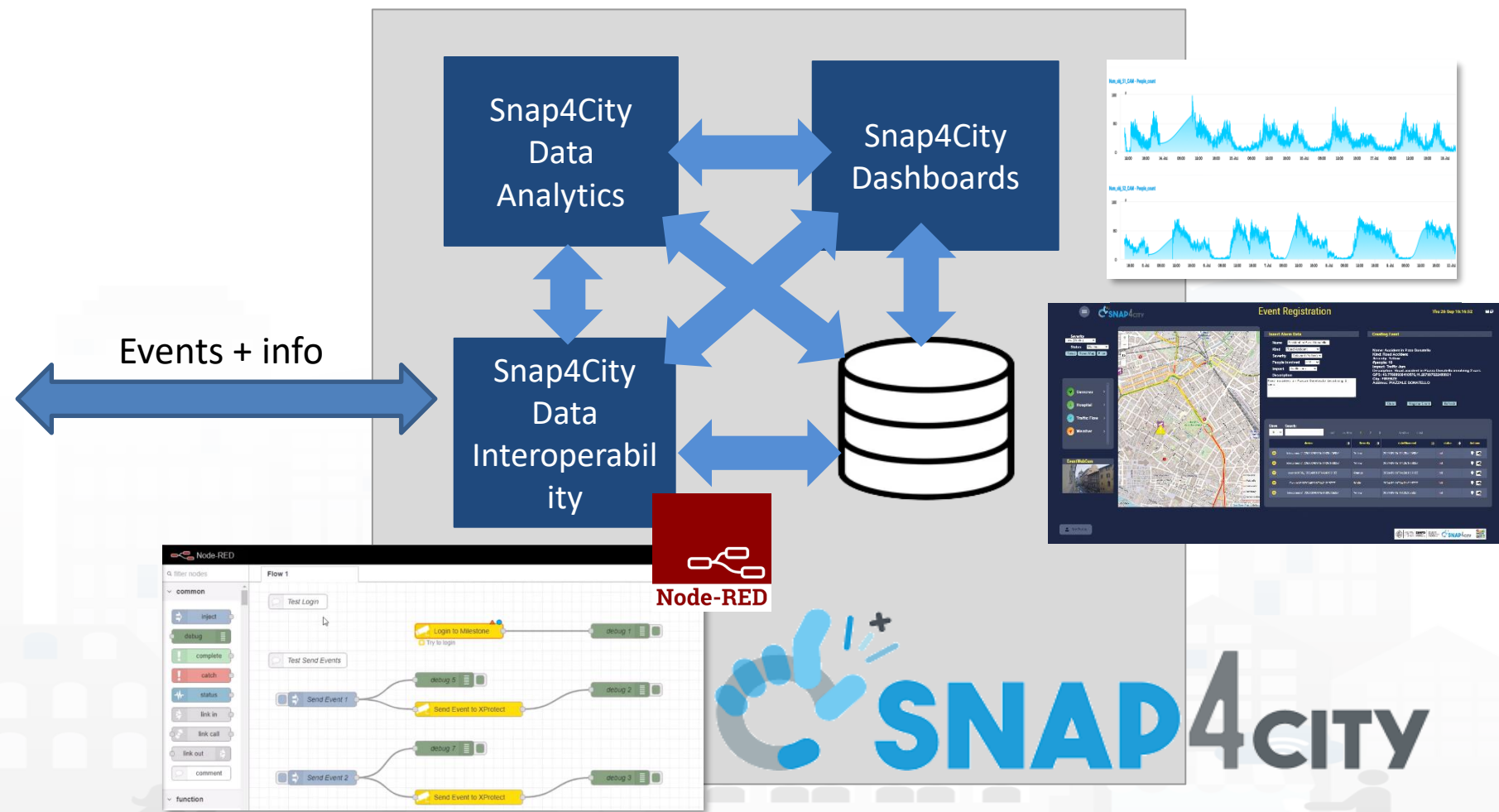
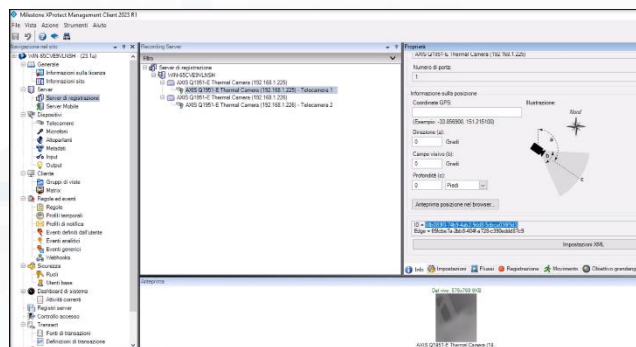
Stato Attuale

0

1721612145 - GeneralStatus - Andamento Settimanale



# VMS vs Snap4City: sending and getting events, AI solutions





# Developing on Snap4City

| 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 |
|          |            |                      |                |                          |                           |                                |                                    |
|          |            |                      |                |                          |                           |                                |                                    |



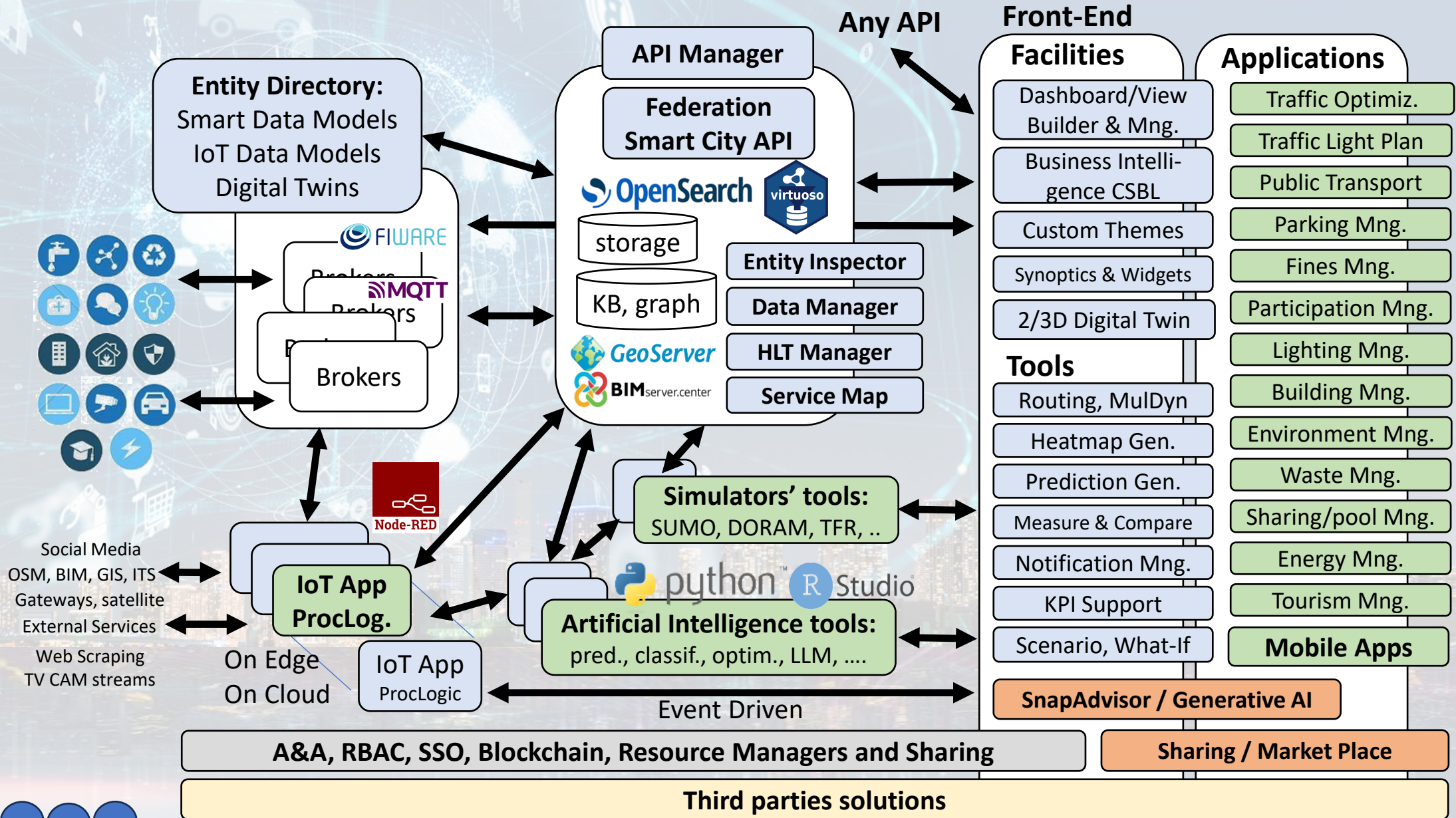


# Why/How to Develop <https://www.snap4city.org/1093>

1. Data Integration Interoperability, standards
2. Advanced Analytics and AI Integration
3. Dashboard and Visualization Tools, custom graphics
4. Digital Twin Support
5. Scalability and Modularity, cloud usage
6. Compliance and Security
7. Real-World Applications, use cases
8. Applications development



# Technical Architecture





# Visual Development Tools



The collage displays several key features of the SNAP4CITY platform:

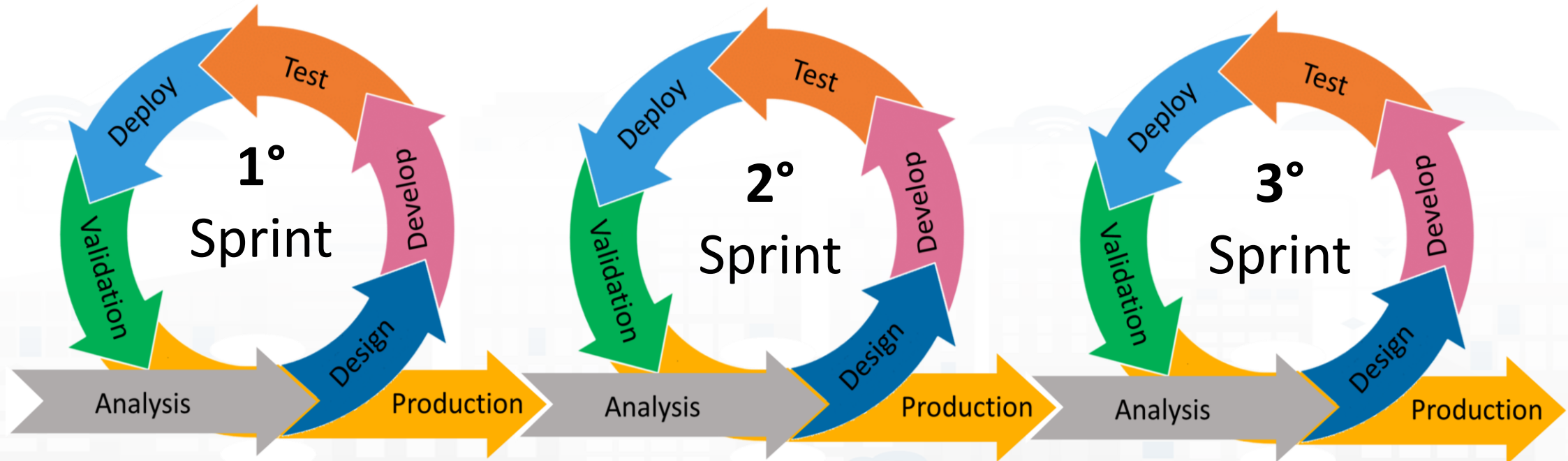
- My IoT Sensors and Actuators:** A form to add new devices with fields for Identifier, Latitude, and Longitude, alongside a map.
- Entities/Devices Management:** A table listing various devices with columns for Name, ID, Status, and Location.
- Service Map (Toscana):** A map showing service locations and data points.
- Data Inspector:** A detailed view of data points with a map and a list of attributes.
- My Dashboards in My Organization:** A collection of widgets showing different data visualizations.
- 3D MAP GLOBAL DIGITAL TWIN - NEWGUI:** A 3D visualization of a city model.
- Client-Side Business Logic - Test:** A flowchart and data visualization for testing business logic.
- FIRENZE - TRAFFIC - AIRQUALITY HEATMAPS - NEWGUI:** A heatmap showing traffic and air quality data in Florence.
- Jupyter2-(75) Hub - Python:** A code editor for running Python scripts.
- Custom Widgets / Synoptics:** A collection of custom widgets for data visualization.
- Proc.Logic / IoT App:** A visual programming interface for creating IoT applications.
- Node-RED:** A visual programming tool for connecting devices and services.
- 15MinIndex:** A dashboard for monitoring 15-minute indices.





# Agile Development Life Cycle by sprint

## Smart Solutions





<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

<https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf>



## 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>
- <https://twitter.com/snap4city>
- <https://www.facebook.com/snap4city>
- <https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg>

**Coordinator:** Paolo Nesi, [Paolo.nesi@unifi.it](mailto:Paolo.nesi@unifi.it)

DISIT Lab, <https://www.disit.org>  
DINFO dept of University of Florence,  
Via S. Marta 3, 50139, Firenze, Italy  
Phone: +39-335-5668674



Logged in as:  
edoardo\_tester

 Your Profile

Logout

SnapAssistant model:

