
Smart
COMMUNITIES
Tech
SMART AND
HUMAN CITIES
RESEARCHTOBUSINESS
BOLOGNA FIERE

Smart City and Digital Twin

https://www.Snap4City.org

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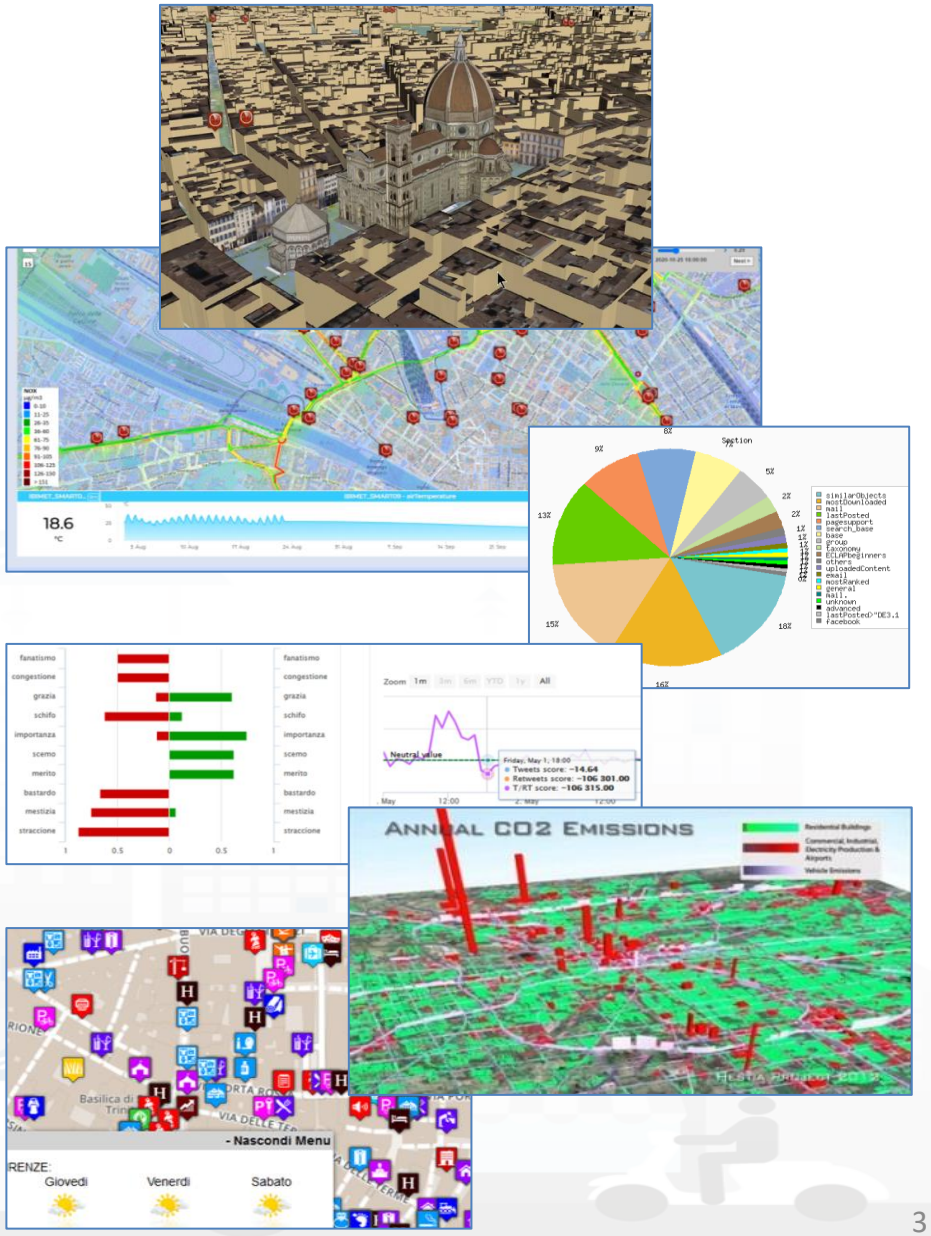
https://www.Km4City.org
https://www.disit.org

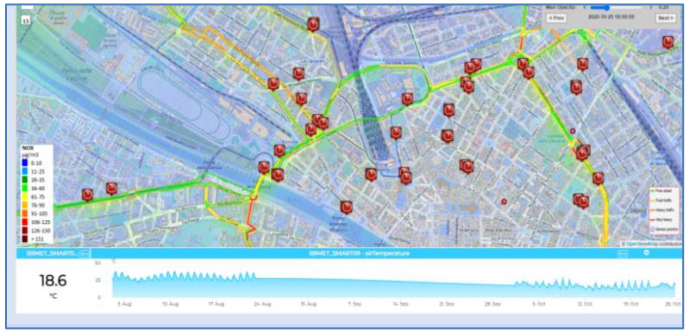
Challenges vs Technologies

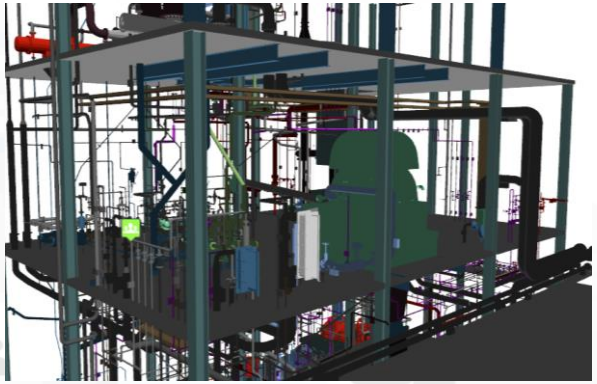
- **DSS, Decision Support Systems**, with multiple objectives:
  - **Quality of life** for citizens, improvements of services, cost reduction, innovation, attractiveness for tourists and/or industries and/or commercial activities, etc.
- **provide the decision-making process with simulation tools integrated with short-, long- and very long-term prediction algorithms**
  →*what-if analysis*
  - Analyze incipient events to cope with events;
  - analyze future situations for structural planning.
- **Opportunities and needs**
  - exploit **huge amounts of heterogeneous data (Big Data)** that come from the territory, from the structures and services of the city and from the stakeholders;
  - **flexible, dynamic and interoperable models and analysis tools;**
  - **accessible for:**
    - Operators, decision-makers, stakeholders;
    - citizens as a tool for illustrating and discussing possible solutions and development plans with them.



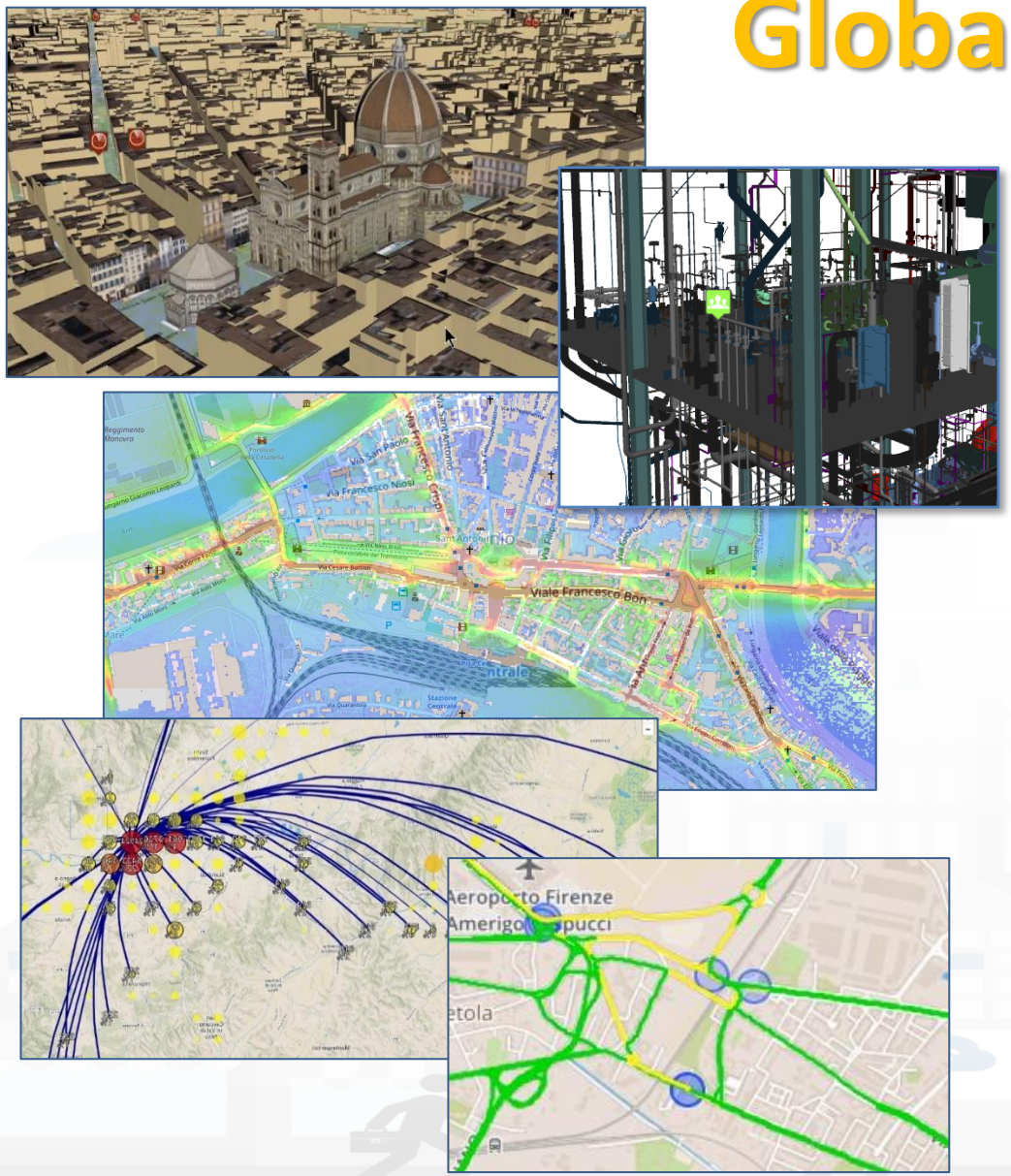
Digital Twin

- **Digital Twin**
  - **Connected** with real systems
  - **Modelling** aspects: structural, visual, informative, real time data sensors (context), POI, functional, resources, etc.
  - **Integration:** AI/XAI techniques, simulations, users' needs, etc.
- **Utility to**
  - Experiment via simulations and analysis by case
    - Reduction of costs to experiments new solutions
    - Share the possibilities with city users
  - Virtual Representation
    - Easier to understand the context, review from multiple points of view
  - Who
    - Discussion with city users, decision makers
    - Support: decision makers, proposers of solutions





Global/Local Digital Twin



3D representation of the city with…

- geomorphological, hydrogeological aspects,
- private and public transport networks,
- waste recovery systems,
- weather conditions, climate and microclimate,
- events, emergencies, ..., parking, sharing, ...
- tourist and city user flows, origin destination matrices,
- commercial activities, urban decorum, public lighting,
- green areas, cleanliness, safety on the road and in pedestrian areas,
- places for entertainment events, cultural activities, attraction and aggregation points of the city,

Complex and heterogeneous information, structured and unstructured, historical series and in real time data, public/private and sensitive data for security aspects.

- → **Reuse of legacy systems**
  - GIS (Geographical Information System),
  - ITS (Intelligent Transportation System),
  - AVM (Automatic vehicle monitoring),
  - from IoT (Internet of Thing) systems and networks.

100% OPEN SOURCE

Powered by FIWARE

FREE TRIAL

PEN Test Passed

EU GDPR COMPLIANT

SNAP4 Appliances and Dockers Installations

EUROPEAN OPEN SCIENCE CLOUD

Node-RED

JS Foundation

EØ15 digital ecosystem

NVIDIA

SNAP4CITY

KM4CITY

SMART SOLUTIONS AND DECISION SUPPORT SYSTEMS

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

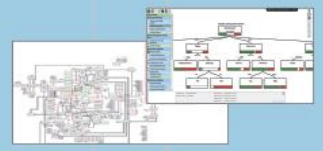
DASHBOARDS - VISUAL ANALYTICS - SYNOPTICS - DIGITAL TWIN - GRAPHICAL WIDGETS - ANALYTICS - GUI CUSTOM STYLES - VISUAL PROGRAMMING

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

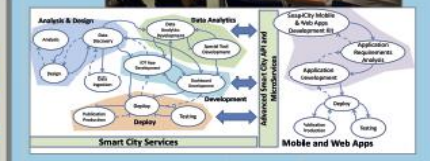
BIG DATA ANALYTICS, ARTIFICIAL INTELLIGENCE
EXPLAINABLE AI, MACHINE LEARNING
OPERATIVE RESEARCH, STATISTICS

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

Native and External Applications

- Smart Parking
- Smart Light
- Smart Waste
- Smart Energy
- Social Media Analysis

...



