



www.snap4city.org

www.snap4solutions.org



UNIVERSITÀ
DEGLI STUDI
FIRENZE

DINFO
DIPARTIMENTO DI
INGEGNERIA
DELL'INFORMAZIONE

DISIT
DISTRIBUTED SYSTEMS
AND INTERNET
TECHNOLOGIES LAB



www.km4city.org

***AI Digital Twin Platform
for Sustainable
Decision Support Systems
& Business Intelligence tools***

Paolo Nesi: paolo.nesi@unifi.it

#snap4city
#km4city
#disitlab
@snap4city

Public Spaces as Critical Infrastructures

- The City is a system of systems for city users
 - Cascading effects
- **Transport** networks
 - Main means for rescue teams, food, water, etc.
- **Communication**, ICT infrastructure
 - TV cam, switches, cyber,
- **Energy** networks
 - power supply for health, cyber systems, etc.
- **Hospitals** networks
- Aggregation areas

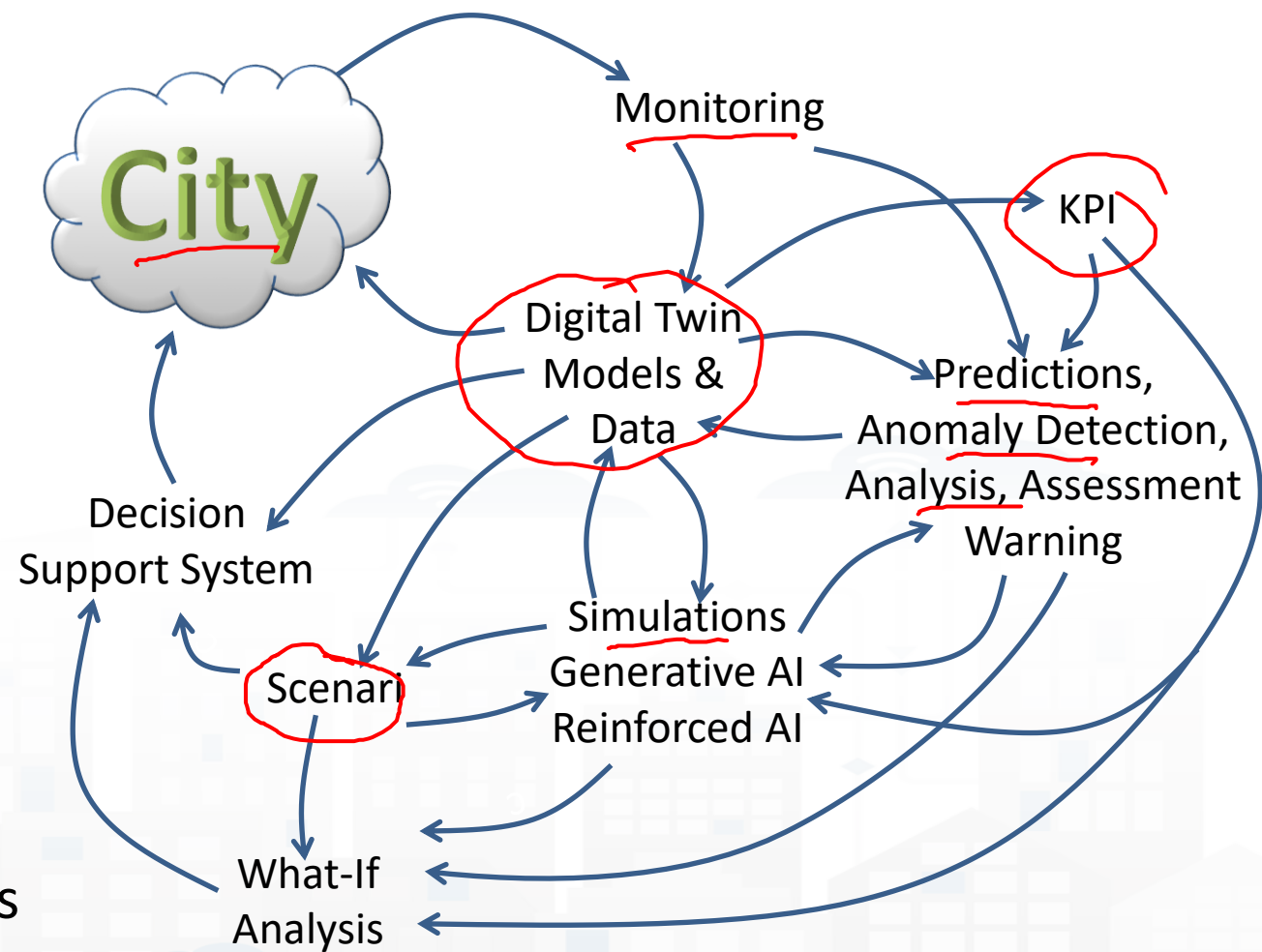


https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf

Complex Smart Applications

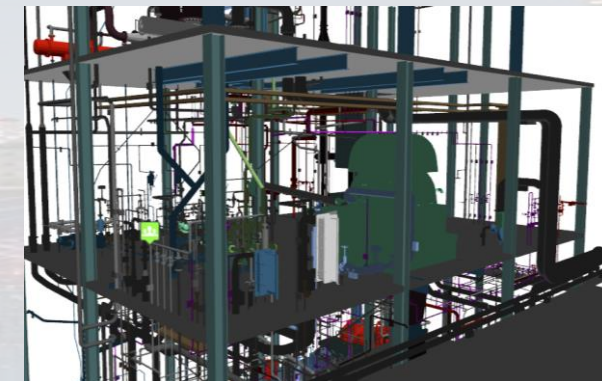
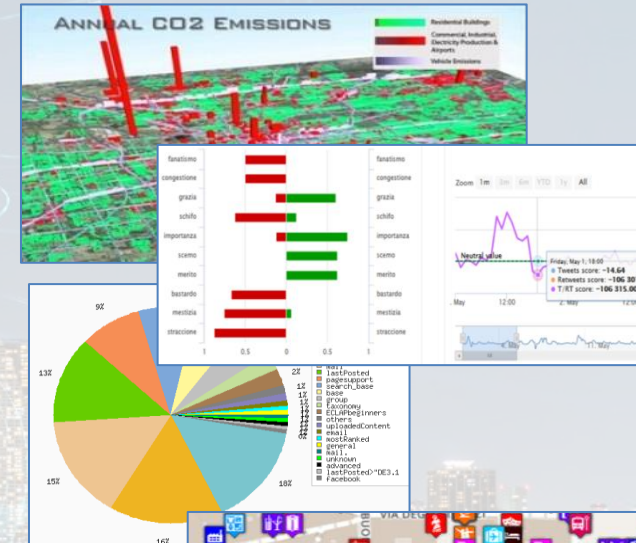
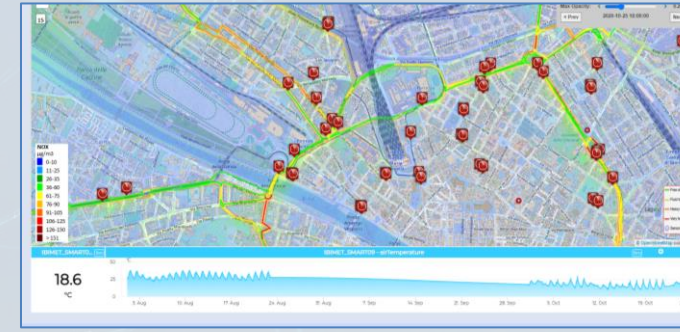
- **Recent solutions**
 - MaaS, sharing, evolution of info-mobility
 - Connected Vehicles
 - Energy vs Environmental applications
 - Etc.
- **Most of them share the same modules, differently implemented and combined, but the same modules**
 - Real time data gathering and derived info distribution
 - Predictive and/or simulative models, on edge or cloud
 - Data gathering + monitoring + plan + rendering: dashboard, visual analytics, mobile apps

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

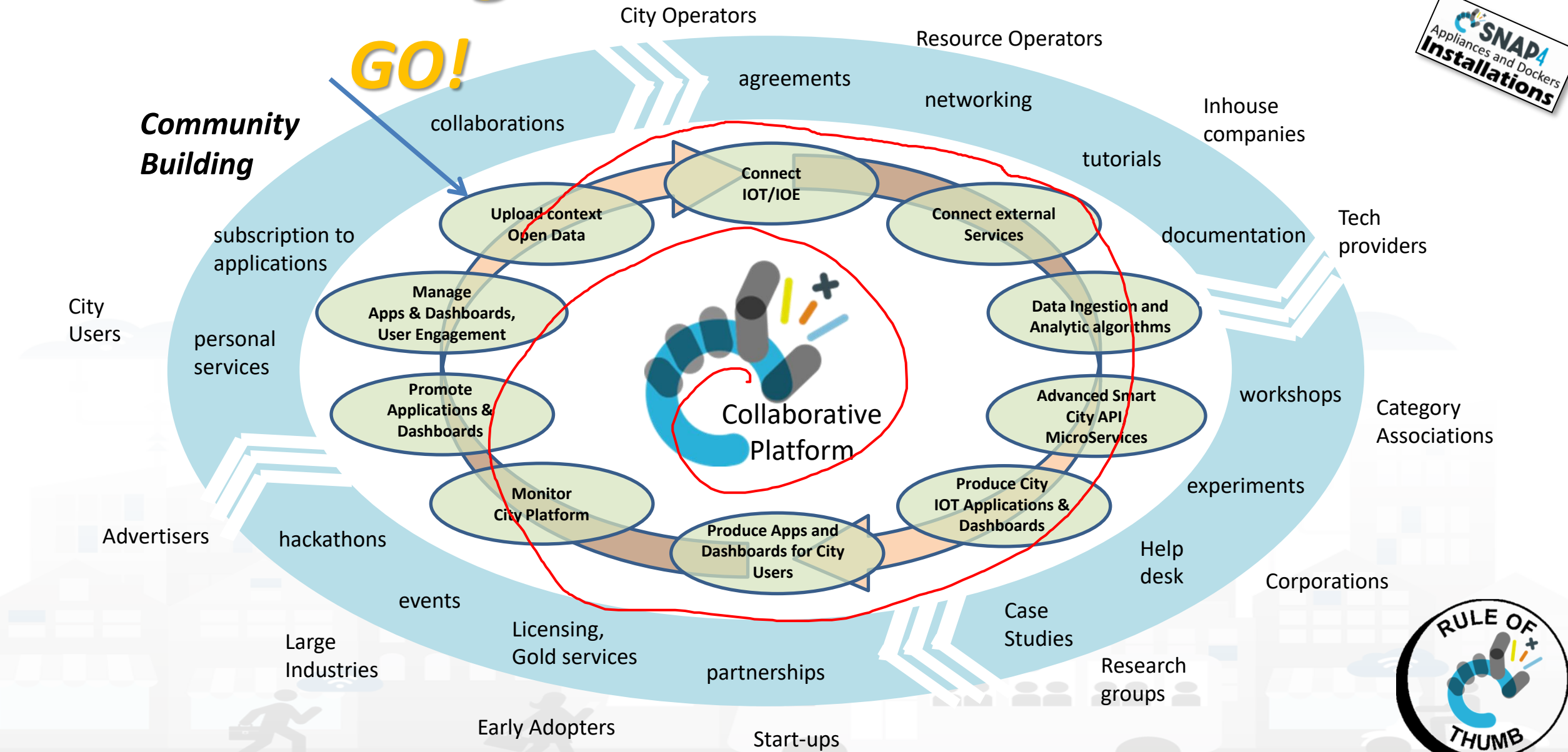


Digital Twin

- **Digital Twin**
 - **Connected** with real systems
 - **Modelling** aspects: structural, visual, informative, real time data sensors (context), POI, functional, resources, etc.
 - **Analytics:** AI/XAI techniques, simulations, users' needs, etc.
- **Easier to understand the context, review from multiple points of view**
- **Useful to perform**
 - Discussion with city users
 - Support decision makers
 - By Case Experiments for analysing
 - New solutions, impact of disaster (natural and provoked)
 - Reduction of costs in the analysis, in reduction of mistakes



Accelerating



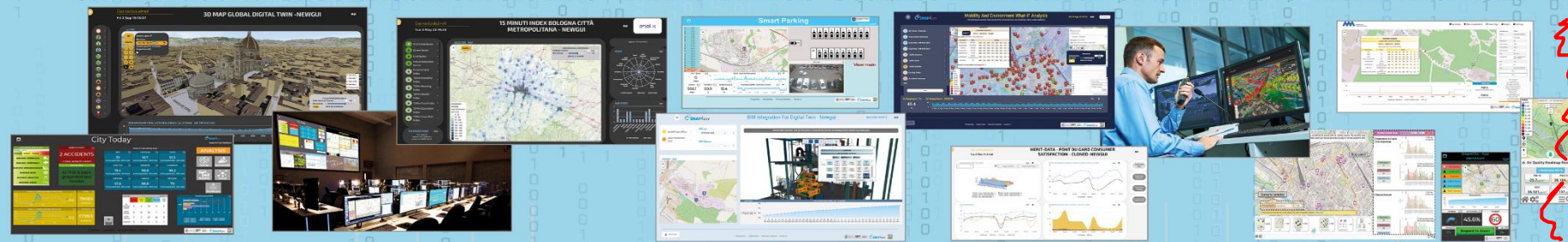
Snap4City



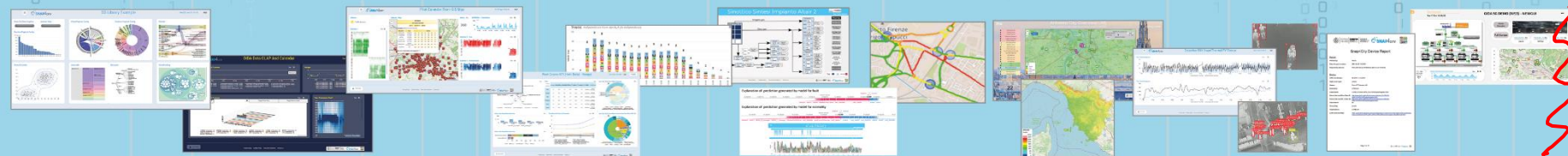


Smart Solutions and Decision Support Systems

CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS - BUSINESS INTELLIGENCE - SIMULATIONS - SMART APPLICATIONS



DASHBOARDS - VISUAL ANALYTICS - SYNOPTICS - DIGITAL TWIN - GRAPHICAL WIDGETS - ANALYTICS - GUI CUSTOM STYLES - VISUAL PROGRAMMING



DASHBOARDS, WIDGETS
TEMPLATES

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

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

ANY: DATA, BROKER, NETWORK AND VERTICAL

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

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

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

Native and External
Smart Applications

Mobility & Transport

Light & Energy

Waste

Environment

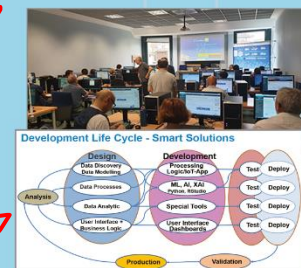
Building

Tourism

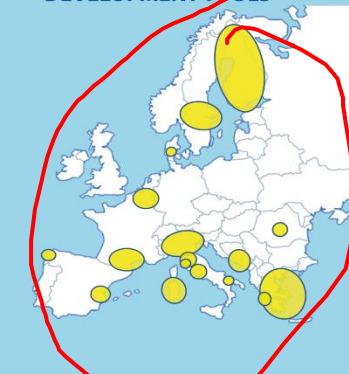
Asset Management

Security and Safety

Social Media



METHODOLOGIES
LIVING LABS
COURSES AND COMMUNITY
DEVELOPMENT TOOLS



Powered by
FIWARE

FREE
TRIAL

PEN Test
Passed

EU GDPR
COMPLIANT

SNAP4
Appliances and Dockers
Installations

EUROPEAN OPEN
SCIENCE CLOUD

Node-RED

JS Foundation

E015
digital ecosystem

NVIDIA

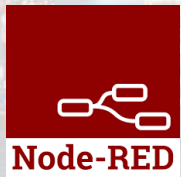
Standards and Interoperability (6/2023)



Compliant with:

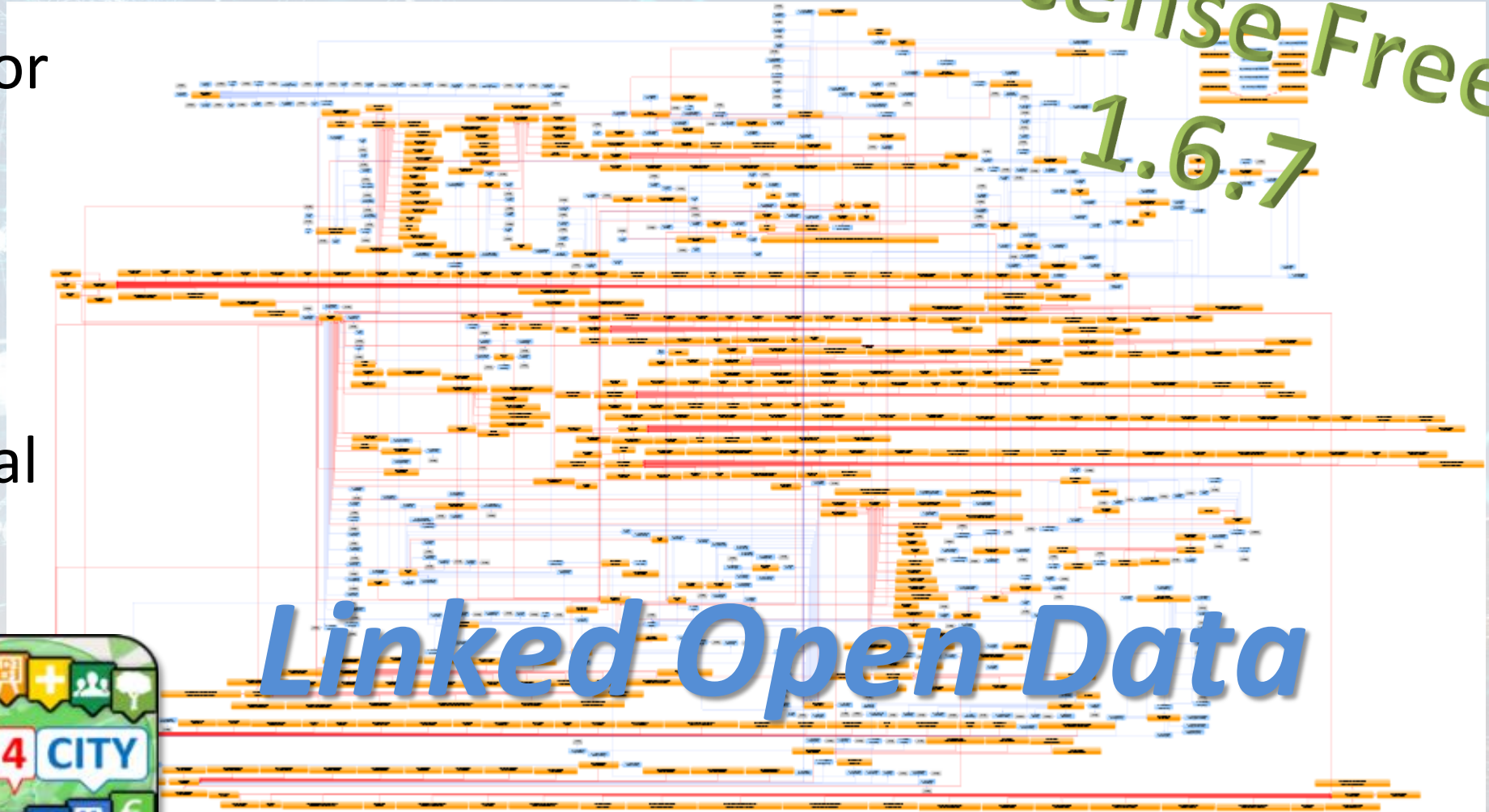
- **IoT:** NGSI V2/LD, LoRa, LoRaWan, MQTT, AMQP, COAP, OneM2M, TheThingsNetwork, SigFOX, Libelium, IBIMET/IBE, Enocean, Zigbee, DALI, ISEMC, Alexa, Sonoff, HUE Philips, Tplink, BACnet, TALQ, Protocol Buffer, KNX, OBD2, Proximus, ..
- **IoT model:** FIWARE Smart Data Model, Snap4City IoT Device Models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

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



Expert System *semantic queries*

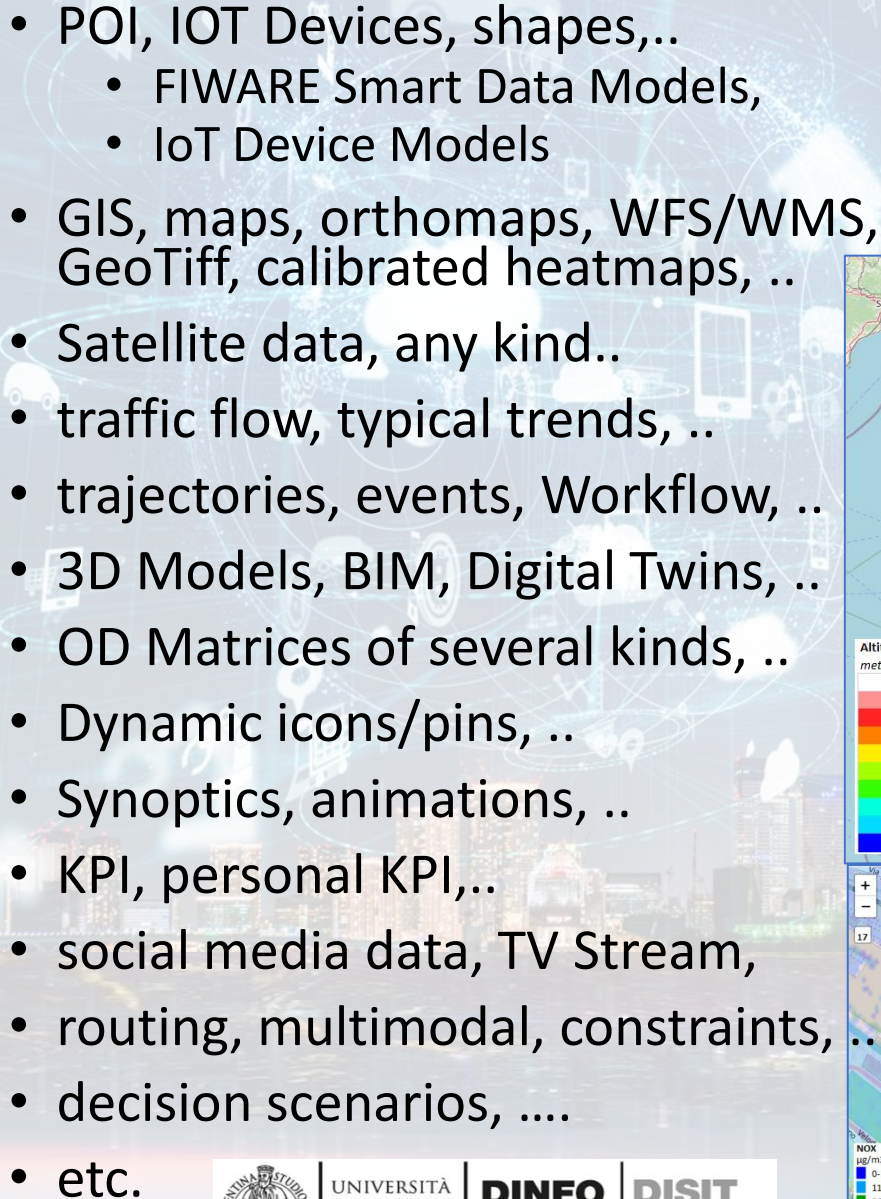

- via:
- **Smart City API** for Apps and third party
- **MicroServices** data driven develop via visual language Node-RED