Llama3.3 ▾

New Chat

EdoChat1

EdoChat2

EdoChat3

EdoChat4

prova

chatNuova

chatTest1LLAMA

chatTest2LLAMA

testGianniLLAMA

testTastoInvioPreChanges

ChatTestPostPSWINVIO

# 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==>](<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...



## Part 2: Dashboard production and management

Part 2: Dashboards  
production and  
management

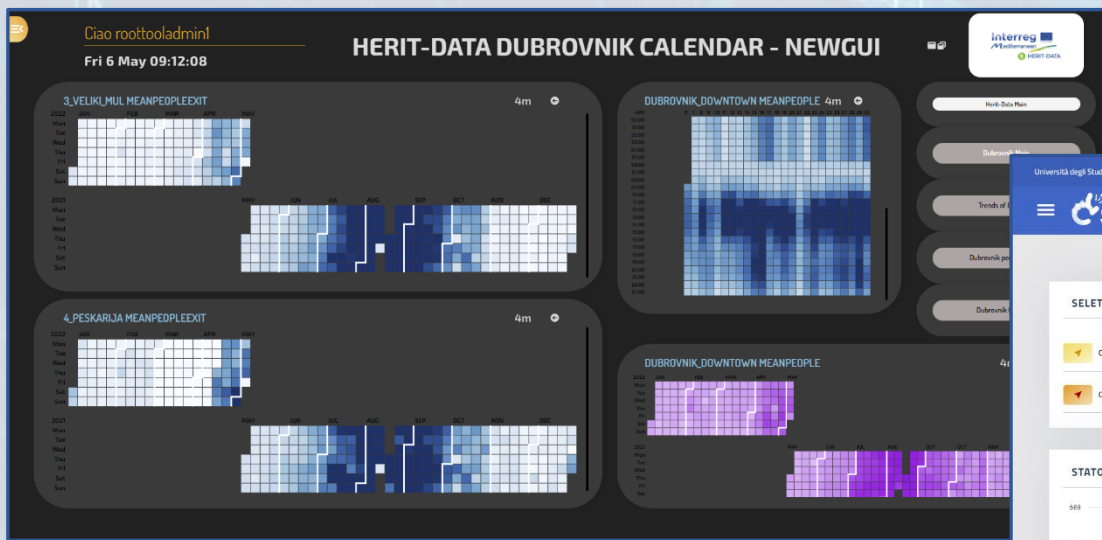
SLIDES

Interactive Slides

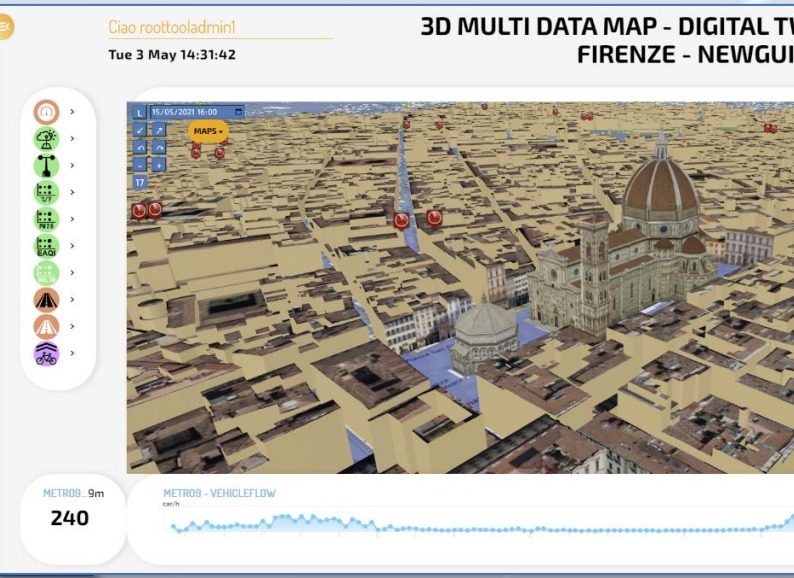
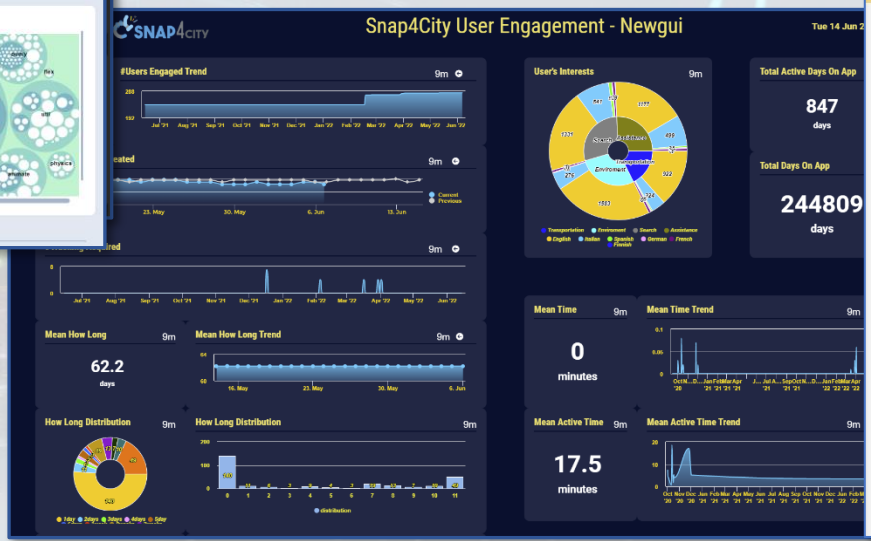
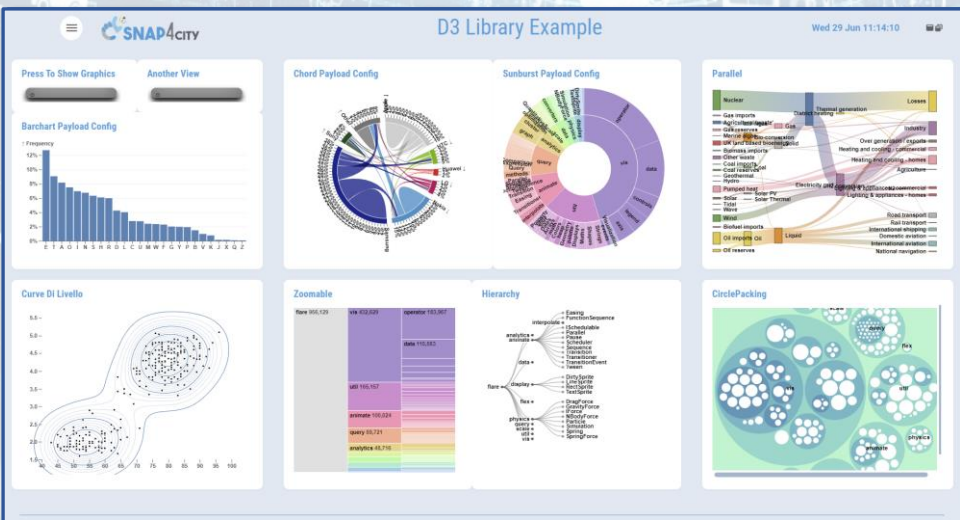
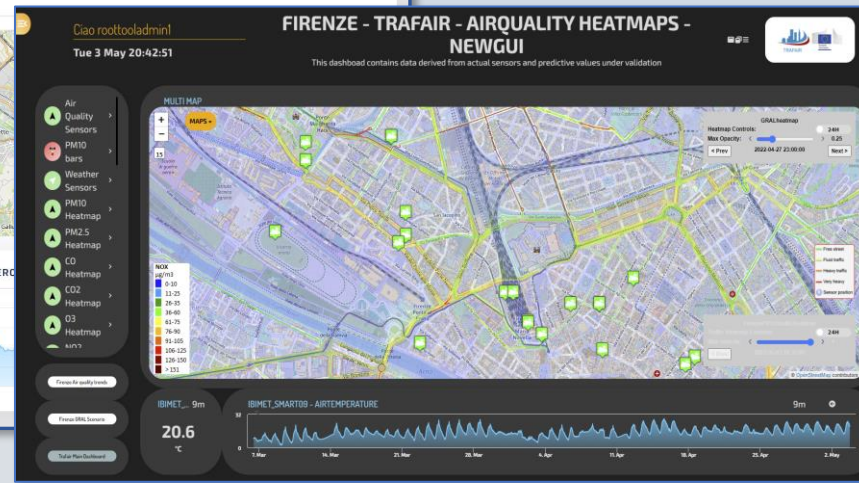
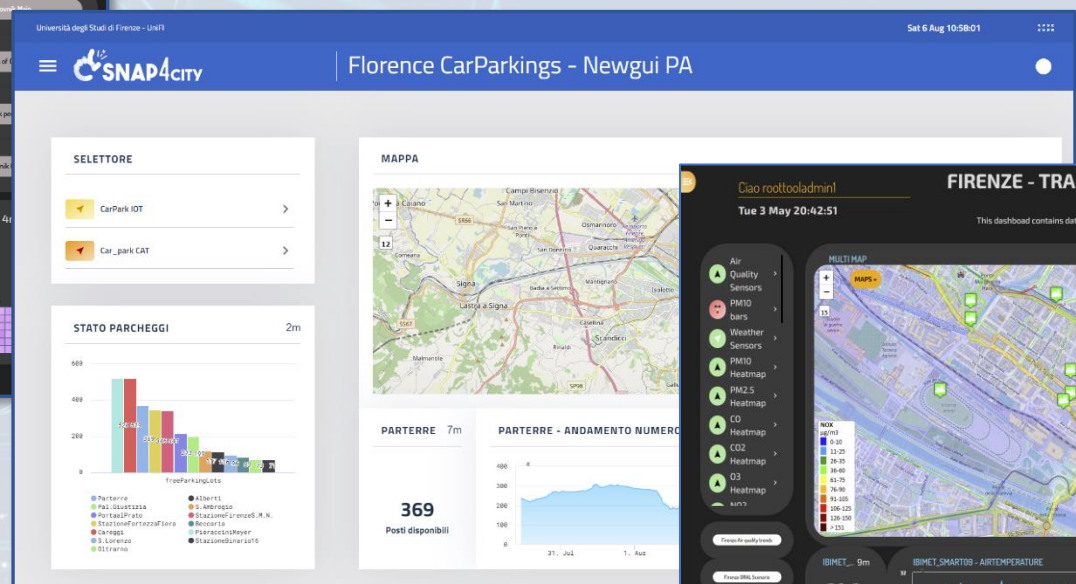


- Recall on Snap4City Architecture
- Dashboards Purposes and Uses
- Main Data Kinds: data vs representations
- Dashboards Main Concepts and simple Widgets
- Creating a Snap4City Dashboard, wizard
- Multi Data Map Widget
- High Level Types, video, external services, synoptics
- Selector for the Multi Data Map Widget
- Data Inspector vs Data Processes Details
- Dashboard Management





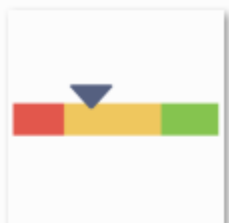
# Different Themes



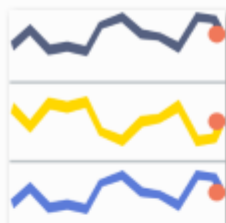
New styles/themes can be developed by specializing a few files from open source

<https://www.snap4city.org/793>

# Visual Representations



Slider with multiple steps for KPI



sparklines



kpi



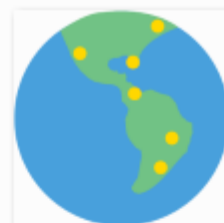
histogram



heatmap



flow-maps



geo-maps



donut-chart



Data-grid



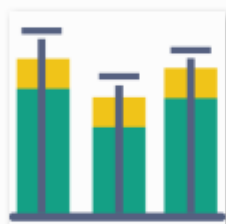
chord



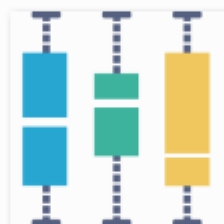
Cone



Bubble-matrix chart



Bullet



Box-plot



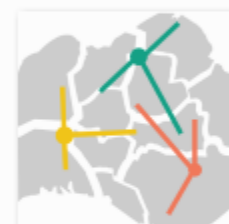
staked-area



Stacked-line chart



Stacked-combination Chart



spider-maps



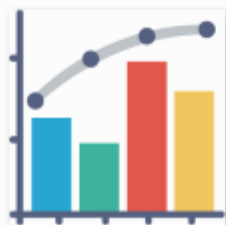
Sequence-Sunburst



Pivot



pie-chart-1



Pareto-chart



radar



Bubble-maps



waterfall



Sunburst



Sankey



# New Data Inspector/Wizard

**Data Inspector BETA OS**

**Map View:** A map of Florence, Italy, showing various data points (triangles) overlaid on the city streets. The map is titled "Data Inspector BETA OS".

**Single data widgets:** A grid of icons representing different data visualization types, including line graphs, bar charts, pie charts, and maps. Some icons are highlighted with red boxes.

**Multi data widgets:** A grid of icons representing different data visualization types, including line graphs, bar charts, pie charts, and maps. Some icons are highlighted with red boxes.

**Map Controls:** A set of buttons for map interaction, including "FilterMap", "GPSUser", and "GPSOrg".

**Data sources:** A table listing various data sources, including "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected", "All selected".

| Level | Type       | Nature             | Subnature  | Device            | Model | Broker             | Value Name          | Value Type | Data Type | Value Unit | Last Date           | Last Value | Healthiness | Last Check         | Ownership |
|-------|------------|--------------------|------------|-------------------|-------|--------------------|---------------------|------------|-----------|------------|---------------------|------------|-------------|--------------------|-----------|
| DT    | EM Devi... | Environment        | Weather    | DIDA1             |       | Santa Verdiana ... | Mio sensore         |            | webpage   |            | 2021-11-23 13:44... |            |             | 2023-07-18 16:0... | public    |
| DT    | EM Devi... | TransferService... | SensorSite | METRO11           |       | Altair-soda        | Altair Valve State  |            | webpage   |            | 2021-06-05 00:00... |            |             | 2024-01-10 01:3... | public    |
| DT    | EM Devi... | IndustryAndMa...   | Computer   | AltairStatoPom... |       | Altair-soda        | Altair Pump St...   |            | webpage   |            | 2021-05-20 13:51... |            |             | 2024-01-10 01:3... | public    |
| DT    | EM Devi... | Environment        | Air        | IBIMET_SMART...   |       | Altair-soda        | Altair Pump 43...   |            | webpage   |            | 2021-06-07 17:3...  |            |             | 2024-01-10 01:3... | public    |
| DT    | EM Devi... | Environment        | Air        | ARPAT_QA_FI...    |       | Altair-soda        | Altair valve 541    |            | webpage   |            | 2021-06-07 17:3...  |            |             | 2024-01-10 01:3... | public    |
| DT    | EM Devi... | TransferService... | SensorSite | METRO514          |       | Altair-soda        | Altair Pump 4321    |            | webpage   |            | 2021-06-07 00:00... |            |             | 2024-01-10 01:3... | public    |
| DT    | EM Devi... | TransferService... | SensorSite | SI052032FS990...  |       | Altair-soda        | Altair Stock sta... |            | webpage   |            | 2021-06-07 00:00... |            |             | 2024-01-10 01:3... | public    |
| DT    | EM Devi... | TransferService... | SensorSite | METRO831          |       | Altair-soda        | Altair Pump 92...   |            | webpage   |            | 2021-06-07 00:00... |            |             | 2024-01-10 01:3... | public    |

**Time Trend:** A line graph showing data over time, with a blue area representing the data trend. The x-axis is labeled "Time" and the y-axis is labeled "Value".

- Filtering/Searching for individual fields (even for some fields not displayed as geographic coordinates)
- Geographic Filtering
- Text Search on all fields
- Menu for choosing the fields to display in the table
- View on Map(via PREVIEW)
- Data and Trend visualization
- Opening Digital Twin
- Pass to Synoptic mode
- Select the graph representation

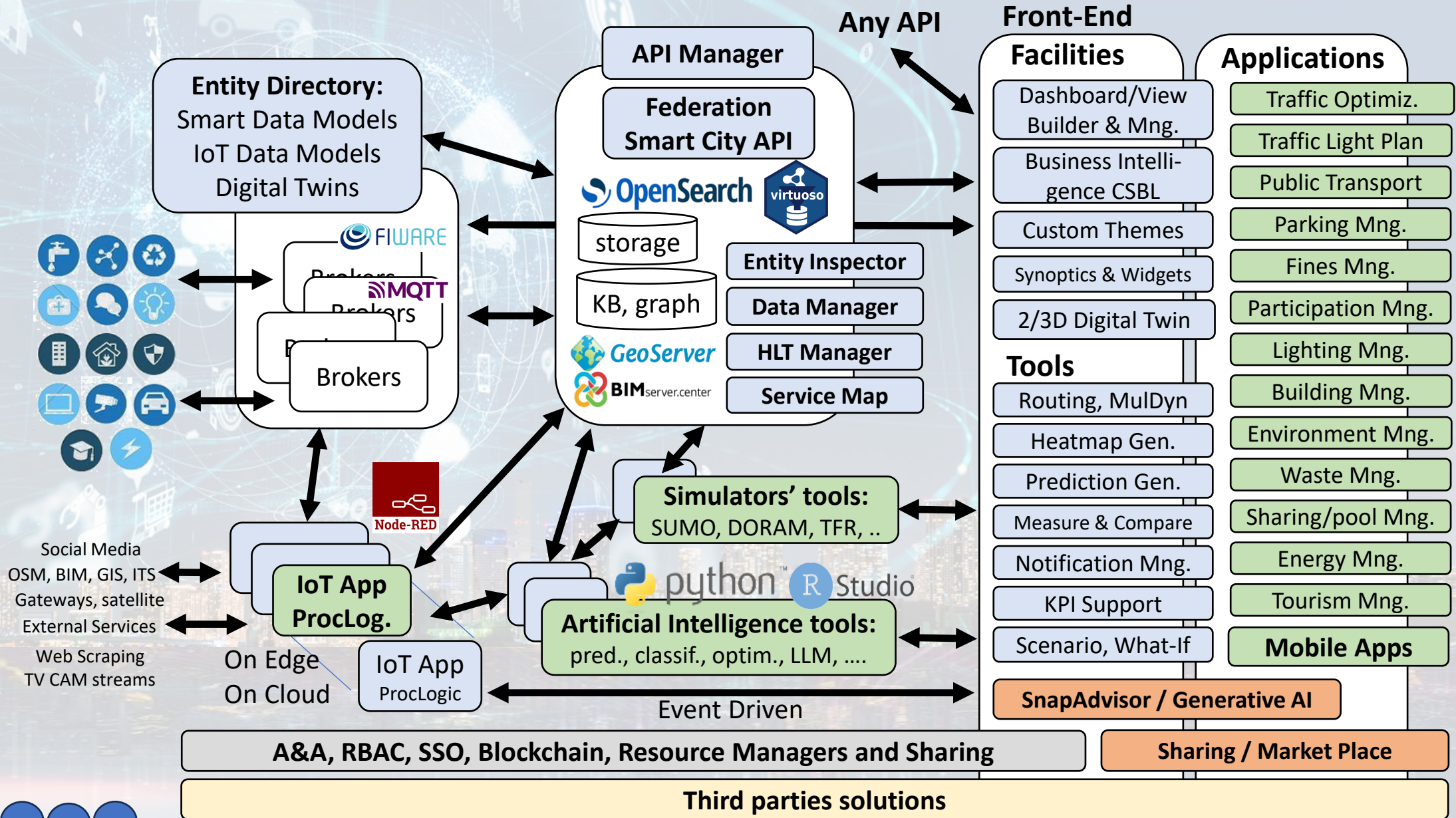
## Part 3: IoT App, process logic, server side BL

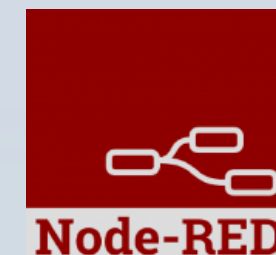
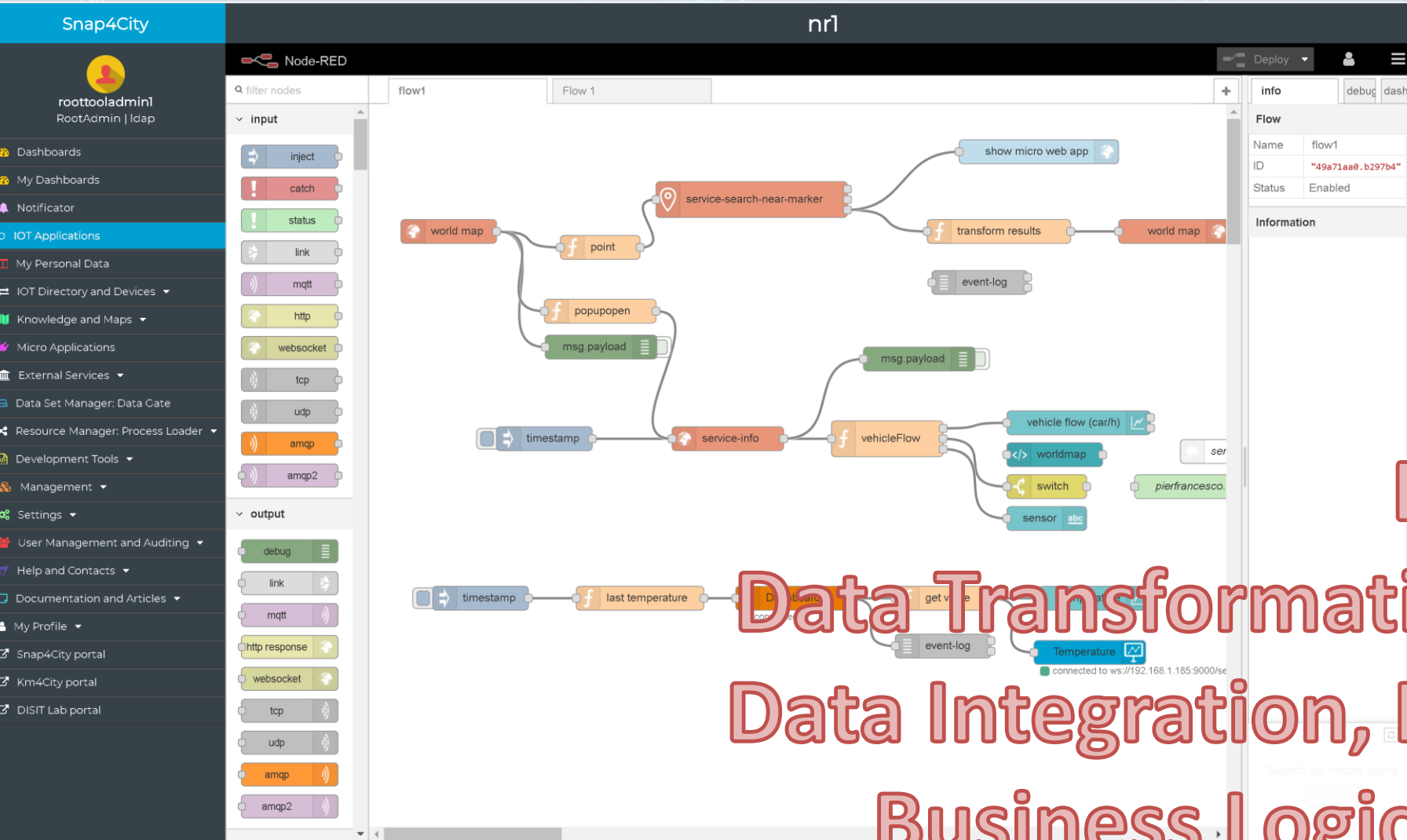
- Recall on Snap4City Architecture
- Node-RED
- IOT App = Node-RED + Snap4City
  - IoT App === Proc.Logic
- Examples of IOT App for Smartening Solutions
- Exploiting/Generating data by using: IoT App/Proc.Logic
- External Service <=> IoT App/Proc.Logic
- Dashboards <=> IoT App/Proc.Logic
  - Server Side Business Logic
- training material

|                                                                                                                                           |                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Part 3: IOT App, Process Logic, Server Side Business Logic</p> <p><a href="#">SLIDES</a></p> <p><a href="#">Interactive Slides</a></p> | <br> |
|-------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



