

www.snap4city.org www.snap4solutions.org











Al Digital Twin Platform to set-up Sustainable Decision Support Systems & Business Intelligence

> #snap4city #km4city #disitlab @snap4city





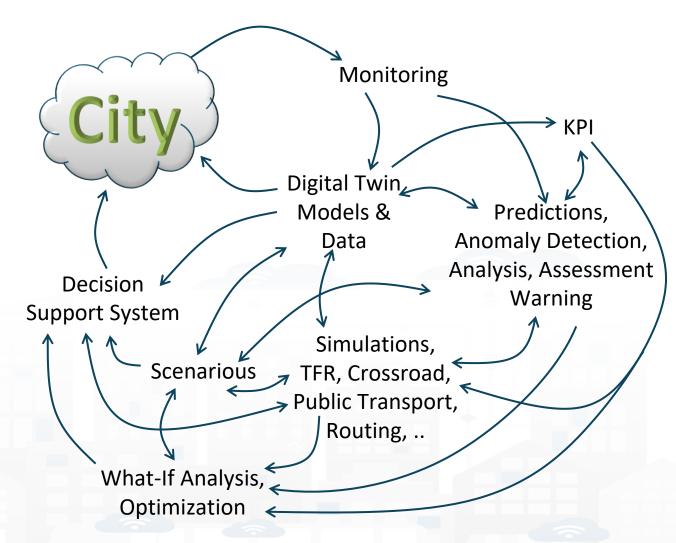




## **Main tasks**



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

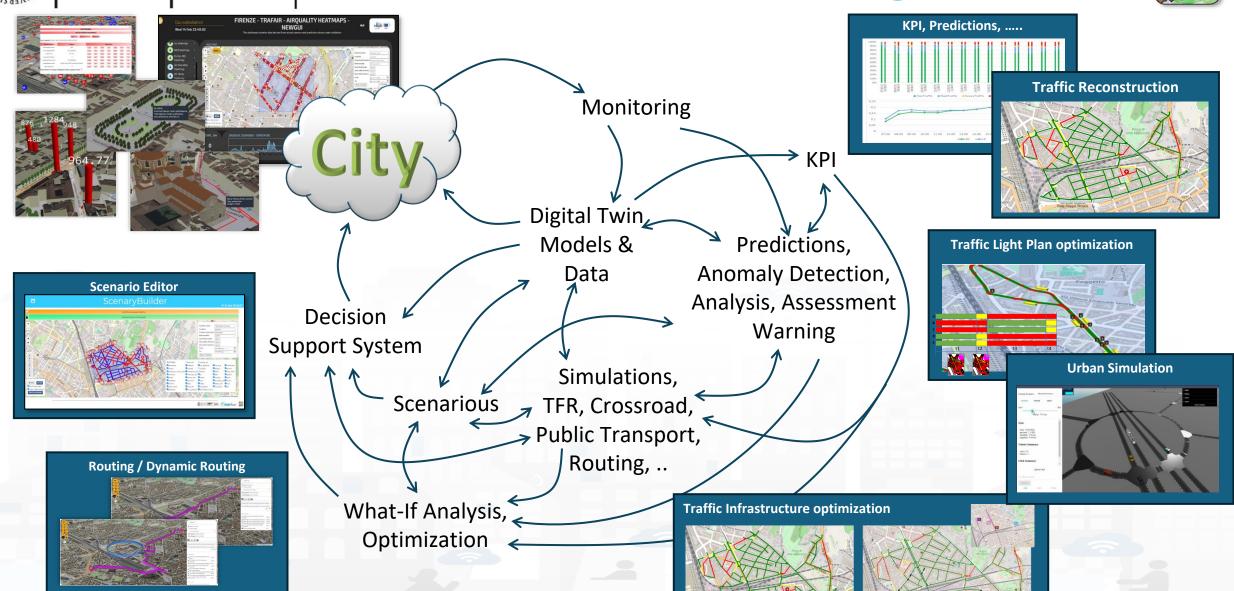












Snap4City (C





#### **FREE** TRIAL



















## **Digital Twin Solutions for Sustainability**

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





**SEMANTIC REASONING** 

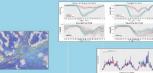
**SMART DATA MODEL** 

**IOT DEVICE MODELS, STORAGE** 















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

#### DEVELOMENT ENVIRONMENT **AND METHODOLOGY**

- VISUAL PROGRAMMING, ML, AI, HPC
- TRAINING COURSES
- LIVING LABS
- **GUI CUSTOM STYLES**
- FULL APPLICATIONS, DASHBOARDS













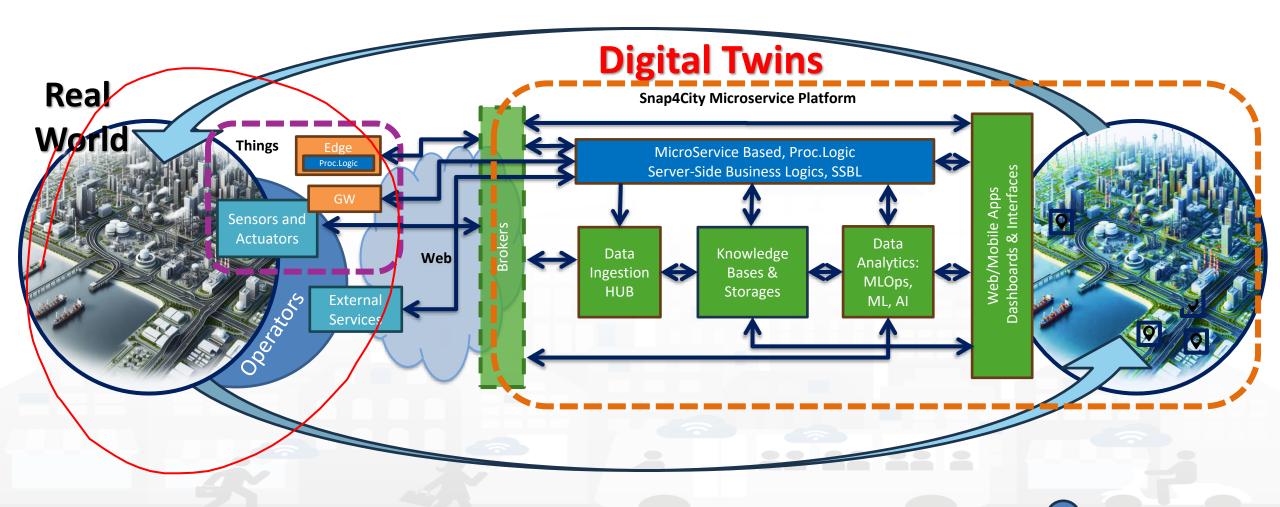








# **Digital Twin Development Platform**



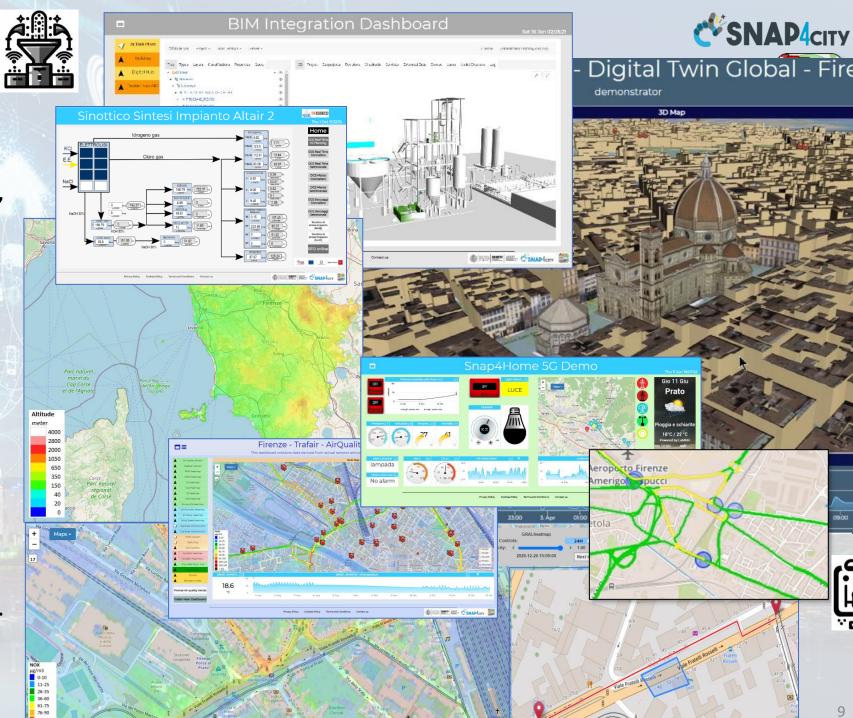
#### **Technical Architecture** KM 4 CITY Front-End **Any API** Applications API Manager **Entity Directory: Facilities Smart Data Models** Traffic Optimiz. **Federation** Scenario Editor **IoT Data Models** /TrafficLightPlan **Smart City API Digital Twins Business Intellig** OpenSearch PublicTransport **CSBL SET STATE** Parking Mng. virtuoso Dashboard Bld storage <del>Drok</del>9rs & Manager Lighting Mng. KB, graph CustomThemes Building Mng. **Brokers** GeoServer **EntityInspector Synoptics Environment** BIMserver.center Data Managers **KPI Support** Waste Mng. MobAppSuppor Sharing/pool 0 Service Map Energy Mng. Social Media Studio **HLT Manager IoT App** BIM GIS Tourism Mng. **Artificial Intelligence:** Gateways, satellite ProcLog. 3D Digital Twin ML, AI, XAI, DA, HPC **Mobile Apps External Services** On Edge Web Scraping IoT App **Event Driven** Tv CAM streams On Cloud Market/Sharing Nace Third parties solutions A&A, SSO, Blockchain, Resource Managers and Sharing: IoT App, Data Analytics, 5/25

# High Level Types

Snap4City (C), May 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, ...





# Standards and Interoperability

# CY SNAP4CITY KM 4 CITY

#### **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, ....
- Formats: JSON, GeoJSON, XML, CSV, GeoTIFF, OWL, WKT, KML, SHP, db, XLS, XLSX, TXT, HTML, CSS, SVG, IFC, XPDL, 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.



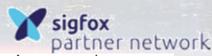






















https://www.snap4city.org/65







# Ingestion, aggreg. > exploitation

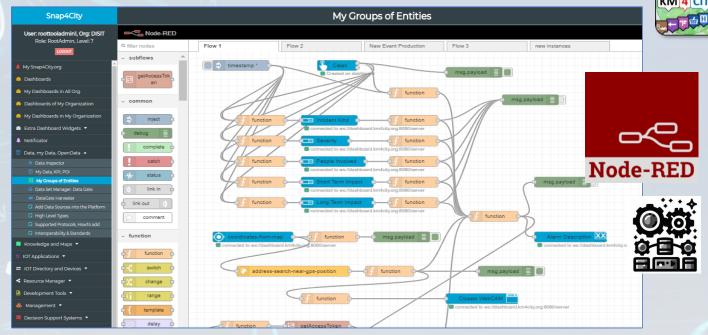








- IoT App Visual Programming, no coding
  - Data transformation
  - Integration, Interoperab.
  - Scripting Data Analytics
  - Data ingestion
  - Business logic Server Side
- Edge and Cloud
- MicroServices data event driven develop via visual language Node-RED









**Areas** 





## > 60.000 downloads (up to 2024)

Open Data CKAN Ticket Management, workflow **BIM Servers** Social Networks Video Management system Gateways

**Data Analytics** Statistic, Optimization Simulation Artificial Intelligence What-if Analysis Support Geo Utilities Support Routing & Traffic Flow MLOps support Python support R Studio Support

Entities Nanagemenx Visualitation service **Snap4City** Microservices *M<sub>ana</sub>g*ement P/atform Analytic Services Proc.Logic **SSBL** other Third Party microservices

Data Load / Search / Retrieval KPI, POI, GIS Data, Scenarios Time Series, Public transport High Level Types: heatmaps, **DM**,... IoT / Entity Discovery **Delegation Management Data Mapping** 

> Dashboards Widgets: Graphic Libraries **Interactive Widgets** Maps, 3D representations Synoptics, External Content Micro Web App

JetApp Management Data Logs, A&A, Security Ownership Management **VPN** remote access

# Expert System semantic queries

UNIVERSITÀ DEGLI STUDI PRATIMENTO DI PRATIME





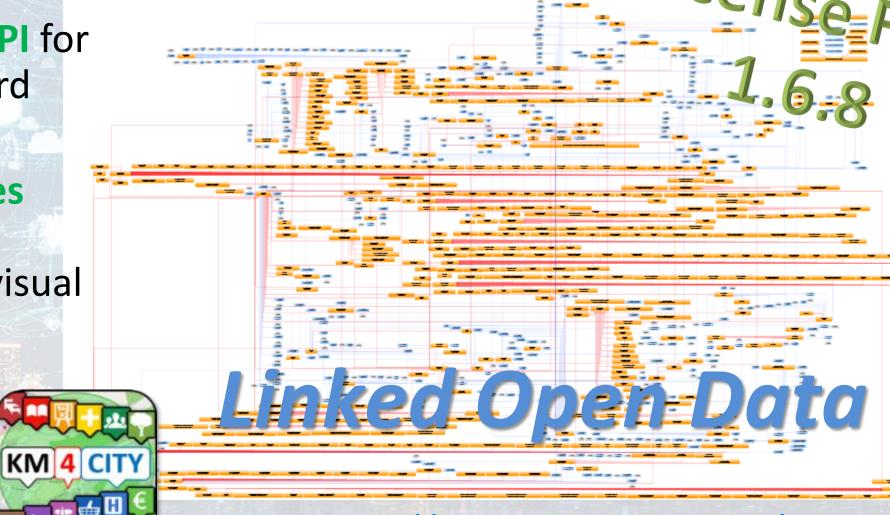
• via:

 Smart City API for Apps and third party

MicroServices
 data driven
 develop via visual
 language
 Node-RED







https://www.snap4city.org/19

## Available AI Solutions on Snap4City

SNAP4city

https://www.snap4city.org/997

More than 80 Available Solutions & 300 Al 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/





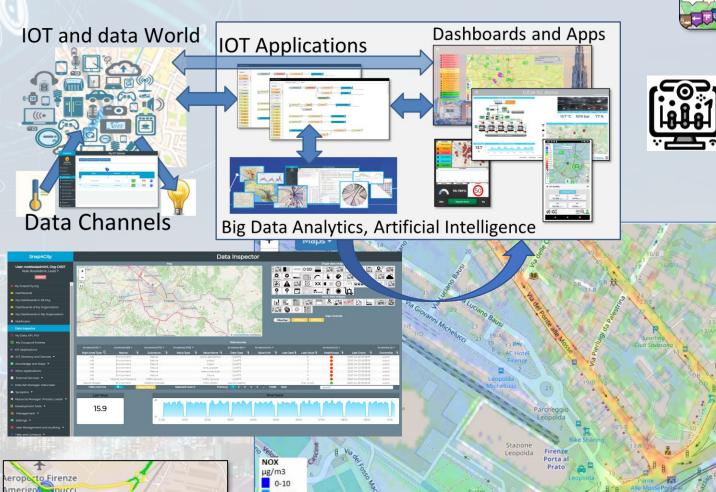
https://www.snap4city.o rg/download/video/DPL SNAP4SOLU.pdf

Snap4City (C), May 2025

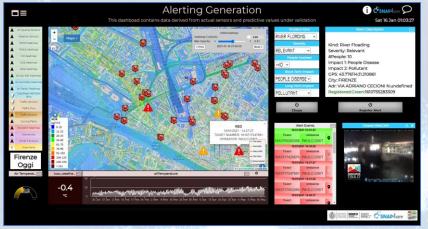
## Solutions: reliable, secure and fast to realize

KM 4 CITY

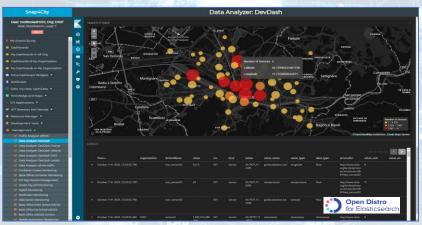
- Via Snap4City tools
  - Dashboard Wizard
  - Dashboard Builder
  - Data/Visual Analytic
- Smart Solutions results to be
  - Real time data drive
  - Secure end-to-end
  - GDPR compliant
  - Reliable, interoperable
  - Auditable, marketable



106-125 126-150

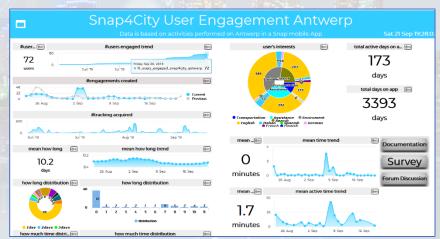


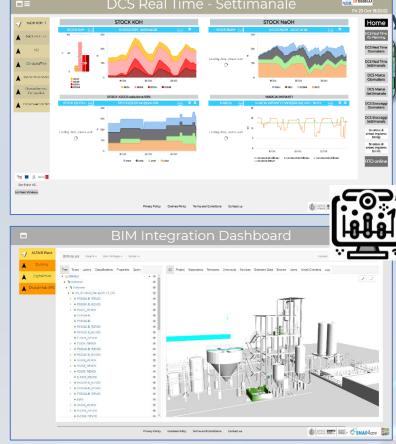


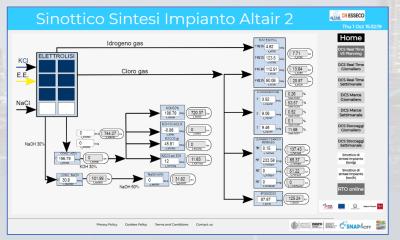


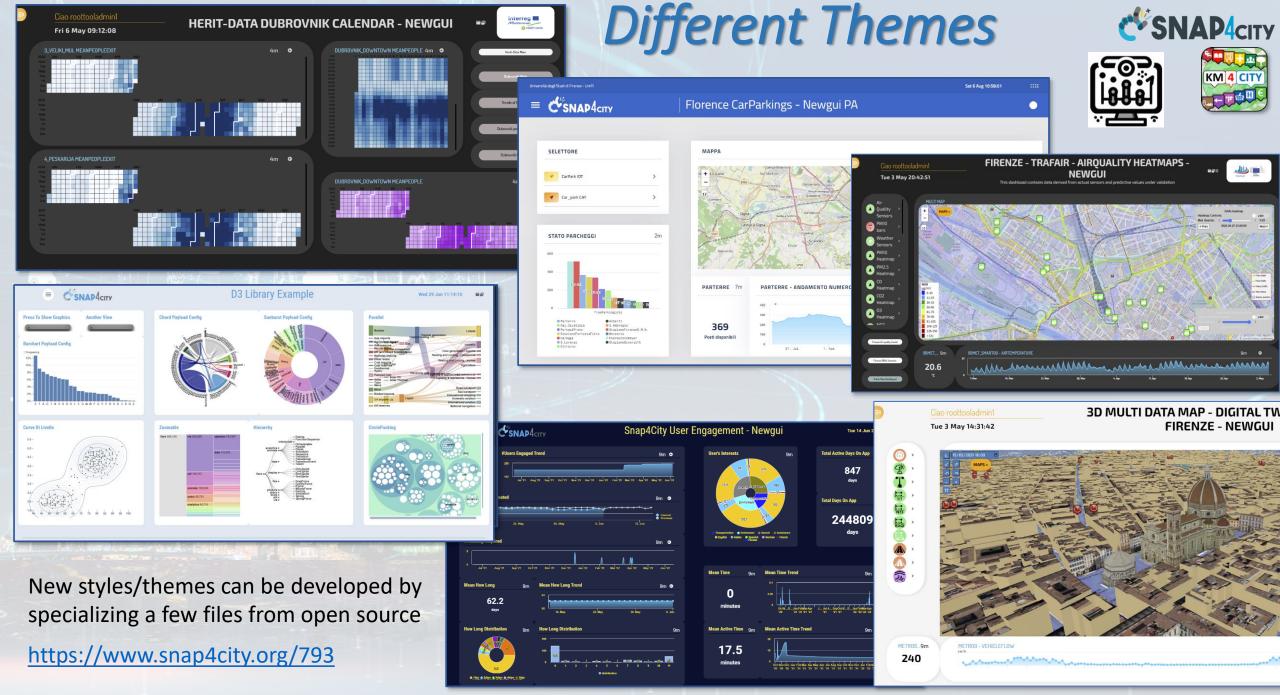












Snap4City (C), May 2025

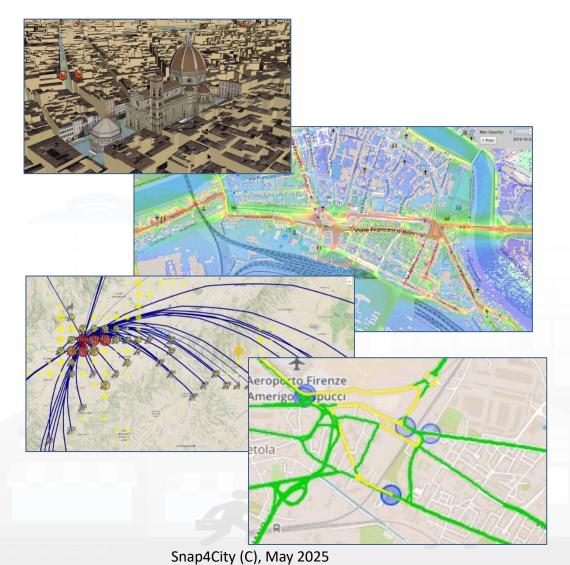








# **Smart City Digital Twin**



## 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

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





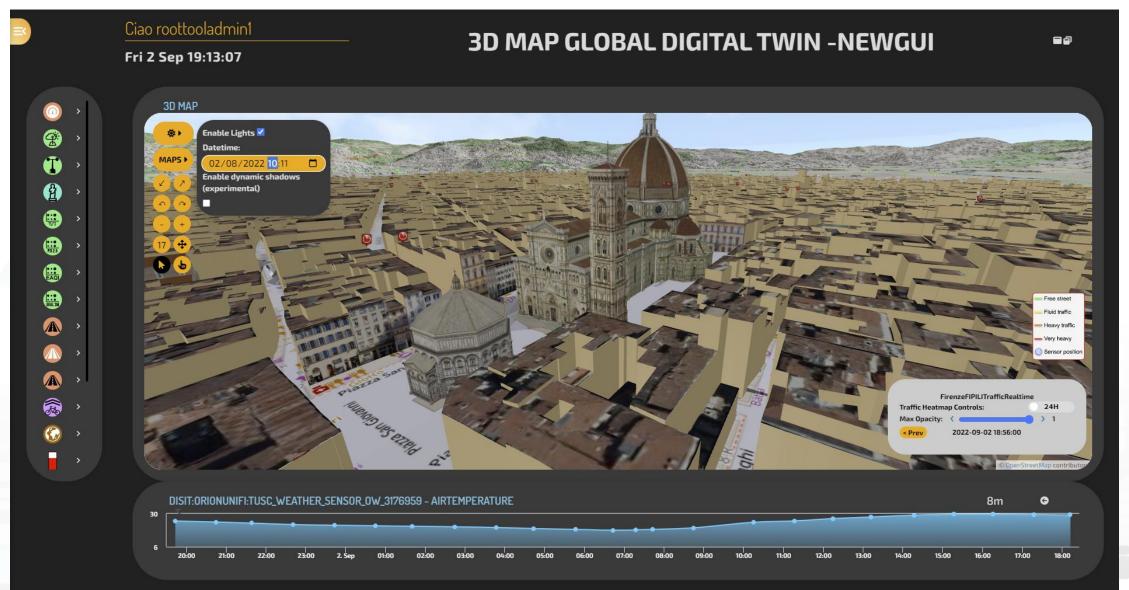








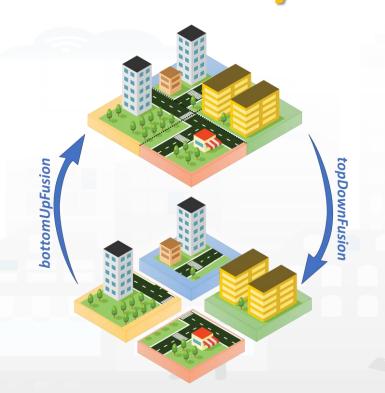


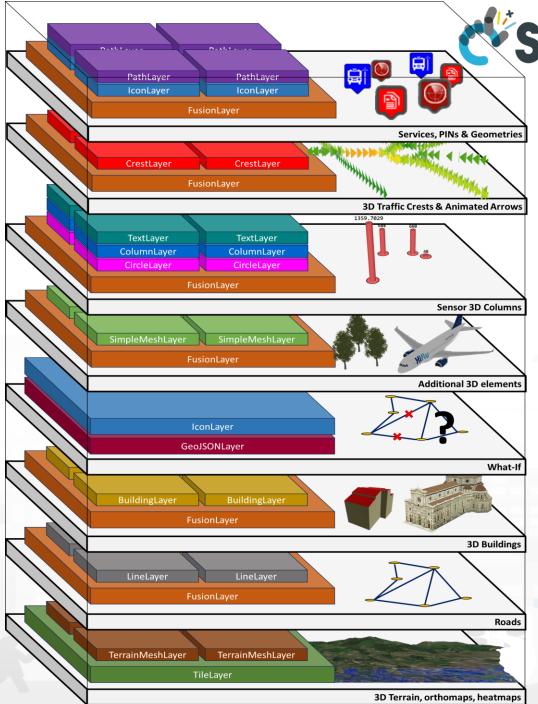




## DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

# Layers **Fusion Layers**



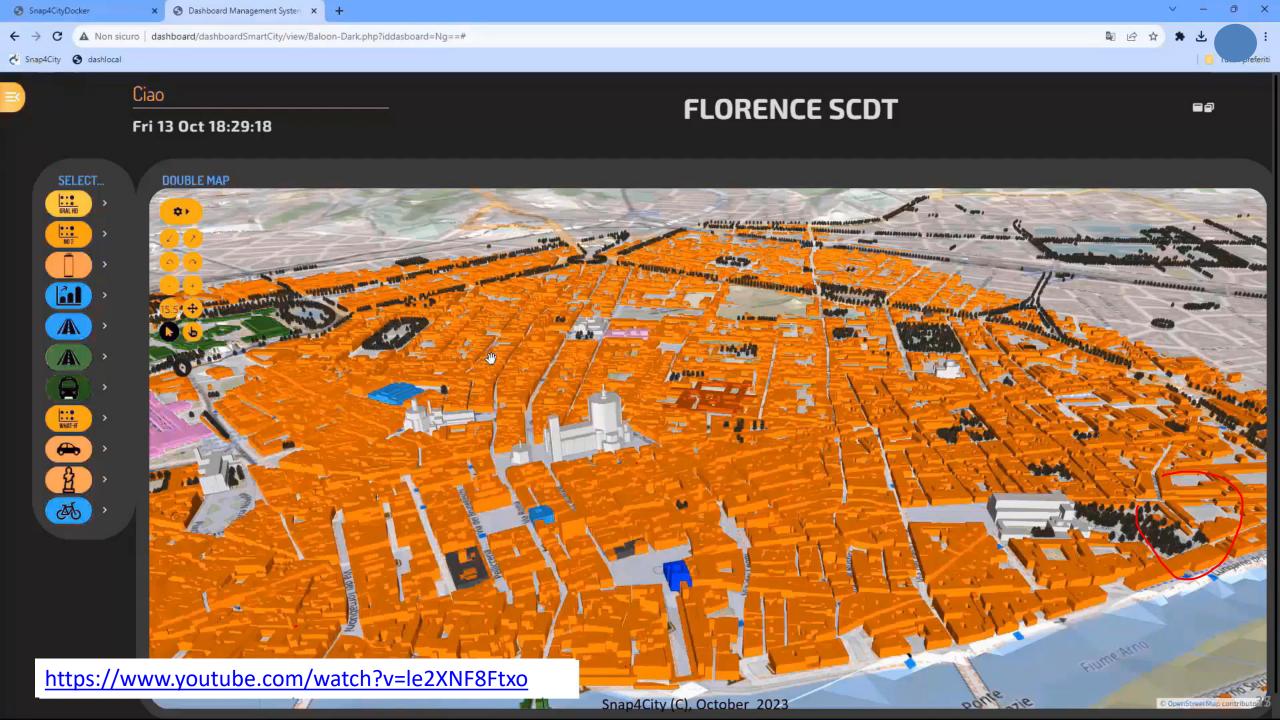






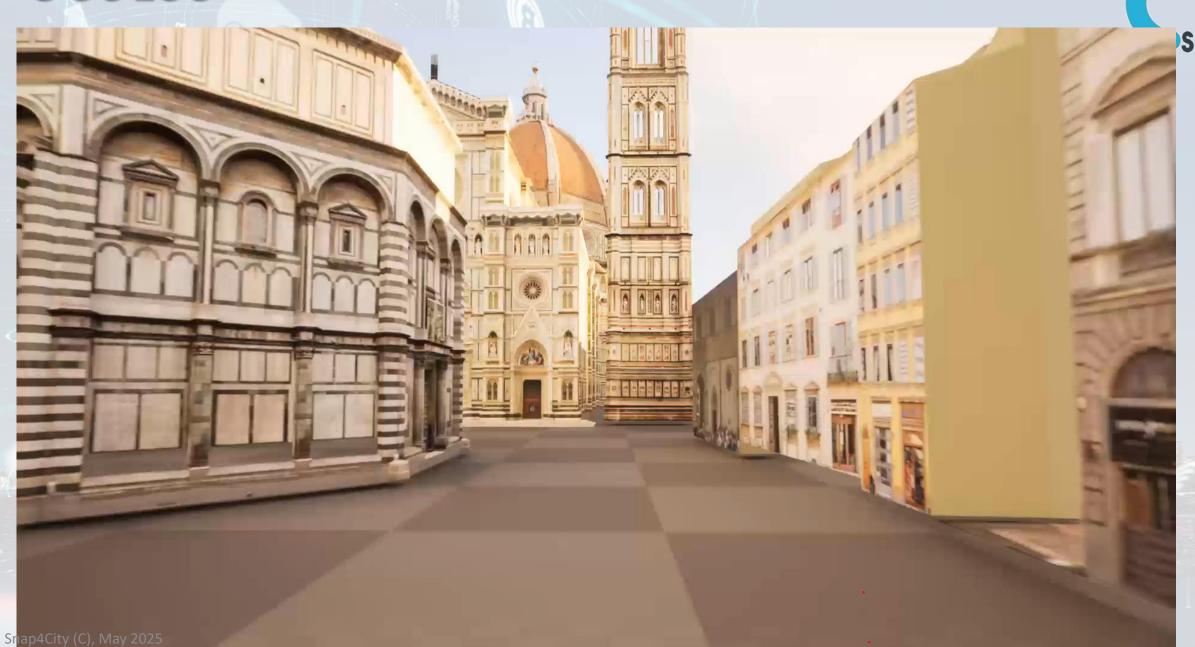






**OCULUS** 

https://www.youtube.com/watch?v=Rcf B2 GOio



SNAP4

# https://www.Snap4City.org













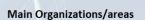
## 11 running installations in Europe

- 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

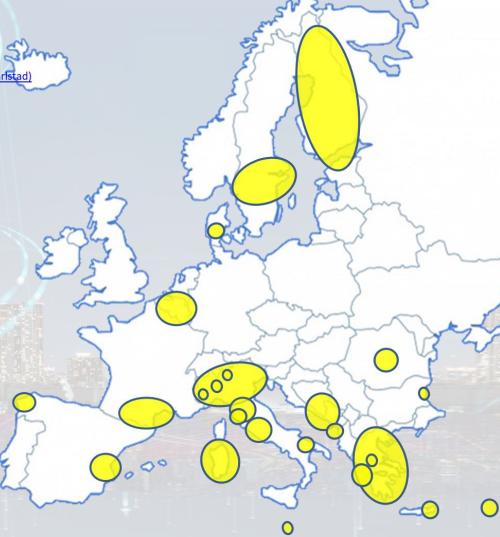
## Widest MULTI-tenant deploy has

- 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





- Antwerp area (Be)
- Bisevo, Croatia
- Brasov (Ro), by ICEBERG
- Capelon (Sweden: Västerås, Eskilstuna, Karlst
- Cuneo (I)
- DISIT demo (multiple)
- Dubrovnik, Croatia
- Firenze area (I)
- Garda Lake area (I)
- Greece (Gr)
- łelsinki area (Fin)
- imassol (Cv)
- Livorno area (I)
- onato del Garda (I)
- Malta (Malta)
- Merano (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)
- SmartBed (multiple)
- Toscana Region (I), SM
- Valencia (S)
- Varna (Bulgaria)
- Venezia area (I)
- WestGreece area (Gr)





5/25



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





Scenarious



#### Scenarious



- Snap4City at OSAKA with OPTIFaaS and CN MOST
- SMART3R-FLITS: SMART Transport for TRavellers and Freight Logistics Integration Towards Sustainabilit
- SOLUTION: Security, Smart City Asset Management for Cuneo, Italy
- 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,
- SOLUTION: Smart Light Control and Light Adaptive with Traffic Density
- 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
- 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

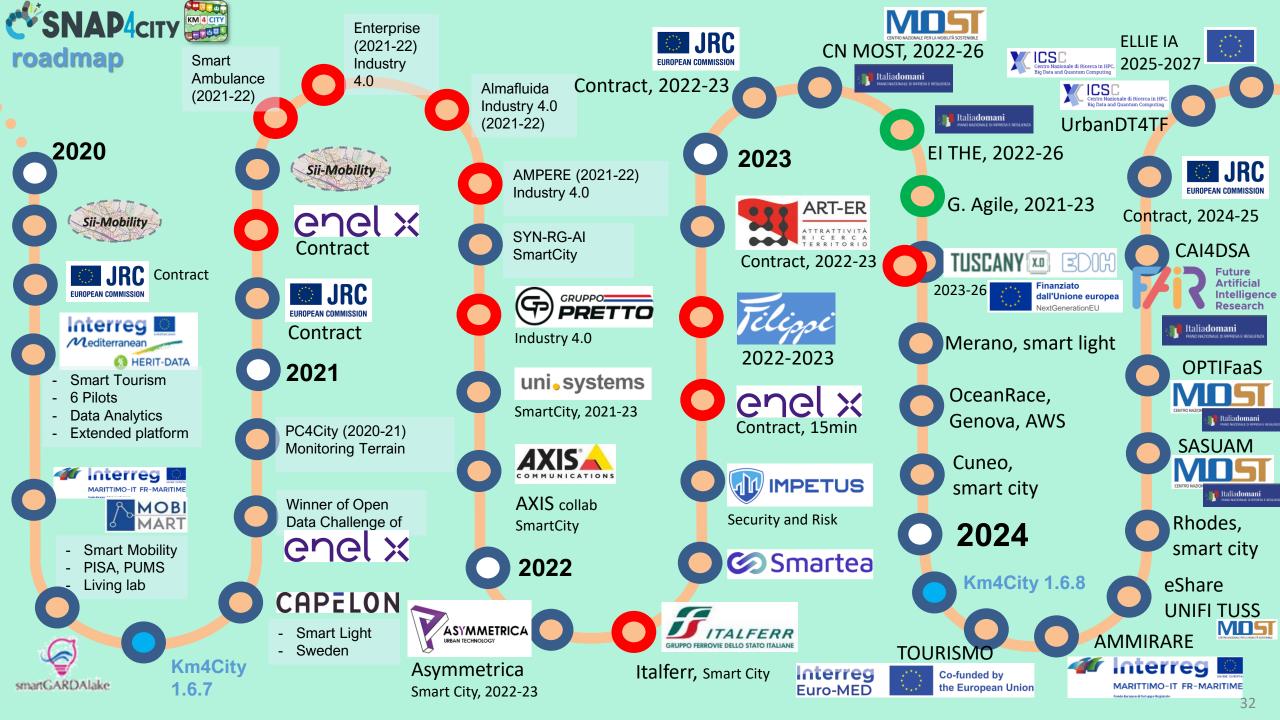
- SCENARIO: Exploit Snap4City in different

  PARA POR Exploit Snap4City in different

  ENARIO: Exploit Snap4City in different

  ENARIO: Exploit Snap4City Asset Manage lies

  Exploit An Micro On the Color of the Color Traffic Density (the actual case of Merano)
  - tà 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 Operation 460 (7), May 2025
  - esses, Ethics and Technology for Urban Safety (Oslo and Padova)





# ++2024/25



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



## booklets

SNAP4city

KM 4 city

Smart City





https://www.snap4city.org /download/video/DPL SN AP4CITY.pdf Industry





https://www.snap4city.org/download/video/DPL SNAP4INDUSTRY.pdf

Artificial Intelligence





https://www.snap4city.o rg/download/video/DPL SNAP4SOLU.pdf



# Control Planning

## 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)





#### **FREE** TRIAL

















## UNIVERSITÀ DINFO DISCITATION DI PROPRIO DI P

**DASHBOARDS, WIDGETS** 

**TEMPLATES** 

**EXPERT SYSTEM, KNOWLEDGE BASE** 

**SEMANTIC REASONING** 

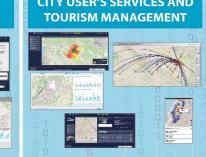
**SMART DATA MODEL** 

**IOT DEVICE MODELS, STORAGE** 

## **Digital Twin Solutions for Sustainability**

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









DEVELOMENT ENVIRONMENT

VISUAL PROGRAMMING, ML, AI, HPC

**AND METHODOLOGY** 

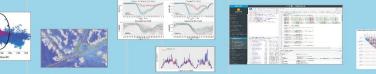
TRAINING COURSES







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



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



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

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











# **Control Horizontal Platform**

#### Goals:

- Increasing quality of Life, quality of services,
- Decongestion, Decarbonization, Sustainability
- increase efficiency and production optimization
- Improve accessibility to services: citizens, Tourists, commuters, etc.
- Improve security/Safety of city users, risk reduction
- Costs reduction of services, energy consumption reduction
- Reduction of emissions and EC taxations

#### Horizontal homogeneous platform Uniform Technology for

- Any Vertical operation/plan: mobility, energy, environment, security, tourism, infrastructure and assets control, buildings, etc.
- Al Solutions: early warning, predictions, simulations, what-if, optimization; Deep Learning, ML, BERT, LLM, XAI (Shap/Lime),
- Development Environment for any vertical, Digital Twin: City Global and Local, IoT, VR, Visual Programming, business intelligence, CSBL, SSBL, etc.
- Interoperability: any format, any protocol, any video management system, any sensor, any device, etc.
- KPI: multidomain KPI, general management, early warning, early detection of critical conditions, 15 Min City Index, SDG
- Mobile App: modular applications, operators' modules, multiple cities, etc.
- Participatory: problem reporting, ticketing, etc.
- Integration of any kind





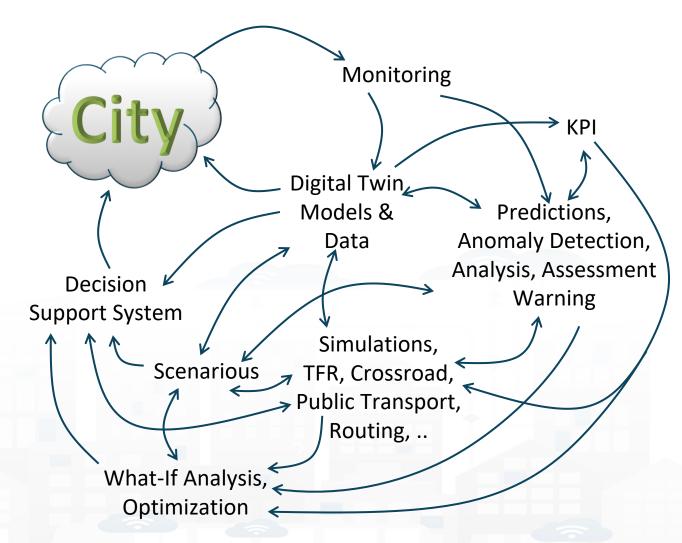




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- Making plan: tactic and strategic, medium and long range, micro/macro
  - Simulation & optimization
  - Generative AI Prescriptions, scenarios
  - Resilience to Unexpected unknows
  - What-if analysis wrt scenarios
  - Collaboration with stakeholders



# Key Performance Indicators, KPI





Weight Average Government Services

Slow Mobility 5 5 Health

Food Services

Economy 5 5 6 Average 5 Housing Culture and Cults

Entertain.