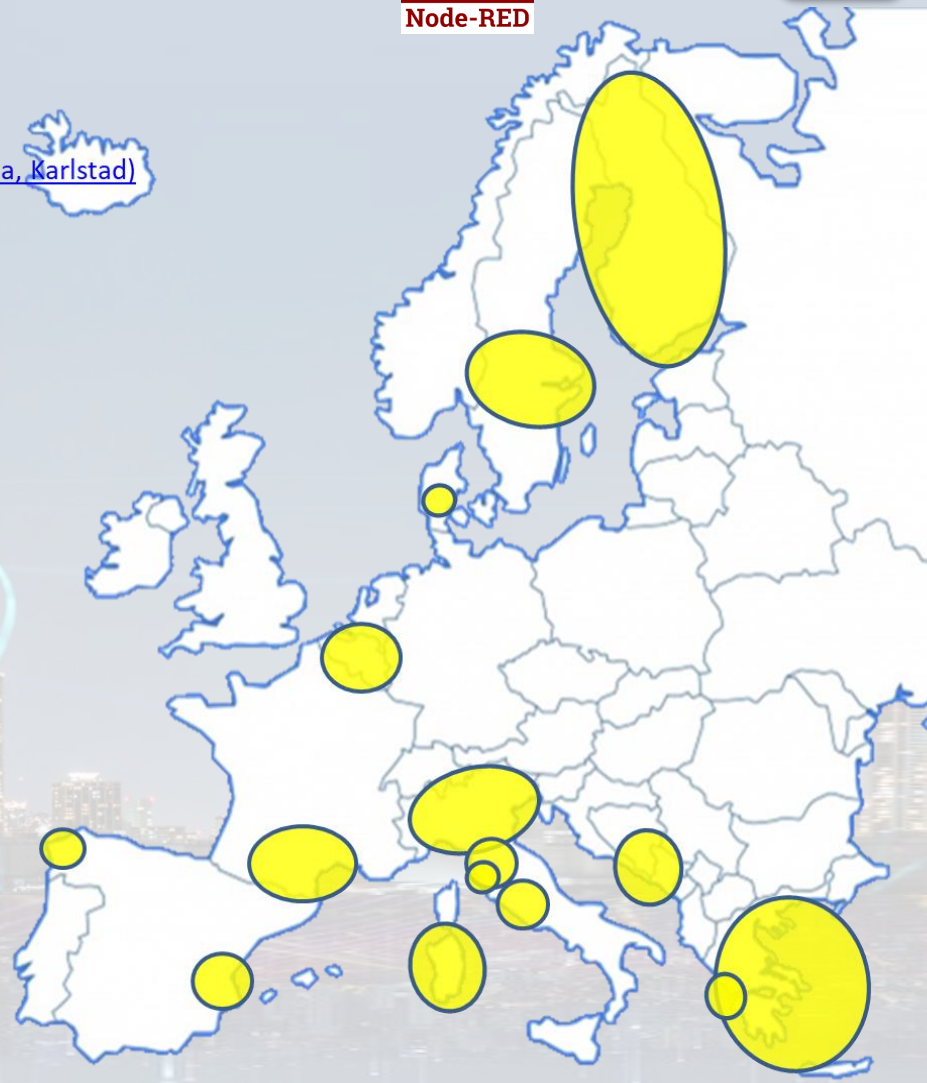
METHODOLOGIES
LIVING LABS
COURSES AND COMMUNITY
DEVELOPMENT TOOLS

https://www.Snap4City.org

- 11 running installations in Europe
  - Snap4.city.org, Greece, Merano, …
  - Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
  - Altair, Italmatic, Sweden, Romania, ….
- 16 projects, 12 pilots on 10 Countries
  - >40 cities/area
- **Widest MULTI-tenant deploy has**
  - 19 Organizations / tenant
  - > 8000 users on
  - > 1600 Dashboards
  - > 16 mobile Apps
  - **> 2.1 Million of structured data per day**
  - > 520 IoT Applications/node-RED
  - > 700 web pages with training
  - > 70 videos, training videos

Main Organizations/areas

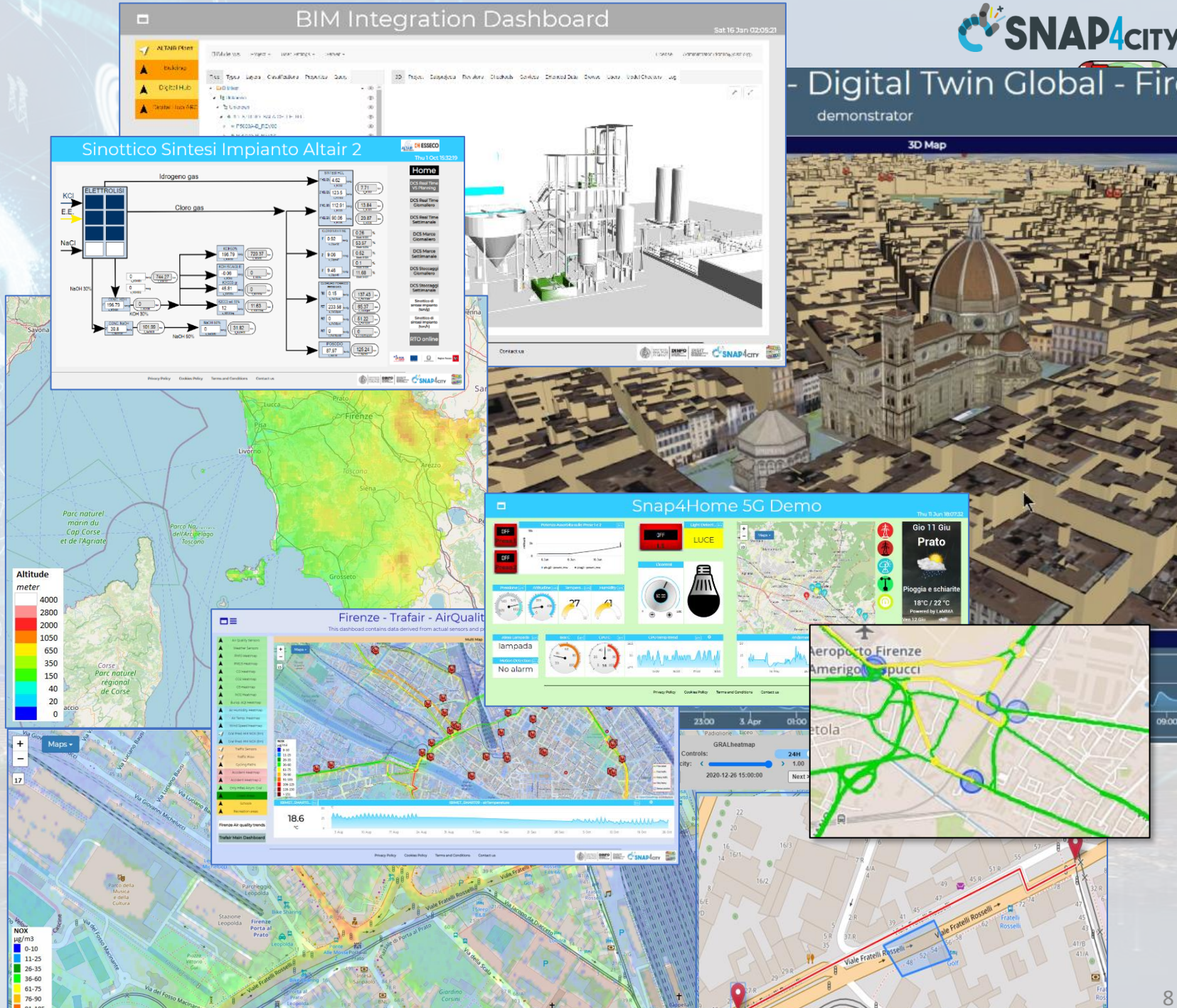
- Antwerp area (Be)
- Bologna (I)
- Capelon (Sweden: Västerås, Eskilstuna, Karlstad)
- DISIT demo (multiple)
- Dubrovnik, Croatia
- Firenze area (I)
- Garda Lake area (I)
- Greece (Gr)
- Helsinki area (Fin)
- Livorno area (I)
- Lonato del Garda (I)
- Modena (I)
- Mostar, Bosnia-Herzegovina
- Oslo & Padova (Impetus)
- Pisa area (I)
- Pistoia (I)
- Pont du Gard, Occitanie (Fr)
- Prato (I)
- Roma (I)
- Santiago de Compostela (S)
- Sardegna Region (I)
- Siena (I)
- SmartBed (multiple)
- Toscana Region (I), SM
- Valencia (S)
- Venezia area (I)
- WestGreece area (Gr)



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

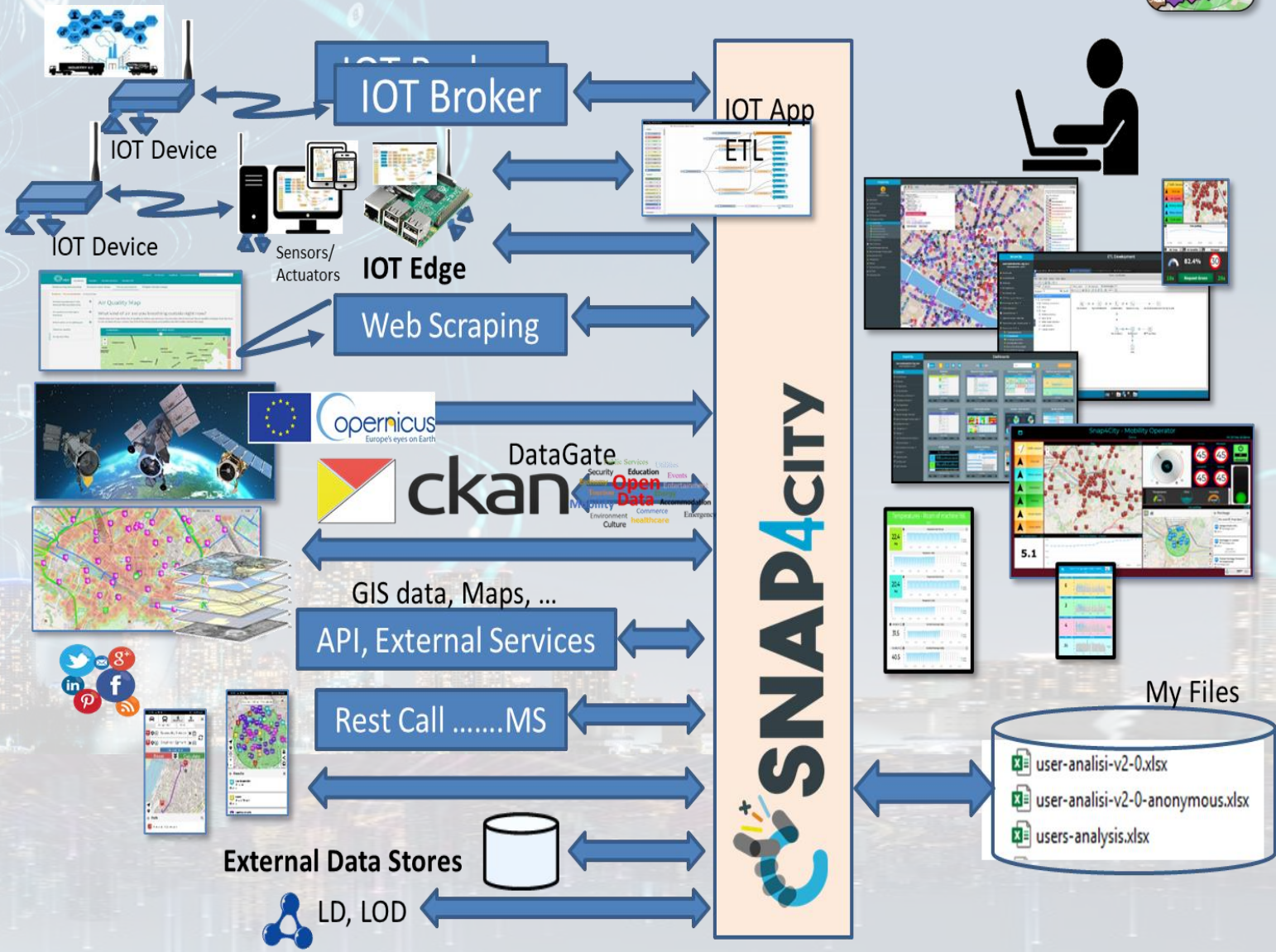
High Level Types

- POI, IOT Devices, shapes,..
- FIWARE Smart Data Models,
- IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ..
- Satellite data, ..
- 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.