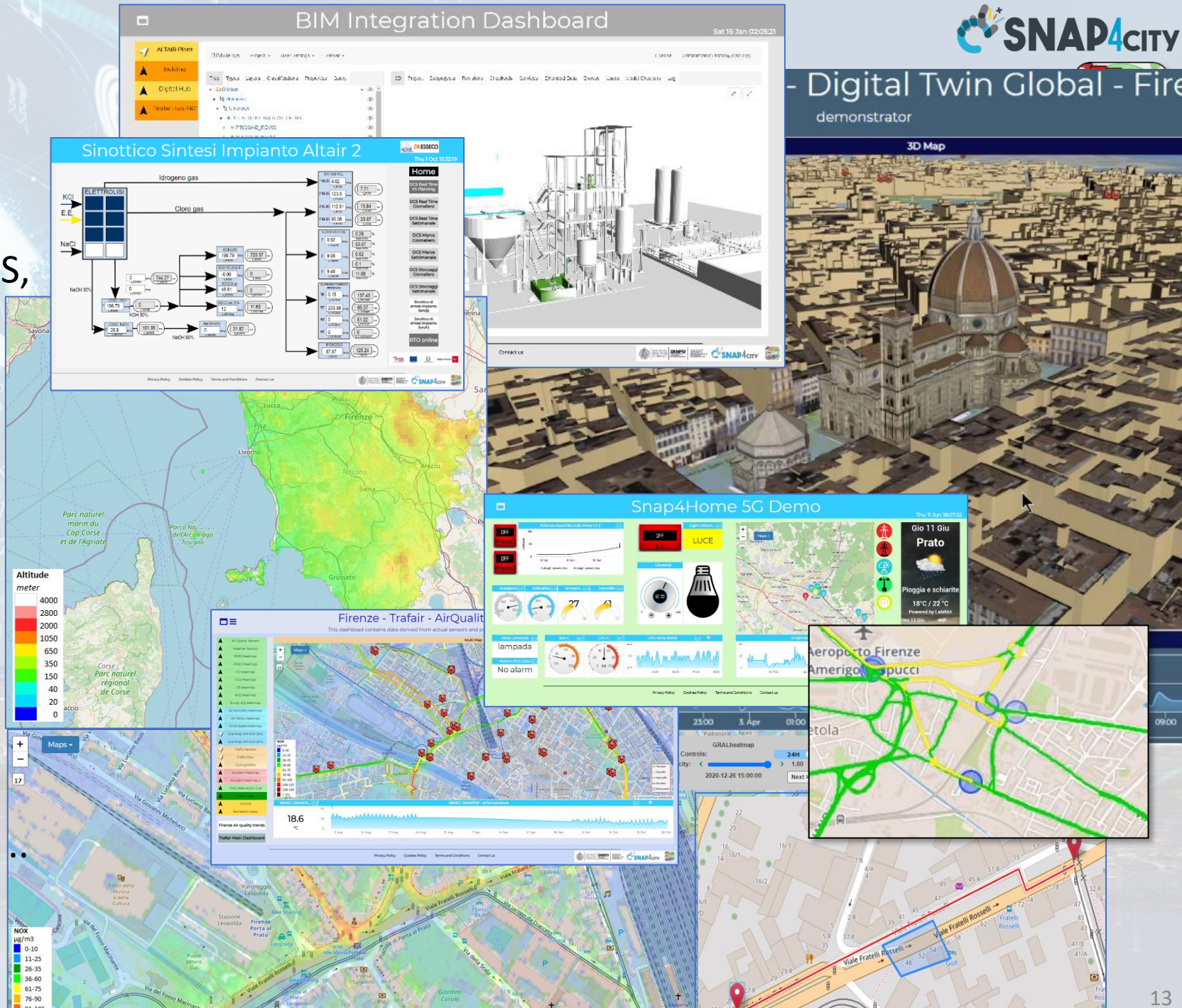


<https://www.snap4city.org/19>

High Level Types

Snap4City (C), February 2024

- 
- 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, ..
 - 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, ..
 - decision scenarios,
 - etc.
- 



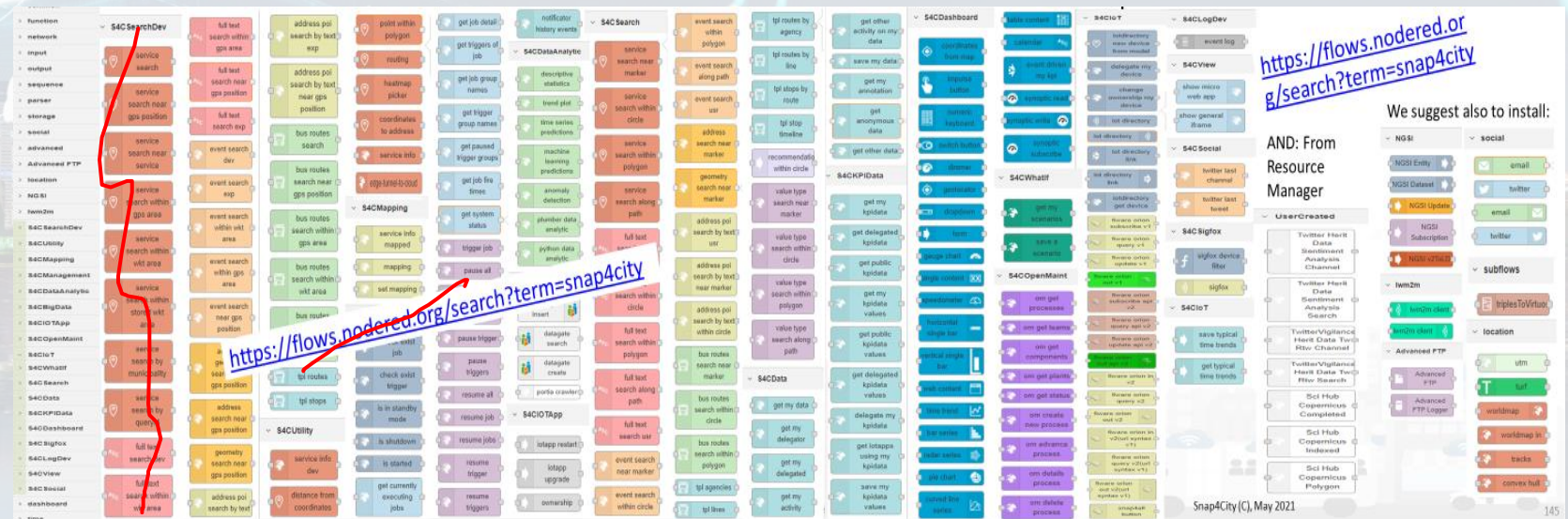
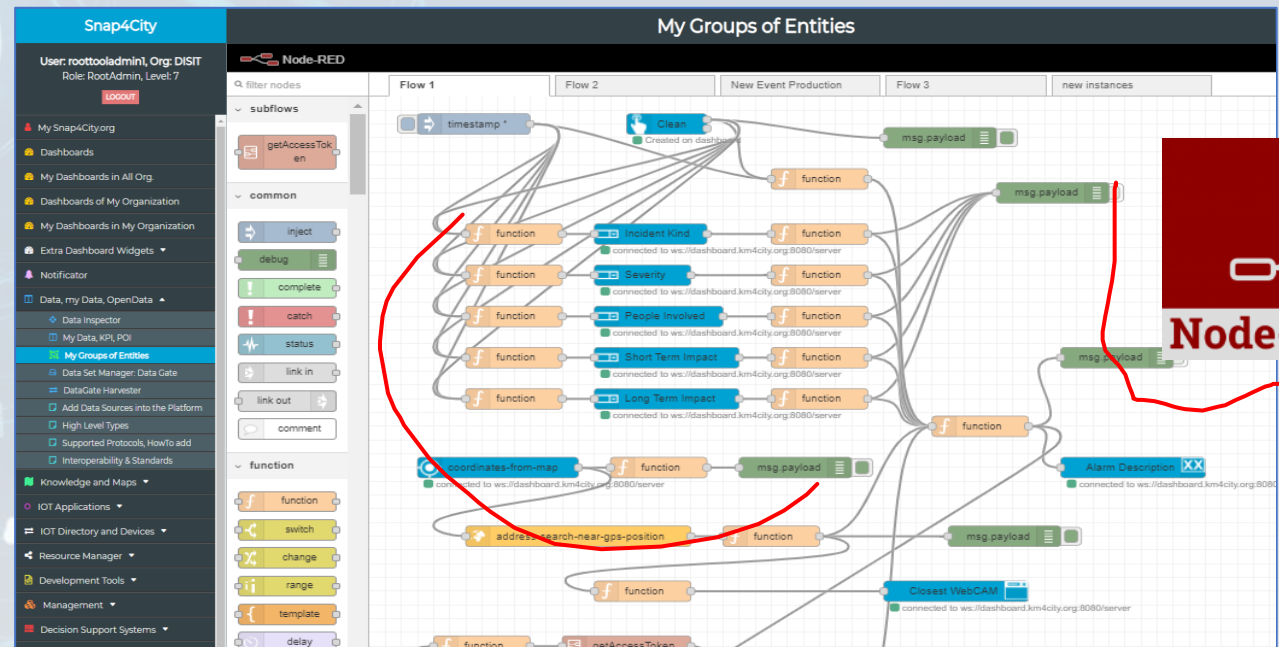
Ingestion, aggreg. → exploitation

• IoT App Visual Programming, no coding

- Data transformation
- Integration, Interoperab.
- Scripting Data Analytics
- Data ingestion
- Business logic

• Edge and Cloud

• MicroServices data driven develop via visual language Node-RED



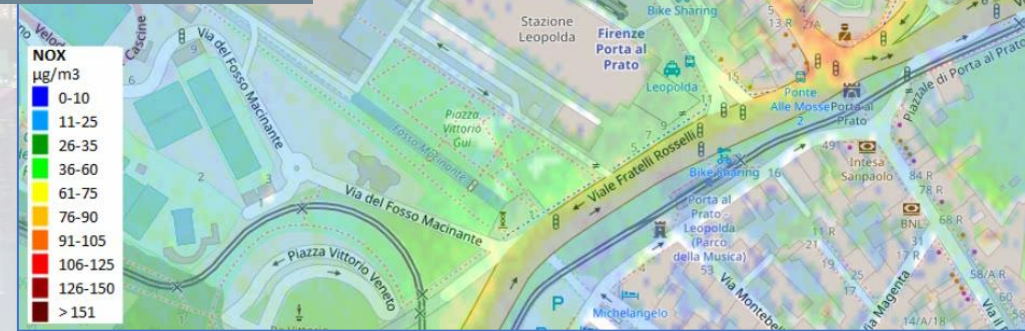
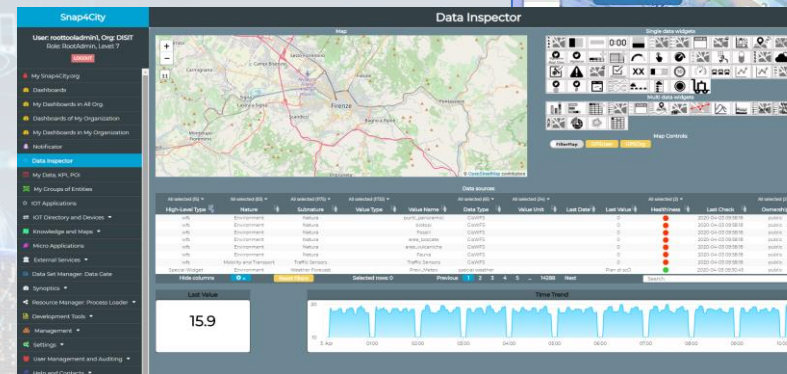
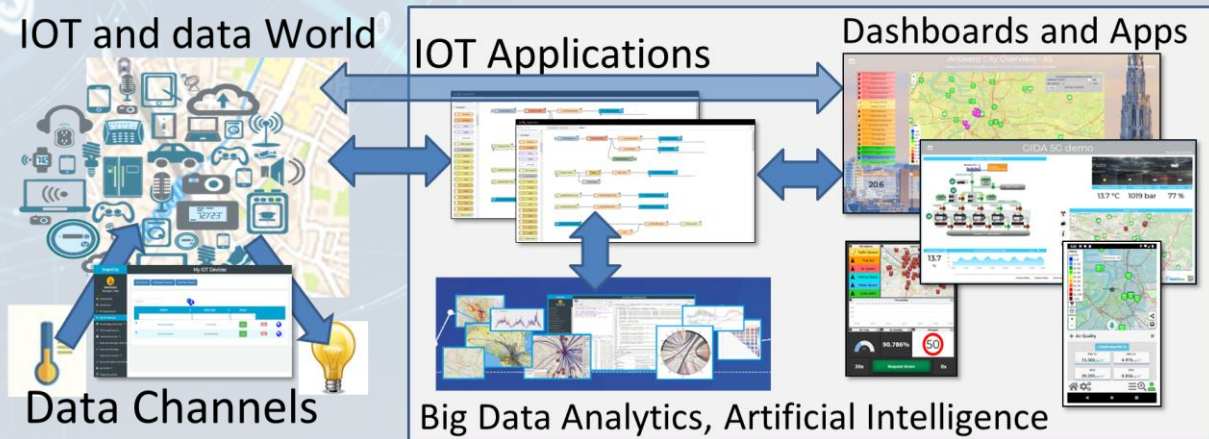
Solutions: reliable, secure and fast to realize

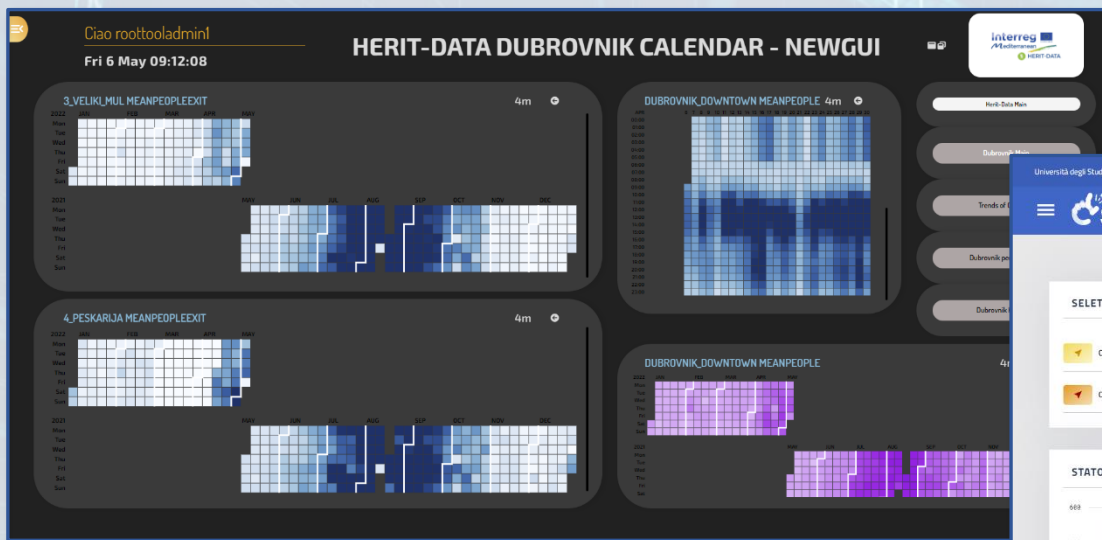
- **Via Snap4City tools**

- **Dashboard Wizard**
- **Dashboard Builder**
- **Data/Visual Analytic**

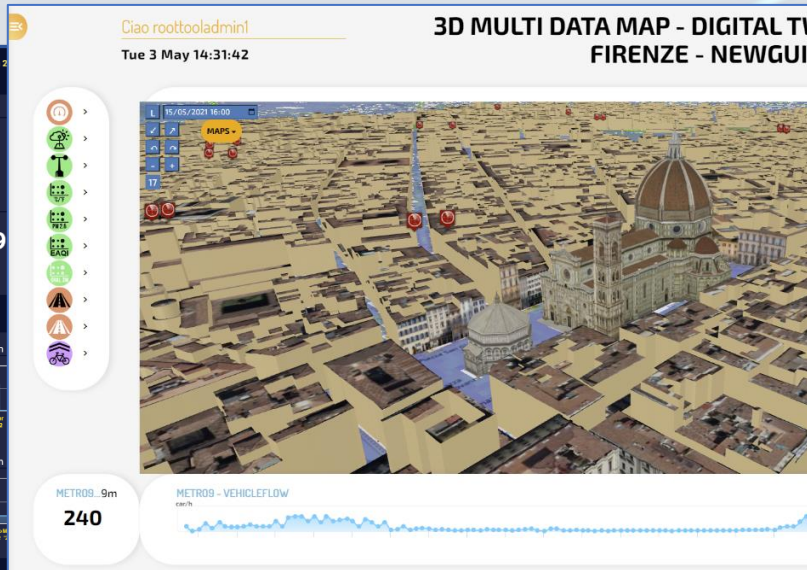
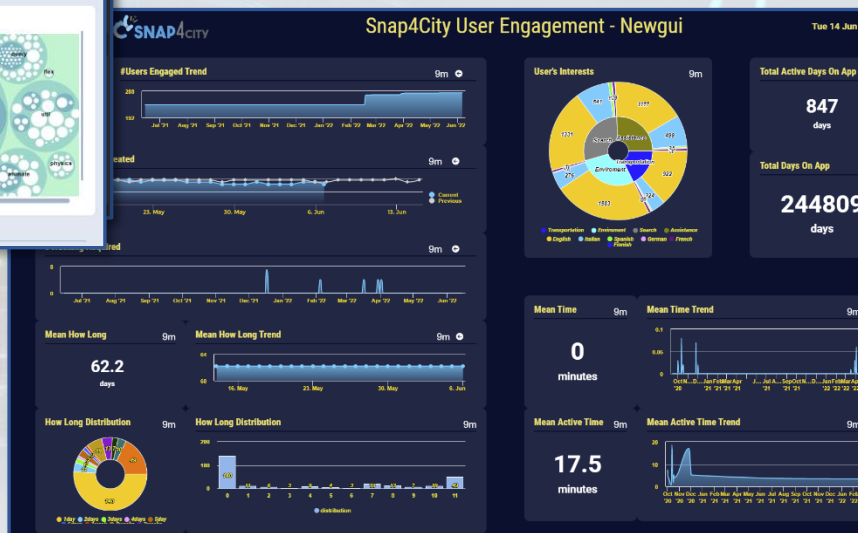
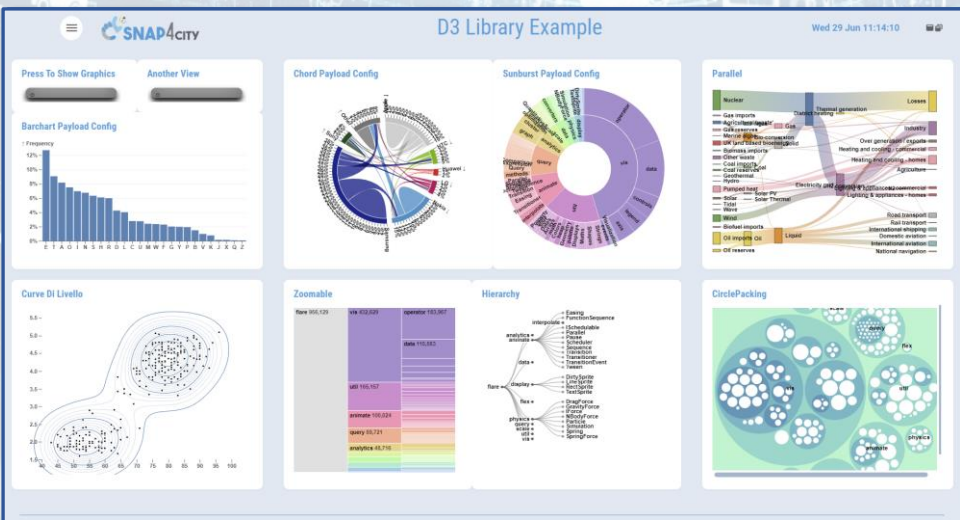
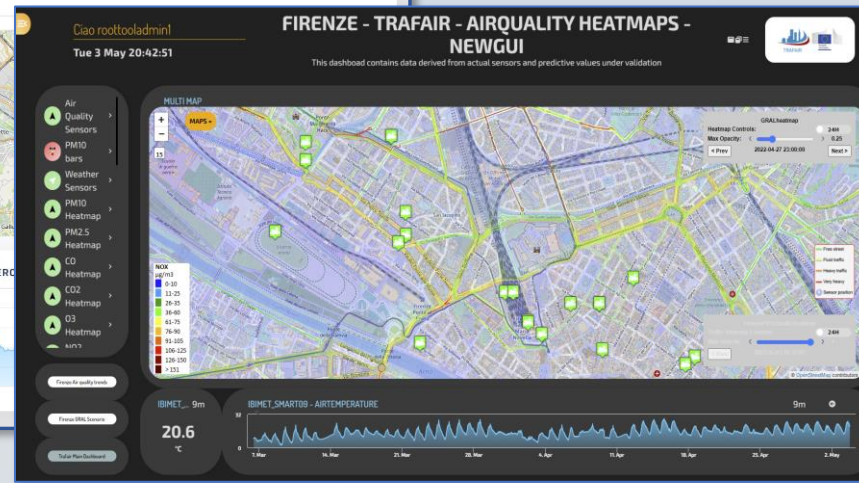
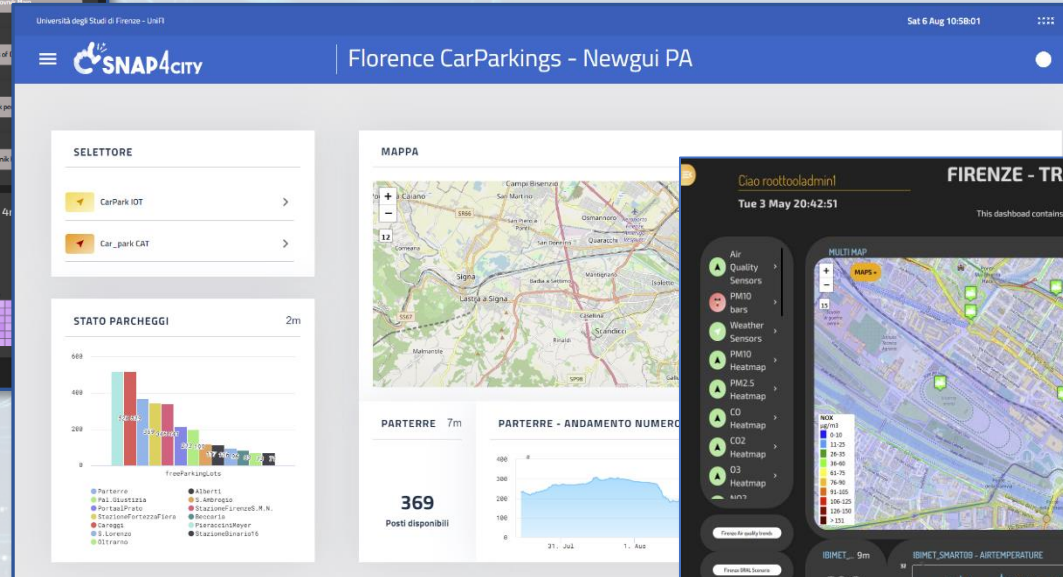
- **Smart Solutions results to be**