15Min

Average

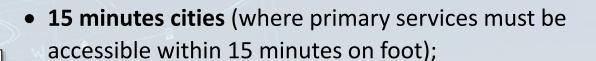
Sustain.

SustainABLE G ALS

SustainABLE G

		Air Quality Directive			WHOguidelines	
Pollutant	Averaging period	Objective and legal natur concentration	re and Comr	ments	Concentration	Comments
PM <sub>2.5</sub>	One day				25 μg/m³ (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>2.5</sub>	Calendar year	Target value, 25 µg/m³	The target value h limit value since 1		10 μg/m³	
PM <sub>10</sub>	One day	Limit value, 50 µg/m³	Not to be exceeded on more than 35 days per year.		50 μg/m³ (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m³ (*	*)		20 μg/m³	
) <sub>3</sub>	Maximum daily 8–hour mean	Target value, 120 μg/m³	Not to be exceed than 25 days per y over three y	ear, averaged	100 µg/m³	
NO <sub>z</sub>	One hour	Limit value, 200 μg/m³ (	*) Not to be exceede *) 18 times a cale		200 μg/m³ (*)	
NO <sub>2</sub>	Calendar year	Limit value, 40 μg/m³		·	40 μg/m³	

United Nations Sustainable Development Goals,
 SDGs (for which cities can do more to achieve some of the 17 SDGs, <a href="https://sdgs.un.org/goals">https://sdgs.un.org/goals</a>);



 objectives of the European Commission in terms of pollutant emissions for: NO2, PM10, PM2.5 (https://environment.ec.europa.eu/topics/air\_en);

- SUMI: mobility and transport vs env
  - https://www.snap4city.org/951
- SUMP/PUMS: mobility and transport vs env.
- **ISO indicators:** city smartness, digitization, tech level.
- Low Level/Real Time: global traffic, quality of service, betweenness, centrality, queue, time to travel, etc.











# 15MinCityIndex

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

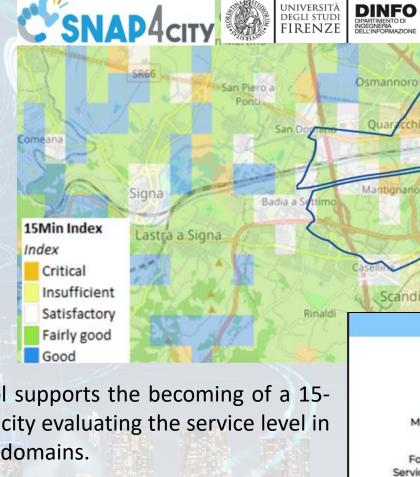
#### **Using the Open Data:**

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.

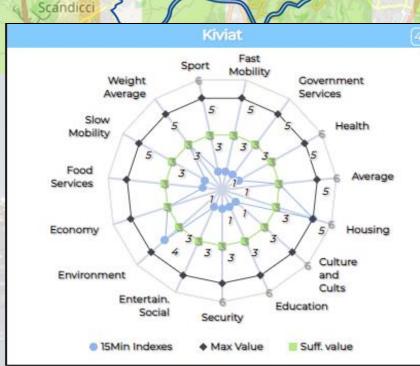


Careggi/Rifredi is a relevant district in Florence because of hosting the main Florence/Tuscany hospitals Careggi and Meyer, but also university headquarters and many other workplaces.



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





DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjkzOA==

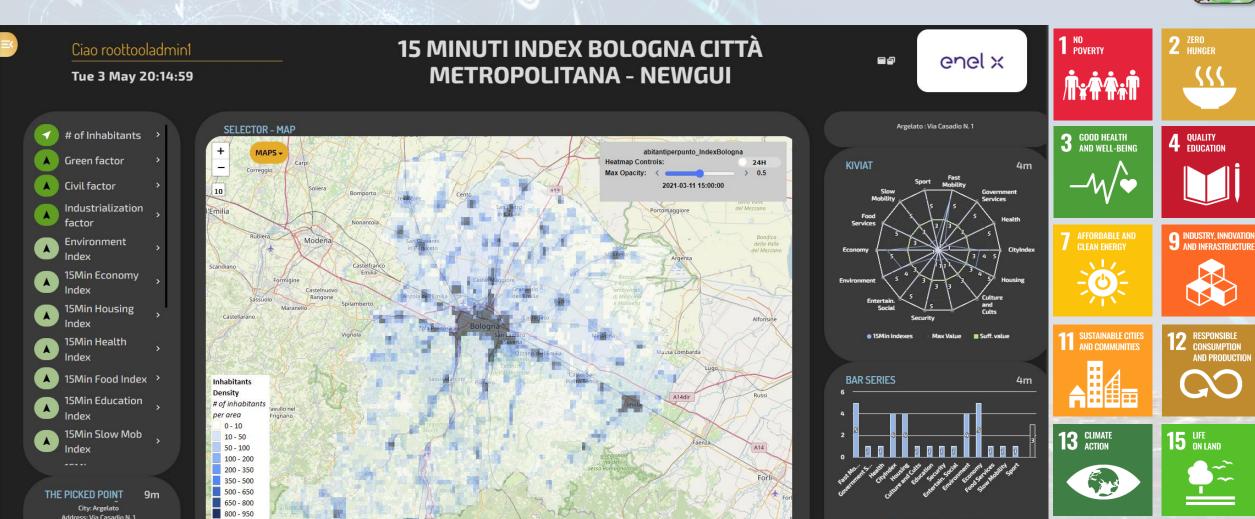
Snap4City (C), May 2025

# 15MinCityIndex on Bologna











>950

lat.lon: 44.61882.11.35437















## • 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



- Reduction of emission, reduction of congestion
- Smart City infrastructure: monitoring and resilience, long terms predictions
- Effective and Low cost smart solutions
- What-if analysis, Simulations
- Origin Destination matrices computation





Reduction of emission, reduction of congestion Monitoring and Predicting: NO2, NOX, CO2, Traffic flow, pollutant, landslide, waste, etc.

Traffic flow reconstruction

Demand vs Offer of Mobility analysis



- Predictive maintenance
- Decisions Support Systems
- Process optimization, control
- Industry 4.0 integrated solutions



- Optimization of Waste Collection
- business intelligence tools for decision makers
- Reduction production costs
- Monitoring resource consumption



- Shortening justice time
- Prediction of mediation proneness
- Assisting institution is taking legal decisions
- Anonymization and indexing legal docs.
- Ethical Explainable Artificial Intelligence

Snap4City (C), May 2025 (10/2024)







# **Smart City Control Room** Florence Metropolitan City



- Thousands of Open/Private data, POI, IOT, etc.
- mobility and transport: accidents, public transport, parking, traffic flow, Traffic Reconstruction, KPI, ...
- AND: environment, civil protection, gov KPI, covid-19, social & social media, people flow, tourism, energy, culture, ...

## Multiple dash/tool Levels & Decision Makers

• Real Time monitoring, Alerting, quality assess.

Predictions, KPI, DSS, what-if analysis

## Historical and Real Time data

Billions of Data

## Services Exploited on:

Multiple Levels, Mobile Apps, API

Since 2017



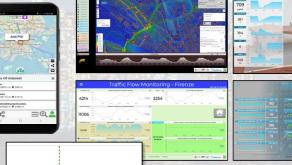




















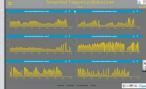






















# s Security and Control



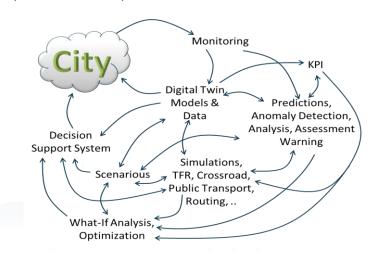


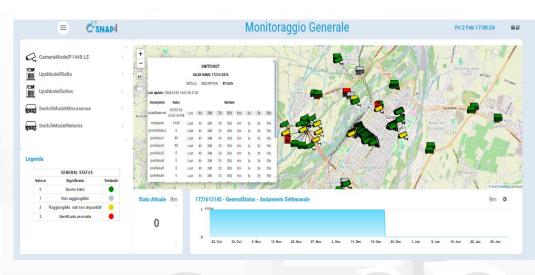


## • Goals:

## **Assets Control Domain** (2024/8)

- 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
    - Ftc.
  - 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

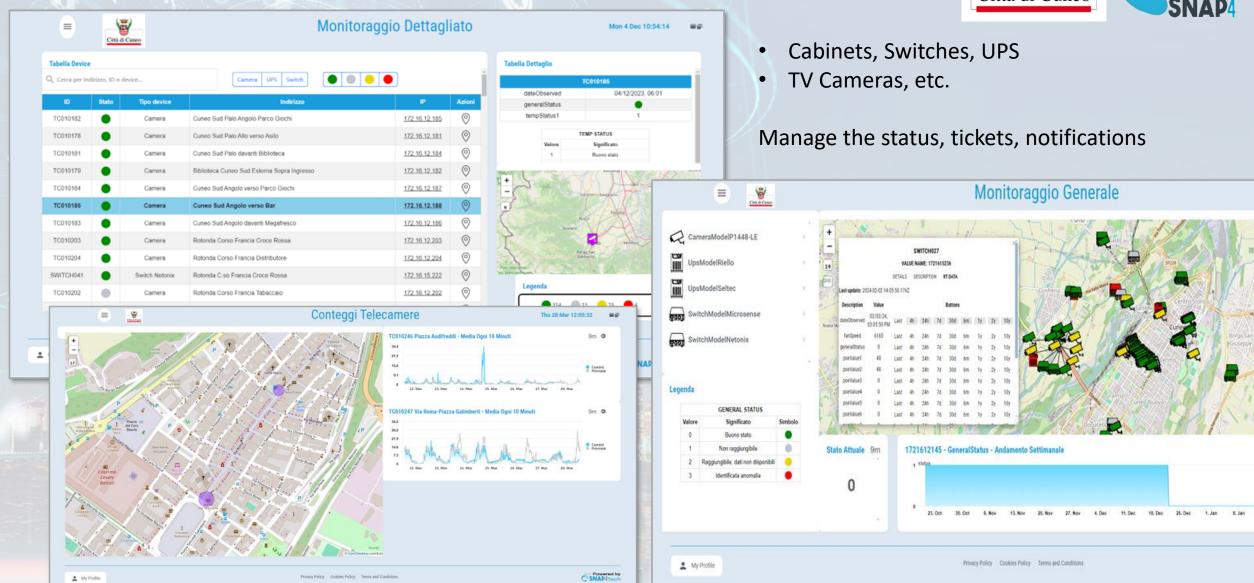




# **ICT Assets Control: CUNEO Municipality**







Snap4City (C), May 2025

53

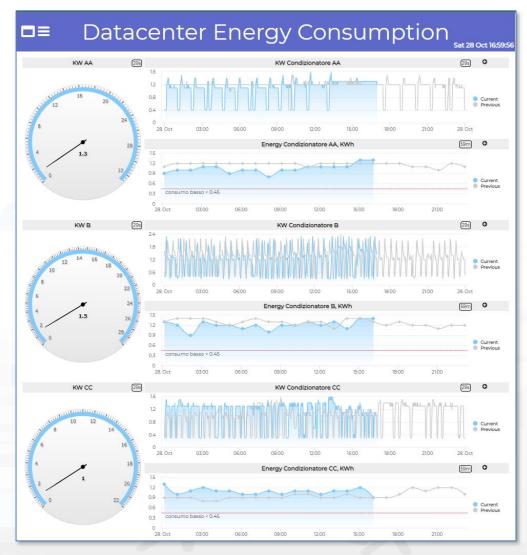


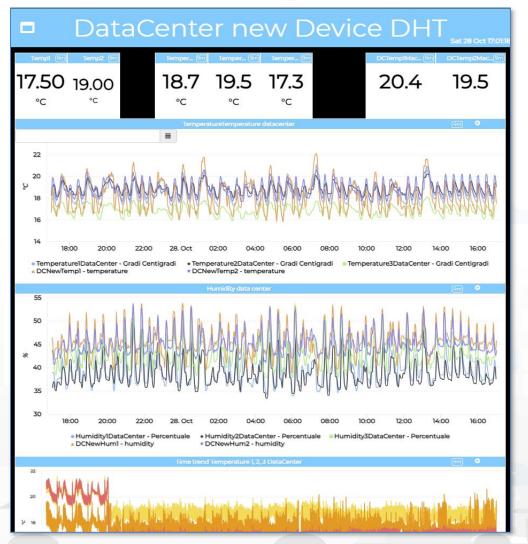






# **Data Center monitoring**









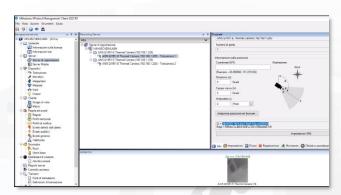


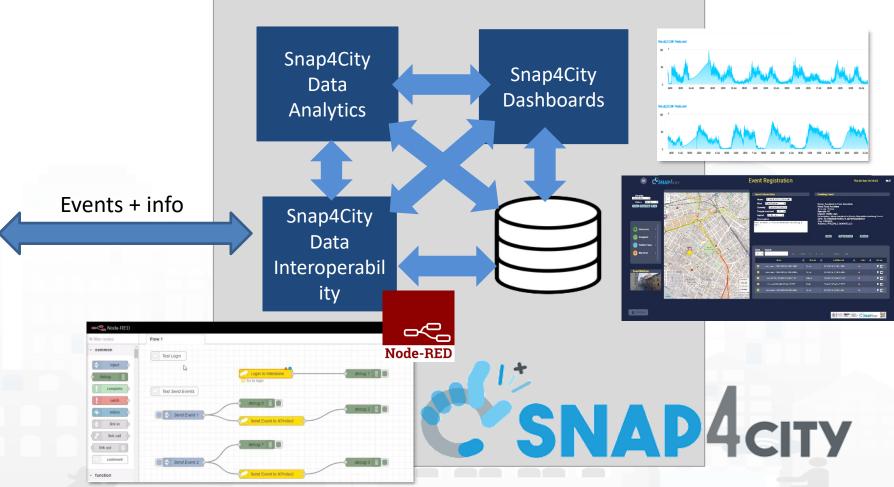




## VMS vs Snap4City: sending and getting events, AI solutions







# Engaging via Mobile.

SNAPACH Y ARCHITECTU AND ECOSYSTEM. OPENED TO DEVELOPERS AND STAKEHOLDERS

TWITTER

VIGILANCE SOCIAL

SNAP4CITY

SNAP4CITY AND KM4CITY PROJECTS

SNAP4CITY THE VIEW OF THE ADMINISTRATORS

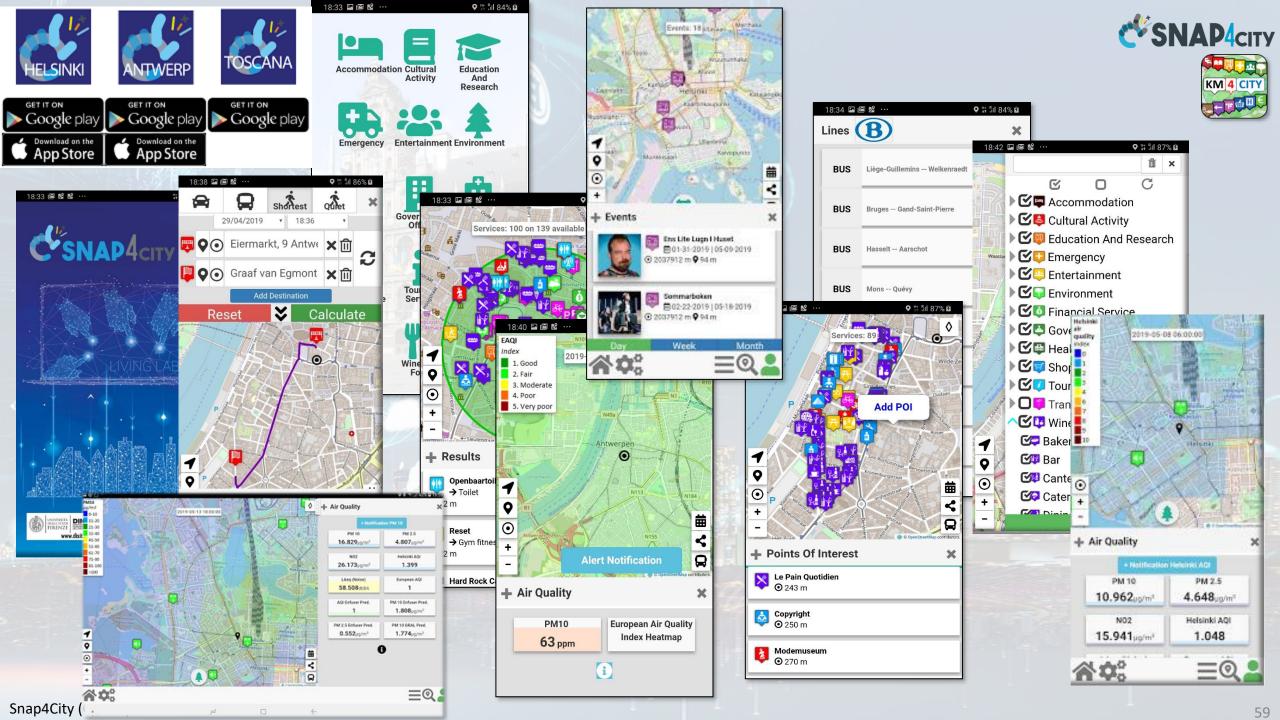
FROM CITY DASHBOARD TO APPLICATIONS

> DATA AND KNOV MAN









## Citizen Engagement/Participation via Mobile Apps

- **GPS Positions**
- Selections on menus
- Views of POI
- Access to Dashboards
- searched information
- Routing
- Ranks, votes
- Comments
- **Images**
- Subscriptions to not fications

### **Produced information**

- Viewed?
- Accepted?
- Performed?



Snap4City (C), May 2025



#### **Derived information**

- Trajectories
- Hot Places by click and by move
- Origin destination matrices
- Most interested topics
- Most interested POI
- Delegation and relationships
- Accesses to Dashboards
- **Cumulated Scores from Actions**
- Requested information
- Routing performed



#### **Produced information**

- Suggestions
- **Engagements**
- **Notifications**

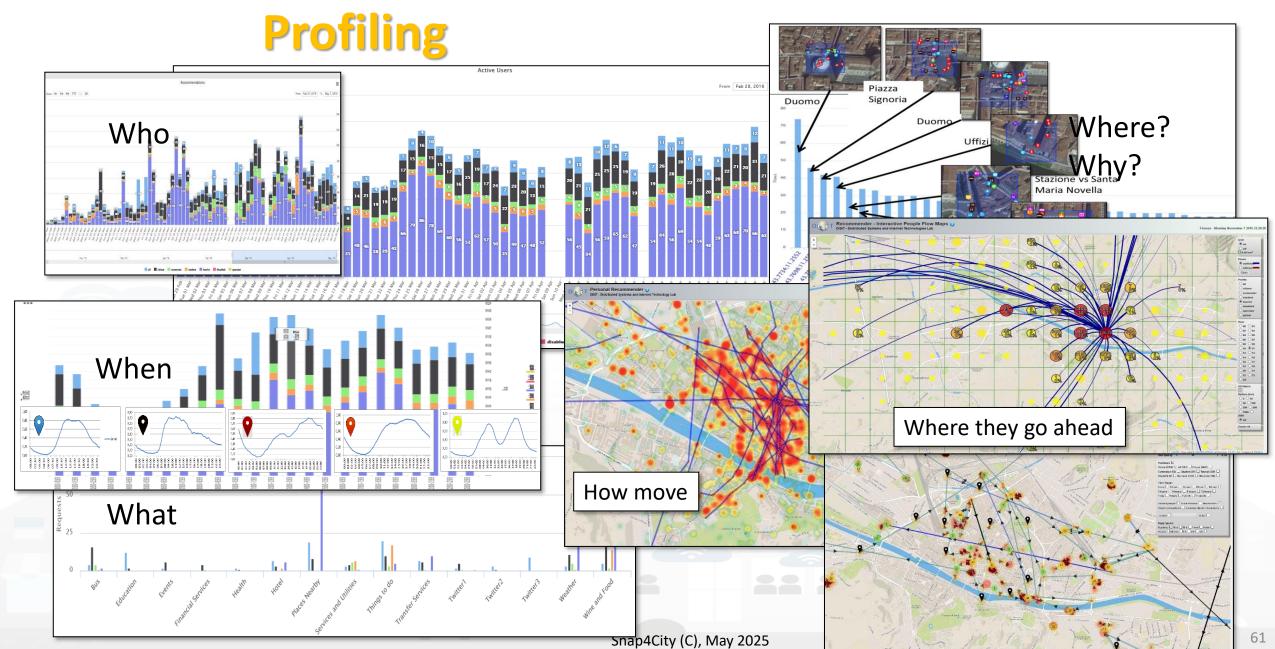






# **User Behavior Analyser for Collective**







INGEGNERIA DELL'INFORMAZIONE

# QR Engagement SNAP4city





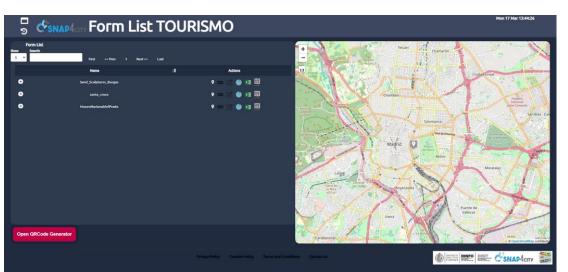


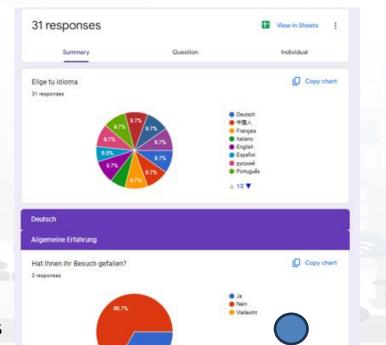




















# **Participation and Engagement**

City users: residents, students, commuters, tourists, visitors, business visitors, etc.

## Participation

- Collect complaints about city services
- Multichannel: mobile Apps, open call numbers, web pages and blogs, social media, help desk, info points, white boxes in the city, telegrams, SMS, etc.
- Data integration, usage of LLM, AI deep learning

## Engagement

- Involving city users to perform actions: take photo, provide a suggestion a rank, etc.
- Commonalities: data collection, workflow management, operators, etc.

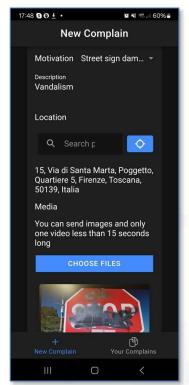






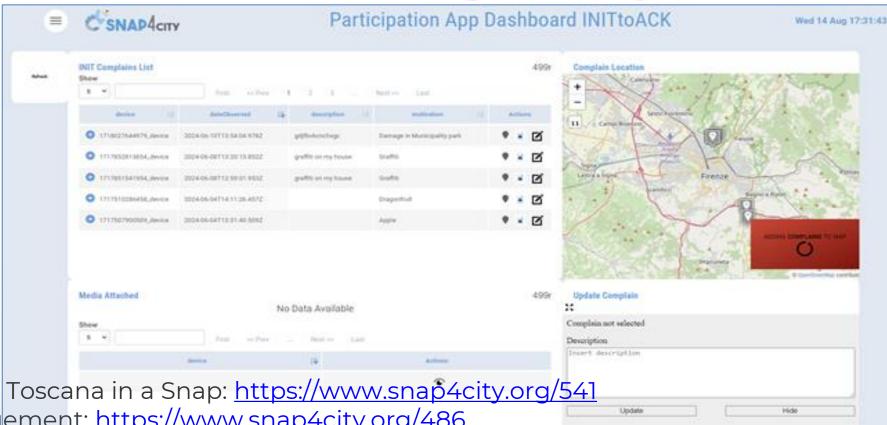


# Operator Interface to manage complains









- •mobile app Toscana in a Snap: https://www.snap4city.org/541
- •User Engagement: https://www.snap4city.org/486
- •MultiPurpose user engagement: <a href="https://www.snap4city.org/548">https://www.snap4city.org/548</a>
- •User Engagement admin: https://www.snap4city.org/472

https://www.snap4city.org/1018

# 









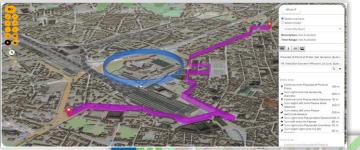
# **Mobility & Transport**

#### 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.







Smart Energy and Smart Building





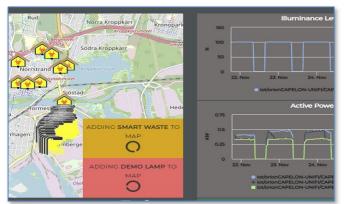


# SNAP4city MACITY

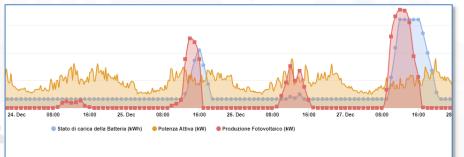


## **Energy and Buildings**

- 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

















# **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, missions, pollutants, aerosol, chemical plants analysis
  - Traffic Flow impact emissions, predictions
  - Sea conditions, UV conditions, etc.
- Land slide prediction warning
- Coastal erosion monitoring and analysis
- Smart Waste Management and Optimisation:
  - costs reduction, optimal routing production, pay as you throw,
  - avoiding out of bins, predictions of waste production on bins, alarms
- KPI: SDG, 15MinCityIndex, QOS, costs, Km, colleting time, EC KPI, emissions
- Mobile App: final users services/informing and operators
  - Info Waste for operators, participation, optimal routing, RAEE Collection, ...
- Participatory: problem reporting, ticketing, etc.
- Integration of any kind: env/weather, mobility, ticketing, presences, POI, ..





City Users' Services and Tourism Management

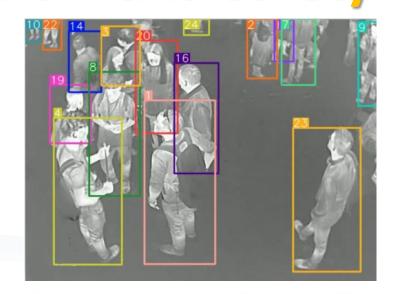


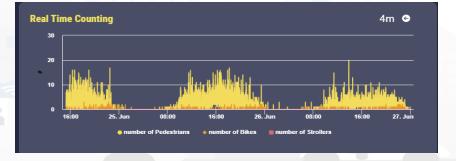






- - Improve Quality of Life and quality of services,
  - Over tourism mitigation, sustainability
  - Costs reduction of services
  - Improve accessibility to services: citizens, Tourists, commuters, etc.
  - Improve Security/Safety of city users
- **People Flow Analysis / Management:** in/out-door, retail, 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, ...







Tools for rapid implementation of - Sustainable Smart Solutions - Decision Support Systems as a no-coding, low-coding







info@disit.org https://www.Snap4city.org, https://www.Snap4Industry.org



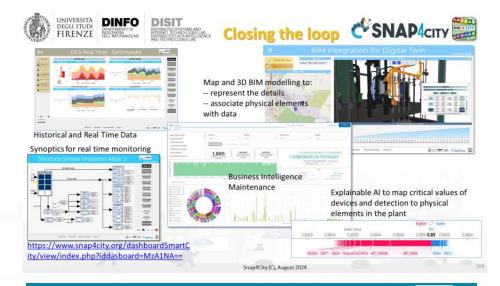


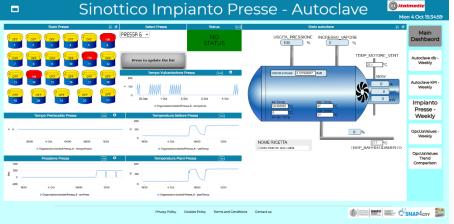




# **Industry production Domain** (2025/5)

- Goals:
  - Cost reduction, increase control on production
  - Production optimisation
  - Quality Level
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring KPI: administration, production, commercial, faults, etc.
  - Early detection/warning, alarm, of critical conditions.
     Multichannel Event reporting: email, Telegram, mob apps, etc.
  - Managing maintenance operation, predictive maintenance
  - Simulation of Fluid dynamic on Autoclaves
- Solutions for Planning (optimization and what-if analysis)
  - Generative AI and predictive AI for production plan optimisation
  - Reduction maintenance costs, reduction of critical SLA conditions, improving quality level
- Algorithms and computational solutions





# Developing on Snap4City















# Why/How to Develop <a href="https://www.snap4city.org/1093">https://www.snap4city.org/1093</a>

- 1. Data Integration Inter-operability, standards
- 2. Advanced Analytics and Al 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

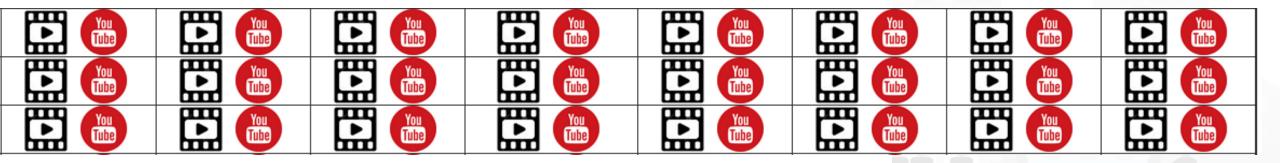
## https://www.snap4city.org/944

## On Line Training Material (free of charge)





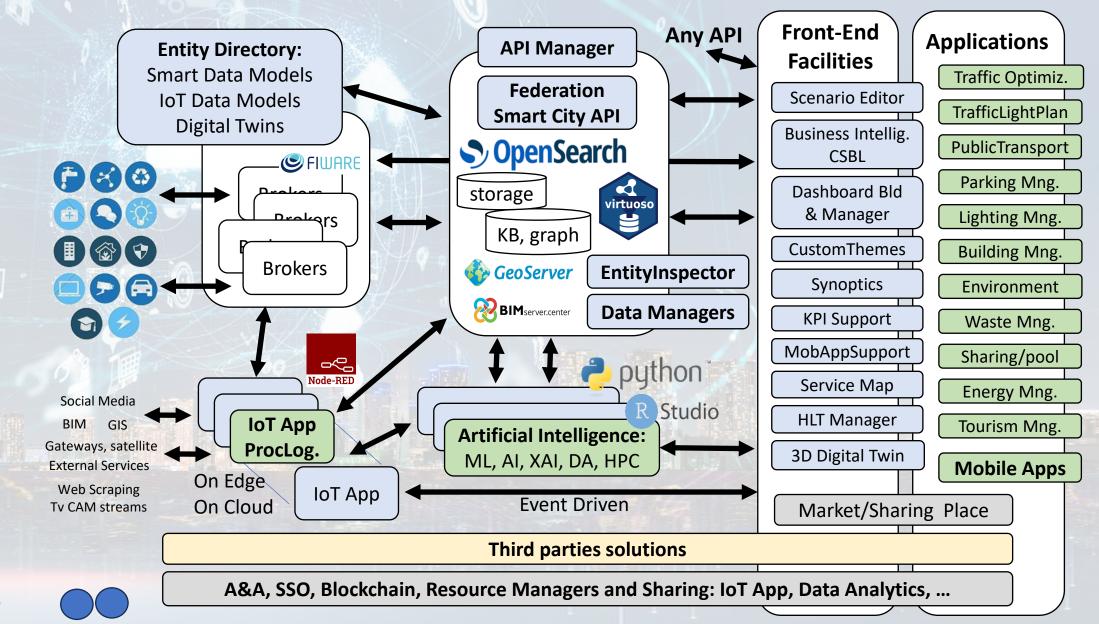
2nd part	3rd part	4th part	5th part	6th part	7th part	8th
Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App	Design and Develop Smart Solutions
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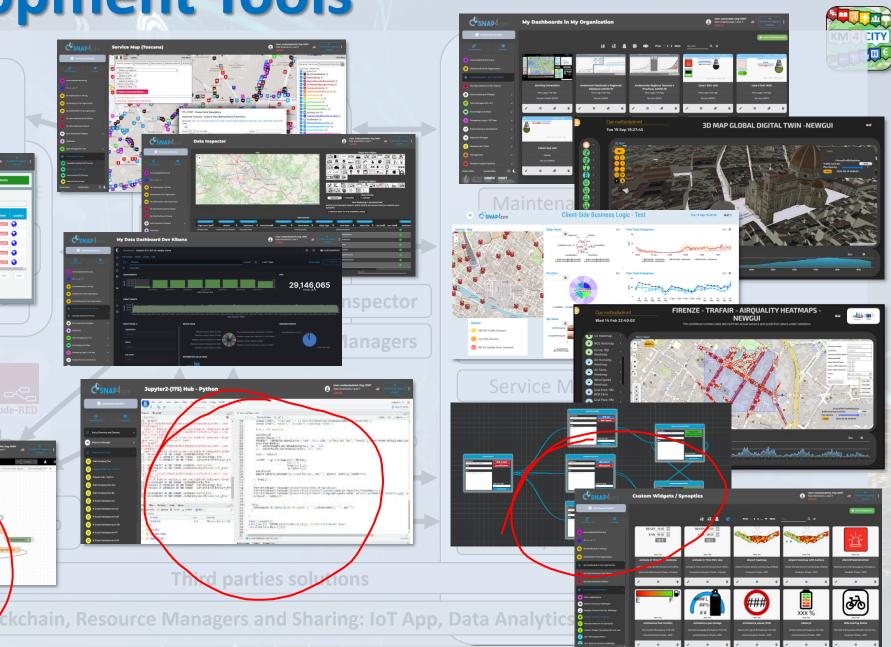
## **Technical Architecture**



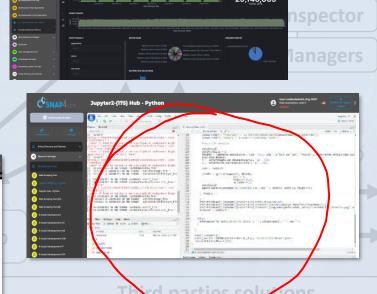




**Visual Development Tools** 









Logged in as: edoardo tester



Your Profile

Logout

SnapAssistant model:

Llama3.3 V

New Chat

EdoChat1

EdoChat2

EdoChat3

EdoChat4

prova

chatNuova

chatTest1LLAMA

chatTest2LLAMA

testGianniLLAMA

testTastoInvioPreChanges

ChatTestPostPSWINVIO

## SnapAdvisor

Current chat: debug0

Visualize references





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.