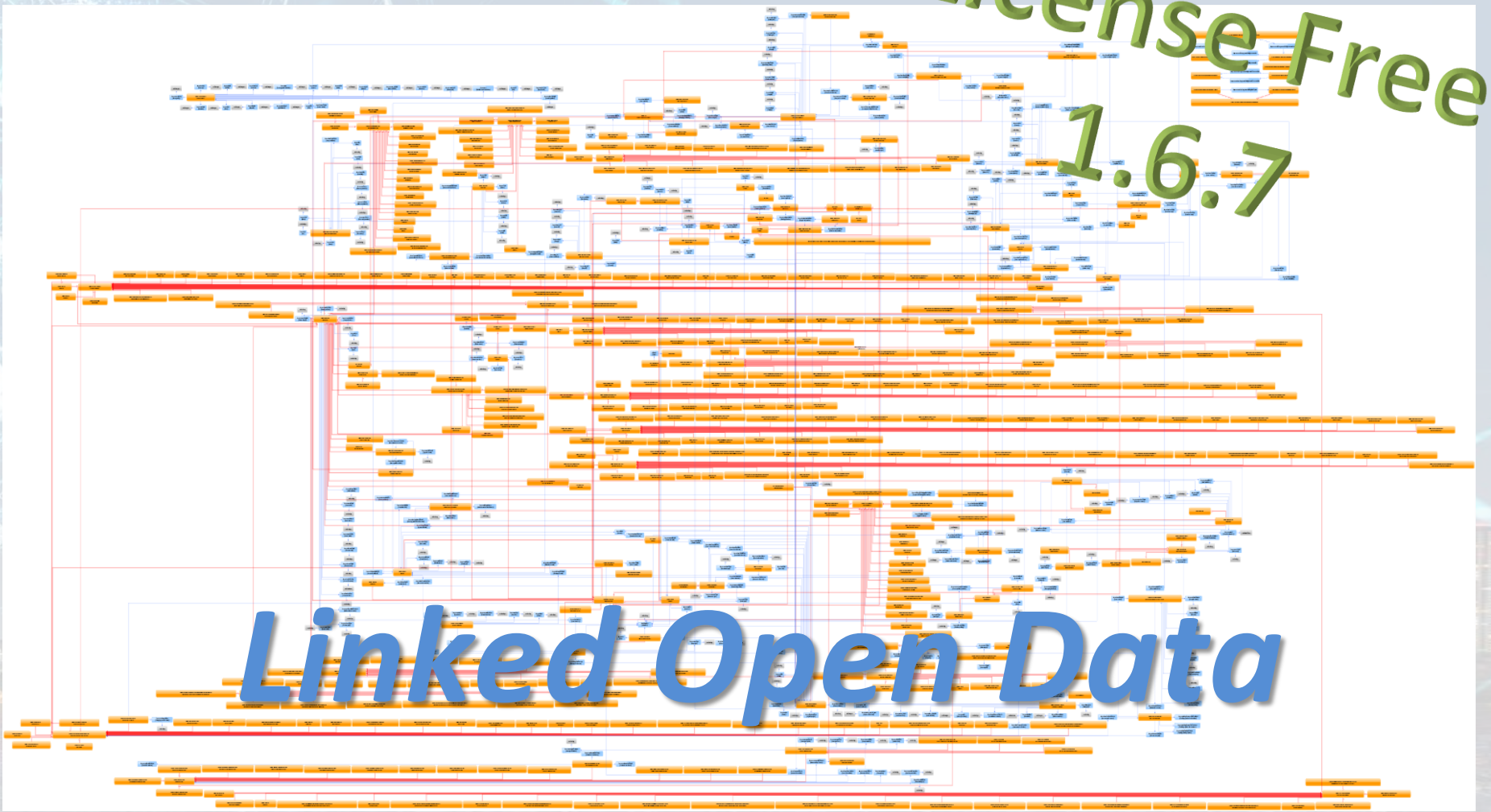
Ingestion, agg. → exploitation

- **> 190 protocols and formats / standards**
  - Any format, any channel, any data, any broker, any protocol, …
  - **Km4City** Knowledge base Ontology reasoning on geo, space, time, relationships
- **efficient tools for**
  - Bidirectional data channels



Expert System semantic queries

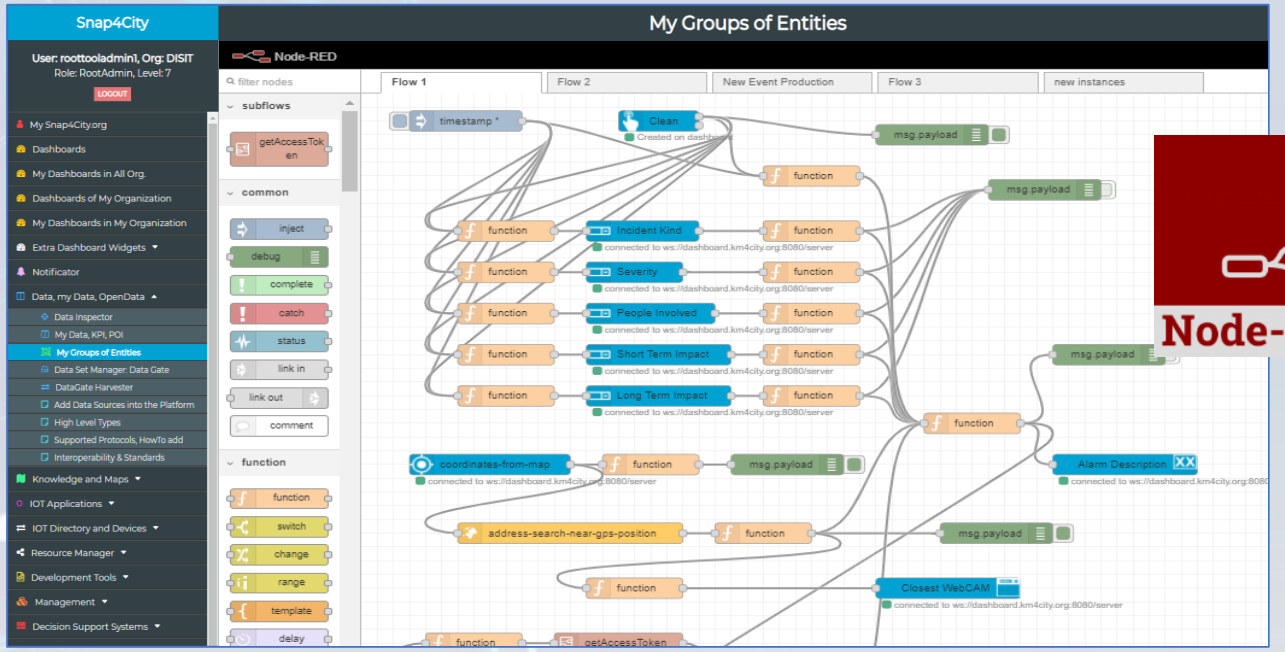
- **via**:
- **Smart City API** for Apps and third party
- **MicroServices** data driven develop via visual language Node-RED

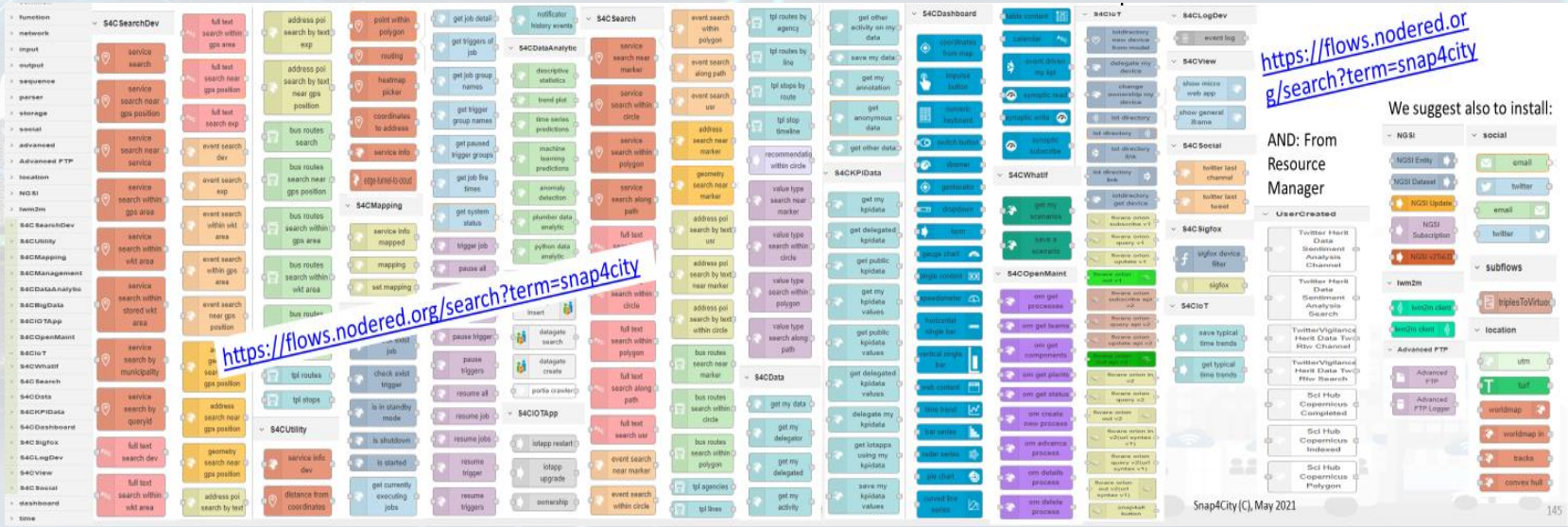


https://www.snap4city.org/19

Almost no coding platform

- **IoT App Visual Programming, no coding**
  - **Data transformation**
  - **Integration**
  - **Scripting Data Analytics**
  - **Data ingestion**
  - **Business logic**
- **MicroServices** data driven develop via visual language Node-RED

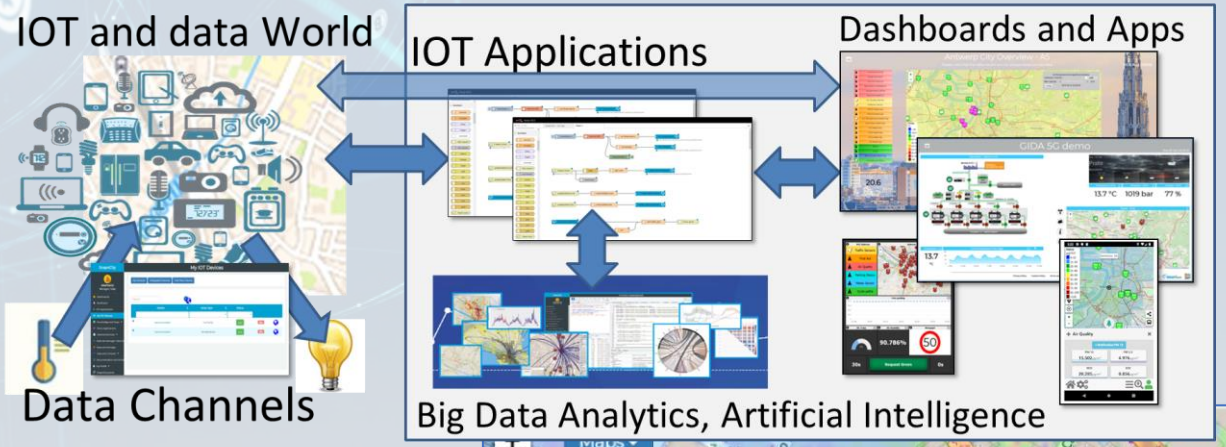


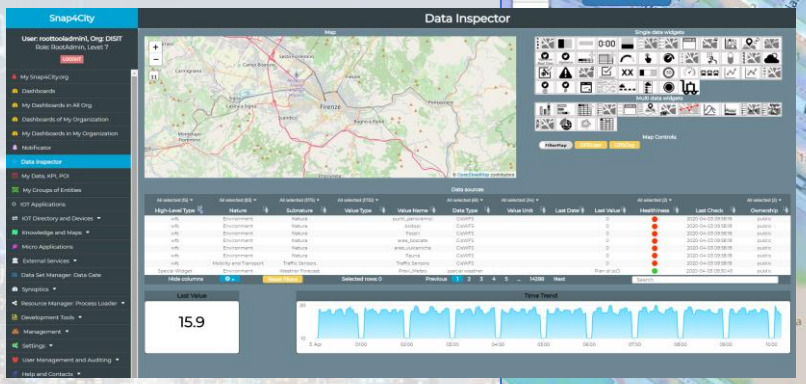


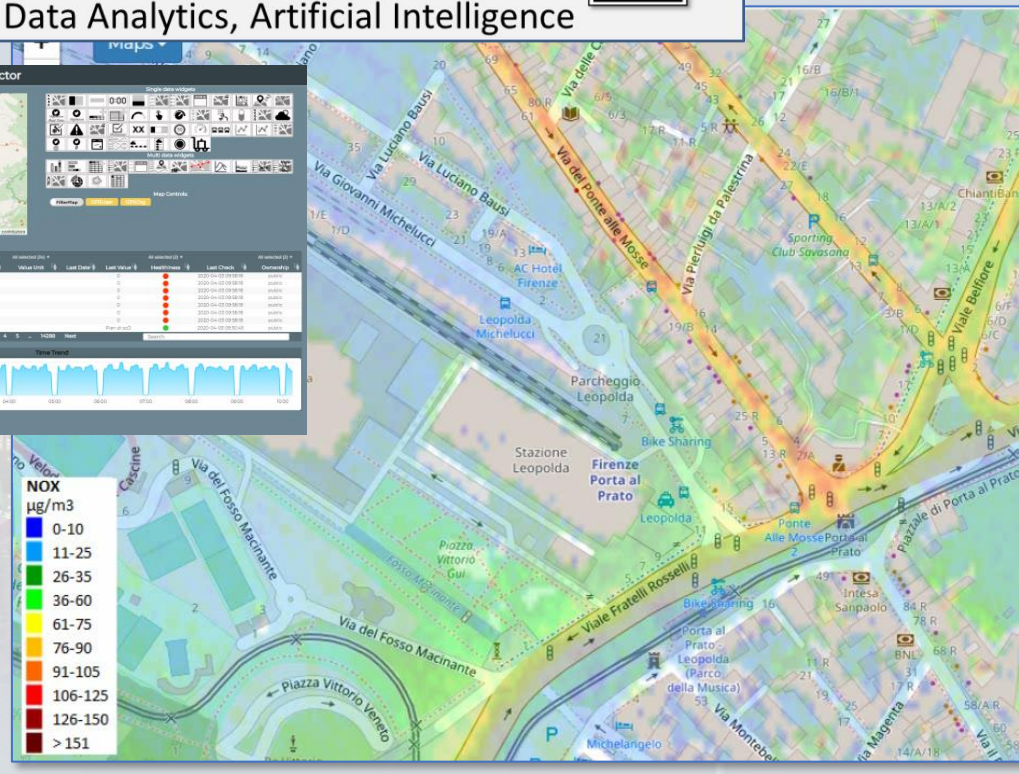
Fast to realize reliable & secure Solutions