- **Real time data drive**
- **Secure end-to-end**
- **GDPR compliant**
- **Reliable, interoperable**
- **Auditable, marketable**





Different Themes

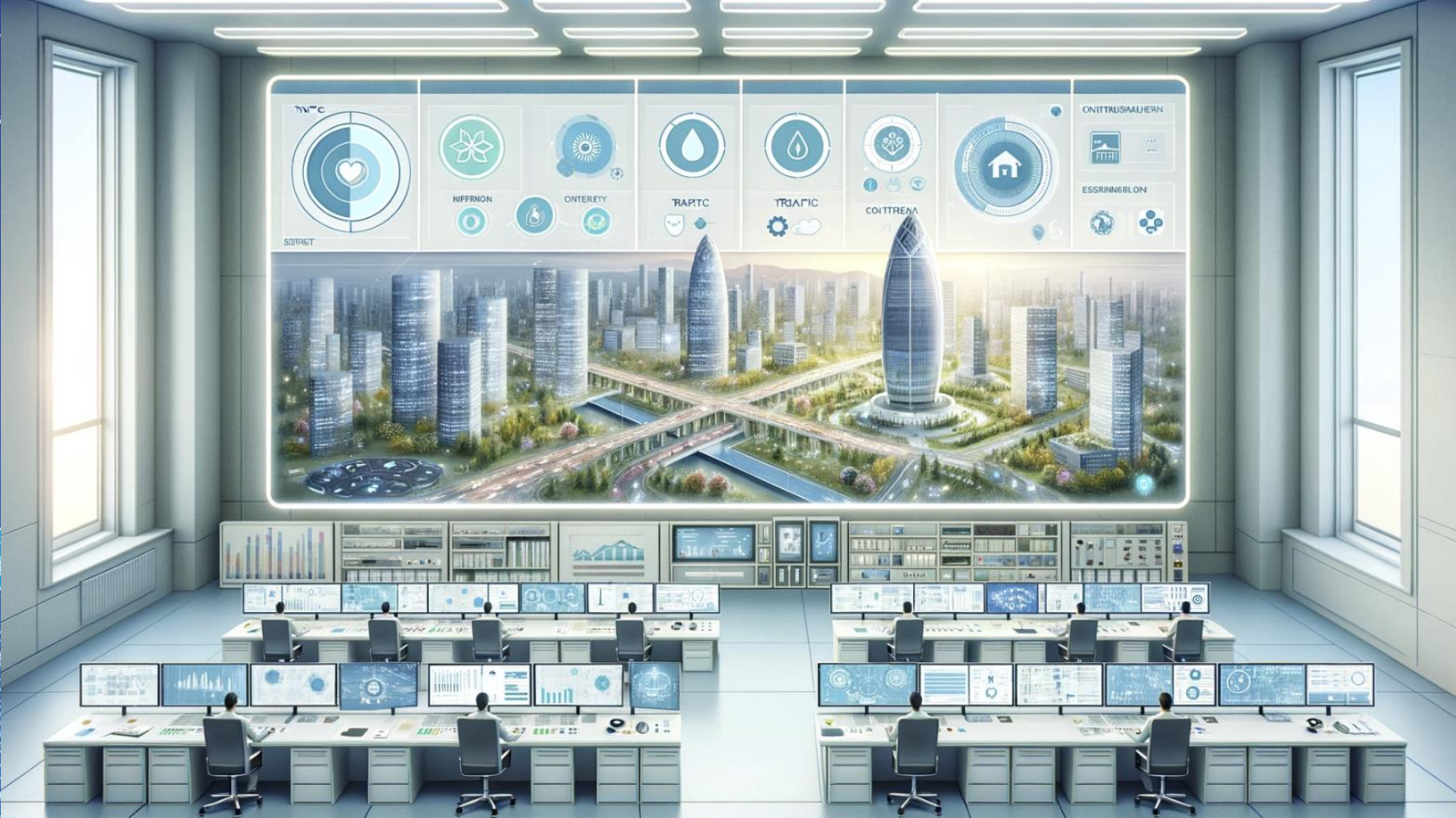


New styles/themes can be developed by specializing a few files from open source
<https://www.snap4city.org/793>

TOP

Monitoring and Control

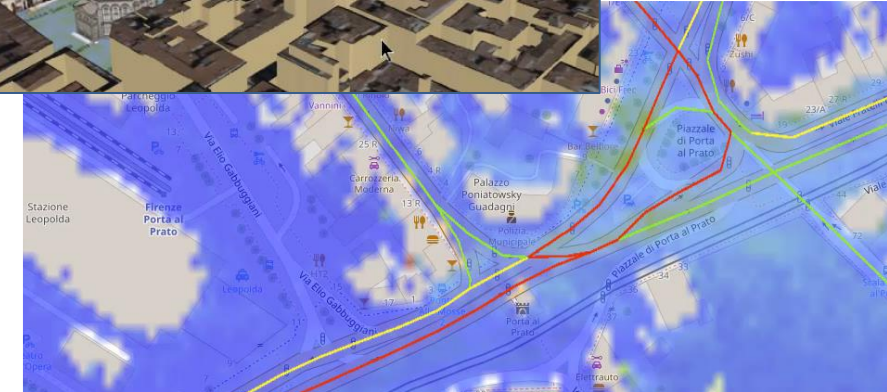
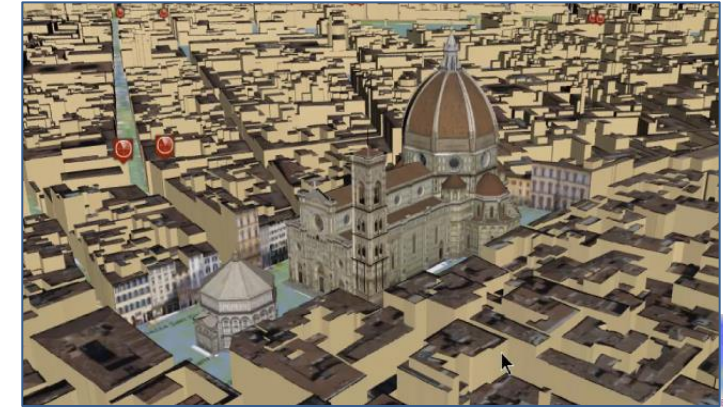
DATA GATHERING
AND CITY DATA
KNOWLEDGE
MANAGEMENT



HOW TO ADOPT
SNAP4CITY, AND
OUR ROADMAP

SNAP4CITY THE
VIEW OF THE
ADMINISTRATORS

- **Controlling Status:** management, and operational
 - Monitoring via KPI
 - Computing predictions and KPI
 - Anomaly detection, Early warning
 - Control Rooms, situation rooms
- **Reacting: Computing in real time**
 - Changing semaphore maps
 - Changing Dynamic signage
 - Real time Info Mobility
 - User engagement via Mobile Apps
 - What-if analysis
 - etc.,



Smart City Control Room

Florence Metropolitan City



reference



- **Multiple Domain Data**

- 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**



<https://www.snap4city.org/747>



Key Performance Indicators, KPI



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

- **United Nations Sustainable Development Goals, SDGs** (for which cities can do more to achieve some of the 17 SDGs, <https://sdgs.un.org/goals>);
- **15 minutes cities** (where primary services must be accessible within 15 minutes on foot);
- **objectives of the European Commission** in terms of pollutant emissions for: NO₂, PM₁₀, PM_{2.5} (https://environment.ec.europa.eu/topics/air_en);
- **SUMI: mobility and transport vs env**
 - <https://www.snap4city.org/951>
- **SUMP/PUMS: mobility and transport vs env.**
- **ISO indicators:** city smartness, digitization, tech level.
- **Low Level/Real Time:** global traffic, quality of service, betweenness, centrality, queue, time to travel, etc.

**Global
&
Local**

**Periodic
&
Realtime**



• 15 Minute City Index:

- 13 subindexes: energy, slow mobility, fast mobility, housing, economy education, culture and cults, health, entertainment, gov, food, security...



- Monitoring and Prediction of energy consumption
- Stimulating: Bike sharing, e-bikes, car charge, etc.



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



- Monitoring and Predicting: NO₂, NO_x, CO₂, Traffic flow, pollutant, landslide, waste, etc
- Traffic flow reconstruction
- Demand vs Offer of Mobility analysis



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



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



- Shortening justice time
- Anonymization and indexing legal docs.
- Prediction of mediation proneness
- Ethical Explainable Artificial Intelligence

15MinCityIndex on Bologna

enel x



Ciao roottooladmin!

Tue 3 May 20:14:59

15 MINUTI INDEX BOLOGNA CITTÀ METROPOLITANA - NEWGUI

enel x

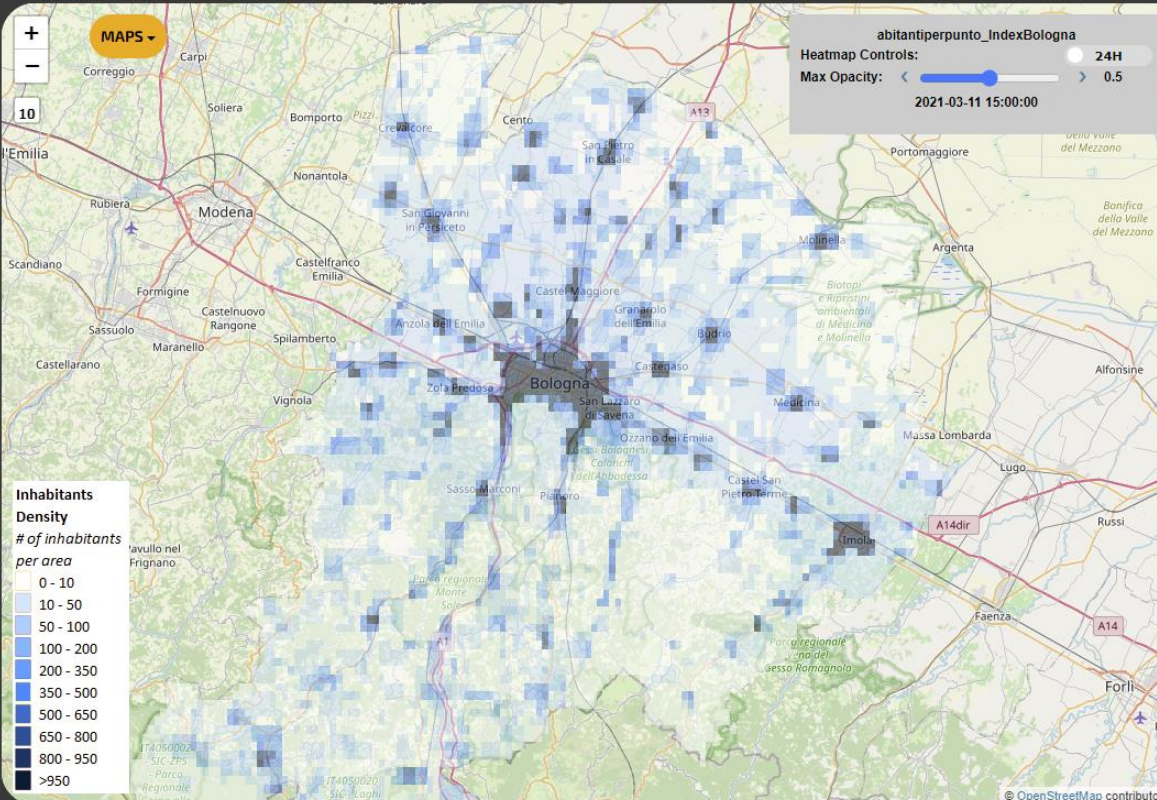
- # of Inhabitants
- Green factor
- Civil factor
- Industrialization factor
- Environment Index
- 15Min Economy Index
- 15Min Housing Index
- 15Min Health Index
- 15Min Food Index
- 15Min Education Index
- 15Min Slow Mob Index

THE PICKED POINT

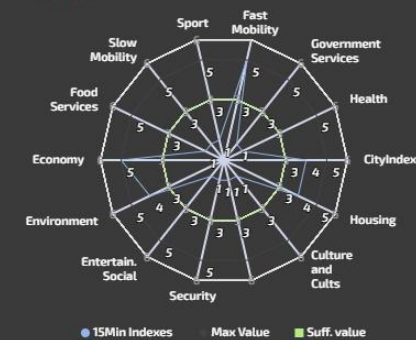
9m

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

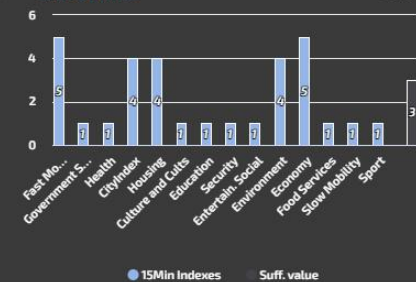
SELECTOR - MAP



KIVIAT



BAR SERIES



1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



7 AFFORDABLE AND CLEAN ENERGY



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



15 LIFE ON LAND



TOP

FROM CITY
DASHBOARD TO
APPLICATIONS

FORGING &
MANAGING OPEN
ARCHITECTURE
AND ECOSYSTEMS

IOT APPLICATIONS
AND DEVICES

CAPACITY FOR
DEVELOPERS

CAPACITY
ARCHITECTURE AND
ECOSYSTEM, OPENED
TO DEVELOPERS
AND STAKEHOLDERS

TWITTER
VIGILANCE, SOCIAL
MEDIA ANALYSIS

SNAP4CITY
AND KM4CITY
PROJECTS

Decision Support System: Immediate response and Tactical and Strategic Plans, via What-if Analysis

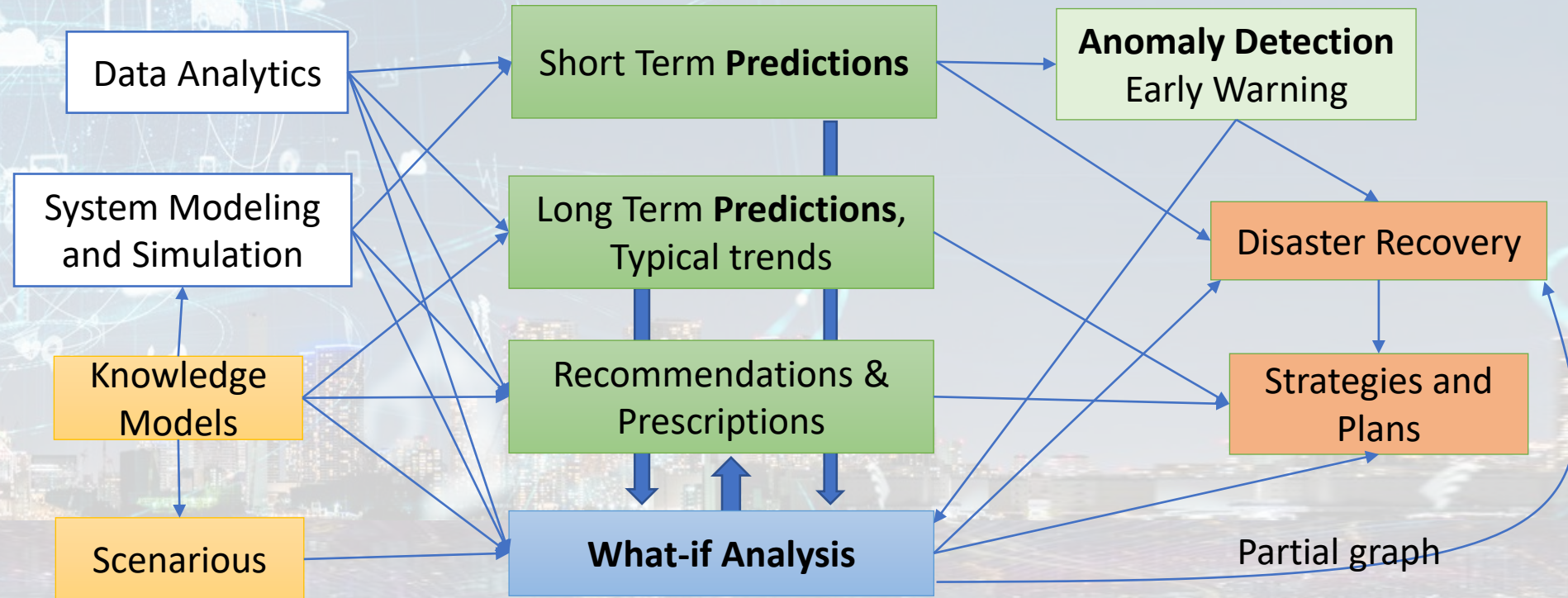
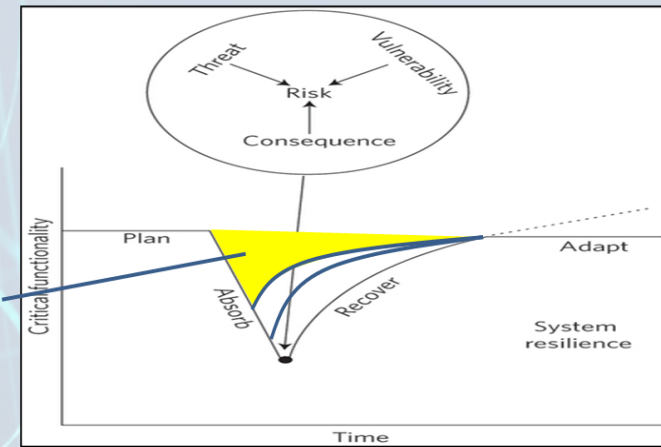


NAP4CITY THE
VIEW OF THE
ADMINISTRATORS

Snap4City What-If

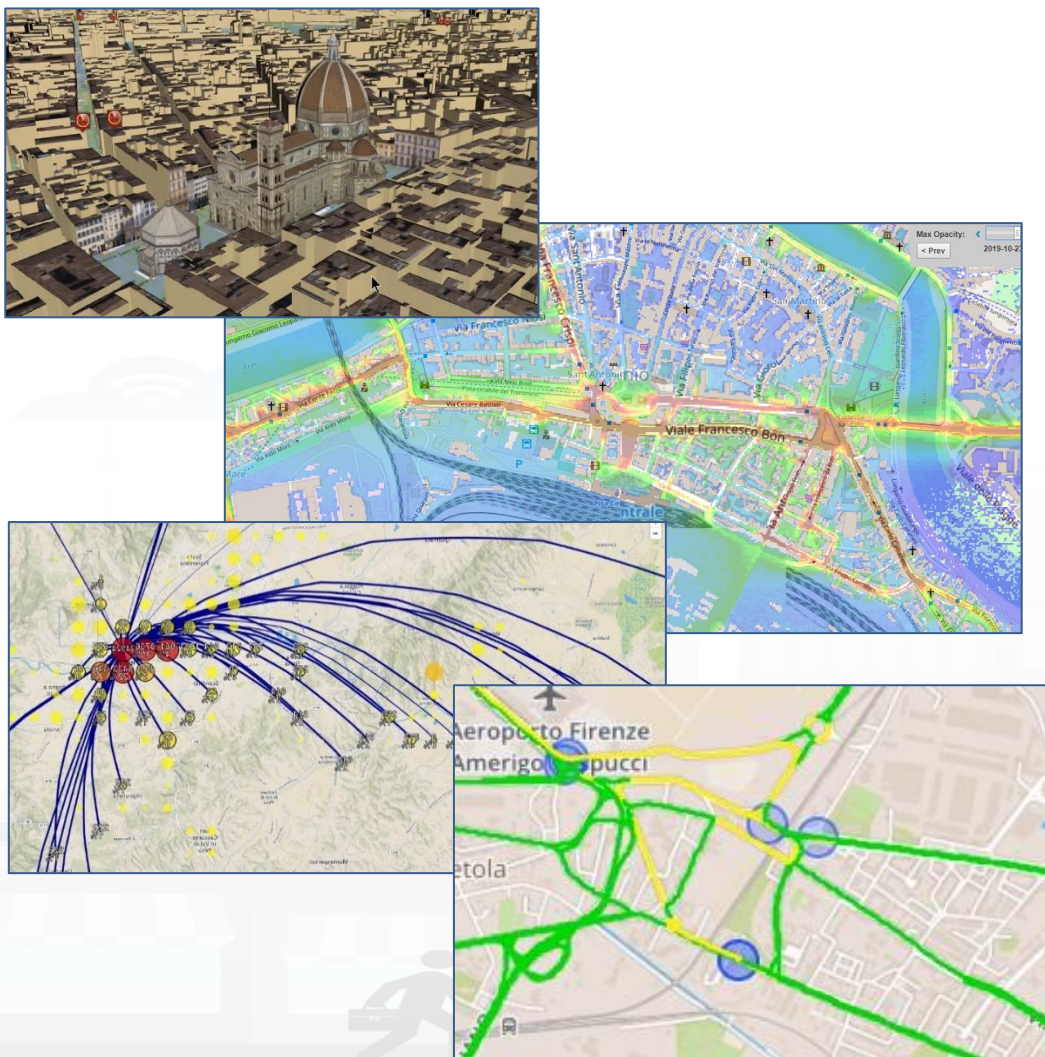
- Decision support systems
- Improvement of life quality
- Sustainable Solutions
- Reduction of costs
- Risk Assessment
- Resilience

Prepare
Absorb
Recover
Adapt



Decision Support System: neuro-symbolic reasoning
 targeting Indicators: Quality of Life, PUMS, SUMI, KPI, SDG, 15MinIndex,...