# Technical Architecture



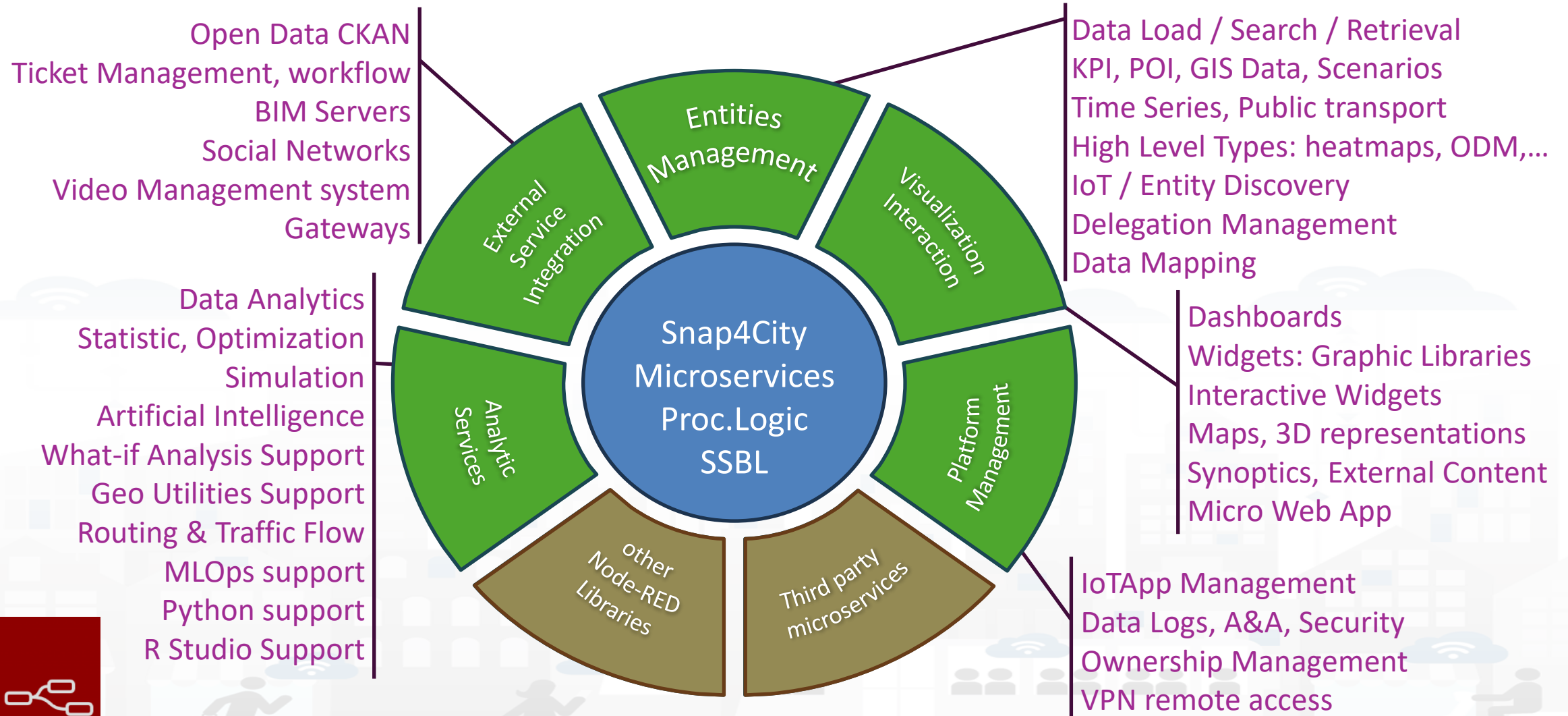


Data Adapation  
Data Transformation, Conversion  
Data Integration, Interoperability  
Business Logic vs Dashboards  
Data Analytics control  
Everywhere: Cloud, on IoT Edge Devices



> 60.000 downloads (up to 2024)

## Areas





# Sept 2024 collection

## Two Snap4City Libraries

Library navigation menu:

- > common
- > function
- > network
- > input
- > output
- > sequence
- > parser
- > storage
- > social
- > advanced
- > Advanced FTP
- > location
- > NGSi
- > lwm2m
- > S4C SearchDev
- > S4C Utility
- > S4C Mapping
- > S4C Management
- > S4C Data Analytic
- > S4C Big Data
- > S4C IoT App
- > S4C Open Maint
- > S4C IoT
- > S4C Whatif
- > S4C Search
- > S4C Data
- > S4C KPI Data
- > S4C Dashboard
- > S4C Sigfox
- > S4C LogDev
- > S4C View
- > S4C Social
- > dashboard
- > time

Available Snap4City Libraries:

- S4C SearchDev**
  - service search
  - service search near gps position
  - service search near service
  - service search within gps area
  - service search within wkt area
  - service search within stored wkt area
  - service search by municipality
  - service search by queryid
  - full text search dev
  - full text search within wkt area
- S4C Utility**
  - full text search within gps area
  - full text search near gps position
  - full text search exp
  - event search dev
  - event search exp
  - event search within wkt area
  - event search within gps area
  - event search near gps position
  - address search near gps position
  - geometry search near gps position
  - address poi search by text
- S4C Mapping**
  - address poi search by text exp
  - address poi search by text near gps position
  - bus routes search
  - bus routes search near gps position
  - bus routes search within gps area
  - bus routes search within wkt area
  - bus routes
- S4C Management**
  - point within polygon
  - routing
  - heatmap picker
  - coordinates to address
  - service info
  - edge-tunnel-to-cloud
- S4C Data Analytic**
  - get job detail
  - get triggers of job
  - get job group names
  - get trigger group names
  - get paused trigger groups
  - get job fire times
  - get system status
  - trigger job
  - pause all
  - pause trigger
  - pause triggers
  - resume all
  - resume job
  - resume jobs
  - resume trigger
  - resume triggers
- S4C Search**
  - service search near marker
  - service search within circle
  - service search within polygon
  - service search along path
  - full text search within circle
  - full text search within polygon
  - full text search along path
  - full text search usr
  - event search near marker
  - event search within circle
  - event search within polygon
  - event search along path
  - event search usr
  - address search near marker
  - geometry search near marker
  - address poi search by text usr
  - address poi search by text near marker
  - address poi search by text within circle
  - address poi search by text within polygon
  - bus routes search near marker
  - bus routes search within circle
  - bus routes search within polygon
  - tpl agencies
  - tpl lines
- S4C Data**
  - event search within polygon
  - event search along path
  - event search usr
  - address search near marker
  - geometry search near marker
  - address poi search by text usr
  - address poi search by text near marker
  - address poi search by text within circle
  - address poi search by text within polygon
  - value type search near marker
  - value type search within circle
  - value type search within polygon
  - value type search along path
  - get my data
  - get my delegator
  - get my delegated
  - get my activity
- S4C IoT App**
  - datagate search
  - datagate create
  - portia crawler
  - iotapp restart
  - iotapp upgrade
  - ownership
- S4C Social**
  - tpl routes by agency
  - tpl routes by line
  - tpl stops by route
  - tpl stop timeline
  - recommendation within circle
- S4C KPI Data**
  - service info mapped
  - mapping
  - set mapping
- S4C Dashboard**
  - is in standby mode
  - is shutdown
  - is started
  - get currently executing jobs
- S4C LogDev**
  - distance from coordinates

<https://flows.nodered.org/search?term=snap4city>

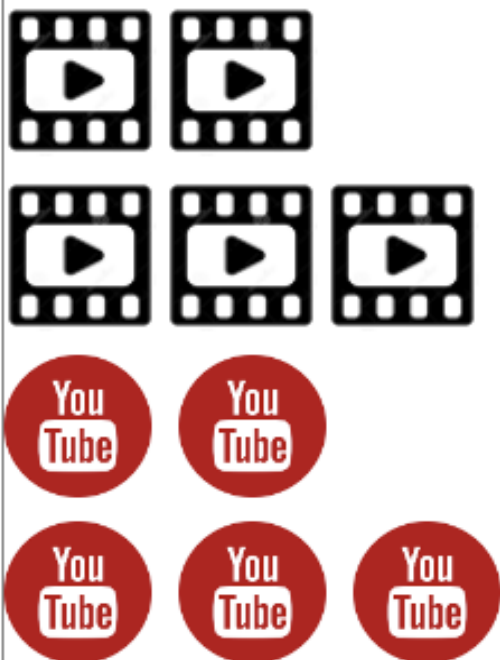


# Part 5: Data Ingestion and Interoperability

Part 5: Data Ingestion  
and Interoperability

SLIDES

Interactive Slides



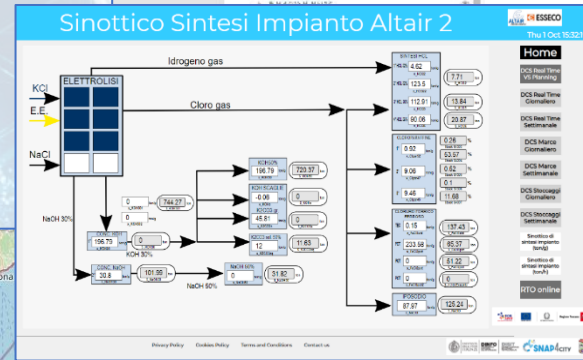
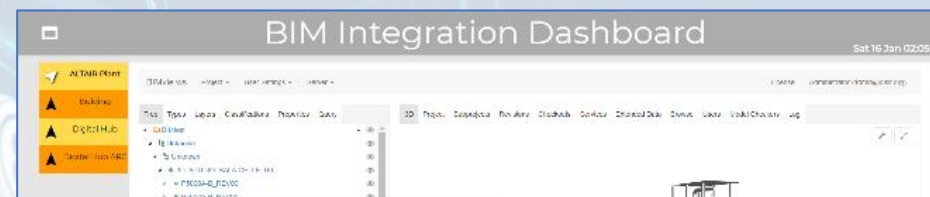
- When Solutions and tools for Data Ingestion and Interoperability are needed
- Overview of Snap4City Data Storage and Stack
- Knowledge Base: Modelling and Setting Up
- High Level Types vs Ingestion Process
- Data Ingestion Strategy and Orientation
- Ingestion of Points of Interest with POI Loader
- Models vs Devices/Entities and Registration
- Verification of Data Ingestion
  - Digital Twin Data Inspector vs Data Processes Details
  - My Data Dashboard Dev to assess data on Open Search Storage
- An Integrated Example for Time Series
- Entities Ingestion with Data Table Loader
- High Performance Ingestion via Python
- FIWARE Smart Data Models on Snap4City
- Ingestion of MyKPI with Proc.Logic / IoT App



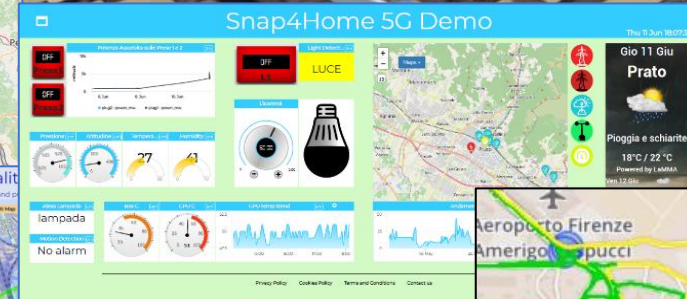
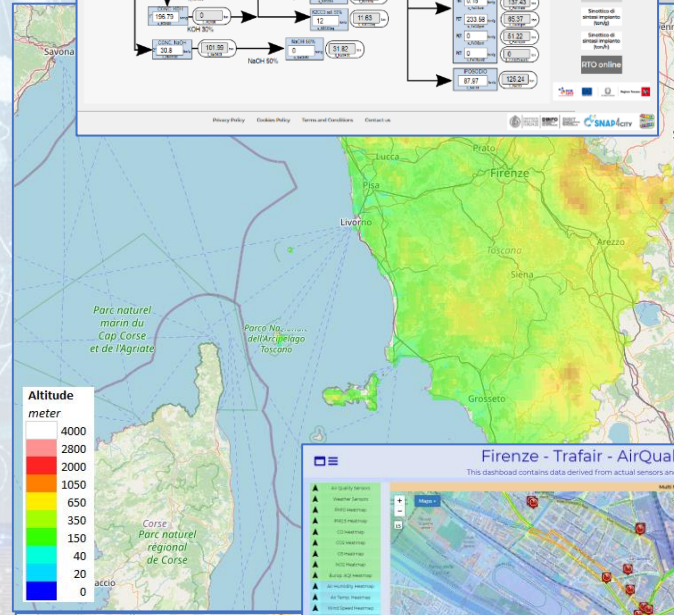
# High Level Types

Snap4City (C), Sett. 2025

- 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.



**SNAP4CITY**  
- Digital Twin Global - Fire  
demonstrator



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

DINFO  
DIPARTIMENTO DI  
INGEGNERIA  
DELL'INFORMAZIONE

DISIT  
DISTRIBUTED SYSTEMS  
AND INTERNET  
TECHNOLOGIES LAB





# Visual Development Tools



**My IOT Sensors and Actuators**

Add My New Device

Select Latitude/Longitude on Map

**Entities/Devices Management**

| Device Identifier         | IoT Sensor       | Device Type | Model            | Category         | Manufacturer     | Status | IP          | Entity           | Location         |
|---------------------------|------------------|-------------|------------------|------------------|------------------|--------|-------------|------------------|------------------|
| IoTQualitySensorVMM420001 | IoTQualitySensor | custom      | IoTQualitySensor | IoTQualitySensor | IoTQualitySensor | active | 192.168.1.1 | IoTQualitySensor | IoTQualitySensor |
| IoTQualitySensorVMM420002 | IoTQualitySensor | custom      | IoTQualitySensor | IoTQualitySensor | IoTQualitySensor | active | 192.168.1.2 | IoTQualitySensor | IoTQualitySensor |
| IoTQualitySensorVMM420003 | IoTQualitySensor | custom      | IoTQualitySensor | IoTQualitySensor | IoTQualitySensor | active | 192.168.1.3 | IoTQualitySensor | IoTQualitySensor |
| IoTQualitySensorVMM420004 | IoTQualitySensor | custom      | IoTQualitySensor | IoTQualitySensor | IoTQualitySensor | active | 192.168.1.4 | IoTQualitySensor | IoTQualitySensor |
| IoTQualitySensorVMM420005 | IoTQualitySensor | custom      | IoTQualitySensor | IoTQualitySensor | IoTQualitySensor | active | 192.168.1.5 | IoTQualitySensor | IoTQualitySensor |