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

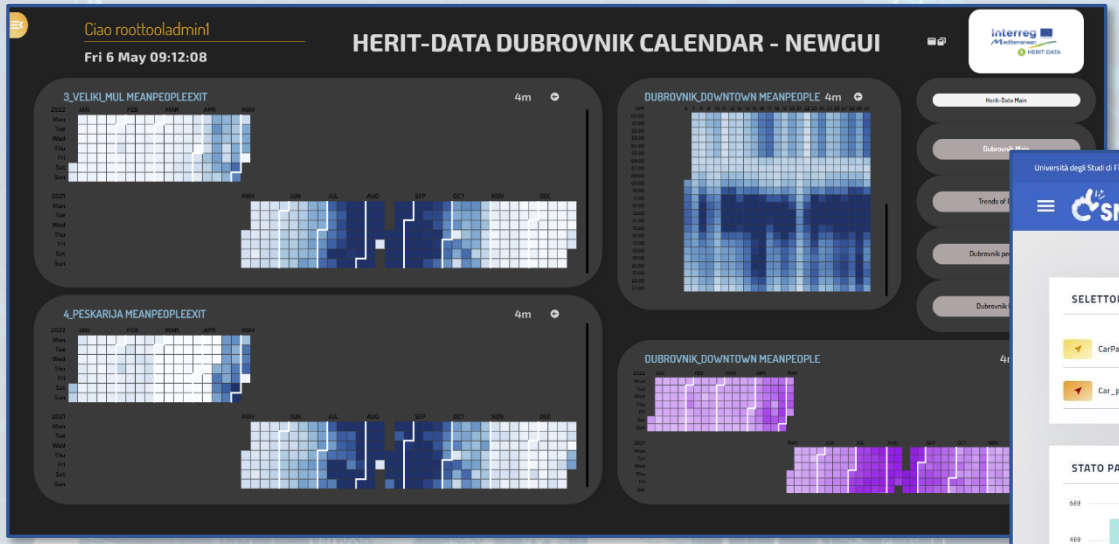
- **Smart Solutions results to be**
  - **Real time data drive**
  - **Secure end-to-end**
  - **GDPR compliant**
  - **Reliable, interoperable**
  - **Auditable, marketable**

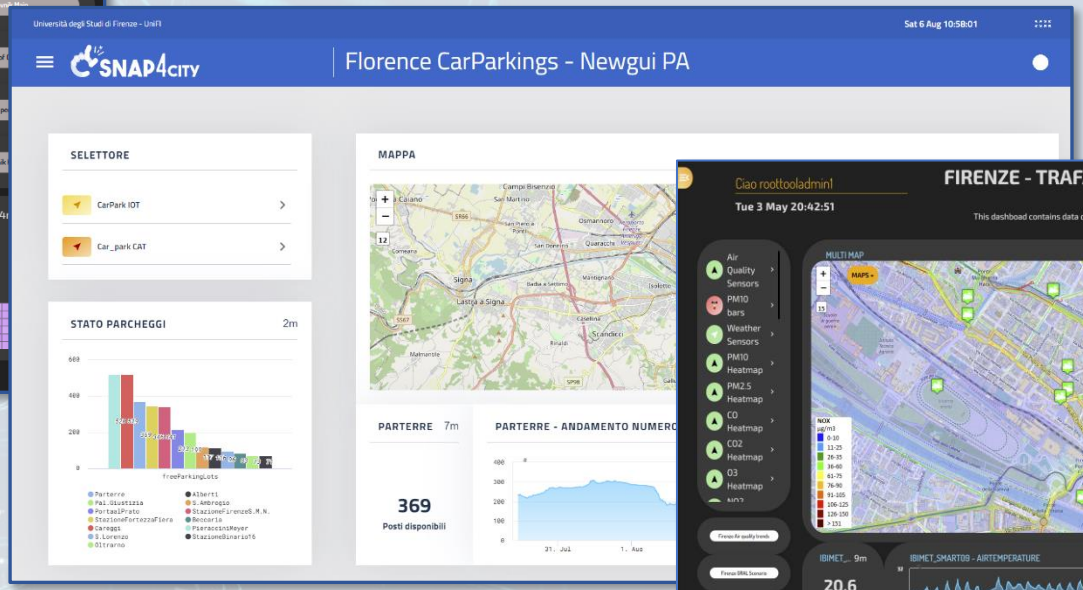


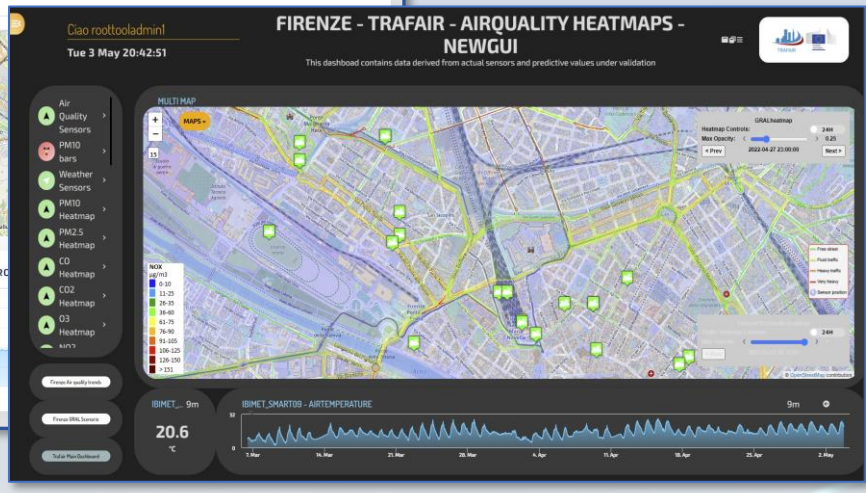


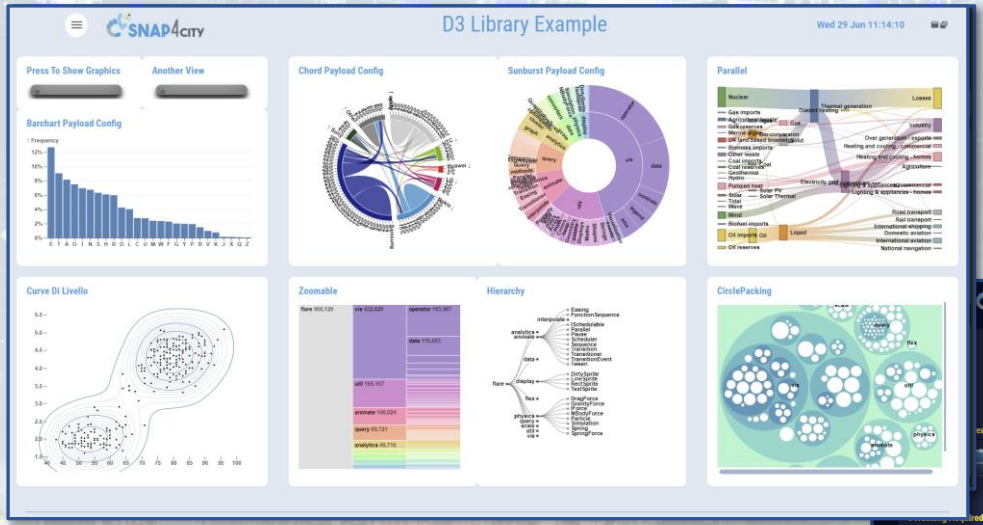


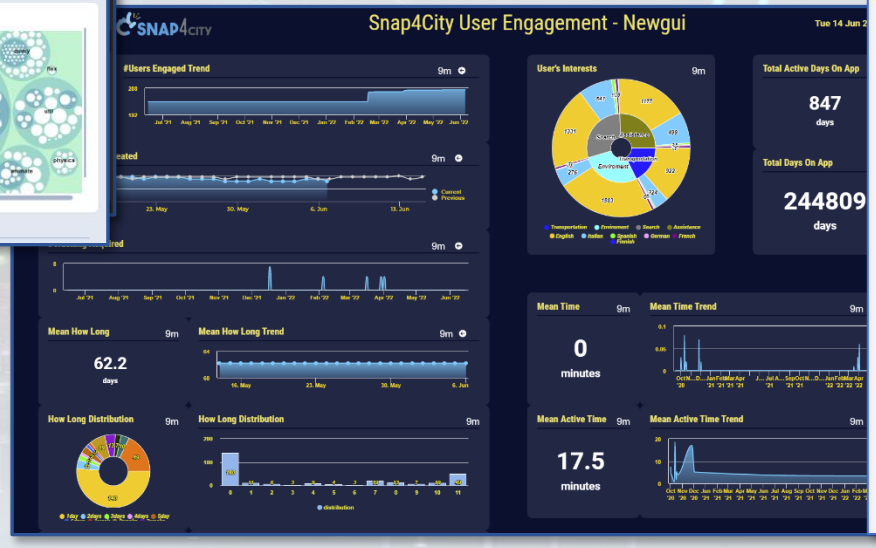
Different Themes

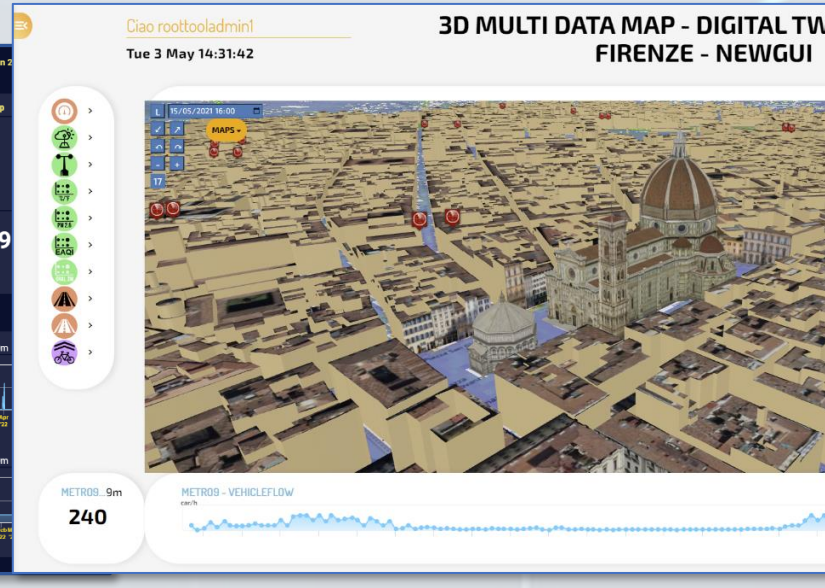












New styles/themes can be developed by specializing a few files from open source

https://www.snap4city.org/793

Domains

- Smart City, control room
- Green Deal, smart light, ..
- Environment, pollutant, ..
- Mobility and transport
- Tourism and People
- Energy , Industry
- Social Media

- Big Data
- Artificial Intelligence
- Public and private data

Publications http://www.disit.org/5487

- ***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.

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

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

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

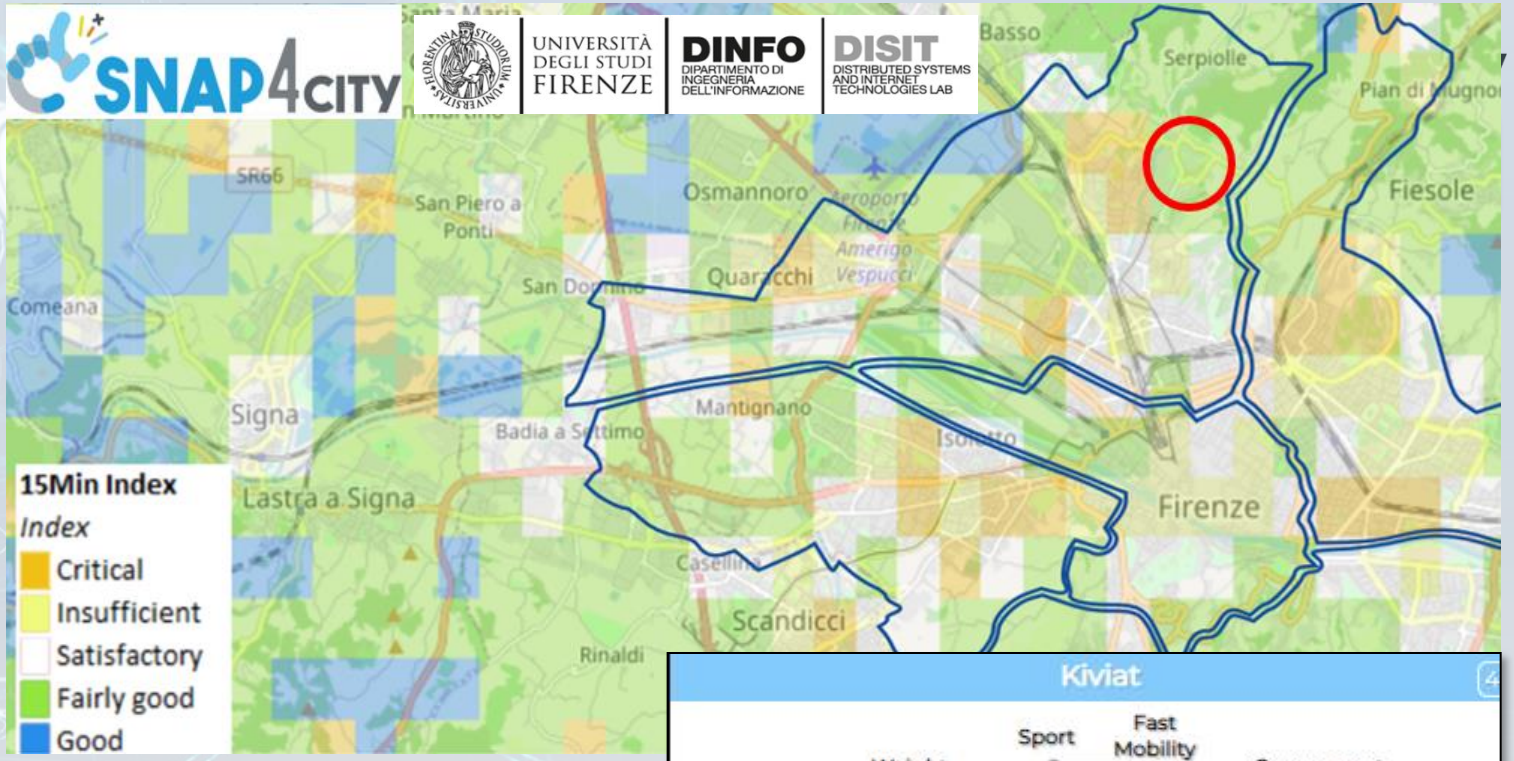
- Monitoring and Predicting: NO2, NOX, CO2, Traffic flow, pollutant, landslide, waste, etc.
- Traffic flow reconstruction
- Demand vs Offer of Mobility analysis