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
- 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
- Collaborative and shared representation
- Sustainable, shared, open source 100%

Complex and heterogeneous information, interoperability

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



Ciao roottooladmin!

Fri 2 Sep 19:13:07

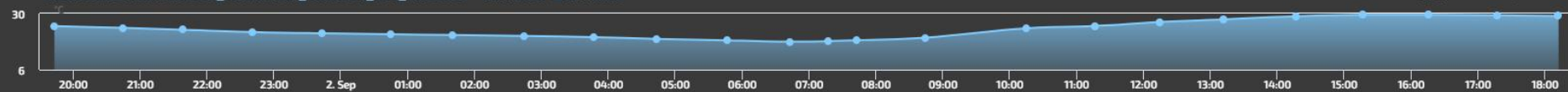
3D MAP GLOBAL DIGITAL TWIN -NEWGUI

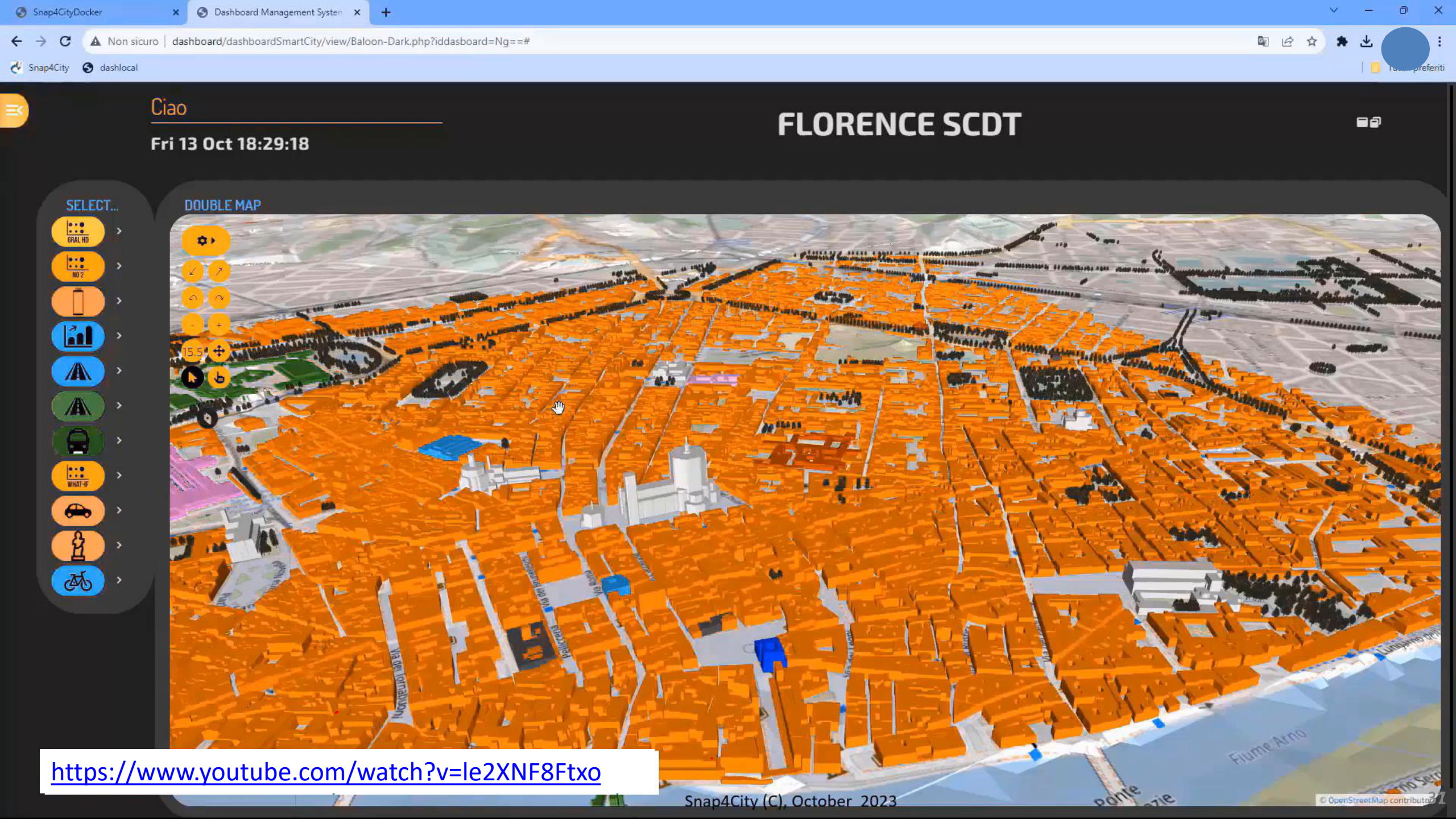


3D MAP



DISIT:ORIONUNIFI:TUSC_WEATHER_SENSOR_OW_3176959 - AIRTEMPERATURE





Ciao

Fri 13 Oct 18:29:18

FLORENCE SCDT

SELECT...

DOUBLE MAP

- ORAL HD
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- NO 100



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

Snap4City (C), October 2023

© OpenStreetMap contributors

TOP

Data Analytic Artificial Intelligence, XAI, Machine and Deep Learning

FROM CITY
DASHBOARD TO
APPLICATIONS

DATA GATHERING
AND CITY DATA
KNOWLEDGE
MANAGEMENT

FORGING &
MANAGING OPEN
AND FLEXIBLE WEB
AND MOBILE APPS

IoT APPLICATIONS
VS IoT EDGE
DEVICES

IoT/IIoT DEVICES
AND NETWORKS

IoT APPLICATIONS
LOGIC AND
PARTNERS

ADVANCED
SMART CITY A
MICROSERVICE
SNAP4CITY A

SNAP4CITY
LIVING LAB FOR
COLLABORATIVE
WORK

DATA ANALYTICS
INTELLIGENCE,
WHAT-IF AND
SIMULATION

SNAP4CITY
ARCHITECTURE AND
ECOSYSTEM. OPENED
TO DEVELOPERS
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TWITTER
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HOW TO ADOPT
SNAP4CITY, AND
OUR ROADMAP

DECISION SUPPORT
SYSTEM AND CITY
RESILIENCE

SNAP4CITY
AND KM4CITY
PROJECTS

SNAP4CITY THE
VIEW OF THE
ADMINISTRATORS

100%
OPEN
SOURCE

 **SNAP4**
Appliances and Dockers
Installations

Available AI Solutions on Snap4City

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

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

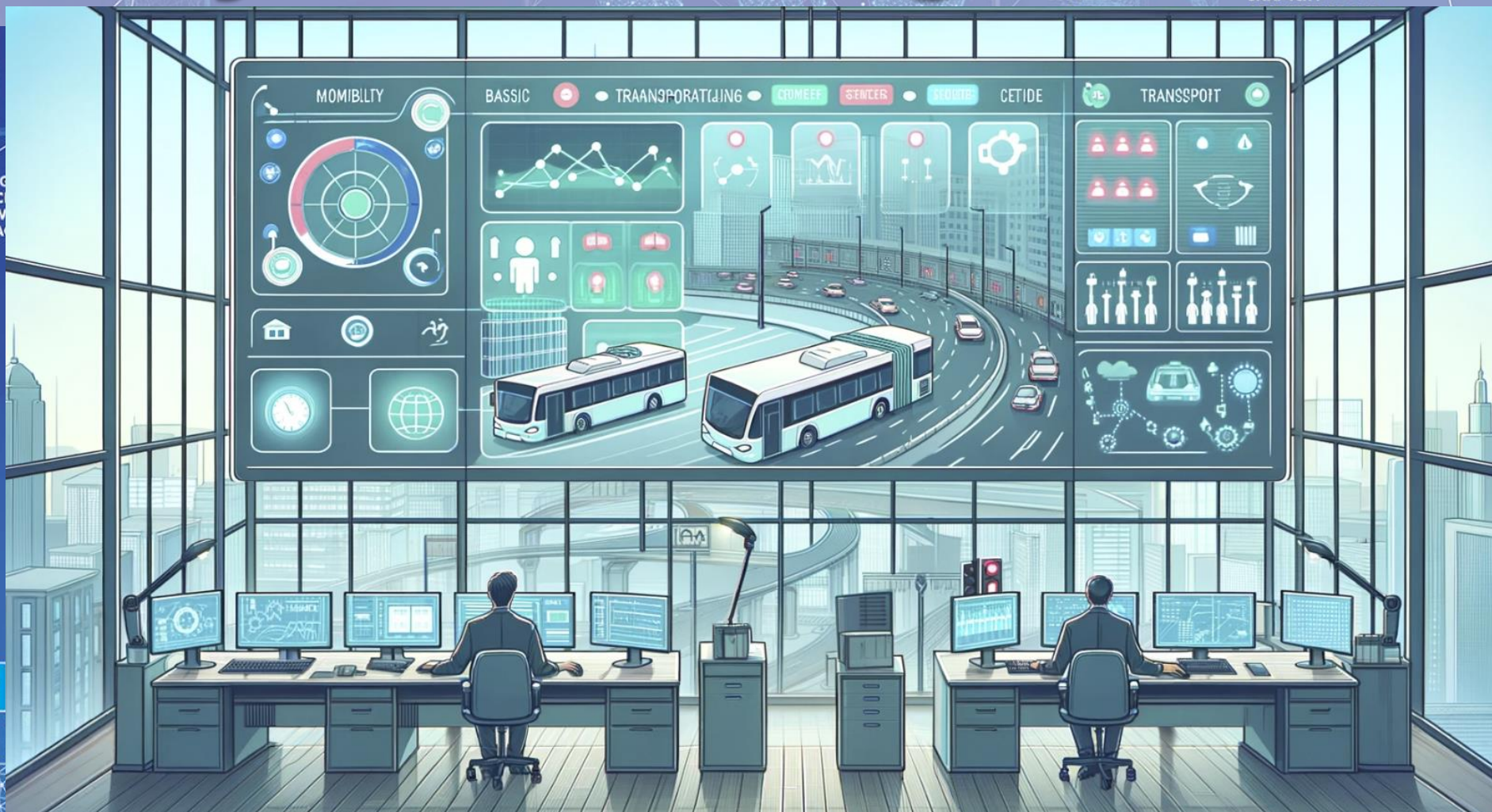


https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf

Mobility Monitoring and Control

FROM CITY
DASHBOARD TO
APPLICATIONS

DATA C
AND C
KNOW
MANA



HOW TO ADOPT
SNAP4CITY, AND
OUR ROADMAP

SNAP4CITY THE
VIEW OF THE
ADMINISTRATORS

SNAP4CITY
AND KM4CITY
PROJECTS

SNAP4CITY FOR
BEGINNERS

SNAP4CITY

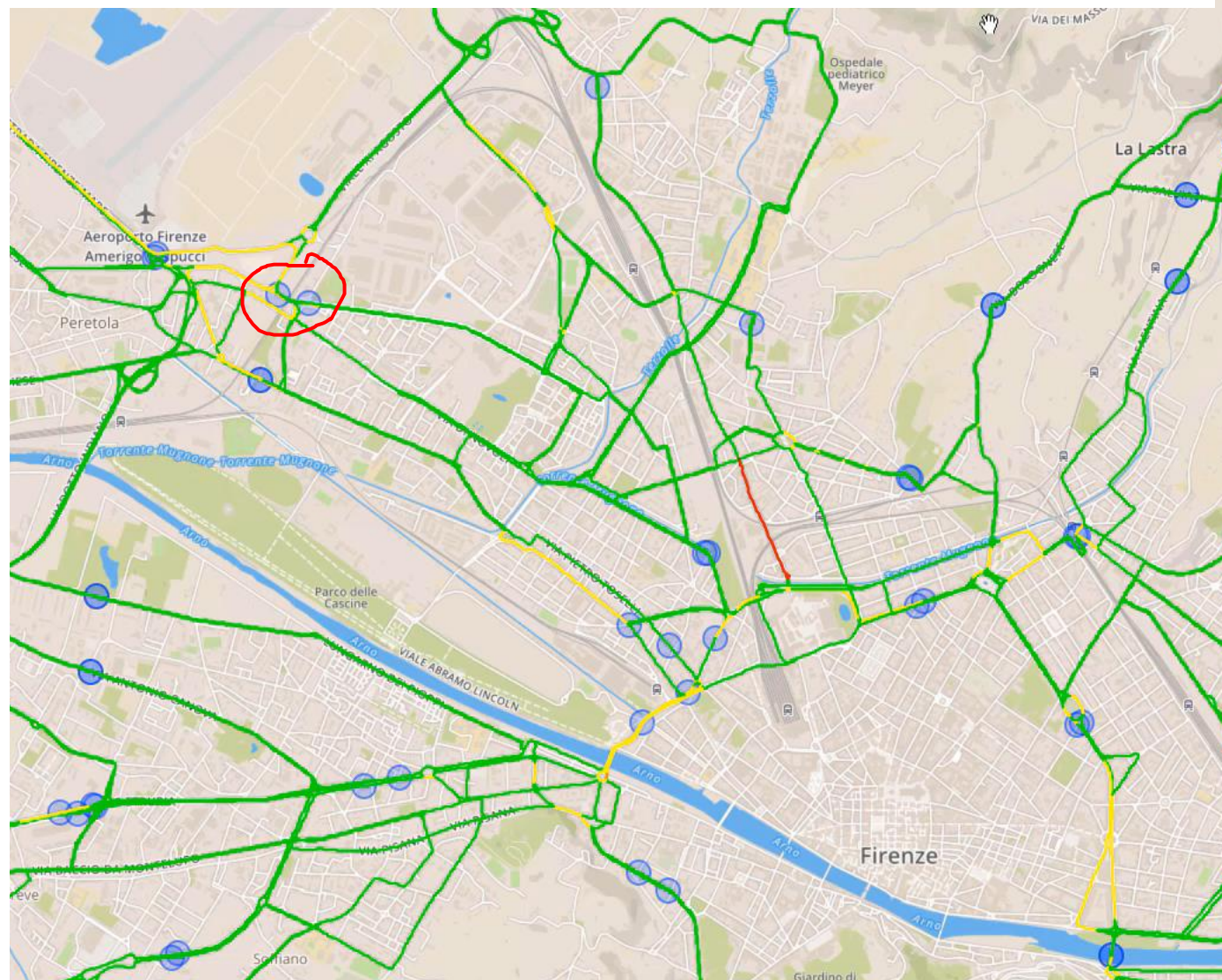
TWITTER
GITHUB
YOUTUBE

Mobility and Transport

- **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)
- **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)
- 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

Dense Traffic Flow Reconstruction ?

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



Decision Support Systems, What-if

○ Event planning, via what-if analysis

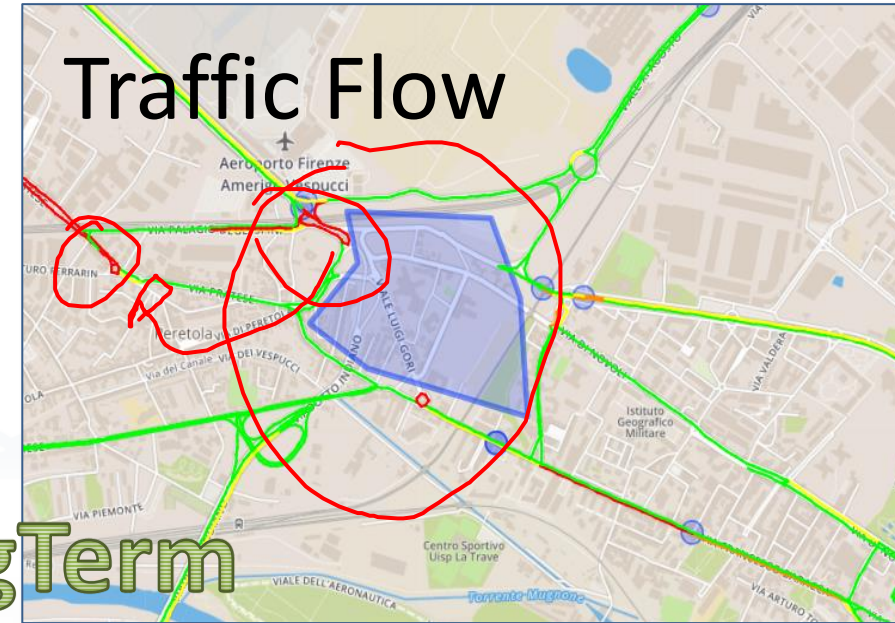
- Change in the graph structure of the city
- Impact on the flow of people and vehicles
- Adaptation: public transport, traffic, pedestrian management, etc.

○ Immediate reaction to natural events or not

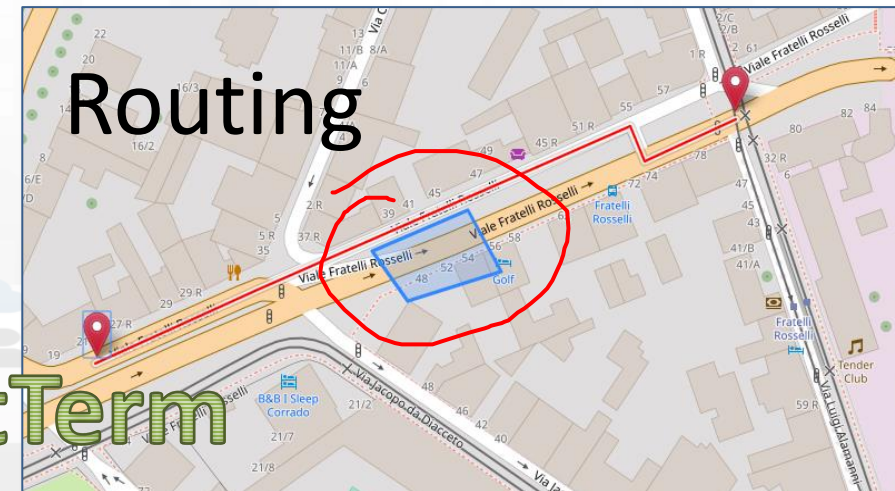
- Everything is ready and updated in real time
- Each view is contextualized in terms of data: descriptive and prescriptive

○ 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



LongTerm



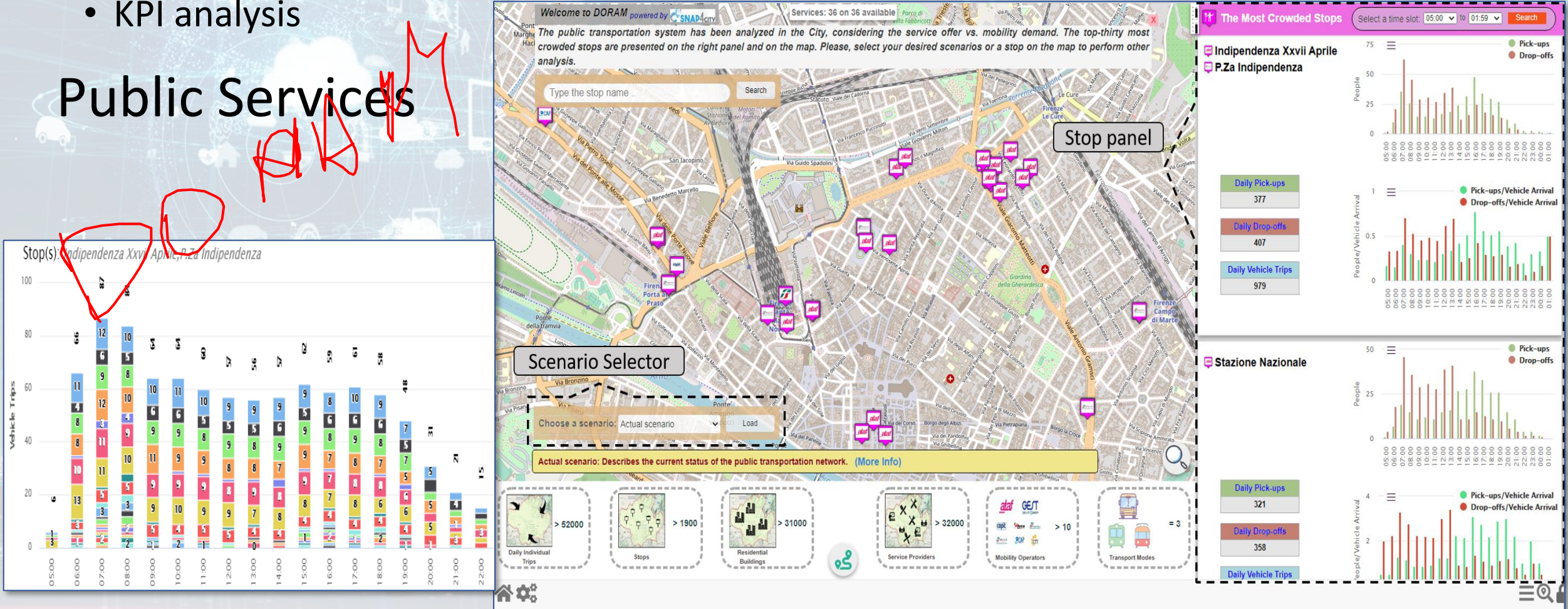
ShortTerm

What-if Analysis on Pub Transport

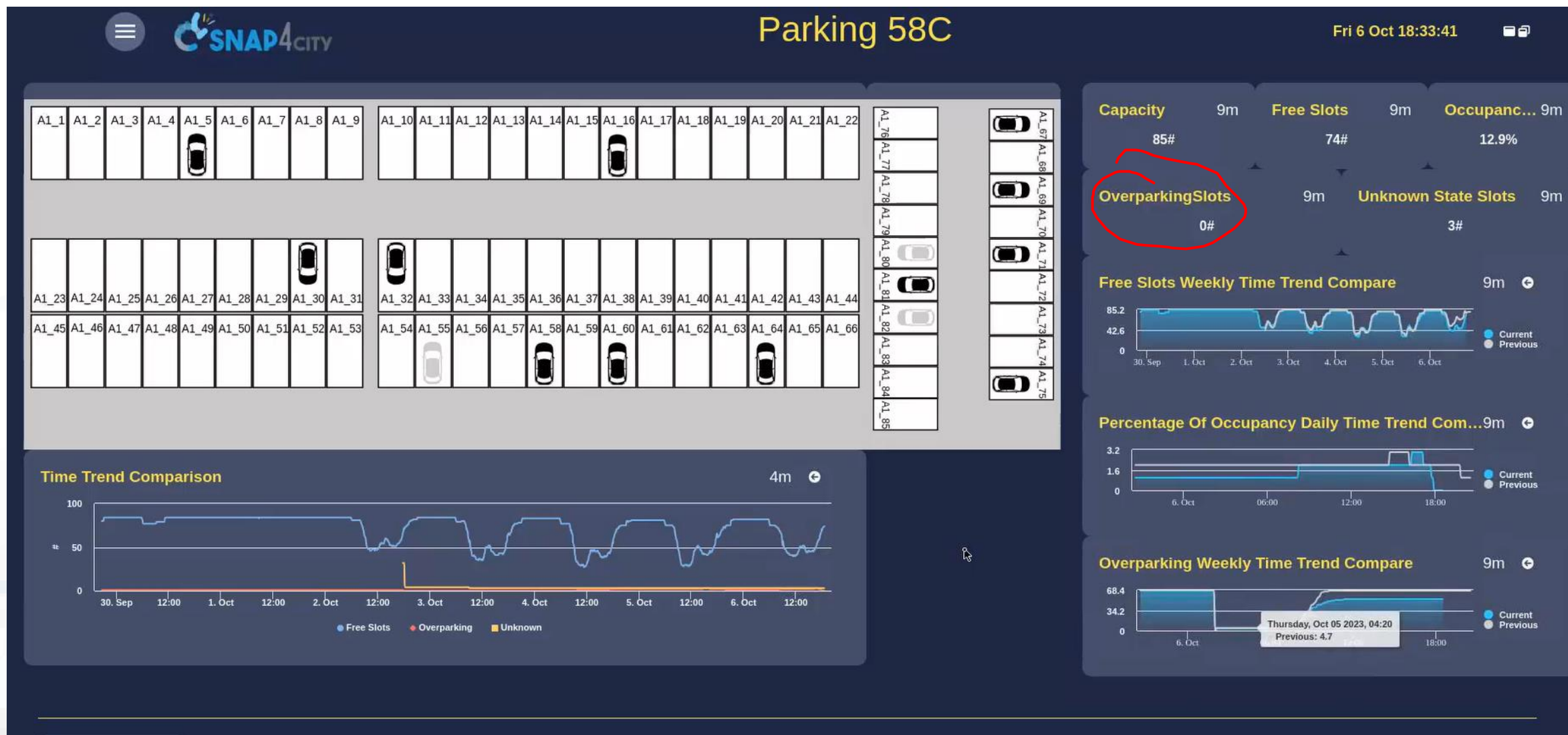


- Definition of scenarios impact on
 - Traffic, Pollutant, parking, public transport, private flows, etc.
 - KPI analysis

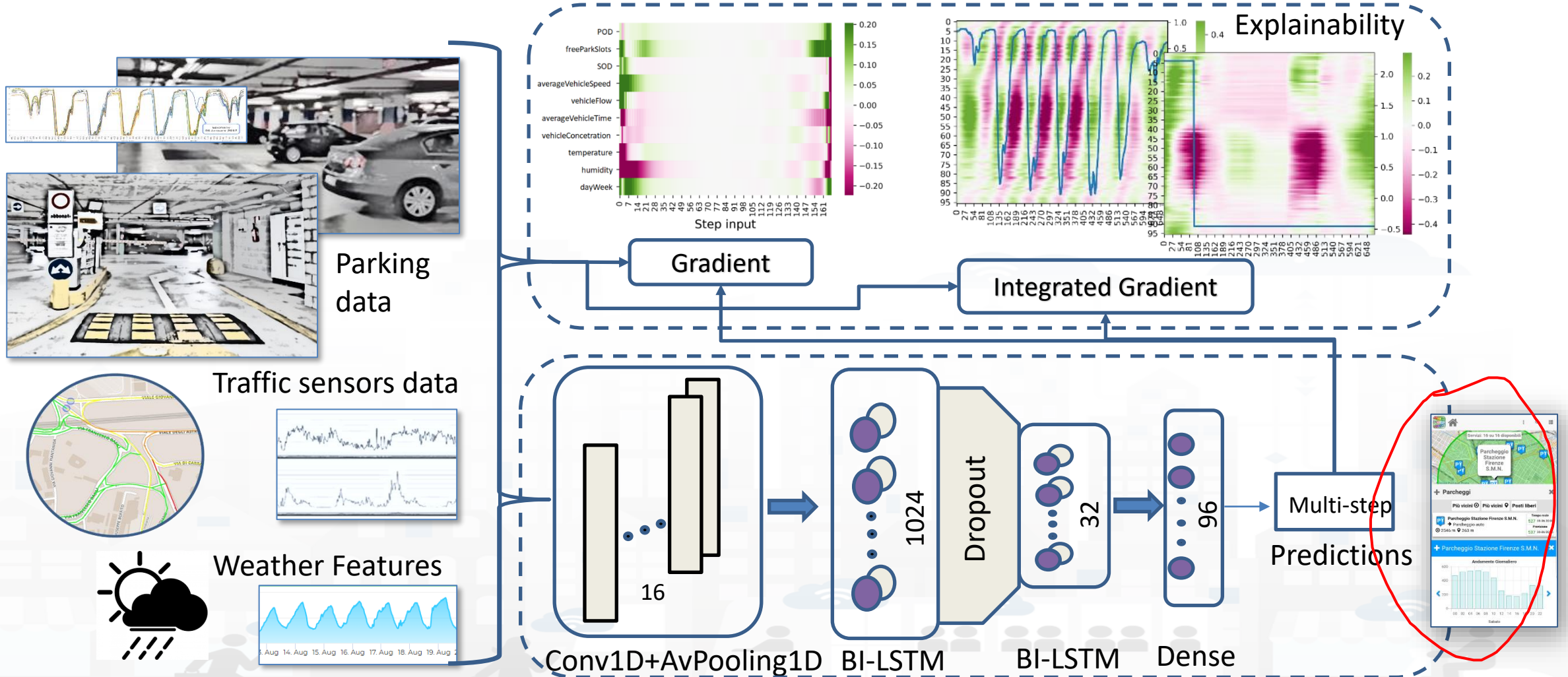
Public Services



Snap4ISPRA Parking: ISPRA JRC

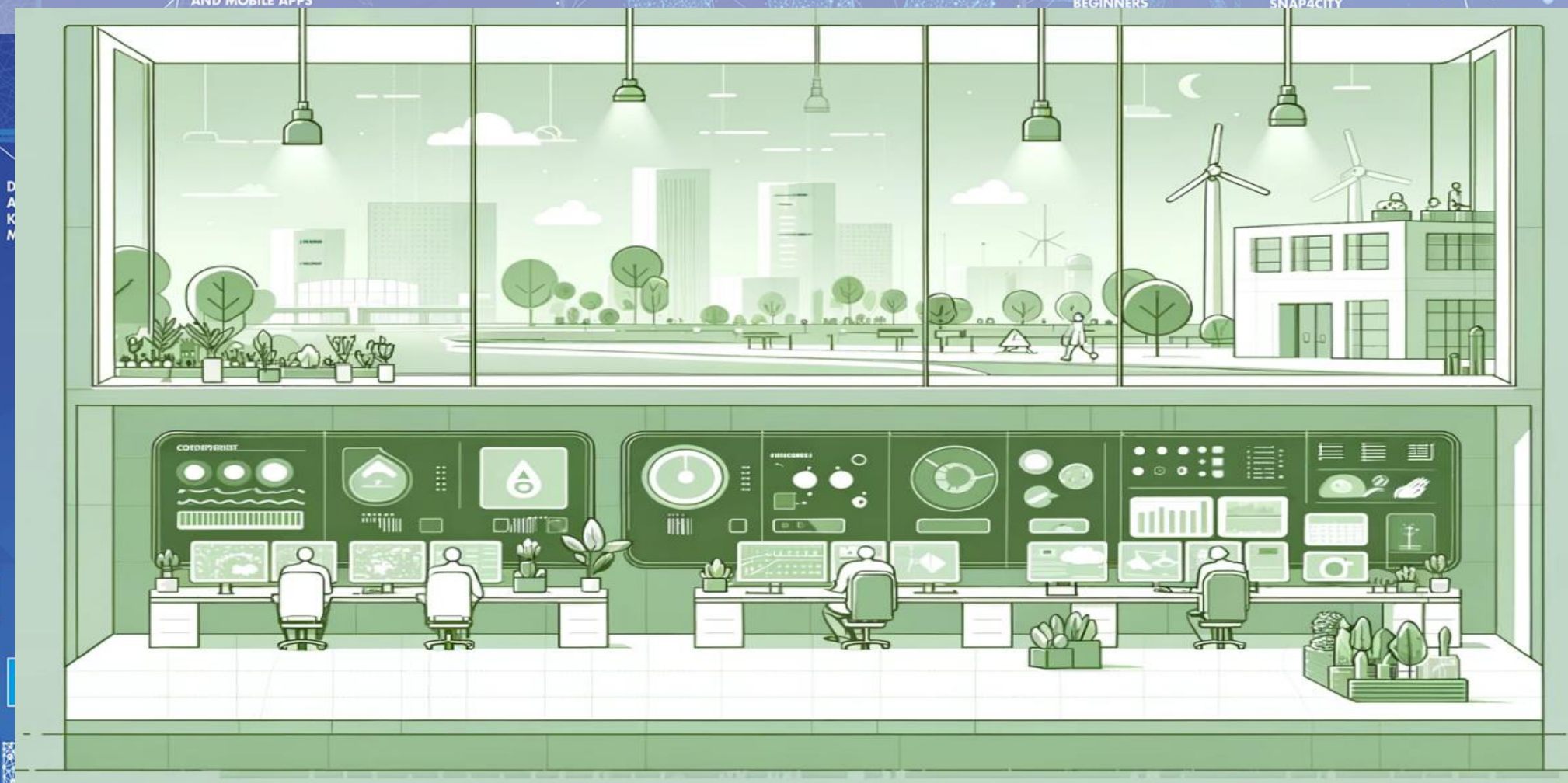


Deep Learning AI to surely Park!



Environmental Monitoring and Control

FROM CITY
DASHBOARD TO
APPLICATIONS



TWITTER
VIRALITY
ANALYSIS

SNAP4CITY
FOR
BEGINNERS

SNAP4CITY

SNAP4CITY
AND KM4CITY
PROJECTS

ADOPT
BY, AND
OMAP

SNAP4CITY THE
VIEW OF THE
ADMINISTRATORS



Environment and Weather

- **Pollutant Predictions:** short, long and very long term European Commission KPIs
 - NOX, PM10 pollution on the basis of traffic flow, 48 hours (ML, AI, DL)
 - Cumulated NO2 average value over the year, (ML, AI, 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)
- **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)
- Optimisation of **waste collection** schedule and paths (DP, ML)
- Computing **SDG, SUMI, PUMS**, .. (mainly DP)
- Etc.

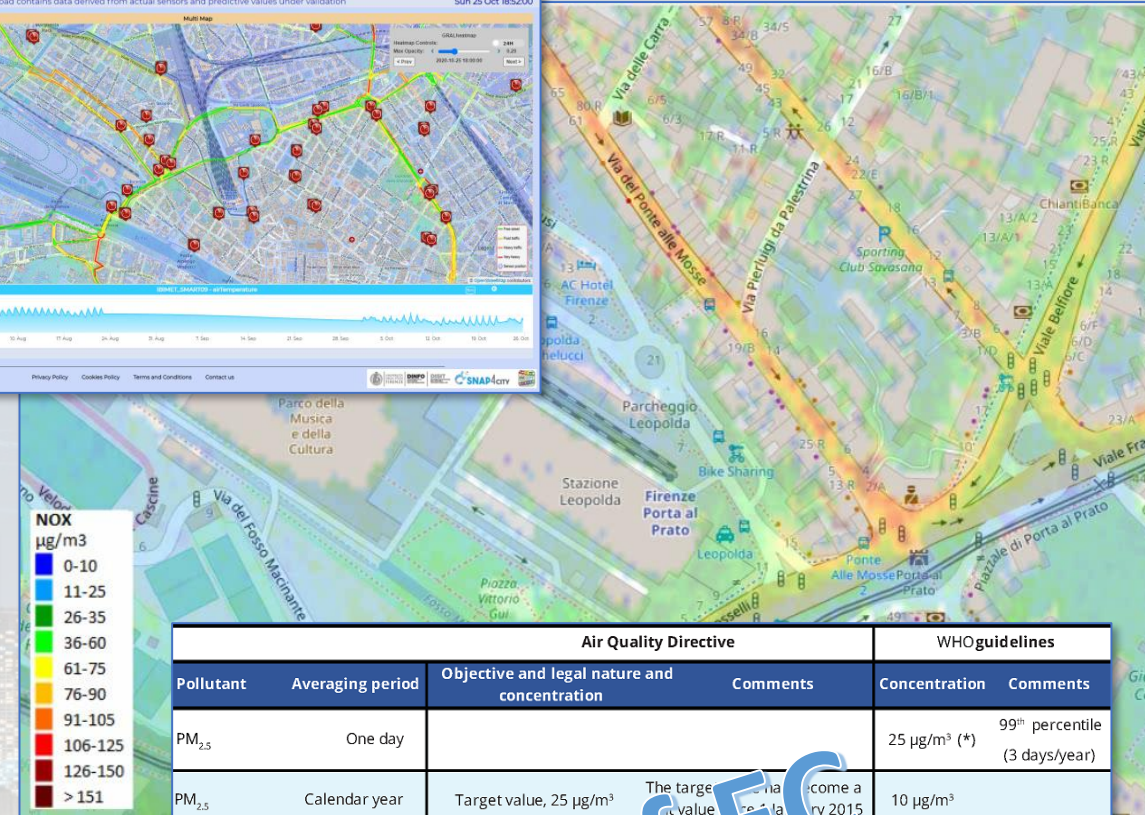
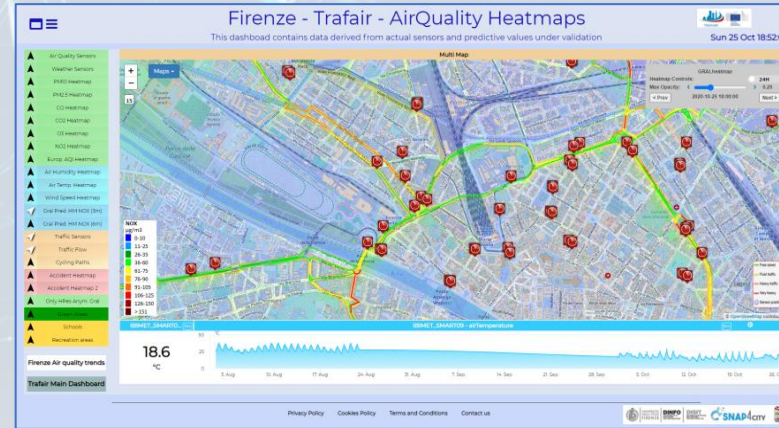
Environment and Quality of Life

Air Quality Predictions

Cities of:
Firenze, Pisa, Livorno



- **Multiple Domain Data**
 - Traffic Flow data, Pollutant: NOX, CO2, PM10, PM2.5, O3,
 - 3D City structure, weather, ...
- **Multiple Decision Makers**
 - Pollutant Predictions: NOX, NO2, ..
 - City officers, energy industries
 - Dashboards, What-IF analysis
 - Traffic Flow Reconstruction
- **Historical and Real Time data**
 - Billions of Data
- **Services Exploited on:**
 - Dashboards, Mobile App
- **Since 2020**



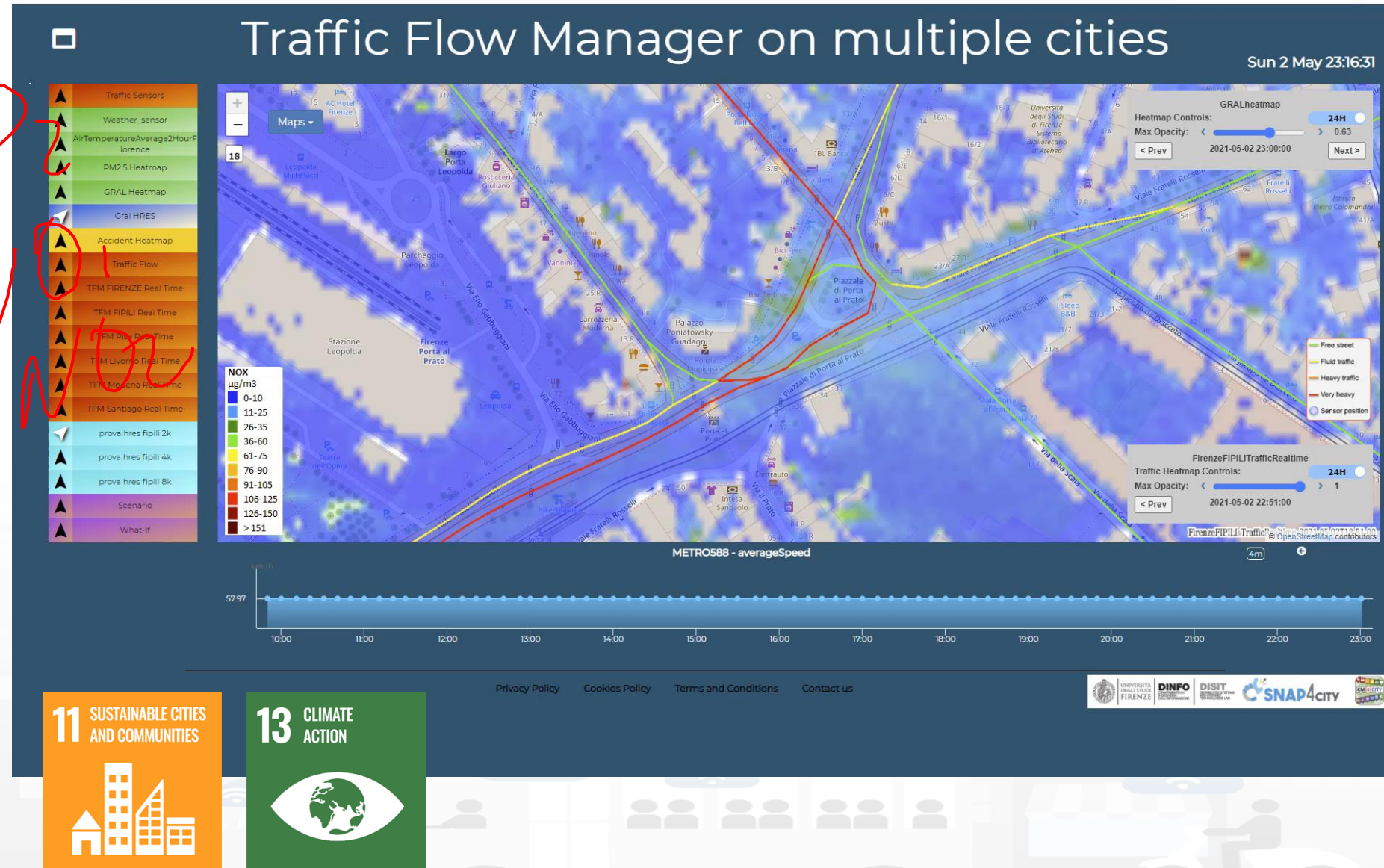
Air Quality Directive				WHO guidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
PM _{2.5}	One day			25 µg/m³ (*)	99 th percentile (3 days/year)
PM _{2.5}	Calendar year	Target value, 25 µg/m³	The target value should become a limit value by 2015	10 µg/m³	
PM ₁₀	One day	Limit value, 50 µg/m³	It should be exceeded on more than 35 days per year	50 µg/m³ (*)	99 th percentile (3 days/year)
PM ₁₀	Calendar year	Limit value, 40 µg/m³ (*)		20 µg/m³	
O ₃	Maximum daily 8-hour mean	Target value, 120 µg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³	
NO ₂	One hour	Limit value, 200 µg/m³ (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m³ (*)	
NO ₂	Calendar year	Limit value, 40 µg/m³		40 µg/m³	

• Prediction

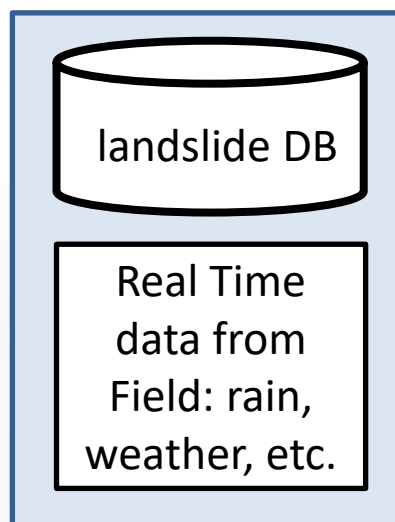
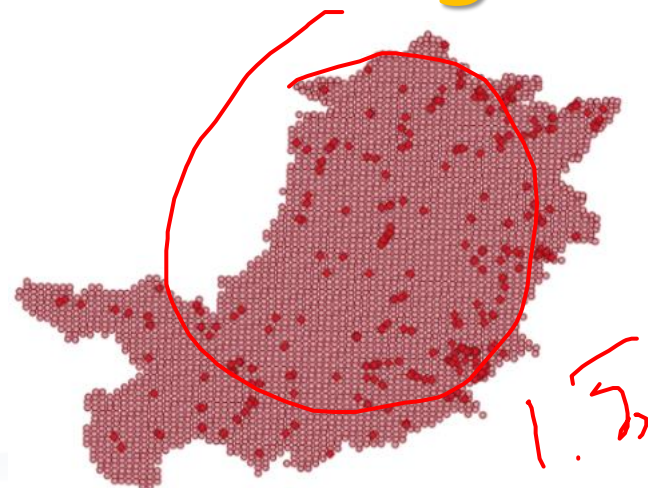
- **NOX Pollutant** diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
- **NO2 progressive average** (Long term)

• Project:

- Trafair CEF EC
- Mixed solutions of Fluidinamics modeling and AI



Predicting Land slides



Ingestion

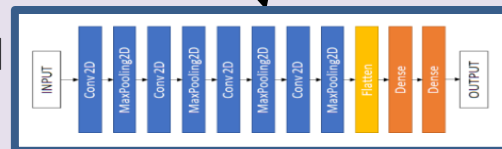
Dataset Construction

Dataset
Construction

Previsional Model

Model training
And validation

Model



SNAP4City Advanced APIs

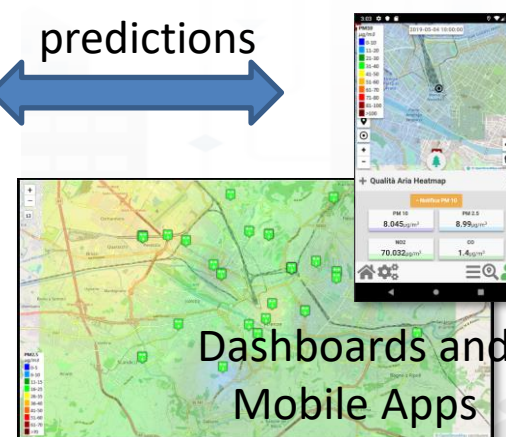
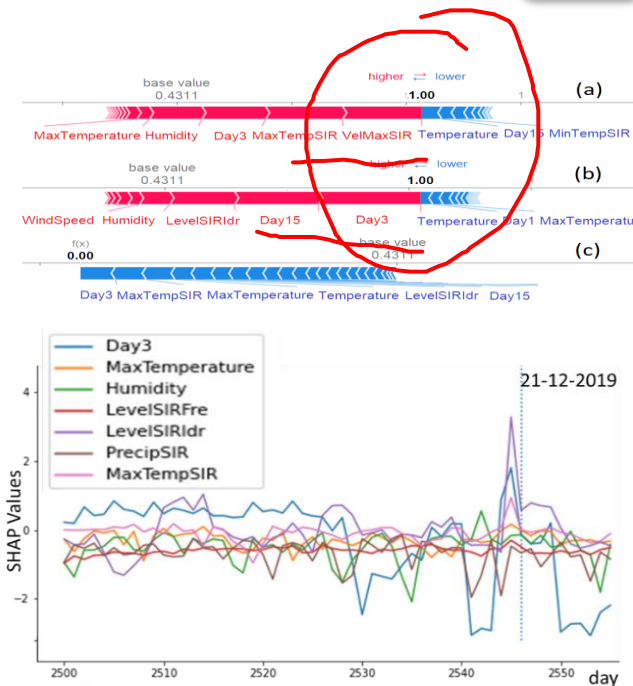


Predictions

Model execution
Shap Assessment

Data Analytics IOT App
Management

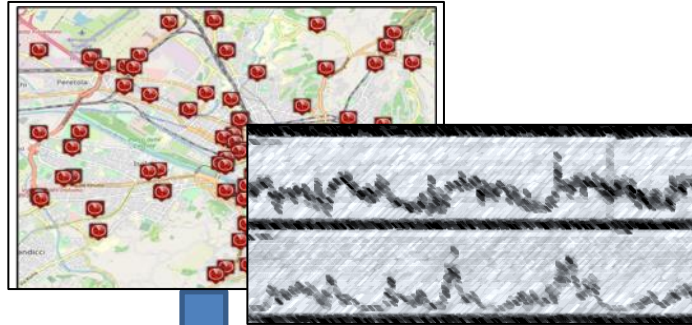
Snap4City Servers and Tools:
Dashboard manager, Heatmap
manager, GeoServer, Smart City API.



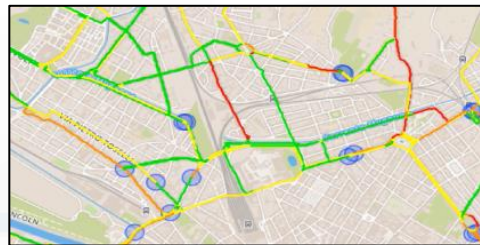
predictions

Dashboards and
Mobile Apps

Estimating City Local CO2 from Traffic Flow Data



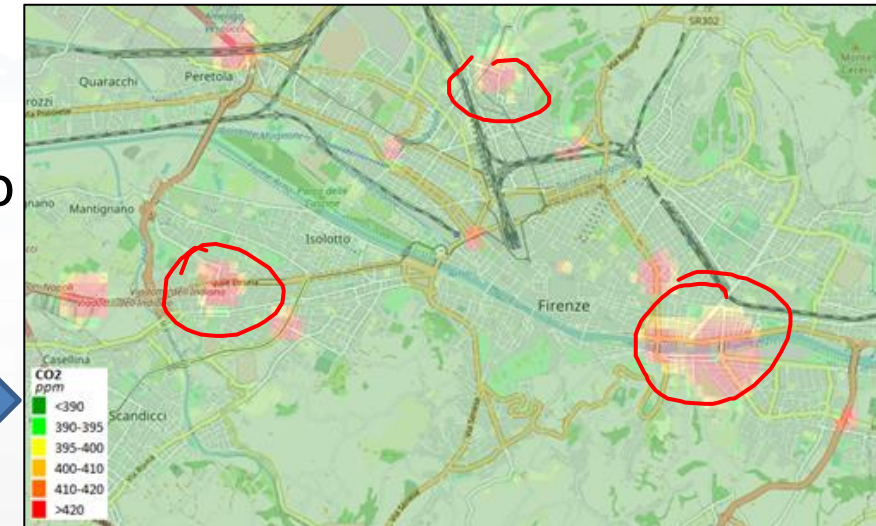
Computing Traffic Flow
into CO2 sensor area



Traffic Flow data

- Traffic Flow is one the main source of CO2 (gCO2/km x Vehicle)
 - K1: Fluid Flow
 - K2: Stop and Go
- **Dense estimation of CO2 into the city** is very useful to know to target EC's KPIs

Computing CO2 on the basis of
traffic flow data



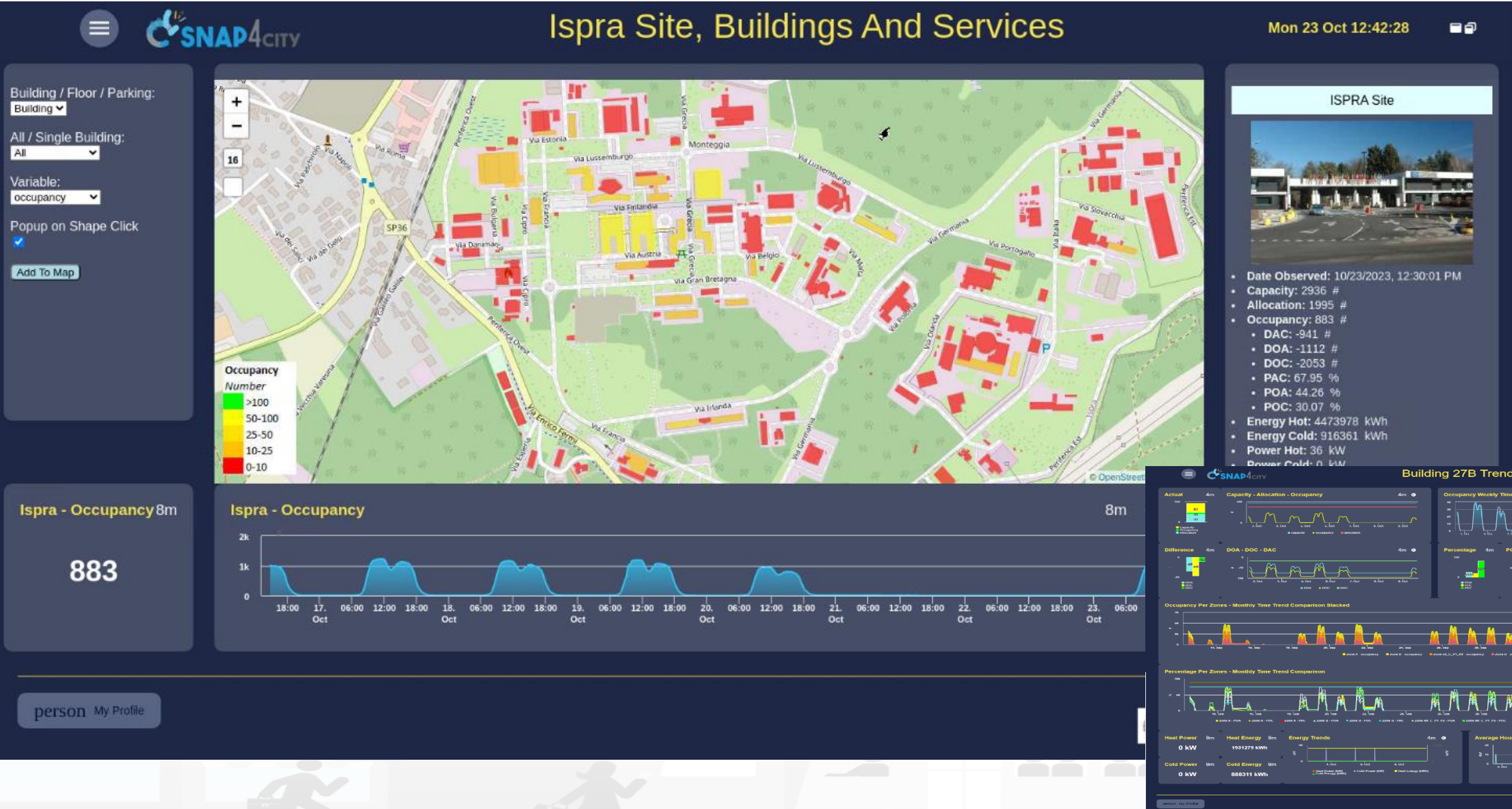
CO2 estimation



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

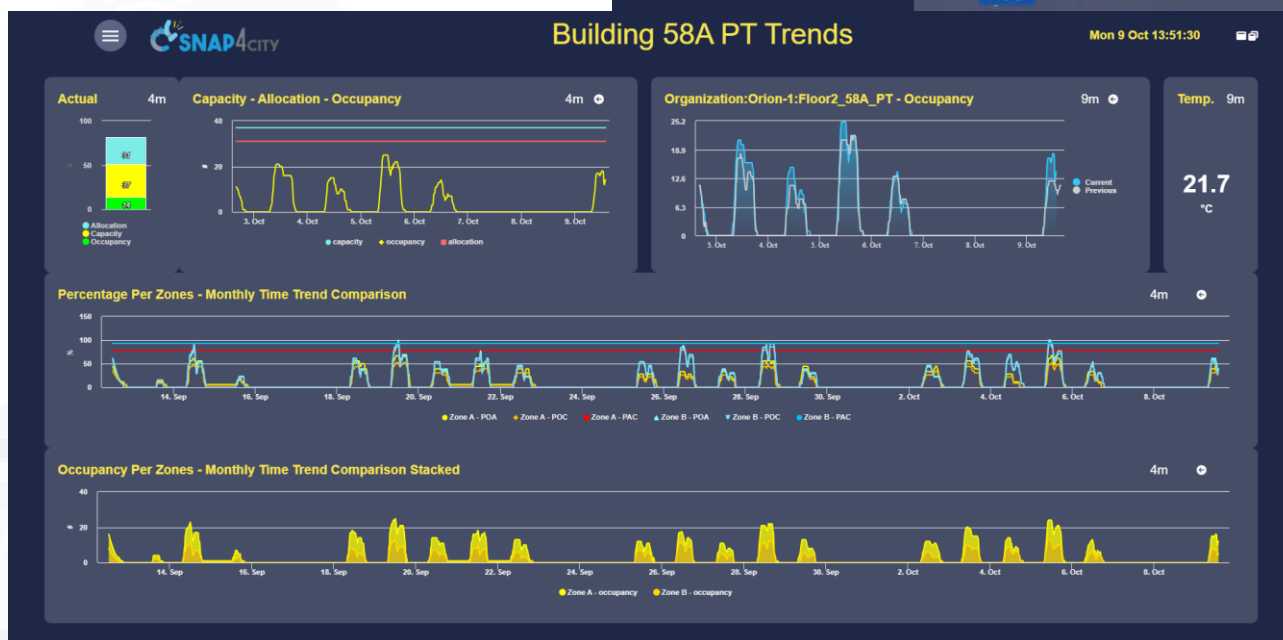
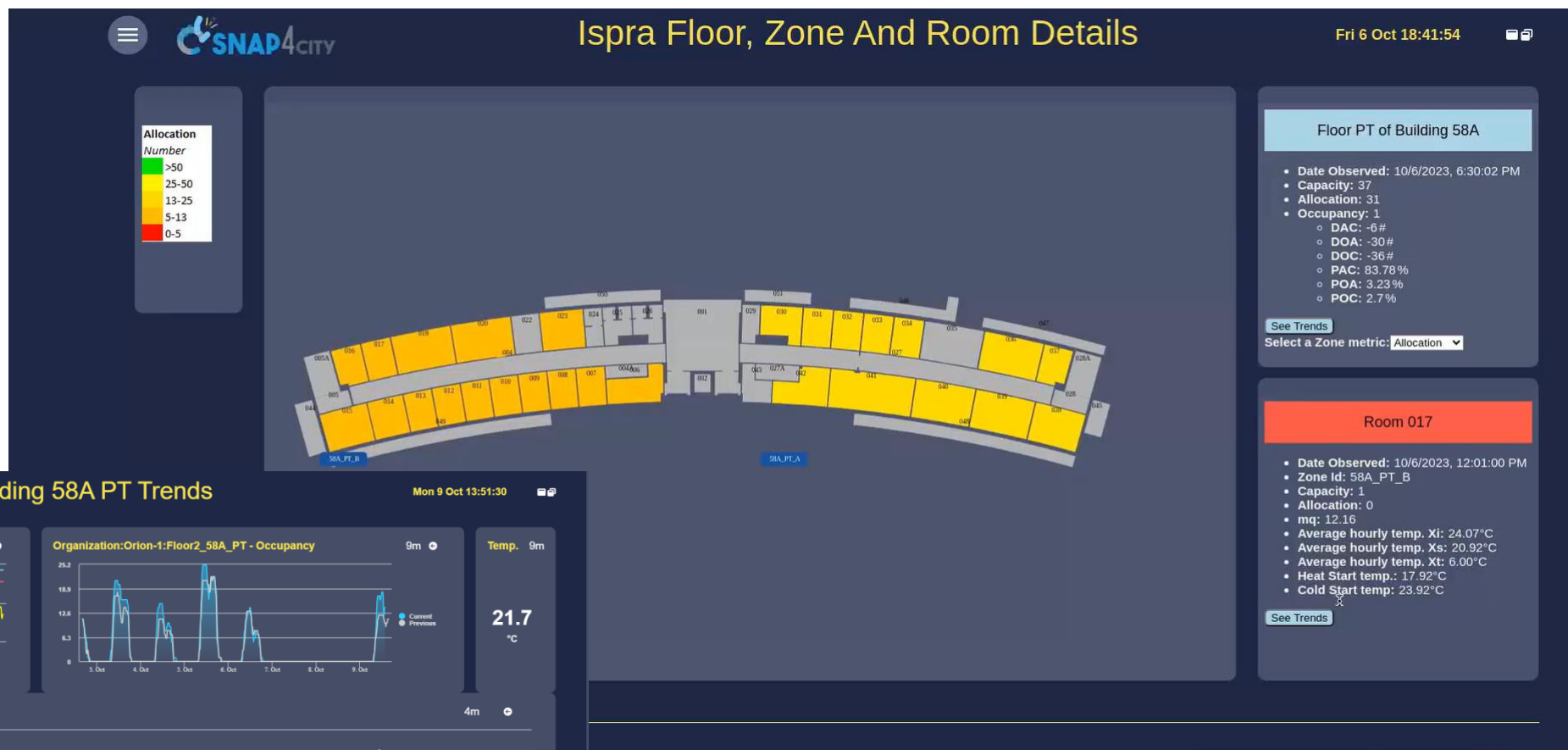
Smart Buildings, Snap4Building

- **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 KPI 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**



Floor Details

ISPRA JRC Site



Energy

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

The screenshot displays the ASM Merano Stadtwerke Meran website. At the top, there are navigation links for Maps, Google, Gmail, YouTube, and a 'Nuova scheda' button. The main header includes the ASM Merano logo and a navigation menu with 'Elenco lampade', 'Visualizzazione dati', 'Log eventi', 'Grafici', and 'Impostazioni'. The central part of the page features a map of the Merano area with a highlighted line segment. Below the map is a line graph showing the status of the line over time. The graph has three data series: 'Regolazione' (blue line), 'Potenza' (yellow line), and 'DR' (red line). The y-axis represents a value from 0 to 120, and the x-axis represents time from 13:15 to 15:45. The 'Regolazione' line is at 120, 'Potenza' is at 40, and 'DR' is at 0. To the right of the graph is a table with the following data:

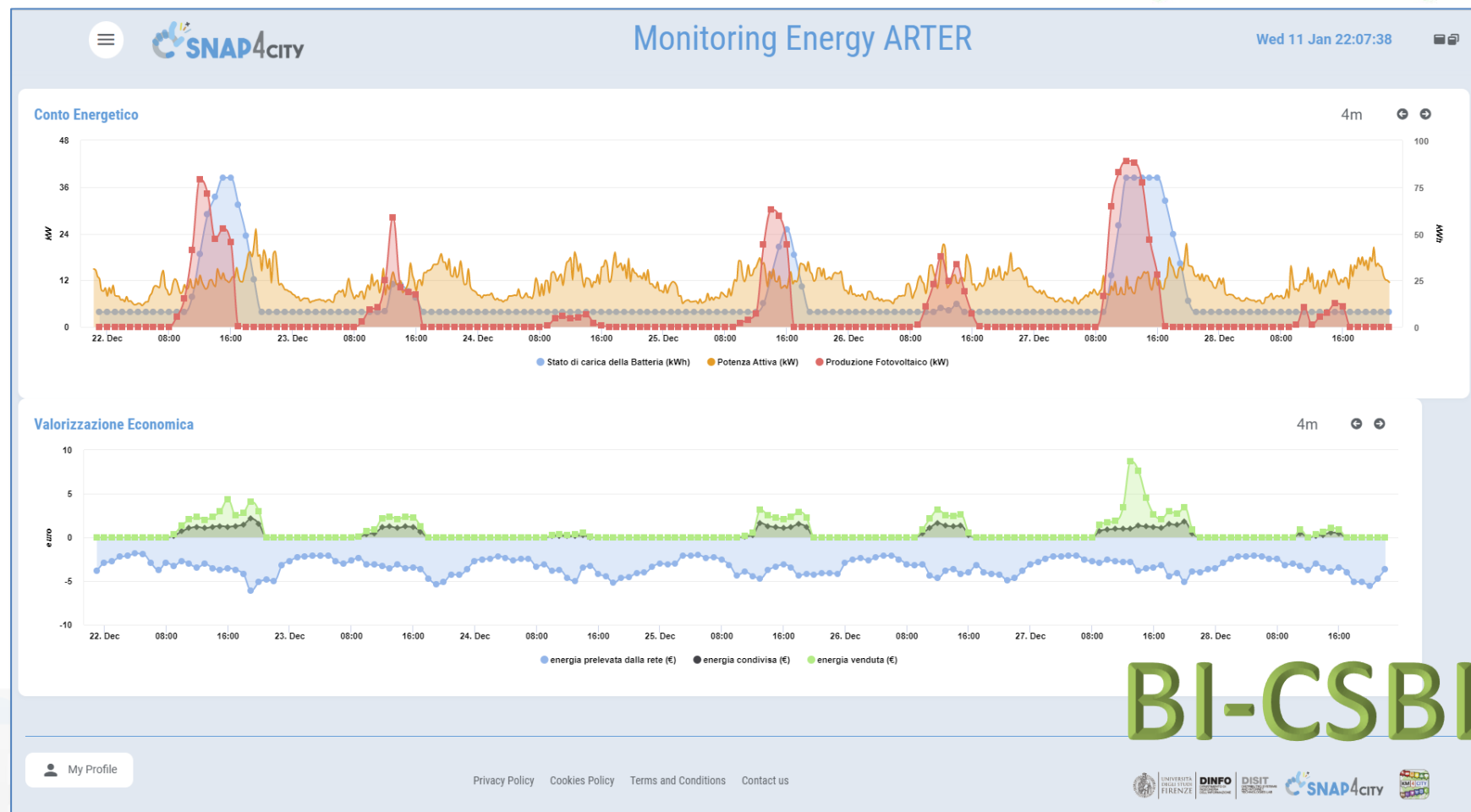
Stato Linea	
Stato	Non Attivo
Stato Linea verso Sinigo	Non Attivo
Stato Linea verso Merano Centro	Non Attivo

Below the table, there is a list of error codes and their descriptions:

- DAL_INTC_MISSING
- INF_AUX_TRIGGER
- DAL_FADTIME_DISABLE
- DAL_BALAST_NOP_CONFIG
- ERR_DAL_THERMAL_SHUTDOWN
- ERR_DAL_THERMAL_DERATING
- ERR_DAL_POWER_LIM
- ERR_DAL_OVERALL
- INF_POWER_FAIL
- INF_BUS_POWERED_BY_FREE
- INF_DAL_BANK_ERR

Smart Light Management

- **Field-tested energy community: the self-consumer 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



BI-CSBL

<https://www.selfuser.it>

<https://www.snap4city.org/dashboardSmartCity/view/Baloon.php?iddashboard=MzczNg==>

Ciao roottooladmin1

Sat 11 Nov 17:26:28

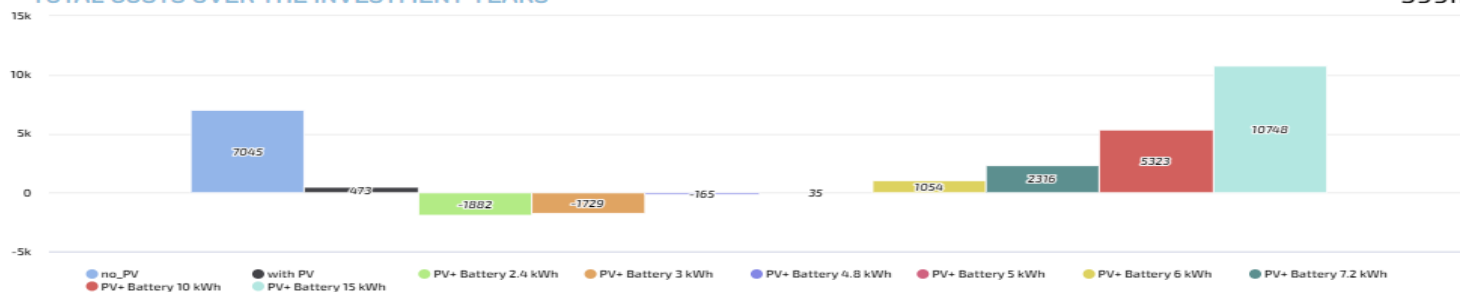
ONLINE PHOTOVOLTAIC SYSTEM SIMULATOR

User Manual

Italian Version

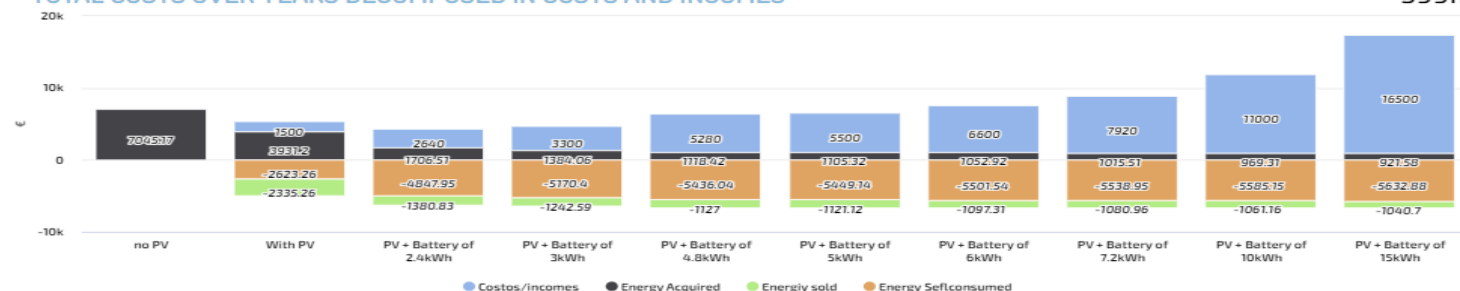
TOTAL COSTS OVER THE INVESTMENT YEARS

599m



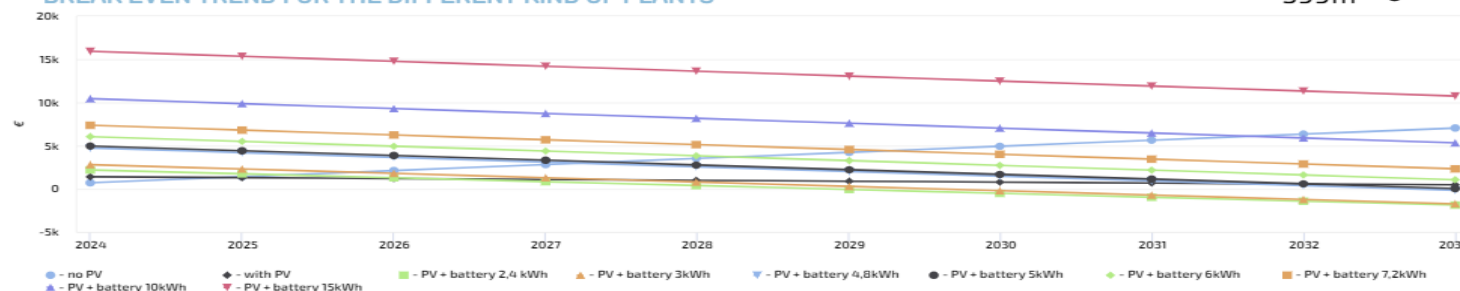
TOTAL COSTS OVER YEARS DECOMPOSED IN COSTS AND INCOMES

599m



BREAK EVEN TREND FOR THE DIFFERENT KIND OF PLANTS

599m



PARAMETERS OF YOUR PV PLANT

We suggest you PV plus battery of 2.4 kWh

Annual Consumption

Price of energy sold (€/kWh)

Price of Energy Acquired (€/kWh)

Years of Investment

Months for typical trends

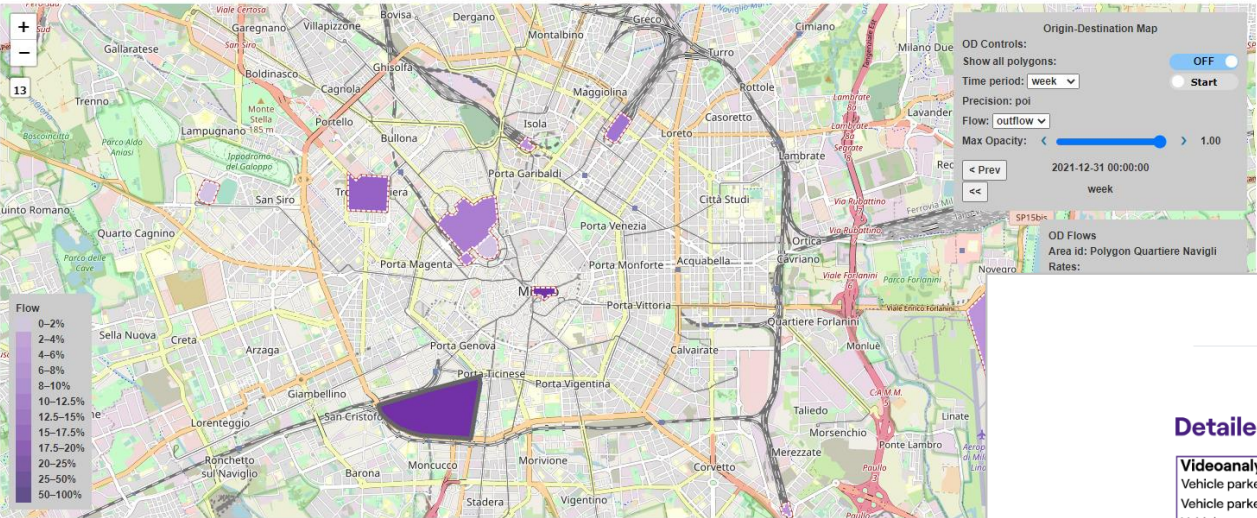
Compute



Green and Data Driven District

Aggregated KPI JuicePark SmartPole CityAnalytics

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



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7 AFFORDABLE AND CLEAN ENERGY



11 SUSTAINABLE CITIES AND COMMUNITIES



Green and Data Driven District

Aggregated KPI JuicePark SmartPole CityAnalytics

Detailed KPIs

Videoanalysis

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

Power meter

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

WiFi

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

eBike

Daily number of sessions: 0
Number of sessions to date: 0
Total Energy consumed: 0
Average energy consumed: 0
Last charger session: 17/06/2022 11:25

Emergency

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

Green and Data Driven District

Aggregated KPI JuicePark SmartPole CityAnalytics

Detailed KPIs

Videoanalysis

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

Power meter

Energy consumed daily: 0 kWh
Energy consumed to date: 0 kWh
Energy produced daily: 0 kWh
Energy produced to date: 0 kWh

WiFi

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

Emergency

SOS Requests to date: 0
SOS request daily: 0

EV charged

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

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Human Behavior Monitoring

FROM CITY
DASHBOARD TO
APPLICATIONS

SNAP4CITY FOR
BEGINNERS

SNAP4CITY
ARCHITECTURE AND
PROJECTS

TWITTER
FACEBOOK
SOCIAL
MEDIA ANALYSIS

SNAP4CITY
AND KM4CITY
PROJECTS

SNAP4CITY THE
VIEW OF THE
ADMINISTRATORS



City Users Behaviour, Safety, Security and Social Analysis

- **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)
- Etc.



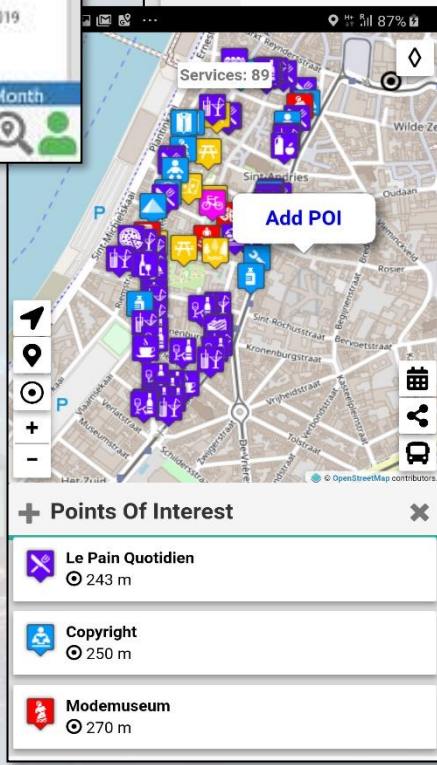
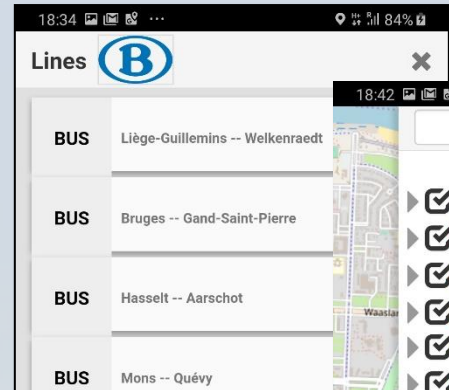
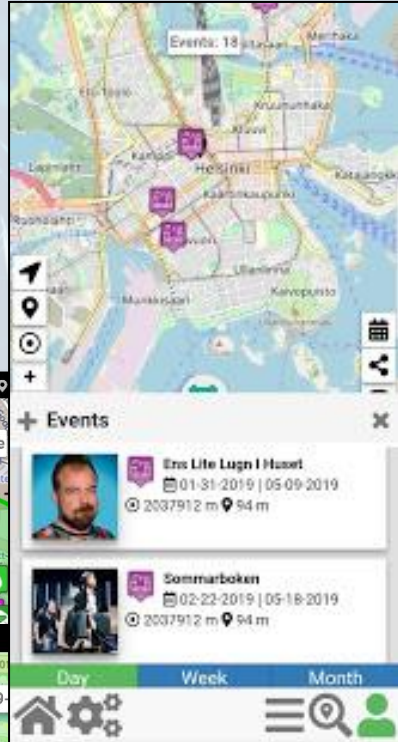
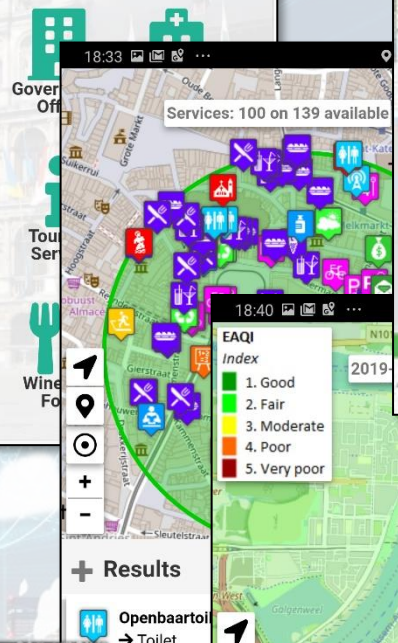
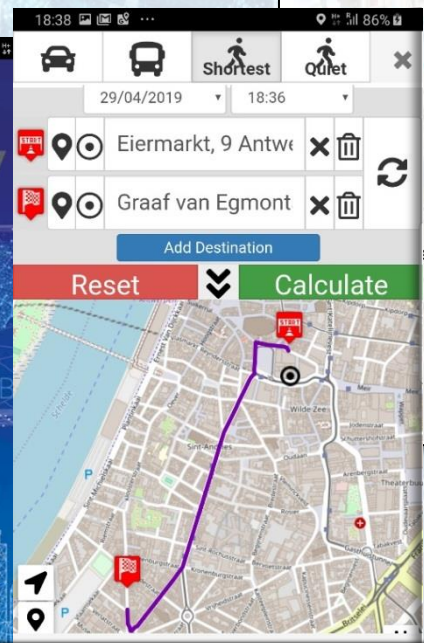
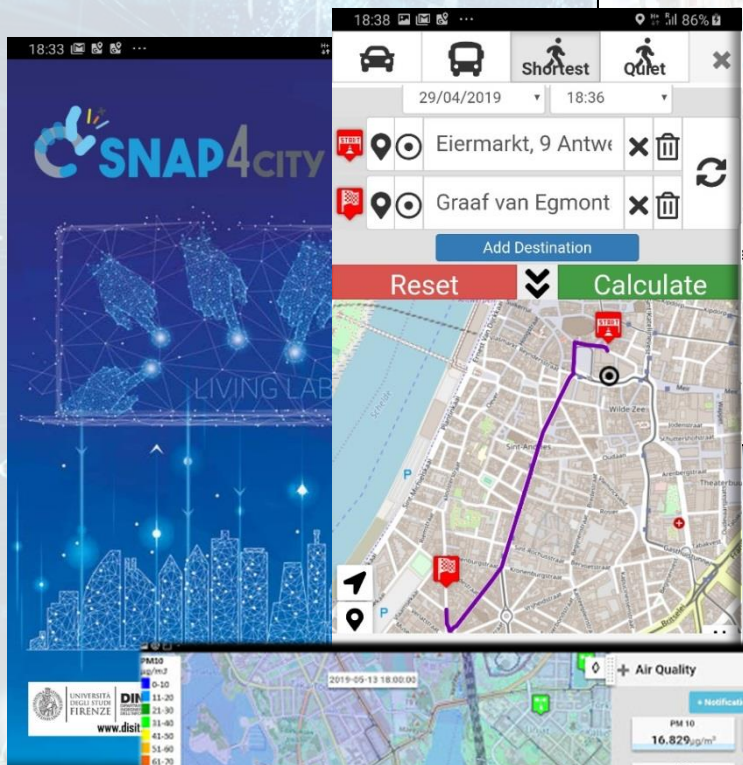
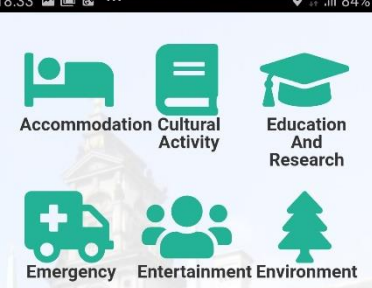
A view and data from the Thermal Camera

Detection BOX Snap4Thermal PV Firenze Tue 15 Mar 13:30:41



11 SUSTAINABLE CITIES
AND COMMUNITIES







Citizen Engagement via Mobile Apps

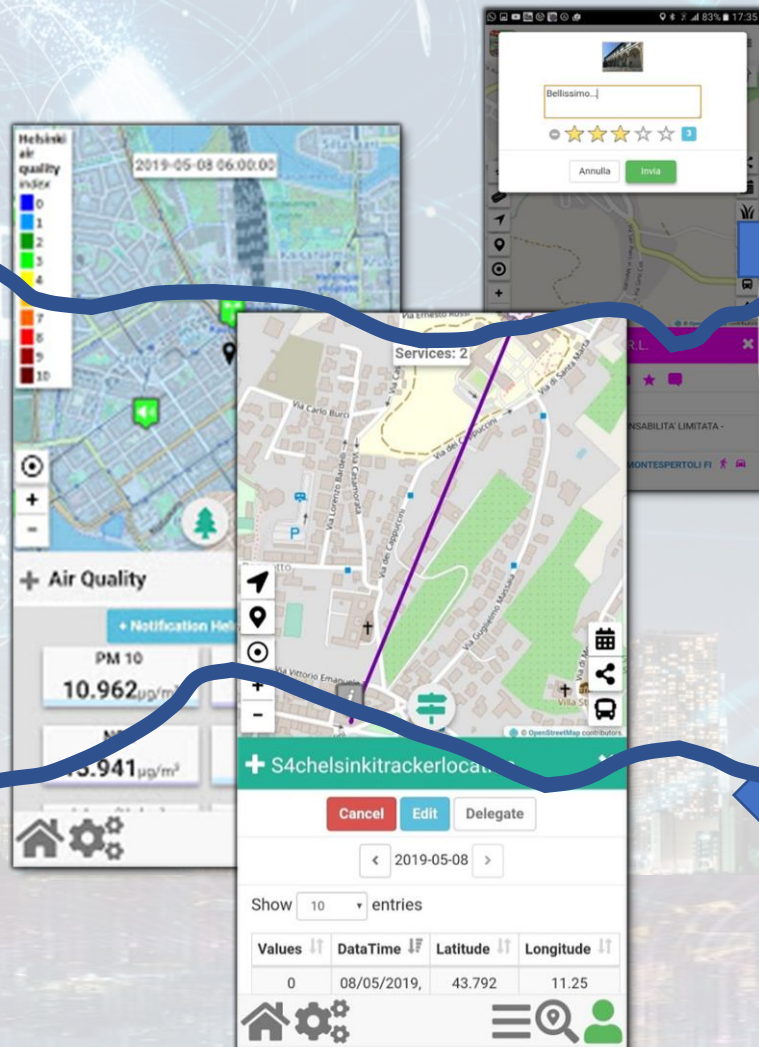
- GPS Positions
- Selections on menus
- Views of POI
- Access to Dashboards
- searched information
- Routing
- Ranks, votes
- Comments
- Images
- Subscriptions to notifications
-

Produced information

- Viewed ?
- Accepted ?
- Performed ?
- ...

Users

Snap4City (C), February 2024



Derived information

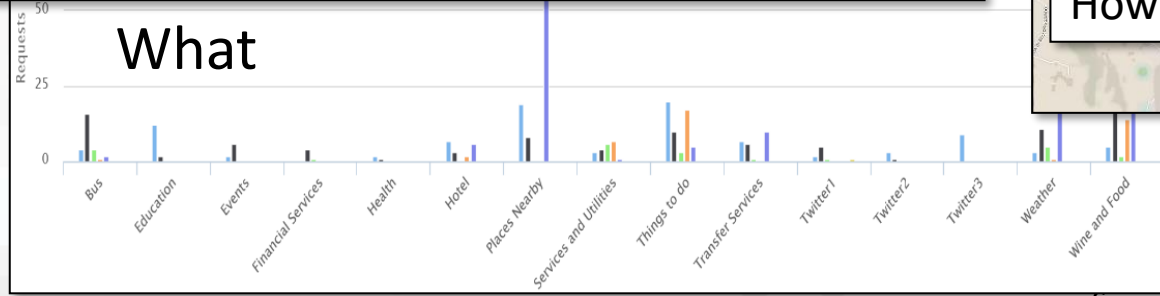
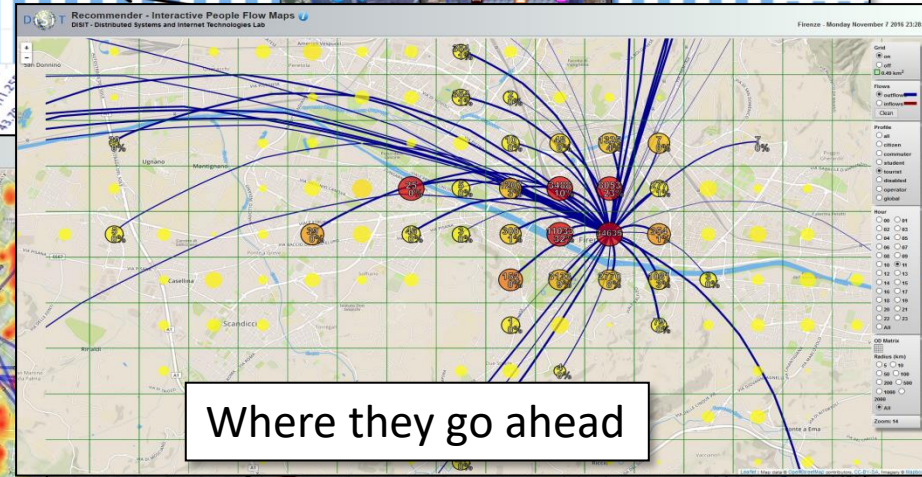
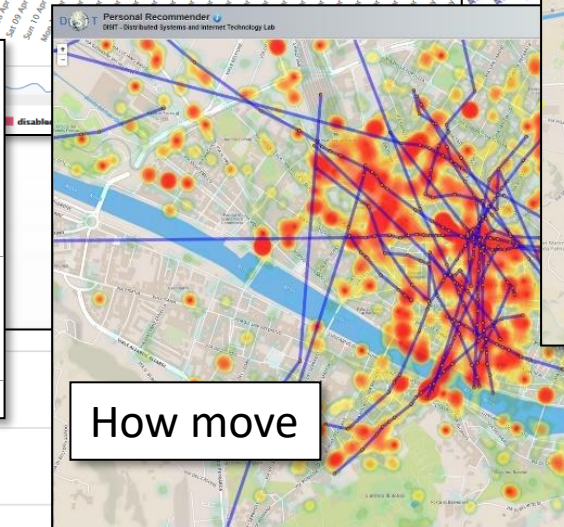
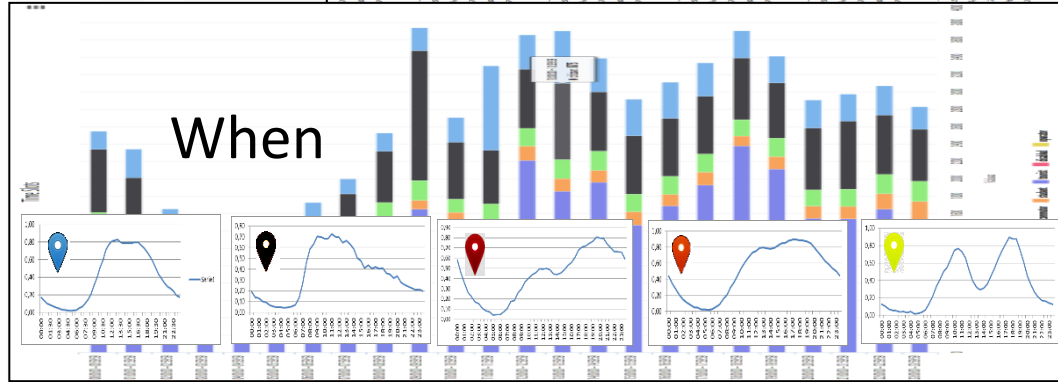
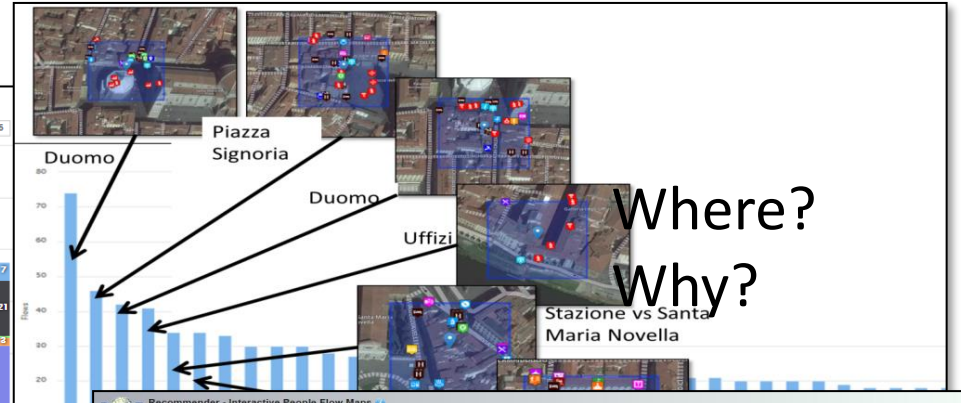
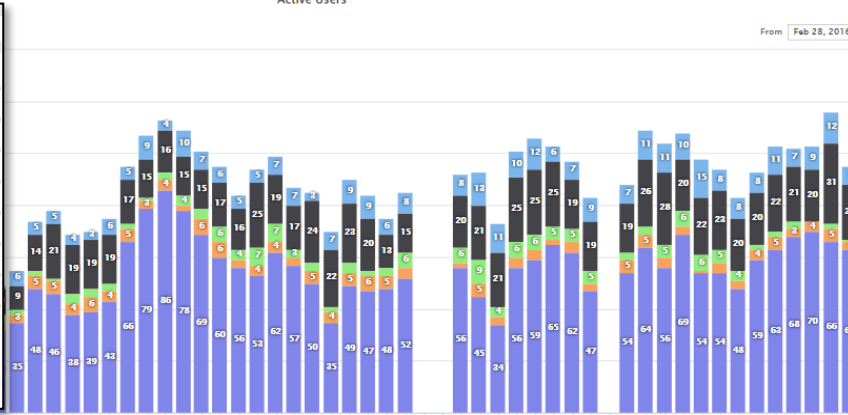
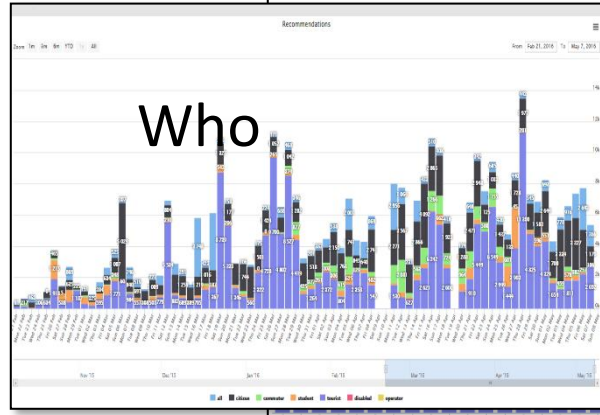
- Trajectories
- Hot Places by click and by move
- Origin destination matrices
- Most interested topics
- Most interested POI
- Delegation and relationships
- Accesses to Dashboards
- **Cumulated Scores from Actions**
- Requested information
- Routing performed
-

Produced information

- Suggestions
- Engagements
- Notifications
- ...

System

User Behavior Analyser for Collective Profiling



TOP

Training and Promotion

FROM CITY
DASHBOARD TO
APPLICATIONS

DATA GATHERING
AND CITY DATA
KNOWLEDGE
MANAGEMENT

FORGING &
MANAGING OPEN
AND FLEXIBLE WEB
AND MOBILE APPS

IOT APPLICATIONS
VS IOT EDGE
DEVICES

IOT APPLICATIONS,
THE LOGIC AND
THE SMARTNESS

ADVANCED
SMART CITY API,
MICROSERVICES,
SNAP4CITY API

SNAP4CITY
LIVING LAB FOR
COLLABORATIVE
WORK

SNAP4CITY FOR
BEGINNERS

DATA ANALYTICS,
BUSINESS
INTELLIGENCE,
WHAT-IF AND
SIMULATION

SNAP4CITY
ARCHITECTURE AND
ECOSYSTEM. OPENED
TO DEVELOPERS
AND STAKEHOLDERS

TWITTER
VIGILANCE: SOCIAL
MEDIA ANALYSIS

HOW TO ADOPT
SNAP4CITY, AND
OUR ROADMAP

DECISION SUPPORT
SYSTEM AND CITY
RESILIENCE

















SNAP4CITY
AND KM4CITY
PROJECTS

SNAP4CITY THE
VIEW OF THE
ADMINISTRATORS

100%
OPEN
SOURCE

 **SNAP4**
Appliances and Dockers
Installations

<https://www.snap4city.org/944>

Title	Videos	Preliminary content description
Part 1: Overview SLIDES Interactive Slides	   	<ul style="list-style-type: none"> Needs of the Operators vs platform Platform Overview: from data to interactive tools Data Analytics, Artificial Intelligence Some Cases by Domains: solutions vs analytics Other Cases and scenarios Overview of the next parts of the Course References to other training material
Part 2: Dashboards production and management SLIDES Interactive Slides	     	<ul style="list-style-type: none"> 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 training material
Part 3: IOT App, Process Logic, Server Side Business Logic SLIDES Interactive Slides	     	<ul style="list-style-type: none"> Recall on Snap4City Architecture Node-RED IOT App = Node-RED + Snap4City <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> Server Side Business Logic training material

2023 booklets



- Smart City



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

- Industry



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

- Artificial Intelligence



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

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

- [Scenario: SnapBot: Real Time Smart City services via Telegram](#)
- [Scenario: Copernicus Satellite Data](#)
- [Scenario: SmartBed, Materasso Intelligente](#)
- [MicroServices Suite for Smart City Applications](#)
- [Scenario: MODBUS for Snap4Industry Snap4City Applications](#)
- [Scenario: MOBIMART Interreg: MOBilità Intelligente MARE Terra](#)
- [Scenario: City of Roma case, mobility and environmental data](#)
- [Scenario: Herit-Data video and aims](#)
- [Scenario: Control Room vs Video Wall](#)
- [Scenario: Snap4Home the case of: Alexa, Philips, Sonoff, TP-link, etc. \(Italiano\)](#)
- [Scenario: how to manage maintenance and accidents workflows](#)
- [Scenario: Snap4Home, how to exploit Snap4City solution on home automation](#)
- [Scenario: Energy Monitoring](#)
- [Scenario: Multipurpose User Engagement Tools](#)
- [Scenario: 5G Enabled Water Cleaning Control \(smart city, industry 4.0\)](#)
- [Scenario: High Level Control of Industrial Plant \(industry 4.0\)](#)
- [Scenario: Vehicle Monitoring via OBD2](#)
- [Scenario: Events and Museums Monitoring in Antwerp](#)
- [Scenario: High Resolution Prediction of Environmental Data](#)
- [Scenario: Mobility and Transport Analyses in multiple cities](#)
- [Scenario: People Flow Analysis via Wi-Fi](#)
- [Scenario: Antwerp Pilot on Environmental Data](#)
- [Scenario: Helsinki Pilot on Environmental Data](#)
- [Scenario: Firenze Smart City Control Room](#)
- [Scenario: Mobile & Web App: Toscana Where What ... Km4City, Toscana in a Snap](#)
- [Scenario: Helsinki Pilot on User Behaviour](#)
- [Scenario: Antwerp Pilot on User Behaviour](#)



Scenariious

- [Data Analytic: Origin Destination Matrices, Algorithms and tools](#)
- [Data Analytic: Traffic Flow Reconstruction](#)
- [Data Analytic: in general, and the cases of Antwerp and Helsinki](#)
- [Data Analytic: Predicting Air Quality](#)
- [Data Analytic: Analyzing Public Transportation Offer wrt Mobility Demand](#)

Tech Overview

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



Technical Overview

From: DINFO dept of University of Florence, with its
DISIT Lab, <https://www.disit.org> with its Snap4City solution

Snap4City:

- Web page: <https://www.snap4city.org>
- <https://twitter.com/snap4city>
- <https://www.facebook.com/snap4city>

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

- Phone: +39-335-5668674
- LinkedIn: <https://www.linkedin.com/in/paolo-nesi-849ba51/>
- Twitter: <https://twitter.com/paolonesi>
- FaceBook: <https://www.facebook.com/paolo.nesi2>

Development

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



Development Life-Cycle

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

From Snap4City:

- We suggest you to read the **TECHNICAL OVERVIEW**:
 - <https://www.snap4city.org/download/video/Snap4City-PlatformOverview.pdf>
- <https://www.snap4city.org>
- <https://www.snap4solutions.org>
- <https://www.snap4industry.org>
- <https://twitter.com/snap4city>
- <https://www.facebook.com/snap4city>
- <https://www.youtube.com/channel/UC3tAO09EbNba8f2-u4vandg>

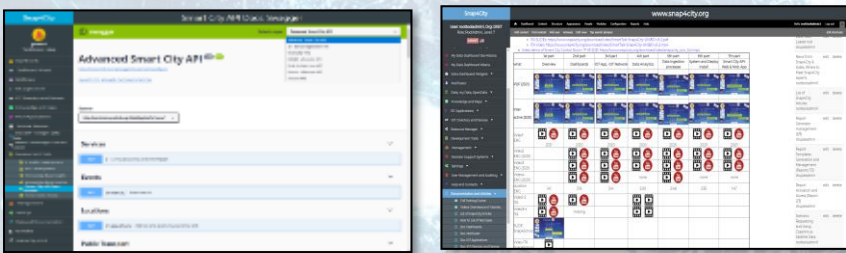
Coordinator: Paolo Nesi, Paolo.nesi@unifi.it

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

Data Analytics on Snap4City platform



Swagger



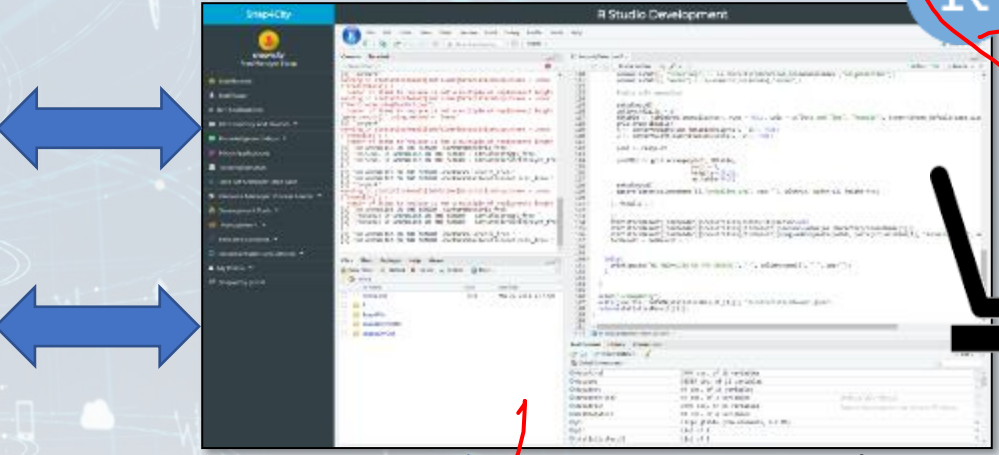
Ontology Schema



LOG.disit.org



Smart City API from Knowledge Base and other tools



Creating MicroServices



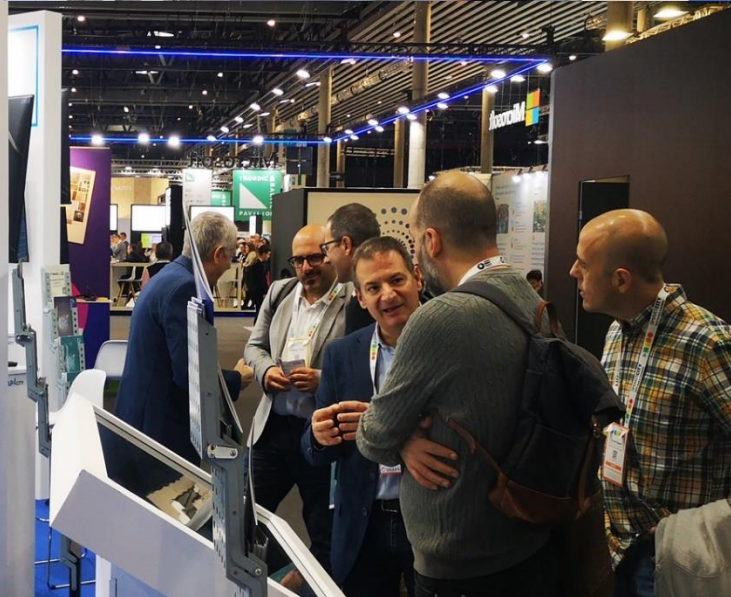
Using them into IOT Applications

Saving / Sharing reusing



Resource Manager





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7 - 9 NOVEMBER 2023



PAVILLON 1 - STAND D 100

TOP

Acknowledgements

FROM CITY
DASHBOARD TO
APPLICATIONS

DATA GATHERING
AND CITY DATA
KNOWLEDGE
MANAGEMENT

FORGING &
MANAGING OPEN
AND FLEXIBLE WEB
AND MOBILE APPS

IOT APPLICATIONS
VS IOT EDGE
DEVICES

IOT APPLICATIONS,
THE LOGIC AND
THE SMARTNESS

ADVANCED
SMART CITY API,
MICROSERVICES,
SNAP4CITY API

SNAP4CITY
LIVING LAB FOR
COLLABORATIVE
WORK

SNAP4CITY FOR
BEGINNERS

DATA BUSINESS
INTELLIGENCE,
WHAT-IF AND
SIMULATION

SNAP4CITY
ARCHITECTURE AND
ECOSYSTEM. OPENED
TO DEVELOPERS
AND STAKEHOLDERS

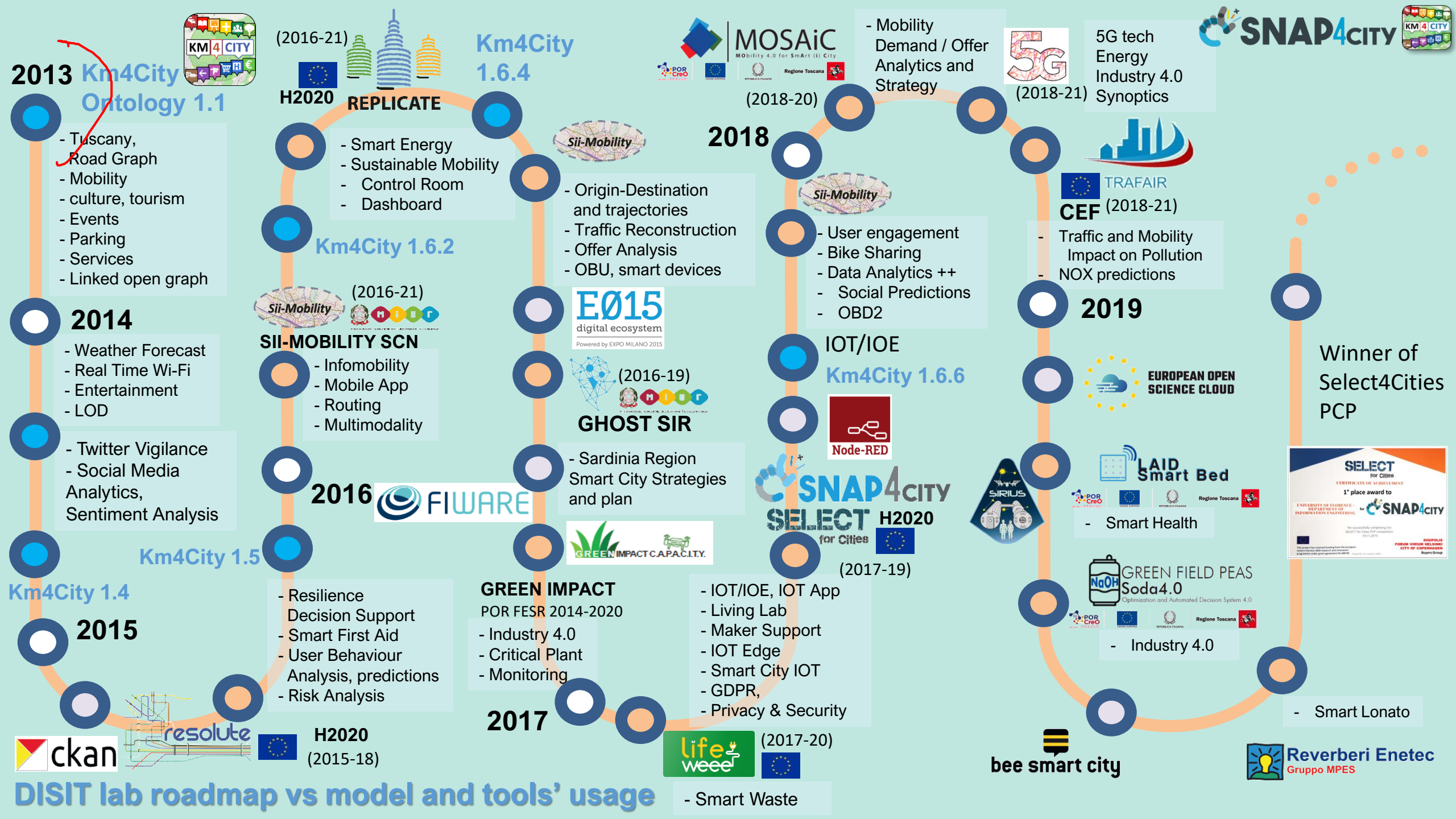
TWITTER
VIGILANCE: SOCIAL
MEDIA ANALYSIS

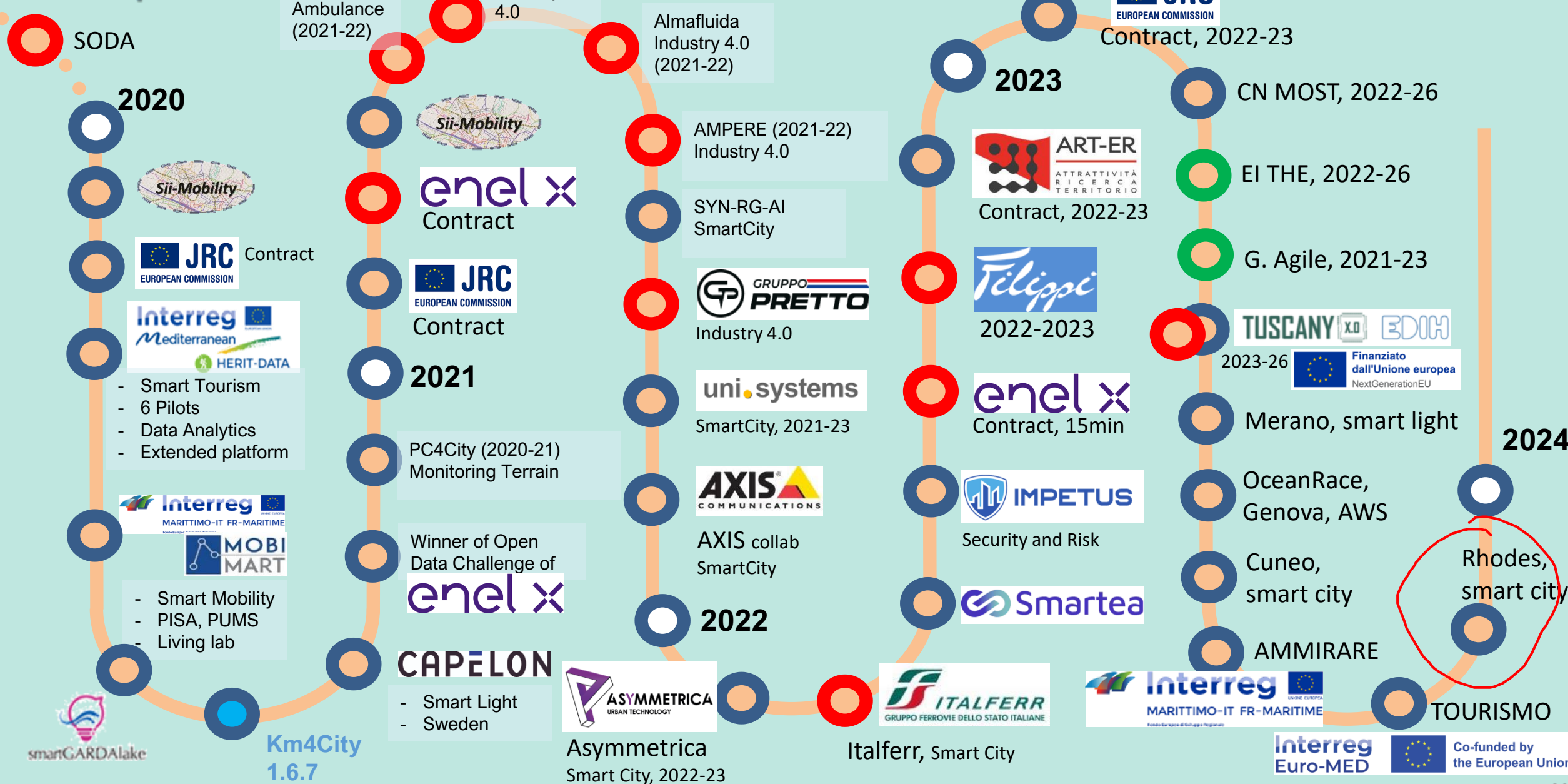
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Be smart in a SNAP!



SMARTCITY
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7-9 November 2023, Barcelona, Spain

Visit Snap4City in Hall 1

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