**Service Map (Toscana)**

**Data Inspector**

**My Data Dashboard Dev Kibana**

29,146,065

**My Dashboards in My Organization**

**3D MAP GLOBAL DIGITAL TWIN - NEWGUI**

**Client-Side Business Logic - Test**

**Proc.Logic / IoT App**

**Node-RED**

**ISMinIndex**

**Jupyter2-(75) Hub - Python**

**Jupyter2-(75) Hub - Python**

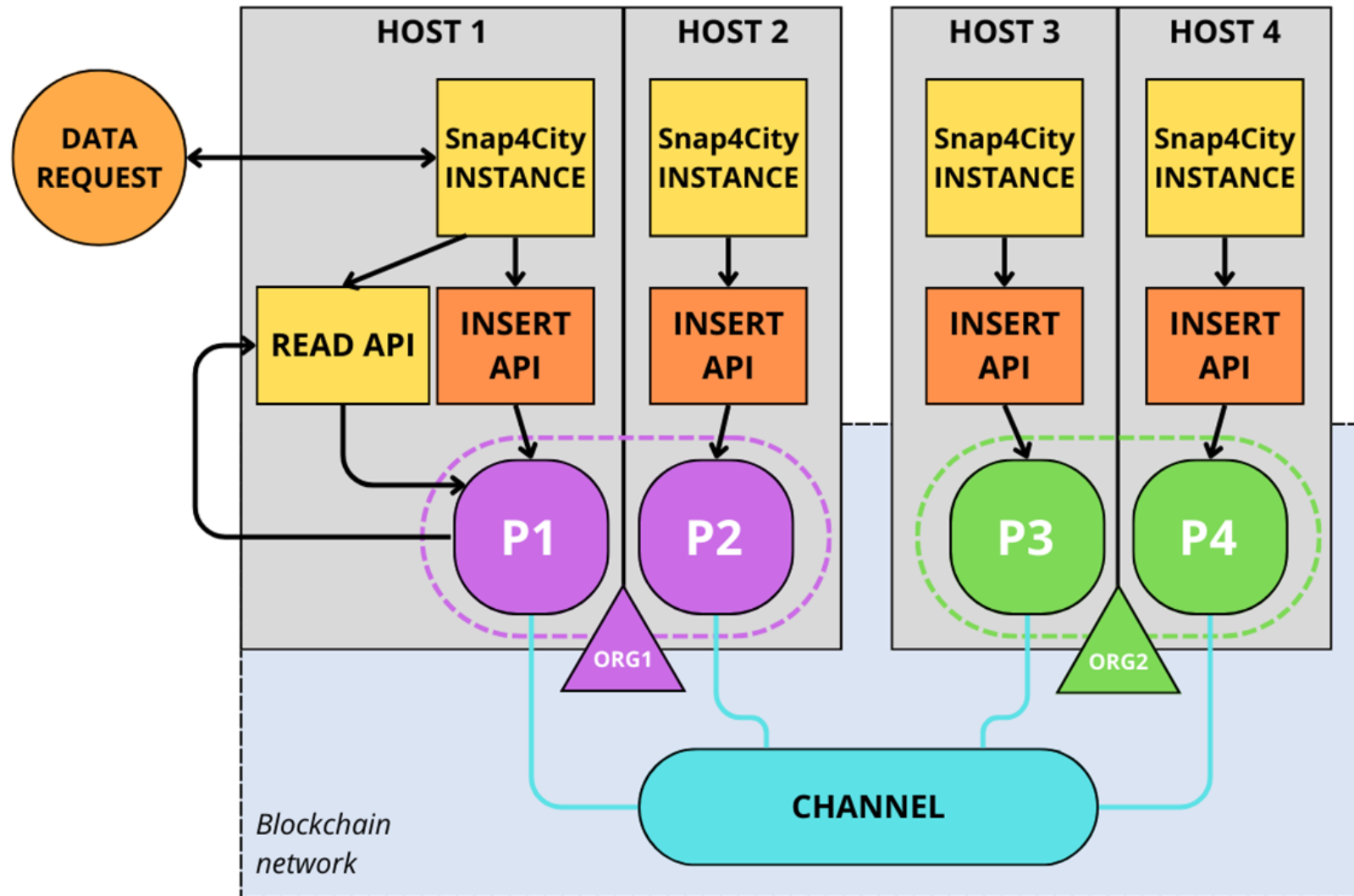
**FIRENZE - TRAFFAIR - AIRQUALITY HEATMAPS - NEWGUI**

**Custom Widgets / Synoptics**

A&A, SSO, Blockchain, Res

Data Analytics

# Snap4City with Blockchain





# Part 4: Data Analytics

Part 4: Data Analytics  
and Artificial  
Intelligence

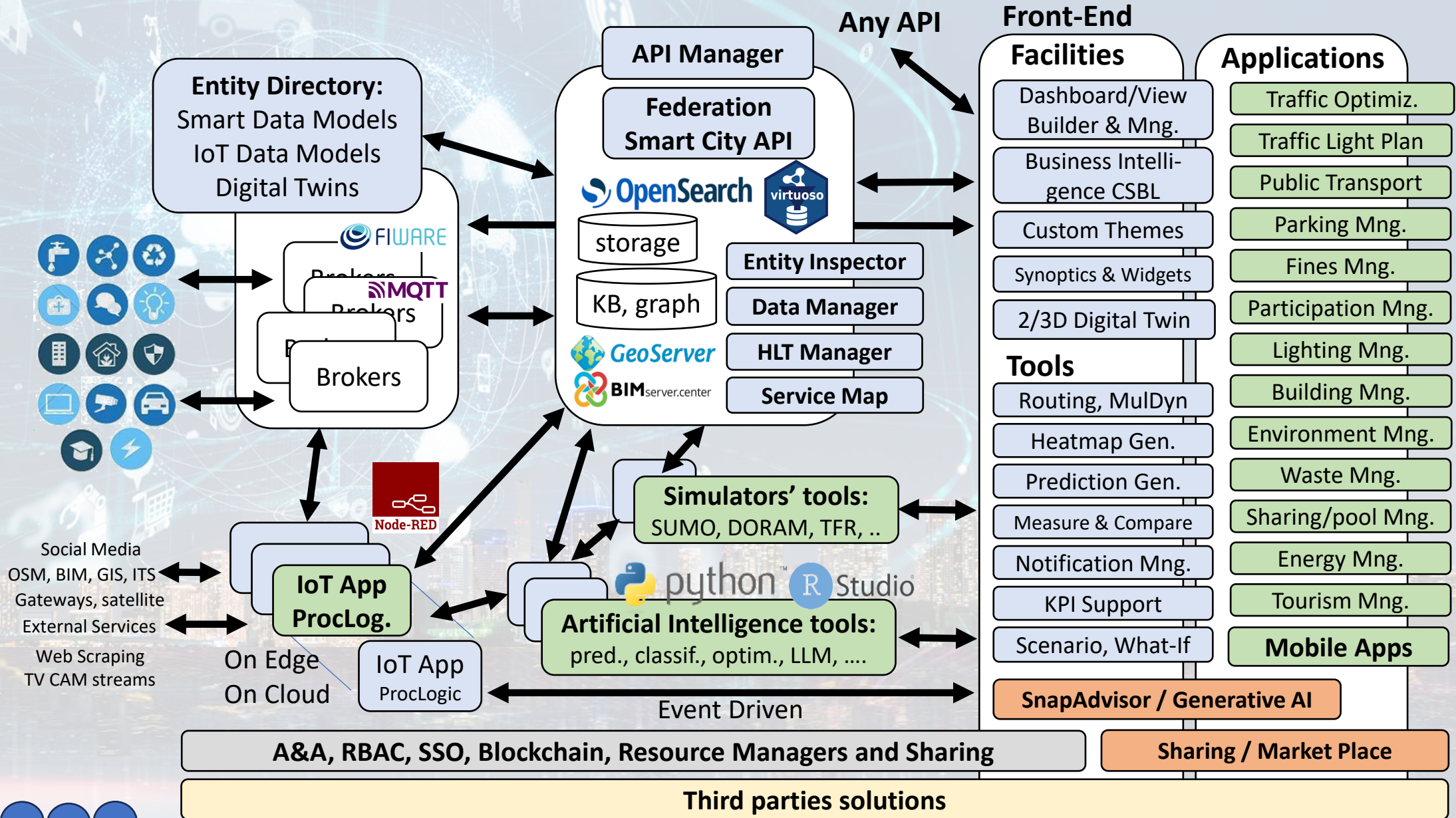
SLIDES

Interactive Slides



- Why and Where use DA, AI and XAI -> General Life Cycle, scenario editor, monitoring and control
- Data Processing: KPI, traffic, emissions, public transport quality, ..
- From Data Analytics, DA to Artificial Intelligence, AI
- List of the most relevant available DA and AI Solutions
- Predictions and Anomaly detections: parking, biking, NOx, landslide, people
- Computing: Higher Level Types Data and their representations: traffic, heatmaps, 3D
- Human Behavior, Engagement, Typical Time trends, WIFI sniffing
- Using AI in main domains: Mobility and transport, traffic optimization, Smart Energy, Smart Building,
- How AI/XAI, and Life Cycle, AI/ML requirements, XAI,
- Using DA, AI/XAI in Snap4City infrastructures
  - Data Analytics <-> IoT App / Proc.Logic
  - MLOps, ClearML, exploiting clusters of GPU/CPU
- Decision Support Systems and What-If Analysis, transport offer, DORAM tool
- Routing, Multimodal Routing, Dynamic Routing
- Predictive Maintenance
- Training Material

# Technical Architecture



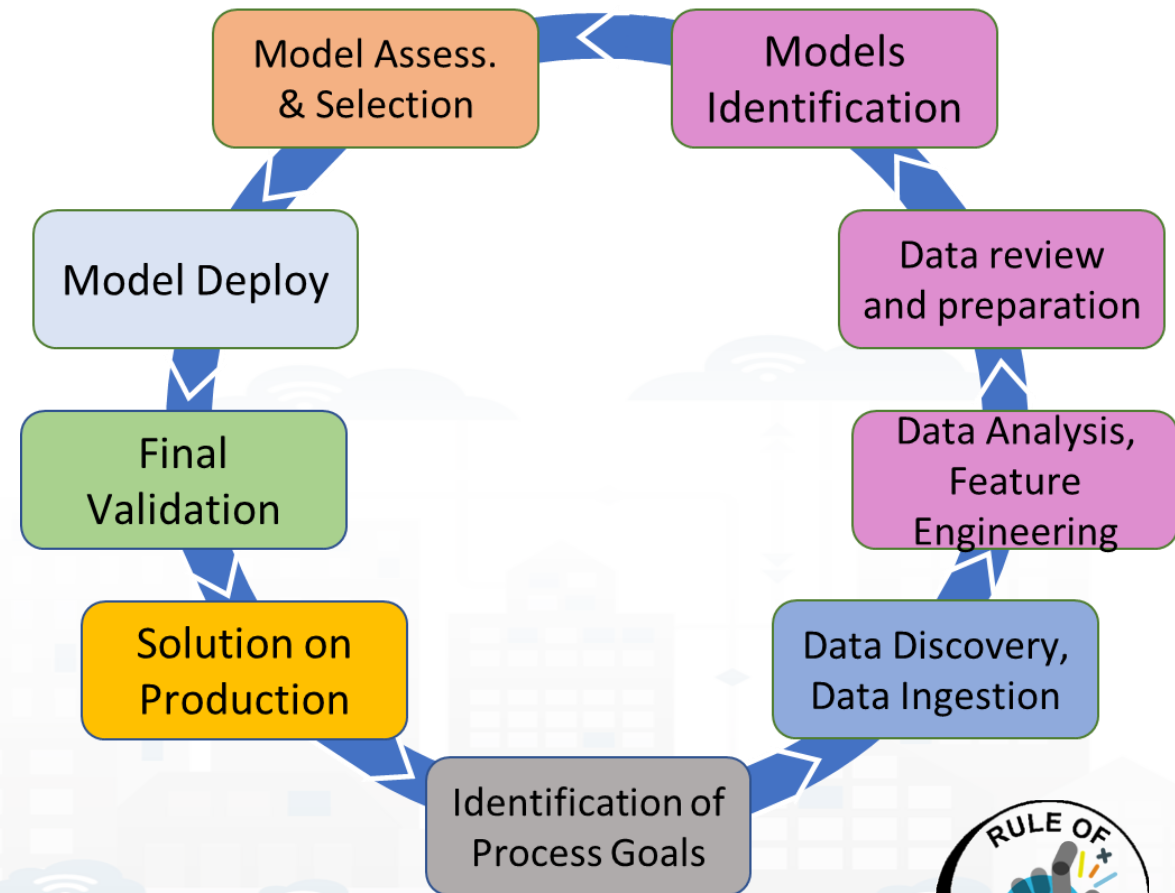


# Main Functionalities of DA, ML, AI Support

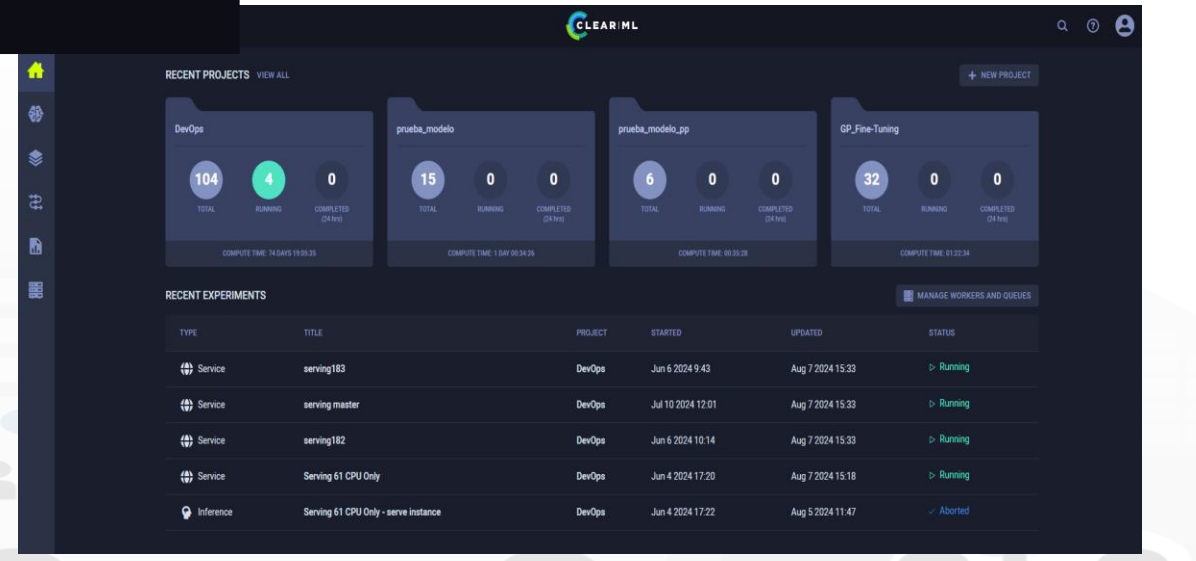
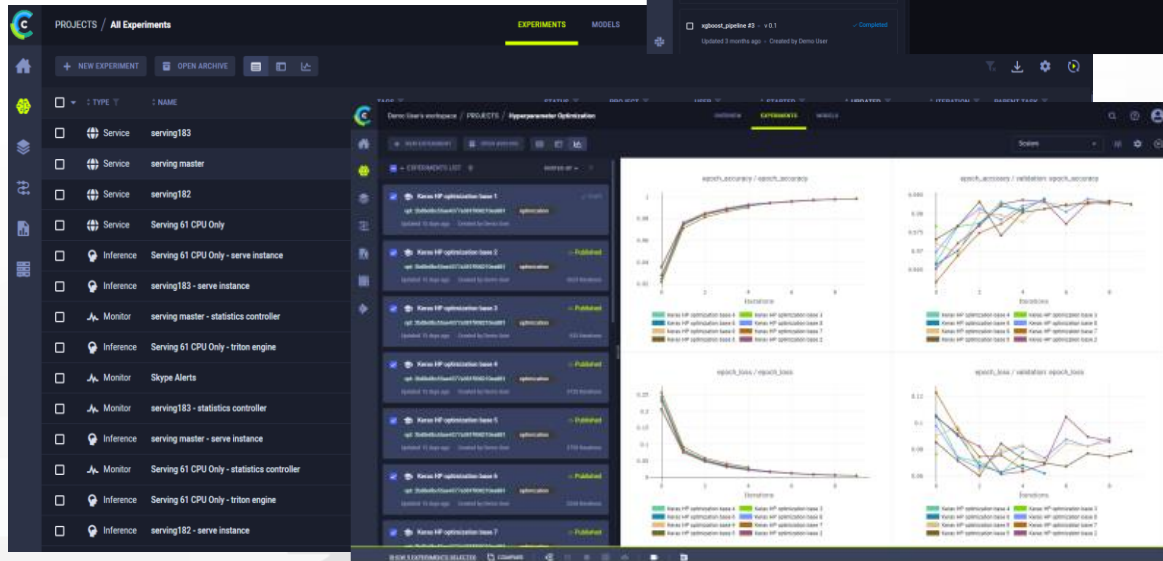
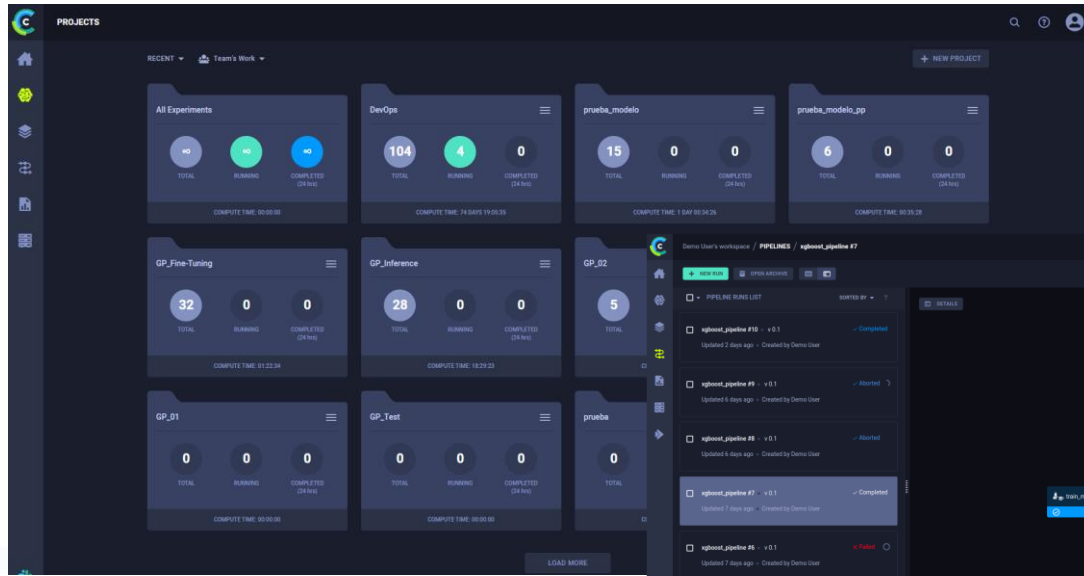
- **High Interoperability**, HLT management, any format/protocol
  - Users and data support GDPR compliant
- **Integrated MLOps, agile CI/CD Orchestration on CPU/GPU, HPC clusters, Kubernetes (DISIT Lab, HPC Lutech, CN MOST, etc.)**
  - Develop, optimization, tracking experiments, etc.
  - Online and Offline development
  - Stable and one demand execution (deploy)
  - Automated transformation of AI,ML,DA processes on MicroServices
  - Node-RED visual programming
- **Monitoring, Accounting and Billing → Market Place**
  - AI Control and Plan as a Service

# Model/Technique Development/testing

- **Identification of Process goals and Planning (problem definition)**
  - Which goals
  - How to compute, which language
  - Which environment, which libraries
- **Data Discovery and Ingestion (from the general life cycle)**
  - Data Collection, Data Preprocessing if needed
- **Data Analysis: feature engineering, feature selection**
  - Data ethics assessment
- **Data review and preparation for the model, splitting, encoding**
- **Model Identification and building: ML, AI, etc....**
  - Model Training
  - Tuning hyperparameters when possible
- **Model Assessment and Selection (Evaluation)**
  - Validation in testing
  - Assessment on a set of metrics depending on the goals: global relevant and feature assessment
  - Assessing computational costs
  - Impact Assessment, Ethic Assessment and incidental findings
  - Global and Local Explanation via Explainable AI techniques
- **Model Deploy and Final Validation**
  - Optimisation of computation cost for features, if needed reiterate
  - Solution on Production (security, scalability, etc.)
- **Monitoring and Maintenance on production**
- **Documentation, incremental documentation**







# MLOperation

<https://www.snap4city.org/download/video/Snap4City-MLOps-Manual.pdf>



## Data Analytics on Snap4City, Machine Learning Operation MLOps on Snap4City via ClearML

### From Snap4City:

- Development Life Cycle user manual:
  - <https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf>
- See Client-Side Business Logic Widget Manual:
  - <https://www.snap4city.org/download/video/ClientSideBusinessLogic-WidgetManual.pdf>
- Videos and PDF of Training slides <https://www.snap4city.org/944>
- You may 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>
- <https://twitter.com/snap4city>
- <https://www.facebook.com/snap4city>

**Coordinator:** Paolo Nesi, [Paolo.nesi@unifi.it](mailto:Paolo.nesi@unifi.it)  
DISIT Lab, <https://www.disit.org>  
DINFO dept of University of Florence,  
Via S. Marta 3, 50139, Firenze, Italy  
Phone: +39-335-5668674

**Access Level:** public  
**Date:** 16-12-2024  
**Version:** 0.6



# Parts 7 & 8: API, Mobile, Business Intelligence

Part 7: Exploiting  
Snap4City API, and  
Web/Mobile  
Applications SDK

[SLIDES](#)

[Interactive Slides](#)



Part 8: Developing  
Smart Applications &  
Business Intelligence  
Solutions

[SLIDES](#)

[Interactive Slides](#)



- **Smart City API: Internal and External**
- Concepts and tools for using Knowledge Base, ServiceMap, API
- Federated Knowledge Bases and Smart City APIs
- **Advanced Smart City API**
- Access to Protected data
- **Forging and managing: Mobile and Web Apps, MicroApplications**
- **Web and Mobile App Development Kit**
- -----
- Developing in the smart city IoT/WoT context
- Smart Solutions Development Life Cycle
- Analysis for Innovation (Co-Creation and Co-Working)
- Design: Data, Data Models, Data Relationships
- Design & Develop: Data Processes Proc.Logic / IoT App
- Design & Develop of Data Analytics
- Design & Develop: user interfaces, visual tools
- Visual Analytic vs Data Analytics: Client Side Business Logic Intelligence
- Design and Control of Smart Applications
- What is missing here and you can get from former course

# Development

<https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf>





 **Powered by**  
**SNAP4Tech**

**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>
- <https://twitter.com/snap4city>
- <https://www.facebook.com/snap4city>
- <https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg>

**Coordinator:** Paolo Nesi, [Paolo.nesi@unifi.it](mailto:Paolo.nesi@unifi.it)

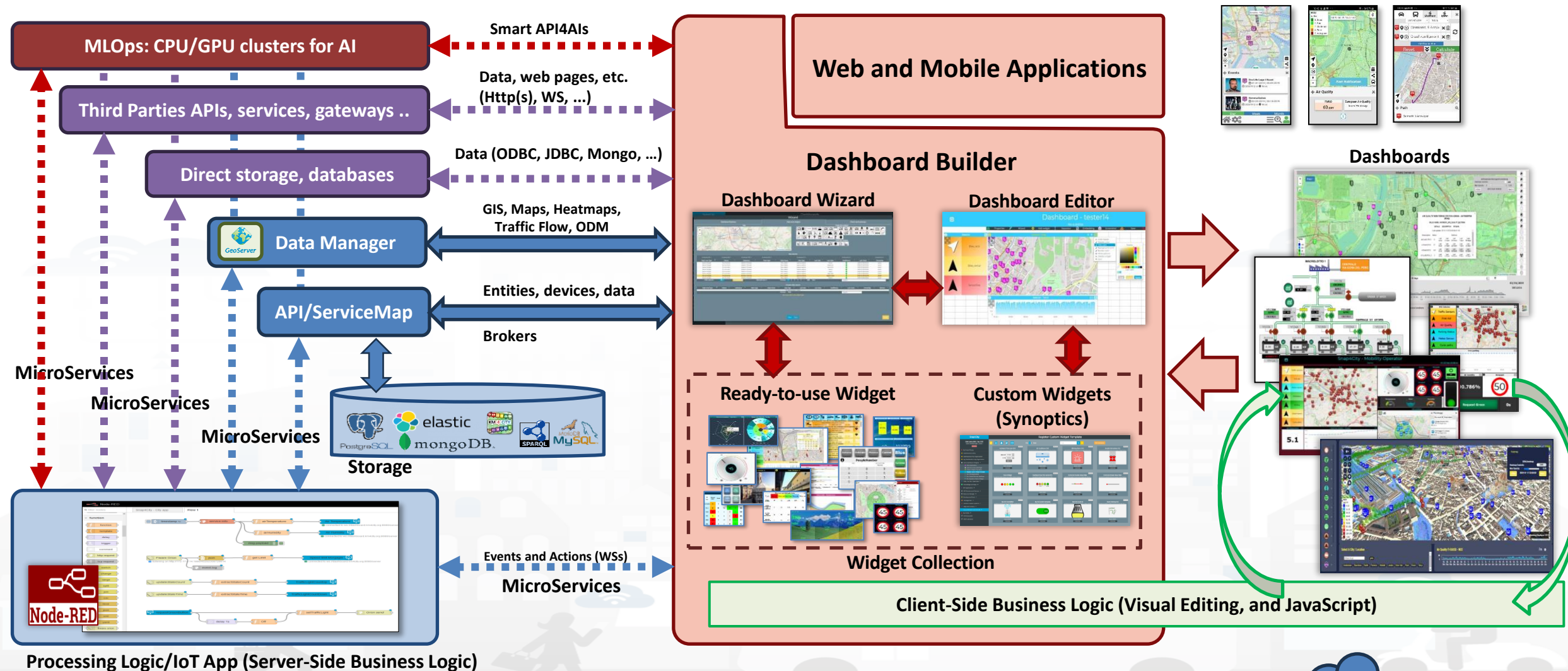
DISIT Lab, <https://www.disit.org>  
DINFO dept of University of Florence,  
Via S. Marta 3, 50139, Firenze, Italy  
Phone: +39-335-5668674