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

15MinCityIndex

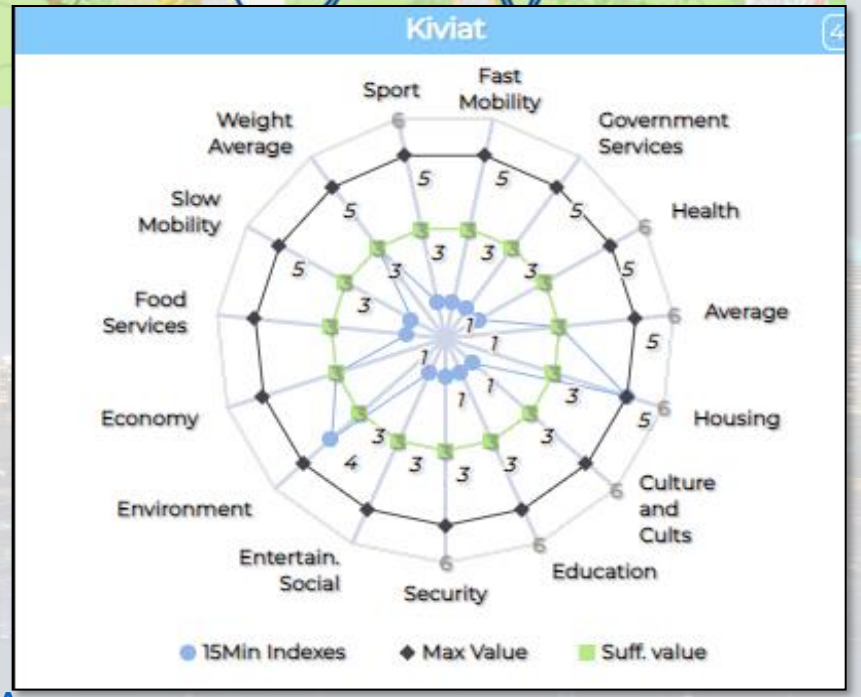
What would support my neighborhood to become a 15-Minute City?

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.

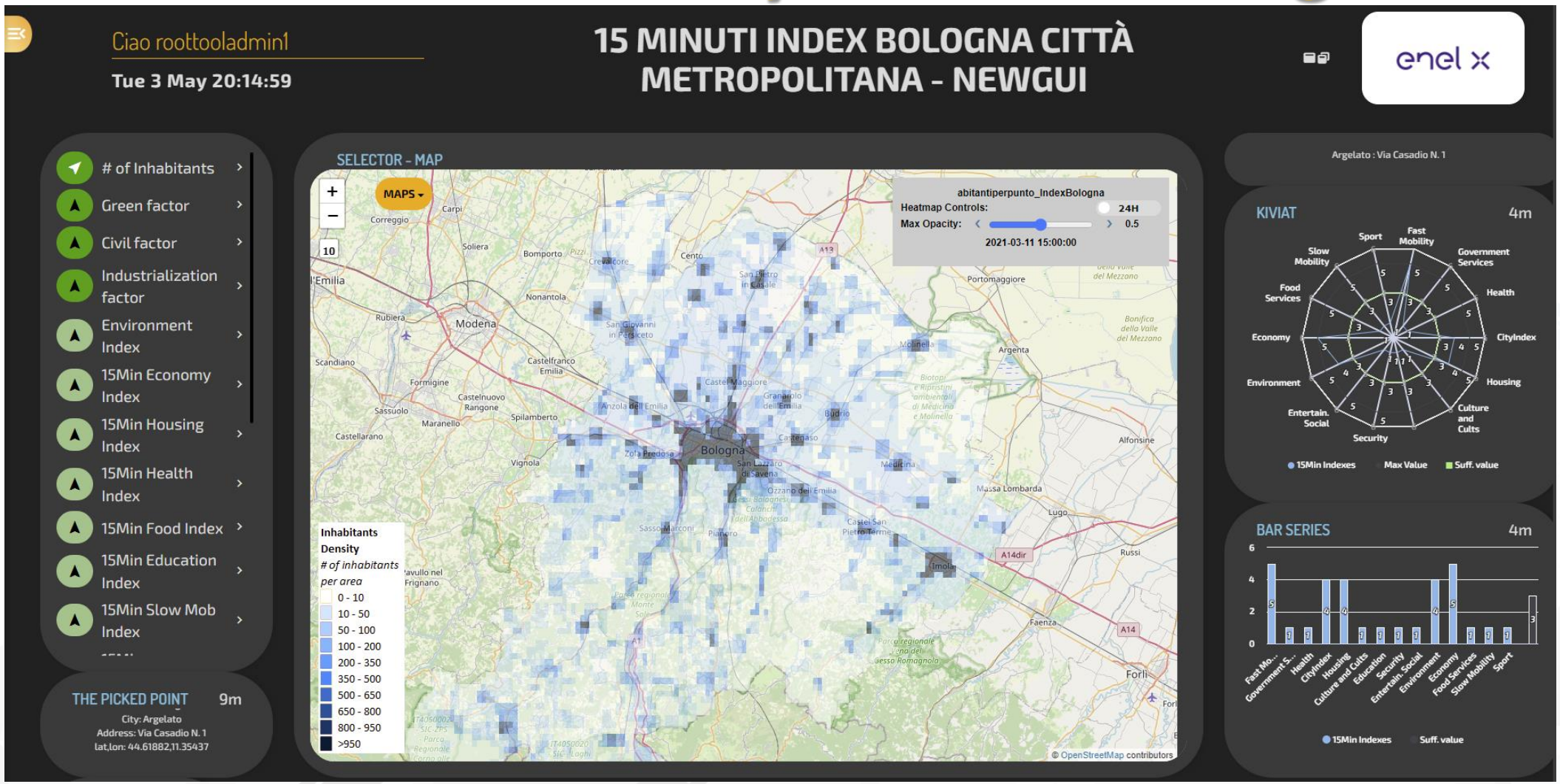
The tool supports the becoming of a 15-Minute city evaluating the service level in various domains.



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.

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

15MinCityIndex on Bologna



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

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

Scenarious

- 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

Florence

Smart City Control Room
Florence Metropolitan City

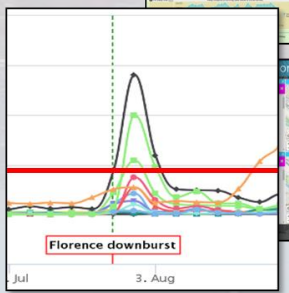
COMUNE DI FIRENZE

reference

SNAP4CITY

KM 4 CITY

- **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

3D Map Global Digital Twin -Newgui2

Thu 25 May 17:54:20

3D Map

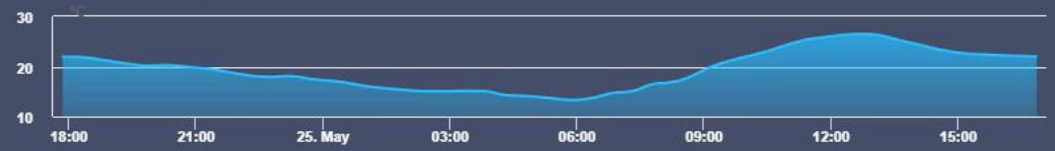
https://youtu.be/JLzT9k3Xbc0

Air Quality FI-BASSI - NO2

6m

Weather_sensor_ Open Weather 3176959 - Air Temperature

6m



OCULUS


Perspective
Lit
Show
Scrivi qui per eseguire la ricerca
6°C
19:09
30/11/2022


Perspective
Lit
Show

OCULUS

https://youtu.be/Rcf_B2_GOio

Snap4City | Dashboard Management System | Nuova scheda

snap4city.org/dashboardSmartCity/view/index.php?iddasboard=Mzg0NA==

Bookmarks | Calcio: ultime news... | Diffusioni in diretta,... | La Repubblica.it - H... | Corriere dello Sport.it | TIM Mail | Tim.it | E... | Gmail | YouTube | Maps | Telecom Italia ROU... | Firenze Traffic Flow | Snap4Altair | dashboard/iotapp/... | ilCorSaRoNeRo.link...

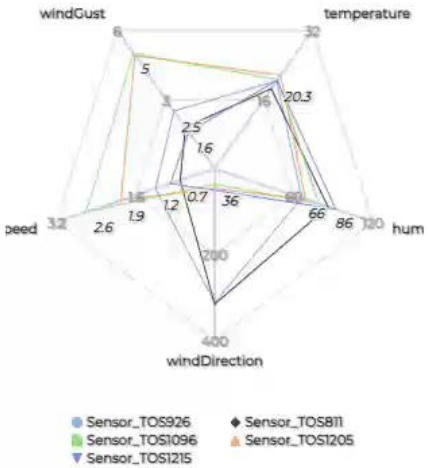
BIM Airport

Thu 25 May 18:16:22

Select the view of interest

- Airport Building 1
- Airport Heatmap dash
- Terminal Heatmap

Sensor Data 4m



https://youtu.be/GZDITP5lsxg

Last Value	Time Trend Chart
No data	

TOP

Data Analytic Artificial Intelligence, XAI, Machine and Deep Learning

Available Data Analytics

- Mobility and Transport
- Users Behaviour analysis
- Environment and Weather analysis
- Management and strategies
  - Early Warning, What-If analysis
  - Resilience and Risks Analysis
  - Semantic Reasoning

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

https://www.snap4city.org/download/video/course/da/

Big Data Analytics + Artificial Intelligence

- **Decision support**
  - **Early warning, City Indexes, etc.**
  - **What-IF analysis** (simulation + AI + data)
- **Predictions**
  - **Short and Long terms predictive models on:**
    - traffic, parking, people flow, maintenance, land sliding, NO2
  - **3D Flow prediction:** Pollutant (NOX, NO2, …)
- **Suggestions and recommendations**
- **Modeling, simulation, routing**
  - **Traffic Flow reconstruction**
  - **Constrained Routing**

AI & XAI:

- RF, XGBoost, BRNN, RNN, SVR, DNN, LSTM, CNN-LSTM, Autoencoders, …
- Clustering: K-means, K-Medoid, …
- XAI: Shap, variations, lime, gradients

Computational processes:

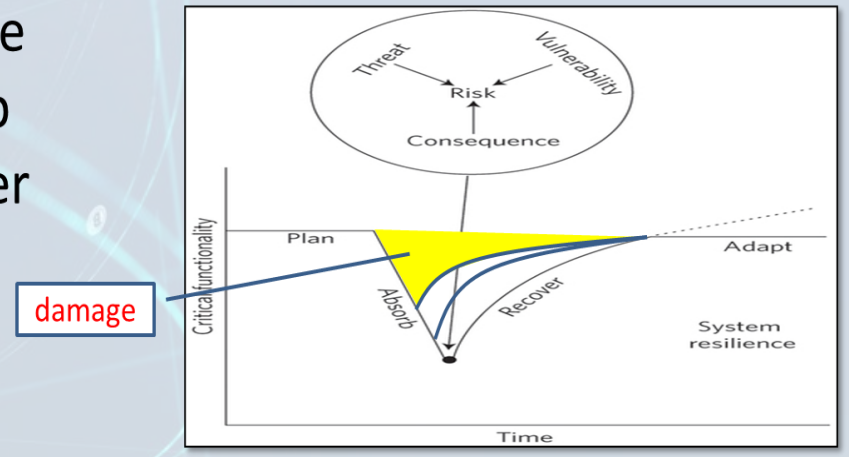
- Heatmaps, ..
- trajectories,
- OD matrices,
- Typical Time Trends, etc.