# Development

https://www.snap4city.org/d ownload/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.snap4citv.org/download/video/Snap4Citv-
- https://www.snap4city.org

- https://www.snap4industrv.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city
- https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg

#### Coordinator: Paolo Nesi, 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







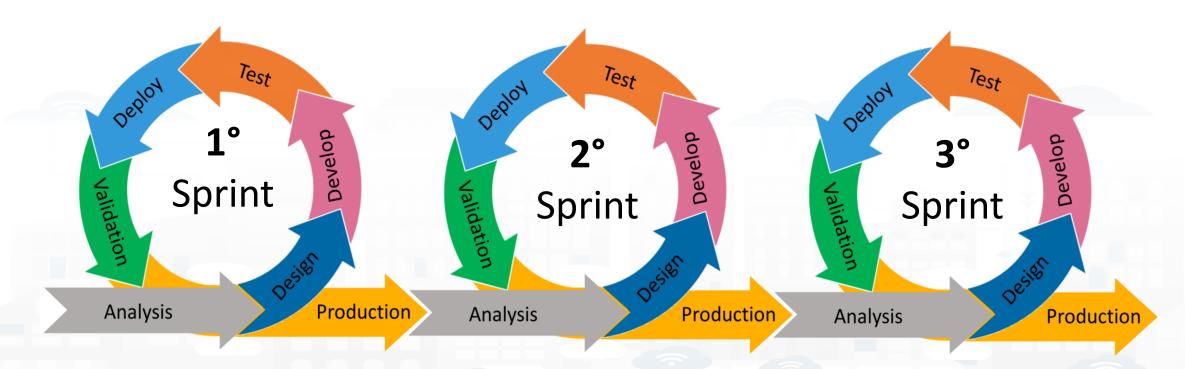






# **Agile Development Life Cycle by sprint Smart Solutions**





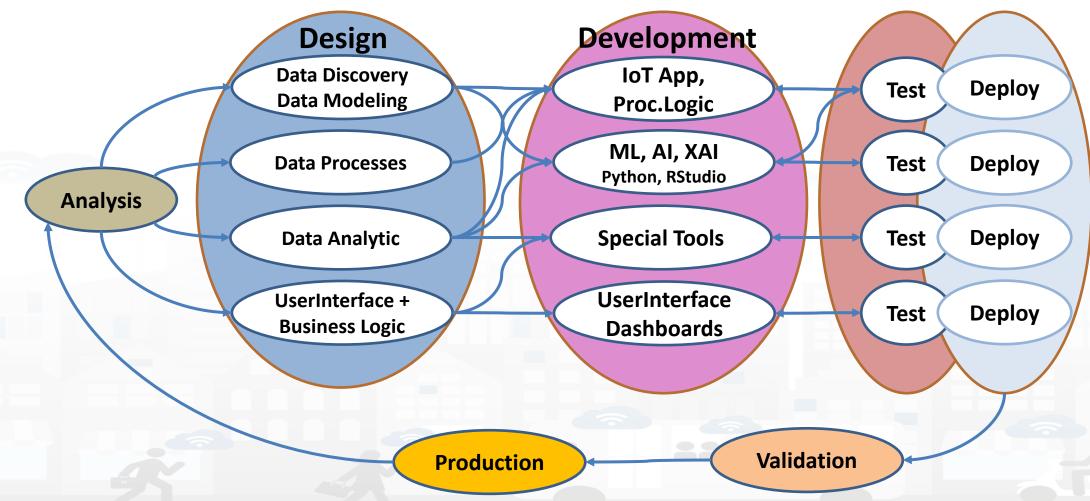


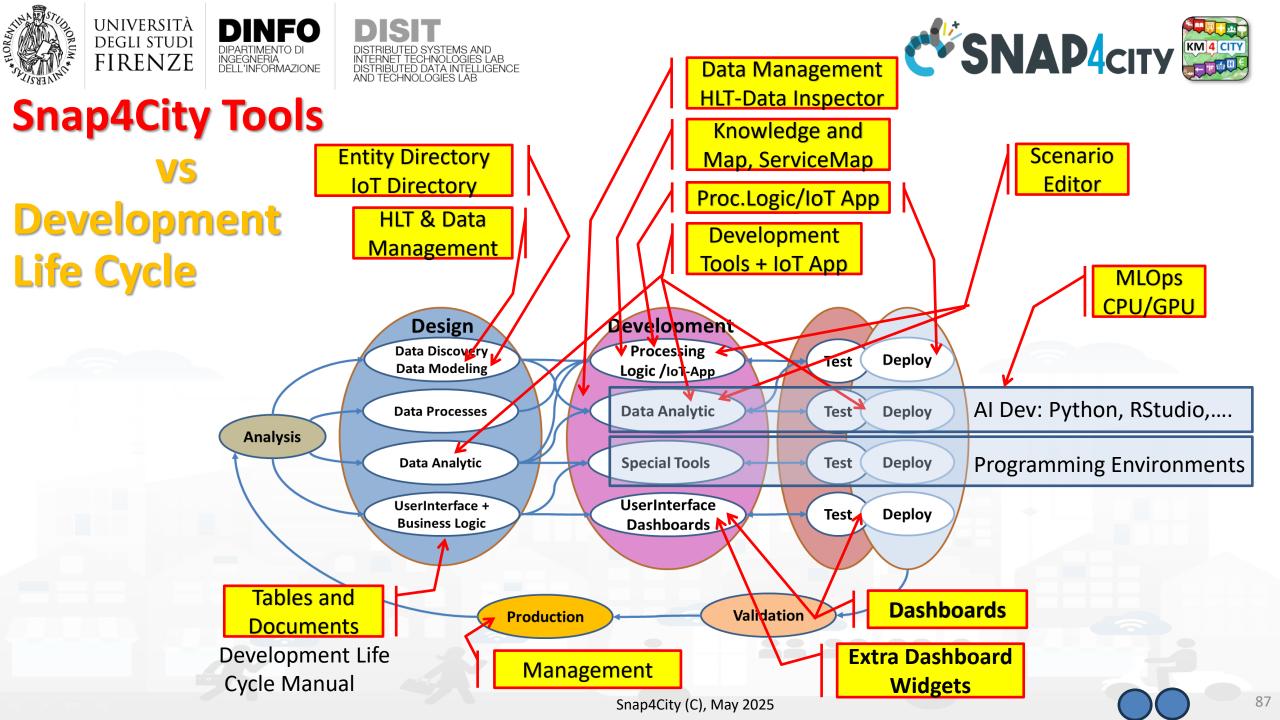






# **Development Life Cycle Smart Solutions**













# Snap4City strongly reduces the effort/costs for

- Learn Visualization Tools or Libraries: 5-15% → 10%
  - Visual tools, visual programming, training course, dev. Manuals, etc.
- Software Licenses: 5-15% → 0%
  - Development environment fully open source
- **Development Time**: 20-30% → **5%** 
  - Dashboard builder, synoptics, widget exchange, dashboard exchange, clone, delegations, etc.
  - Reused cloned and shared solutions, artefacts
- Customization and Interactivity: 10-20% → 10%
  - Dashboards with Business Logic: CSBL, Node-red SSBL
  - Direct development of Business Intelligence without coding all details
- Design for Security/privacy: 5-10% → only respect the guidelines
  - Snap4City is end-to-end secure and GDPR compliant, all is already in place
- Design for Scalability: 5-15% → only respect the guidelines
  - Snap4City is scalable from Back-End to Front-End, all is already in place
- Reduction of: 45% for development effort of smart city solutions









## **Snap4City on Data Collection and PreProcess**

- Effort reduction from 25-35% to 10-15%, >55% reduction of effort for
  - Data Collection via
    - Direct collection access with Brokers, harvesting of external brokers and data models
    - Usage of library of data models, more than 1700 models: saving analysis
      - Custom data models, massive automated construction of entities
    - Automated enrichment of Km4City Ontology and knowledge base: saving time analysis
    - IoT App / Node-red development of data collection processes: fast development

## Data PreProcess via

- Node-red visual programming (node.js) for preprocessing, transcoding, thousands of microservices and libraries, reuse of blocks and data flows, etc.
- Semantic recovering of data relationships via semantic graph DB with Km4City models
- Eventually usage of Python or R-studio or others when needed
- Reuse and share of Node-RED solutions, large number of cases









### Part 2: Dashboard production and management

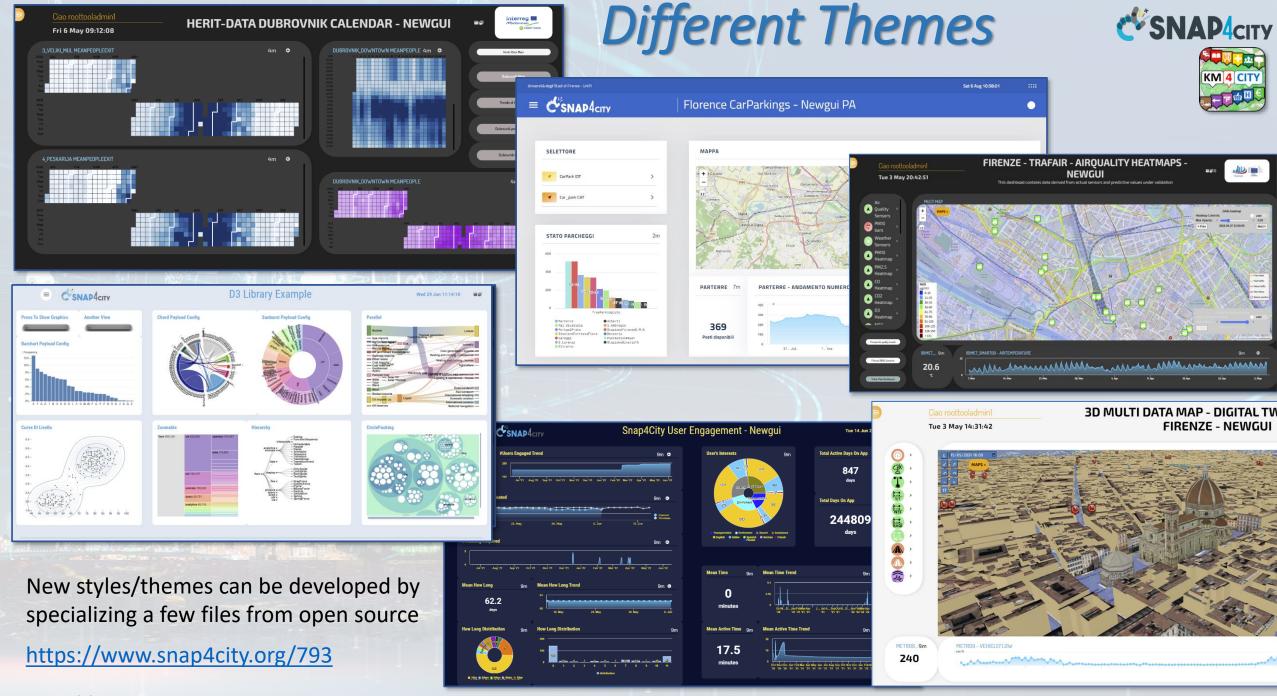
Part 2: Dashboards production and management

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



Snap4City (C), May 2025









### **Visual Representations**





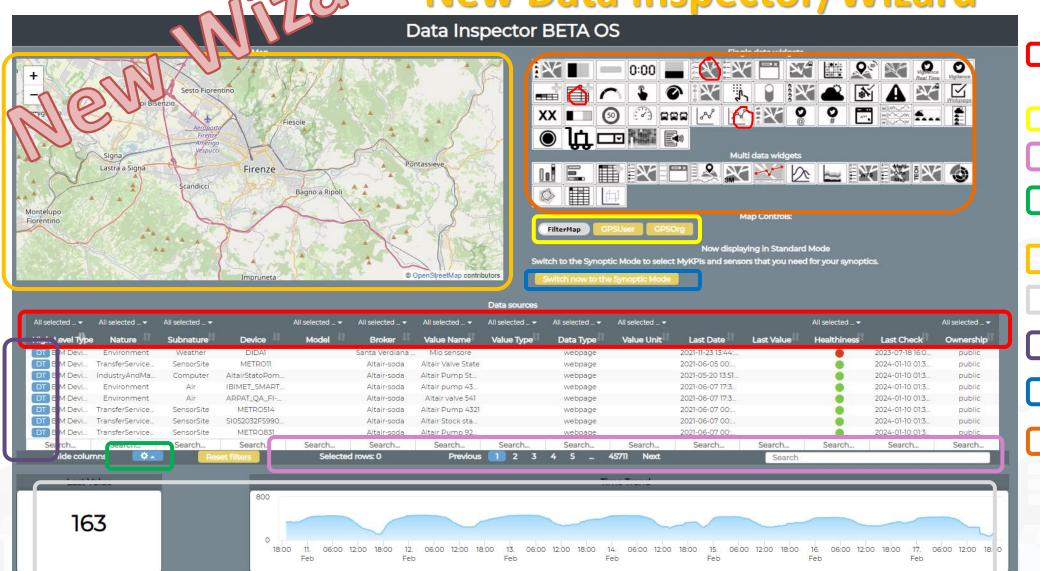
INGEGNERIA DELL'INFORMAZIONE







lew Data Inspector/Wizard



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





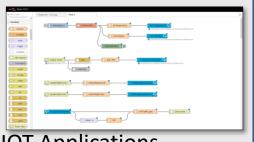
### Part 3





Custom Widget Development
Inkscape editor on your computer SVG

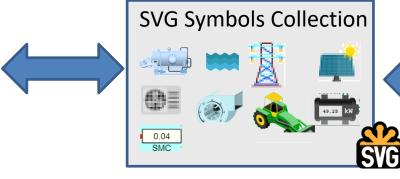


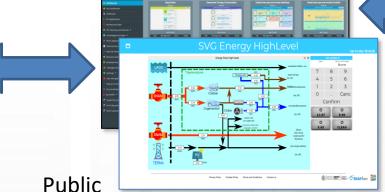


**IOT Applications** 



Knowledge and Storage Data from the Field and City





Dashboard Collection

My Own Dash/App



Create, save a Custom Widget in SVG



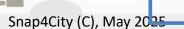
Create, save, load, delegate, grant access

- Create and Load a Custom SVG
- Select/Reuse an SVG

**Dashboard Editor** 

- Make and Instance of Synoptic by Associate Variables with MyKPI
- 4. Create on Dashboard a Widget based on Synoptic HLT such as Ext. Srv.:
  - https://www.snap4city.org/synoptic/v 2/synoptic.html?id=xxxx







DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB



#### Smart parking

- Smart Energy
- Smart Light
- Smart ....

Begin

Finish

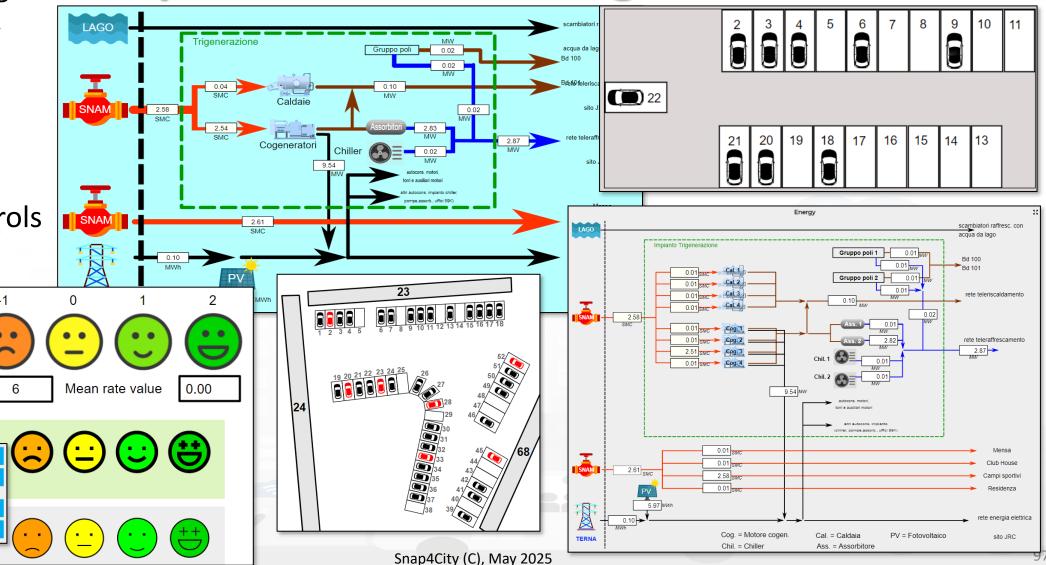
- Energy View
- Custom Controls

Total clicks

17:00

4:00

### **Special Custom Widgets**











### 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

Part 3: IOT App, Process Logic, Server Side Business Logic



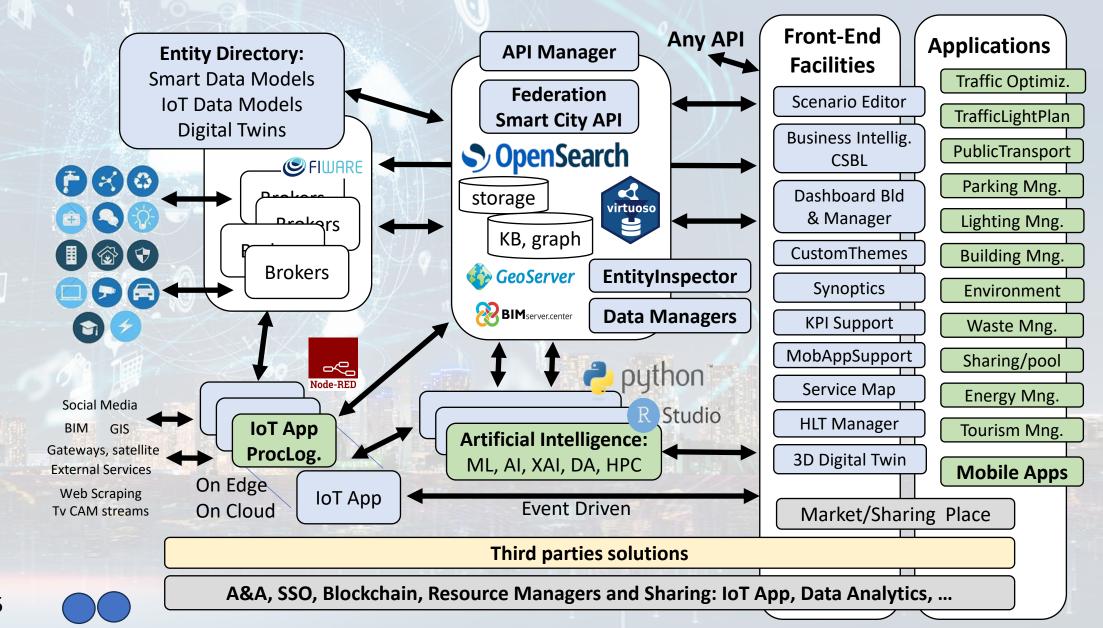
Interactive Slides

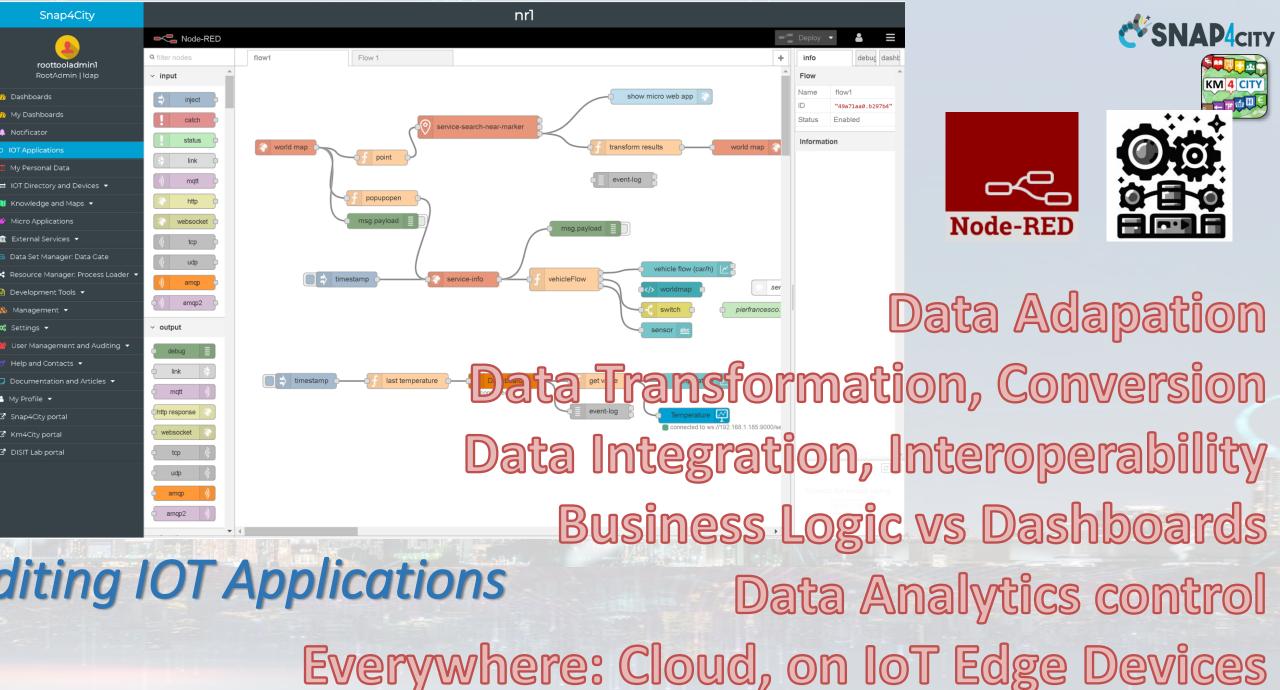


#### **Technical Architecture**









Snap4City (C), May 2025 100









#### > 60.000 downloads (up to 2024)

**Areas** 

Open Data CKAN Ticket Management, workflow **BIM Servers Social Networks** Video Management system Gateways

**Data Analytics** Statistic, Optimization Simulation Artificial Intelligence What-if Analysis Support Geo Utilities Support **Routing & Traffic Flow** MLOps support Python support R Studio Support

Entities Managemenx Visualitation service **Snap4City** Microservices *M<sub>ana</sub>g*ement P/atform Analytic Services Proc.Logic **SSBL** Third Party microservices

Data Load / Search / Retrieval KPI, POI, GIS Data, Scenarios Time Series, Public transport High Level Types: heatmaps, ODM,... IoT / Entity Discovery **Delegation Management Data Mapping** 

> **Dashboards** Widgets: Graphic Libraries **Interactive Widgets** Maps, 3D representations Synoptics, External Content Micro Web App

IoTApp Management Data Logs, A&A, Security Ownership Management **VPN** remote access







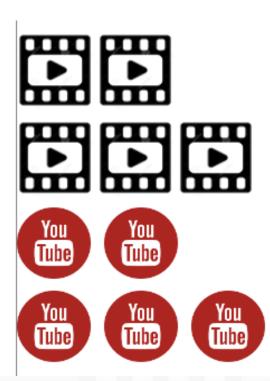


### Part 5: Data Ingestion and Interoperability

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

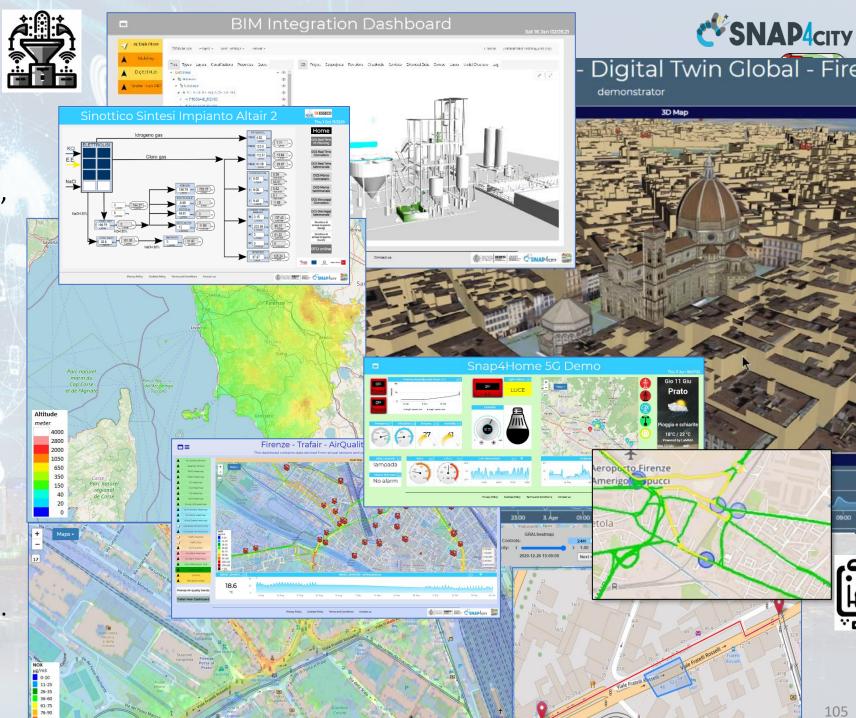
### High Level Types

Snap4City (C), May 2025

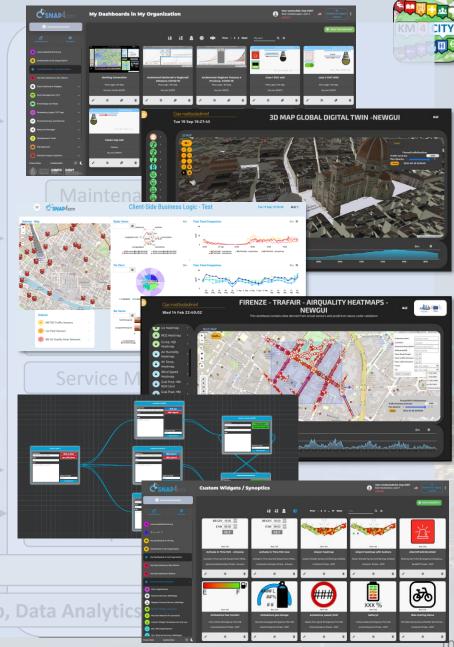
- POI, IOT Devices, shapes,...
  - FIWARE Smart Data Models,
  - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ..
- Satellite data, any kind...
- traffic flow, typical trends, ...
- Vector fields + heatmaps, ...
- trajectories, events, workflow, ...
- 3D Models, BIM,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

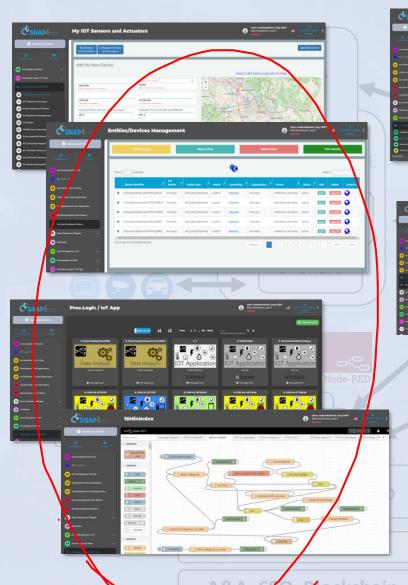




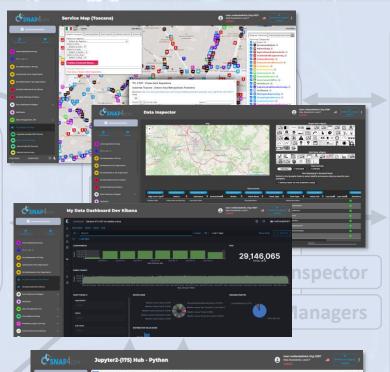


### **Visual Development Tools**





2024/8



Jupyter2-(175) Hub - Python

The second state of the second state

Third parties solutions

&A, STO, Mockchain, Resource Managers and Sharing: IoT App, Data Analytics

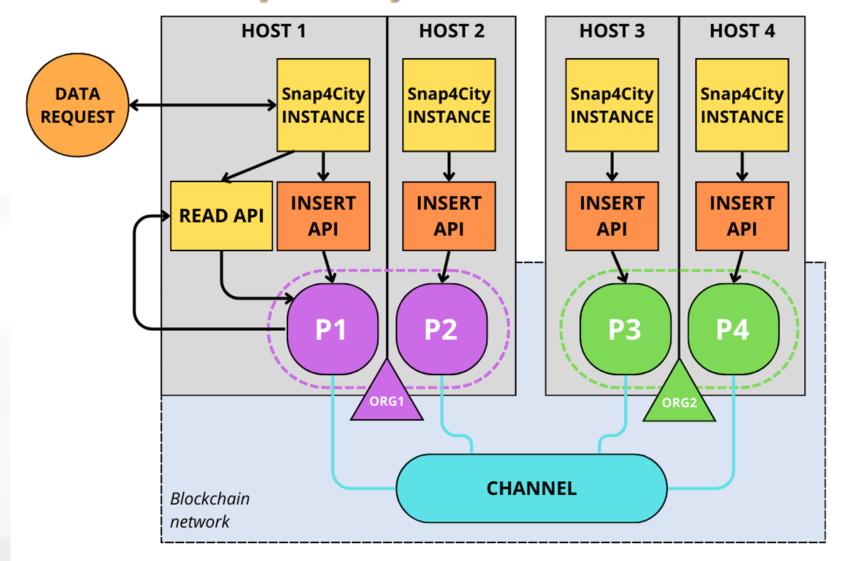








### **Snap4City with Blockchain**











### **Part 4: Data Analytics**

- - 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, Al
  - 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 sniffina
  - 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



SLIDES

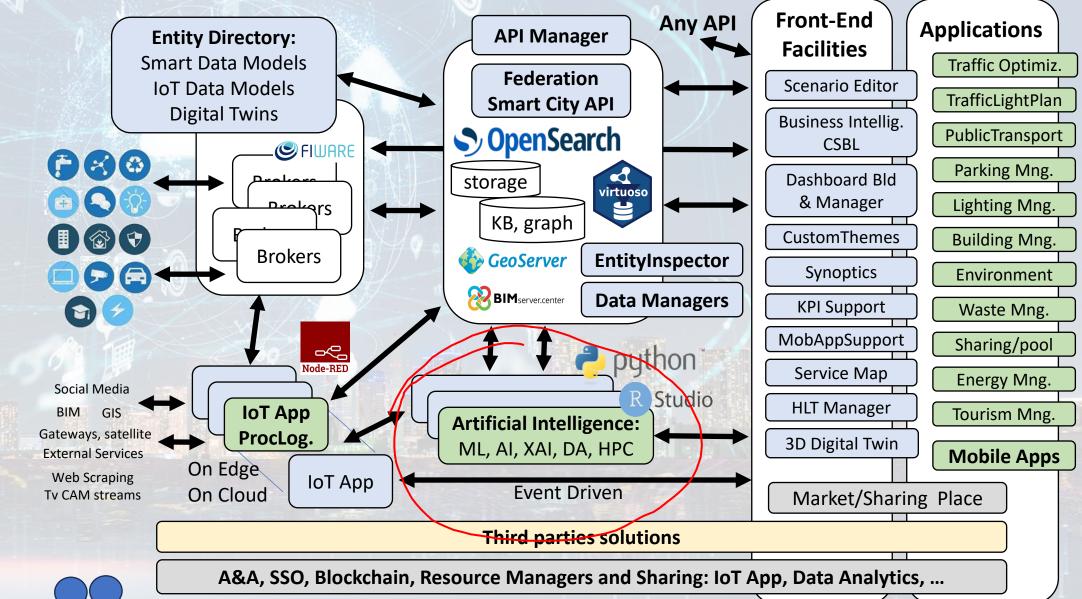
Interactive Slides



#### **Technical Architecture**













#### Artificial Intelligence usually also includes

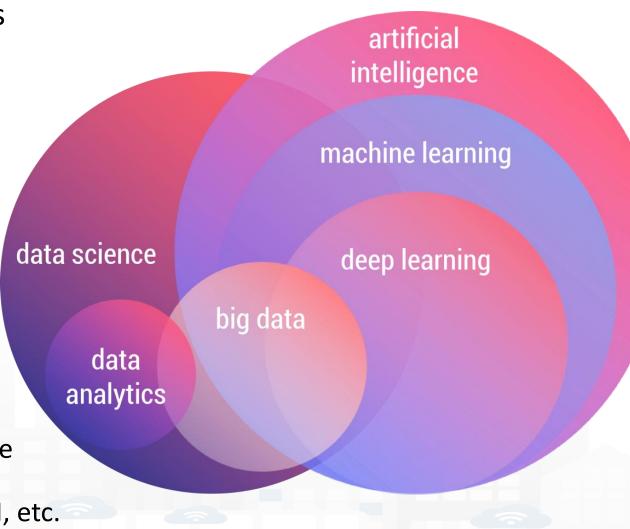
- Code, learning and reasoning
- Semantic computing, Knowledge Bases
- Neuro-symbolic reasoning
- Decision Support Systems
- Problem solving

#### Machine Learning usually includes

- Learn without coding
- Predictions, decisions (classifications)
- Supervised or not
- NLP, vision, pattern recognition

#### Deep Learning usually includes

- Capability to learn complex patterns on huge amount of data
- Generative AI, continous learning, graph NN, etc.
- Specialized ML solutions



### Data Analytics on Snap4City platform



Studio











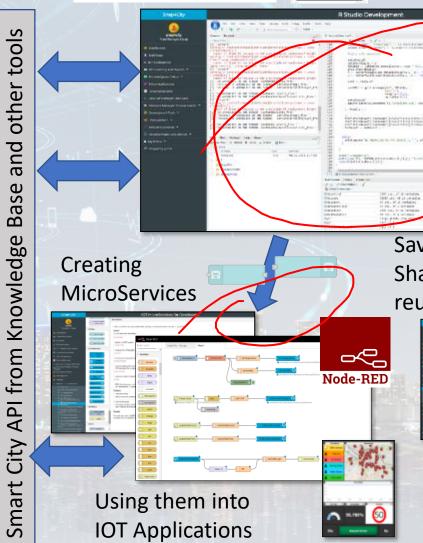


**Ontology Schema** 

LOG.disit.org



Big Data Store Facility



TensorFlow

OUDA.

Saving / Sharing reusing



Resource Manager



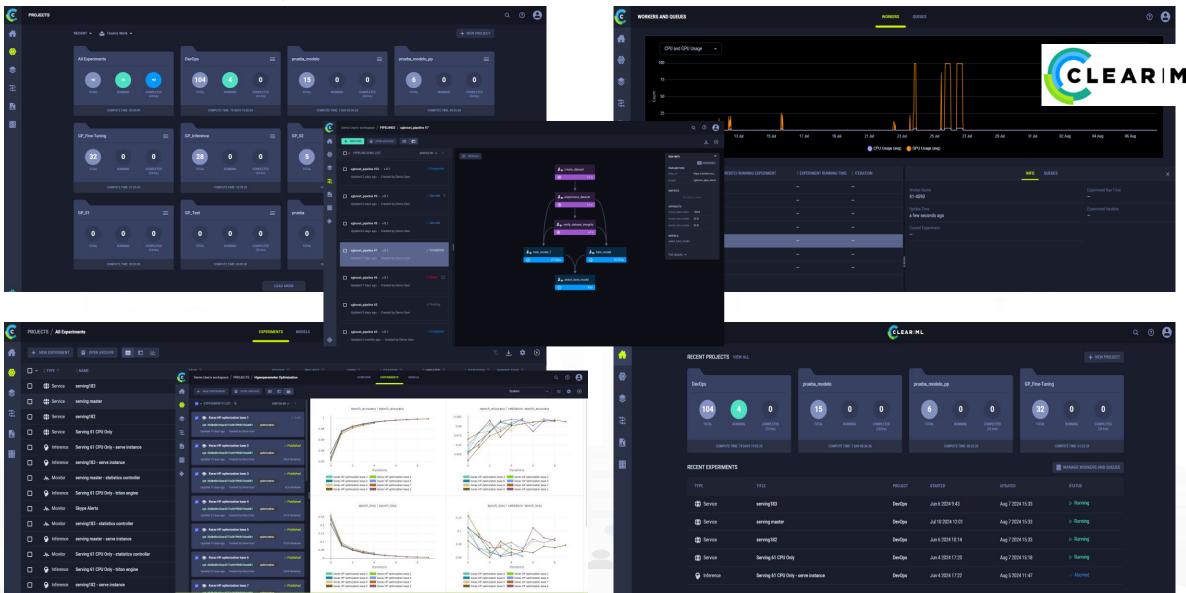




DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB















## MLOperation <a href="https://www.snap4city.org">https://www.snap4city.org</a>

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.or
- https://twitter.com/snap4city
- https://www.facebook.com/span4city

#### Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

DISIT Lab, https://www.disit.org DINFO dept of University of Florence, Via S. Marta 3, 50139, Firenze, Italy Phone: +39-335-5688674

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



INFO













### 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

<u>Interactive Slides</u>









- 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/d ownload/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.snap4citv.org/download/video/Snap4Citv-
- https://www.snap4city.org

- https://www.snap4industrv.org
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city
- https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg

Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

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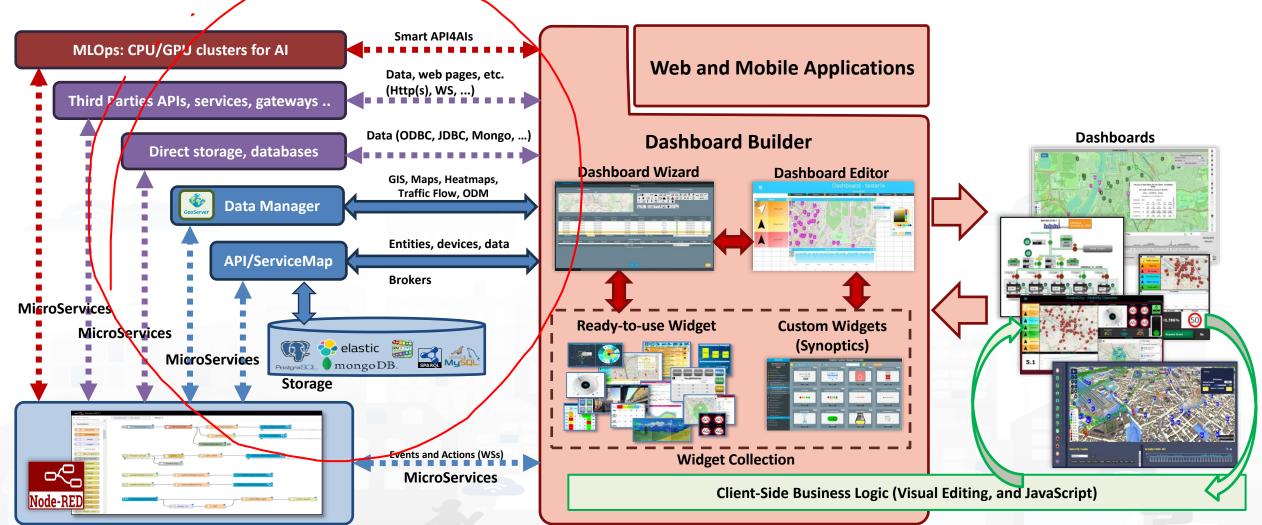








How the Dashboards / Apps Exchange data (2024/8)



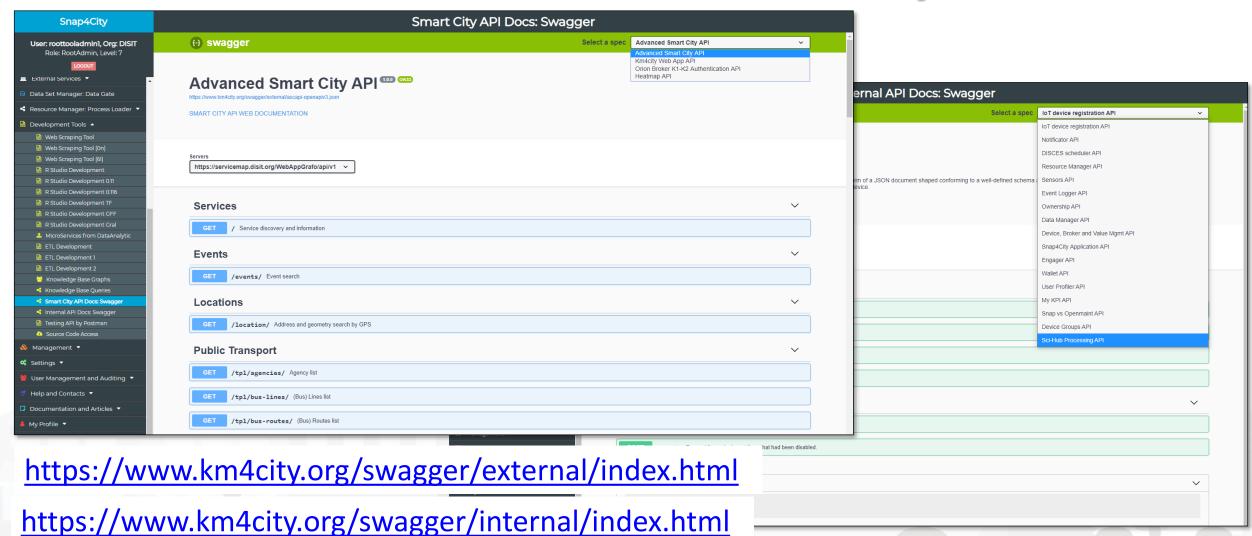


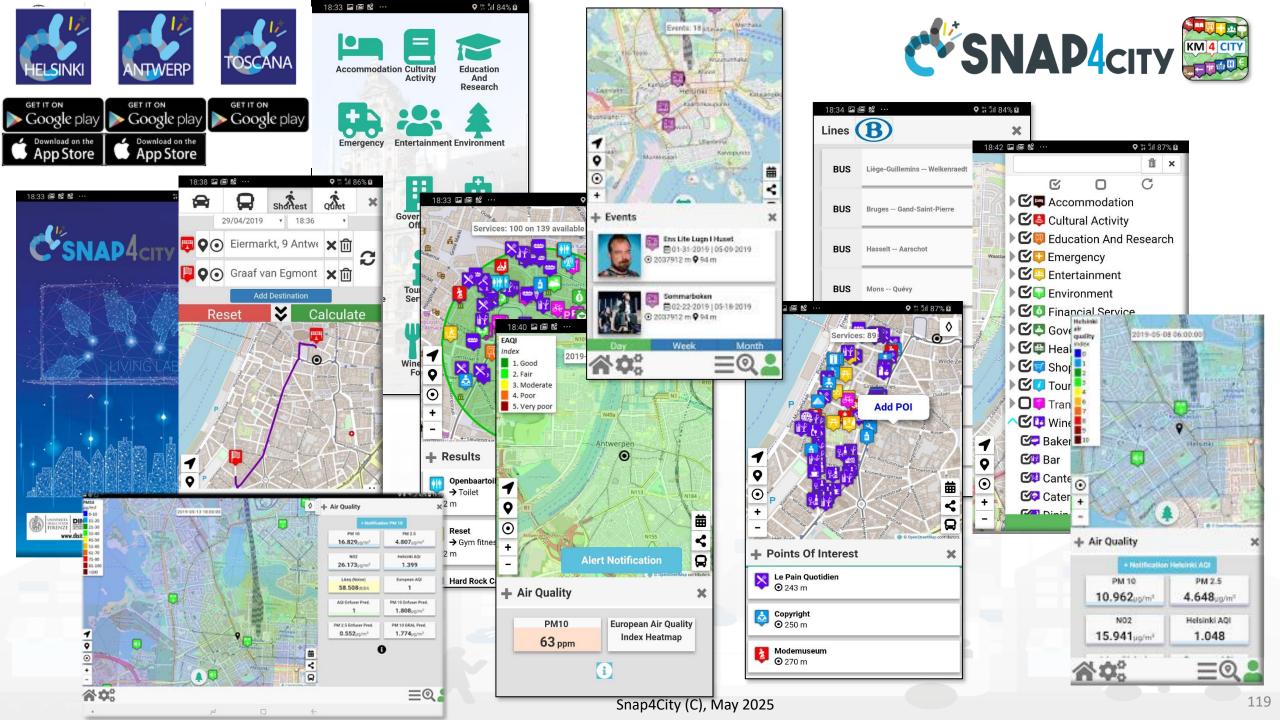






### **Internal and External Smart City API**











### CSBL





### **Client Side Business Logic**











#### **Client-Side Business Logic Widget Manual**

#### From Snap4City:

- We suggest you read <a href="https://www.snap4city.org/download/video/Snap4Tech-">https://www.snap4city.org/download/video/Snap4Tech-</a> Development-Life-Cycle.pdf
- We suggest you read the TECHNICAL OVERVIEW
  - https://www.snap4city.org/download/video/Snap4City-

Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

DISIT Lab, https://www.disit.org DINFO dept of University of Florence, Via S. Marta 3, 50139, Firenze, Italy







https://www.snap4city.org/do wnload/video/ClientSideBusin essLogic-WidgetManual.pdf





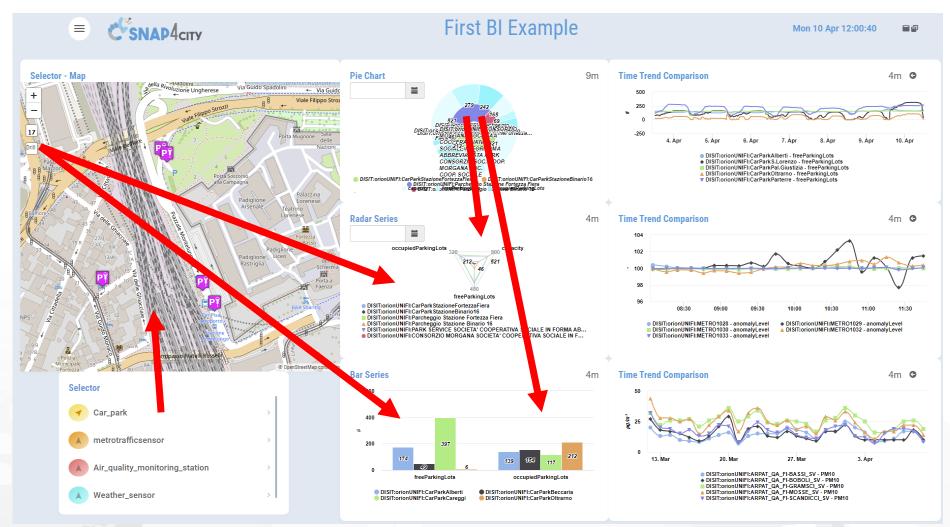






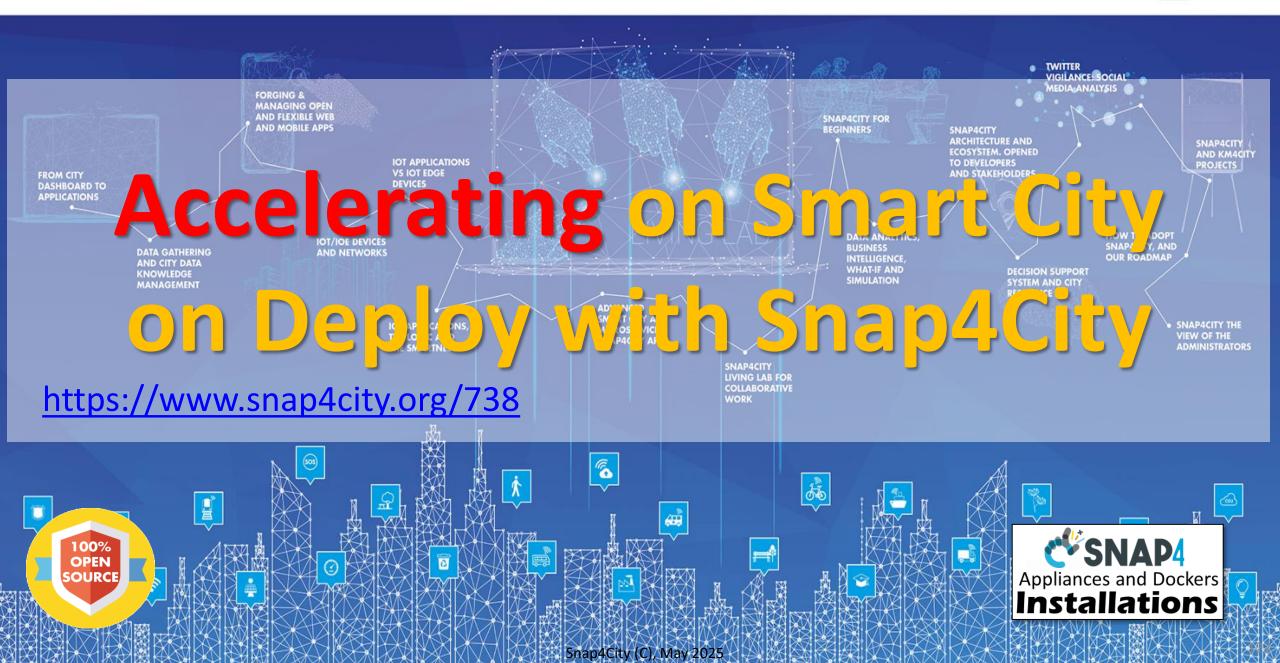
### **Example: From Map to Graphs (spatial drill down)**

- 1) Select the area of interest on map
- 2) Select the sensors kind of interest
- 3) Drill down on map
- 4) The JavaScript
  CSBL on Map will send data to the programmed
  Widgets. In this case, arrowed in RED



#### SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES













#### Part 6: Platform Architecture, interop and Deploy

Part 6: Snap4City Platform Architecture, Interoperability, Management and Deploy

**SLIDES** 

Interactive Slides



- Snap4City Architecture
- Interoperability of Snap4City Platform
- Interoperability with respect to Hardware staff
- Adding Features and Modules to Snap4City
- FIWARE and Snap4City
- Snap4City vs State of the Art Solutions
- Smart City planning with Snap4City Team Support
- The Role of the Living Lab Support
- Snap4City Platform: Administration Overview
- Snap4Tech: Smart Solutions as a Service
- Deploy Snap4Tech solutions: Docker
   Based





















#### **Technical Overview**

 $\textbf{From} \colon \mathsf{DINFO} \ \mathsf{dept} \ \mathsf{of} \ \mathsf{University} \ \mathsf{of} \ \mathsf{Florence}, \ \mathsf{with} \ \mathsf{its}$ 

DISIT Lab, Https://www.disit.org with its Snap4City solution

#### Snap4City:

- Web page: <a href="https://www.snap4city.org"><u>Https://www.snap4city.org</u></a>
- https://twitter.com/snap4city
- https://www.facebook.com/snap4city

#### Contact Person: Paolo Nesi, Paolo.nesi@unifi.it

- o Phone: +39-335-5668674
- o Linkedin: https://www.linkedin.com/in/paolo-nesi-849ba51/
- Twitter: <a href="https://twitter.com/paolonesi">https://twitter.com/paolonesi</a>
- o FaceBook: https://www.facebook.com/paolo.nesi2



### **Tech Overview**

 https://www.snap4city.o rg/drupal/sites/default/f iles/files/Snap4City-PlatformOverview.pdf



### How to adopt Snap4City









#### **Smart City as a Service**

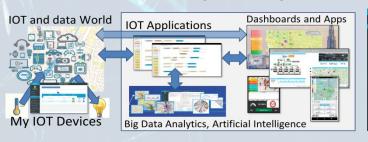
- Supporting Org
- 100% Open Source Platform: Github
- Further developments
- Publishing Appliances and Dockers
- Training courses, docs
- Consulting
- Forums
- Etc.



**Download** 

and deploy

#### On your premise





#### Installation on your premise

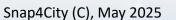


- Different configurations
  - From small to scalable
  - Exploiting your legacy tools
  - Interoperable with any tool
- No vendor lock-in, No tech lock-in

#### 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





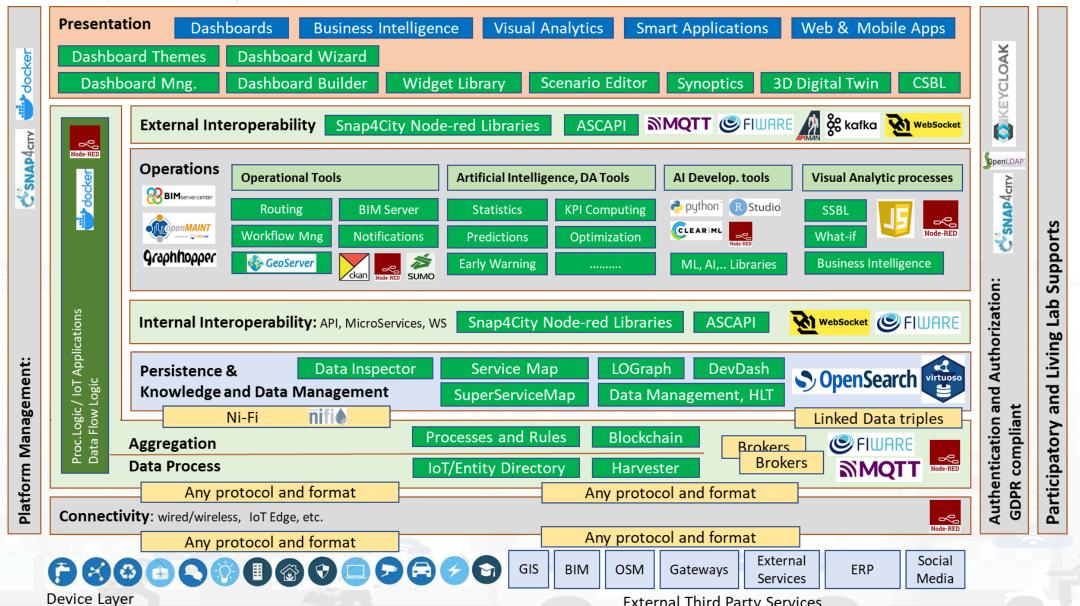












Device Layer External Third Party Services

Snap4City (C), May 2025

# Application on Requested Scenarious









### 1. Complete Fleet Management solution

#### Need to manage:

- Fleet Inventory Data
- **Driver Information**: Personal and professional details of drivers
- **Trip Data**: Historical and real-time information about trips taken by fleet vehicles
- **Telematics Data**: Real-time location tracking, speed, acceleration, braking, engine diagnostics, and other sensor readings from onboard telematics devices
- Maintenance Records: Documentation of scheduled and unscheduled maintenance activities, repairs, and replacements performed on fleet vehicles
- Incident Reports: Information about accidents, near-misses, violations, and other incidents involving fleet vehicles.
- **Customer Feedback**: Input from customers regarding their experience with the fleet, including satisfaction ratings, comments, and suggestions
- By ingesting and analyzing these data types, Snap4City can:
  - deliver actionable insights
  - automate workflows
  - empower fleet managers to make informed decisions
  - Provide Routing, Predictions, Suggestions, Early warning on different aspects exploiting Al
  - Monitor in operation day by day estimating KPIs





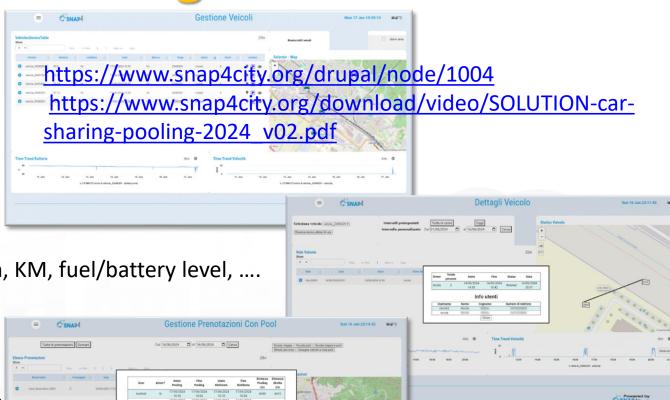




### 1. Complete Fleet Management solution

#### eShare in a Snap features

- Control platform for operators
  - User management and authorization
  - Fleet management
  - Requests management
  - Pool creation via automatic suggestions
- Mobile app for final users
- Monitoring vechicles: gps, status, on/off activation, KM, fuel/battery level, ....
- Business models: sharing, pooling
- Integrated Information
  - Position of vechicles, etc.
  - parking
  - Routing and public transport information and timetable
  - Notifications to the users, to a set of conditions
  - Collection and management of feedbacks
- Etc. etc. other information can be added as well



### 1. Fleet management use case



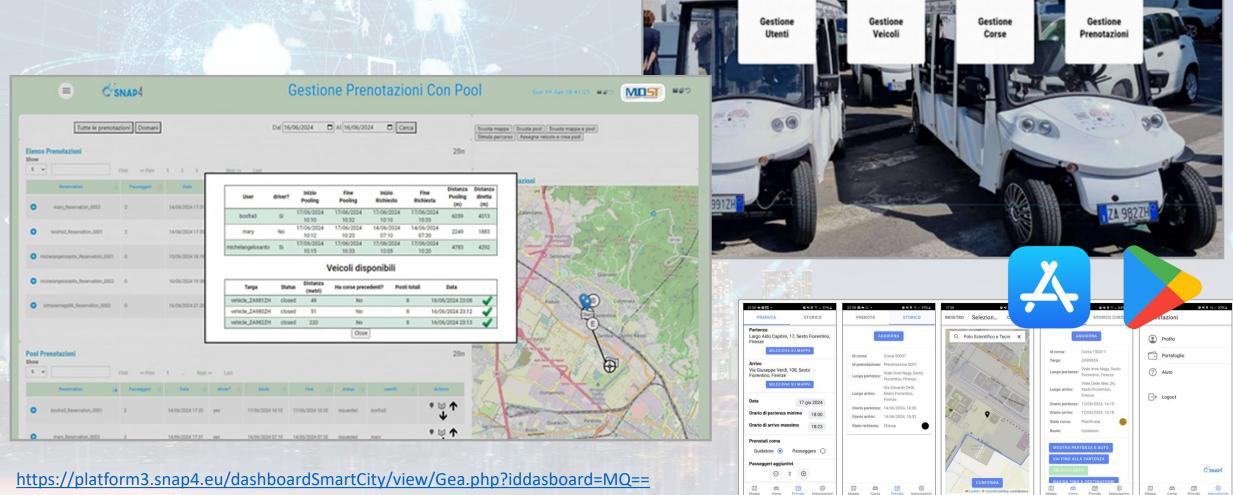
EShare In A Snap



SERVICE OF MOST WE

Mobility and Transport Operation and Plan

CN-MOST: eShare in a Snap

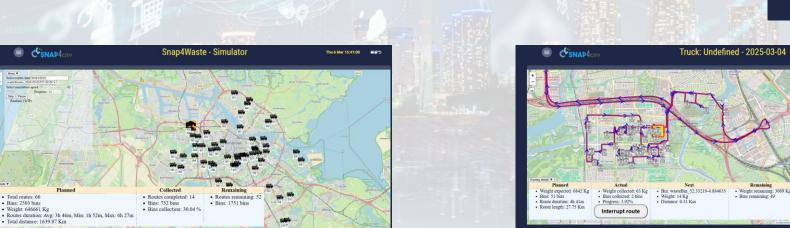


Snap4City (C), March 2025

#### 1. Fleet management use case

Fleet of Truck for Smart Waste use cases

- Routes planner according to different scenarious and parameters
- Truck auto assignment according to truck capabilities
- Guided routing for truck drivers
- Fleet simulator and real time monitoring









Snap4City (C), March 2025











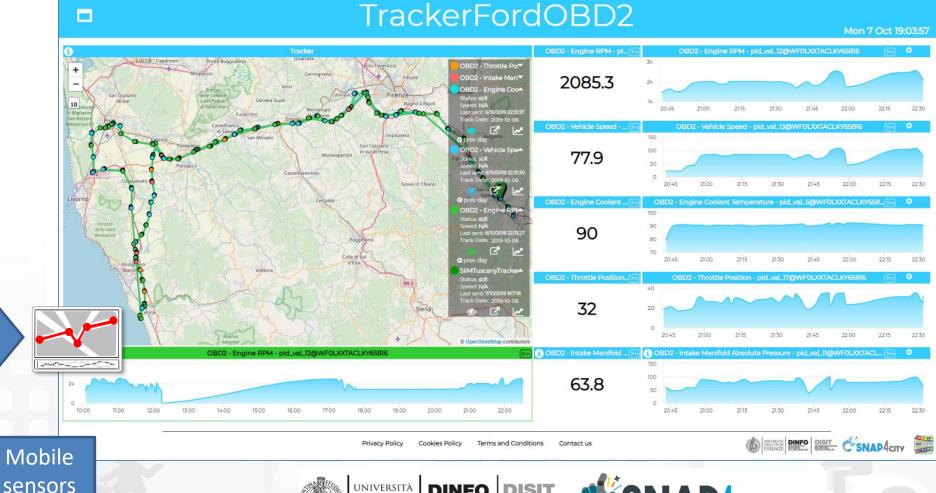
# For Fleet Management SNAP4city

MyKPI: Tracking of Devices and Mobiles
• Real Time Trajectories for

- - Mobile Phone
  - Moving IOT Devices
  - OBU, Vehicular Kits
  - Multiple tracks
  - Day by day

Micro Application













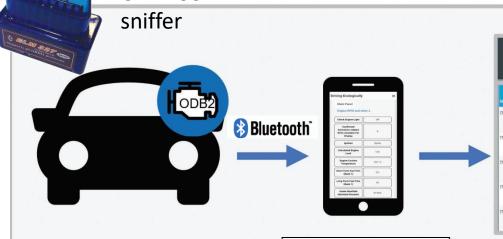
**CANBUS** 







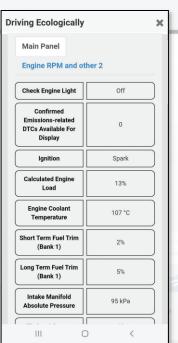
## **IOE – Vehicle Monitoring**

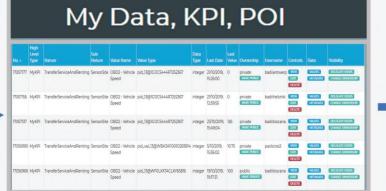


Tuscany in a **Snap Mobile** App on **Android** 

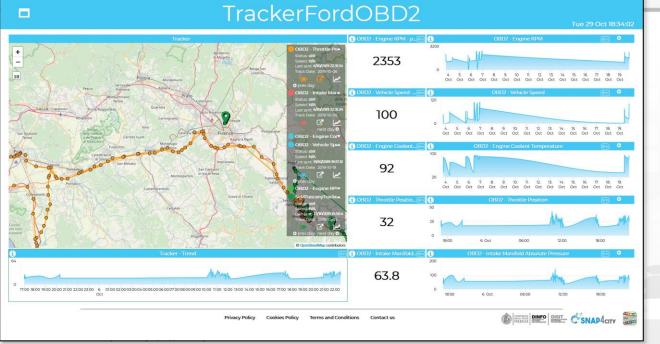










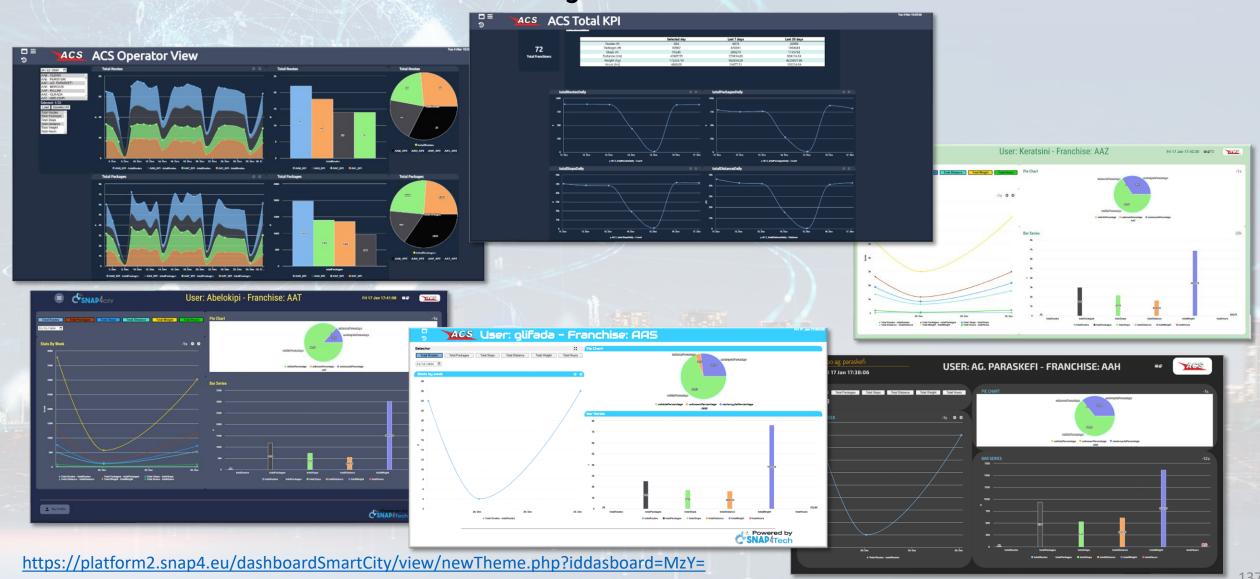


#### 1. Fleet management use case





**ACS: Administrative tool for KPI monitoring** 









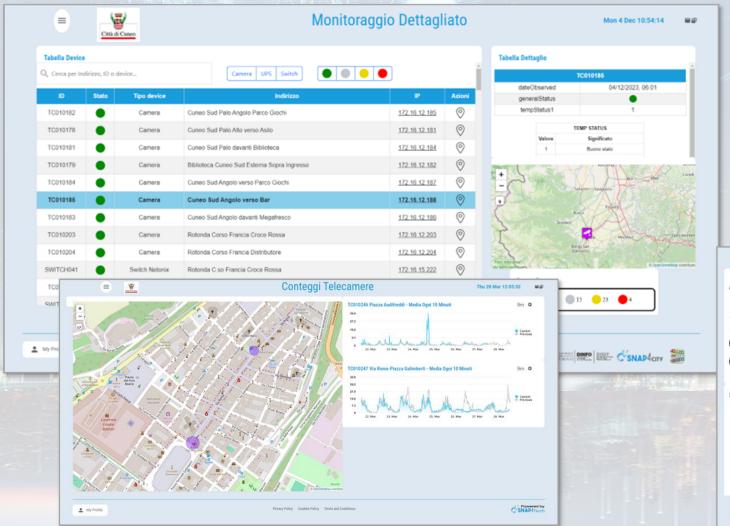


### 2. Connected rooms/cabinets

- Connected rooms/cabinets for:
  - remote monitoring and
  - early alarming from different remote sensors
    - temp, humidity, other.. flooding,
    - water leakage, etc..
  - If do you intend distributors of goods there are specific solutions to which we can interface for:
    - IoT-Based Temperature & Humidity Monitoring
    - Hygiene & Compliance Monitoring
    - Predictive Maintencance and Energy Efficiency
    - •

# 2. Connected rooms/cabinets

ICT Assets Control: CUNEO Municipality

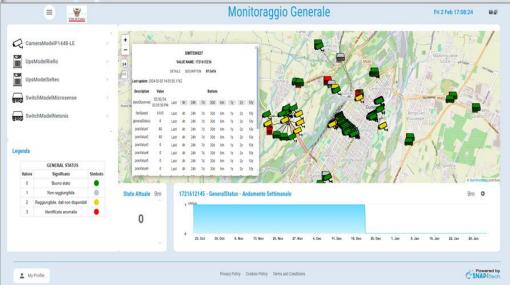






- Cabinets
- Switches
- UPS
- TV Cameras
- Etc. etc.

Manage the status, tickets, notifications



# 2. Connected rooms/cabinets Smart Energy Mng: Capelon (Sweden)

Cabinets On Stockholm By Capelon

SNAP4CITY





- Cabinets (energy consumption)
- Luminaries status



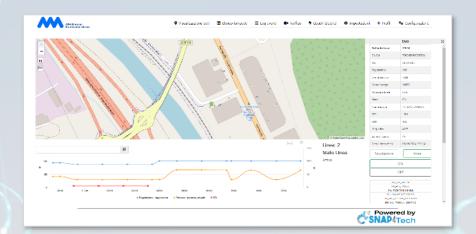
#### 2. Connected rooms/cabinets

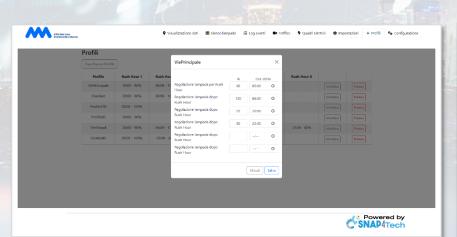
#### **Smart Light Operation and Plan: Merano Municipality**

Stadtwerke Meran ASM Merano



- Monitoring and management of 1009 smart light controllerns
- 70 Cabinets on street: monitoring and controlling
- 50 Traffic sensors
- Luminaries profiles programming and command (unicast and multicast)
- Monitoring and control the service operation
- Monitoraggio e Controllo dello stato del servizio
- Notifications
- In the next:
  - implementation of the TAI (Traffic Adaptive Installation)
  - Mobile app for workers on street







#### 2. Connected rooms/cabinets

# SNAD4

#### Rooms/Buidings

- Digital Twin of the rooms connected with real time data:
  - BIM representation (3D) connected with realt time data
  - Indoor environmental data (CO2, Lux, Temperature, Wall temperature, Humidity, Irradiation, ...)
  - Energy consumption
  - Cooling/Heating consumption ...
- Data center monitoring (with more that 40 different sensors)
  - Accessible from mobile and PC



# European Commission Joint Research Centre



#### ISPRA JRC Security Operation Center (EC)



ISPRA JRC is a military fenced area with more than 300 Building

- Presence monitoring in buildings, floor, areas
- Parking monitoring
- Energy consumption (Heating/Cooling systems)





#### 2. Other real time monitoring for early warning solutions



DINFO DISIT CSNAP4CITY









Gestore Notifiche Laboratorio - GeNotiLab Analisi rodotto V A 19/01/2025 16:43 V98CFEROPOT 19/01/2025 16:23 V98CFEROPOT 19/01/2025 16:23 19/01/2025 16:23 V97CFERIPOT 19/01/2025 16:23 W98CFEROB V97CFERI V97CFERI 19/01/2025 16:23 19/01/2025 16:21 KCLDECANTATOR KCLVASCA 250119KCLVASCA 19/01/2025 16:21 KCLDECANTATOR

- Any chemical measure from the Quality Lab analysis
- 500 measures per day
- Years of work

Authomatic notification system managing the status, tickets.

#### Notifications to

- Single
- Different Groups of users involved (Production, logistic, security, Management, ...)
- Actionable notifications, mobile decisions



#### 2. Other real time monitoring for early warning solutions



#### **ENEL X: Energy Management**

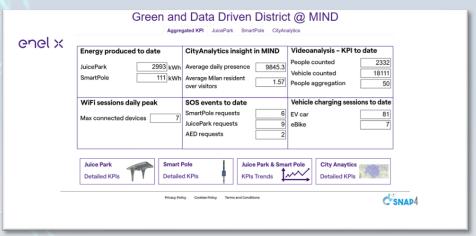
Real time monitoring of energy consumption from:

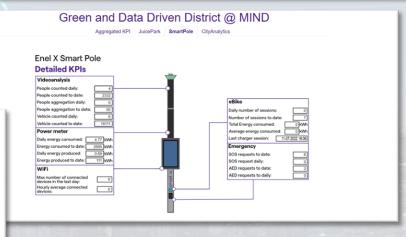
- Recharging stations for cars
- Recharging stations for bikes
- People counting from WiFi
- Video analysis for car and people counting
- SOS/Emergency devices status
- KPIs monitoring



enel x















#### 3. A sensor based solution

- 3. A sensor based solution where the areas that Municipalities
  - Environment: Air quality, any pollutant, any aerosol, etc.
  - Costal erosion, landslide, UV, see conditions, etc.
  - water today (such as grass fields/plots, other plants, etc) to be able to
    - sense enough humidity or rain and
    - stop/delay the automatic watering for a few days.
- Solutions for sensing: Smart gardening
  - Thousands of sensors from Libelium to Amazon, to full solutions which can be exploited and integrated on Snap4City tech
    - Smart Irrigation Systems for Water Efficiency
    - Al-Powered Plant Health Monitoring
    - Al for strategic garden planning
    - ...

### 3. Sensor based solutions in Snap4city

SNAD4

#### Rooms/Buidings

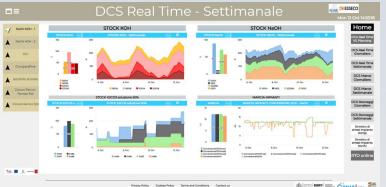
- Digital Twin of the rooms connected with real time data:
  - BIM representation (3D) connected with real time data
  - Indoor environmental data (CO2, Lux, Temperature, Wall temperature, Humidity, Irradiation, ...)
  - Energy consumption
  - Cooling/Heating consumption ...
- Data center monitoring (with more that 40 different sensors)
  - Accessible from mobile and PC

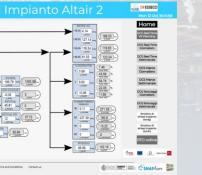


#### 3. Sensor based solutions in Snap4city

- Ingestion of:
  - Production lines monitoring (more than 300 different variables via OPC-UA)
  - Administrtive Data from AS400
  - Cost of energy (from National entity)
  - Production capability and storage
- Results: Production Optimization and predictions
- Predictive Maintenance
- Environment monitoring via drones for contamination detections (leaks of dangerous fluids)
- Synoptics

















### 4. Energy companies want early warnings

- 4. Energy companies want early warnings from their customers (households, companies) with
  - tanks with petrol for central heating.
    - to be proactive and when the tank level is below a threshold to get on their dashboards notifications so that they inform their customers and proactively to propose a new tank fill.
- Solutions for sensing:
  - https://www.madisonco.com/fuels-oils
  - https://www.holykell.com/products/Fuel Level Sensor With Submersible T ype For Fuel Tank In Model HPT604-LT.html
  - https://www.centretank.com/products/types/fuel-tank-gauges/heating-oiltank-gauges





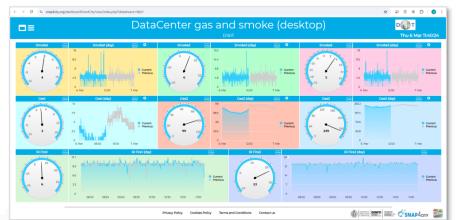


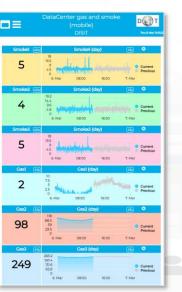


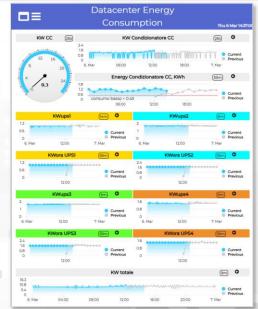
### 4. Energy companies want early warnings

Fuel Tank Monitoring and Control with Snap4City

- 1. Integration of IoT Devices for accurate monitoring (Leaks, theft, inefficiency)
  - Level Sensors: Real-time fuel quantity measurement
  - Temperature Gauges: Ensuring safe storage temperatures
- 2. Data Collection and Analysis
- 3. Al powered solutions in Snap4City:
  - Advanced analytics for trend identification and forecasting
  - Predictive Maintenance and Demand Forecasting
  - Preventative alerts for maintenance needs
  - Optimizing refueling schedules based on usage patterns
  - Security and Alerts
    - Anomaly detection for immediate response
    - Secure notifications for unauthorized access attempts
- Enhanced operational efficiency
- Improved safety and reduced environmental impact











#### ISPRA JRC Security Operation Center (EC)



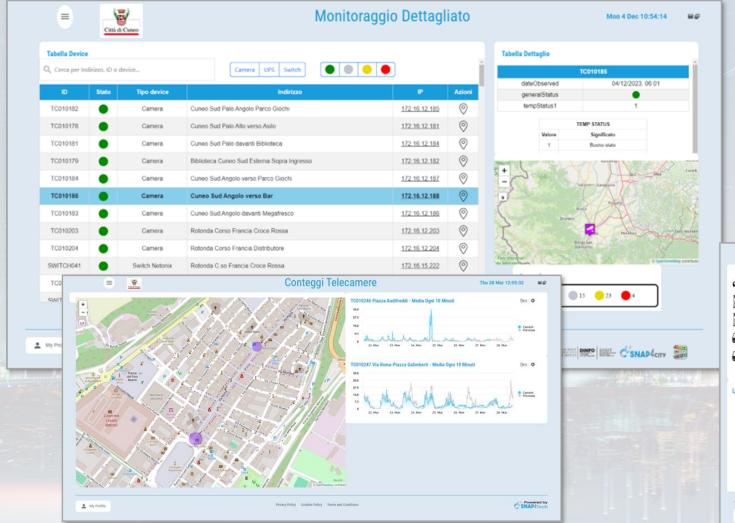
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- Parking
- Energy consumption (Heating/Cooling systems)





ICT Assets Control: CUNEO Municipality

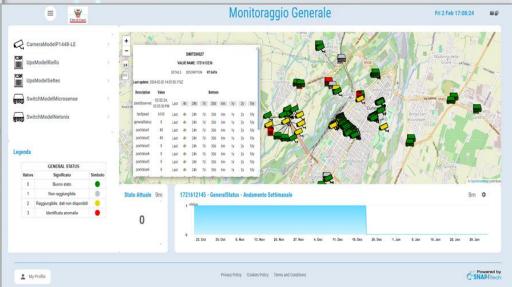






- Cabinets
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- TV Cameras
- Etc. etc.

Manage the status, tickets, notifications



Smart Energy Mng: Capelon (Sweden)



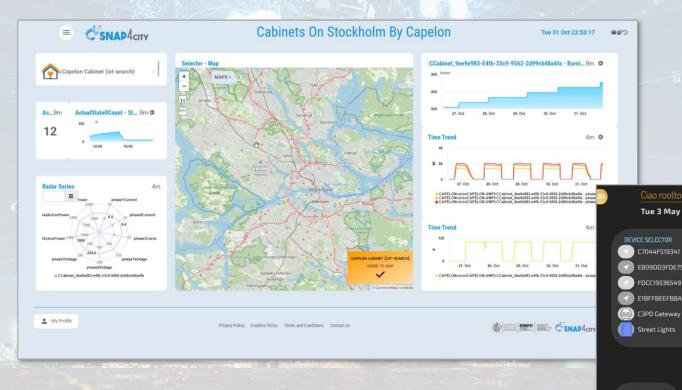


Cabinets

5.1 °C

Luminaries status

Manage the status, notifications



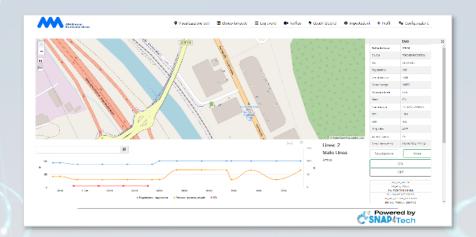


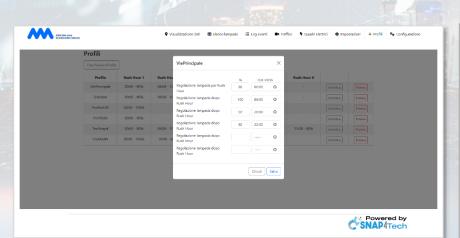
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- Notifications
- In the next:
  - implementation of the TAI (Traffic Adaptive Installation)
  - Mobile app for workers on street















#### 5. Gas bottles monitoring

- 5. The same as 4 but with Gas bottles installed by energy companies in restaurants, in hotels, etc.
  - want early warnings from their customers (households, companies) with
  - Gas bottles
    - to be proactive and when they are below a threshold to get on their dashboards notifications so that they inform their customers and proactively to propose a new tank fill.
- Solutions for sensing, non invasive via sonar:
  - https://www.thincke.com/product/gas-cylinder-level-sensor/
  - <a href="https://pulsasensors.com/">https://pulsasensors.com/</a>
  - https://mopeka.com/



Details





**FREE** TRIAL



















**EXPERT SYSTEM, KNOWLEDGE BASE** 

**SEMANTIC REASONING** 

**SMART DATA MODEL** 

**IOT DEVICE MODELS, STORAGE** 

#### **Digital Twin Solutions for Sustainability**

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









DEVELOMENT ENVIRONMENT

VISUAL PROGRAMMING, ML, AI, HPC

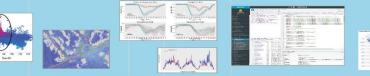
**AND METHODOLOGY** 

TRAINING COURSES

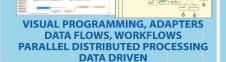
• LIVING LABS







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













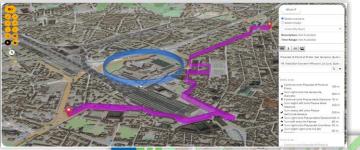
### **Mobility & Transport**

#### 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.

















## Mobility and Transport Domain (2024/8)

- Goals:
  - Decongestion
  - Decarbonization
  - Accessibility to services
  - Security/Safety of city users
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring traffic, parking, people flow, services, boats, ports, beaches, etc.
  - Early detection/warning of critical conditions: traffic, congestion, security/safety
  - Managing Smart Parking, transportation services, fines, etc.
  - Managing fleets: personal, sharing, waste collection, maintenance, etc.
  - Managing E-sharing, pooling services, MaaS, etc.
  - Managing entrances in city areas: restricted areas, touristic busses, etc.
  - Production of suggestions, recommendations, nudging
  - Computing predictions of any kind
- Solutions for Planning (optimization and what-if analysis)
  - Reduction of traffic congestion, via optimization: traffic light plans, viability, routing
  - Reduction of Pollutant Emissions, via optimization: traffic light plans, viability
  - Optimization of transportation offers wrt multimodal mobility demand
- Algorithms and computational solutions, see next slide













- Tools for Mobility and Transport (2024/8)
- Optimisation of viability of an area for reducing congestion, waiting time, stops
- Optimisation of Traffic Light Plans, synchronization, in an area for reducing congestion, waiting time, stops
- Predictions for: traffic flow, smart parking, smart bike sharing, people flows, etc. (ML, DL)
- What if analysis: routing, traffic flow, demand vs offer, pollutant, etc. (Simulation + ML)
- **Traffic flow reconstruction** from sensors and other sources (simulation + ML)
- Public Transportation: Ingestion and modelling of GTFS, Transmodel, NeTEx, etc. (DP)
  - Analysis of the demand mobility vs offer transport of according to public transportation and multiple data sources (Simulation)
  - Assessing quality of public transportation (analysis)
- Accidents heatmaps, anomaly detection (analysis, ML)
- Road light controlled by traffic conditions
- Tracking fleets, people, via devices: OBU, OBD2, mobile apps, etc. (DP)
- Routing and multimodal routing (multistop travel planning), constrained routing, dynamic routing (DA)
- Computing Origin Destination Matrices from different kind of data (analysis, DP, DP)
- Computing typical trajectories on the basis of tracks (analysis, ML)
- Fleet management, monitoring, booking, allocation, maintenance
- Computing Messages for Connected drive (DP)
- Slow and Fast Mobility 15 Minute City Indexes (analysis, DP, ...ML)
- Computing and comparing traffic flow on devices and at the city border (analysis)
- Typical time trends for traffic flow and IoT Time series. (analysis, ML)
- Impact of COVID-19 on mobility and transport
- Computing SUMI, PUMS, etc. (mainly DP)
- Definition of Scenarios: traffic, road graph, conditions, etc.
- Etc.









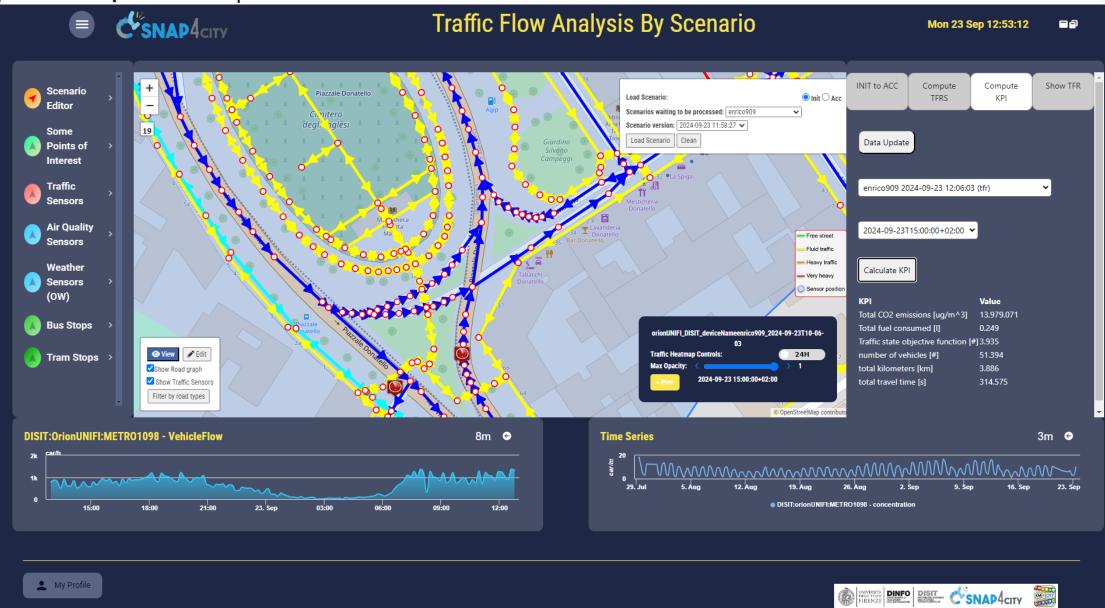
#### università degli studi FIRENZE

DINFO
DIPARTIMENTO DI
INGEGNERIA
DELL'INFORMAZIONE

DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

#### What-if on TFR







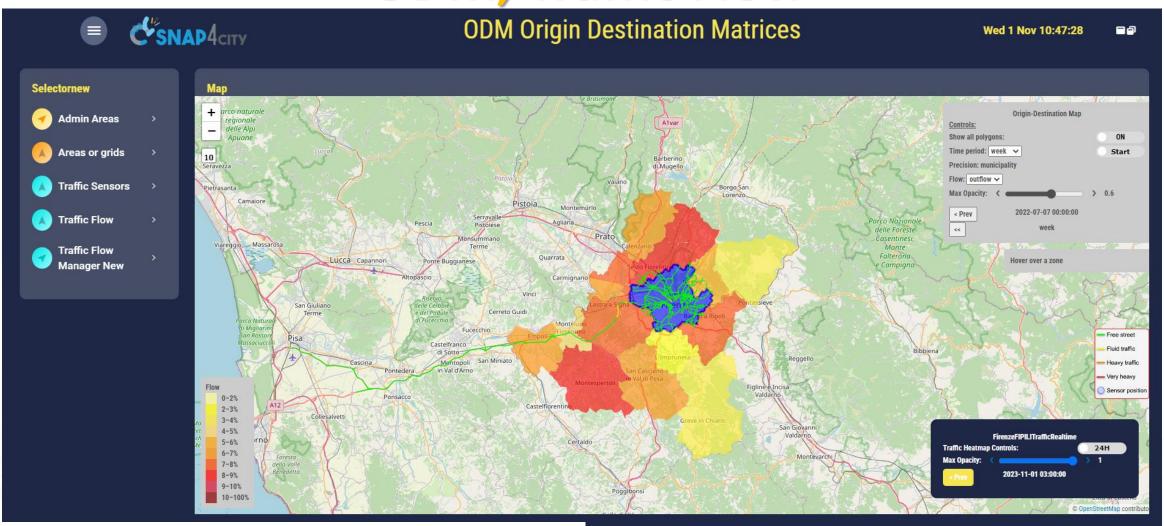








#### **ODM, Traffic Flow**



https://www.snap4city.org/dashboardSmartCity/view/Gea-Night.php?iddasboard=Mzk3Nw==

















# **Traffic Flow Tools**

Spire and Virtual Spires (cameras), Bluetooth, ...
Specifically located: along, around, on gates, on x...



Snap4City (C), May 2025

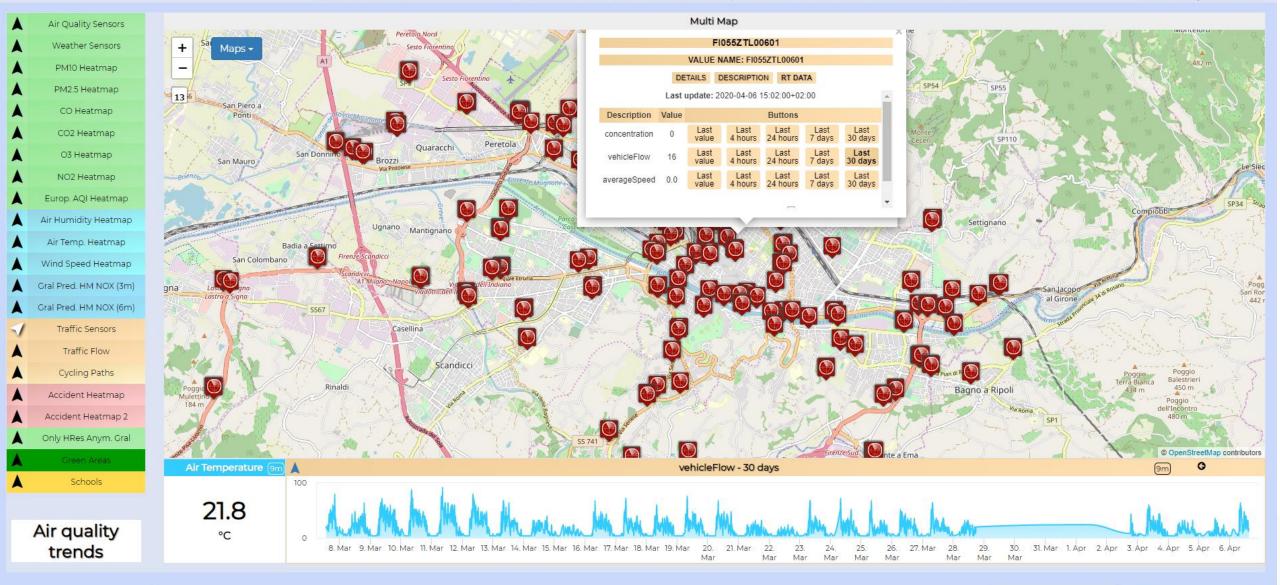


#### Firenze - Trafair - AirQuality Heatmaps

This dashboad contains data derived from actual sensors and predictive values under validation



Mon 6 Apr 15:12:27







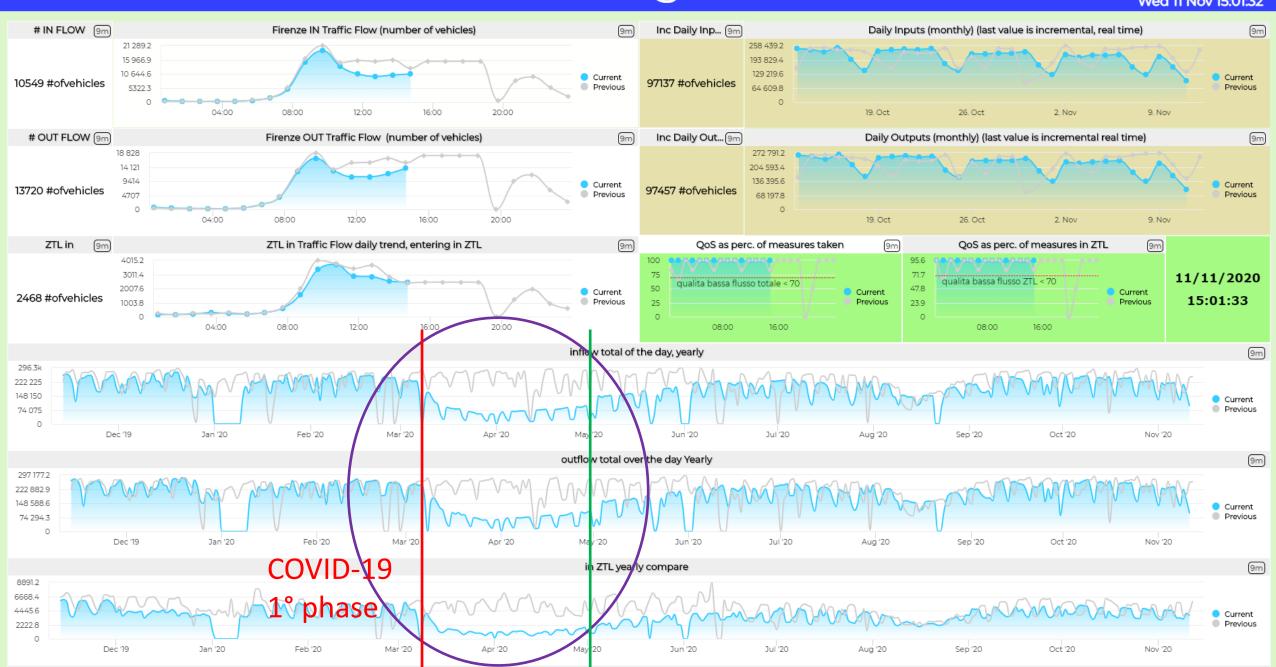






#### Traffic Flow Monitoring - Firenze - Cloned2

Wed 11 Nov 15:01:32



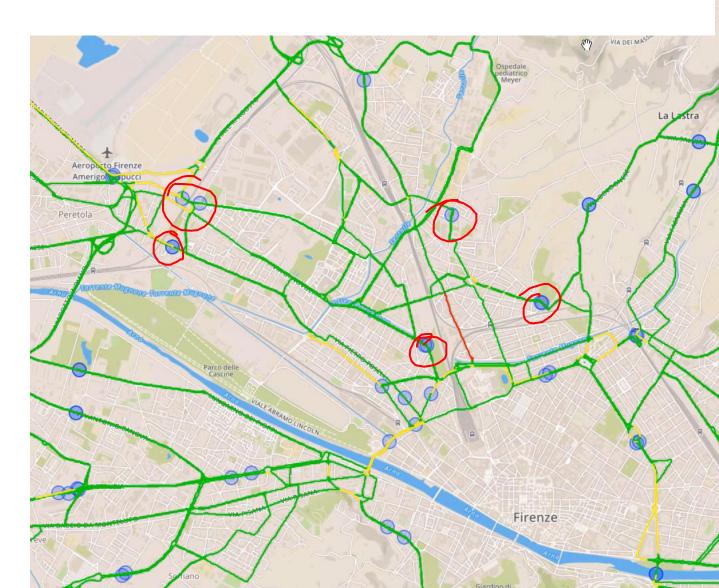






#### **Dense Traffic Flow Reconstruction?**

- Controlling pollution
- Dynamic Routing for Firebrigade, Ambulances, general public
- Planning Public
   Transportation routing





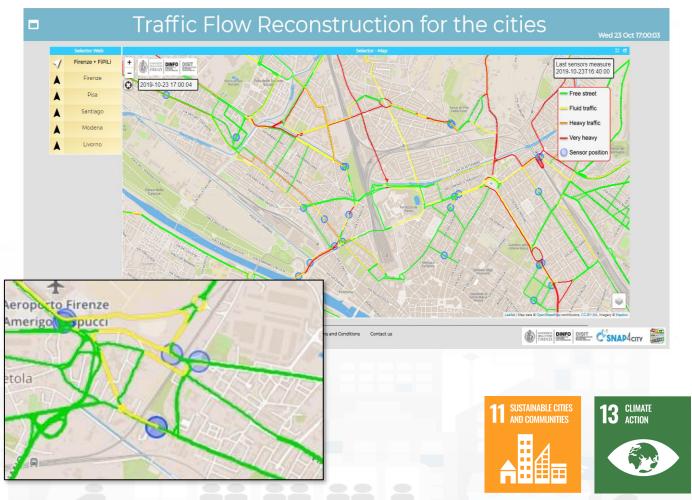






### Why Dense Traffic Flow Reconstruction?

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



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc5NQ==





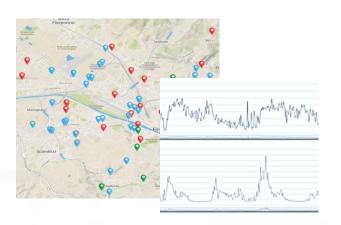


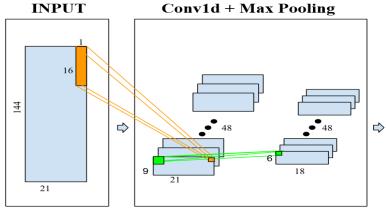


# Short-Term Prediction of City Traffic Flow via Convolutional Deep Learning

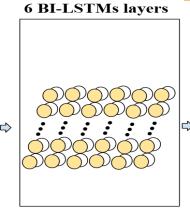


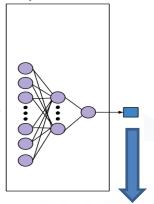






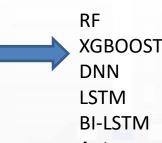
**CONV-BI-LSTM** 



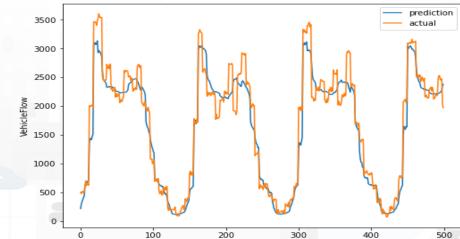


#### Urban data:

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



Autoencoder BI-LSTM
Attention CONV-LSTM
CONV-BI-LSTM







## What-If Analysis SNAP4city



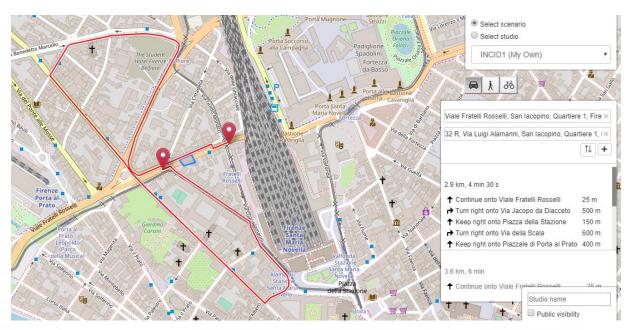


Accidents and elements blocking Points and Shapes taken into account for:

- Routing
- Traffic Flow reconstruction
- Evacuation paths
- Rescue team paths

Assessment on the basis of changes:

- Mobility demand assessment
- Mobility Offer assessment





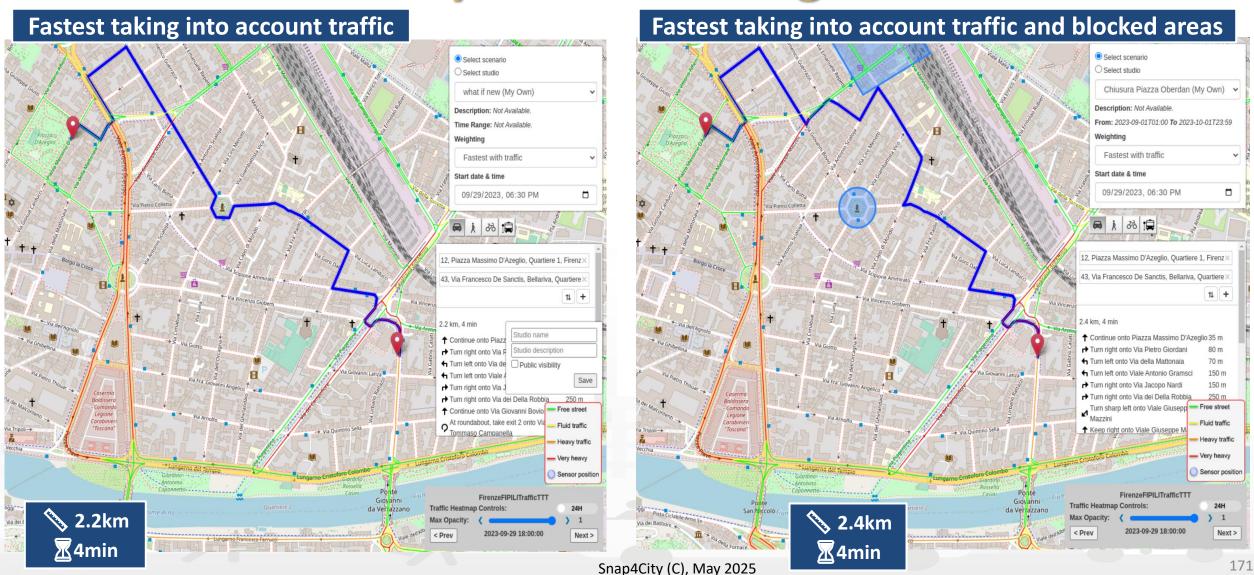








#### **Constrained Dynamic Routing: Traffic Flow**











Categ

ory

Features

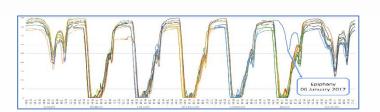
# Parking predictions SNAP4INDUSTRY





## I would arrive to surely Park in 45 Minutes??

Description of features variable



Real number of available slots recorded Free parking slots every 15 minutes Baseline features of free slot data Time Hours and minutes Month Month of the year (1-12) Day Day of the month (1-31) Day of the week (0-6) Day week Weekend 0 for working days, 1 else Previous Difference between the number of free observation's spaces at time i and number of free difference spaces at time (i - 15 minutes) recorded (POD) in the previous week Subsequent Difference between the number of free observation's spaces at time i, and the number of free difference spaces at time (i + 15 minutes) recorded (SOD) in the previous week City temperature measured one hour Temperature Weather features earlier than Time (°C) City humidity measured one hour earlier Humidity than Time (%) City rainfall measured one hour earlier Rainfall than Time (mm) Average speed of vehicles on the road Average being closest to the parking, over oneraffic Sensors Vehicle Speed hour period (km/h) Number of vehicles passing by closest to Vehicle Flow the parking, over one-hour period Average Average of distance between vehicles, Vehicle Time over one-hour period Vehicle Number of vehicles per kilometer, over Concentration one-hour period

> Artificial Intelligence **Predictions**

> > 97% of precision



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13 CLIMATE ACTION





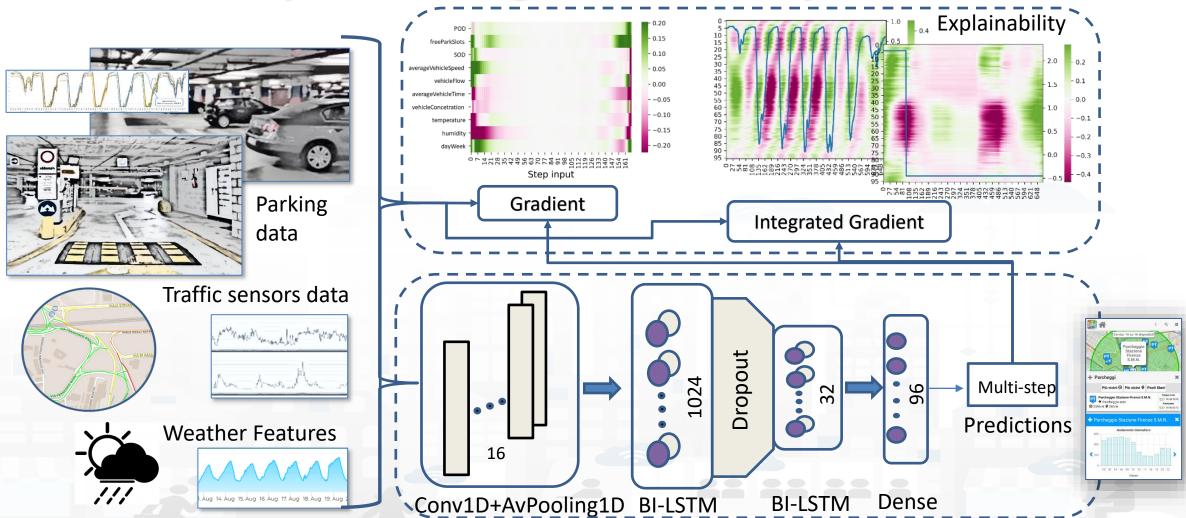








#### **Deep Learning AI to surely Park!**











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

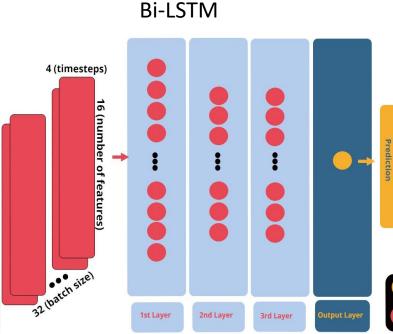


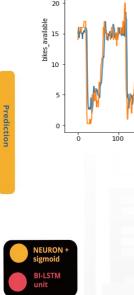
60 minutes Cluster 1 Bi-LSTM













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







### **Road Parking**



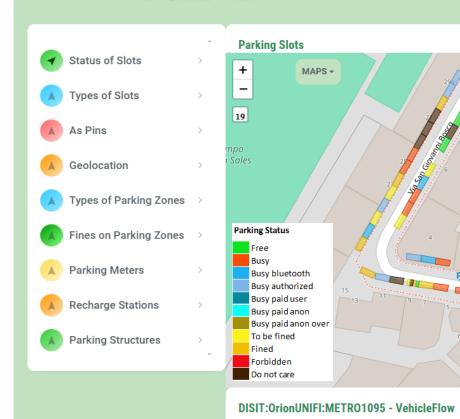
**Parking KPIs** 



#### **Parking Conditions Monitoring**

Wed 23 Oct 16:24:41









Management









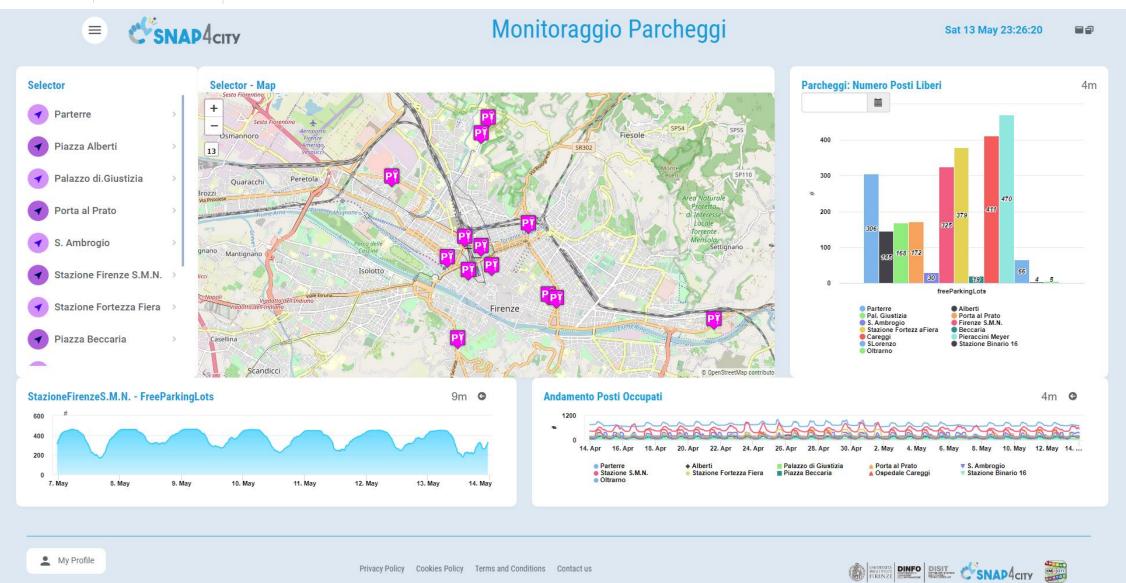












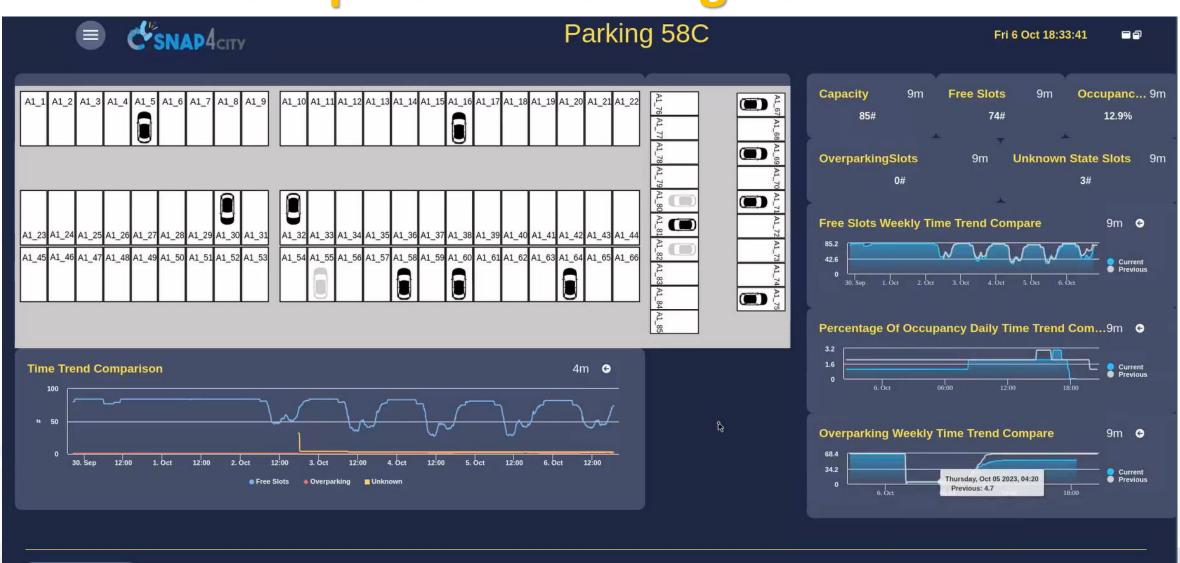








#### **Snap4ISPRA Parking: ISPRA JRC**











## Decision Support Systems, What-if

#### Event planning, via what-if analysis

- Change in the graph structure of the city
- Impact on the flow of people and vehicles
- Adaptation: public transport, traffic, pedestrian management, etc.

#### Immediate reaction to natural events or not

- Everything is ready and updated in real time
- Each view is contextualized in terms of data: descriptive and prescriptive

#### Digital Twin

- More detail in the context integrated data
- Greater realism in deductions and representations
- Less fragmentation and non-uniformity in the views to support decisions

Snap4City (C), May













# Mobility Demand vs Transportation Offer



#### What-if Analysis on Pub Transport









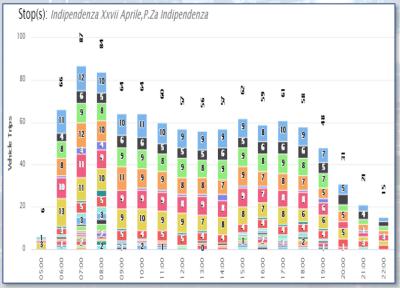


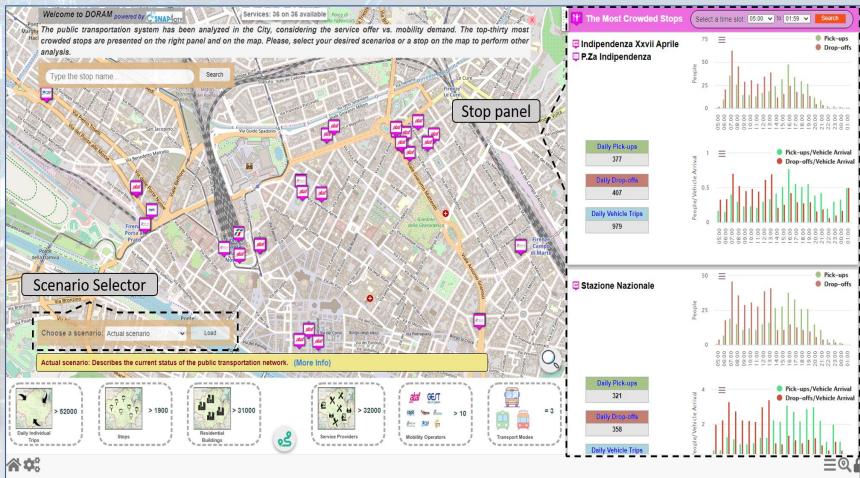
#### Simulation / analysis of Mobility Demand wrt Transportation Offer

- Definition of scenarious impact on
  - Traffic, Pollutant, parking, public transport, private flows, etc.

KPI analysis

#### **Public Services**



















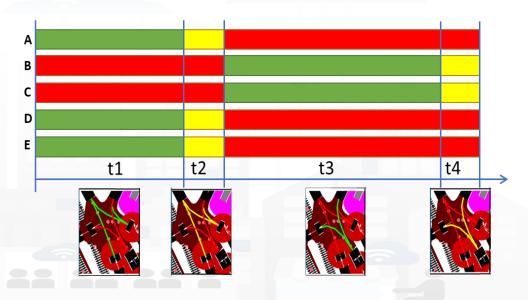




### **Traffic Light Plan Optimisation, Digital Twin**

- Match Multiple Objectives and Synchronization:
  - public and private traffic, tramway priority
  - Micro and Macro Scales
  - Al: Genetic Algorithms, Reinforced Learning
    - Fixed and Actuated Cycles
    - Adjusted on Demand
- Validation/integ. with SUMO simulation
  - Travel Time, waiting time, waiting count
  - Specific travel time on directions
  - CO2 emissions, etc.
- Reductions from 5% to 15%



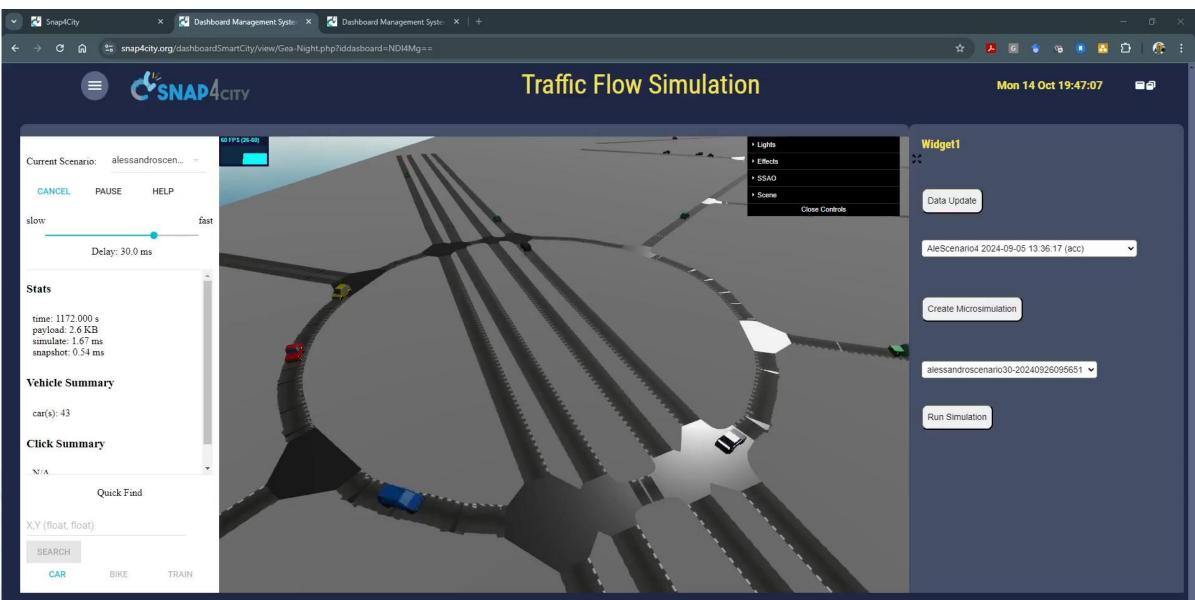






# DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB













# Traffic Infrastructure Optimization









VIEW OF THE **ADMINISTRATORS** 









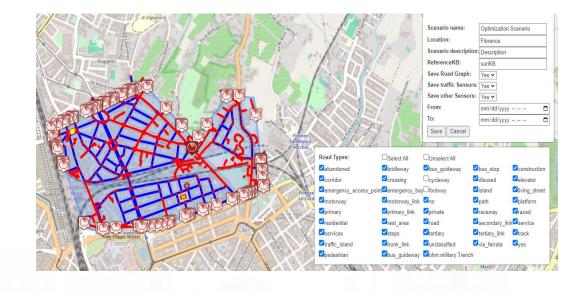






#### **Traffic Infrastructure Optimisation, Digital Twin**

- Identification of Scenario (Scenario Editor), any changes
  - Definition of traffic loads by flows
- What-if or Automated Optimisation
- Automated Optimisation:
  - Stochastic Relaxation, Simulated Annealing, Traffic Flow Reconstruction
  - Multiple objectives targeting
    - Travel time, emissions, fuel consumption, traffic status
  - Limiting the number of changes





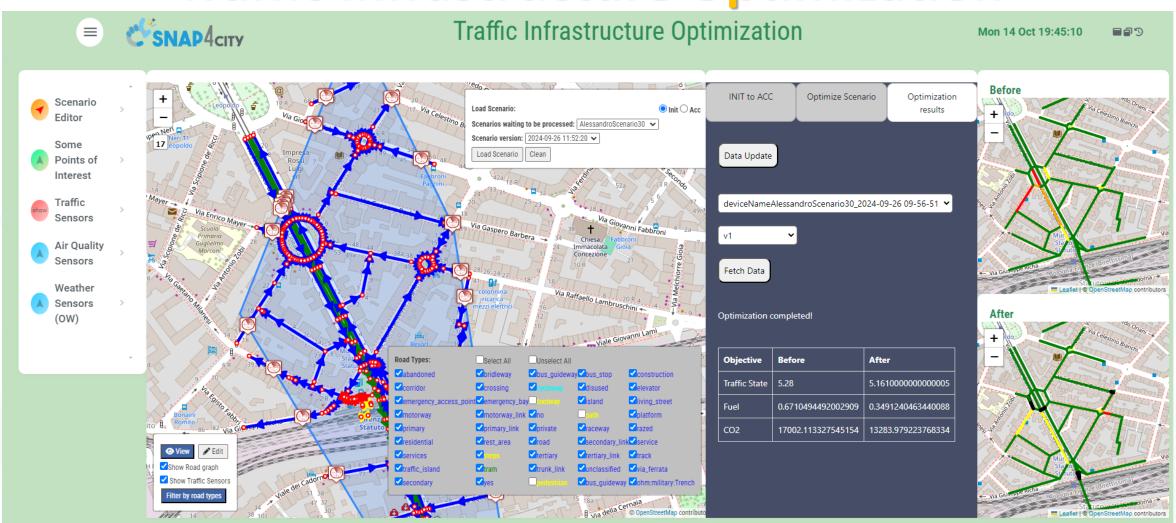








#### **Traffic Infrastructure Optimization**











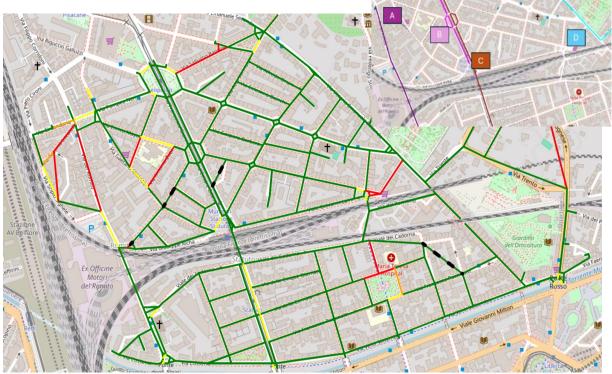




**Optimization Results** 



Case max 4 changes	KPI estimation on the best solution					
Optimization Target	Traffic State	Fuel	CO2			
Optim 4 Traffic State	91.341-21%	17.964	128536			
Optim 5 Fuel	91.514	16.633 <b>-35</b>	<b>%</b> 128227			
Optim 6 CO2	92.859	19.192	127876 - <b>23</b> 9			
Original	115.475	25.680	165822			



Travel Time [s]	Path A	Path B	Path C	Path D	Total Time
Original Scenario	183.2	59.6	80.9	132.5	456.4
Optim 4 Traffic State	93.2	60.0	63.7	96.0	313.1
Optim 5 Fuel	89.6	51.2	59.7	96.4	296.9
Optim 6 CO2	89.5	53.2	58.4	100.1	301.3

-28%



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## eShare in a Snap, by Snap4



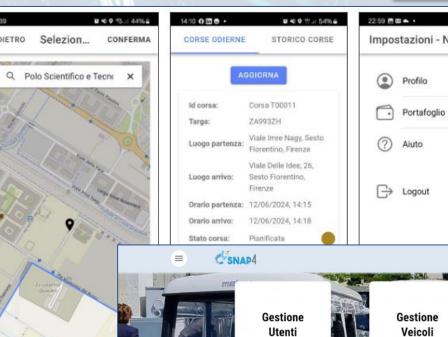
EShare In A Snap



















Integrated car sharing and pooling
Multiple drivers on the same means
Dynamic pooling and e-sharing

Snap4City (C), May 2025

# eShare in a Snap, by Snap4









Gestione Prenotazioni Con Pod Tutte le prenotazioni Domani Svuota mappa | Svuota pool | Svuota mappa e pool 14/06/2024 17/06/2024 Veicoli disponibili 16/06/2024 19 16/06/2024 23:08 16/06/2024 23:13

Integrated car sharing and pooling Multiple drivers on the same means Dynamic pooling and e-sharing

Time Trend Batteria







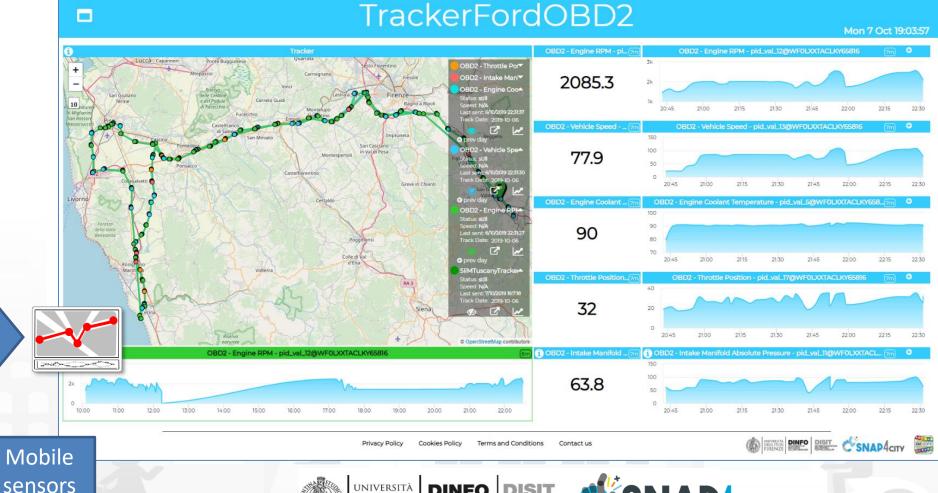


MyKPI: Tracking of Devices and Mobiles
• Real Time Trajectories for

- - Mobile Phone
  - Moving IOT Devices
  - OBU, Vehicular Kits
  - Multiple tracks
  - Day by day

Micro Application













**CANBUS** 



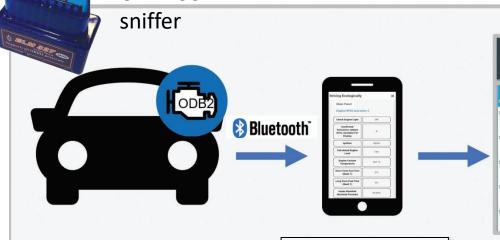


**OBD2** Telemetry

FIRENZE DINFO DISIT C'SNAP4CITY



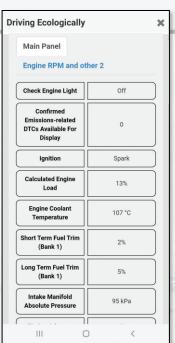
## **IOE – Vehicle Monitoring**

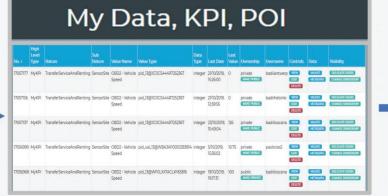


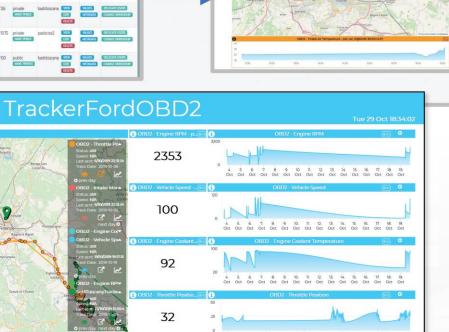
Tuscany in a **Snap Mobile** App on **Android** 











63.8





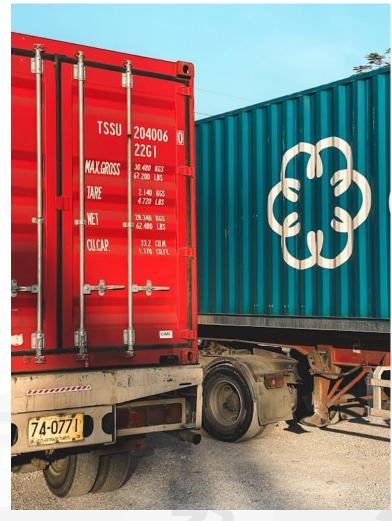








## **Trucks' Plates and Container ID Recognition**



- **Managing Gates to Salerno Port**
- Gates: in/out
- Recognition and decoding
  - BIC code: TSSU 204006
  - ISO code: 22G1
  - Seal status: on/off
  - Multinational Plate: 74-0771



Details





#### **FREE** TRIAL



















#### **Digital Twin Solutions for Sustainability**

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



















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



- VISUAL PROGRAMMING, ML, AI, HPC
- TRAINING COURSES
- LIVING LABS
- GUI CUSTOM STYLES
- FULL APPLICATIONS, DASHBOARDS AND VIEWS
- MOBILE APPS



















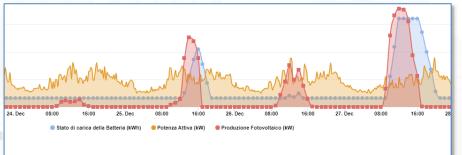
#### Goals:

#### **City Energy and Buildings**

- 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











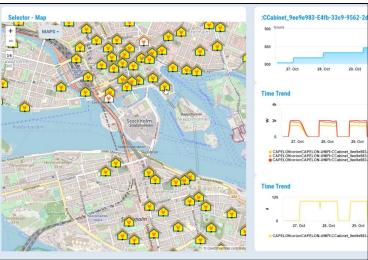


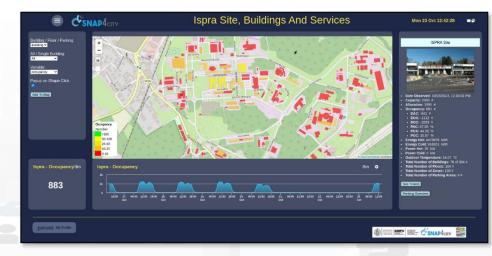




#### Goals:

- Energy Domain (2024/8)
- Energy consumption reduction, increment of efficiency, sustainability
- accessibility to services
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring energy consumption (heating, cooling, prod.,..), conditions, charging stations, etc.
  - Managing Smart Light for city: dimering, programming, traffic control, controllers, legacy, etc.
  - Early detection/warning, alarm, of critical conditions
  - Managing smart services: cabinets, lockers, etc.
  - Production of suggestions, nudging
  - Global and local 3D/2D representations of area and buildings
  - Managing Communities of Energy, certification via Blockchain
  - Computing predictions of any kind
- Solutions for Planning (optimization and what-if analysis)
  - Reduction of energy costs, via optimization
  - Identification of roofs with better orientation
  - Optimization of battery storage size for PV plants
  - Community of Energy planning and viability
- Algorithms and computational solutions, see next slide





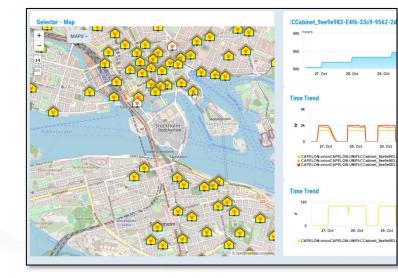




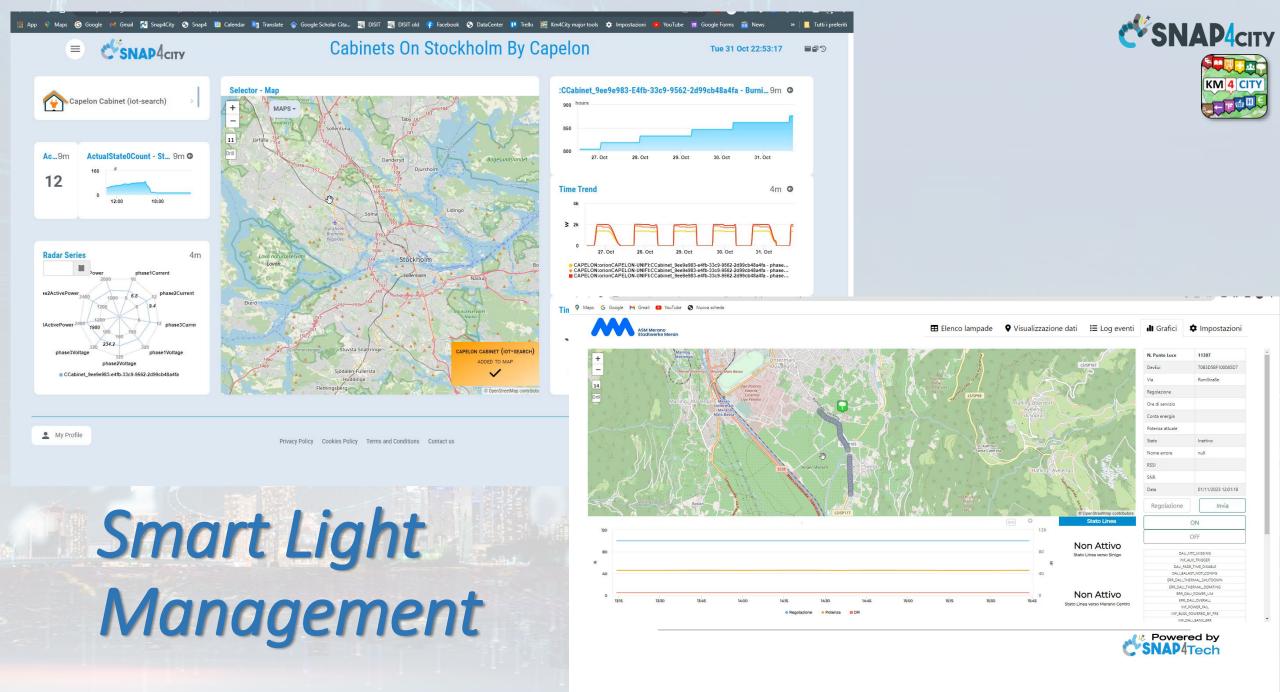


## Tools: Energy Domain (2024/8)

- Monitoring Energy Consumption in single building, area and per zone
- Smart Light management, unicast and multi cast management, smart light controlled by traffic flow data
- Monitoring Energy provisioning on recharging station
- Matching Energy consumption with respect to the actual usage
- Computing Roof orientation for Photovoltaic installations
- Optimisation of Photovoltaicc installations to identify the best parameters of size and storage
- Collecting and managing Communities of Energy
- Computing KPI
- Etc.



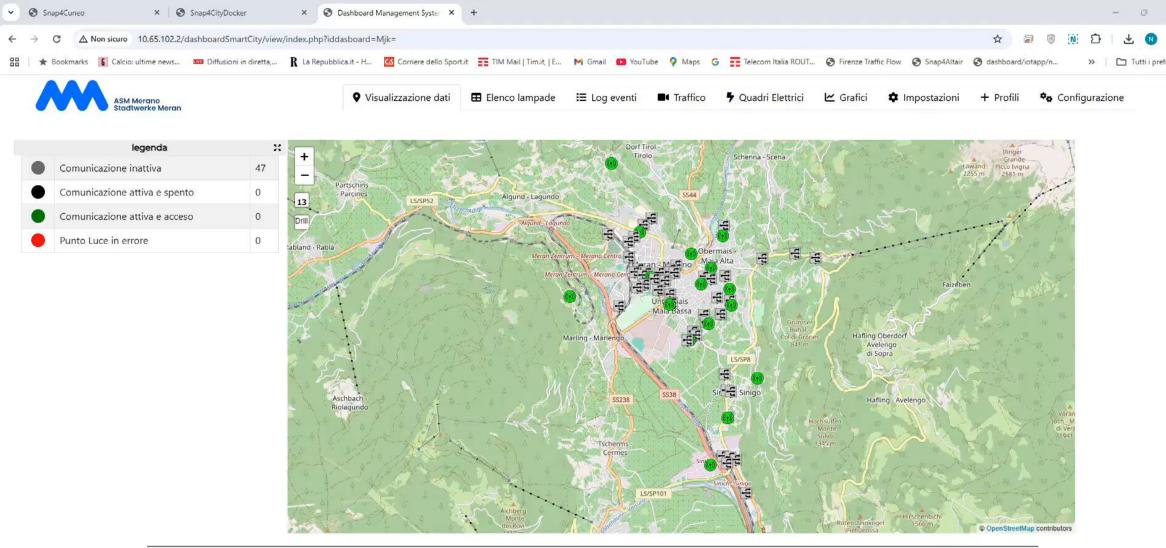




Snap4City (C), May 2025



KM 4 CITY





Snap4City (C), May 2025 202







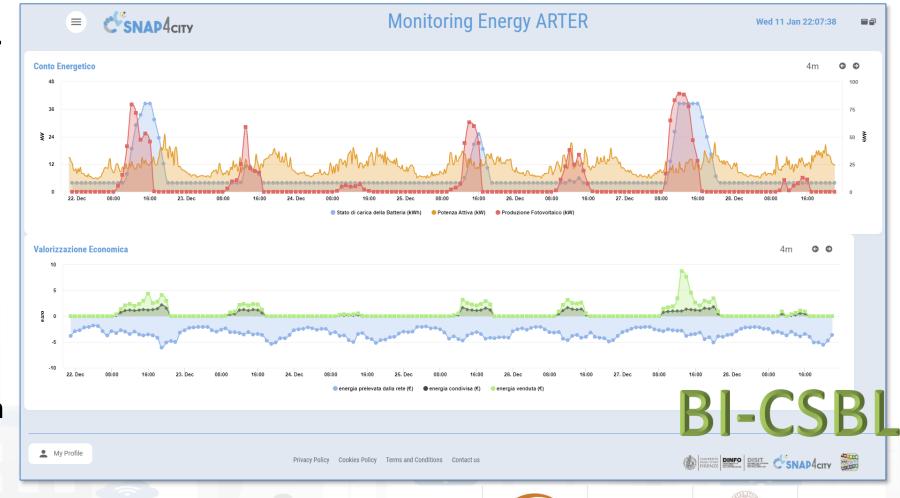








- Field-tested energy community: the selfconsumer condominium
- The Self User project creates in the pilot condominium, through the collection and analysis of data, a model for calculating and enhancing the impact of an energy community on a community of people, with a view to actions to combat energy poverty



https://www.selfuser.it













▲ - PV + battery 10kWh

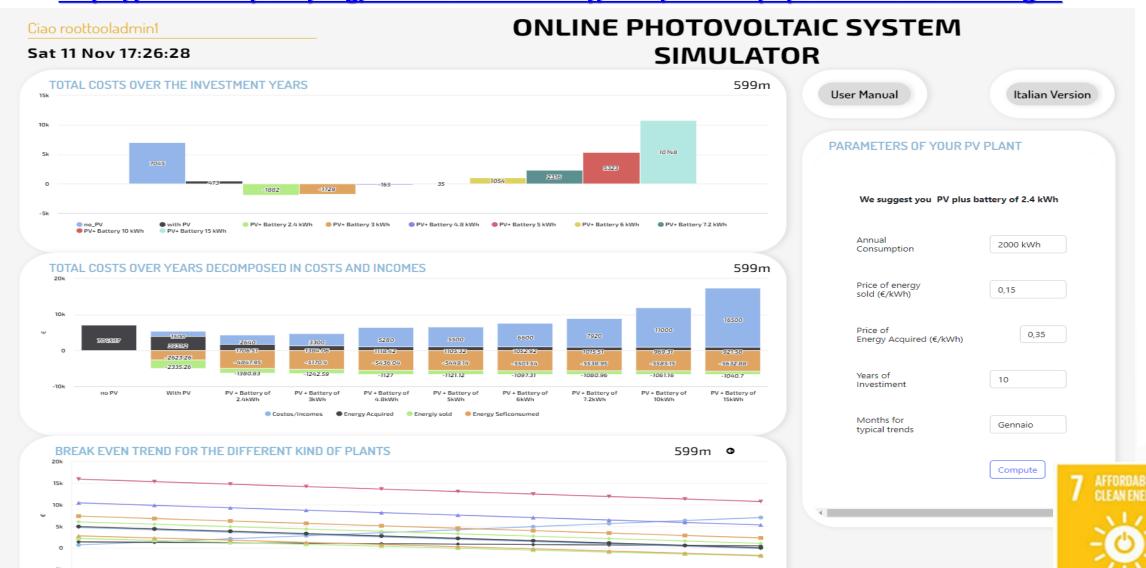
PV + battery 15kWh







#### https://www.snap4city.org/dashboardSmartCity/view/Baloon.php?iddasboard=MzczNg==



2032



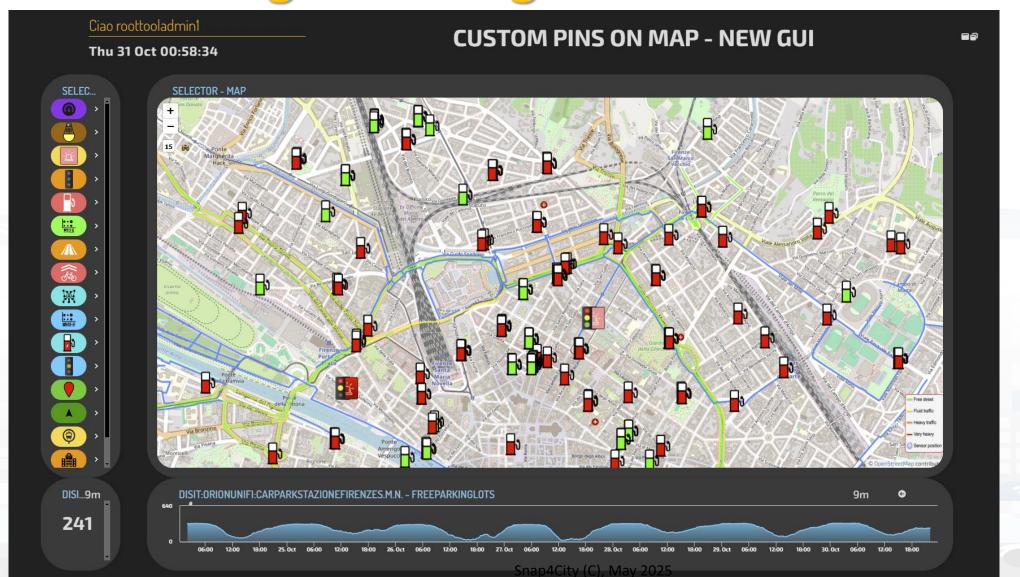






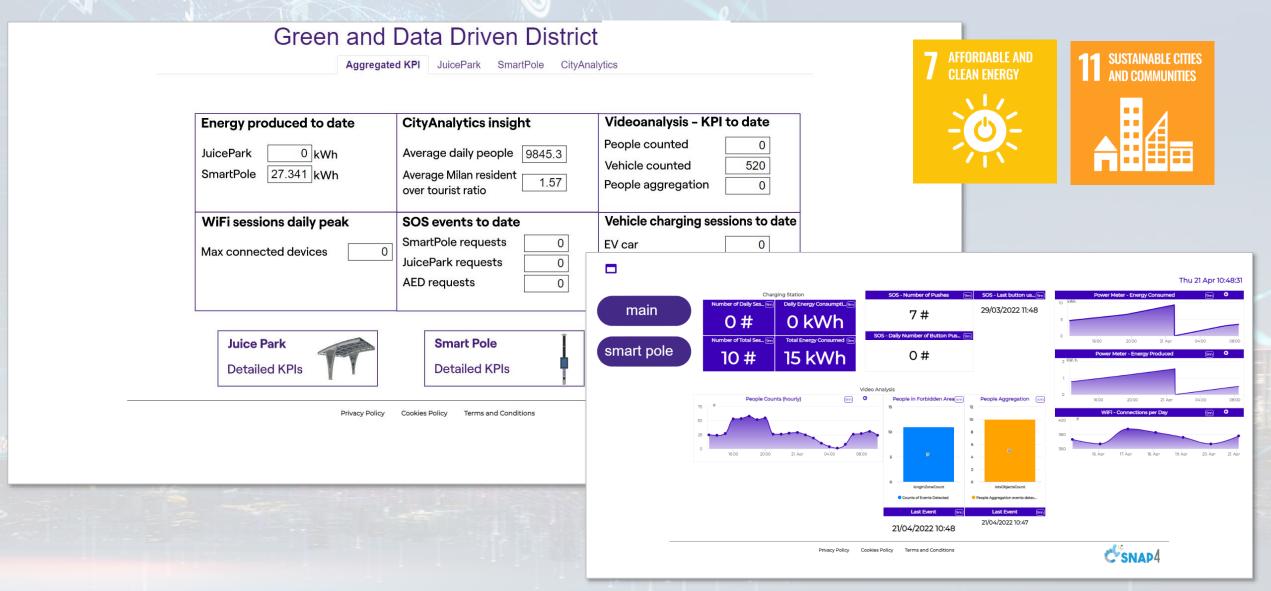


## Monitoring recharing station and assets





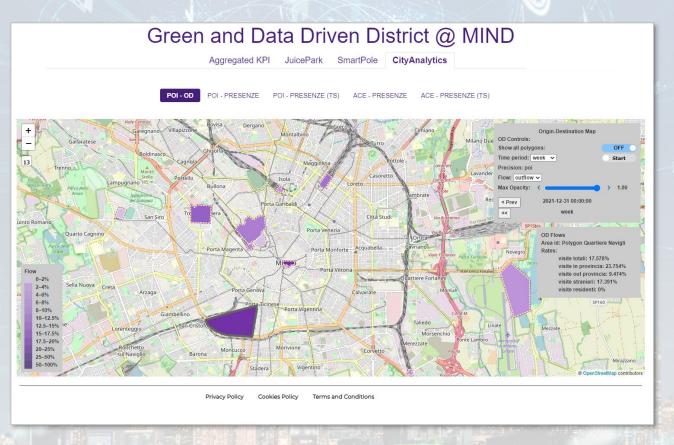
#### **Energy monitoring and business intelligence**



Snap4City (C), May 2025 206

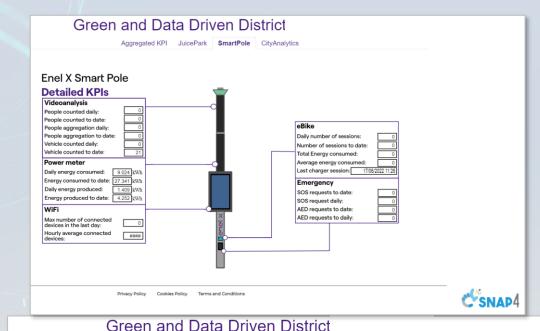
#### **Energy monitoring and business intelligence**





















# Snap4Building Domain (2024/8)

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













# Smart Buildings, Snap4Building (2024/8)

- Digital Twin for monitor, control and manage distributed infrastructures
  - 2D/3D representations of the whole set of buildings, BIM modeling
  - Entities (building, floors, rooms, parking, charging stations, gates, etc.) with their shapes and descriptors, and data monitoring the allocation to office, meeting, cafeteria, storage, stairs, elevator, etc.
- Monitoring and computing KPIs on real time for
  - energy consumed or produced (hot/cold), parking, logistic, presences, cleaning, air quality, departments, subareas, maintenance, etc.
  - allocation/designation, dispositions, heating, cooling, temperature, equipment, etc.
  - grouped in Zones





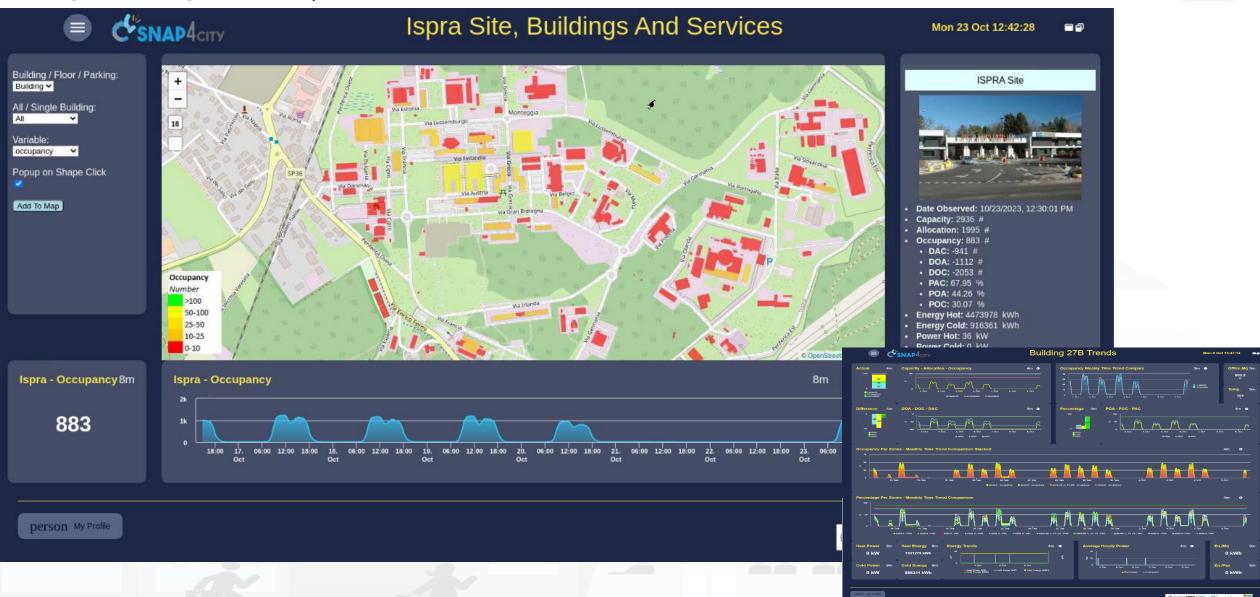






#### **ISPRA JRC Site**











## **Floor Details**



ISPRA JRC Site

C'SNAP4CITY

Percentage Per Zones - Monthly Time Trend Comparison

Occupancy Per Zones - Monthly Time Trend Comparison Stacked

Capacity - Allocation - Occupancy





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# DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB Smart Building SNAP4city AND TECHNOLOGIES LAB









Details





#### FREE TRIAL



















### Digital Twin Solutions for Sustainability

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









VISUAL PROGRAMMING, ADAPTERS
DATA FLOWS, WORKFLOWS
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  AND VIEWS
- MOBILE APPS



















## **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, missions, pollutants, aerosol, chemical plants analysis
  - Traffic Flow impact emissions, predictions
  - Sea conditions, UV conditions, etc.
- Land slide prediction warning
- Coastal erosion monitoring and analysis
- Smart Waste Management and Optimisation:
  - costs reduction, optimal routing production, pay as you throw,
  - avoiding out of bins, predictions of waste production on bins, alarms
- KPI: SDG, 15MinCityIndex, QOS, costs, Km, colleting time, EC KPI, emissions
- Mobile App: final users services/informing and operators
  - Info Waste for operators, participation, optimal routing, RAEE Collection, ...
- Participatory: problem reporting, ticketing, etc.
- Integration of any kind: env/weather, mobility, ticketing, presences, POI, ..







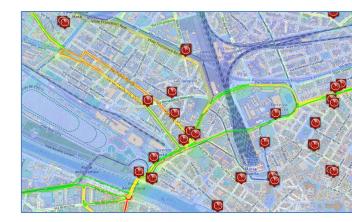






## Environment, waste, land, etc., domain (2024/8)

- Goals:
  - Reduction of emissions and EC taxations
  - Cost Reduction for waste collection, reduction of waste collection impact on mobility
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring emissions, weather, waste, water, etc.: sensors, traffic, flows, ....
  - Early detection/warning of critical conditions on emissions, weather, waste, water, fire, animals, ...
  - Early detection/warning of critical conditions for landslides, water flooding, beach
  - Smart Waste Management: bins/lockers, waste collection daily plan, pay as you throw, PAYT, etc.
  - Short terms prediction of emissions: CO2, NO2, etc.
  - Production of suggestions, nudging
  - Computing and predicting of long terms KPI indicators of the European Commission
- Solutions for Planning (optimization and what-if analysis)
  - Identification of main CO2/NO2 emissions locations in the city, total production from traffic
  - Reduction of Pollutant Emissions, via optimization: semaphore cycles, viability
- Algorithms and computational solutions, see next slide













## Tools: Environment, waste, land, (2024/8)

- Pollutant Predictions: short, long and very long term European Commission KPIs
  - NOX, PM10, PM2.5 pollution on the basis of traffic flow, 48 hours (ML, Al, DL)
  - Cumulated NO2 average over year (ML, Al, DL)
- Computation of CO2 on the basis of traffic flows (DP), computing emission factor (DA)
  - each road for each time slot of the day
- **Prediction of MicroClimate** conditions for diffusion (ML, AI)
  - NO2, PM10, PM2.5, etc.
- **Prediction of landslides**, 24 hours in advance (AI, DL)
- prediction of waste collection, & optimisation of schedule and paths (DP, ML)
- Heatmaps production dense data interpolation (DP) for
  - Weather conditions: temperature, humidity, wind, DEW
  - Pollutants and Aerosol: NO, NO2, CO2, PM10, PM2.5, etc.
- Impact of COVID-19 on Environmental aspects (DP)
- Computing SDG, SUMI, SUMP, .. (mainly DP)
- Etc.





**Environment and Quality of Life** 

**Air Quality Predictions** 

#### Multiple Domain Data

- Traffic Flow data, Pollutant: NOX, CO2, PM10, PM2.5, O3, ....
- 3D City structure, weather, ...

### Multiple Decision Makers

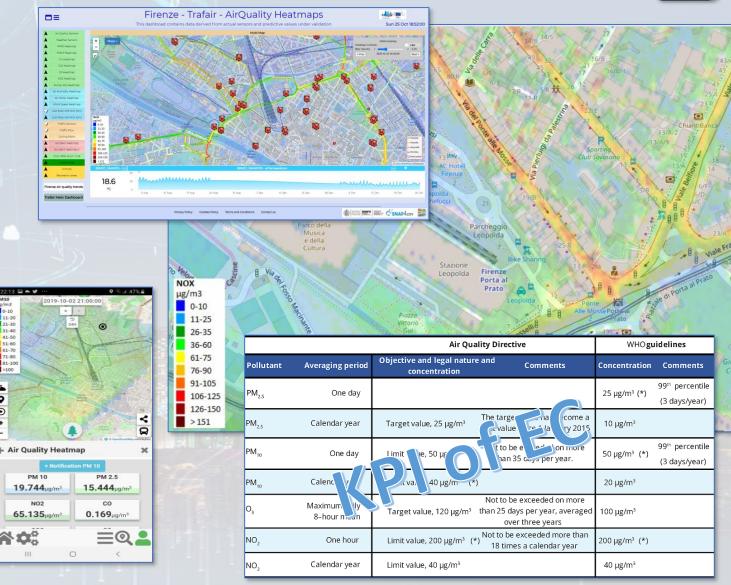
- Pollutant Predictions: NOX, NO2, ...
- City officers, energy industries
- Dashboards, What-IF analysis
- Traffic Flow Reconstruction

#### Historical and Real Time data

- Billions of Data
- Services Exploited on:
  - Dashboards, Mobile App
- Since 2020









## **Devices data**



### Air Quality sensors are

- Collected on scattered positions
- Not all sensors have sull set of data, complexity of computing AQI

### AirQuality Services

- AirQuality indicators independent on the sensors' position, in any GPS position of the area
- Multiple data:  $PM_{10}$ ,  $PM_{2.5}$ , CO,  $CO_2$ ,  $SO_2$ ,  $O_3$ ,  $H_2S$ , NO,  $NO_2$ ,  $NO_{\chi}$ , air temperature, air humidity, velocity of wind speed, dew point, etc.

### Applications

- Control Room Rendering
- Alerting on specific personal GPS locations
- Constrained routing for: runners, walking with baby, people with pulmonary problems,
- Mobile Phone Rendering, this means to have thousands of users active at the same time, and a reasonable memory consumption in the server.





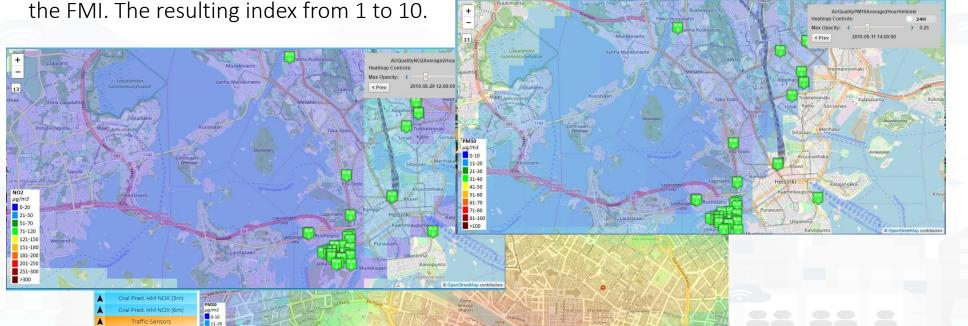




## **Environmental Real Time Measures**

- **Noise:** real time noise levels (measured in dBA).
- **PM<sub>10</sub>:** real time pollutant levels in air in terms of PM<sub>10</sub> (measured in  $\mu g/m_3$ ) particles.
- PM<sub>2,5</sub>: real time pollutant levels in air in terms of PM<sub>2.5</sub> (measured in  $\mu$ g/m<sub>3</sub>) particles
- $NO_2$ : real time pollutant levels in air in terms of nitrogen dioxide (measured in  $\mu g/m_3$ ).

Air Quality Index (AQI): real time air quality index of the Helsinki area, provided by



BusStop Ticket sale Traffic Sensor Weather sensor Air Temp heatmap Humidity Heatmap Air Quality Sensors Noise sensors Noise Heatmap PM10 heatmap PM2.5 Heatmap NO2 heatmap Air Quality Index HeatM EAQI HeatM. CAQI HeatM. Enfuser pred. AQI Enfuser pred. PM10 Enfuser pred. PM2.5 Gral pred. PM10 Gral pred. PM10 (6m) PM10 Jätkäsaari PM2.5 Jätkäsaari EAQI Jätkäsaari Appreciated POIs







## AQI Indexes estimation via R studio and IOT App

### European Air Quality Index EAQI

http://airindex.eea.europa.eu/

Pollutant	Index level (based on pollutant concentrations in µg/m3)				
	Good	Fair	Moderate	Poor	Very poor
Particles less than 2.5 µm (PM <sub>2.5</sub> )	0-10	10-20	20-25	25-50	50-800
Particles less than 10 µm (PM <sub>10</sub> )	0-20	20-35	35-50	50-100	100-1200
Nitrogen dioxide (NO <sub>2</sub> )	0-40	40-100	100-200	200-400	400-1000
Ozone (O <sub>3</sub> )	0-80	80-120	120-180	180-240	240-600
Sulphur dioxide (SO <sub>2</sub> )	0-100	100-200	200-350	350-500	500-1250

Measurements of up to five key pollutants supported by modelled data determine the index level that describes the current air quality situation at each monitoring station.

The index corresponds to the poorest level for any of five pollutants according to the following scheme.

### Legend of Environmental data:

https://www.snap4city.org/435

### Common Air Quality Index CAQI

http://www.airqualitynow.eu

Qualitative name	Index or sub-index	Pollutant (hourly) density in µg/m <sup>3</sup>				
		NO <sub>2</sub>	PM <sub>10</sub>	<b>O</b> <sub>3</sub>	PM <sub>2.5</sub> (optional)	
Very low	0–25	0–50	0–25	0–60	0–15	
Low	25–50	50–100	25–50	60–120	15–30	
Medium	50–75	100–200	50-90	120-180	30–55	
High	75–100	200–400	90–180	180–240	55–110	
Very high	>100	>400	>180	>240	>110	

The index is defined away from roads (a "background" index). **CAQI** is computed on the basis of **NO<sub>2</sub>**, **PM<sub>2,5</sub>**, **PM<sub>10</sub>** and **O<sub>3</sub>**.











## **AQI** Indexes estimation Heatmaps

Hourly pollutant concentration



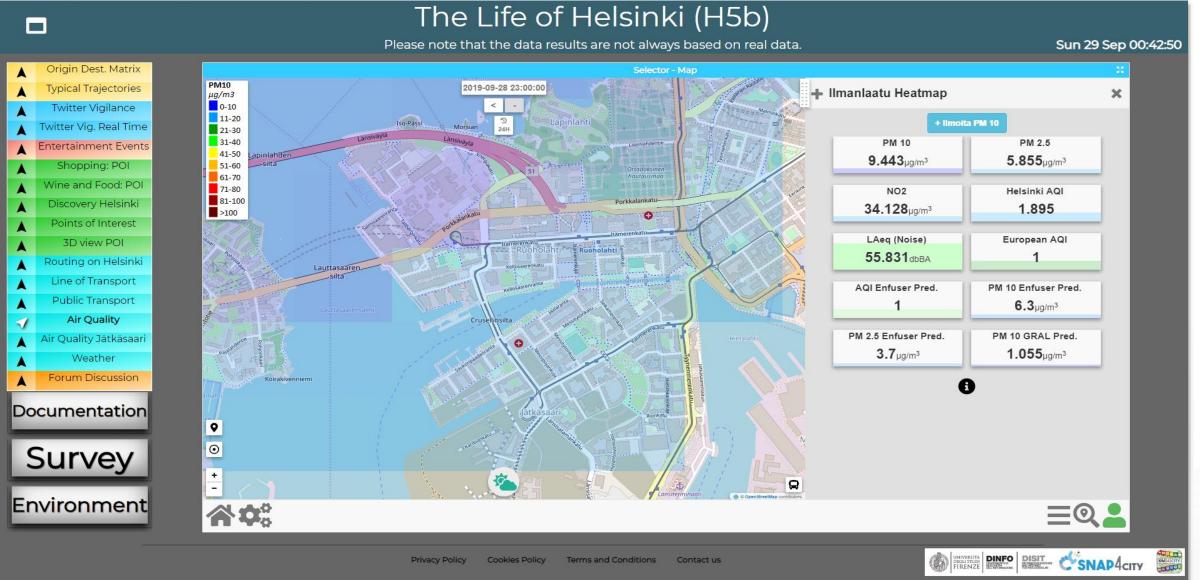










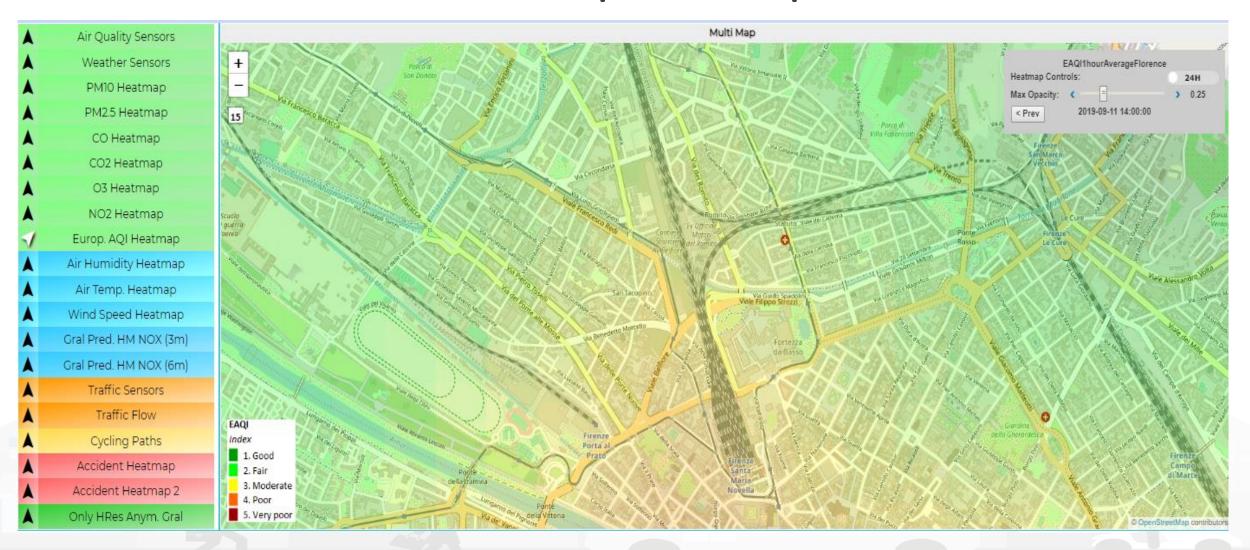








## EAQI Heatmap and sequence













#### **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 Al



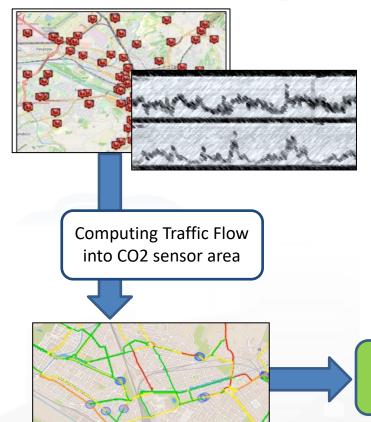








## **Estimating City Local CO2 from Traffic Flow Data**



Traffic Flow data

 Traffic Flow is one the main source of CO2 (ton of CO2 x Km x Vehicle)



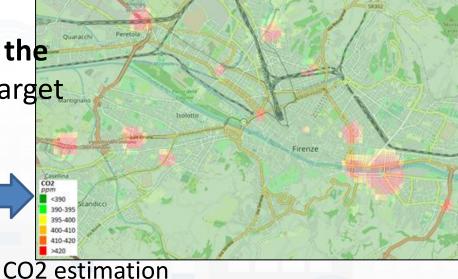


• K1: Fluid Flow

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/





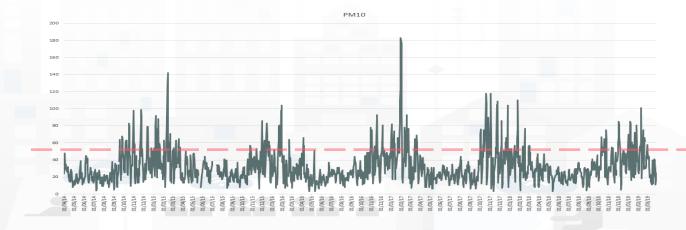




- European Air Quality Directive
- Predicting critical days
  - PM10 with an accuracy of more than 90% and precision of 85%;
  - PM2.5 with an accuracy of 90% and precision greater than the 95%.
- Simulating Long terms values
  - For long terms predictions



	Air Quality Directive			WHOguidelines	
Pollutant	Averaging period	Objective and legal natur concentration	e and Comments	Concentration	Comments
PM <sub>2.5</sub>	One day			25 μg/m³ (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>2.5</sub>	Calendar year	Target value, 25 μg/m³	The target value has become a limit value since 1 January 2015	10 μg/m³	
PM <sub>10</sub>	One day	Limit value, 50 μg/m³	Not to be exceeded on more than 35 days per year.	50 μg/m³ (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>10</sub>	Calendar year	Limit value, 40 μg/m³ (*	·)	20 μg/m³	
O <sub>3</sub>	Maximum daily 8–hour mean	Target value, 120 μg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 μg/m³	
NO <sub>2</sub>	One hour	Limit value, 200 µg/m³ (*	Not to be exceeded more than 18 times a calendar year	200 μg/m³ (*)	
NO <sub>2</sub>	Calendar year	Limit value, 40 μg/m³		40 µg/m³	







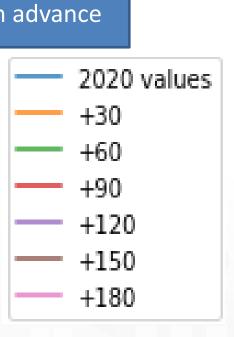




## Predicting EC's KPI on NO2 months in advance

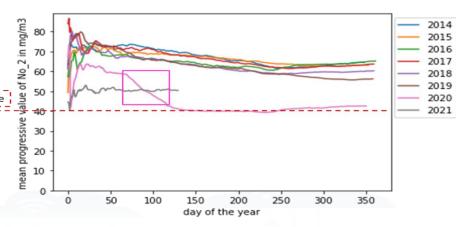
Deep Learning Long Terms Predictions of NO2 mean values, From 30 to 180 days in advance

- The features used as input for the predictive models are:
- Month
- dayOfTheYear
- NO2
- Tmean
- Humidity
- windMean 🦃
- **NoxDomestic**
- numberOfVehicles
- NO2cumulated
- NO2progresseveMean
- numberOfVehiclesCumulated









		Air Quality Directive			WHOguidelines	
Pollutant	Averaging period	Objective and legal nature concentration	and Comments	Concentration	Comments	
PM <sub>2.5</sub>	One day			25 μg/m³ (*)	99 <sup>th</sup> percentile (3 days/year)	
PM <sub>2.5</sub>	Calendar year	Target value, 25 μg/m³	The target value has become a limit value since 1 January 2015	10 μg/m³		
PM <sub>10</sub>	One day	Limit value, 50 μg/m³	Not to be exceeded on more than 35 days per year.	50 μg/m³ (*)	99 <sup>th</sup> percentile (3 days/year)	
PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m³ (*)		20 μg/m³		
O <sub>3</sub>	Maximum daily 8–hour mean	Target value, 120 μg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³		
NO <sub>2</sub>	One hour	Limit value, 200 μg/m³ (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m³ (*)		
NO <sub>2</sub>	Calendar year	Limit value, 40 μg/m³		40 μg/m³		





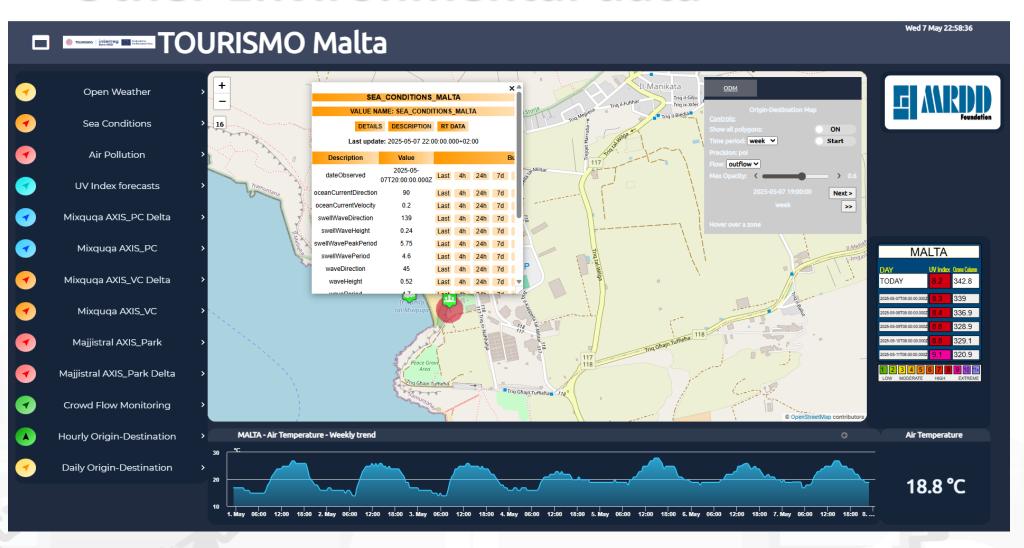






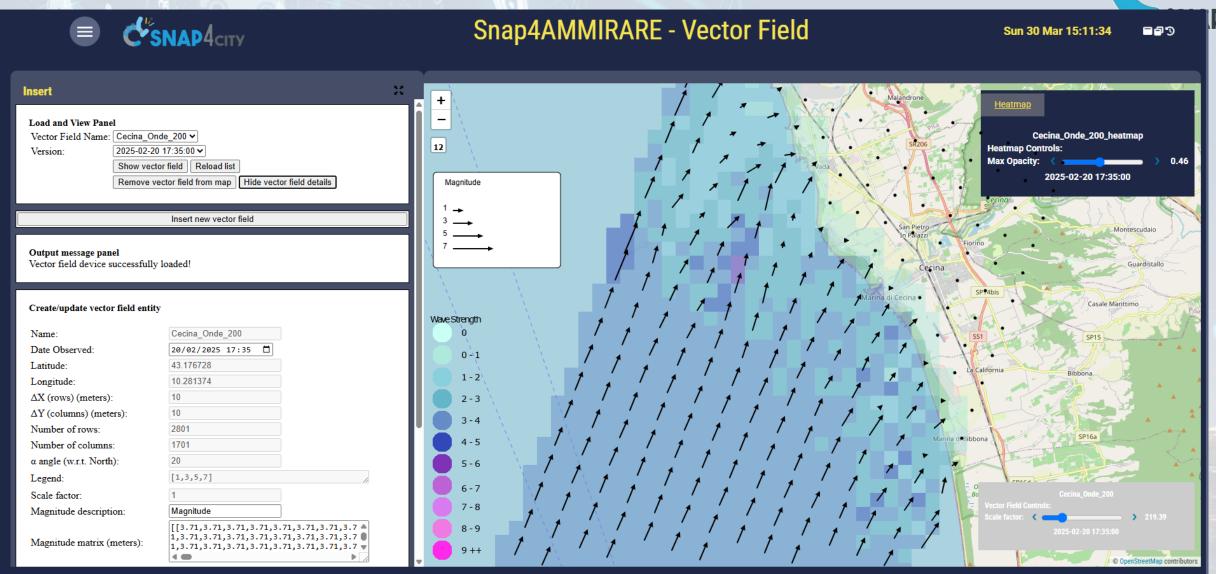
## **Other Environmental data**

- Sea **Conditions**
- UB Index
- Ozone
- Pollution
- Weather **Forecast**



## Monitoring Costal Bathymetry and Waves









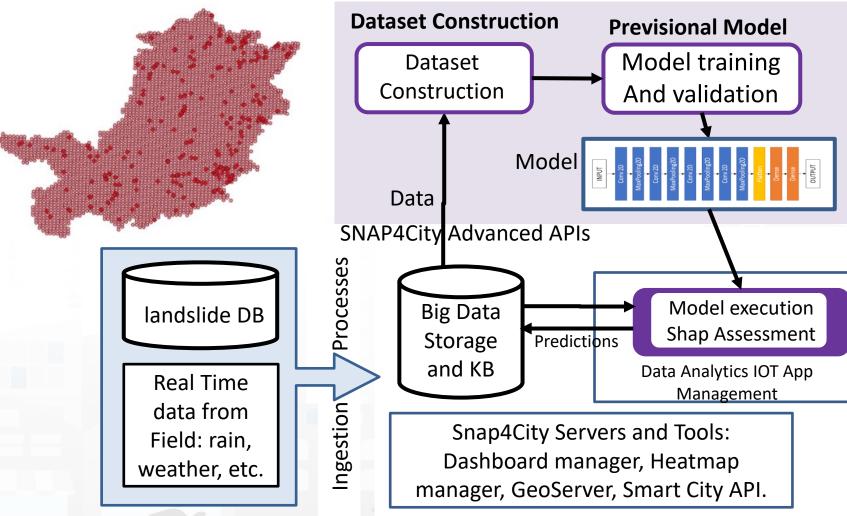


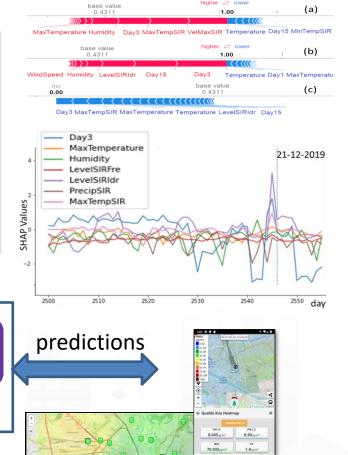






## **Predicting Land slides**





Dashboards and

Mobile Apps

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



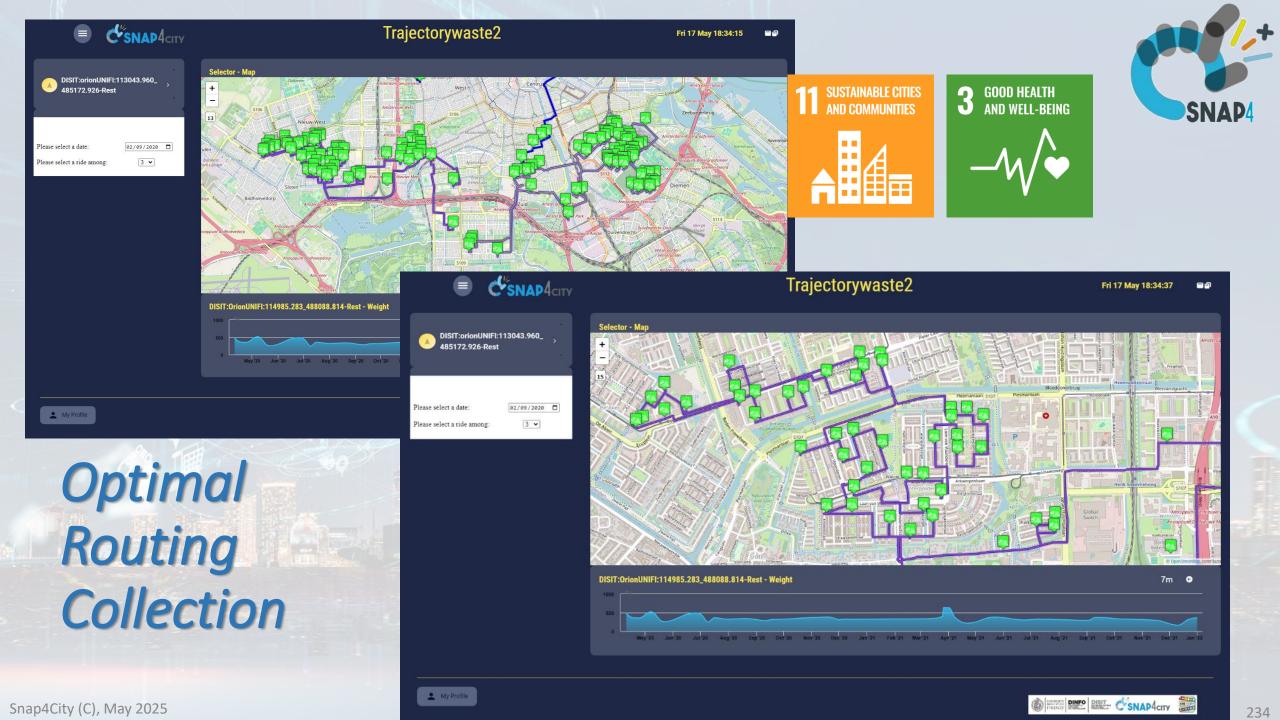


### **Smart Waste**



#### **Waste Manager:**

- Collects and monitors data from bins (status, temperature, and a number of alarms, etc.) and trucks (weights collected, when possible) according to differentiated waste collection;
  - Interoperable with different waste bin sensors and lockers.
  - Monitor waste bin status including alarms of critical conditions notified from the citizens, and/or detected by sensors such as: fire, up-side-down, hurts, too filled, run out of battery, errors, etc. (some of these events can be enabled on the basis of the sensors positioned to the bin)
- **supports of policies** as Pay As You Throw, PAYT, provided that the bins are controlled with fobs, NFC, rfid, etc.
- **promoting citizen engagement/participation**, to help cities optimize their waste management practices and move towards a more sustainable future. The engagement is especially addressed to the city commercial operators which have special need in providing a large amount of waste (such as restaurants, fast food, bars, and shopping centers). <a href="https://www.snap4city.org/1018">https://www.snap4city.org/1018</a>
- Reduce costs: optimize waste collection and management in urban environments
  - identify the bins that risk to become full in advance (using predictive technologies based on AI, Deep Learning).
  - Computer the optimal path for waste collection provided to map on mobiles, reduction of costs for waste collection.
  - dashboards provides statistics and forecast.
- Custom user interface and theme can be defined for each municipality as usual on Snap4City.

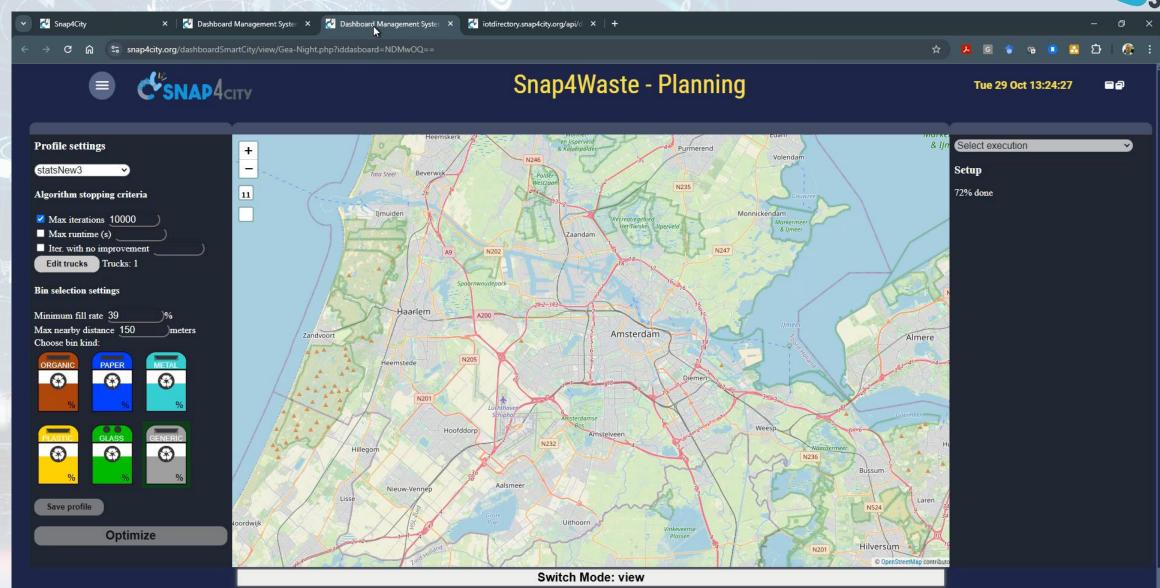


## Waste Collection Optimization











Details



#### Powered by **S**FIWARE

#### **FREE** TRIAL



















### **Digital Twin Solutions for Sustainability**

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









**DATA FLOWS, WORKFLOWS** PARALLEL DISTRIBUTED PROCESSING **DATA DRIVEN** 



- TRAINING COURSES
- LIVING LABS
- GUI CUSTOM STYLES
- FULL APPLICATIONS, DASHBOARDS AND VIEWS
- MOBILE APPS











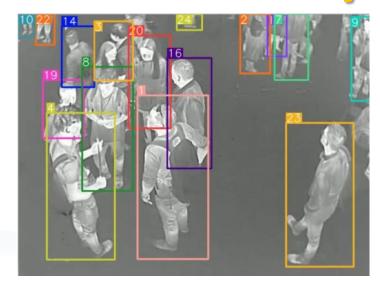


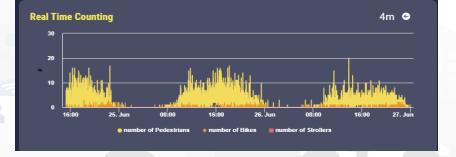






- Improve Quality of Life and quality of services,
- Over tourism mitigation, sustainability
- Costs reduction of services
- Improve accessibility to services: citizens, Tourists, commuters, etc.
- Improve Security/Safety of city users
- **People Flow Analysis / Management:** in/out-door, retail, attractions
  - 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, ...









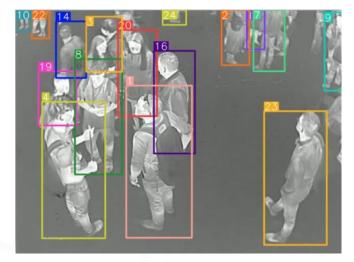




#### • Goals:

## City User Behaviour/services, Tourism and Safety (2024/8)

- Quality of Life, quality of services, over tourism mitigation, sustainability
- Costs reduction of services
- Accessibility to services: citizens, Tourists, commuters, etc.
- Security/Safety of city users
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - People Mobility Demand via Origin Destination Matrices
  - Monitoring services: tickets, reputation, usages, areas, etc.
  - Monitoring user behaviour (counting, trajectories): indoor/outdoor, hot places/services, ports, beaches,
  - Computing: origin destination, trajectories, travel means, etc.
  - Early detection/warning of critical conditions, connection with Video Management Systems
  - Managing entrances in city areas: restricted areas, touristic busses, etc.
  - Production of info-toursim, recommendations, nudging to city users and operators, second offer promotion
  - Providing Virtual Assistants for City Services, Tourist Offices, etc.
  - Monitoring reputation of services via: social media, blogs, etc.
  - Collecting complains, requests, participations from City users via mobile apps
  - Computing predictions of any kind
- Solutions for Planning (optimization and what-if analysis)
  - Reduction of Pollutant Emissions, via optimization
  - Optimization plan to distribution of workload on multiple touristic offers/services, area cleaning, etc.
  - Predicting reputation of services, touristic and operative











### City Users Behaviour, Safety, Security and Social Analysis (2024/8)

- People detection and classification: persona, strollers, bikes, etc. (ML, DL)
- people counting and tracking, head counting, people trajectories (via thermal cameras, ML, DL)
- People flows prediction and reconstruction, (ML, DL)
  - Wi-Fi data, mobile apps data, Mobile Data, etc.
- User's behaviour analysis, People flow analysis from PAX Counters and heterogenous data sources (ML, AI)
  - origin destination matrices, hot places, time schedule,
  - Recency and frequency, permanence, typical trajectory, etc.
- Computing User engagement and suggestions for sustainable mobility (Rule Based, ML)
- Social media analysis on specific channel, specific keywords: see Twitter Vigilance,
  - Reputation, service assessment: MultiLingual NLP and Sentiment Analysis, SA
  - Tweet proneness, retweet-ability of tweets, impact guessing
  - Audience predictions on TV channels and physical events, locations
  - Prediction of attendance of events and on attractions
- Virtual Assistant construction, LLM, NLP, Sentiment Analysis (DL, NLP)
- Video management System integration for security
- 15 Minute City Index , etc. (modeling and computability)
- Computing SDG, etc., (DP)





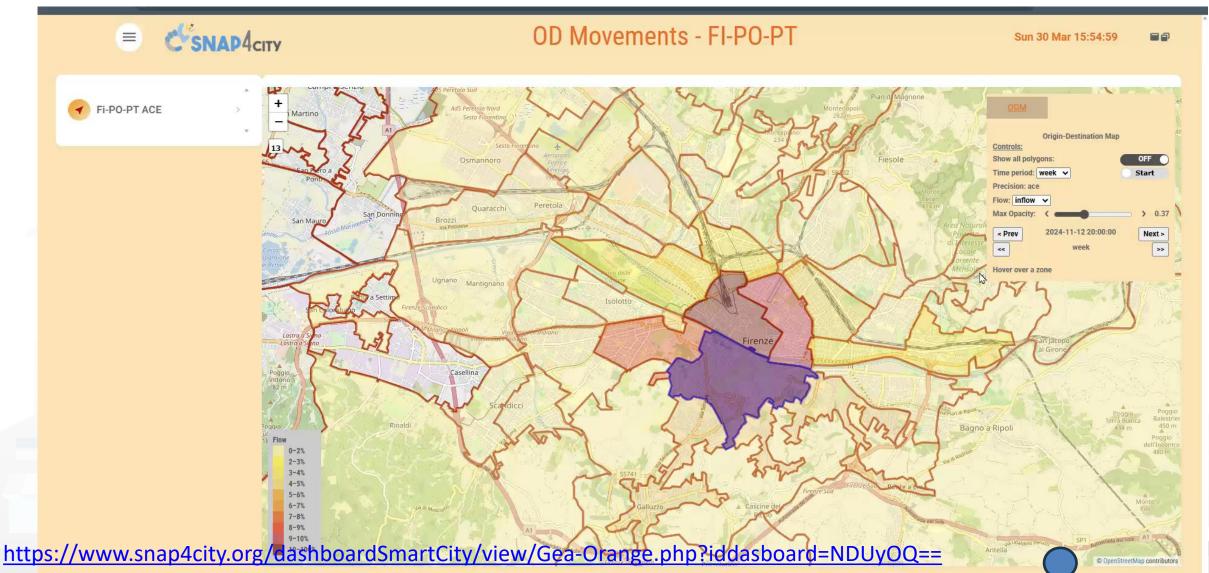








# Origin Destination Matrices: Mobility Demand



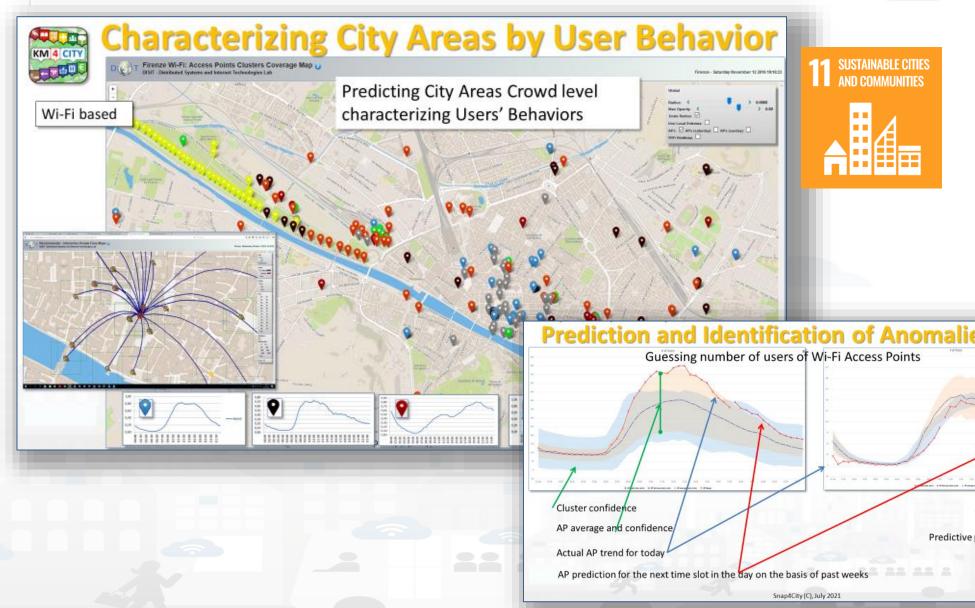




Snap4City (C), May 2025



- Prediction of people flows on the basis of Wi-Fi data
- Anomaly detection
- Resolute H2020
- Classification of city areas



## User Behaviour: People Counting, Tracking, etc. SNAP4CITY



#### 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

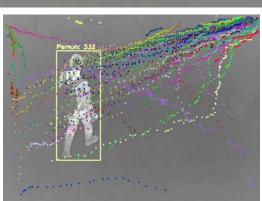
#### Al injection

- classification and counting
- Identification of critical situations
- Early warning
- Integration with PAX counters, and with ODM data from operators

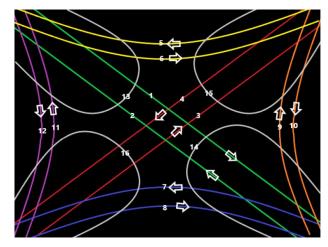
#### **Real-time estimation**

- Directly on the camera
- High precision and reliability
- Used by: Cuneo, Florence, Genoa, etc



























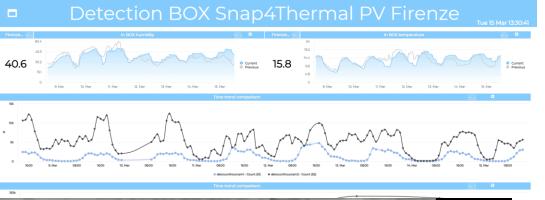




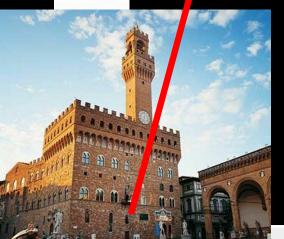




## A view and data from the Thermal Camera











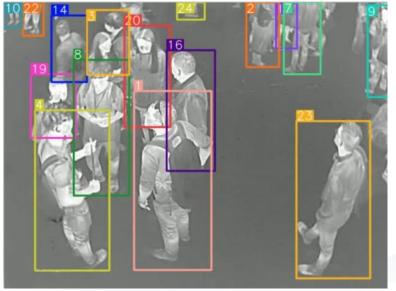


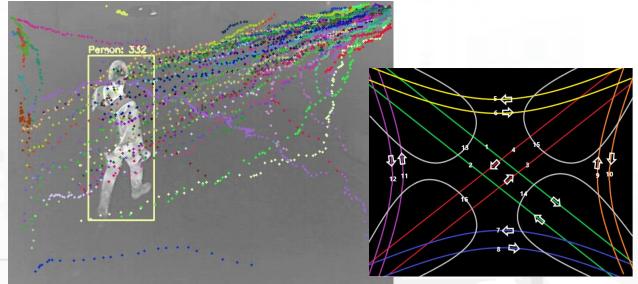




## **People Counting and Tracking**



















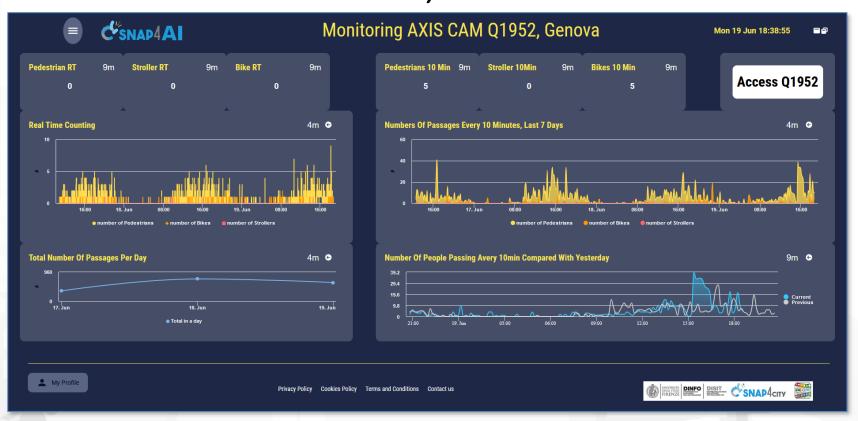




# **SUSTAINABLE CITIES** AND COMMUNITIES

## **Monitoring Passages AXIS Q1952**

Genova: Ocean Race, 2023





## Valencia, FSMLR

#### Tourism Domain

- Counting People
- Environmental data
- Social Media

#### Dashboards

- Monitoring and real time control
- People flow
- Twitter Vigilance
- Historical and Real Time data
- Services Exploited on:
  - Dashboard
- Since 2020











## Dubrovnik

- Tourism Domain
  - Counting People
  - TV Cameras and WiFi
  - Social Media
- Dashboards
  - Monitoring and real time control
  - People flow
  - Twitter Vigilance
- Historical and Real Time data
- Services Exploited on:
  - Dashboard
- Since 2020



















## Pont du Gard

- Tourism Domain
  - KPIs
  - Social Media
  - People Flows
  - Bike Flows
- Dashboards
  - Monitoring KPI
  - People and bikes flows
  - Twitter Vigilance
- Historical and updated data
- Services Exploited on:
  - Dashboard
- Since 2020

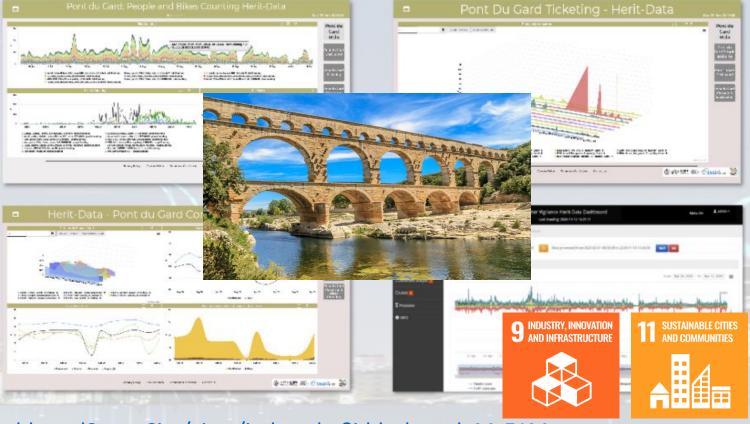












Pilots of Snap4City on:

• Greece - READ S.A.: Rodi

• Italy – FRI, UNIFI: Firenze

• Spain – FV, FSMLR: Valencia

• Cyprus – ANELEM: Limassol

• Bulgaria – VEDA: Varna

 Croatia – RERA SD: Splitskodalmatinska županija

• Malta - MRDDF: La Valletta

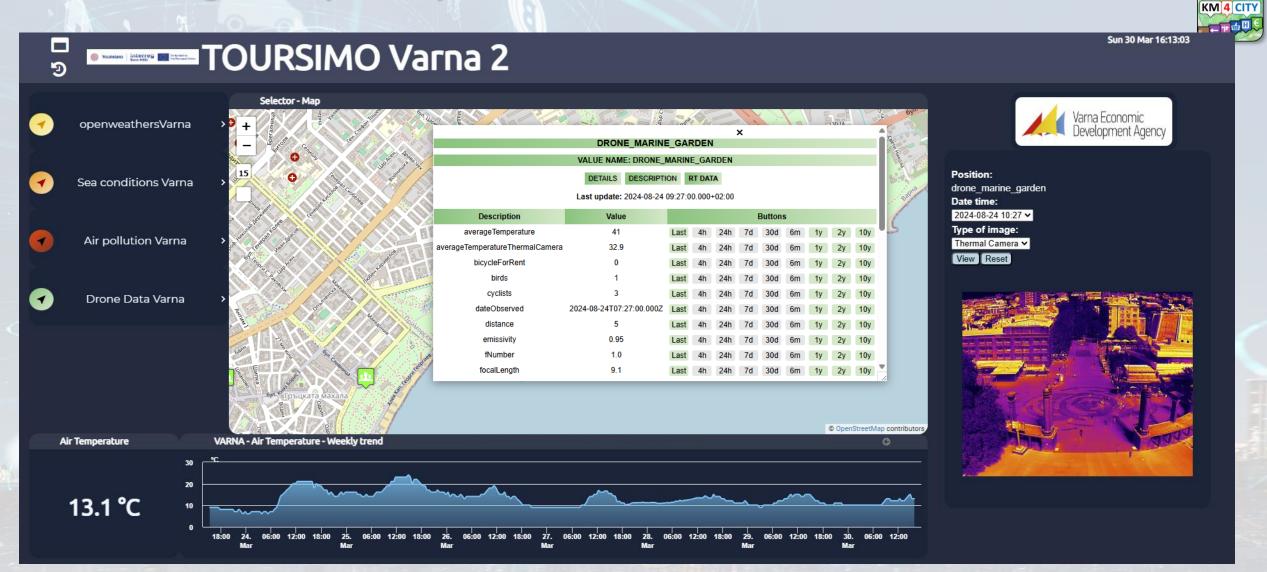




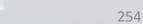


## Counting People by Drones in Varna





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





## Tracking People vs Environment in Malta







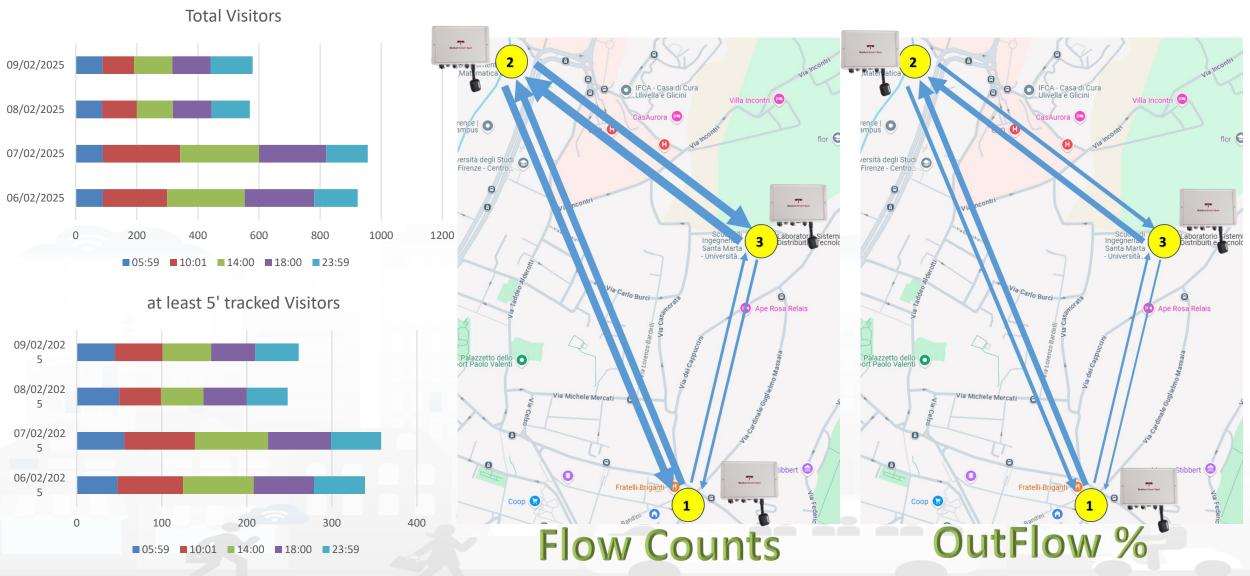








## **Libelium PaxCounters**

















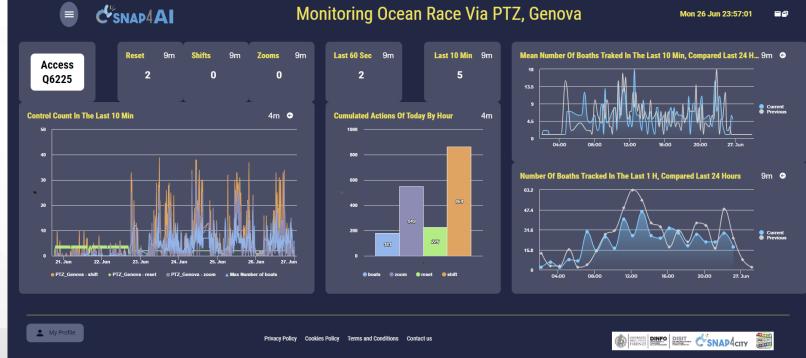


# **SUSTAINABLE CITIES** AND COMMUNITIES

## **Monitoring Boats AXIS Q6225**

Genova: Ocean Race, 2023







Details

Tools for rapid implementation of - Sustainable Smart Solutions - Decision Support Systems as a no-coding, low-coding







Snap4City (C), May 2025 258





#### **FREE TRIAL**











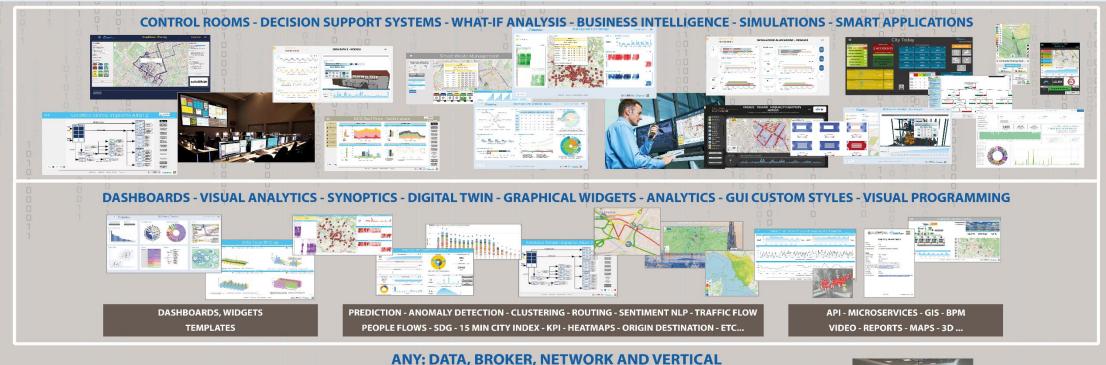


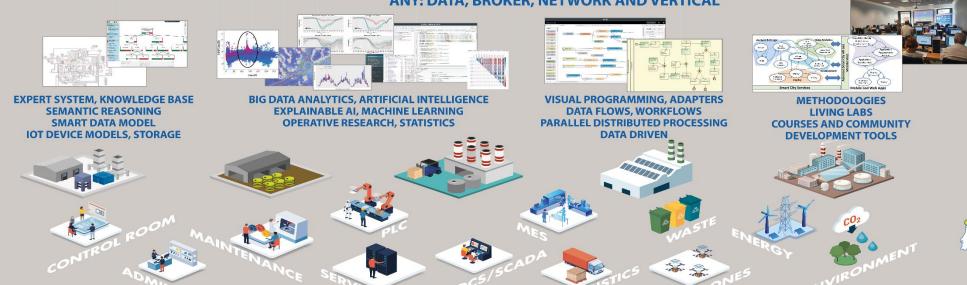






#### Smart Solutions and Decision Support Systems







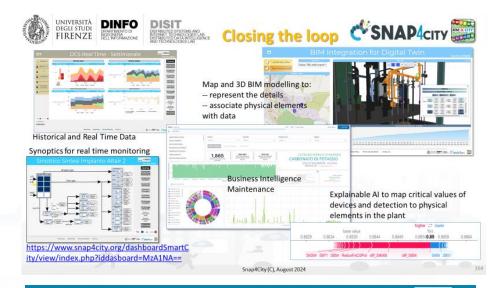


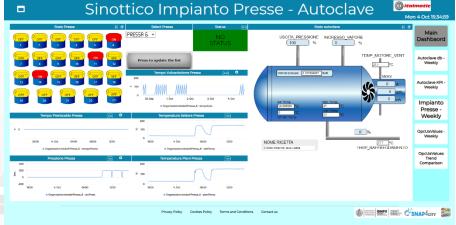




## **Industry production Domain** (2025/5)

- Goals:
  - Cost reduction, increase control on production
  - Production optimisation
  - Quality Level
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring KPI: administration, production, commercial, faults, etc.
  - Early detection/warning, alarm, of critical conditions.
     Multichannel Event reporting: email, Telegram, mob apps, etc.
  - Managing maintenance operation, predictive maintenance
  - Simulation of Fluid dynamic on Autoclaves
- Solutions for Planning (optimization and what-if analysis)
  - Generative AI and predictive AI for production plan optimisation
  - Reduction maintenance costs, reduction of critical SLA conditions, improving quality level
- Algorithms and computational solutions

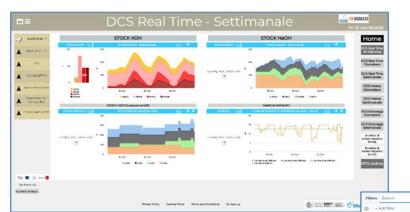




#### **Predictive Maintenance**







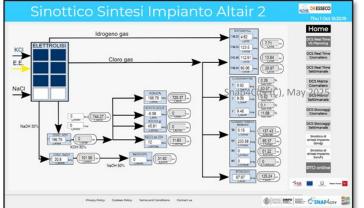
Map and 3D BIM modelling to:

- -- represent the details
- -- associate physical elements

with data

Historical and Real Time Data

Synoptics for real time monitoring



https://www.snap4city.org/dashboardSmartC ity/view/index.php?iddasboard=MzA1NA==





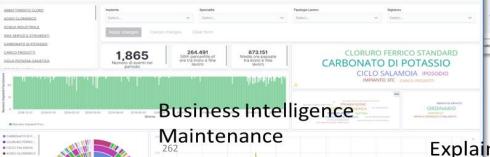






Valve 786 with trend





Explainable AI to map critical values of devices and detection to physical elements in the plant



# Snap4Altair Decision Support supervision and control, Industry 4.0







Multiple Domain Data

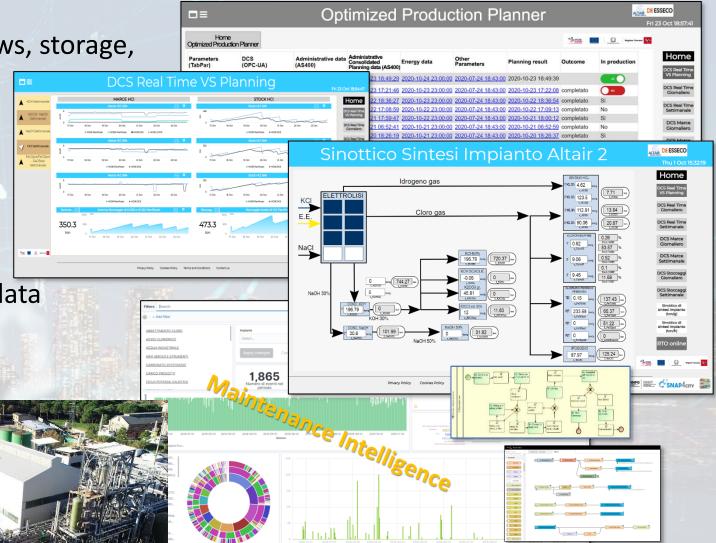
Distributed Control System: energy, flows, storage,

chemical data, settings, ...

Cost of energy, Orders,

- Production Parameters
- Maintenance data
- Multiple Levels & Decision Makers
  - Optimized planning on chemical model
  - Business Intelligence on Maintenance data
- Historical and Real Time data
  - Billions of Data
- Services Exploited on:
  - Multiple Levels, Mobile Apps, API

• Since 2020



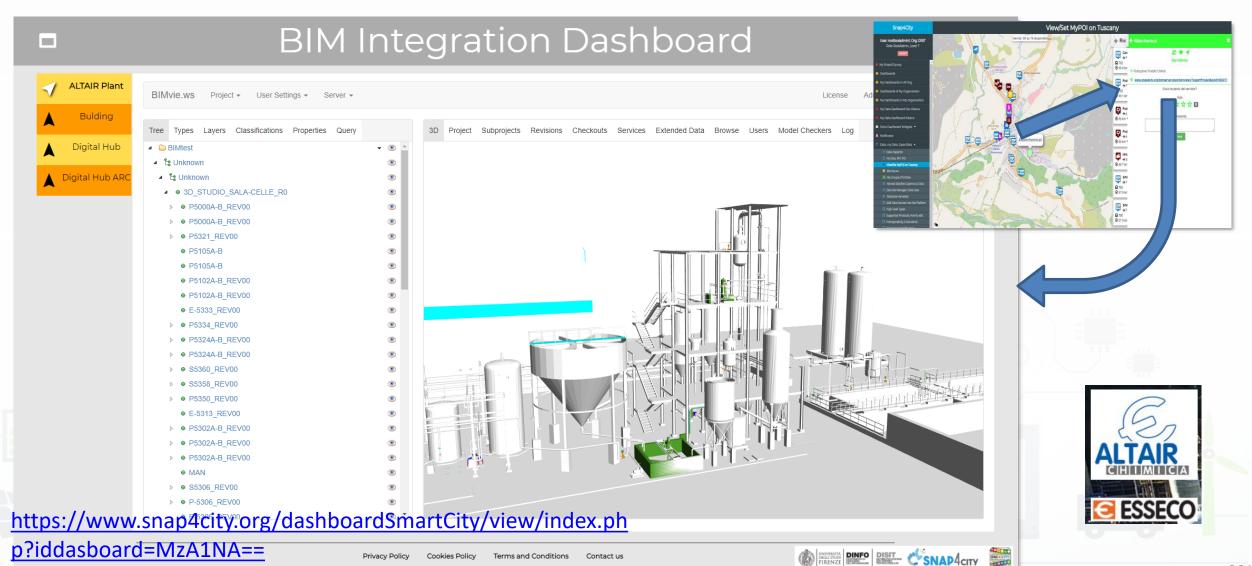








## **BIM view of the Altair Chemical Plant**



Snap4City (C), May 2025

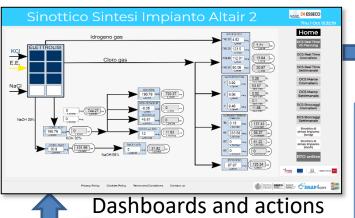




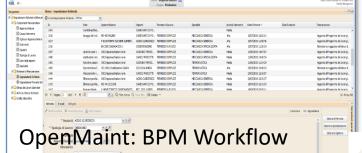




## **Workflow for Ticket management**



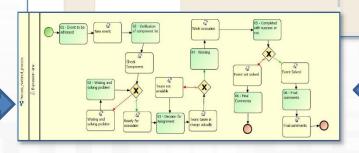




**Events/actions** 



OpenMaint: BPM Workflow management, team assignement, material control, ...





IOT App, Data event firing, event detection and firing Critical event management

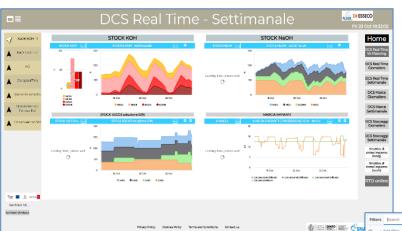






## **Closing the loop**



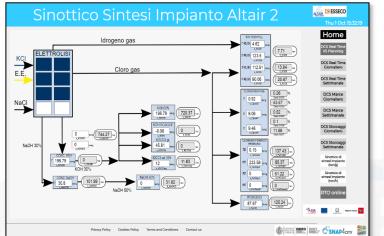


Map and 3D BIM modelling to:

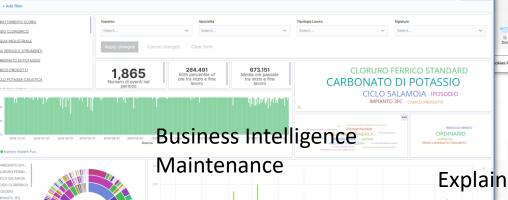
- -- represent the details
- -- associate physical elements with data

Historical and Real Time Data

Synoptics for real time monitoring



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA1NA==



Explainable AI to map critical values of devices and detection to physical elements in the plant

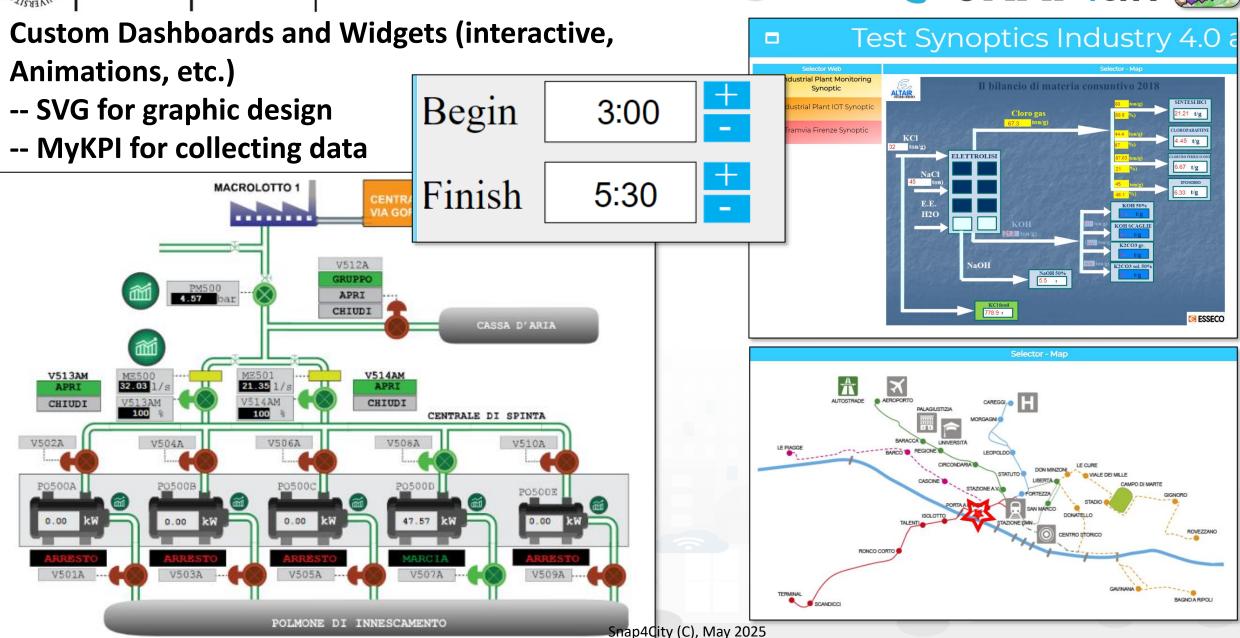






## DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB Custom Widgets





## EN.TE.R.PR.I.S.E.

(ENhanced TEchnological R&D of new PRoducts and Processes for Innovation, Smart factory and green Economy)

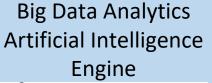




Administrative Data from AS400

Real Time Data, Historical, Events from DCS PC UA

Unique National Energy Costs (PUN)











## Analytical Data from the product quality Lab (LIMS/SAM)



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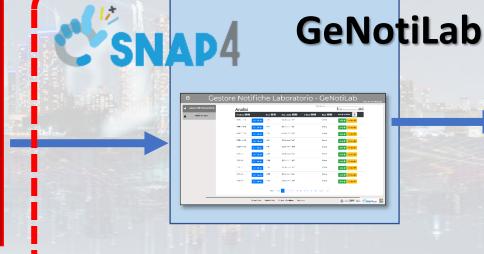






Regione Toscana







## **GeNotiLab Architecture for ALTAIR**





## Analytical Data from the product quality Lab(LIMS/SAM)

**AS400** 

**IOT App** 



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Users

Analysis

Notifications



IOT App Analytics

## Dashboards



IOT App Management



Tools:

- -- List of Chemical Analyses
- -- List of Notifications
- -- Define notifications
- -- Program, send notifications
- -- see notification status





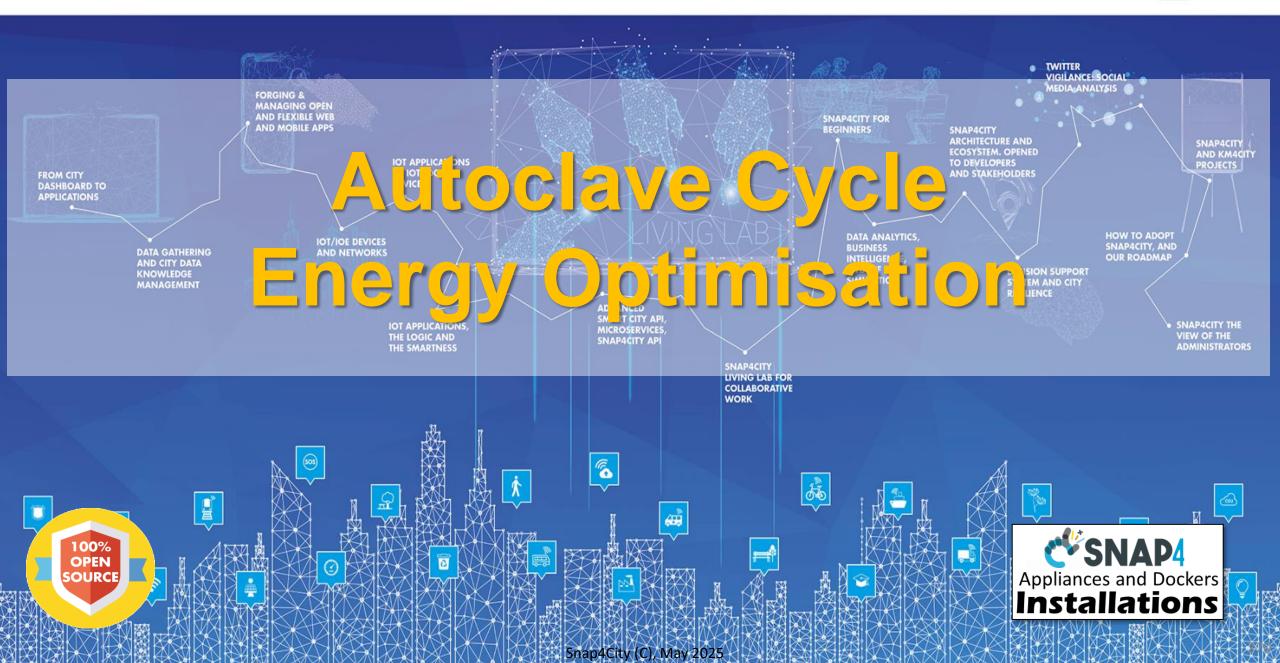
Telegram Bot



Snap4City (C), May 2025

#### **SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES**





## **Smart Manufacturing**

- Autoclave: curation process for: composite materials, rubber, ..
  - Reduction of computing costs for simulating load effect into the autoclaves curing process
  - Similar to design problems to be validated in wind galleries
- Solving Navier-Stokes PDE (partial differential equations) equation,
  - PINN plus new Transfer Learning techniques
  - Precision on steady and transitory cases
  - Validation wrt Open Foam
  - Reduction of computational time
- Videos on <a href="https://www.snap4city.org/1010">https://www.snap4city.org/1010</a>



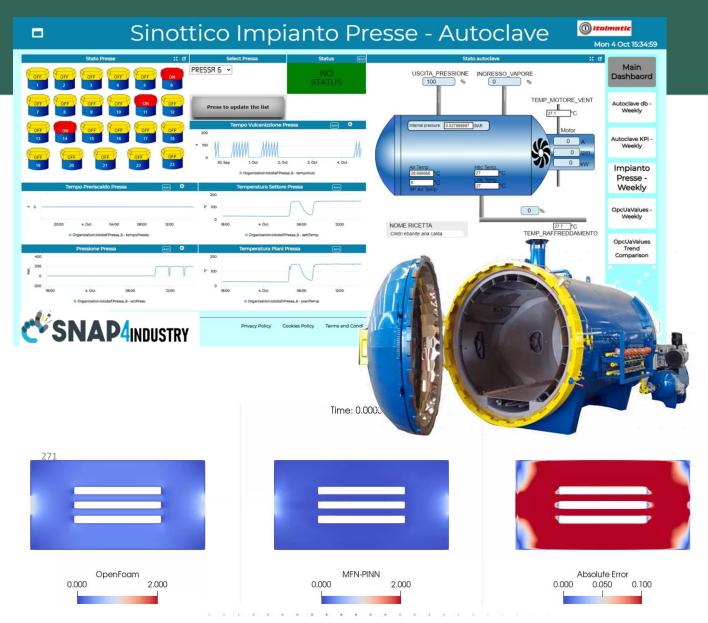












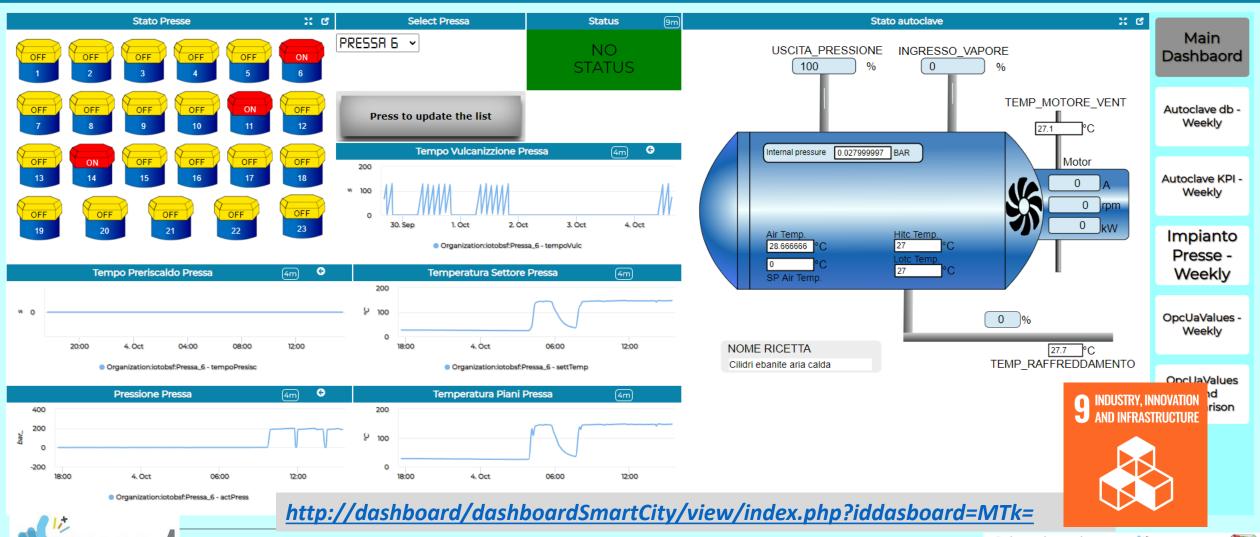


## **Sinottico Impianto**

#### Sinottico Impianto Presse - Autoclave



Mon 4 Oct 15:34:59

















## PINN: Physically Informed Neural Neworks Models

Solving Navier-Stokes PDE (partial differential equations)
equation, via PINN approach

Reduction of computing costs for simulating load effect into the

autoclaves curing process

Validation wrt Open Foam

Precision on steady and transitory cases

Definition of Transfer Learning techniques

• Videos on <a href="https://www.snap4city.org/1010">https://www.snap4city.org/1010</a>



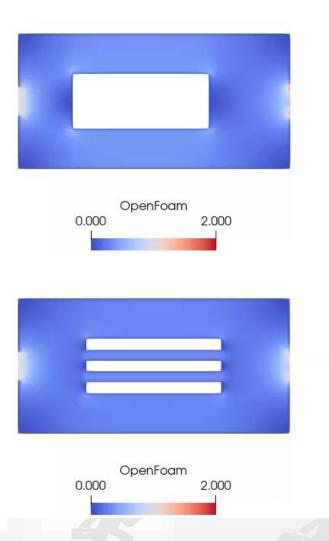


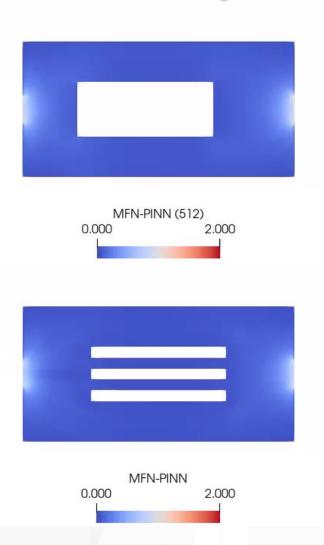


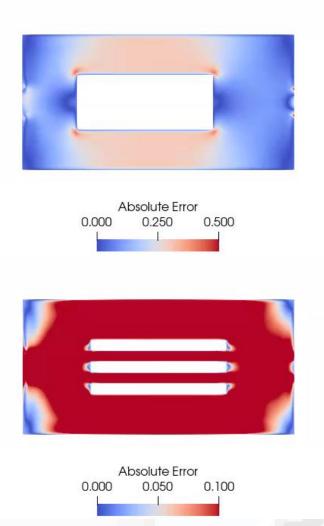




## Comparison of PINN vsoopenFoam and error











# MOST@EXPO Osaka: From Research to Business

Auditorium Padiglione Italia April 20, 2025

OPTIFaaS

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



**Decongestion** 



Safety





**Accessibility** 



Cost





**Decarbonization** 

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







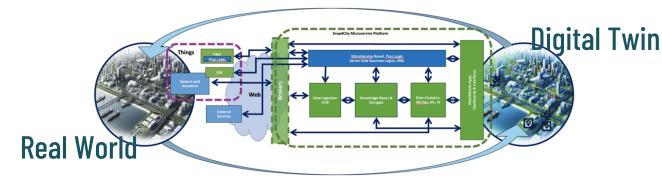






Smart & Sustainable Mobility with Snap4City / OPTIFaaS Empowering Cities with AI based Digital Twin

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



#### Al Technologies

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

# Traffic Flow Analysis By Scenario Traffic Flow Ana

# 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













Platform Value & Business Model

**OPTIFaaS** 

Scalable Solutions for Smart City Growth

#### Snap4City

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



#### Open

open source, interoperable, modular, microservices

Snap4City (C), May 2025

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#### Scalable

with city size and complexity



#### Al-powered platform

data-driven platform for mobility innovation



sustainability

#### **Optimizing Transportation Systems**

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

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













Sustainability & Social Benefits

Driving the Future: Smarter. Greener.

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

"

**Social Impact** 

Reduced travel times and emissions

Accessibility and inclusivity

Road safety



#### Sustainability Features

Traffic optimization

Multimodal transport integration

Data-driven simulation and what-if analysis

Fuel consumption reduction















#### Be smart in a SNAP!





#### CONTACT

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