1



# How the Dashboards / Apps Exchange data (2024/8)



# Internal and External Smart City API

**Snap4City**

User: roottooladmin1, Org: DISIT  
Role: RootAdmin, Level: 7

**Smart City API Docs: Swagger**

**Advanced Smart City API** 1.0.0 GA53

<https://www.km4city.org/swagger/external/ascapi-openapi3.json>

SMART CITY API WEB DOCUMENTATION

Servers

<https://servicemap.disit.org/WebAppGrafo/api/v1>

**Services**

[GET](#) / Service discovery and information

**Events**

[GET](#) /events/ Event search

**Locations**

[GET](#) /location/ Address and geometry search by GPS

**Public Transport**

[GET](#) /tpl/agencies/ Agency list

[GET](#) /tpl/bus-lines/ (Bus) Lines list

[GET](#) /tpl/bus-routes/ (Bus) Routes list

**Internal API Docs: Swagger**

**IoT device registration API**

[GET](#) /device-registration

[GET](#) /device-groups

<https://www.km4city.org/swagger/external/index.html>

<https://www.km4city.org/swagger/internal/index.html>



# Client Side Business Logic

<https://www.snap4city.org/download/video/ClientSideBusinessLogic-WidgetManual.pdf>



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**SNAP4Tech**

## Client-Side Business Logic Widget Manual

### From Snap4City:

- We suggest you read <https://www.snap4city.org/download/video/Snap4Tech-Development-Life-Cycle.pdf>
- We suggest you read the TECHNICAL OVERVIEW:
  - <https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf>
- slides go to <https://www.snap4city.org/577>
- <https://www.snap4city.org>
- <https://www.snap4solutions.org>
- <https://www.snap4industry.org>
- <https://twitter.com/snap4city>
- <https://www.facebook.com/snap4city>
- <https://www.youtube.com/channel/UC3tAQ09EbNba8f2-u4vanda>

Coordinator: Paolo Nesi, [Paolo.nesi@unifi.it](mailto:Paolo.nesi@unifi.it)  
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Phone: +39-335-5668674

# Accelerating on Smart City on Deploy with Snap4City

<https://www.snap4city.org/738>



 **SNAP4**  
Appliances and Dockers  
**Installations**



# Tech Overview

- <https://www.snap4city.org/drupal/sites/default/files/files/Snap4City-PlatformOverview.pdf>



# How to adopt Snap4City



## Smart City as a Service

- Supporting Org
- 100% Open Source Platform: Github
- Further developments
- Publishing Appliances and Dockers
- Training courses, docs
- Consulting
- Forums
- Etc.



**Download  
and deploy**

## On your premise



## Installation on your premise

- **Dockers / Kubernetes, VM**
- Different configurations
  - From small to scalable
  - Exploiting your legacy tools
  - Interoperable with any tool
- No vendor lock-in, No tech lock-in

## Mixed solutions! For example:

- Start on Cloud as Smart City as a Service
  - Migrate on premise on the fly
- Start on Cloud into a sand box
  - Pass to install on premise what you need



# Smart Energy and Smart Building

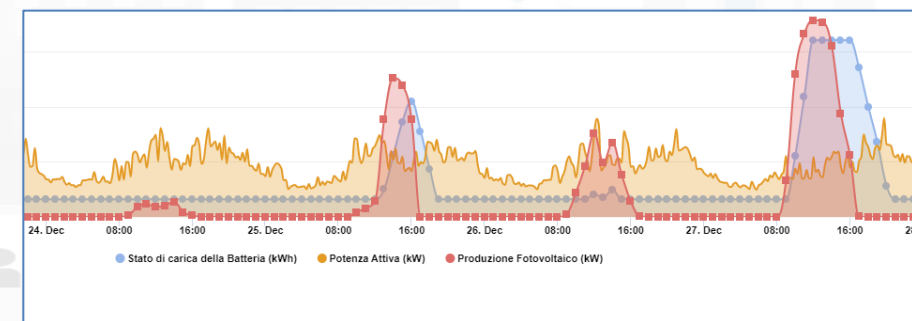
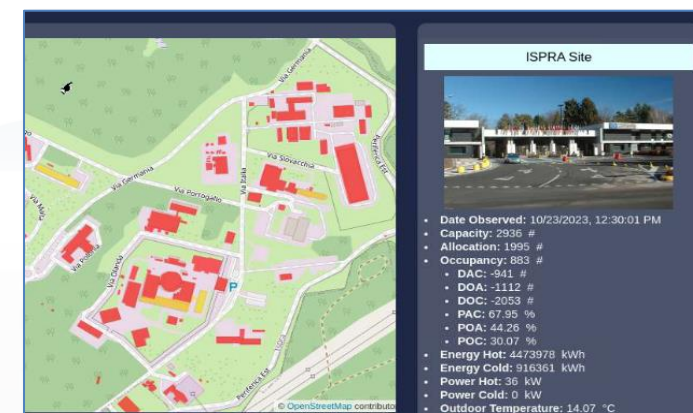
# Goals



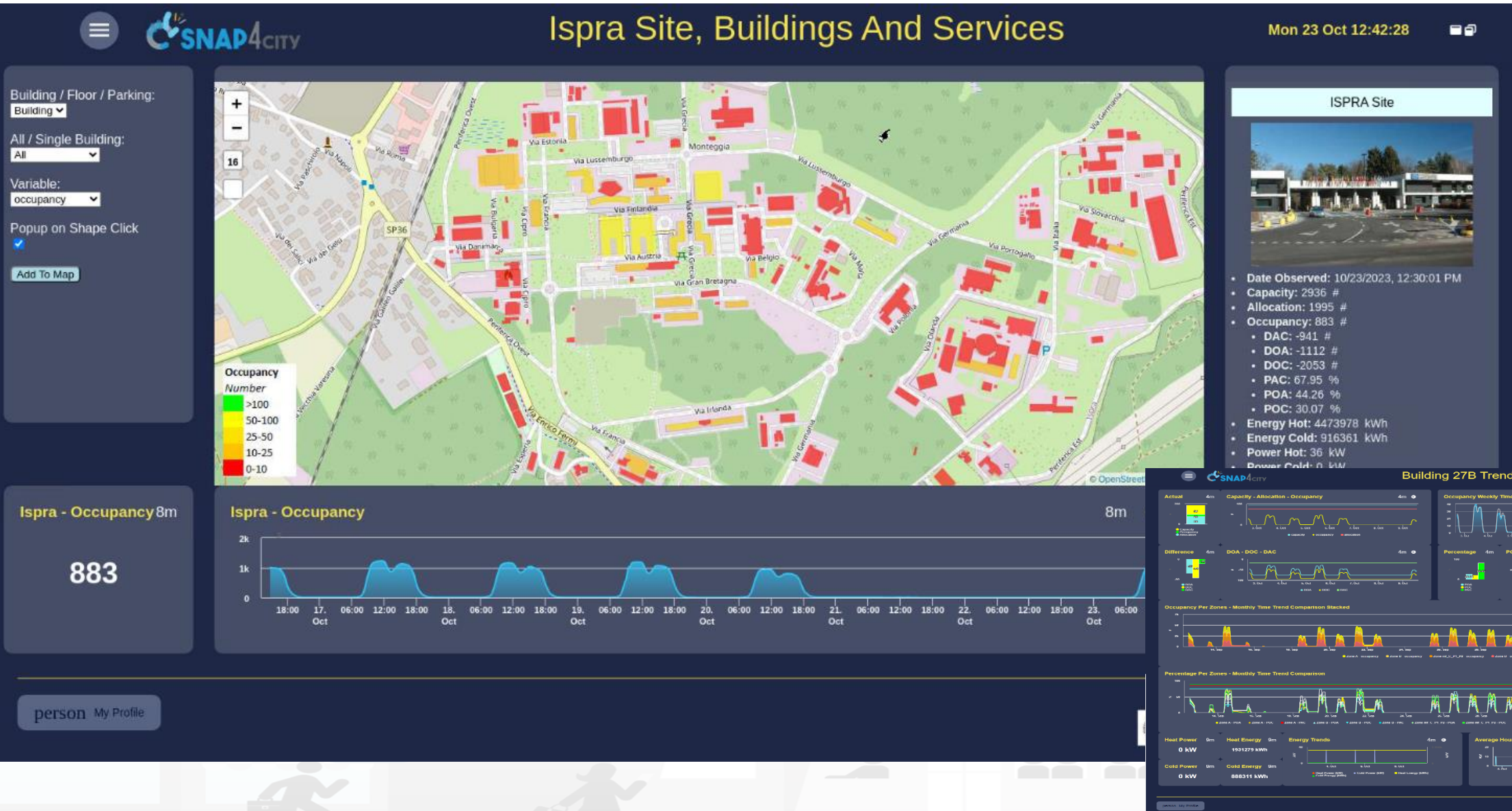
Cost Reduction

# City Energy and Buildings

- **Goals:**
  - Energy consumption reduction, increment of efficiency,
  - Areas and building sustainability
  - Improve accessibility to services, security and safety
- **Energy Monitoring:** Building, floors, rooms, recharging poles, cabinets, Community of Energy, Data centers, Energy for Hot / cold, air condition, energy vs temperature and usage, etc.
- **Energy Management:** Predictions, early warning, identification of critical conditions
- **Smart Light Management:** LED/mixt, cabinets, lights vs traffic, lights vs security, energy saving, luminaries profiling, group management.
- **Smart Building Management:** consumption, number of people, etc.
  - Communities of Energy, Photovoltaic plants, sustainability
  - What-if analysis, optimisation tools
- **KPI: Energy consumption, efficiency, pros/cons**
  - Light profiling and adaptation
  - Autoclave industrial plants simulation, Photovoltaic plant simulation
  - consumption / usage, energy vs temperature
- **Mobile App:** monitoring, info-recharge, eSharing, booking, ..
- **Participatory:** problem reporting, ticketing, etc.
- **Integration of any kind**







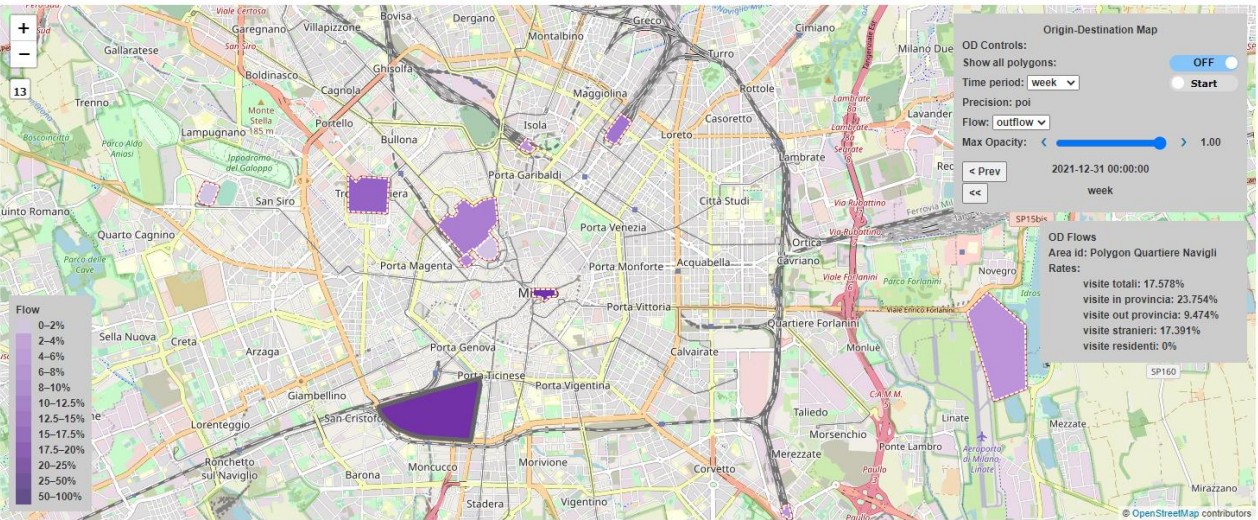


# Energy monitoring and business intelligence

## Green and Data Driven District @ MIND

Aggregated KPI JuicePark SmartPole CityAnalytics

POI - OD POI - PRESENZE POI - PRESENZE (TS) ACE - PRESENZE ACE - PRESENZE (TS)



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7 AFFORDABLE AND CLEAN ENERGY



11 SUSTAINABLE CITIES AND COMMUNITIES



## Green and Data Driven District

Aggregated KPI JuicePark SmartPole CityAnalytics

### Enel X Smart Pole

#### Detailed KPIs

**Videoanalysis**  
People counted daily: 0  
People counted to date: 0  
People aggregation daily: 0  
People aggregation to date: 0  
Vehicle counted daily: 0  
Vehicle counted to date: 21

**Power meter**  
Daily energy consumed: 9.024 kWh  
Energy consumed to date: 27.341 kWh  
Daily energy produced: 1.409 kWh  
Energy produced to date: 4.252 kWh

**WiFi**  
Max number of connected devices in the last day: 0  
Hourly average connected devices: ###

**eBike**  
Daily number of sessions: 0  
Number of sessions to date: 0  
Total Energy consumed: 0  
Average energy consumed: 0  
Last charger session: 17/05/2022 11:25

**Emergency**  
SOS requests to date: 0  
SOS request daily: 0  
AED requests to date: 0  
AED requests to daily: 0

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## Green and Data Driven District

Aggregated KPI JuicePark SmartPole CityAnalytics

### Detailed KPIs

**Videoanalysis**  
Vehicle parked daily: 8  
Vehicle parked to date: 87  
Vehicle count daily: 24  
Vehicle count to date: 520

**Power meter**  
Energy consumed daily: 0 kWh  
Energy consumed to date: 0 kWh  
Energy produced daily: 0 kWh  
Energy produced to date: 0 kWh

**WiFi**  
Max number of connected devices in the last day: 0  
Hourly average connected devices: ###

**Emergency**  
SOS Requests to date: 0  
SOS request daily: 0

**EV charged**  
Number of sessions daily: 0  
Number of sessions to date: 0  
Total Energy consumed: 0  
Average energy consumed: 0  
Last charger session: 0

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Cabinets On Stockholm By Capelon

Tue 31 Oct 22:53:17






Capelon Cabinet (iot-search)

Ac...9m

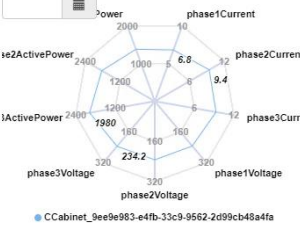
ActualState0Count - St... 9m

12



Radar Series

4m



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ASM Merano  
Stadtwerke Meran

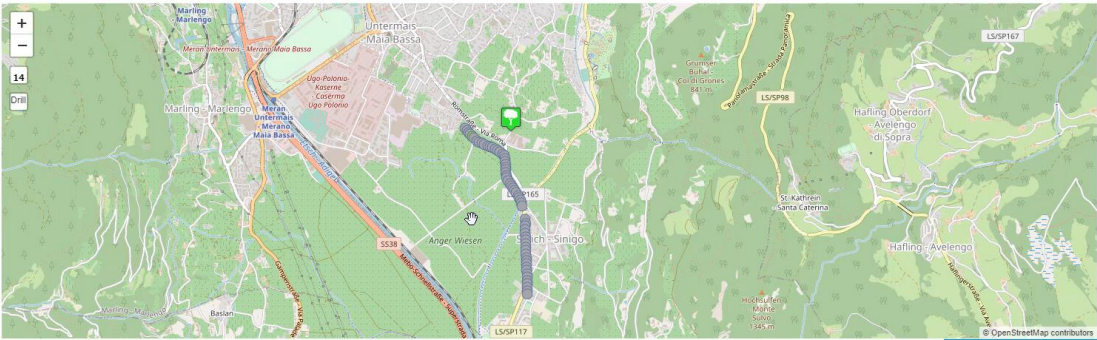
Elenco lampade

Visualizzazione dati

Log eventi

Grafici

Impostazioni



120

80

40

0

13:15

13:30

13:45

14:00

14:15

14:30

14:45

15:00

15:15

15:30

15:45

Regolazione

Potenza

DR

Stato Linea

Non Attivo

Stato Linea verso Sinigo

Non Attivo

Stato Linea verso Merano Centro

N. Punto Luce

11307

DevEui

7083D5BF100085D7

Via

RomSträße

Regolazione

Onre di servizio

Conta energia

Potenza attuale

Stato

Nome errore

RSSI

SNR

Data

01/11/2023 12:01:18

Regolazione

Invia

ON

OFF

DALUTCMISSING

INF\_AULTTRIGGER

DAL\_BALAST\_NOT\_DISABLE

ERR\_DAL\_BALAST\_NOT\_CONFIG

ERR\_DAL\_THERMAL\_SHUTDOWN

ERR\_DAL\_THERMAL\_DERATING

ERR\_DAL\_POWER\_LIM

ERR\_DAL\_OVERALL

INF\_POWER\_FAIL

INF\_BUS\_POWERED\_BY\_FREE

INF\_DAL\_BATT\_ERR

Snap4City (C), Sett. 2025

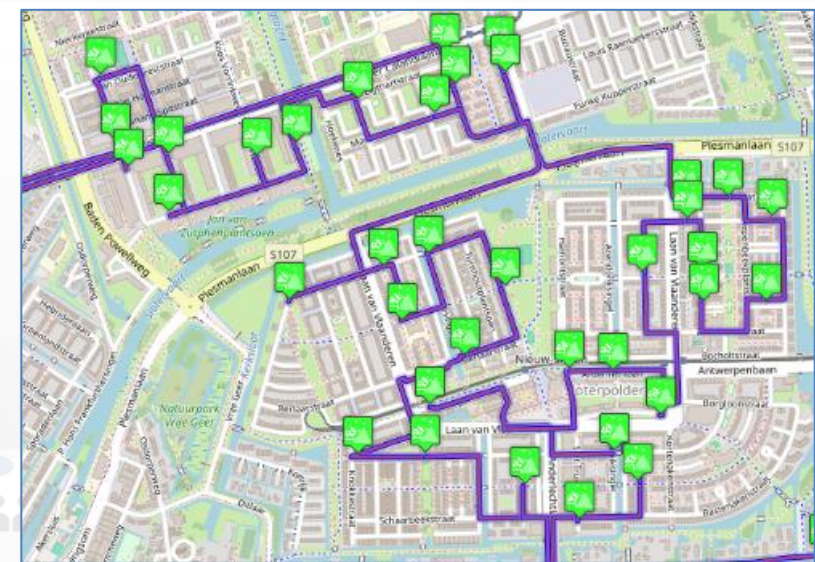
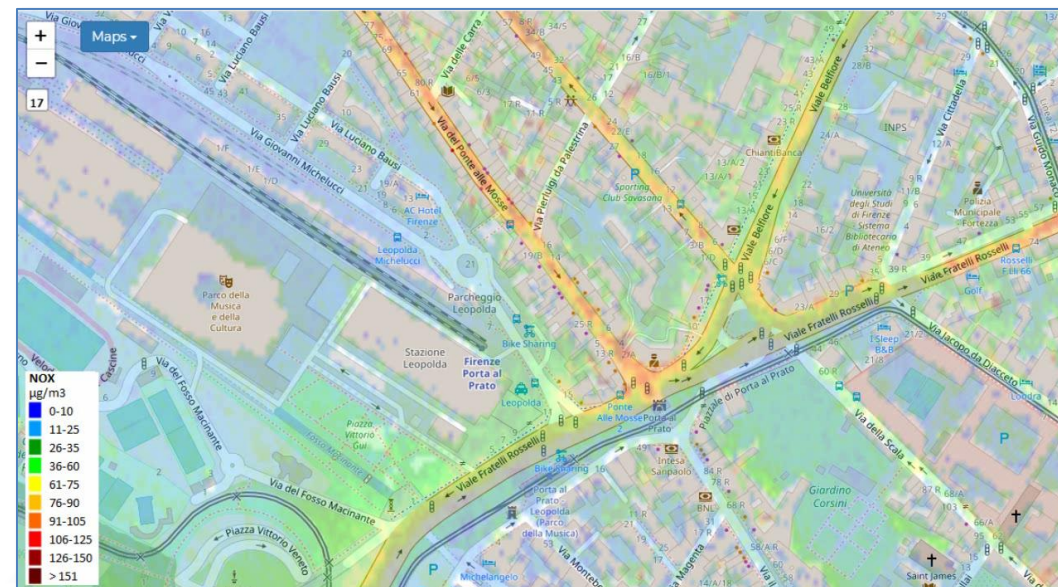
92