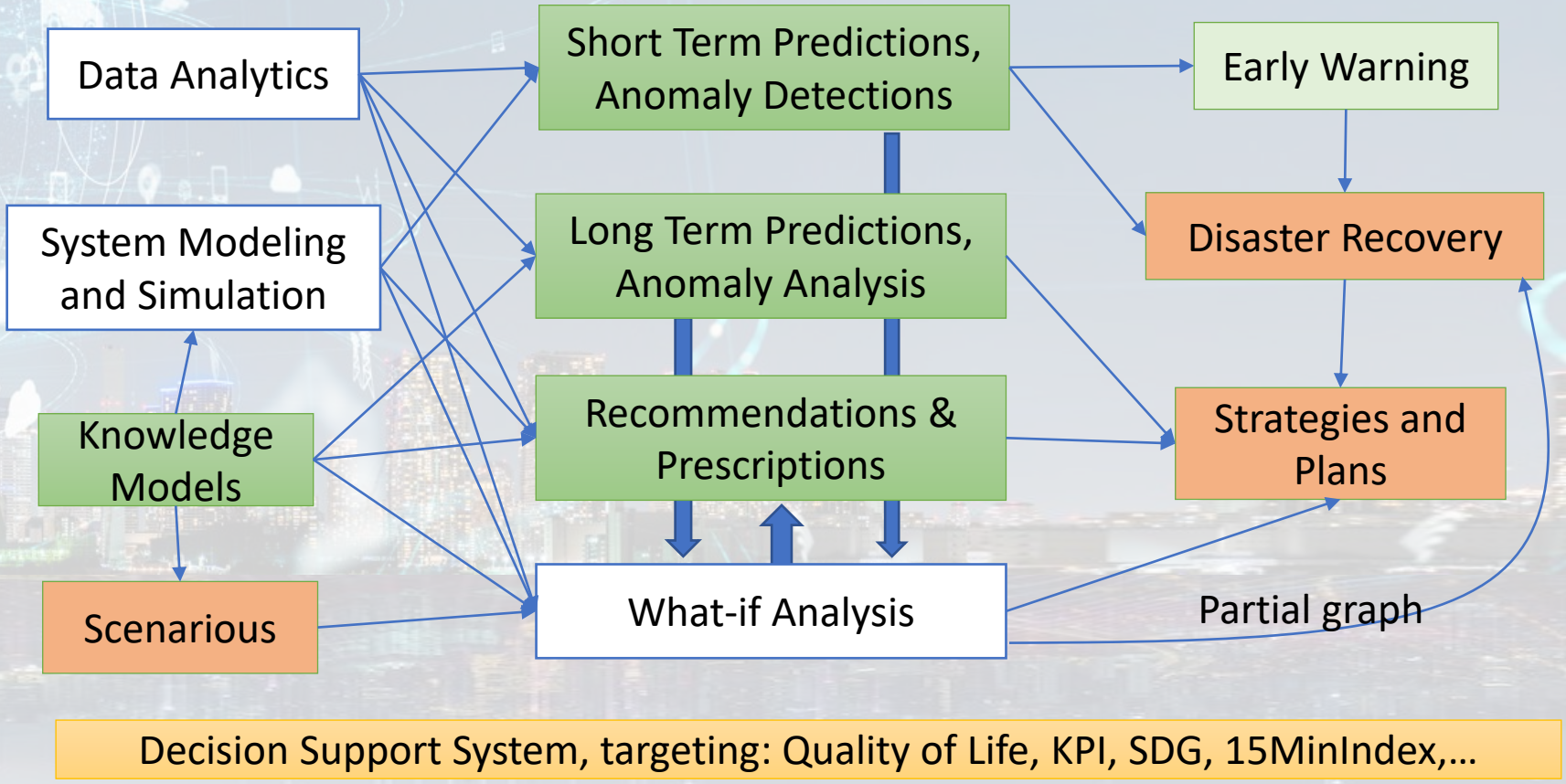
https://www.snap4city.org/download/video/course2020/da/Snap4City-4th-slot-Data-Analytic-v4-6.pdf

Snap4City Analytics

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

Prepare
Absorb
Recover
Adapt

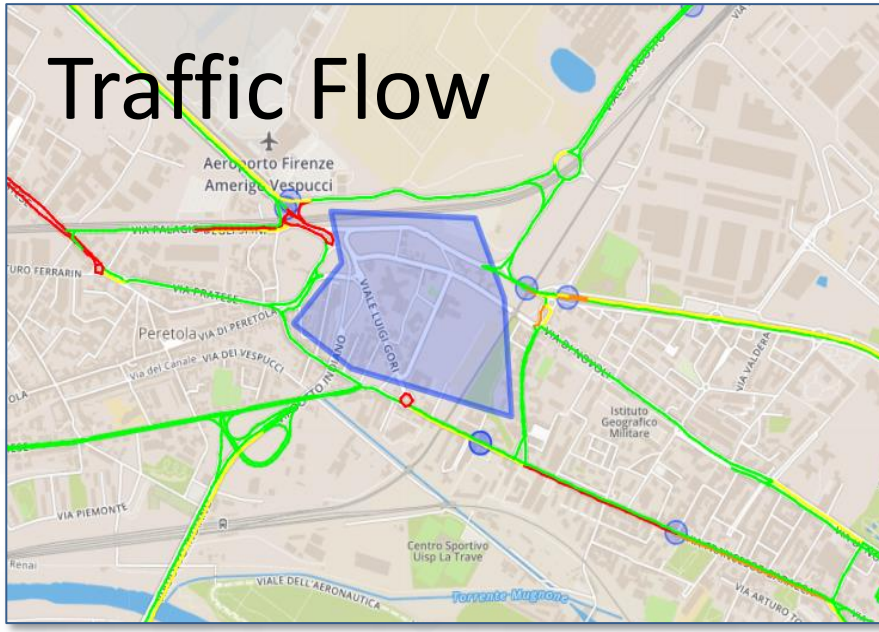


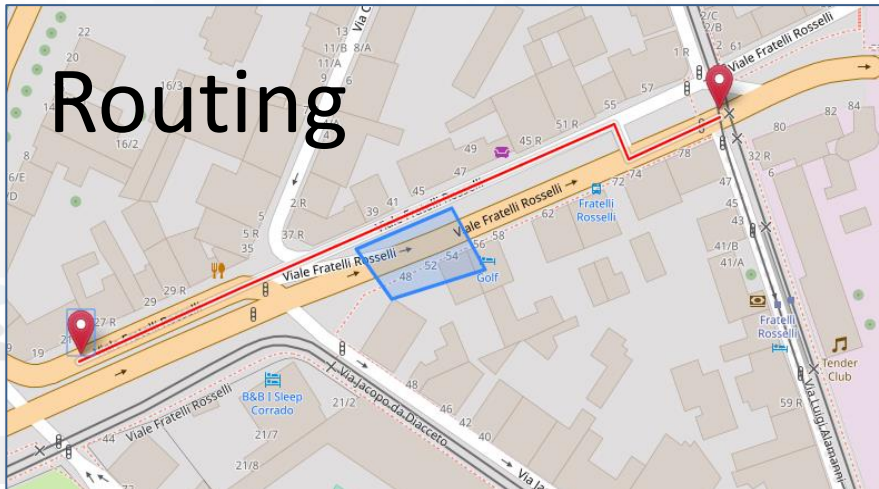


Decision Support System, targeting: Quality of Life, KPI, SDG, 15MinIndex,…

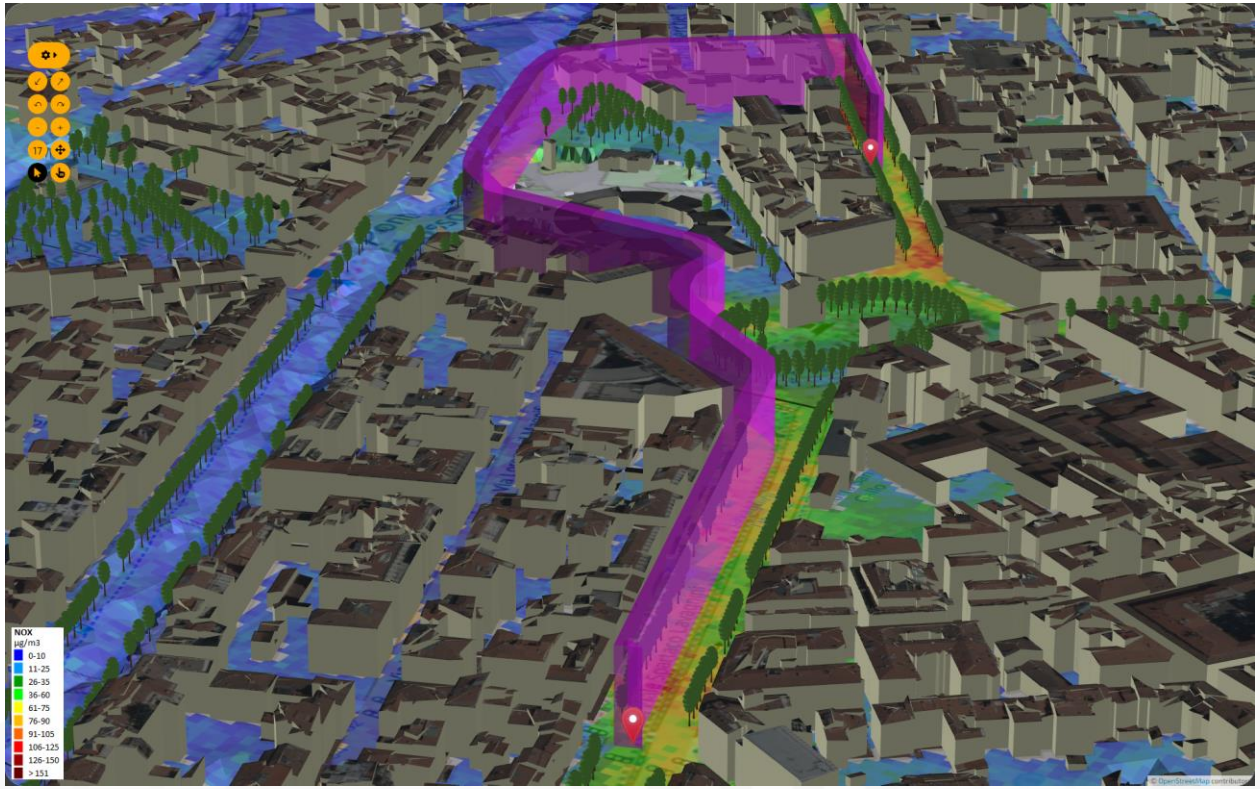
Decision Support Systems, What-if

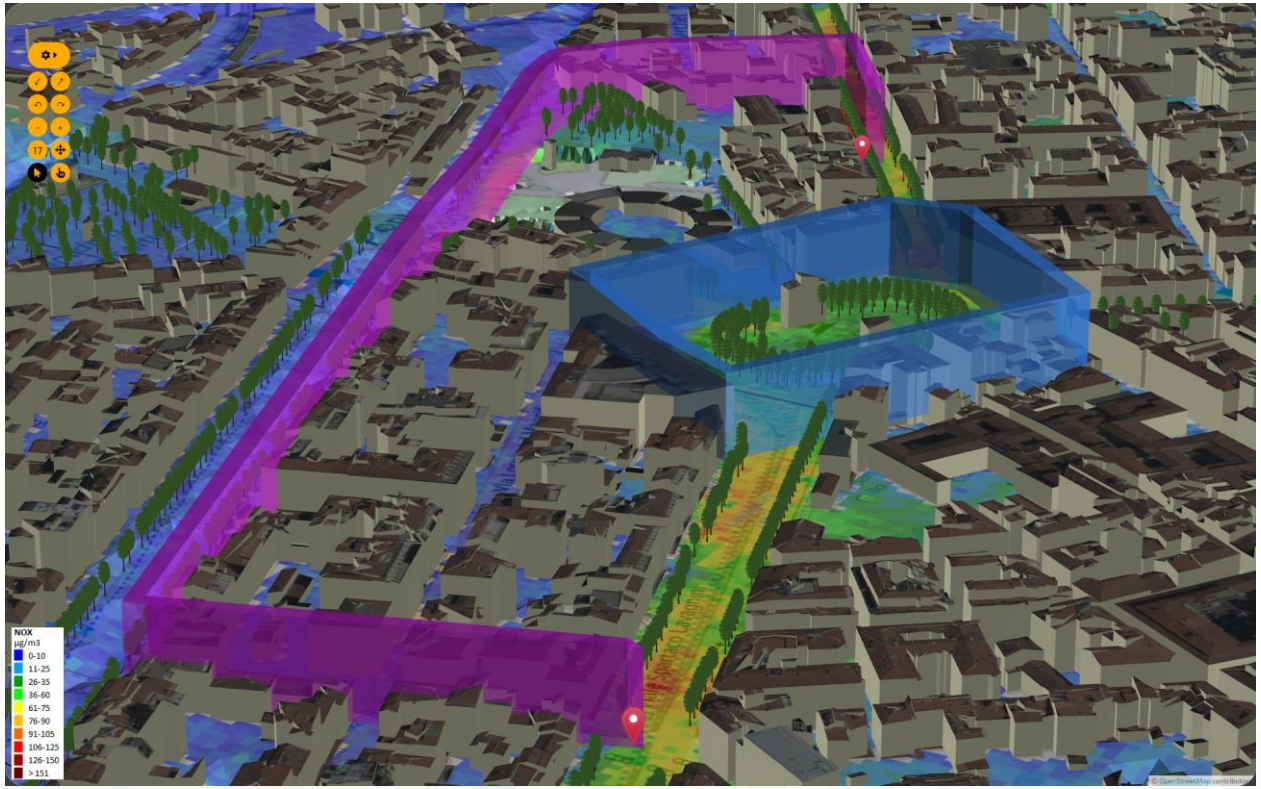
- **Event planning, via what-if analysis**
  - Change in the graph structure of the city
  - Impact on the flow of people and vehicles
  - Adaptation: public transport, traffic, pedestrian management, etc.
- **Immediate reaction to natural events or not**
  - Everything is ready and updated in real time
  - 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





Dyamic Routing in 3D space

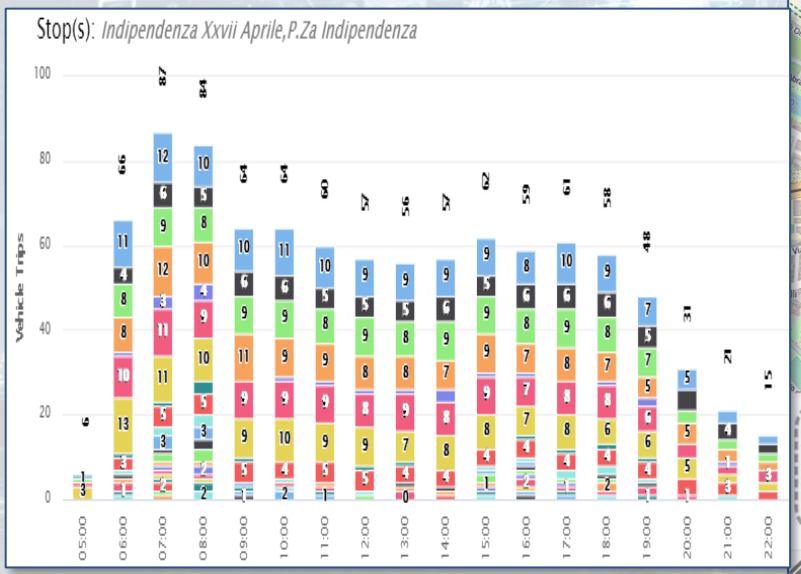


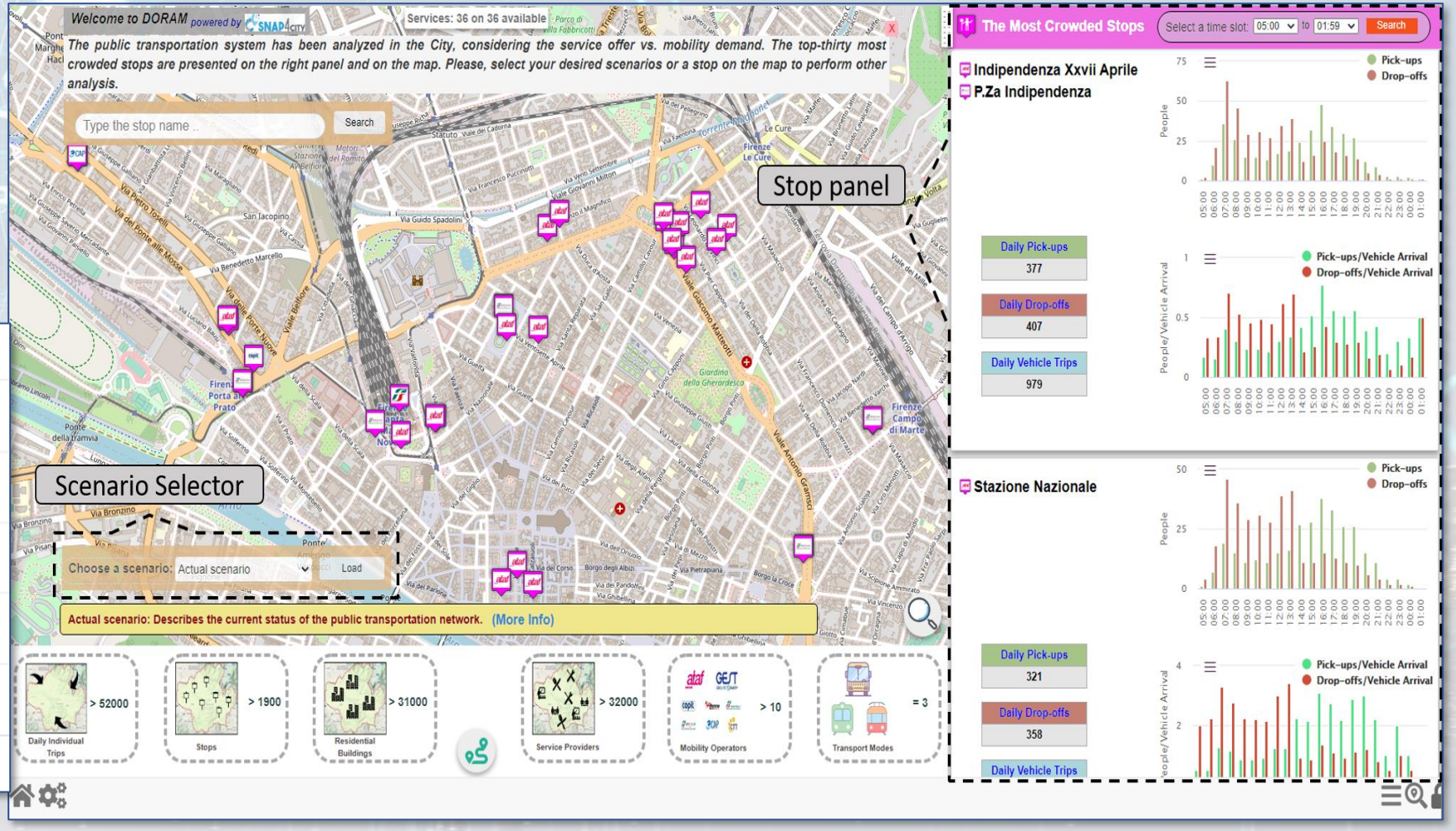


What-if Analysis on Pub Transport

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

Public Services





AI/XAI on: Mobility and Transport

- **What if analysis**: routing, traffic flow, demand vs offer, pollutant, etc. (Simulation + ML)
- **Traffic flow reconstruction** from sensors and other sources (simulation + ML)
- **Predictions** for: traffic flow, smart parking, smart bike sharing, people flows, etc. (ML, DL)
- **Public Transportation**: Ingestion and modelling of GTFS and Transmodel
  - 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.
- **Routing** and multimodal routing (multistop travel planning), constrained routing, dynamic routing
- Computing **Origin Destination Matrices** from different kind of data (analysis)
- Computing **typical trajectories** on the basis of tracks (analysis, ML)
- Computing Messages for Connected drive
- Slow and Fast Mobility **15 Minute City Indexes** (analysis, 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

Towards a Sustainable Mobility

Traffic and Mobility of people is the key:

- High costs for society and for people
- Sources of pollution: NO2, CO2, etc.
- Increased multimodal supply / demand
- Increased complexity of mobility
- Impact on quality of life: SDG, 15MinCityIndex
- Impact on primary and emergency services: firefighters, ambulances, security, freight transport, ..

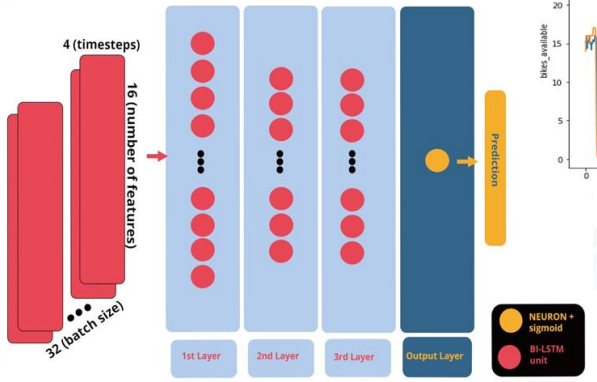
Environmental impact

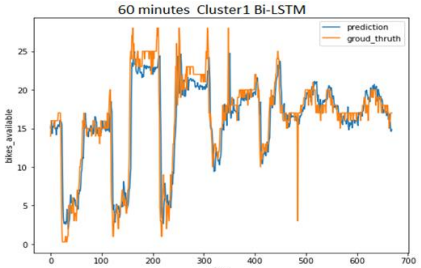
- Due to traffic but also to climatic factors

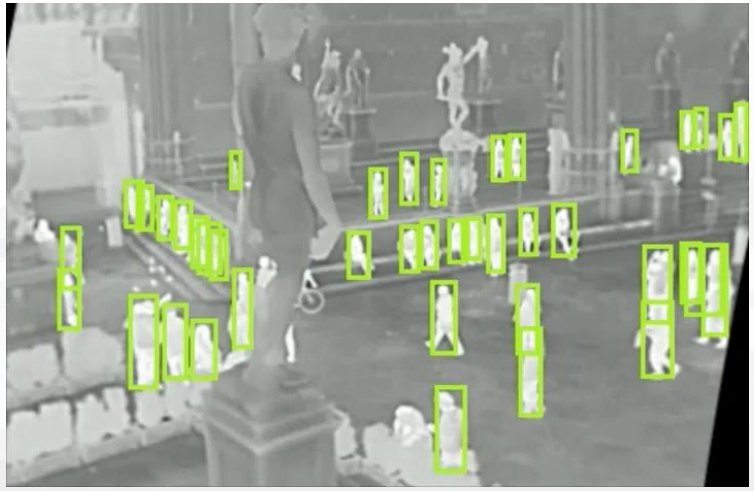
Towards Sustainable Mobility

Information on complex networks
Few measuring points with data over time

Traffic predictions with respect to unforeseen events
Predictions on parking, bike sharing, etc.







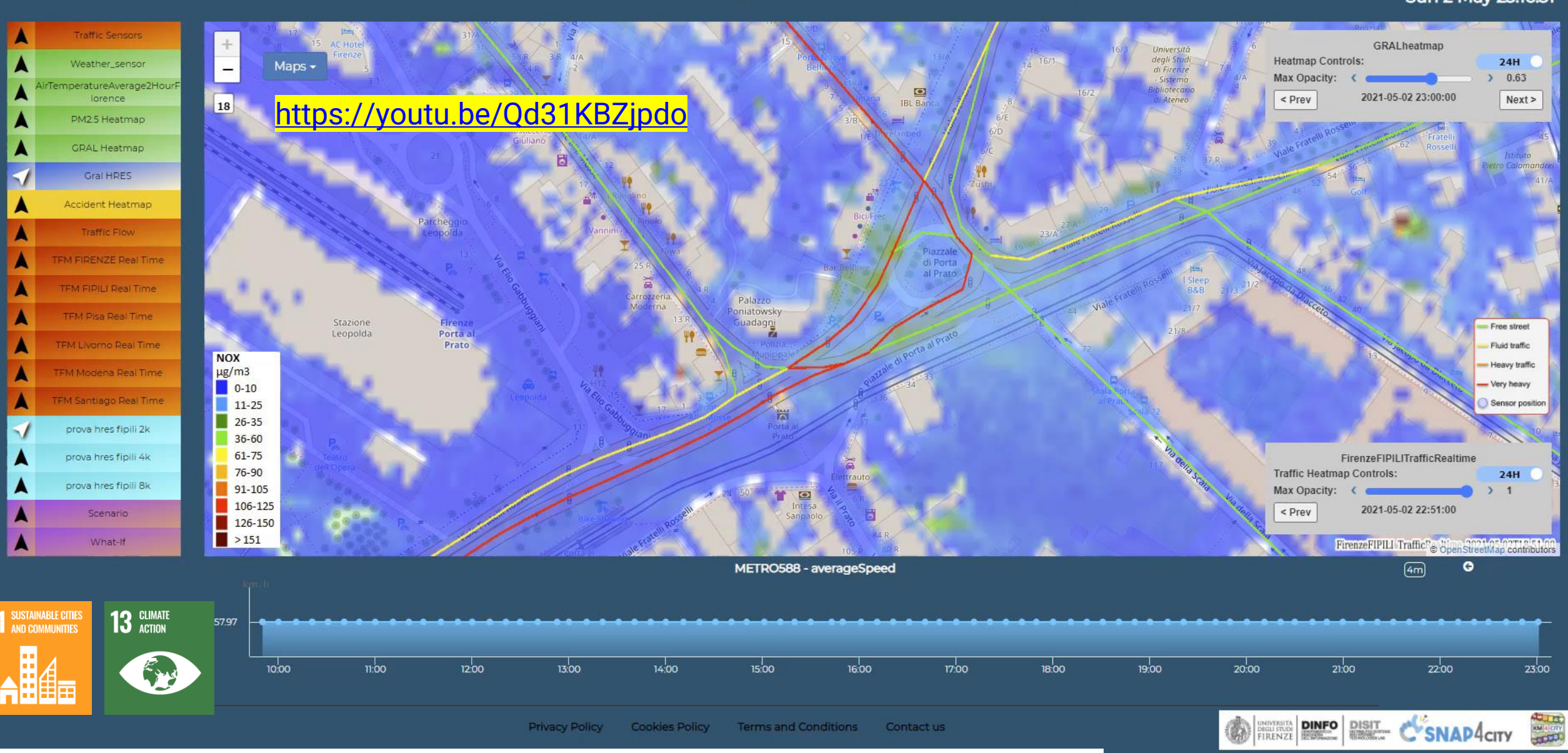
Assessment of local CO2

Predictions NO, NO2 (NOX)

AI/XAI on: Environment and Weather

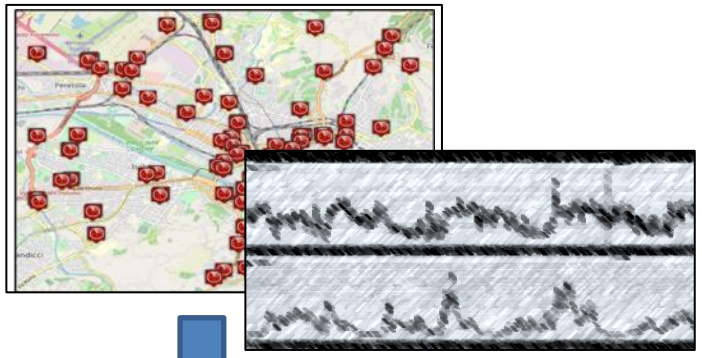
- **Predictions** of pollution conditions for diffusion NOX, PM10, PM2.5, on the basis of traffic flow, 48 hours
- **Long term predictions** of European Commission KPIs on
  - NO2 average value over the year
  - PM10 …….
- **Prediction of landslides**, 24 hours in advance
- **Computation of CO2** on the basis of traffic flows
  - each road for each time slot of the day
- **Heatmaps production**, dense data interpolation for
  - Weather conditions: temperature, humidity, wind, DEW
  - Pollutants and Aerosol: NO, NO2, CO2, PM10, PM2.5, etc.
- **Impact of COVID-19** on Environmental aspects

Traffic Flow Manager on multiple cities



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

Estimating City Local CO2 from Traffic Flow Data



Computing Traffic Flow into CO2 sensor area

Traffic Flow data

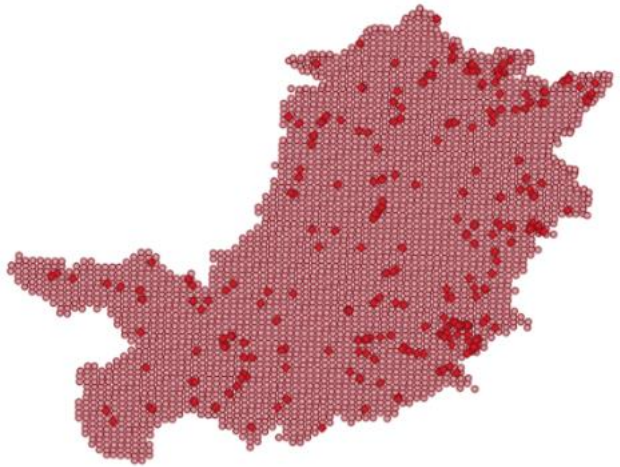
- Traffic Flow is one the main source of CO2
  - K1: Fluid Flow
  - K2: Stop and Go
- **Dense estimation of CO2 into the city** is very useful to know to target EC's KPIs