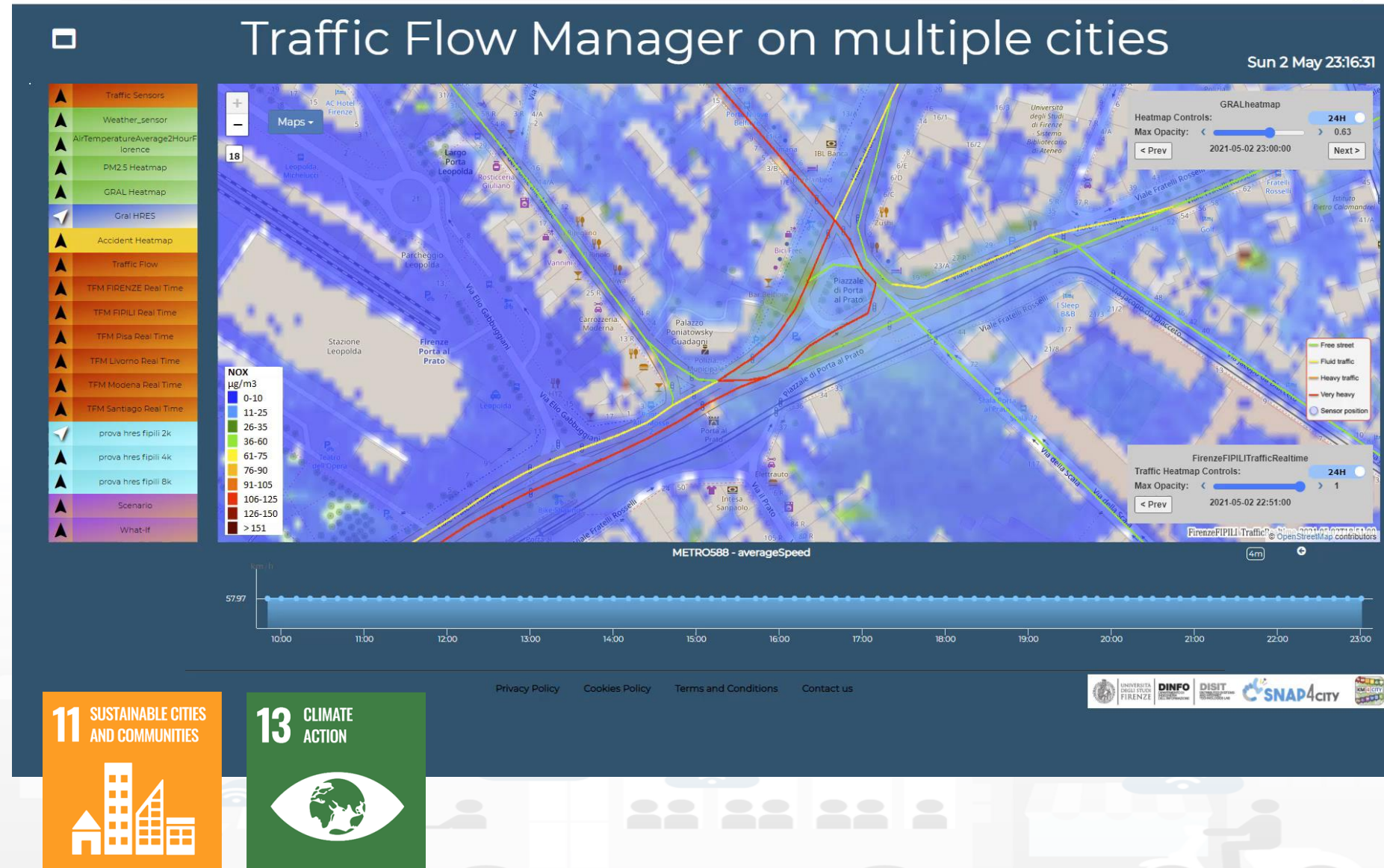
# Environment and Waste

- **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 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, collecting 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, ..**



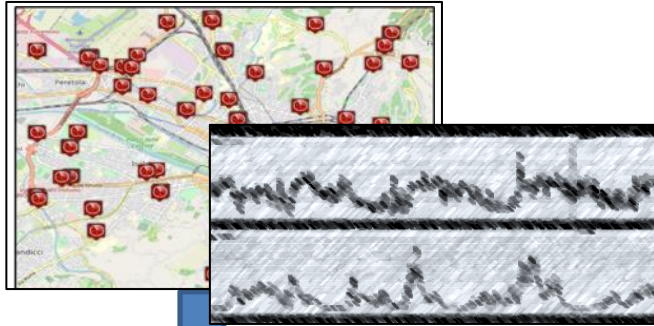


- **Prediction**
  - **NOX Pollutant** diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
  - **NO2 progressive average** (Long term)
- **Project:**
  - **Trafair CEF EC**
  - Mixed solutions of Fluidinamics modeling and AI

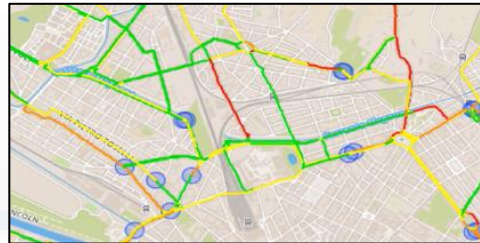




# Estimating City Local CO2 from Traffic Flow Data



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

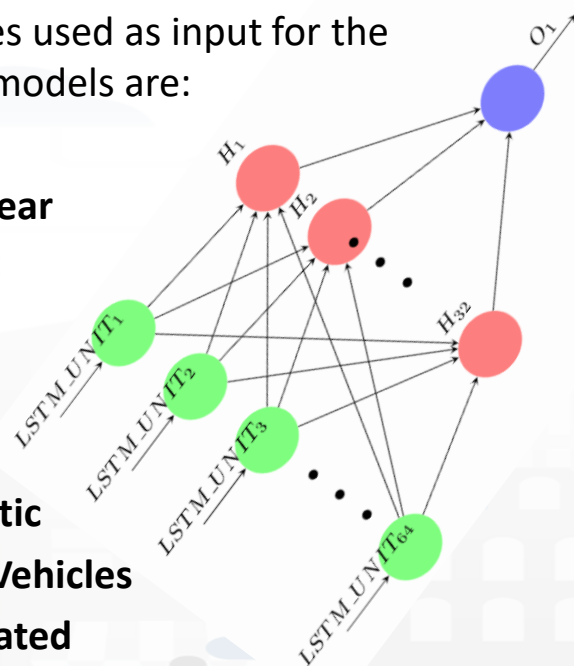
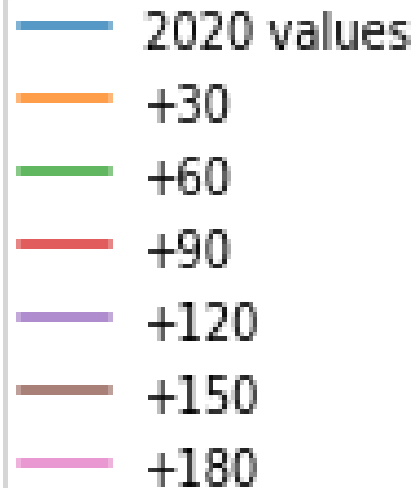
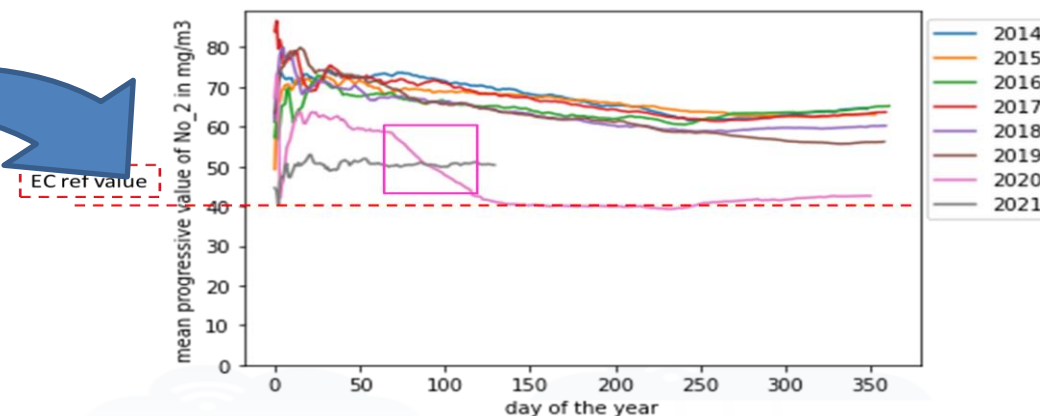
Computing CO2 on the basis of  
traffic flow data



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 EC's KPI on NO2 months in advance

Deep Learning Long Terms Predictions of NO2 mean values, From 30 to 180 days in advance



| Air Quality Directive |                           |                                              |                                                                             | WHO guidelines            |                                           |
|-----------------------|---------------------------|----------------------------------------------|-----------------------------------------------------------------------------|---------------------------|-------------------------------------------|
| Pollutant             | Averaging period          | Objective and legal nature and concentration | Comments                                                                    | Concentration             | Comments                                  |
| PM <sub>2.5</sub>     | One day                   |                                              |                                                                             | 25 µg/m <sup>3</sup> (*)  | 99 <sup>th</sup> percentile (3 days/year) |
| PM <sub>2.5</sub>     | Calendar year             | Target value, 25 µg/m <sup>3</sup>           | The target value has become a limit value since 1 January 2015              | 10 µg/m <sup>3</sup>      |                                           |
| PM <sub>10</sub>      | One day                   | Limit value, 50 µg/m <sup>3</sup>            | Not to be exceeded on more than 35 days per year.                           | 50 µg/m <sup>3</sup> (*)  | 99 <sup>th</sup> percentile (3 days/year) |
| PM <sub>10</sub>      | Calendar year             | Limit value, 40 µg/m <sup>3</sup> (*)        |                                                                             | 20 µg/m <sup>3</sup>      |                                           |
| O <sub>3</sub>        | Maximum daily 8-hour mean | Target value, 120 µg/m <sup>3</sup>          | Not to be exceeded on more than 25 days per year, averaged over three years | 100 µg/m <sup>3</sup>     |                                           |
| NO <sub>2</sub>       | One hour                  | Limit value, 200 µg/m <sup>3</sup> (*)       | Not to be exceeded more than 18 times a calendar year                       | 200 µg/m <sup>3</sup> (*) |                                           |
| NO <sub>2</sub>       | Calendar year             | Limit value, 40 µg/m <sup>3</sup>            |                                                                             | 40 µg/m <sup>3</sup>      |                                           |

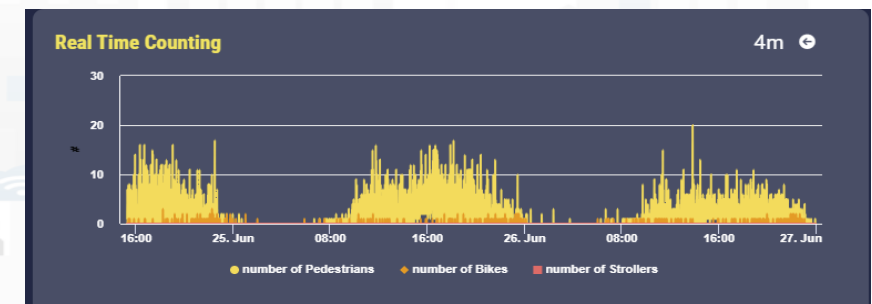
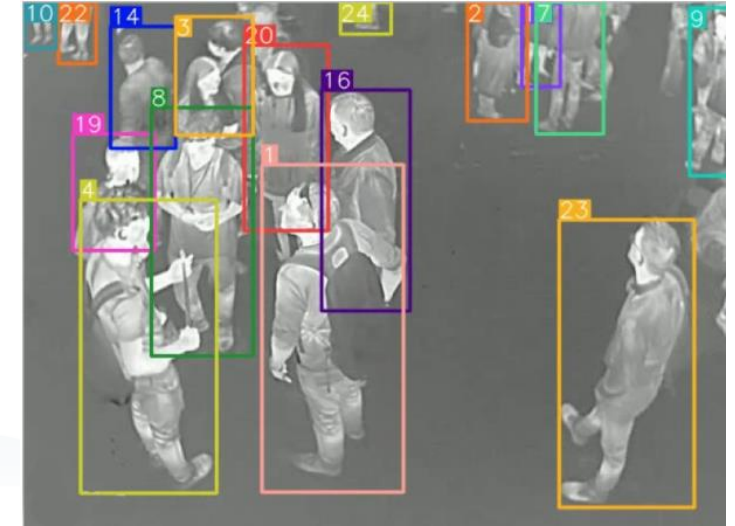


City Users' Services  
and Tourism Management

Goals

# City User Behaviour/services, Tourism and Safety

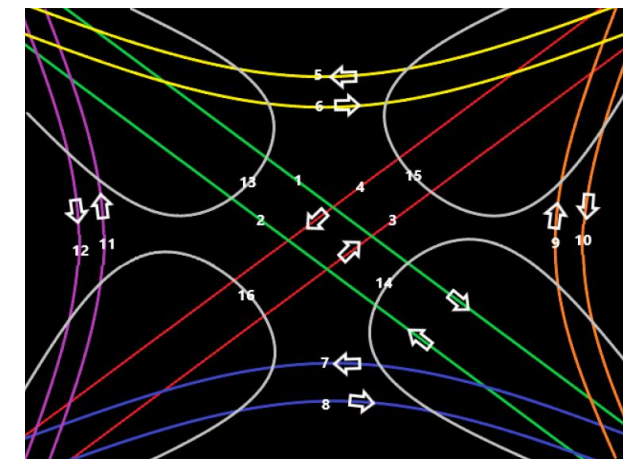
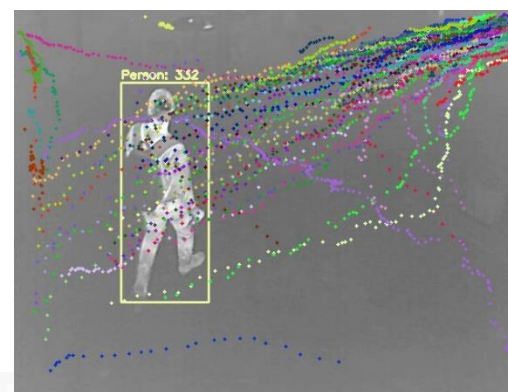
- **Goals:**
  - Improve Quality of Life and quality of services,
  - Over tourism mitigation, sustainability
  - Costs reduction of services
  - Improve accessibility to services: citizens, Tourists, commuters, etc.
  - Improve Security/Safety of city users
- **People Flow Analysis / Management:** in/out-door, retail, attractions
  - Counting, tracking, Flows, ODM, sentiment, recency/frequency, etc.,
  - multiple sources: thermal & TV cameras, radar sensors, PAX sniffers, mobile data, ...
  - Data and/or **OD matrices** from: Wi-Fi, traffic data, mobile phone data
  - **Suggestions:** info Tourism, digital signages, engagement, ..
- **Tourists Flows & Retail Management:** predictions of presences, services' reputations, suggestions on second offer, over-tourism, notifications, early warning,
- **KPI:** 15 MinCityIndex, energy vs people, over-tourism, accepted suggestions, precision
- **Mobile App:** final users services/informing and operators
  - Info Tourism, people flows, info mobility, sharing, ...
  - Participation, engagement, ..
- **Participatory:** problem reporting, ticketing, etc.
- **Integration of any kind:** env/weather, mobility, ticketing, presences, POI, ..