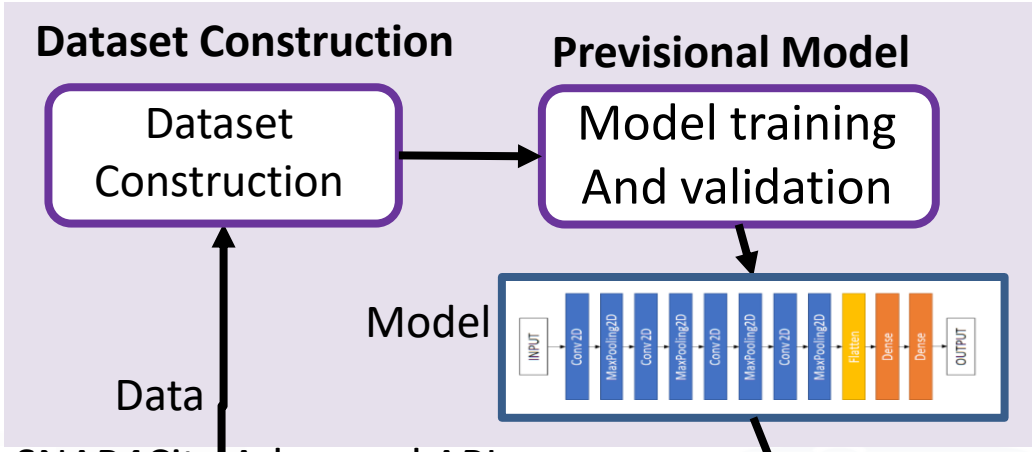
Computing CO2 on the basis of traffic flow data

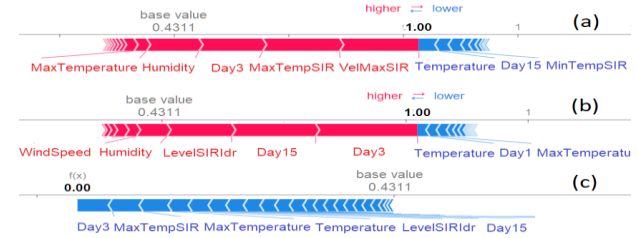
CO2 estimation

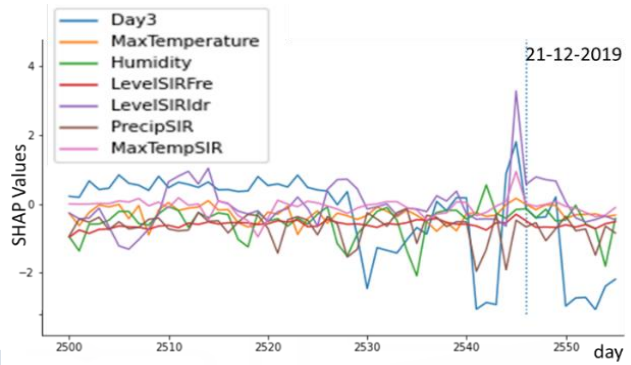
S. Bilotta, P. Nesi, "Estimating CO2 Emissions from IoT Traffic Flow Sensors and Reconstruction", Sensors, MDPI, 2022. https://www.mdpi.com/1424-8220/22/9/3382/

Predicting Land slides









landslide DB

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

Ingestion Processes

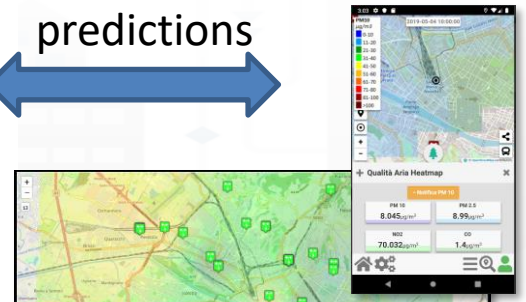
Big Data Storage and KB

Predictions

Model execution Shap Assessment

Data Analytics IOT App Management

predictions



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

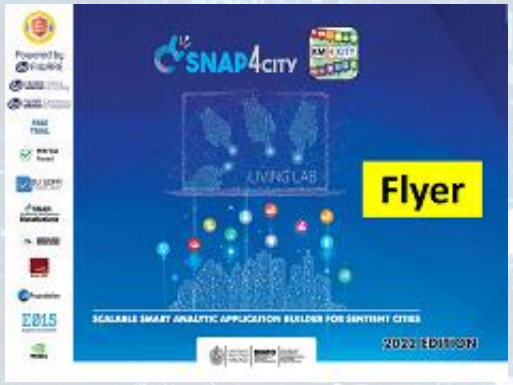
E. Collini, L. A. I. Palesi, P. Nesi, G. Pantaleo, N. Nocentini and A. Rosi, "Predicting and Understanding Landslide Events with Explainable AI," in *IEEE Access*, doi: 10.1109/ACCESS.2022.3158328.
https://ieeexplore.ieee.org/abstract/document/9732490

TOP

More Info and documentation

2022 booklets

- Snap4City



https://www.snap4city.org/download/video/DPL_SNAP4CITY_2022-v02.pdf

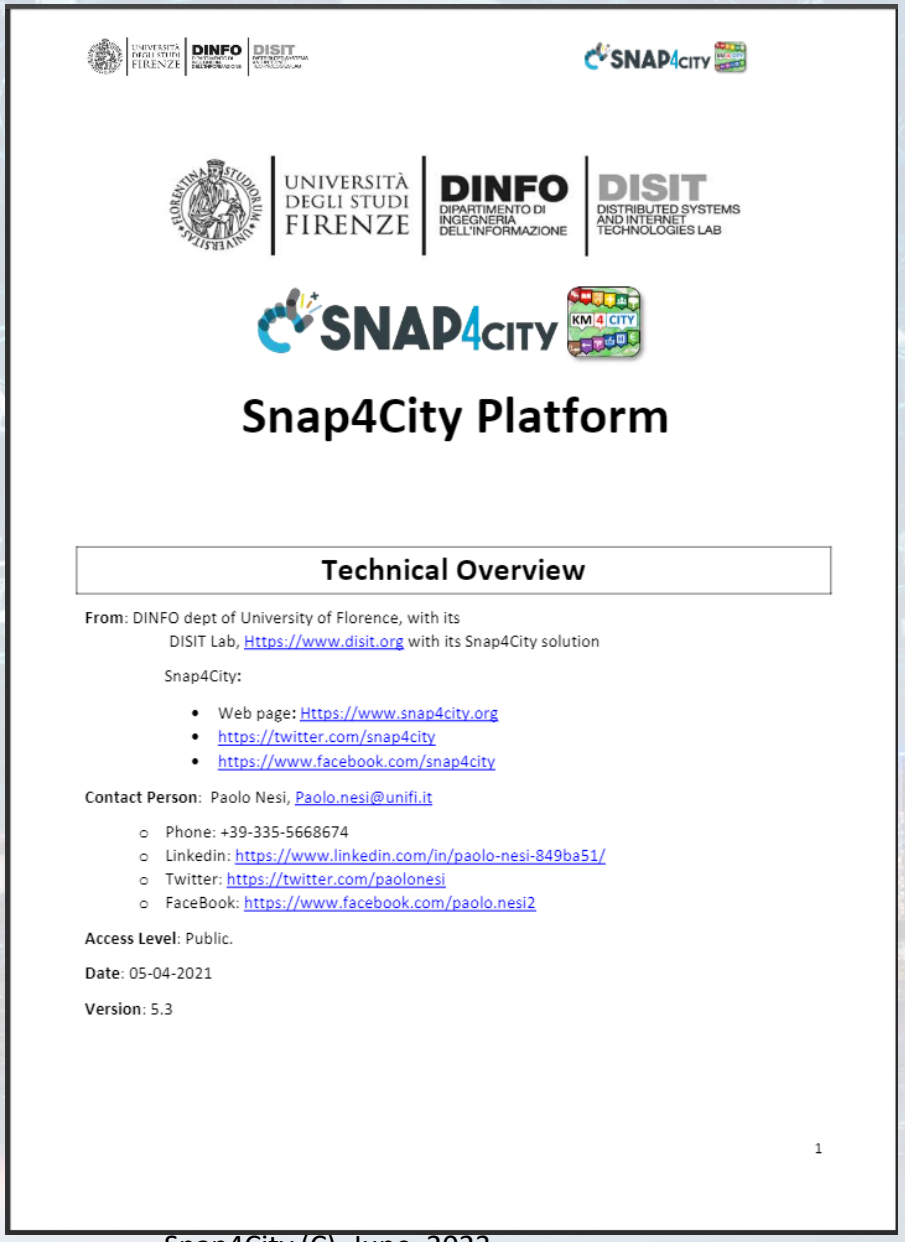
- Snap4Industry

https://www.snap4city.org/download/video/DPL_SNAP4INDUSTRY_2022-v03.pdf

- Solutions
- Data Analytics

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

Overview



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SNAP4CITY

Snap4City Platform

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

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- Twitter: https://twitter.com/paolonesi
- FaceBook: https://www.facebook.com/paolo.nesi2

Access Level: Public.

Date: 05-04-2021

Version: 5.3

1

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

https://www.snap4city.org/577

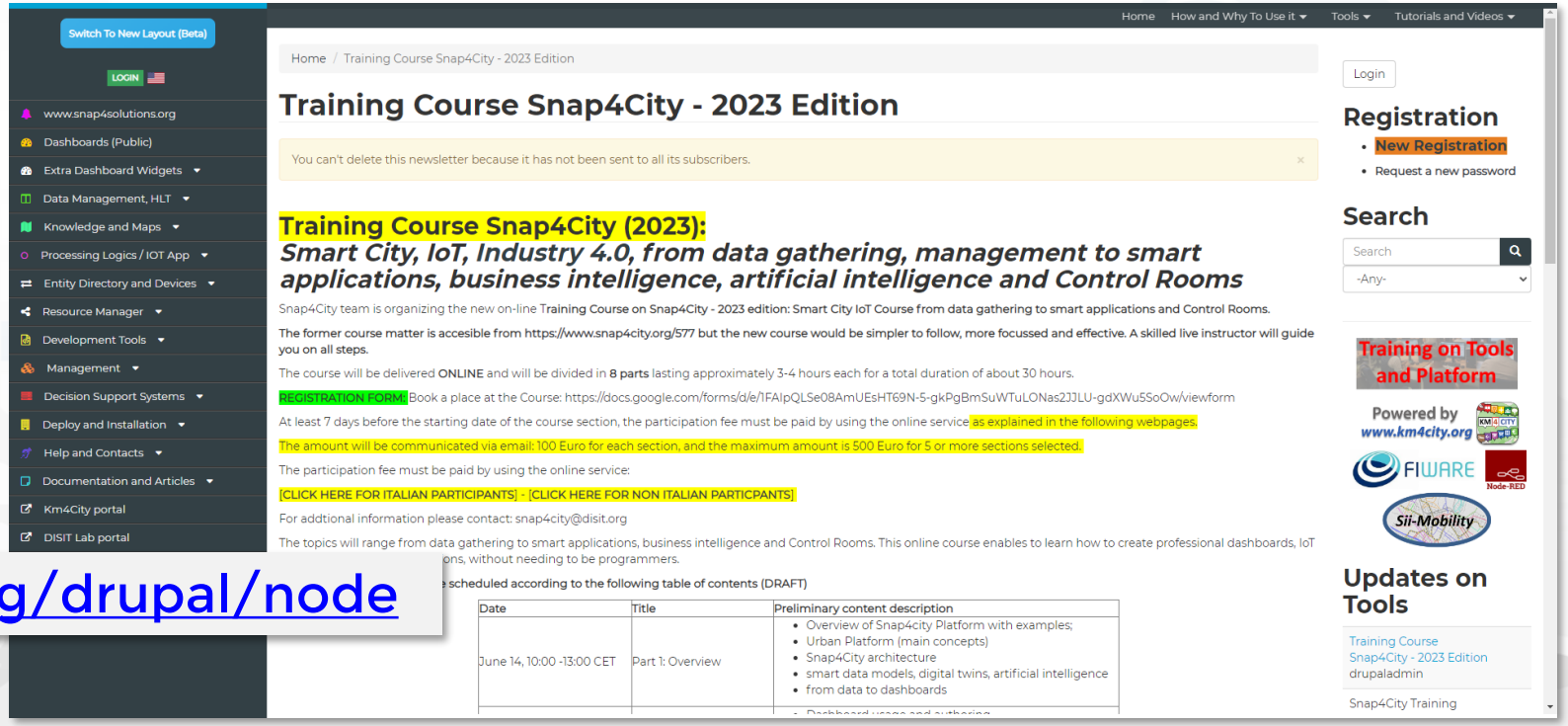
On Line Training Material (free of charge)

	1st part	2nd part	3rd part	4th part	5th part	6th part	7th part	8th
what	Overview	Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App	Design and Develop Smart Solutions
PDF 2022								
Interactive (2022) with video and animations								

Video1							
Video2							
Video3							
Video4				none		none	none

Training Course Snap4City - 2023 Edition

Snap4City team is organizing the new on-line **Training Course on Snap4City - 2023 edition: "Smart City IoT Course from data gathering to smart applications and Control Rooms".**



- https://www.snap4city.org/drupal/node/944

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SNAP4CITY

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100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

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