# User Behaviour: People Counting, Tracking, etc.

- **Behavior analysis in open or closed spaces**
  - HUB, metro, stations, production lines, parking lots, critical areas in cities,
  - shopping centers, retail, etc.
- **Thermal Cameras**
  - GDPR compliant
- **AI injection**
  - classification and counting
  - Identification of critical situations
  - Early warning
  - Integration with PAX counters, and with ODM data from operators
- **Real-time estimation**
  - Directly on the camera
  - High precision and reliability
  - Used by: Cuneo, Florence, Genoa, etc



# Mobility and Transport

# Goals



Decongestion



Safety



Accessibility



Cost Reduction



Decarbonization





# THE POWER OF ARTIFICIAL INTELLIGENCE AT THE SERVICE OF YOUR OPERATION AND PLAN

[www.snap4city.org](http://www.snap4city.org)



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DEGLI STUDI  
FIRENZE

DINFO  
DIPARTIMENTO DI  
INGEGNERIA  
DELL'INFORMAZIONE

DISIT  
DISTRIBUTED SYSTEMS  
AND INTELLIGENT  
TECHNOLOGIES LAB

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



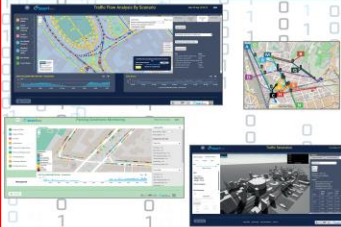
**NVIDIA**

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**



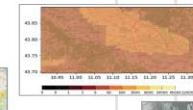
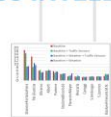
**CITY USER'S SERVICES AND  
TOURISM MANAGEMENT**



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



**DASHBOARDS, WIDGETS  
TEMPLATES**

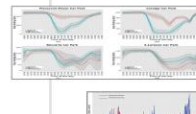
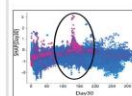


**PREDICTION - ANOMALY DETECTION - CLUSTERING - ROUTING - SENTIMENT NLP - TRAFFIC FLOW - PEOPLE FLOWS - SDG  
15 MIN CITY INDEX - KPI - HEATMAPS - ORIGIN DESTINATION - MAPS - VECTOR FIELD - ETC...**



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

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

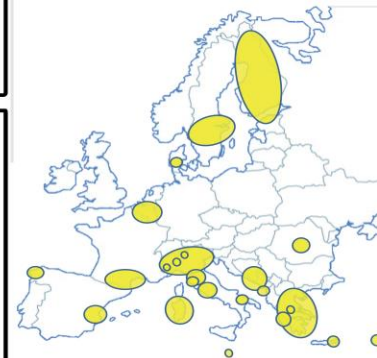


**BIG DATA ANALYTICS, ARTIFICIAL INTELLIGENCE  
EXPLAINABLE AI, MACHINE LEARNING, GENERATIVE AI  
OPERATIVE RESEARCH, STATISTICS**

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

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

- DEVELOPMENT ENVIRONMENT AND METHODOLOGY
- VISUAL PROGRAMMING, ML, AI, HPC
- TRAINING COURSES
- LLM ADVISOR



**NATIVE AND EXTERNAL  
APPLICATIONS**

**Smart Parking**

**Smart Light**

**Smart Waste**

**Smart Energy**

**Smart Building**

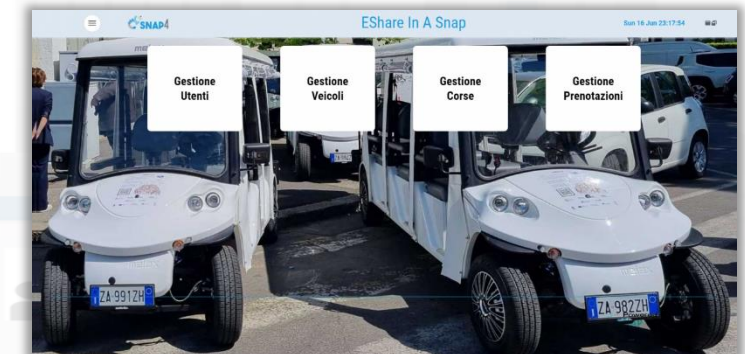
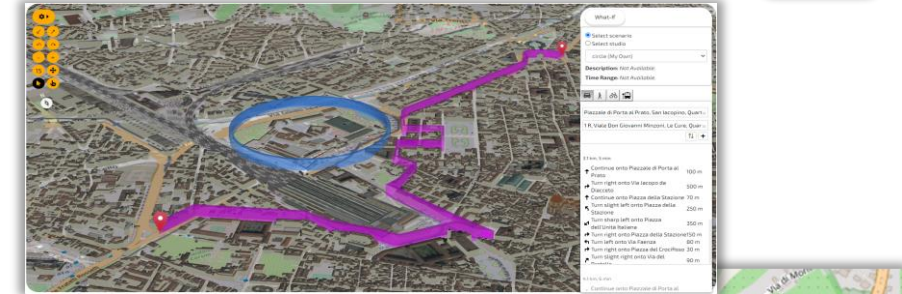
**Smart Tourism**

...





# Mobility & Transport



- **Goals:**
  - Decongestion, Decarbonization, costs reductions
  - Improve Accessibility to services
  - Improve Security/Safety of city users
- **Operation and Plan:**
  - Traffic monitoring, prediction, reconstruction, identification of critical conditions (early warning), fleet management, dynamic routing, multimodal routing, city user behaviour analysis
- **Optimization and what-if analysis traffic light, infrastructure**
  - **Reduction:** travel time, waiting time, stops, CO2 emissions, consume fuel, travel time for tramways
- **Public Transport:** analysis of Mobility Demand vs Offer of Transportation
- **Parking Management:** monitoring, prediction, any payments, on/off-road
- **Sharing / Pooling Management:** eShare and mobile app, bikesharing, smart bike, fleet management
- **KPI:** SUMI/SUMP, travel time, emissions, traffic status, accessibility, ..
- **Mobile App:** final users and operators
  - Info Mobility, traffic reconstruction, charging, participation,
  - Parking, payments, overparking, fine reporting, ..
- **Participatory:** problem reporting, ticketing, etc.
- **Data Integration of any kind:** env, weather. Tickets, presences, POI, sat, etc.



## AI-Powered Digital Twin Platform for Mobility & Transport Operation and Plan

**Urban Challenges & OPTIFaaS Objectives**  
From data to action : Tailored Mobility Services

### The Core

Snap4City / OPTIFaaS delivers mobility solutions for operational management and strategic-tactical planning through an integrated Digital Twin and various AI models, enabling what-if analysis, simulation, and optimization

### Objectives



Decongestion



Safety



Accessibility



Cost



Decarbonization

**OPTIFaaS**



Scalable, flexible, customized mobility solutions  
Reduction  
Supports various urban contexts from small communities to large metropolises

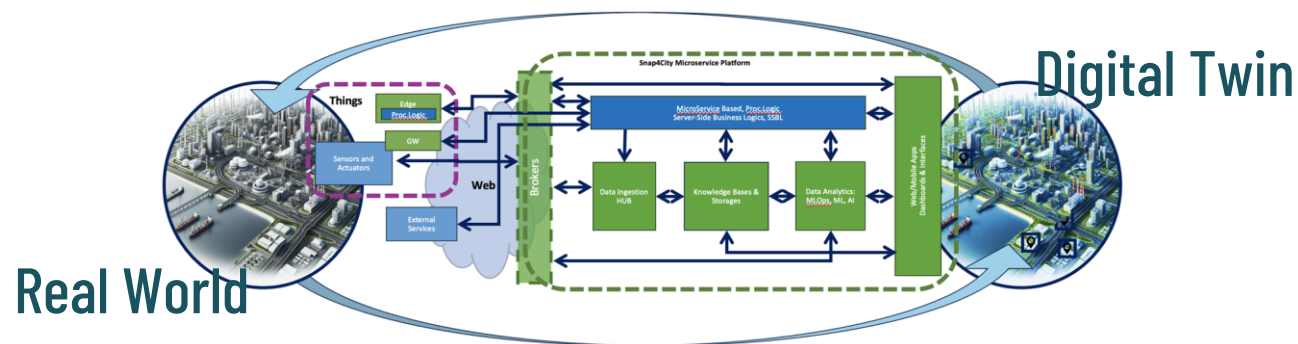
## AI-Powered Digital Twin Platform for Mobility & Transport Operation and Plan

Integrated Digital Twin + Artificial Intelligence platform for real-time urban mobility monitoring and optimization

Smart & Sustainable Mobility with Snap4City / OPTIFaaS  
Empowering Cities with AI based Digital Twin

### AI Technologies

- Deep Learning
- Reinforcement Learning
- Generative AI
- GNN-DRL and similar



### Designed for Tactic and Strategic Planning

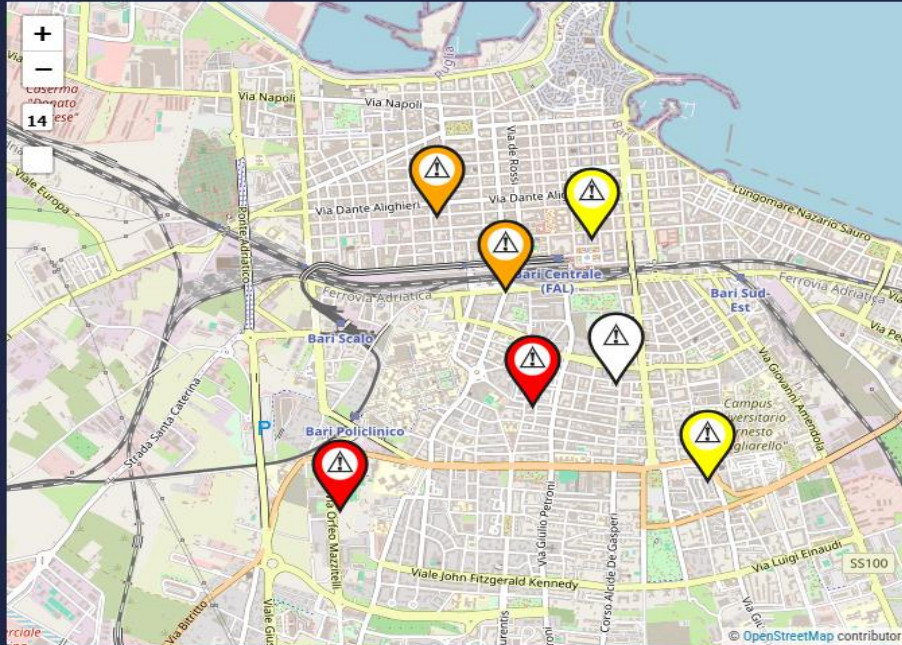
- What-if scenarios
- Simulations
- Optimizations

### Supports Operational Management

- Traffic monitoring, forecasting, and reconstruction
- Infrastructure evaluation
- Traffic light plan generation
- Early warning systems
- Dynamic/multimodal routing
- Analysis of city users' behavior



- [Home](#)
- [Traffic Monitoring](#)
- [Smart Parking](#)
- [15 minuti index](#)
- [Urban Security](#)



## Road Monitoring

| Media congestioniC | Nr. congestioniC | Picco congestioniC | Riduzione Co2 ZTLC | Emissioni medie CO2 C | Emissioni totali CO2 C |
|--------------------|------------------|--------------------|--------------------|-----------------------|------------------------|
| 28.4 %             | 17               | 18:27              | -5.2 %             | 282 ppm               | 846 ppm                |

## Traffico in ingresso



|                            |                   |
|----------------------------|-------------------|
| Tot. veicoli in ingresso C | Velocità media C  |
| <b>12105</b><br>Veicoli    | <b>27</b><br>km/h |

## Traffico in uscita



|                          |                  |
|--------------------------|------------------|
| Tot. veicoli in uscita C | Veicoli totali C |
| <b>11703</b><br>Veicoli  | <b>7825</b><br>- |

## Pannello Rischi Meteo

| MINIMO            | BASSO  | MEDIO                 | ALTO   |
|-------------------|--------|-----------------------|--------|
| Rischio Idraulico | MINIMO | Rischio Idrogeologico | MINIMO |
| Rischio Temporali | MINIMO | Rischio Neve          | MINIMO |
| Rischio Ghiaccio  | MINIMO | Rischio Vento         | MINIMO |

## Viabilità

|                      |   |
|----------------------|---|
| INCIDENTI            | 3 |
| Chiusura Traffico    | 2 |
| Chiusura Lavori      | 0 |
| Limitazioni Traffico | 4 |
| Limitazioni Lavori   | 0 |
| SEGNALAZIONI         | 7 |

## Trasporto Pubblico

|                         |  |
|-------------------------|--|
| Tempo medio di attesa C |  |
| <b>5.9</b> sec          |  |
| Ritardo autobus C       |  |
| <b>0</b> %              |  |

## Attesa Media Fermate

|           |               |
|-----------|---------------|
| Linea 50  | <b>12</b> sec |
| Linea 11  | <b>10</b> sec |
| Linea 33  | <b>6</b> sec  |
| Linea 02/ | <b>5</b> sec  |
| Linea E   | <b>5</b> sec  |
| Linea 19  | <b>4</b> sec  |

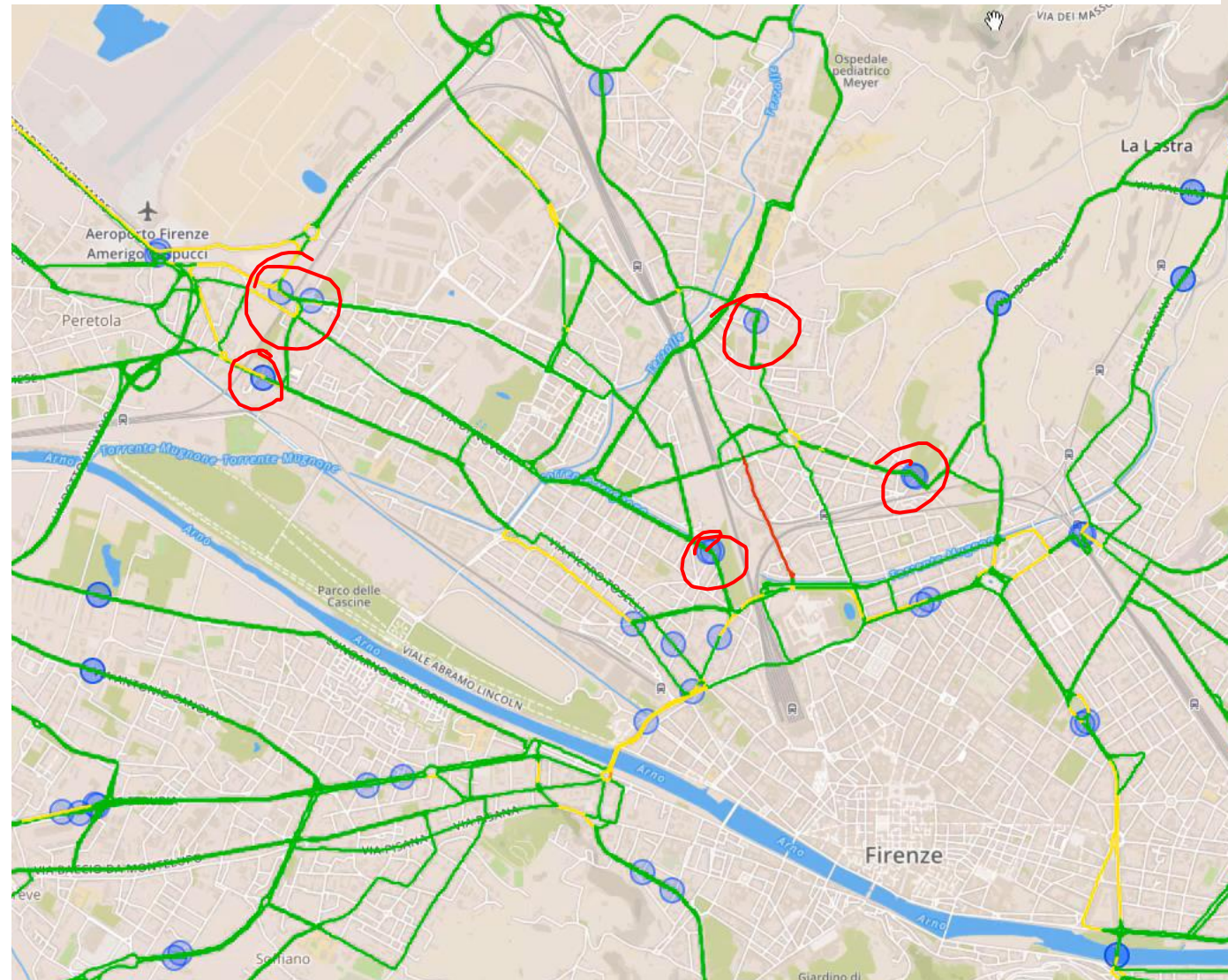
## Sensori

|             |   |
|-------------|---|
| 15          | 3 |
| Semafori    |   |
| 22          | 0 |
| Videocamere |   |
| 4           | 1 |
| Sensori     |   |



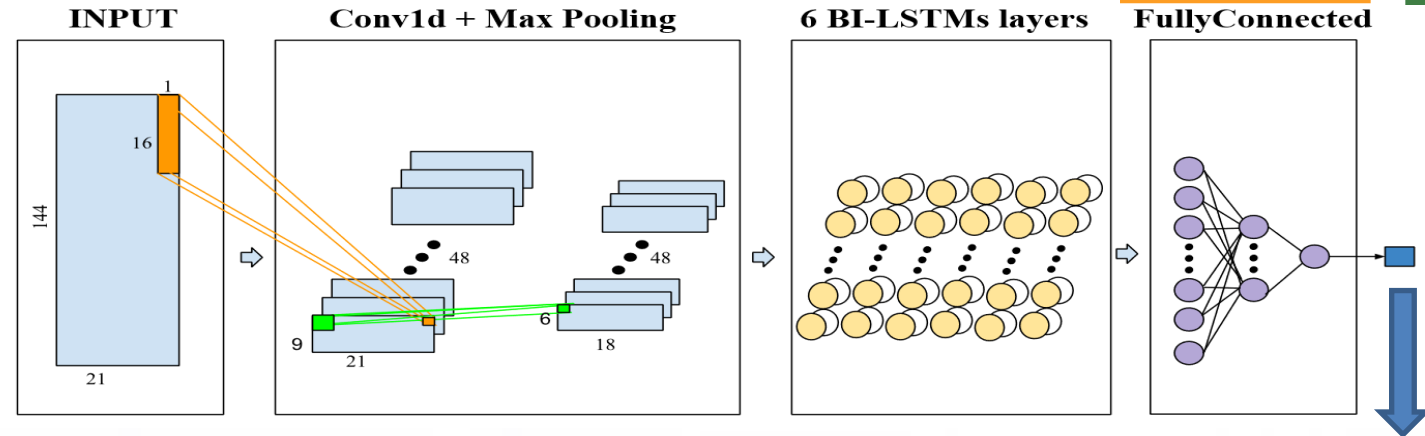
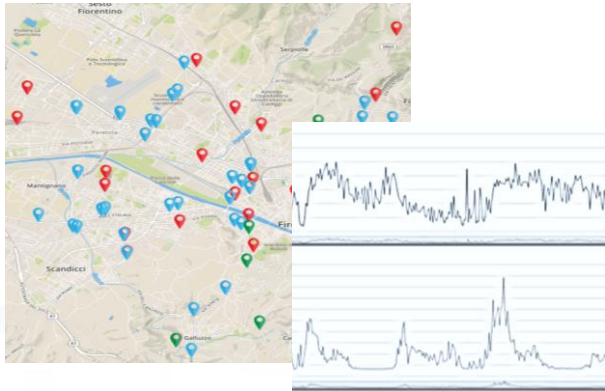
# Dense Traffic Flow Reconstruction ?

- Making decision on mobility and transport solutions → what if analysis
- Controlling pollution
- Dynamic Routing for Firebrigade, Ambulances, general public
- Planning Public Transportation routing





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



Urban data:

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

RF

XGBOOST

DNN

LSTM

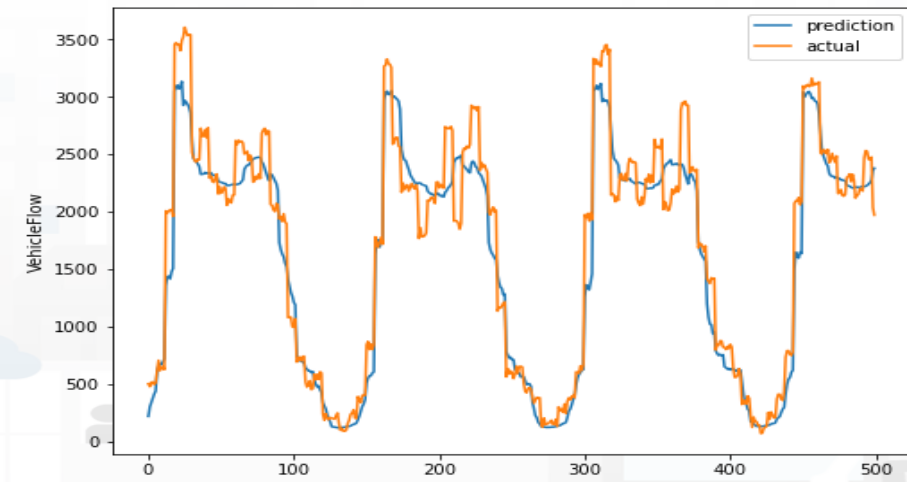
BI-LSTM

Autoencoder BI-LSTM

Attention CONV-LSTM

CONV-BI-LSTM

CONV-BI-LSTM



## AI-Powered Digital Twin Platform for Mobility & Transport Operation and Plan

### Snap4City

Is an open platform designed to support cities and organizations in enhancing urban mobility through the integration of **heterogeneous data sources** and **AI**



#### Open

open source, interoperable, modular, microservices

Snap4City (C), Sett. 2025



#### Scalable

with city size and complexity



#### AI-powered platform

data-driven platform for mobility innovation



#### Optimizing Transportation Systems

improving efficiency, sustainability, quality of life



#### Business Intelligence Tools

available for decision makers, operators, control rooms



#### Minimal Set up Costs

maximum flexibility, visual programming, no-code platform

### OPTIFaaS

Adopts a **service-based business model** tailored to the **needs of small and medium-sized cities and mobility operators**. It emphasizes cost-effectiveness, offering flexible and scalable solutions for urban mobility and sustainability



-  Home
-  Traffic Monitoring
-  Smart Parking
-  15 minuti index
-  Urban Security



### Road Monitoring

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|--------------------|------------------|--------------------|--------------------|-----------------------|------------------------|
| 28.4 %             | 17               | 18:27              | -5.2 %             | 282 ppm               | 846 ppm                |

### Traffico in ingresso



|                            |                  |
|----------------------------|------------------|
| Tot. veicoli in ingresso C | Velocità media C |
| 7152 Veicoli               | 27 km/h          |

### Traffico in uscita



|                          |                  |
|--------------------------|------------------|
| Tot. veicoli in uscita C | Veicoli totali C |
| 6988 Veicoli             | 7825             |

### Pannello Rischi Meteo

|                   | MINIMO | BASSO | MEDIO                 | ALTO   |
|-------------------|--------|-------|-----------------------|--------|
| Rischio Idraulico | MINIMO |       | Rischio Idrogeologico | MINIMO |
| Rischio Temporali | MINIMO |       | Rischio Neve          | MINIMO |
| Rischio Ghiaccio  | MINIMO |       | Rischio Vento         | MINIMO |

### Viabilità

|                      |   |
|----------------------|---|
| INCIDENTI            | 3 |
| Chiusura Traffico    | 2 |
| Chiusura Lavori      | 1 |
| Limitazioni Traffico | 7 |
| Limitazioni Lavori   | 0 |
| SEGNALAZIONI         | 9 |

### Trasporto Pubblico

|                         |  |
|-------------------------|--|
| Tempo medio di attesa C |  |
| 11.6 min                |  |
| Ritardo autobus C       |  |
| 11.1 %                  |  |

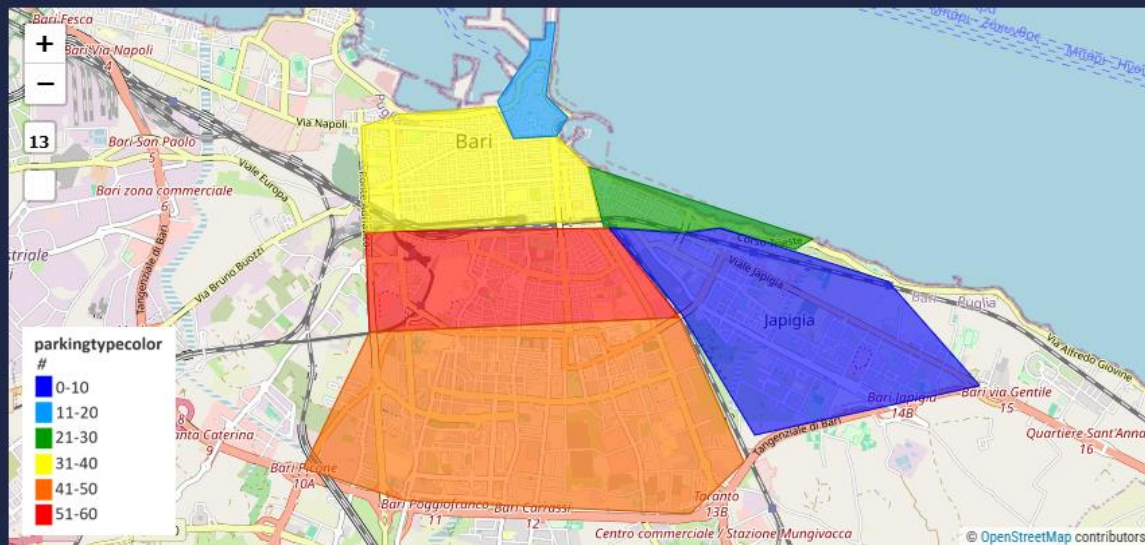
### Attesa Media Fermate

|           |          |
|-----------|----------|
| Linea 22  | 21.1 min |
| Linea 02/ | 10 min   |
| Linea 09  | 10 min   |
| Linea 27  | 8.3 min  |
| Linea 06  | 8.3 min  |
| Linea 01  | 7.2 min  |

### Sensori

|             |   |
|-------------|---|
| 15          | 3 |
| Semafori    |   |
| 22          | 0 |
| Videocamere |   |
| 4           | 1 |
| Sensori     |   |

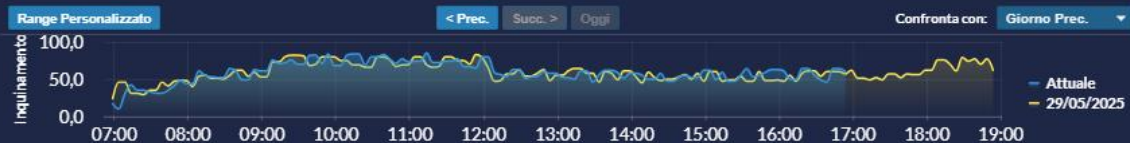
- Home
- Traffic Monitoring
- Smart Parking
- 15 minuti index
- Urban Security



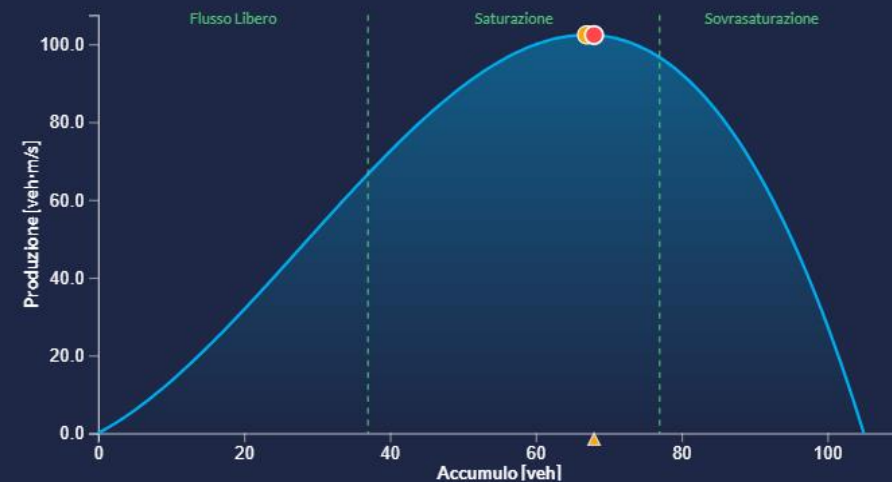
## Trend Accumulo - Poggiofranco (Attuale)



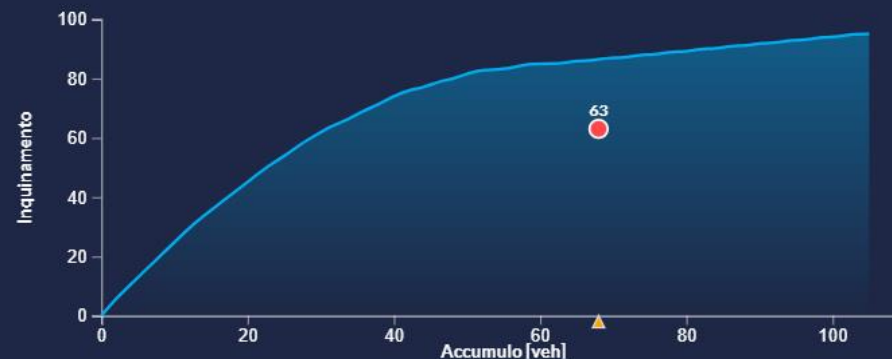
## Trend Inquinamento - Poggiofranco (Attuale)



## MFD - Poggiofranco



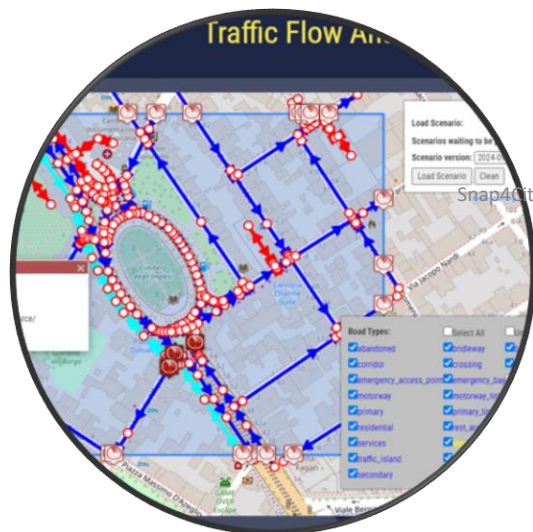
## EMFD - Poggiofranco





## AI-Powered Digital Twin Platform for Mobility & Transport Operation and Plan

“ Snap4City / OPTIFaaS promotes efficient and safe urban mobility, contributing to an improved quality of life and the sustainable growth of the community ”



Snap4City (C), Sett. 2025

112

## Sustainability Features

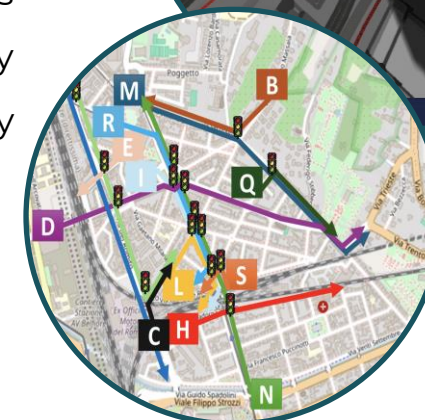
- Traffic optimization
- Multimodal transport integration
- Data-driven simulation and what-if analysis
- Fuel consumption reduction

## Social Impact

- Reduced travel times and emissions
- Accessibility and inclusivity
- Road safety

## Sustainability & Social Benefits

Driving the Future: Smarter. Greener. Together.



- Home
- Traffic Monitoring
- Smart Parking
- 15 minuti index
- Urban Security

**Scenario**

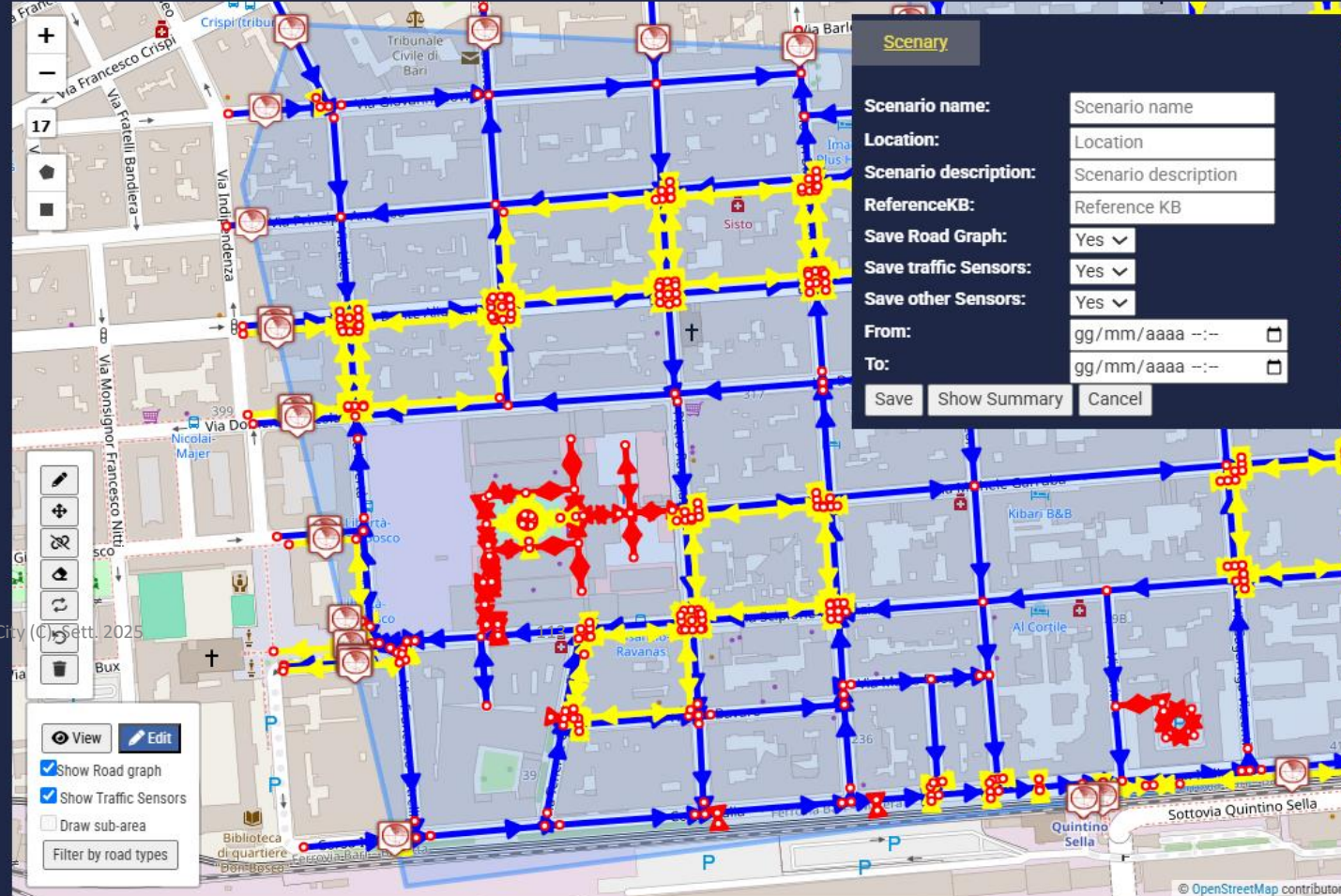
View Edit

☒ Show Road graph

☒ Show Traffic Sensors

☐ Draw sub-area

Filter by road types



INIT to ACC

Compute TFRS

Compute KPI

Show TFR

Data Update

HeatmapScenarioTest

2025-04-01 11:29:35

Execution



Snapshot of the SNAP4city Traffic Flow Simulation interface. The browser address bar shows the URL: `snap4city.org/dashboardSmartCity/view/Gea-Night.php?iddasboard=NDI4Mg==`.

### Traffic Flow Simulation

Mon 14 Oct 19:47:07

**Left Panel (Controls and Stats):**

- Current Scenario: alessandroscen...
- Buttons: CANCEL, PAUSE, HELP
- Speed slider: slow to fast, Delay: 30.0 ms
- Stats**
  - time: 1172.000 s
  - payload: 2.6 KB
  - simulate: 1.67 ms
  - snapshot: 0.54 ms
- Vehicle Summary**
  - car(s): 43
- Click Summary**
  - N/A
- Quick Find: X,Y (float, float) [SEARCH]
- Vehicle type: CAR (selected), BIKE, TRAIN

**Right Panel (Widget1):**

- Data Update
- AleScenario4 2024-09-05 13:36:17 (acc)
- Create Microsimulation
- alessandroscenario30-20240926095651
- Run Simulation

**Central View:** A 3D simulation of a road network with several cars (red, blue, yellow, black) moving through a roundabout and intersecting roads. A control menu on the right of the view includes: Lights, Effects, SSAO, Scene, and Close Controls.

|                              |               |                                                                                                                                                  |
|------------------------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Registrazione</b>         | 10:00 - 10:30 | Registrazione e Welcome Coffee<br>Saluti                                                                                                         |
| <b>Avvio Lavori</b>          | 10:30 - 10:40 | - <b>Prof. Paolo Nesi</b> , UNIFI DISIT Lab/Snap4City<br>- <b>Franco Prampolini</b> , Head of R&D and Innovative Industry Solutions Lutech Group |
| <b>CN MOST SPOKE 8</b>       | 10:40 - 11:00 | Mobility-as-a-Service: tra integrazione e sostenibilità<br>- <b>Prof. Mario Marinelli</b> , Politecnico di Bari                                  |
| <b>Overview OPTIFaaS</b>     | 11:00 - 11:20 | Presentazione generale e obiettivi di <b>OPTIFaaS</b><br>- <b>Mauro Starinieri</b> , Head of Smart City & Mobility Solutions CoE Lutech Group    |
| <b>Strumenti OPTIFaaS</b>    | 11:20 - 11:50 | Presentazione dell'infrastruttura<br>- <b>Prof. Paolo Nesi</b> , UNIFI DISIT Lab/Snap4City                                                       |
| <b>Scenario OPTIFaaS</b>     | 11:50 - 12:10 | Ottimizzazione del Traffico<br>- <b>Prof. Luigi Pariota</b> , Università degli Studi di Napoli                                                   |
| <b>Scenario OPTIFaaS</b>     | 12:10 - 12:40 | Ottimizzazione Semaforica e di Infrastruttura. Ottimizzazione del Trasporto Collettivo<br>- <b>Prof. Paolo Nesi</b> , UNIFI DISIT Lab/Snap4City  |
| <b>Q&amp;A</b>               | 12:40 - 13:00 | Sessione aperta                                                                                                                                  |
| <b>Light Lunch (offered)</b> | 13:00 - 14:00 |                                                                                                                                                  |
| <b>Incontri 1:1</b>          | 14:00 -       | Incontri 1:1 con i referenti di Snap4City/OPTIFaaS (in presenza)                                                                                 |





## IL FUTURO DELLA MOBILITA' INTELLIGENTE E SOSTENIBILE

Digital Twin & Intelligenza Artificiale.  
Innovazione tecnologica “As a Service “  
per la gestione operativa  
e la pianificazione tattico-strategica  
della mobilità urbana sostenibile e interconnessa

Firenze | **Milano** | Roma | Bari



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**MOST**  
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE