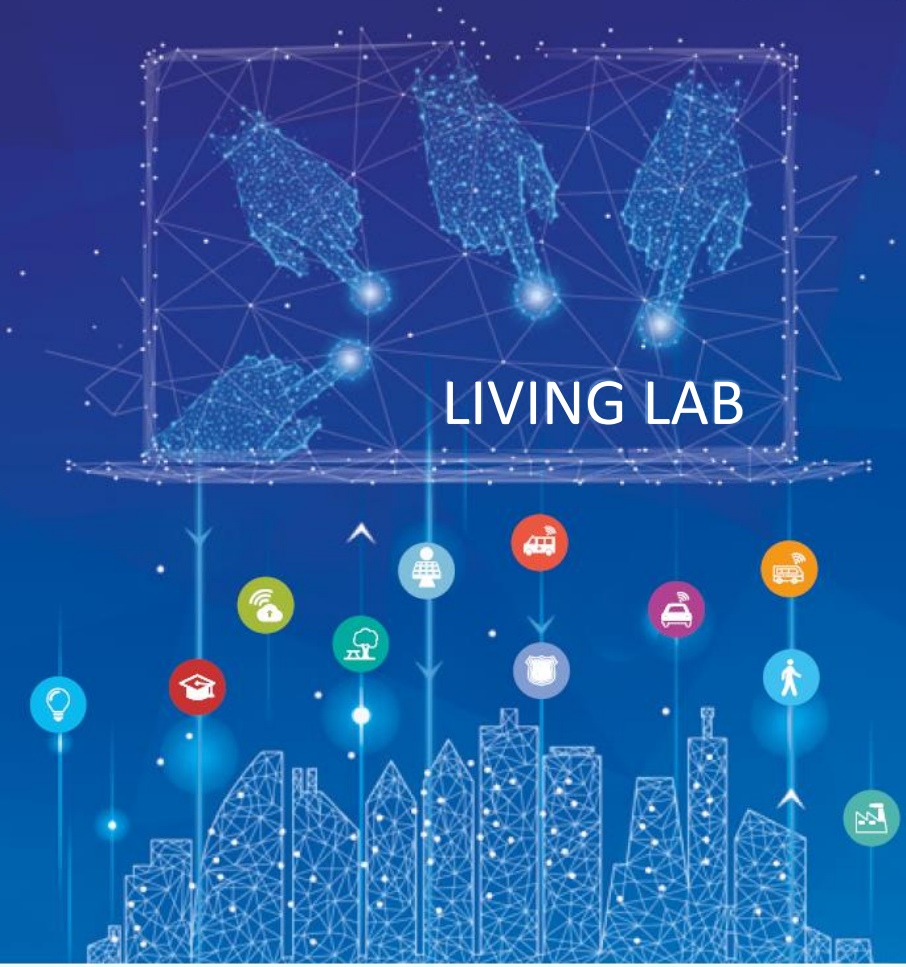
SNAP4CITY

KM4CITY

SNAP4 Appliances and Dockers Installations

Paolo Nesi, 20/09/2022
Paolo.nesi@unifi.it
https://www.snap4city.org



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

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

100% OPEN SOURCE

EU GDPR COMPLIANT

PEN Test Passed

Powered by FIWARE

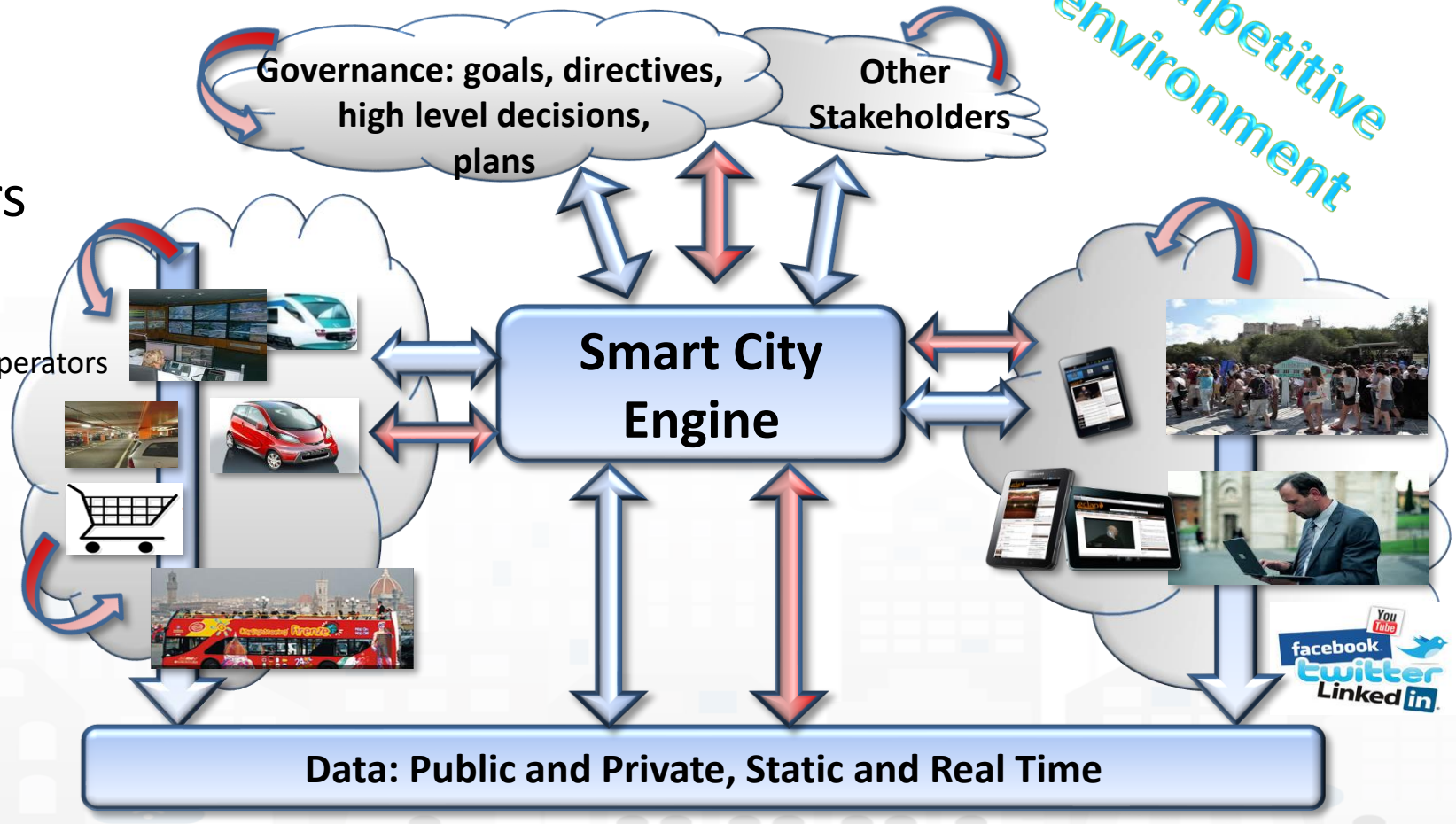
SNAP4CITY on EUROPEAN OPEN SCIENCE CLOUD MARKETPLACE

Node-RED

UNIVERSITÀ DEGLI STUDI FIRENZE | DINFO | DISIT

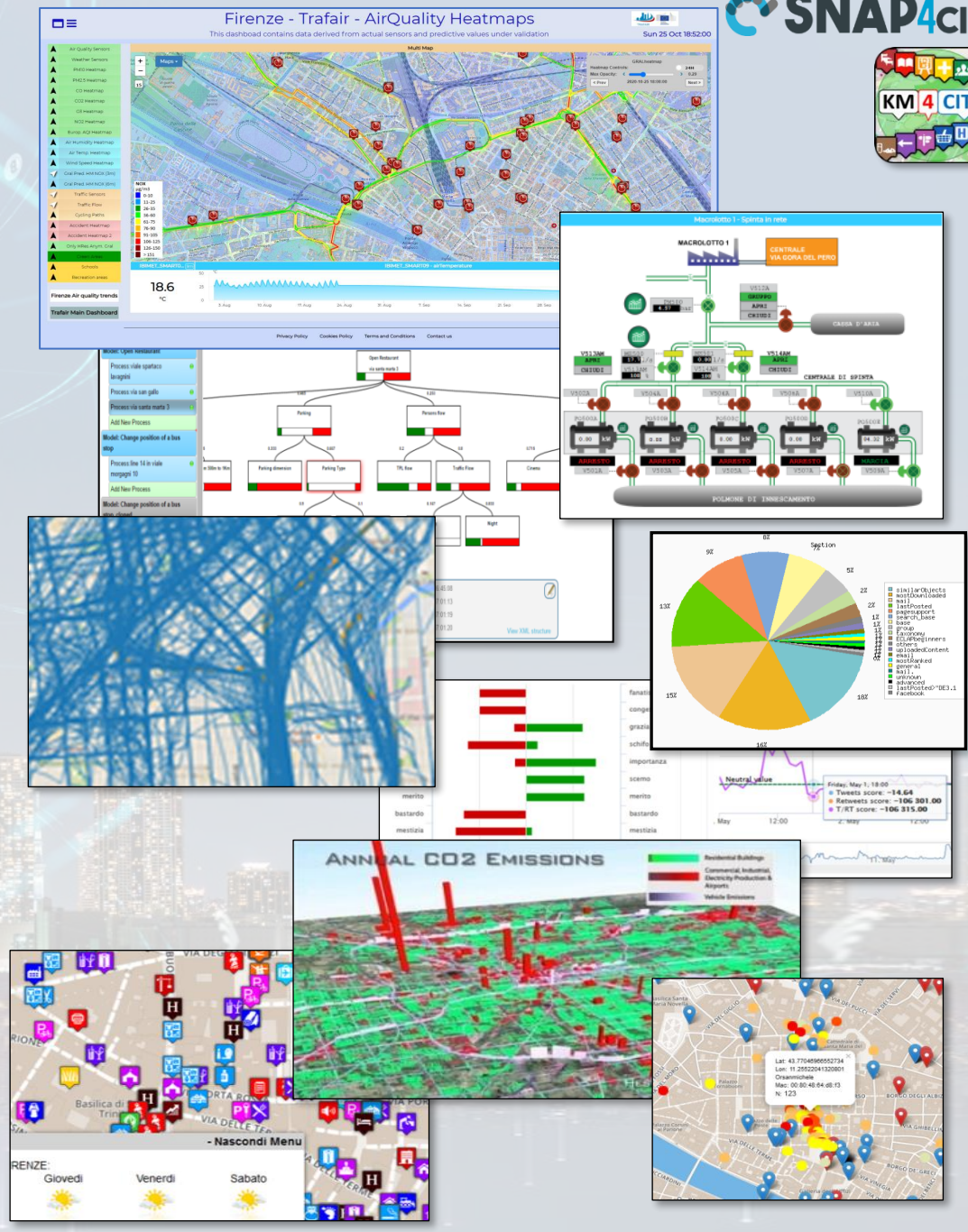
From Strategies to (re-)Actions

- Analyze
- Alerting, Early Warning
- Support Decision makers
- Plans
- Prescriptions
- Inform
- Suggest
- Engage
- Research



Data Driven Decision Support

- Decision Support system
- Assessment / Strategies
- Data Rendering, visual analytics
- Data Processing
- Data aggregation, Storage, indexing
- Data Ingestion



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

SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

TOP

where

100% OPEN SOURCE

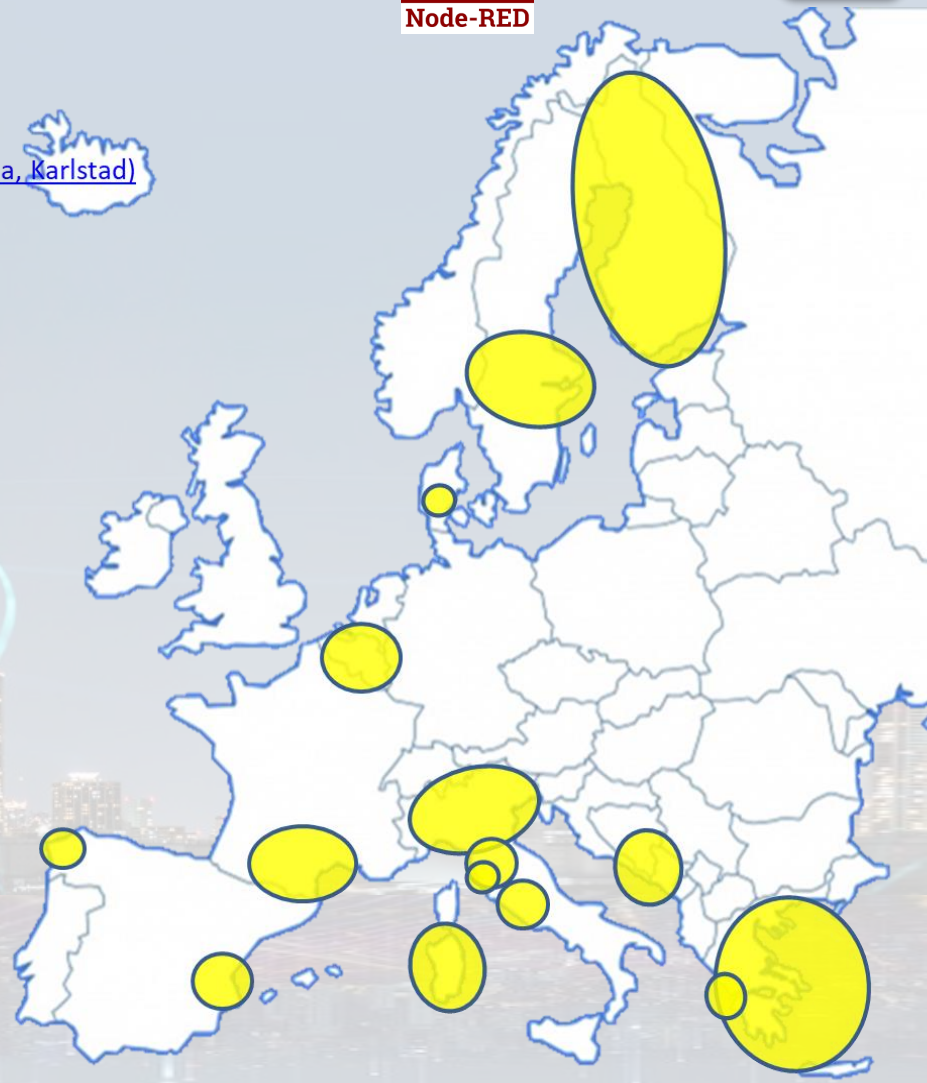
SNAP4 Appliances and Dockers **Installations**

https://www.Snap4City.org

- 8 running installations in Europe
  - Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
  - Altair, Italmatic, Denmark, ….
- 13 projects, 12 pilots on 10 Countries
  - >40 cities/area
- **Wide MULTI-tenant deploy, e.g.,**
  - 18 Organizations / tenant
  - > 7400 users on
  - > 1400 Dashboards
  - > 16 mobile Apps
  - **> 2 Million of structured data per day**
  - > 520 IoT Applications/node-RED
  - > 700 web pages with training
  - > 60 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)

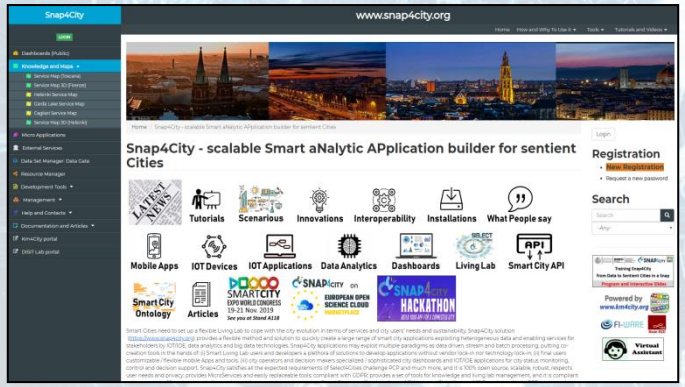


- **Trials in Israel, Colombia, Brasile, Australia, India, Romania, etc.**

How to adopt Snap4City

SNAP4CITY

Https://www.snap4city.org



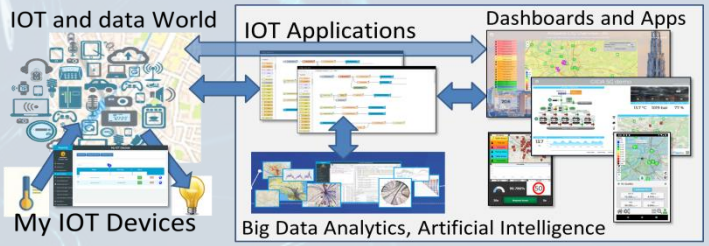
Smart City as a Service

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

SNAP4CITY on EUROPEAN OPEN SCIENCE CLOUD MARKETPLACE

Download and deploy

On your premise



Powered by SNAP4Tech

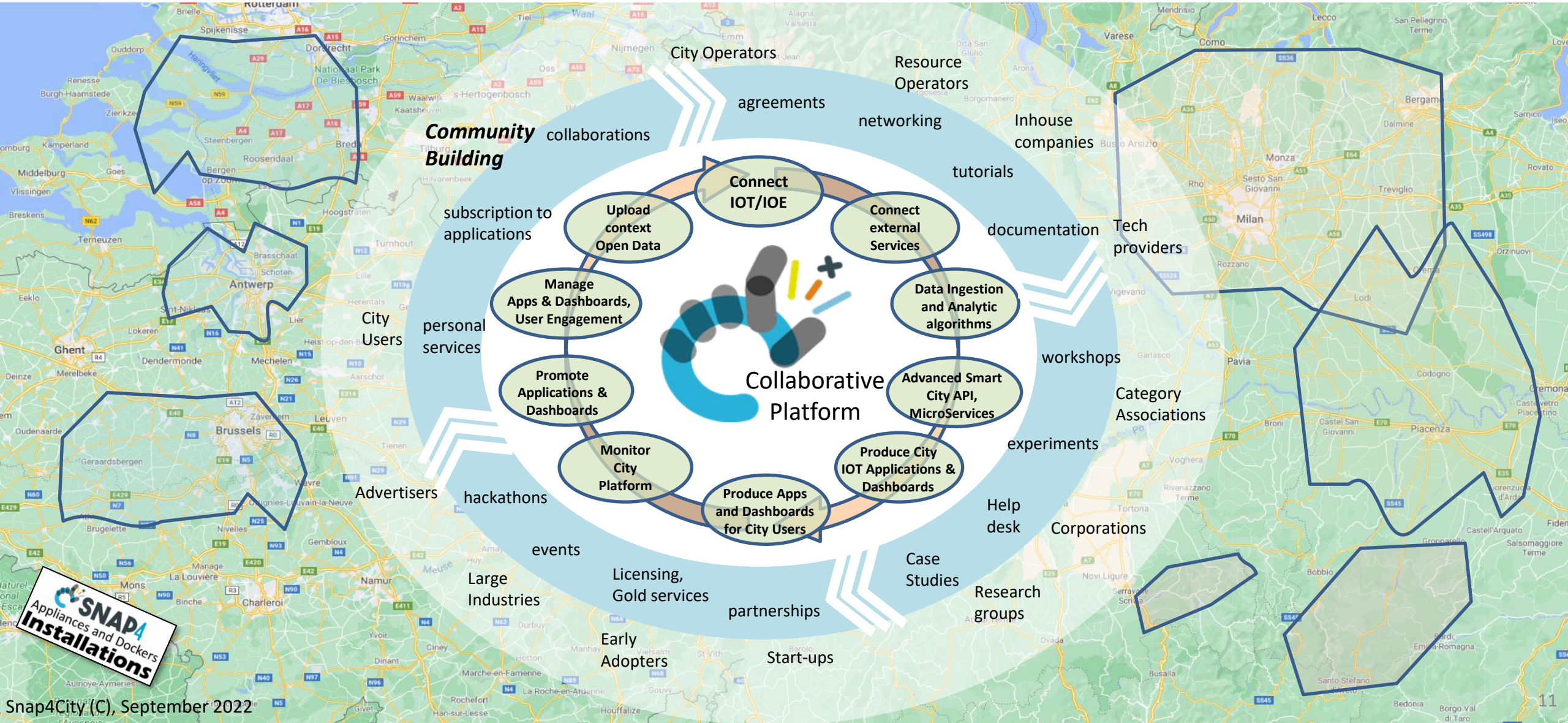
Installation on your premise

- **Virtual Machines or Dockers**
- 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

One Snap4City Platform may serve Multiple Cities



SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

TOP

100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

100% OPEN SOURCE

Powered by FIWARE

FREE TRIAL

PEN Test Passed

EU GDPR COMPLIANT

SNAP4 Appliances and Dockers Installations

EUROPEAN OPEN SCIENCE CLOUD

Node-RED

JS Foundation

E015 digital ecosystem

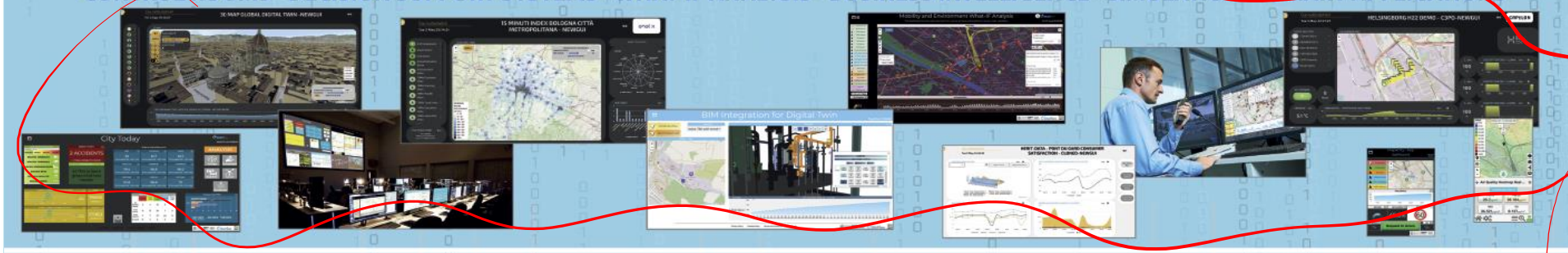
NVIDIA

SNAP4CITY

KM4CITY

SMART SOLUTIONS AND DECISION SUPPORT SYSTEMS

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



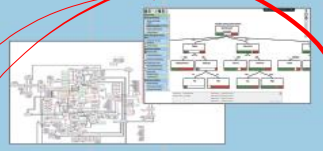
DASHBOARDS - VISUAL ANALYTICS - SYNOPTICS - DIGITAL TWIN - GRAPHICAL WIDGETS - ANALYTICS - GUI CUSTOM STYLES - VISUAL PROGRAMMING

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



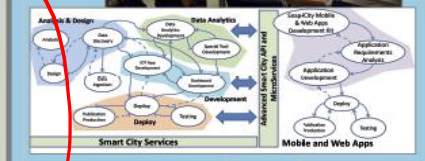
EXPERT SYSTEM, KNOWLEDGE BASE
SEMANTIC REASONING
SMART DATA MODEL
IOT DEVICE MODELS, STORAGE

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

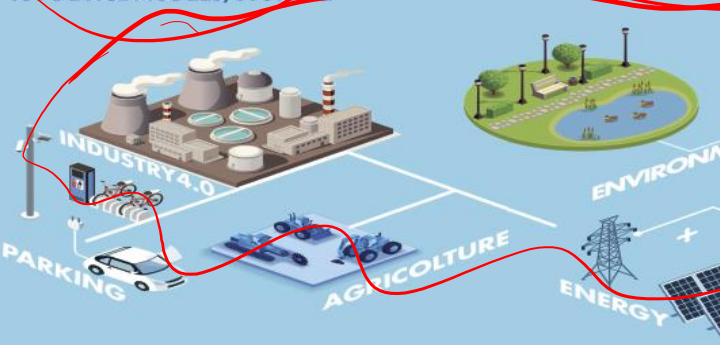
VISUAL PROGRAMMING, ADAPTERS
DATA FLOWS, WORKFLOWS
PARALLEL DISTRIBUTED PROCESSING
DATA DRIVEN

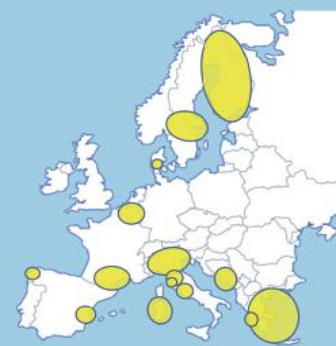
Native and External Applications

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

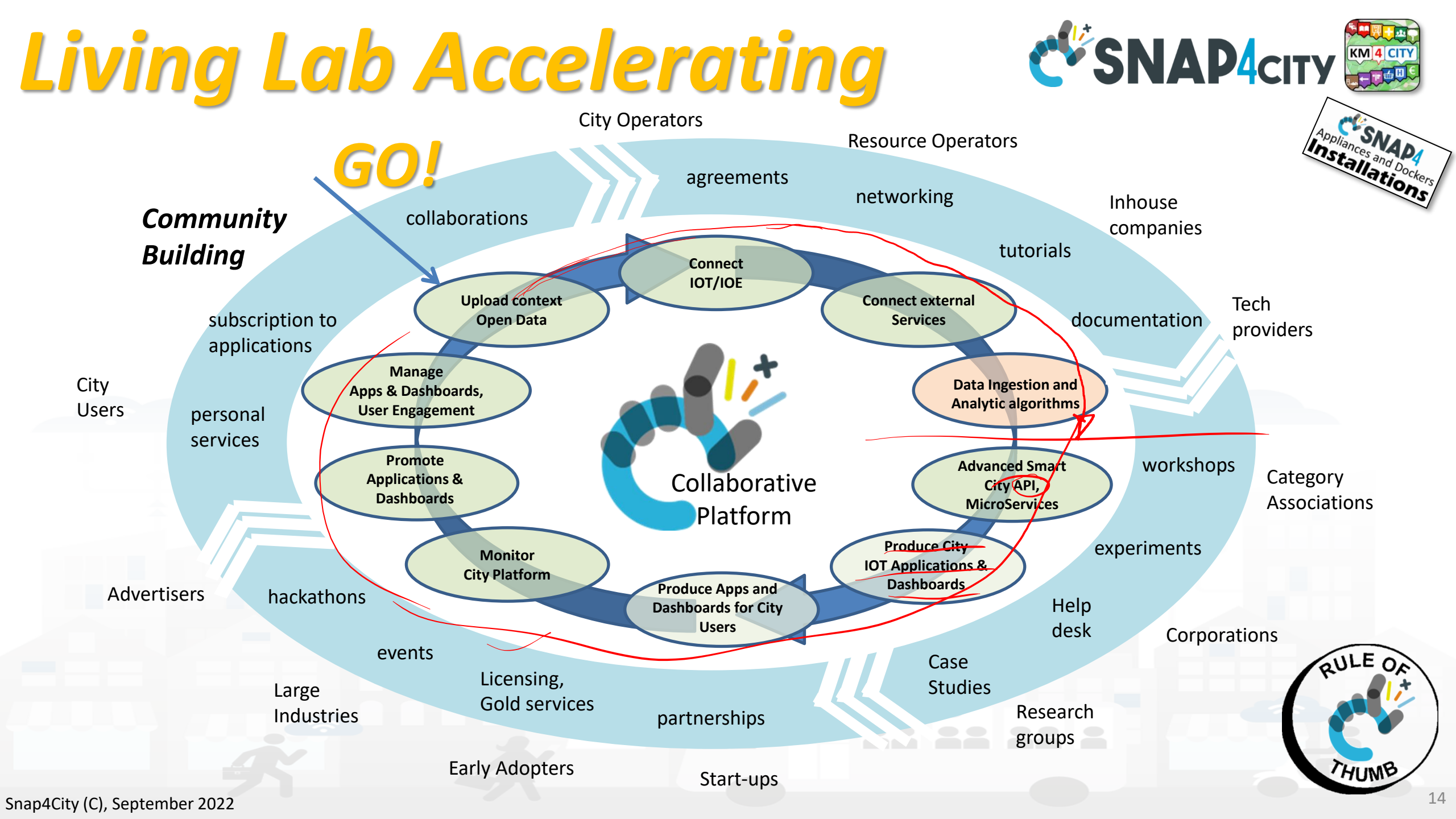


METHODOLOGIES
LIVING LABS
COURSES AND COMMUNITY
DEVELOPMENT TOOLS



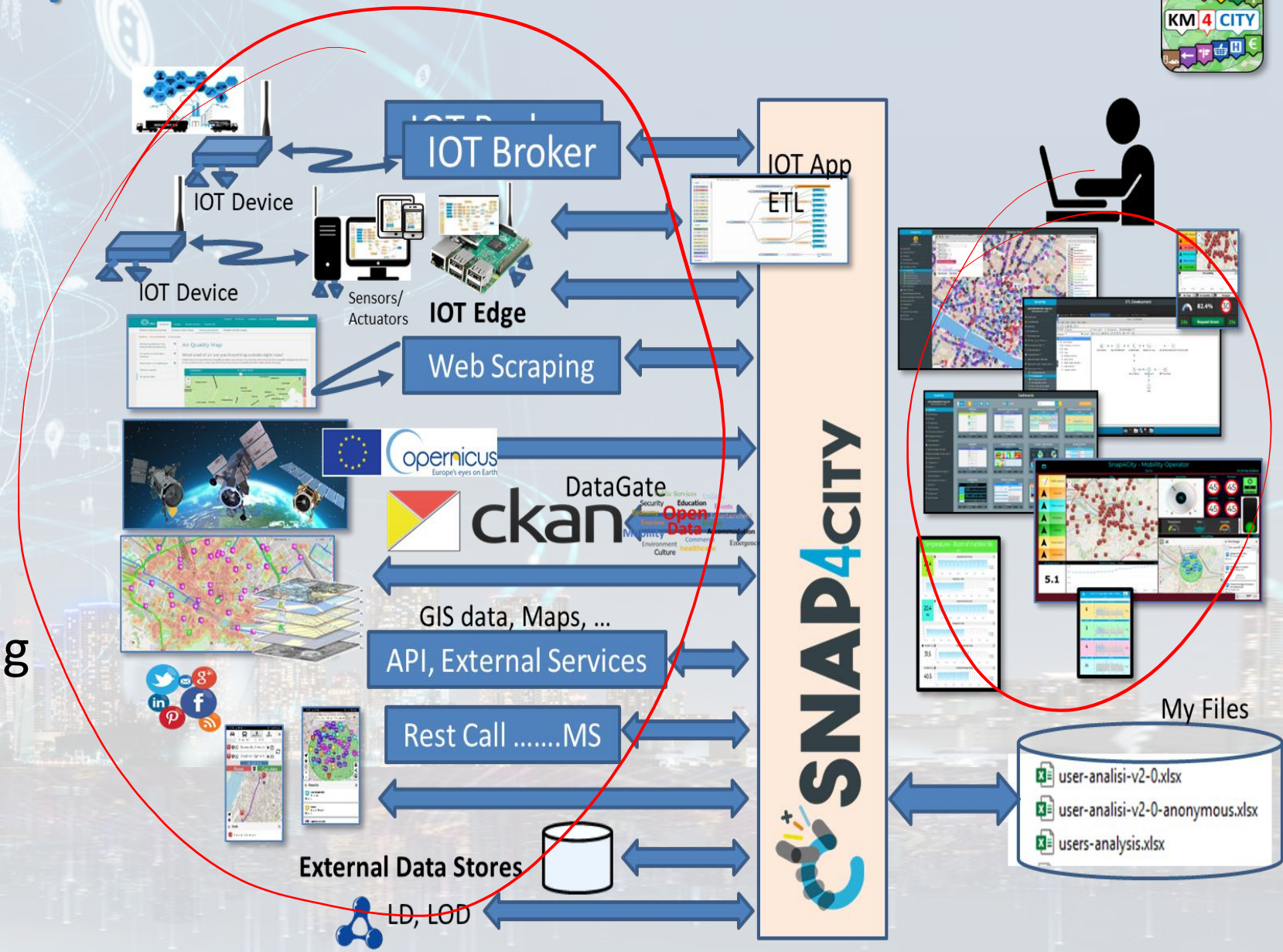


Living Lab Accelerating



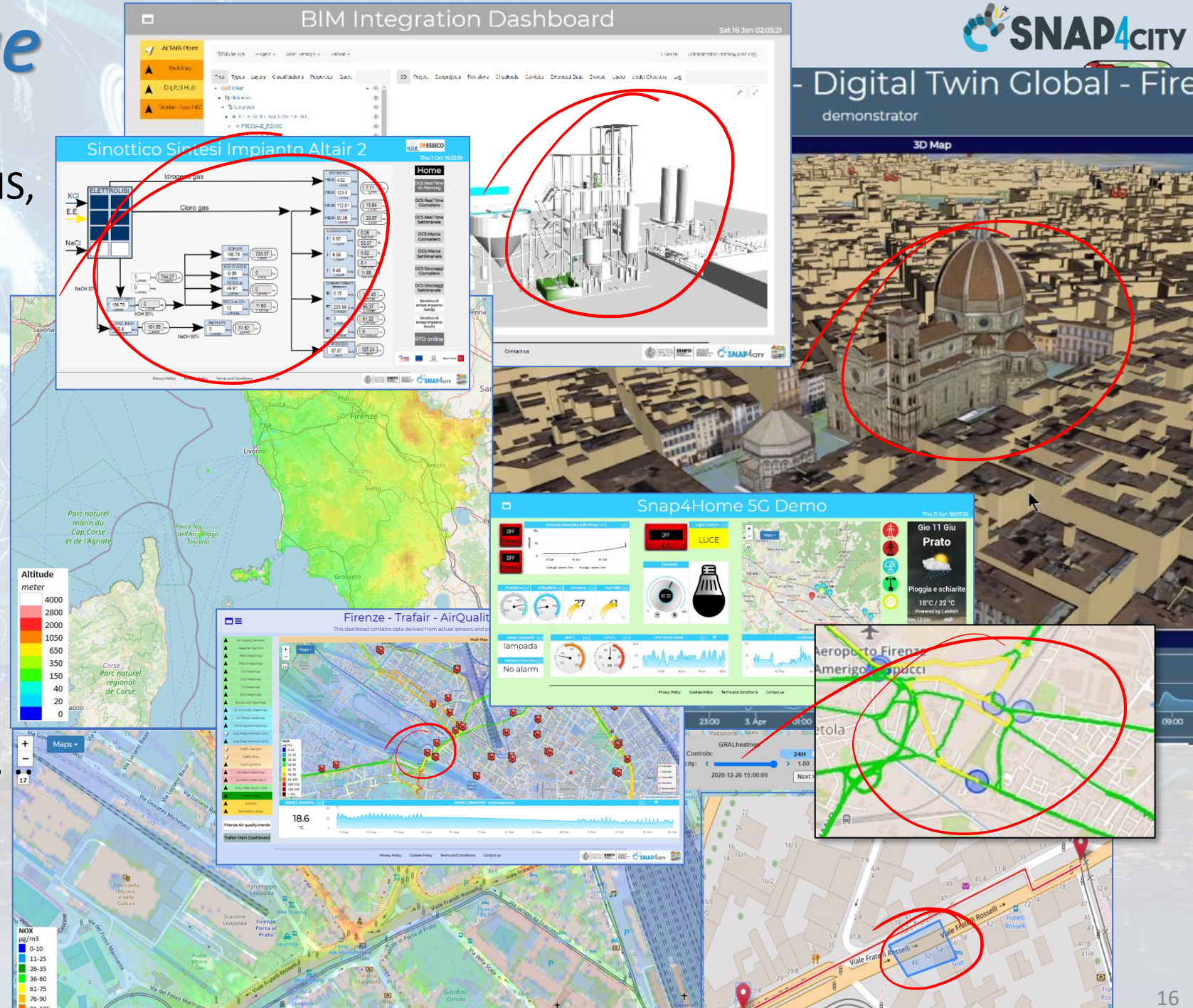
Ingestion, agg. → exploitation

- **Snap4City efficient tools for**
  - Bidirectional data channels
  - Any format, any channel, any data, any broker, any protocol, …
  - **Km4City** Knowledge base Ontology reasoning on geo, space, time, relationships



Data Type Coverage

- POI, IOT Devices, shapes,..
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ..
- Satellite data, ..
- traffic flow, typical trends, ..
- trajectories, events, Workflow, ..
- 3D, BIM, ..
- Dynamic icons/pins, ..
- OD Matrices of several kinds, ..
- Synoptics, animations, ..
- KPI, personal KPI,..
- social media data, TV Stream,
- routing, multimodal, constraints,
- decision scenarios, ….
- prediction models, ….
- etc.



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

Standards and Interoperability (9/2022)

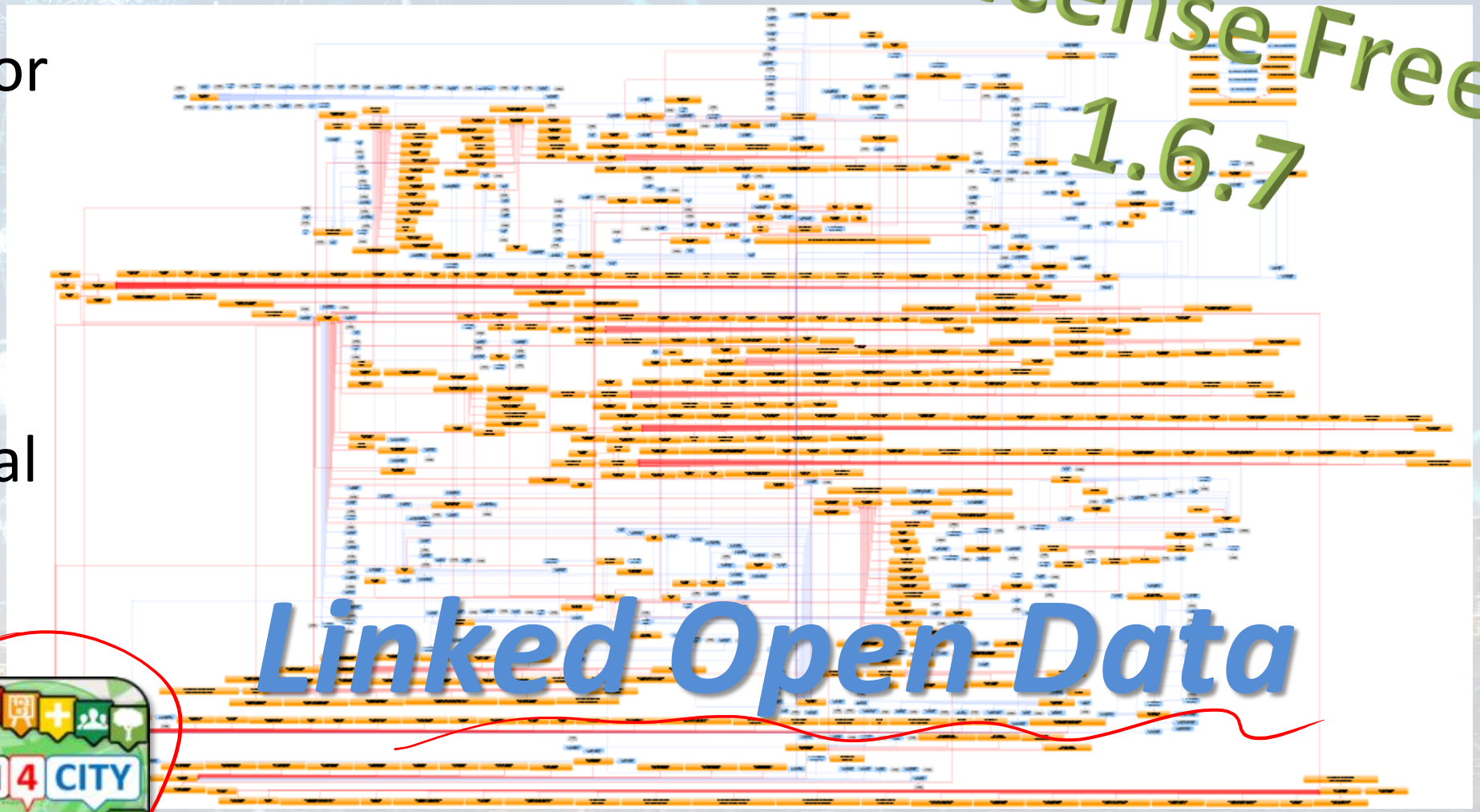
Compliant with:

- **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, ….
- **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, ..
- **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

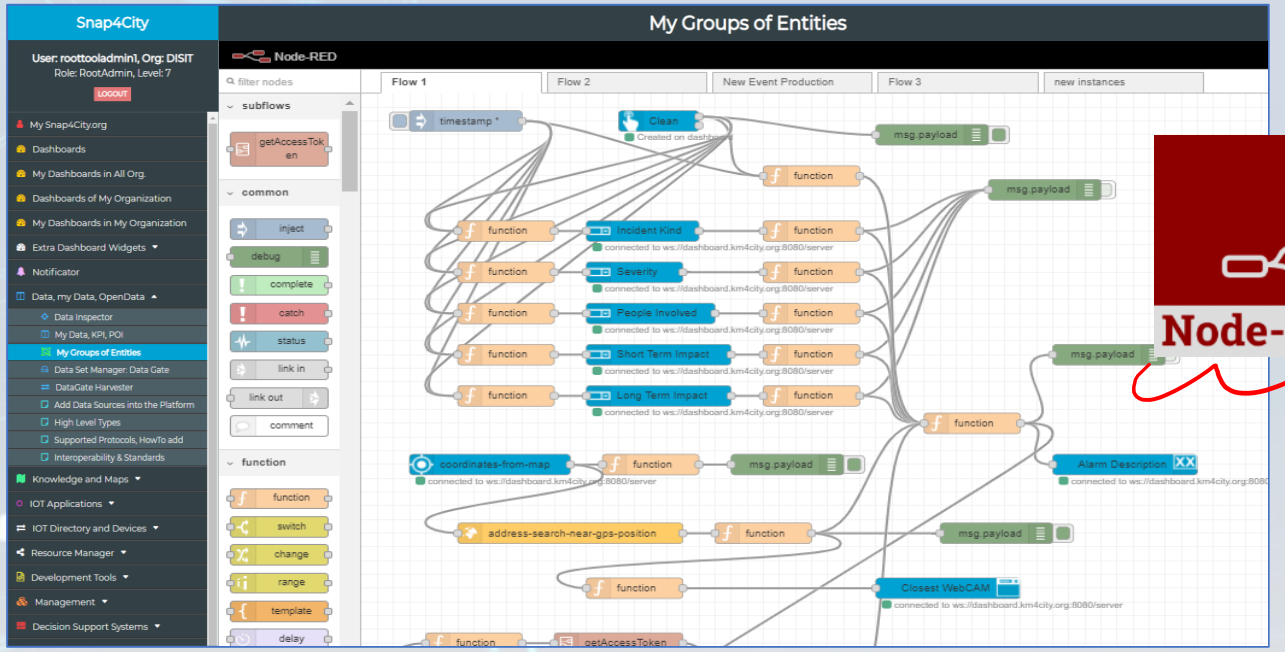
- **via**:
- **Smart City API** for Apps and third party
- **MicroServices** data driven develop via visual language Node-RED

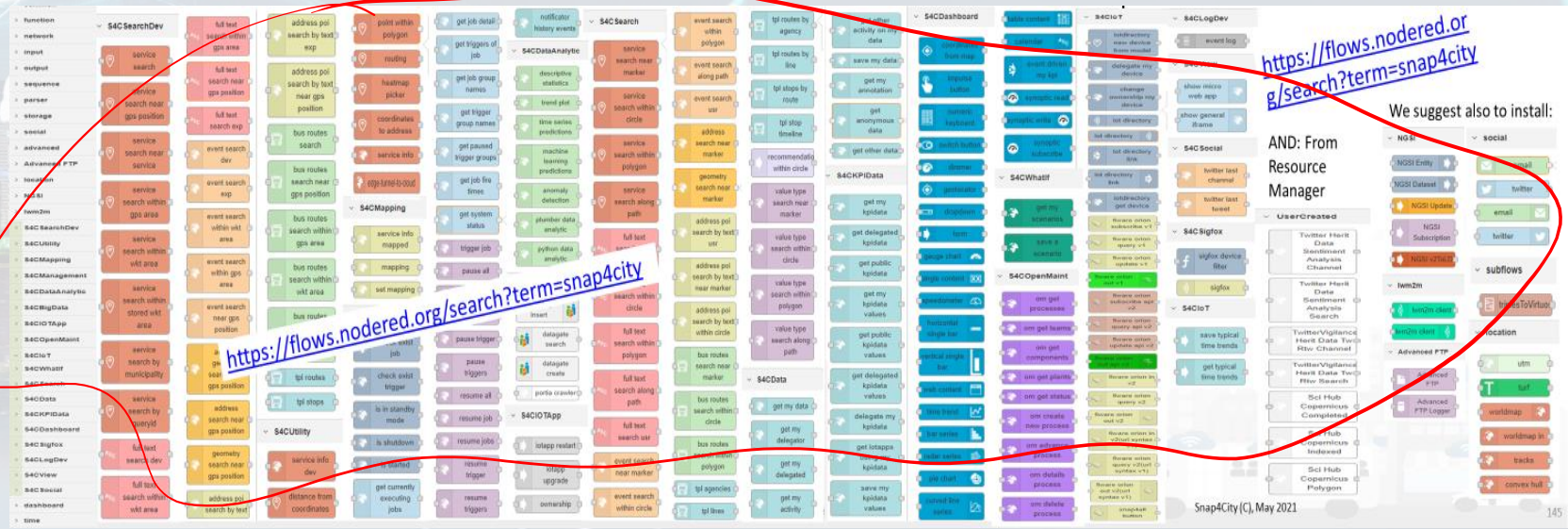


https://www.snap4city.org/19

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

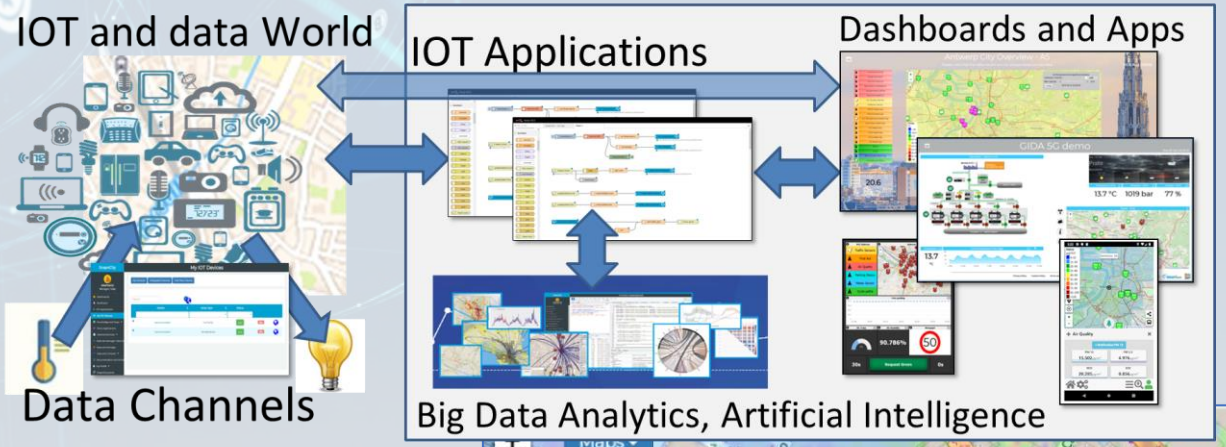


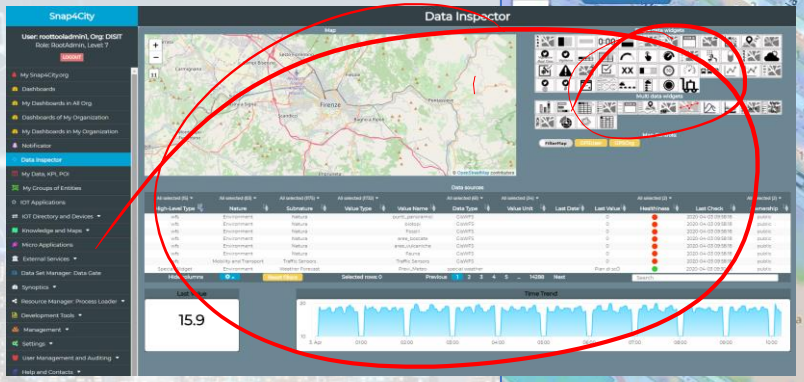


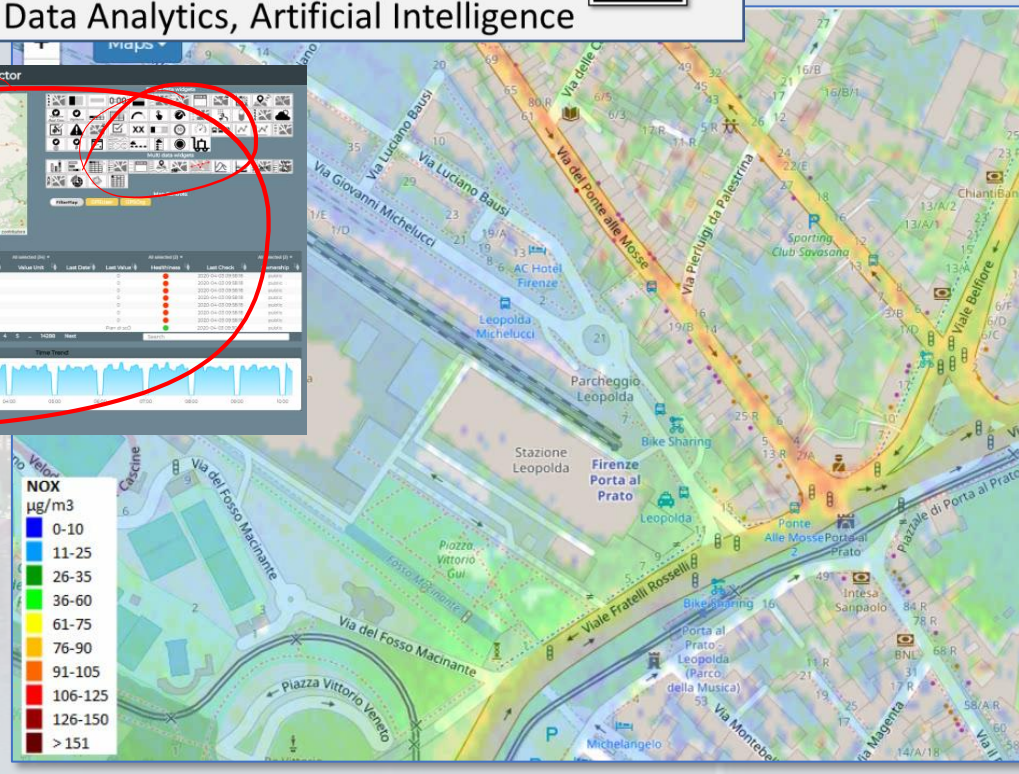
Solutions: reliable, secure and fast to realize

- 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







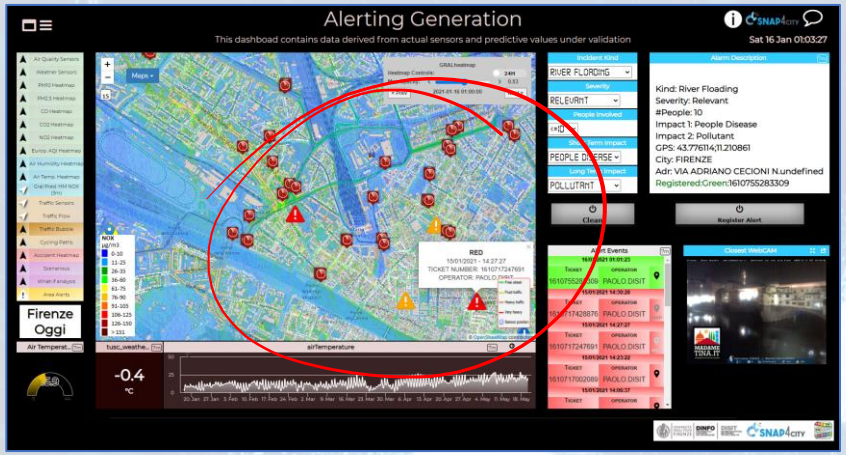
Big Data Analytics + Artificial Intelligence

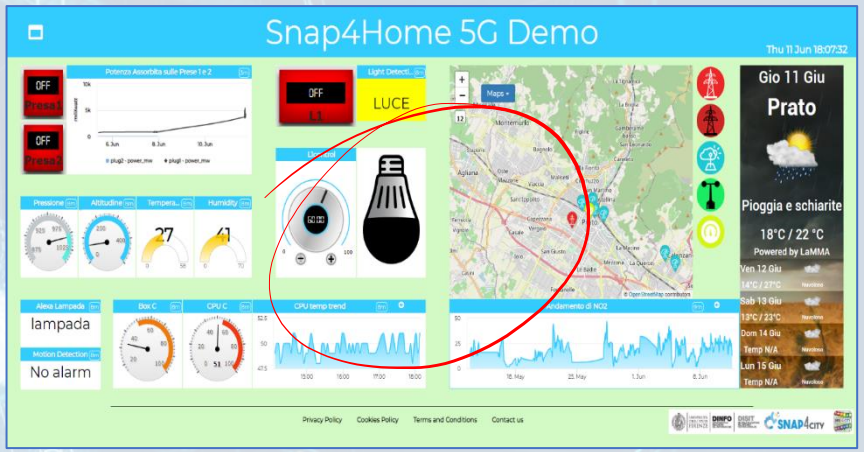
- **Short and Long terms predictive models on:**
  - traffic, parking, people flow, maintenance, land sliding, NO2
- **3D Flow prediction:** Pollutant (NOX, NO2, …)
- **Early warning, City Indexes, etc.**
- **AI & XAI:**
  - RF, XGBoost, BRNN, RNN, SVR, DNN, LSTM, CNN-LSTM, BI-LSTM, Autoencoders, …
  - Clustering: K-means, K-Medoid, …
  - XAI: Shap, variations, ..
- **Modelling, simulation, routing**
  - **Traffic Flow reconstruction**
  - **Constrained Routing**
- **What-IF analysis** (simulation + AI + data)
- **Based on several computational models**:
  - trajectories, OD matrices, Typical Time Trends, etc.

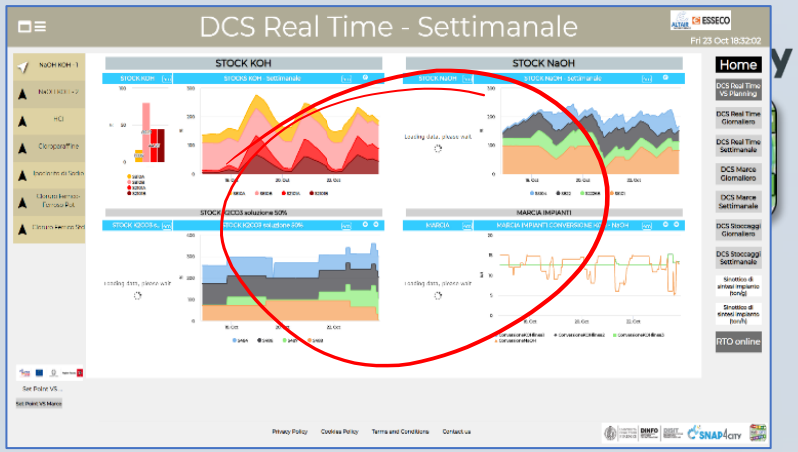
to cope with

- *any data, format*
- *any channel, protocol*
- *any AI/ML*
- *any place*
- *online development*
- *multi-tenant*
- *Secure, PENTest*
- *GDPR, privacy*
- ***→ low costs***
- ***→ easy to evolve***

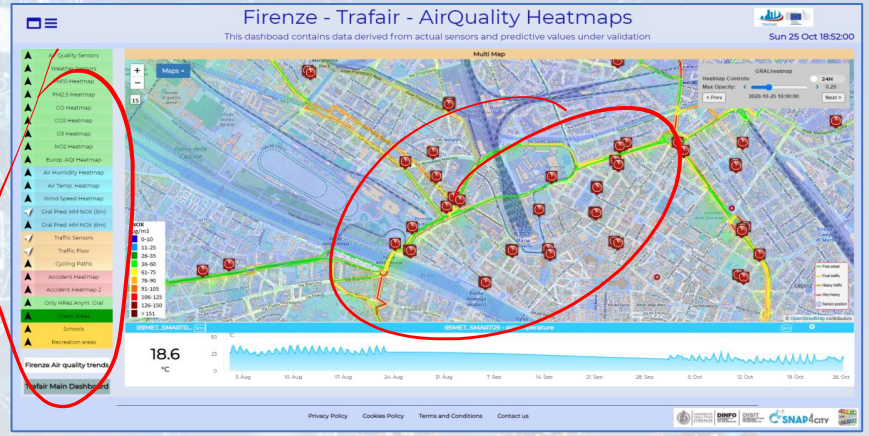
https://www.snap4city.org/download/video/course/da/

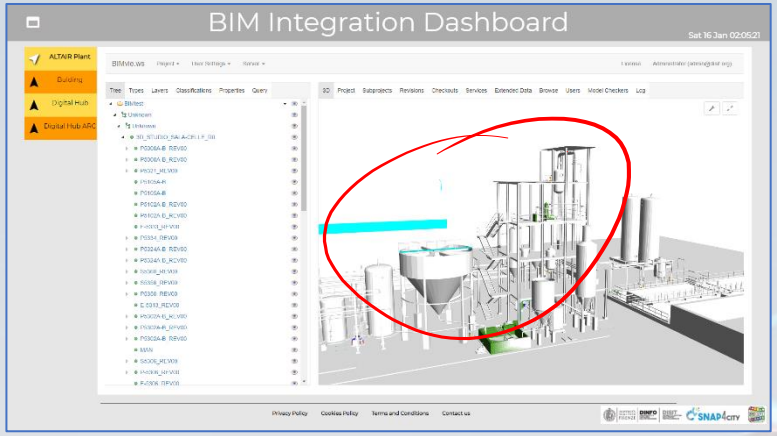

Alerting Generation
This dashboad contains data derived from actual sensors and predictive values under validation
Sat 16 Jan 01:03:27
Firenze Oggi
-0.4

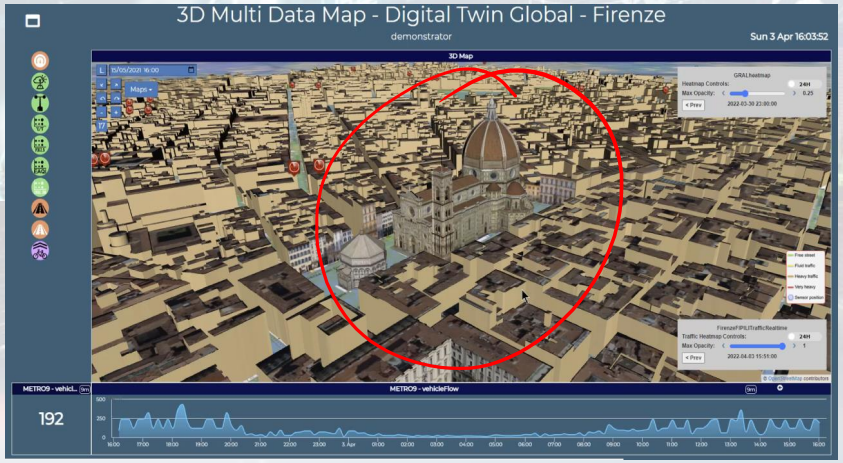

Snap4Home 5G Demo
Thu 11 Jun 18:07:32
LUCE
lampada
No alarm
Gio 11 Giu
Prato
Pioggia e schiarite
18°C / 22 °C
Powered by LaMMA

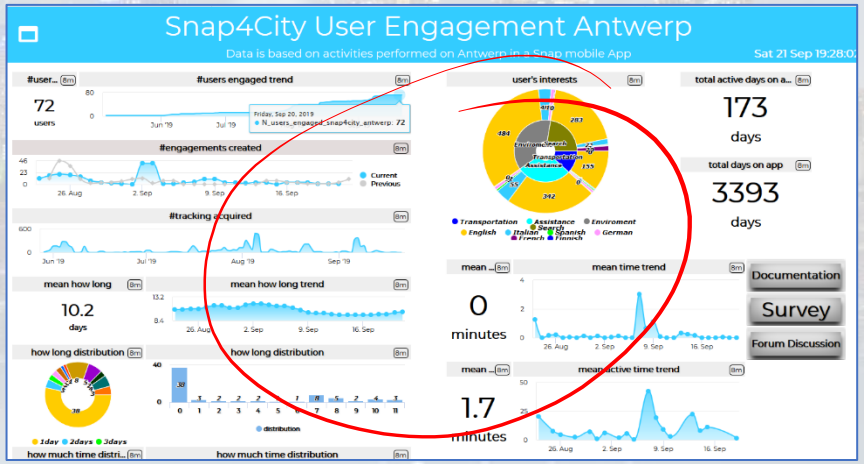

DCS Real Time - Settimanale
Fri 23 Oct 18:32:02
STOCK KOH
STOCK NaOH
Home

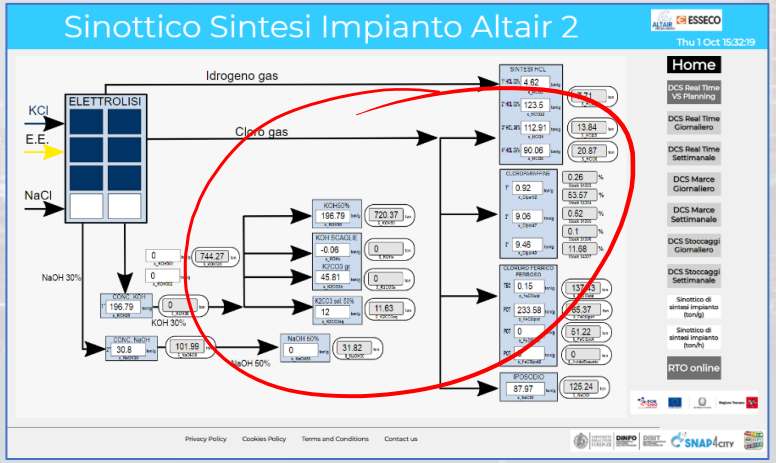
Data Analyzer: DevDash
Open Distro for Elasticsearch


Firenze - Trafair - AirQuality Heatmaps
This dashboad contains data derived from actual sensors and predictive values under validation
Sun 25 Oct 18:52:00
18.6

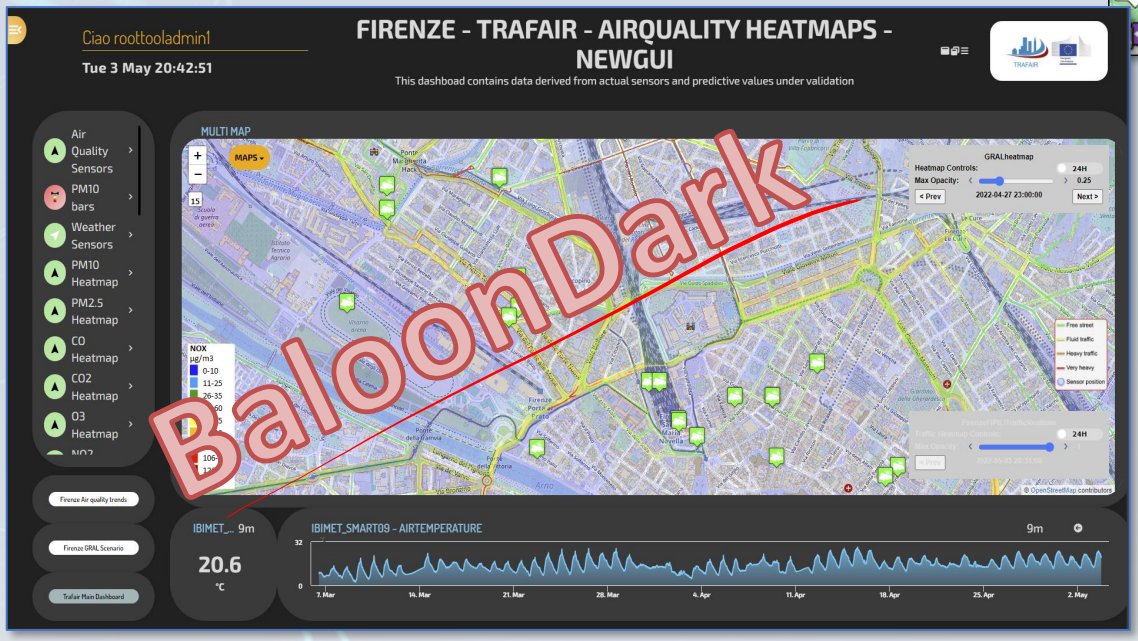

BIM Integration Dashboard
Sat 16 Jan 02:05:21

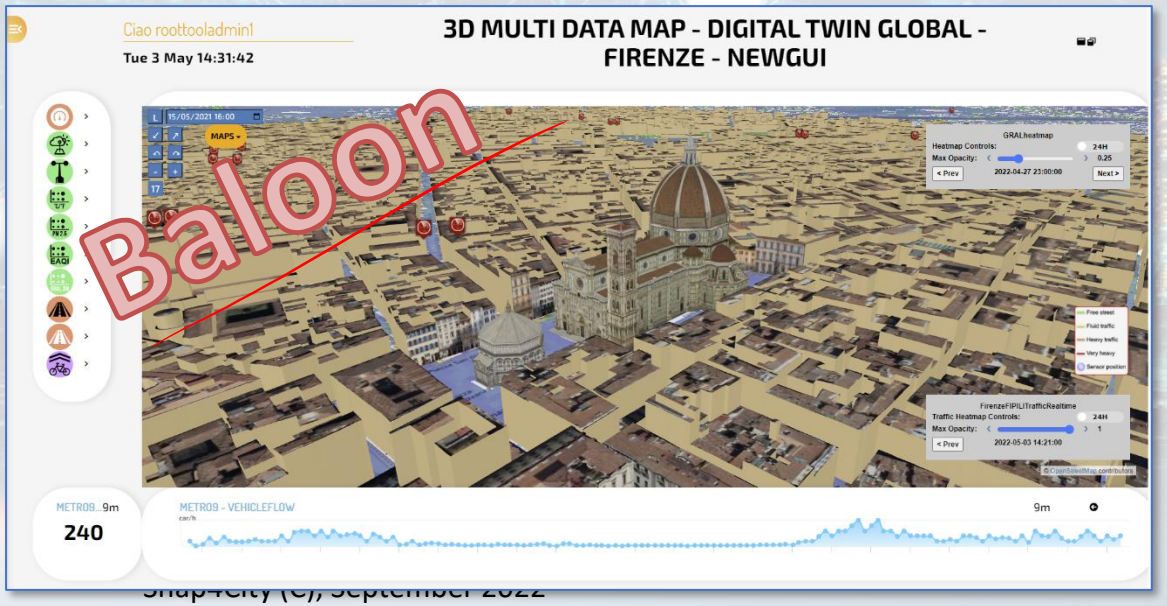

3D Multi Data Map - Digital Twin Global - Firenze
demonstrator
Sun 3 Apr 16:03:52
192

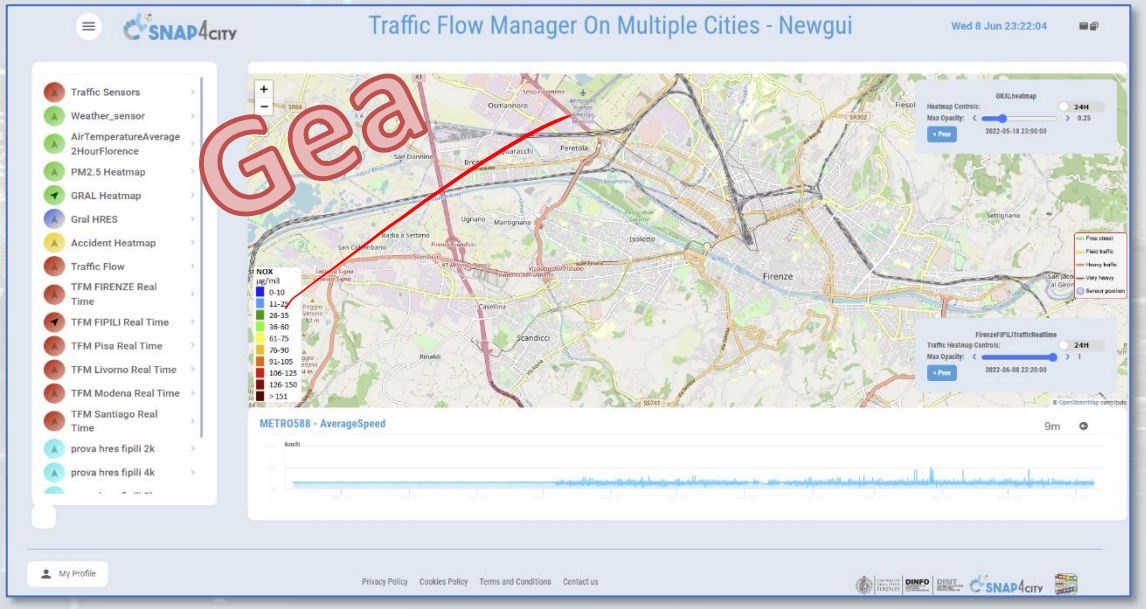

Snap4City User Engagement Antwerp
Data is based on activities performed on Antwerp in a Snap mobile App
Sat 21 Sep 19:28:0
72
173
days
3393
days
0
minutes
1.7
minutes
10.2
days
Documentation
Survey
Forum Discussion

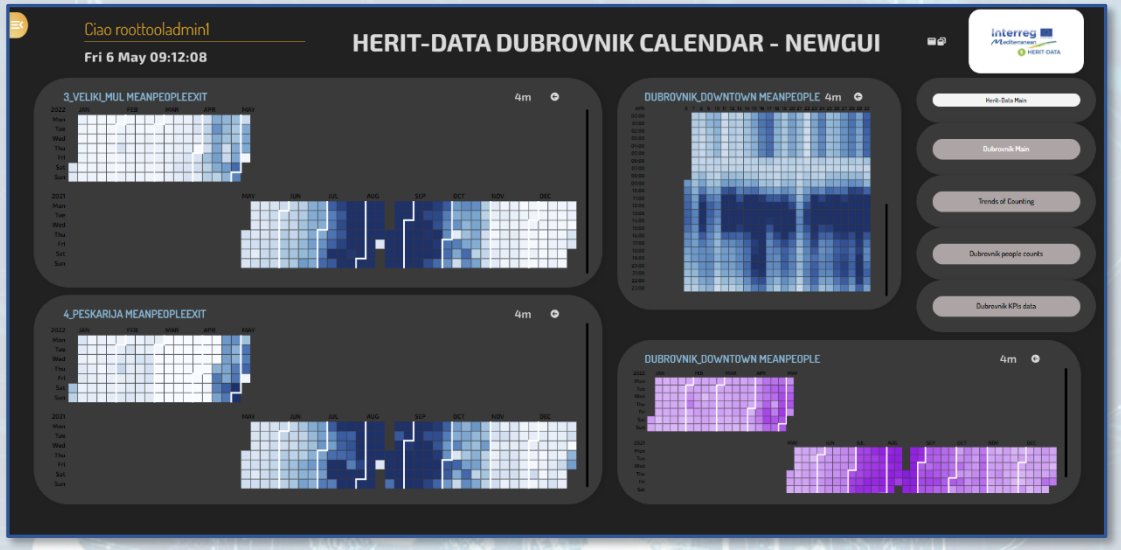

Sinottico Sintesi Impianto Altair 2
Thu 1 Oct 15:32:19
Home
Idrogeno gas
Cloro gas
ELETTROLISI
KCl
E.E.
NaCl
NaOH 30%
KOH 30%

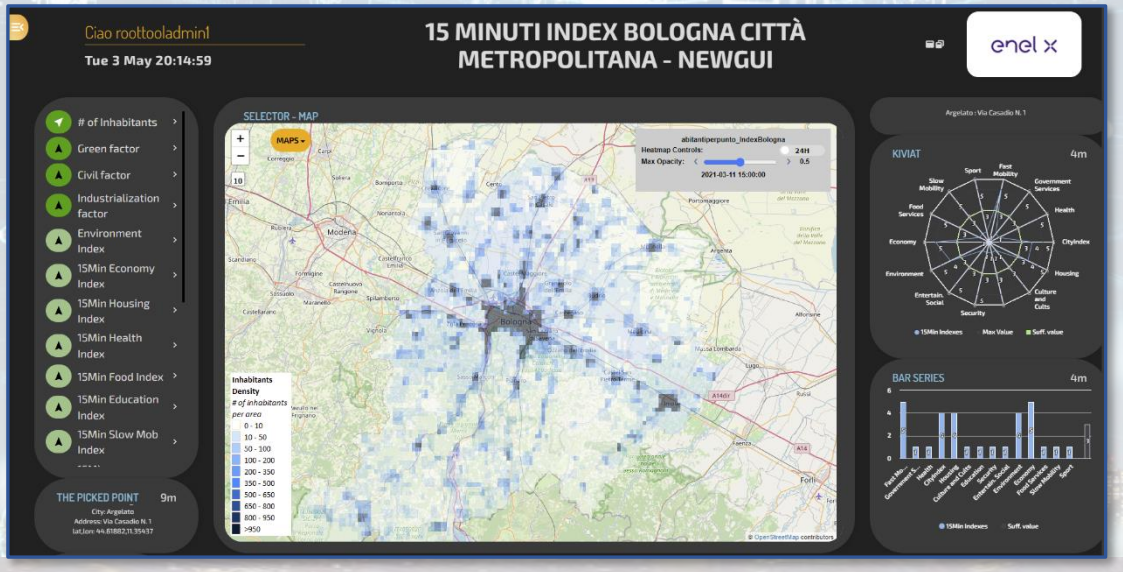
Different Themes

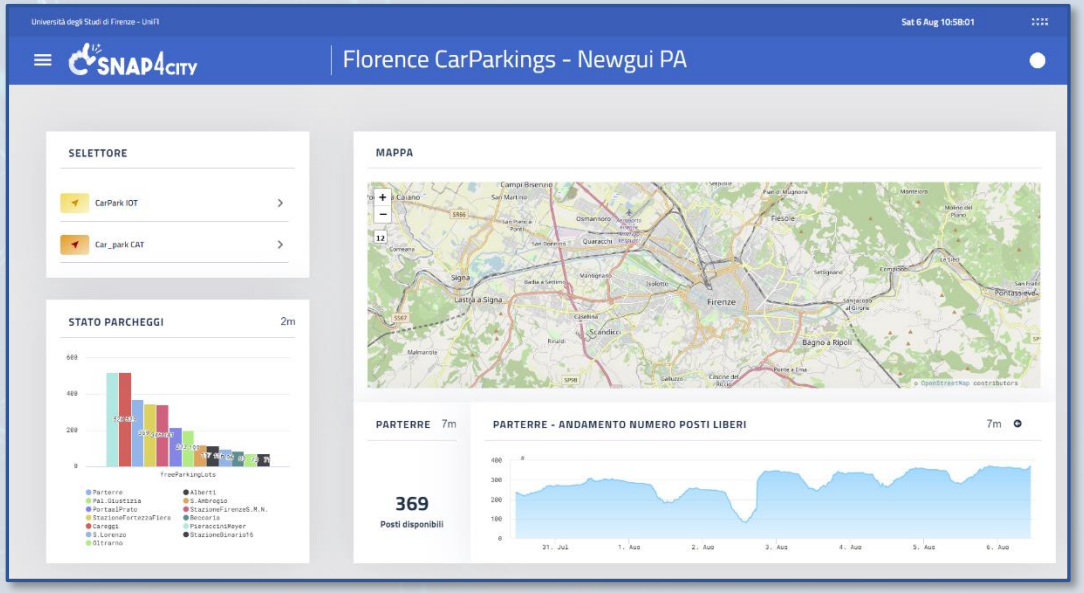


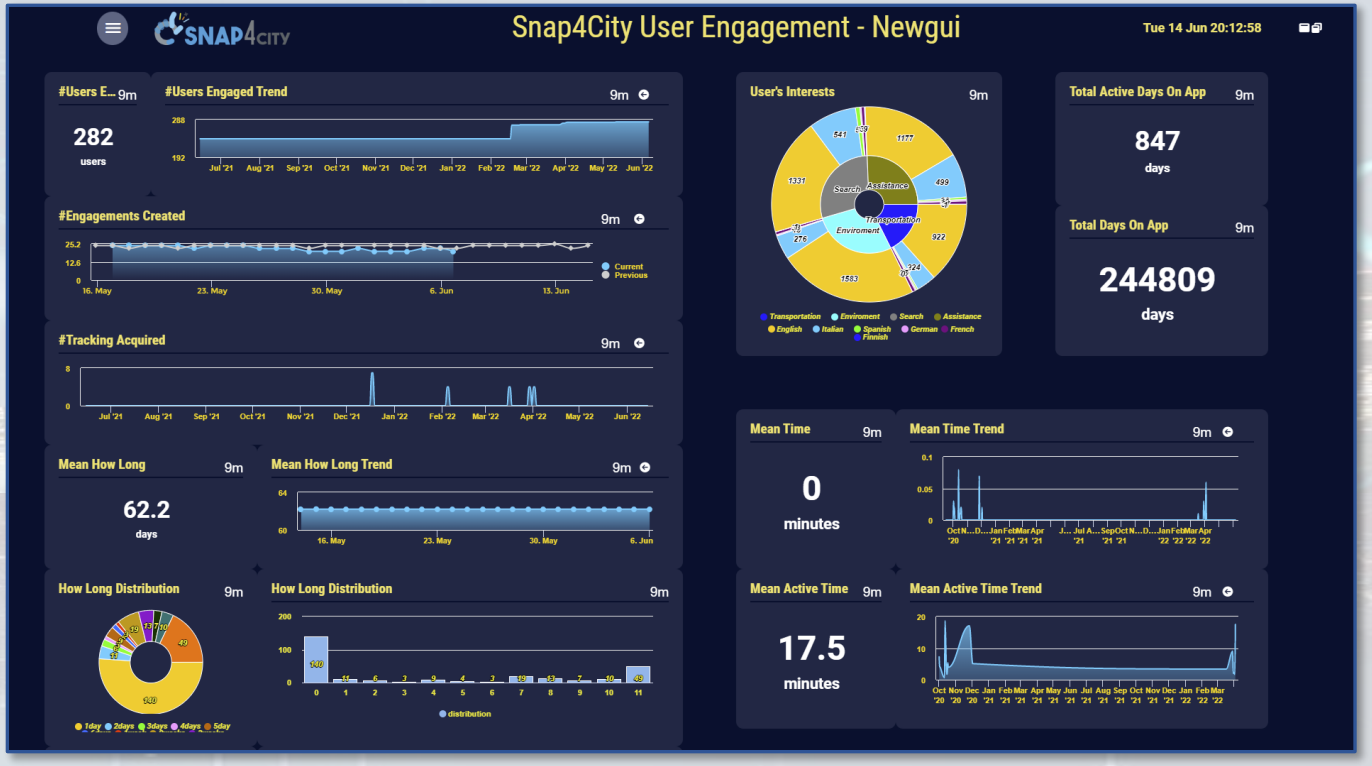








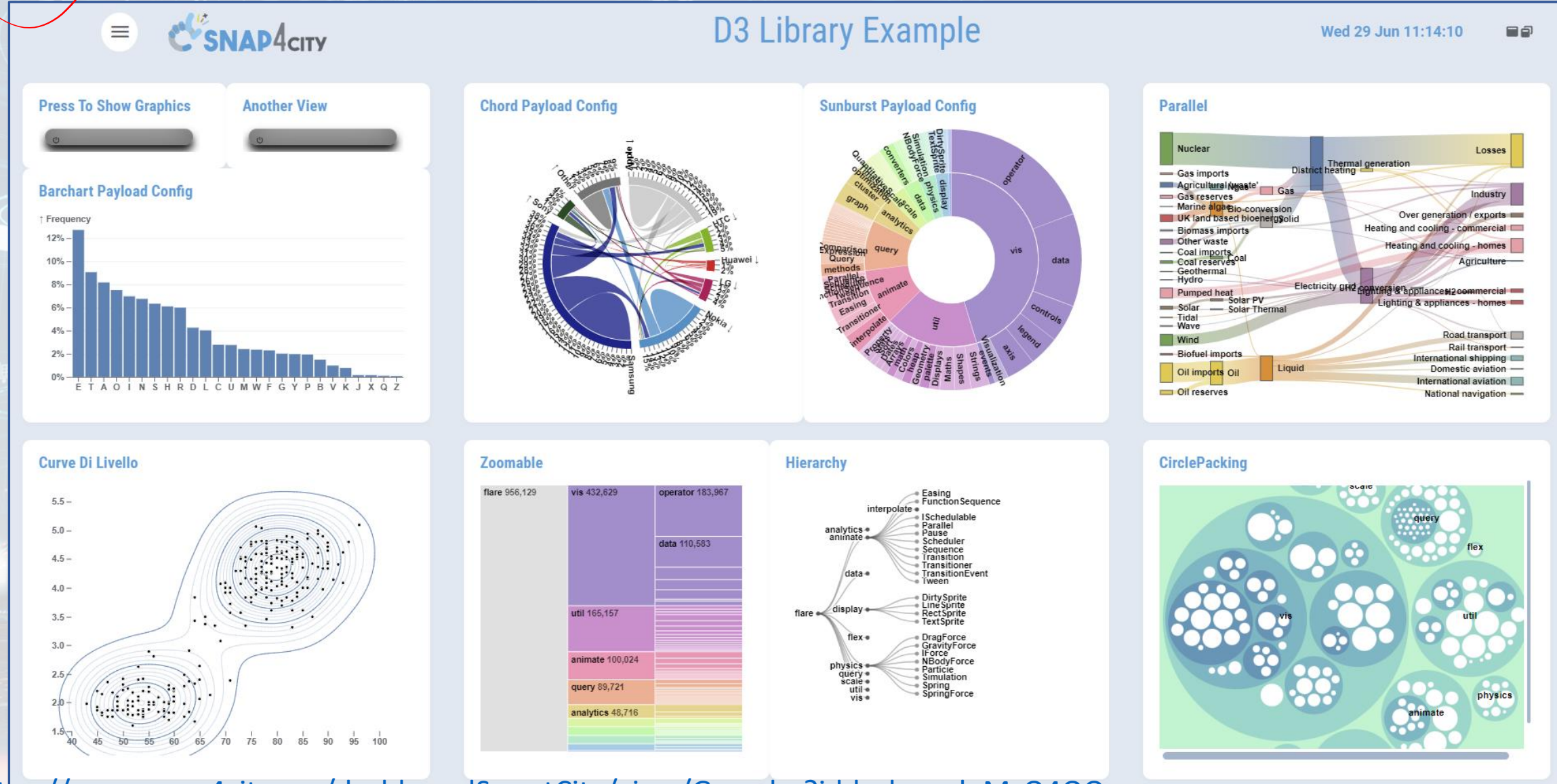




New styles/themes can be developed by specializing a few files from open source

https://www.snap4city.org/793

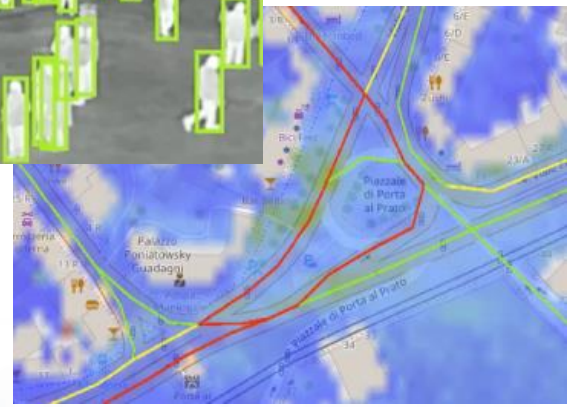
D3 Graph library capability

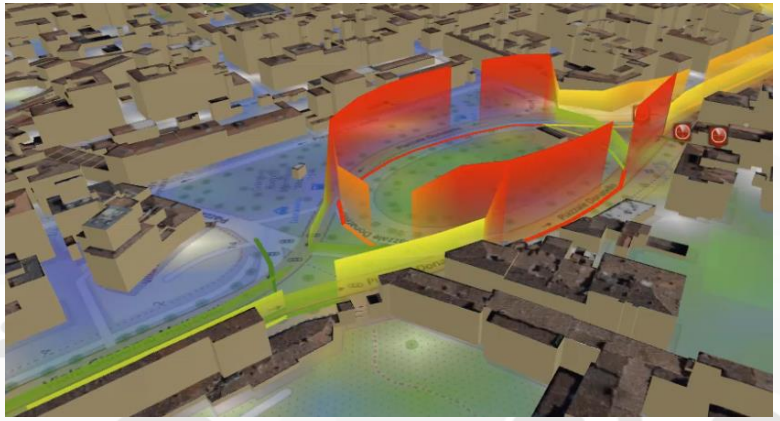


https://www.snap4city.org/dashboardSmartCity/view/Gea.php?iddasboard=MzQ4OQ==

Awareness to manage and improve ….

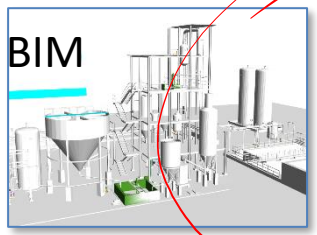
- **Infrastructures** of the cultural cities:
  - **Security and Safety**: roads, buildings, squares
  - **Mobility and Transport**: traffic flow, parking, etc.
  - **Environment**: microclimate, predictions, assessment for acting
- **Services / events**: assessment and plan:
  - **Most of the cities provide diffuse cultural heritage as a wall**
    - Security, clean, public transport, environment, delivery, etc.
  - **Global and Local**: events vs actions
  - **Local Structures**: museums, events, shopping, attractions, ..
- **People and Transport Means (city users: citizens, tourists, etc.) :**
  - **Understand:**
    - flows, density, behaviour, classifications of user/means
    - reputation, appreciation Trip Advisor, Twitter, etc.
  - **Suggest, Recommend, Engage, Guide..**
    - Context based





Concept

BIM

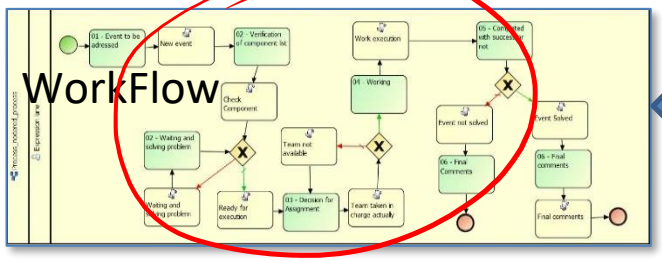


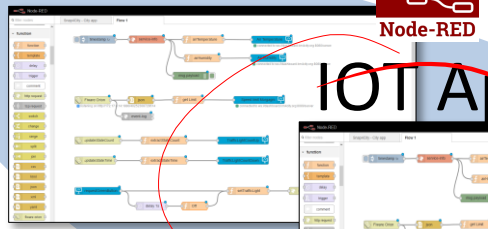
KPI, POI, MyKPI, …

API, External Services

Web Scraping

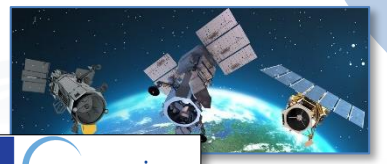
WorkFlow





Node-RED

IOT Apps



Data Analytics,
Artificial Intelligence

IOT Brokers

IOT Broker

IOT Broker

FIWARE

GIS

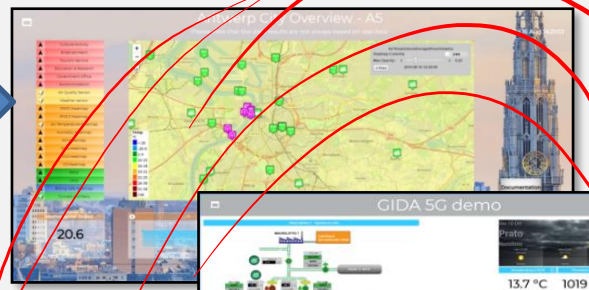
Big Data

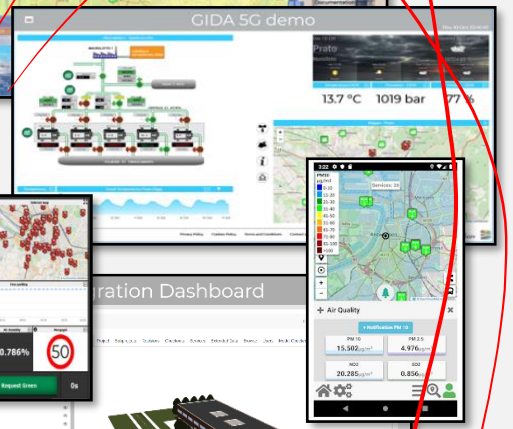
KB

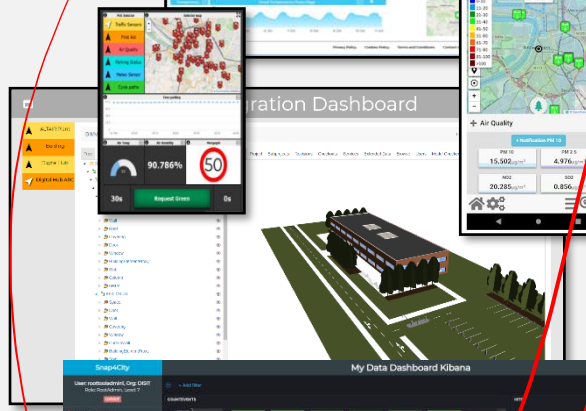
LD, LOD

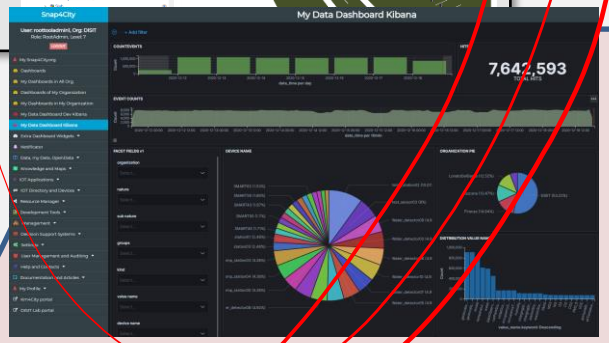
ckan

FI-WARE





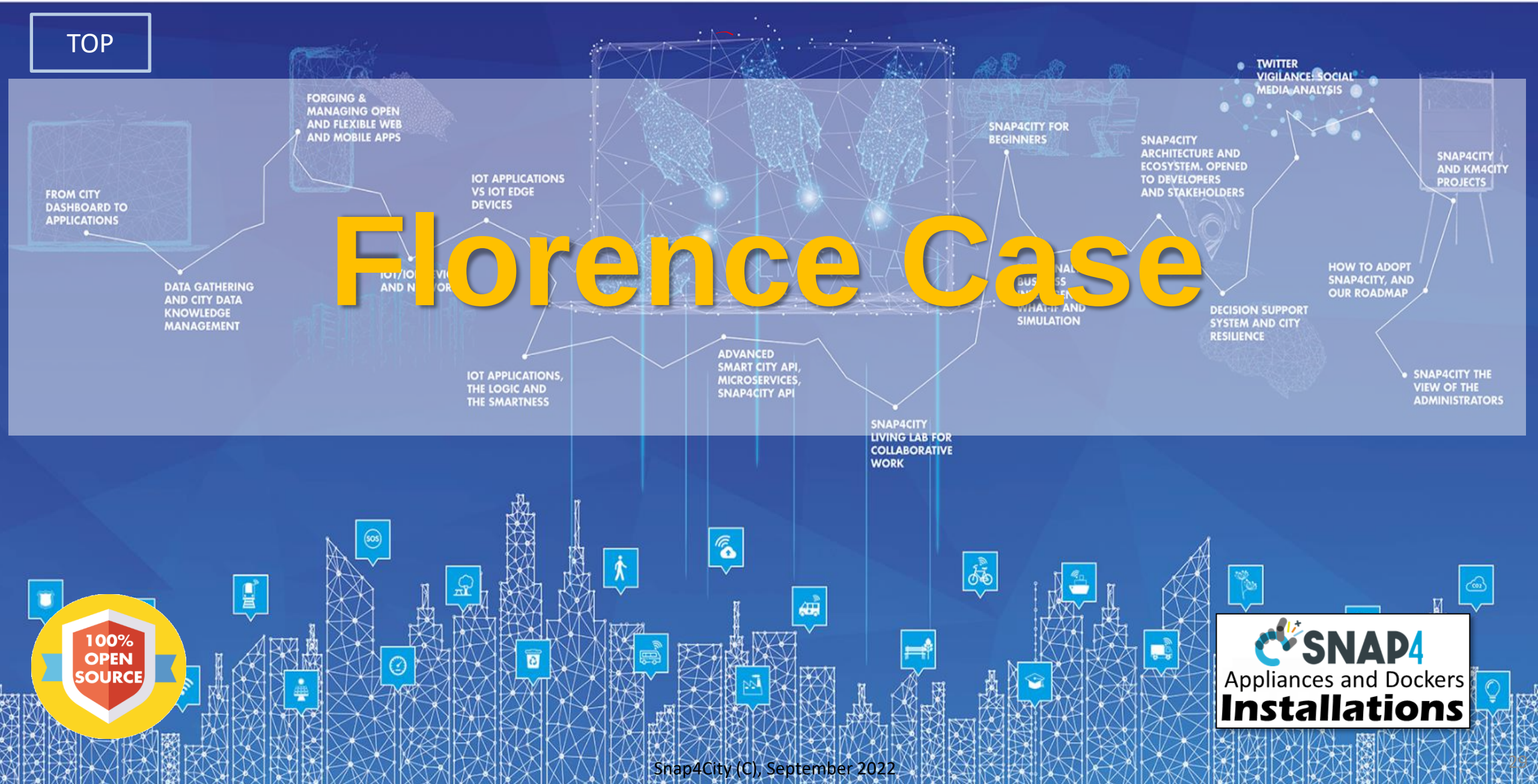




Dashboards and Apps

TOP

Florence Case



Smart City Control Room
Florence Metropolitan City

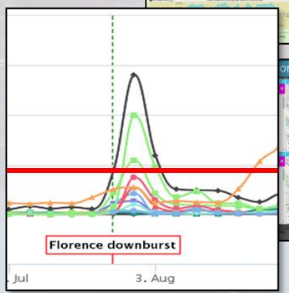
COMUNE DI FIRENZE

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

Firenze Oggi
20991
92207
15964
ANALYSIS
The European House
Ambrosetti

Florence Case

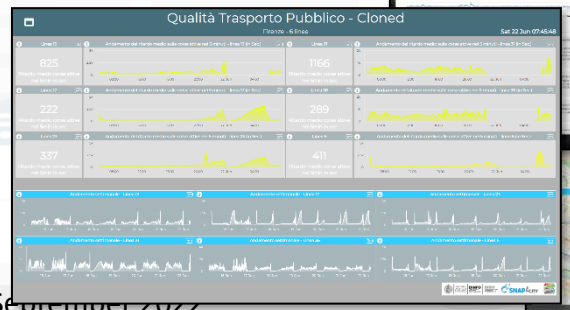
- **Smart City Control Room**
- **Dashboards and Services**
- **Mobile App:** Firenze Where What

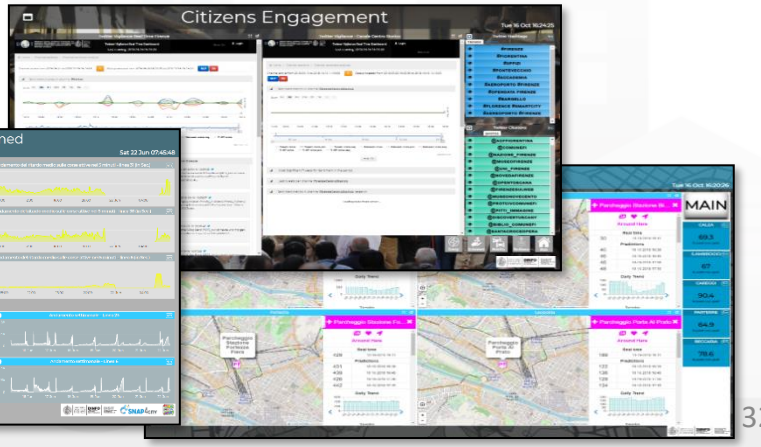
- **Mobility**:
  - quality of public transportation service (mean delay on bus-stops)
  - public transport operators schedule and paths, routing, multimodal routing
  - traffic flow reconstruction
  - Smart parking: predictions
  - Accidents and events, Log, heatmaps
- **Environment**:
  - smart irrigators
  - smart waste
  - Sensors: PM10. PM2.5,…..
  - Heatmaps: PM10, PM2.5, ….
  - NOX predictions
- **Energy**:
  - recharging stations (fast and reg.)
  - consumption meters (smart info)
  - smart light, street lights
- **Weather**
  - Forecast and actual

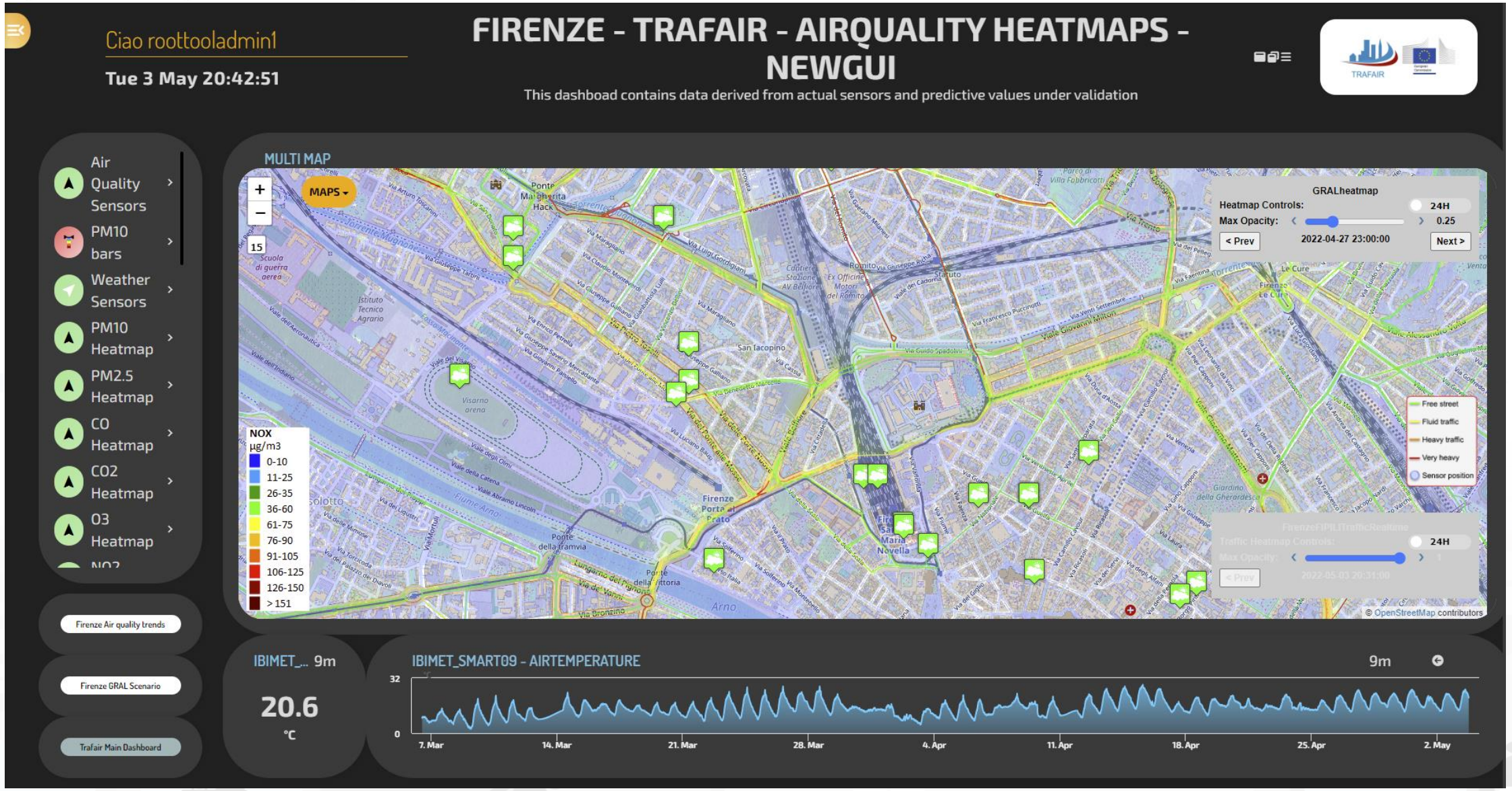
- **Social**:
  - smart benches
  - Twitter monitoring, Sentiment analysis, NLP text
  - TV camera streams
- **People Flows**:
  - Wi-Fi, people flow
  - Origin destination matrices
- **Governmental and Communications**:
  - KPI of the City
  - Digital Signage
  - Civil protection, Resilience (Resolute)
- **Tourism and Culture:**
  - POI, etc.

Analysis:

- **what-if routing, scenarios,**
- **traffic flow, environmental predictions**







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

3D views

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

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

SNAP4CITY KM4CITY

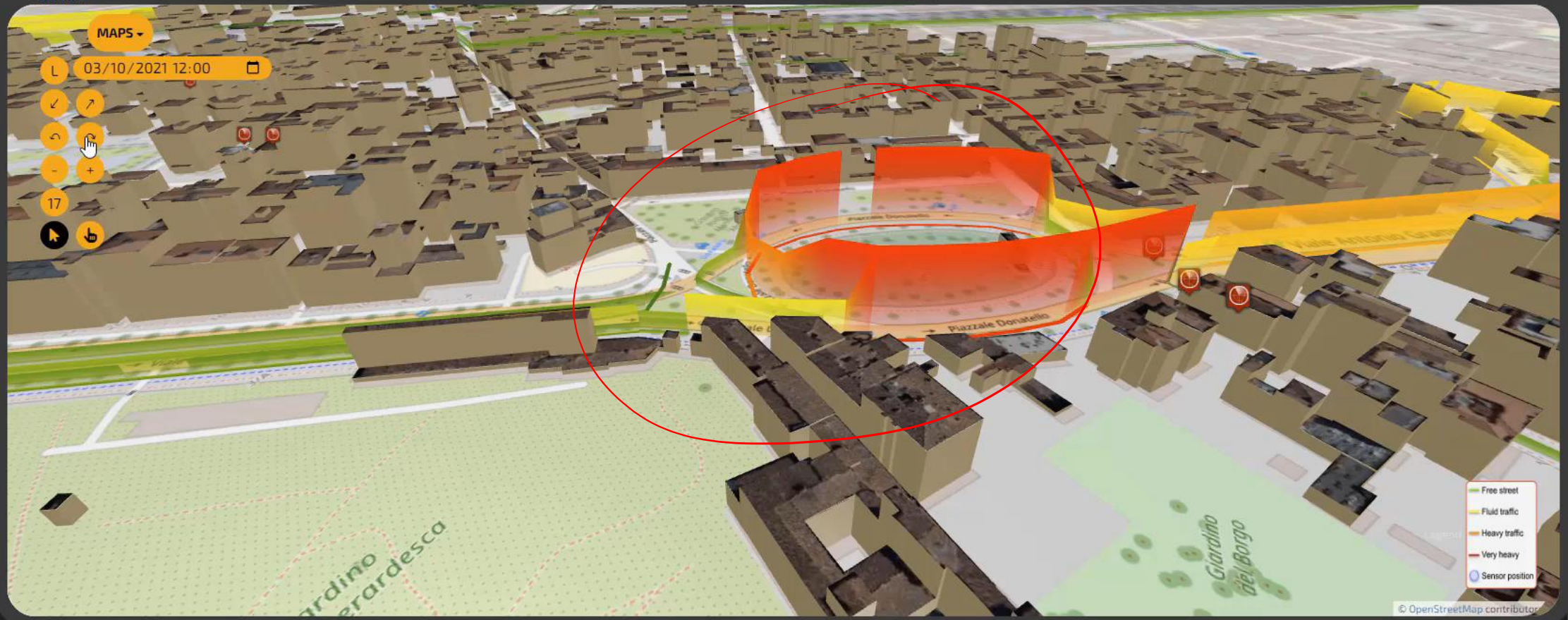
Ciao roottooladmin1

Thu 16 Jun 15:15:03

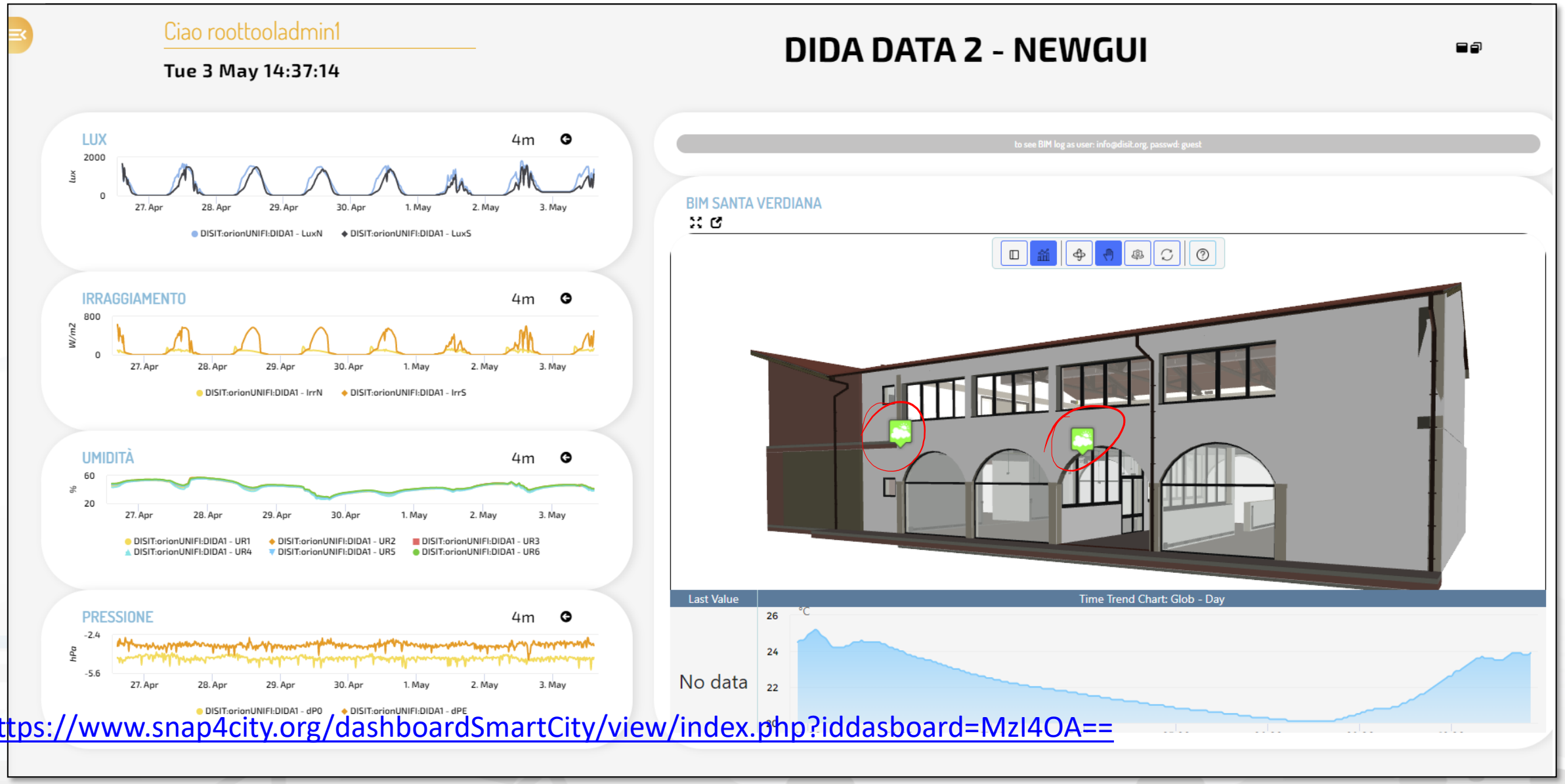
3D MAP DECK TEST-NEWGUI

demonstrator

3D MAP



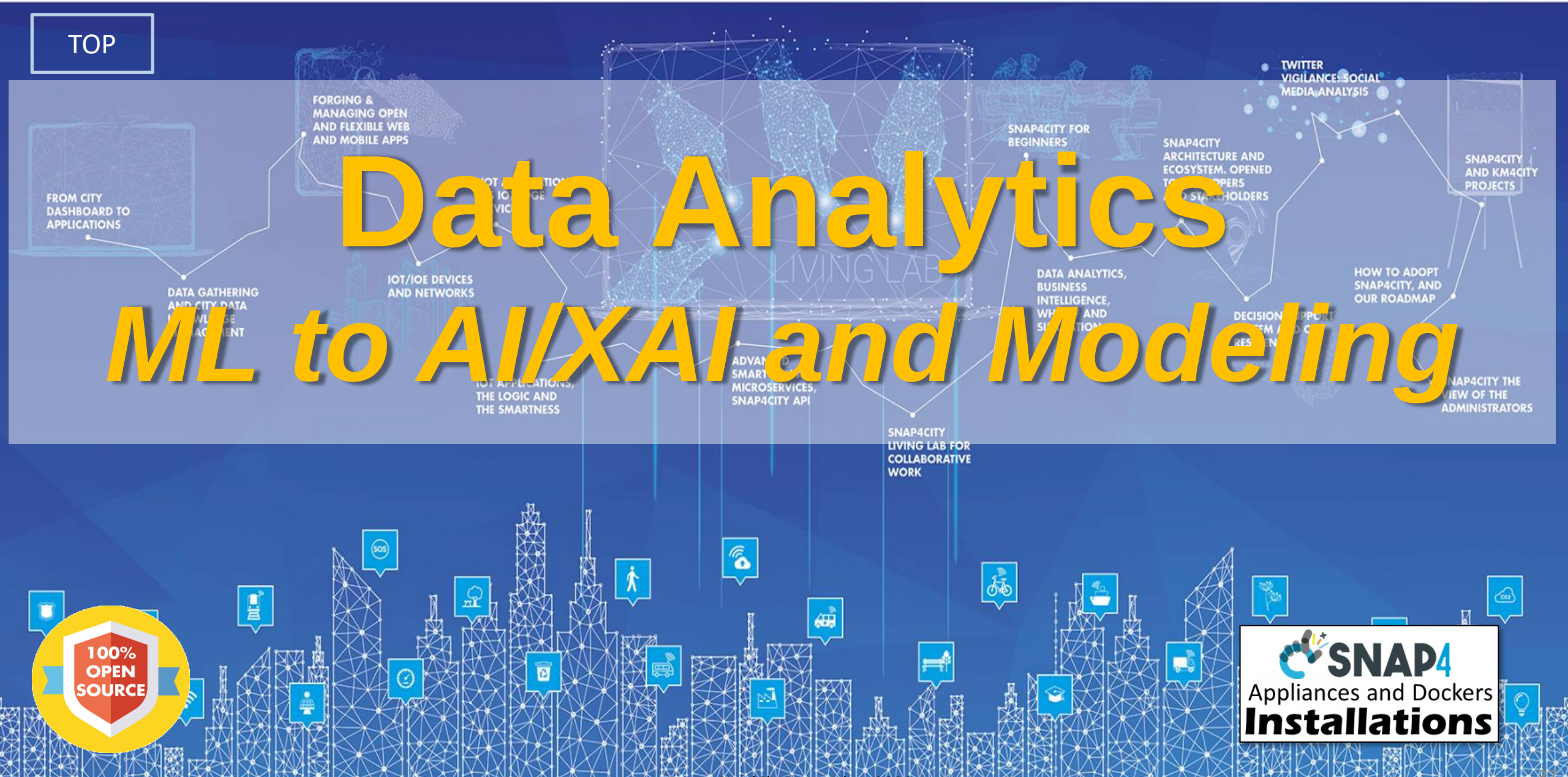
Smart Building



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzI4OA==

TOP

Data Analytics
ML to AI/XAI and Modeling



- ***15 Minute City Index:***
  - 13 differente subindexes

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

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

- Smart City infrastructure: monitoring and resilience
- Effective and Low cost smart solutions
- What-if analysis, Simulations

- Monitoring resource consuption,
- business intelligence tools for decision makers,
- Reduction production costs

- Monitoring and Predictions for
  - NO2, NOX, CO2, Traffic flow, pollutant, landslide, etc.
  - Traffic flow reconstruction

- Shortening justice time
- Predictiction of mediation proneness
- Ethical Explainable Artificial Intelligence

Mobility and Transport

Available DATA ANALYTICS (1)

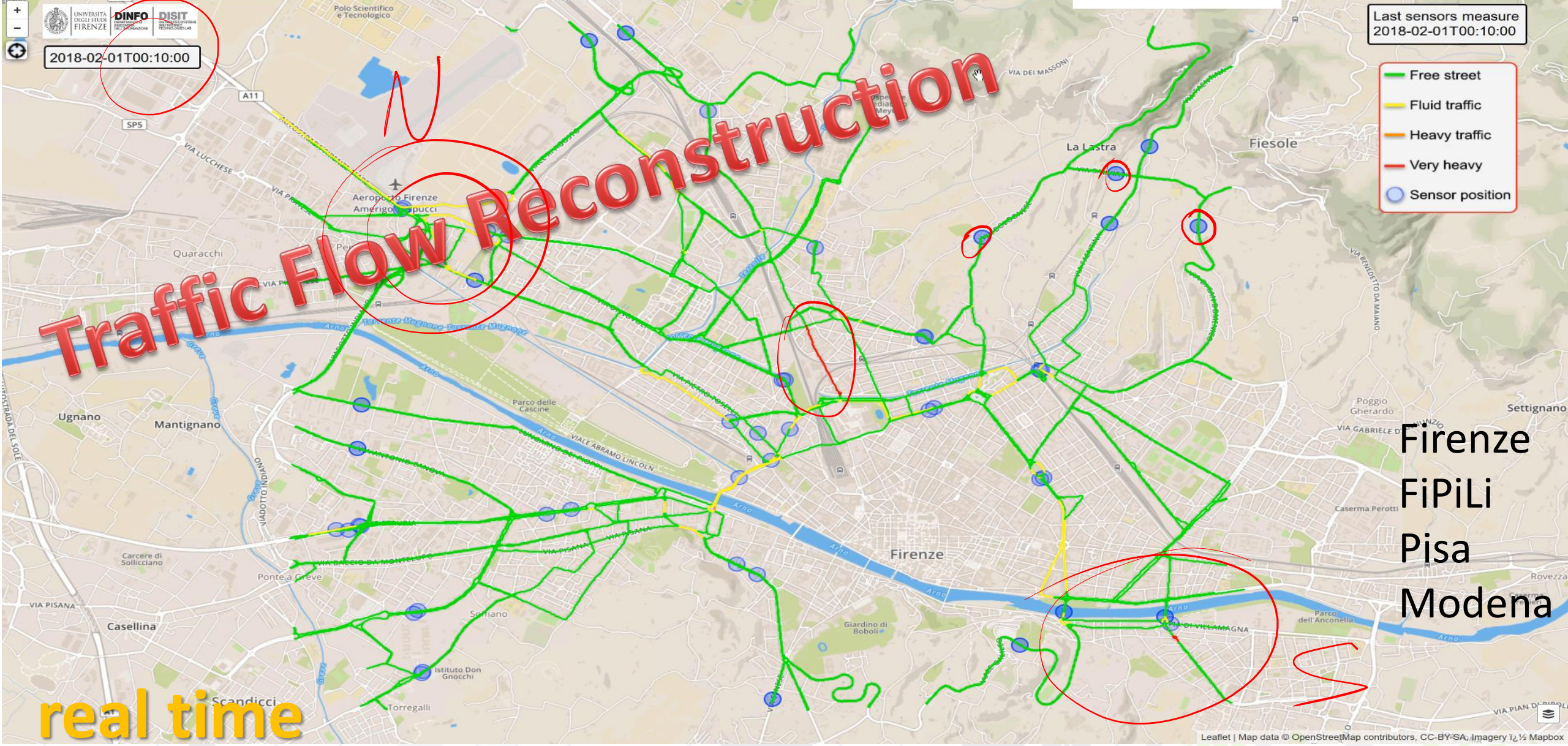
- **Mobility and Transport**
  - **What if analysis**: routing, traffic flow, demand vs offer, pollutant, etc. (Simulation + ML)
  - **Traffic flow reconstruction** from sensors and other sources (simulation + ML)
  - **Predictions** for: traffic flow, smart parking, smart bike sharing, people flows, 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

Mobility and Transport Traffic Flow Analysis

Cities: Firenze, Pisa, Livorno, Modena, Santiago di Compostela

reference

- **Multiple Domain Data**
  - Traffic Flow sensors, city structure, weather
- **Decision Makers Multiple Locations**
  - Real time Monitoring, predictions
  - Traffic Flow Predictions,
  - Traffic Reconstructions, routing
  - Dashboards, What-IF analysis
  - Mobile App, people flows
- **Historical and Real Time data**
- **Services Exploited on:**
  - Dashboards, Mobile App
- **Since 2017, 2019**


2018-02-01T00:10:00
Last sensors measure
2018-02-01T00:10:00
Free street
Fluid traffic
Heavy traffic
Very heavy
Sensor position
Traffic Flow Reconstruction
real time
Firenze
FiPiLi
Pisa
Modena
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery ¿½ Mapbox

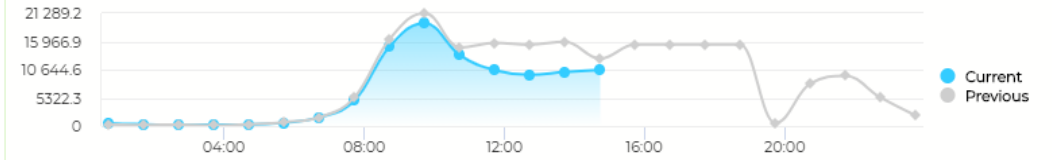
Traffic Flow Monitoring - Firenze - Cloned2

Wed 11 Nov 15:01:32

 # IN FLOW 9m

10549 #ofvehicles

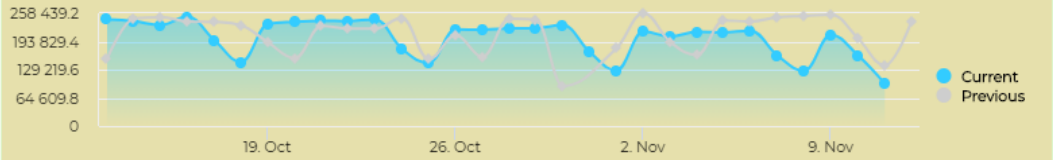
Firenze IN Traffic Flow (number of vehicles) 9m



Inc Daily Inp... 9m

97137 #ofvehicles

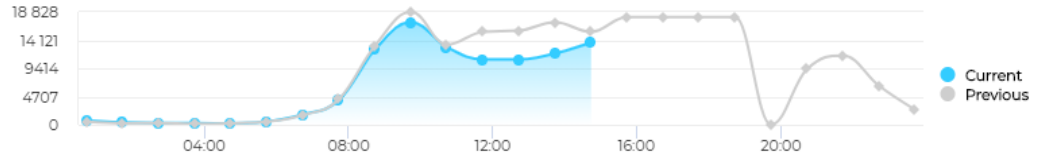
Daily Inputs (monthly) (last value is incremental, real time) 9m



 # OUT FLOW 9m

13720 #ofvehicles

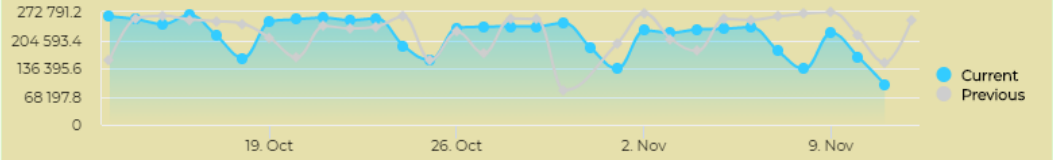
Firenze OUT Traffic Flow (number of vehicles) 9m



Inc Daily Out... 9m

97457 #ofvehicles

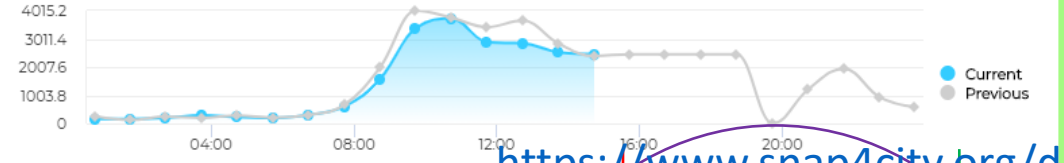
Daily Outputs (monthly) (last value is incremental real time) 9m



ZTL in 9m

2468 #ofvehicles

ZTL in Traffic Flow daily trend, entering in ZTL 9m



QoS as perc. of measures taken 9m

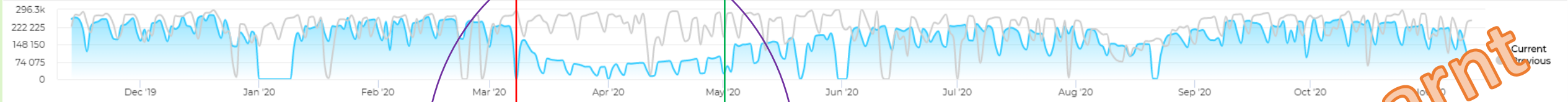
QoS as perc. of measures in ZTL 9m

11/11/2020

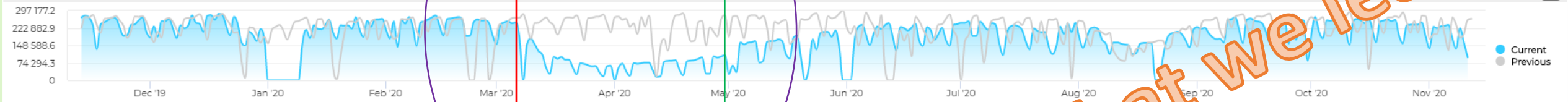
15:01:33

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjY1MQ==

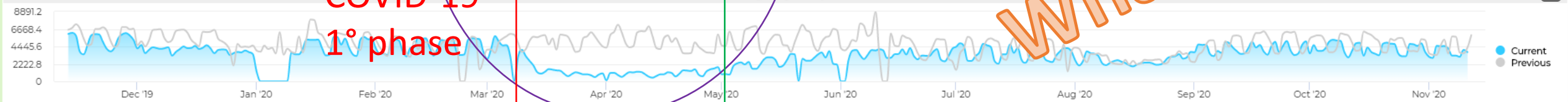
inflow total of the day, yearly 9m



outflow total over the day Yearly 9m



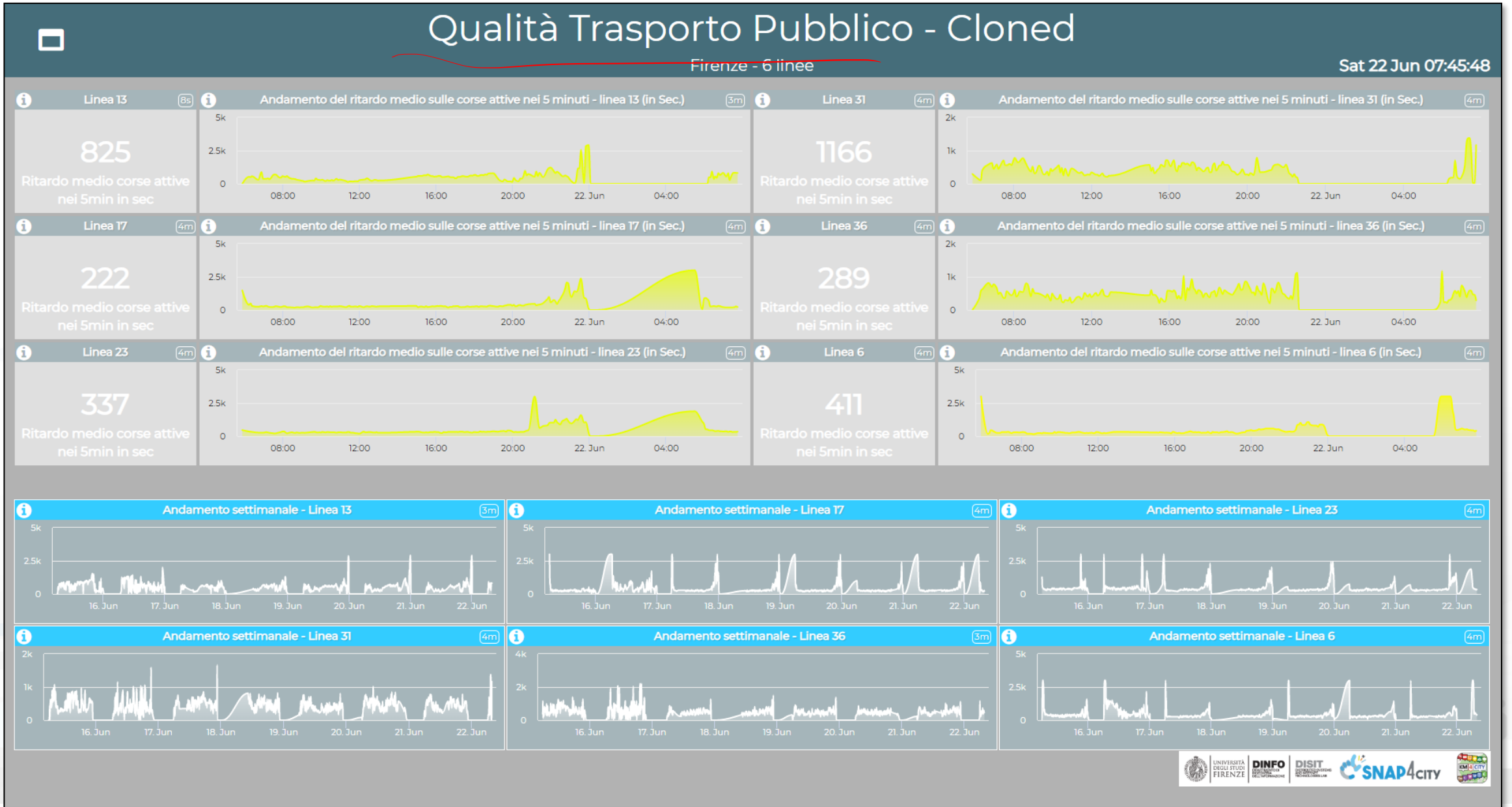
in ZTL yearly compare 9m



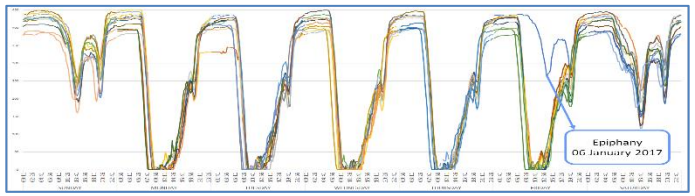
COVID-19

1° phase

What we learnt


Qualità Trasporto Pubblico - Cloned
Firenze - 6 linee
Sat 22 Jun 07:45:48
Linea 13
825
Ritardo medio corse attive nei 5min in sec
Andamento del ritardo medio sulle corse attive nei 5 minuti - linea 13 (in Sec.)
Linea 31
1166
Ritardo medio corse attive nei 5min in sec
Andamento del ritardo medio sulle corse attive nei 5 minuti - linea 31 (in Sec.)
Linea 17
222
Ritardo medio corse attive nei 5min in sec
Andamento del ritardo medio sulle corse attive nei 5 minuti - linea 17 (in Sec.)
Linea 36
289
Ritardo medio corse attive nei 5min in sec
Andamento del ritardo medio sulle corse attive nei 5 minuti - linea 36 (in Sec.)
Linea 23
337
Ritardo medio corse attive nei 5min in sec
Andamento del ritardo medio sulle corse attive nei 5 minuti - linea 23 (in Sec.)
Linea 6
411
Ritardo medio corse attive nei 5min in sec
Andamento del ritardo medio sulle corse attive nei 5 minuti - linea 6 (in Sec.)
Andamento settimanale - Linea 13
Andamento settimanale - Linea 17
Andamento settimanale - Linea 23
Andamento settimanale - Linea 31
Andamento settimanale - Linea 36
Andamento settimanale - Linea 6

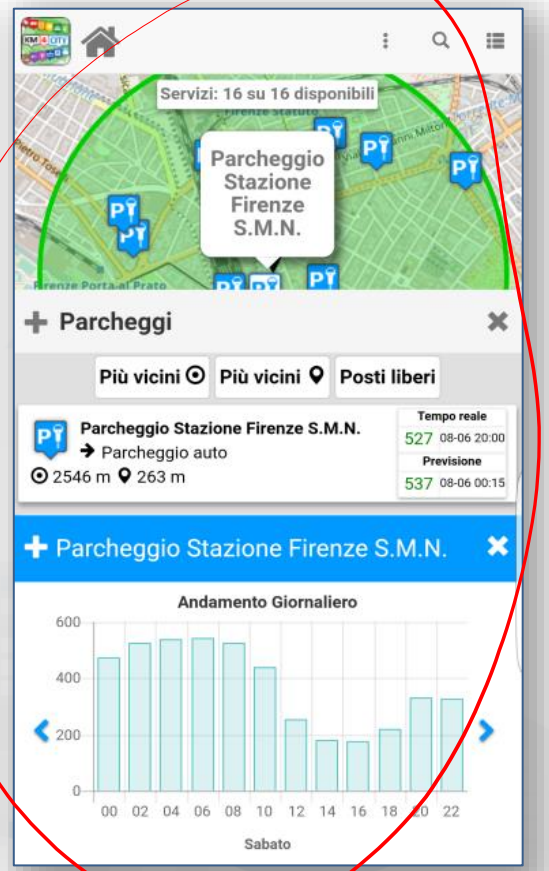
I would arrive to surely Park in 45 Minutes??



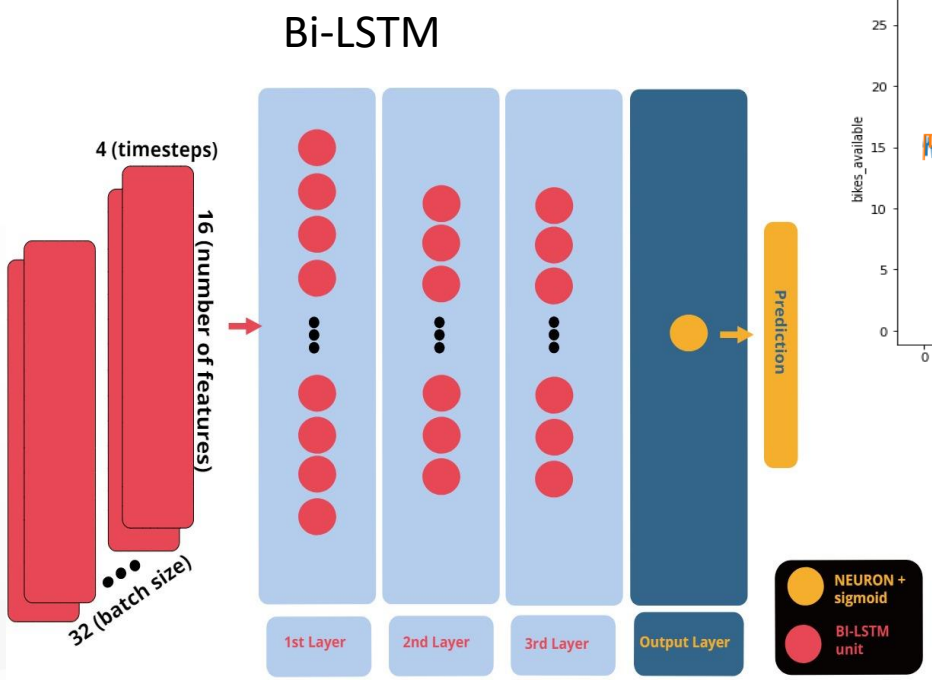
Category	Features	Description of features variable
Baseline features of free slot data	Free parking slots	Real number of available slots recorded every 15 minutes
	Time	Hours and minutes
	Month	Month of the year (1-12)
	Day	Day of the month (1-31)
	Day week	Day of the week (0-6)
	Weekend	0 for working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

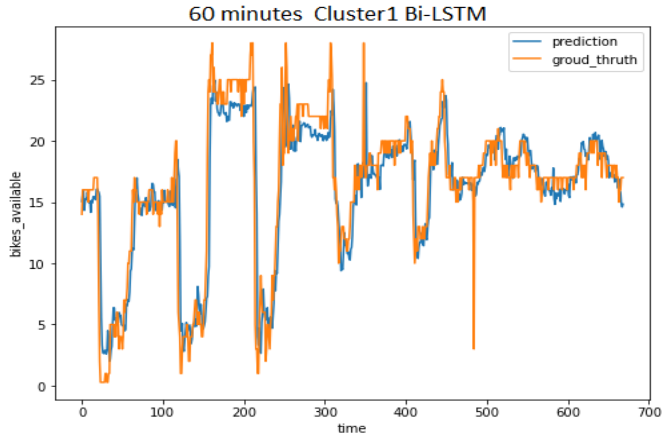
Artificial Intelligence Predictions

97% of precision



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

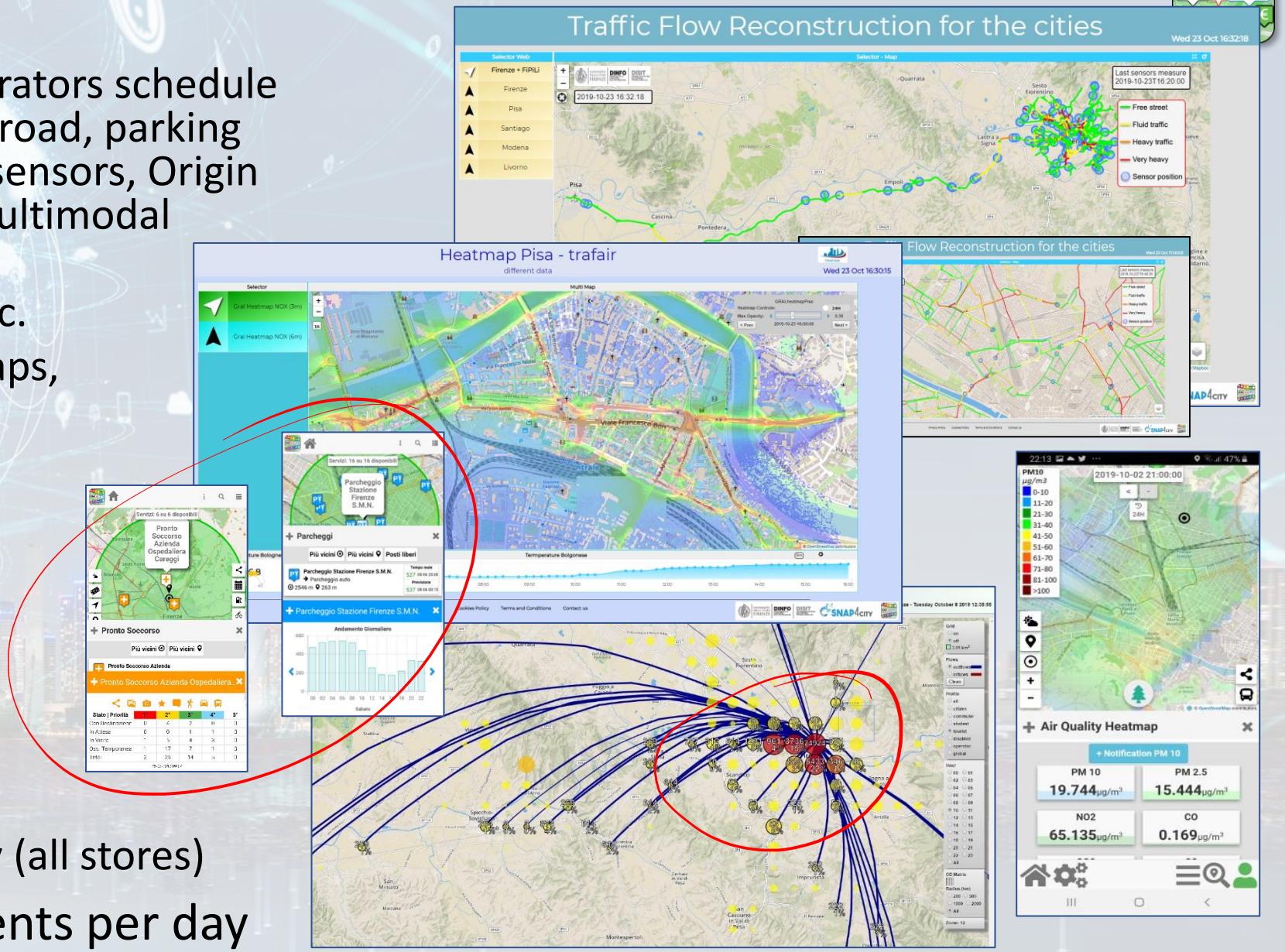




E. Collini, P. Nesi and G. Pantaleo, "Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations," in *IEEE Access*, vol. 9, pp. 124337-124347, 2021, doi: 10.1109/ACCESS.2021.3110794.
https://ieeexplore.ieee.org/abstract/document/9530580

Tuscany Region

- **Dashboards & Services**:
  - **Mobility**: public transport operators schedule and paths, traffic Fi-Pi-Li main road, parking status and predictions, traffic sensors, Origin Destination matrix, routing, multimodal routing, etc.
  - **Social**: Hospitals and triage, etc.
  - **Environment**: sensors, heatmaps,
  - alerting,
    - **Pollution** Forecast: NOX, NO2
    - **Weather** Forecast,
  - **Culture** and **Tourisms**
  - Etc.
- **Mobile App and MicroApplications:**
  - Tuscany in a Snap (all stores)
  - Tuscany where what… km4city (all stores)
- **Numbers**: 1.5 M complex events per day



City User behaviour analysis

Available DATA ANALYTICS (2)

- **City Users and Social**
  - People detection and classification: persona, carts, bikes, etc. (ML, DL)
  - people counting and tracking (via thermal cameras, ML, DL)
  - People prediction: wifi, mobile, etc.
  - People counting via head counting (via thermal cameras, ML, DL)
  - People flows prediction and reconstruction, (ML, DL)
    - Wi-Fi data, mobile apps data, Mobile Data, etc.
  - User engagement and suggestions for sustainable mobility (Rule Based, ML)
  - User's behaviour analysis,
    - origin destination matrices, hot places, time schedule, Recency and frequency, permanence, typical trajectory, etc.
    - People flow analysis from PAX Counters and heterogenous data sources
  - 15 Minute City Index, etc. (modeling and computability)

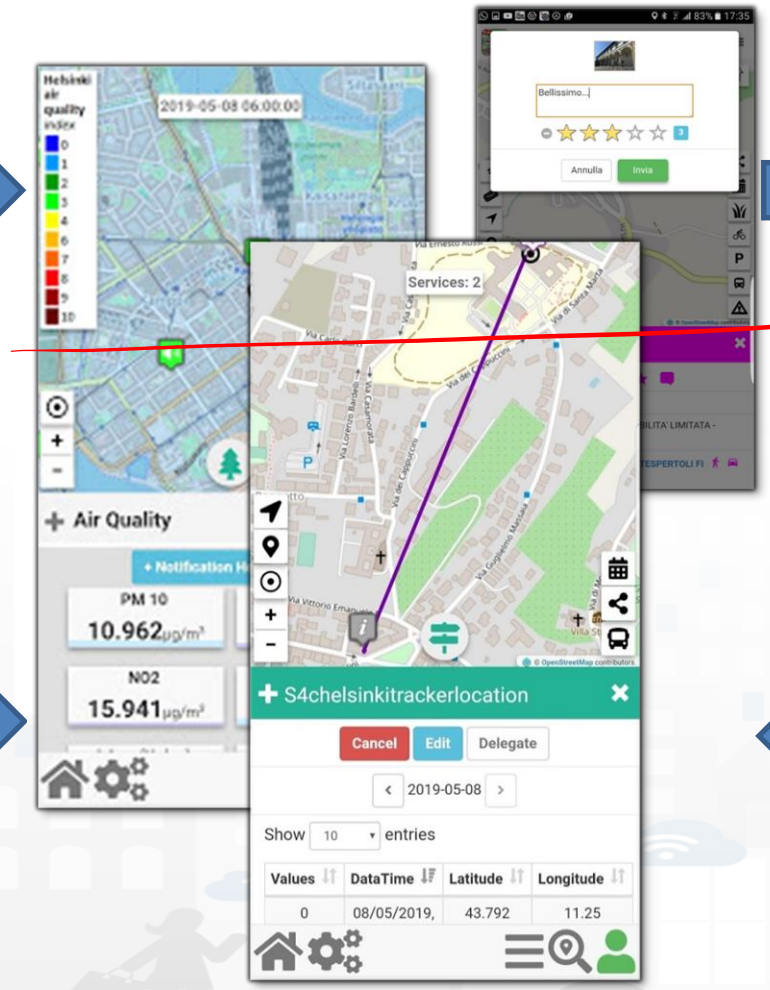
The App is a Bidirectional Device

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

Produced information

- Accepted ?
- Performed ?
- …

Users



Derived information

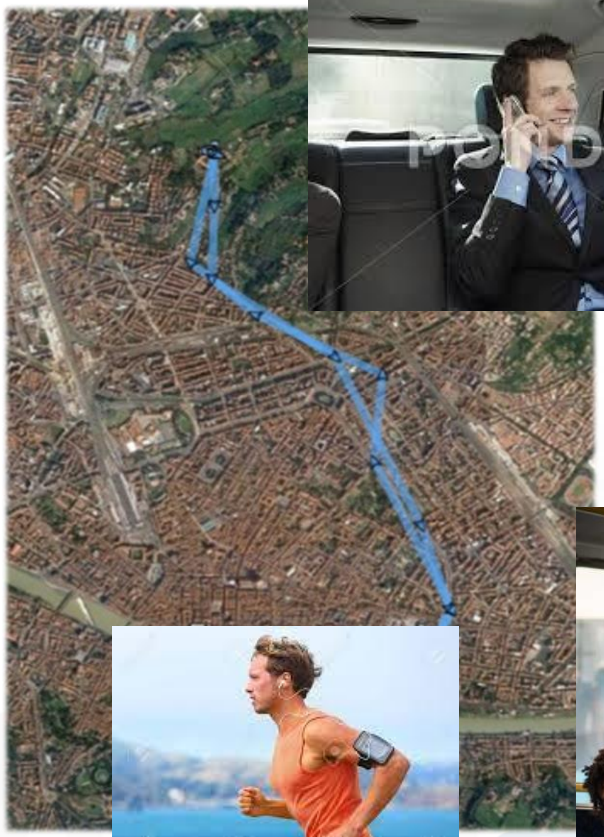
- Trajectories
- Hot Places by click and by move
- Origin destination matrices
- Most interested topics
- Most interested POI
- Delegation and relationships
- Accesses to Dashboards
- **Cumulated Scores from Actions**
- Requested information
- Routing performed
- …..

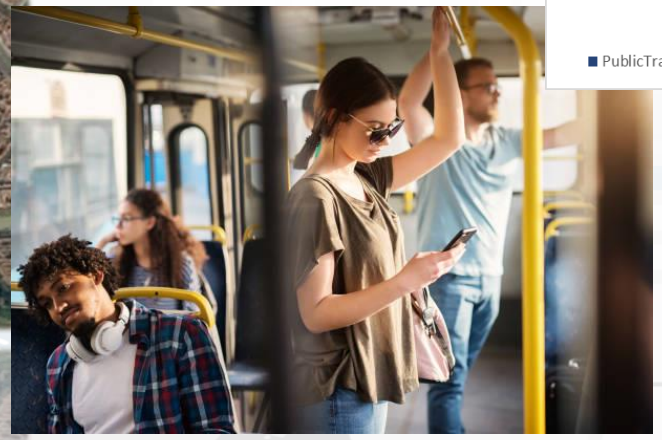
Produced information

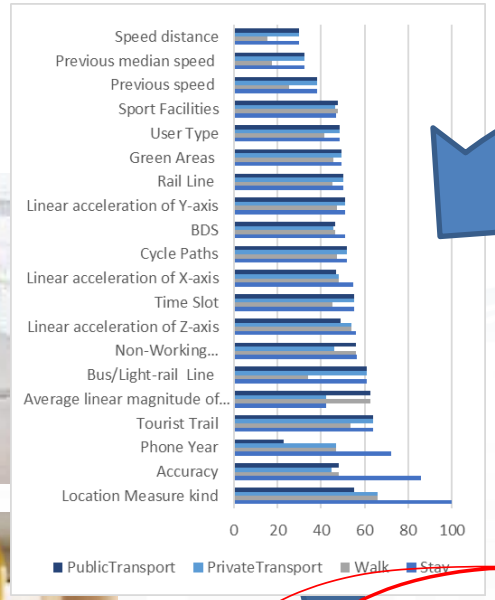
- Suggestions
- Engagements
- Notifications
- …

System

To propose suggestions and Engage city user I need to know how they are moving

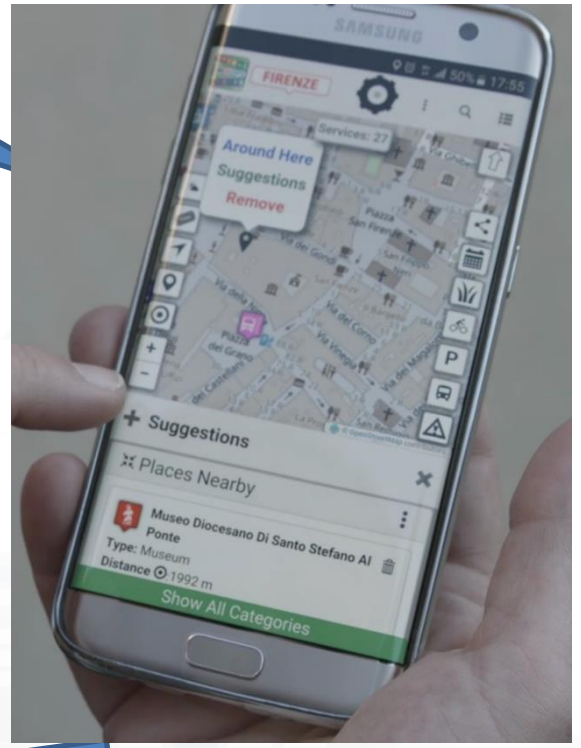






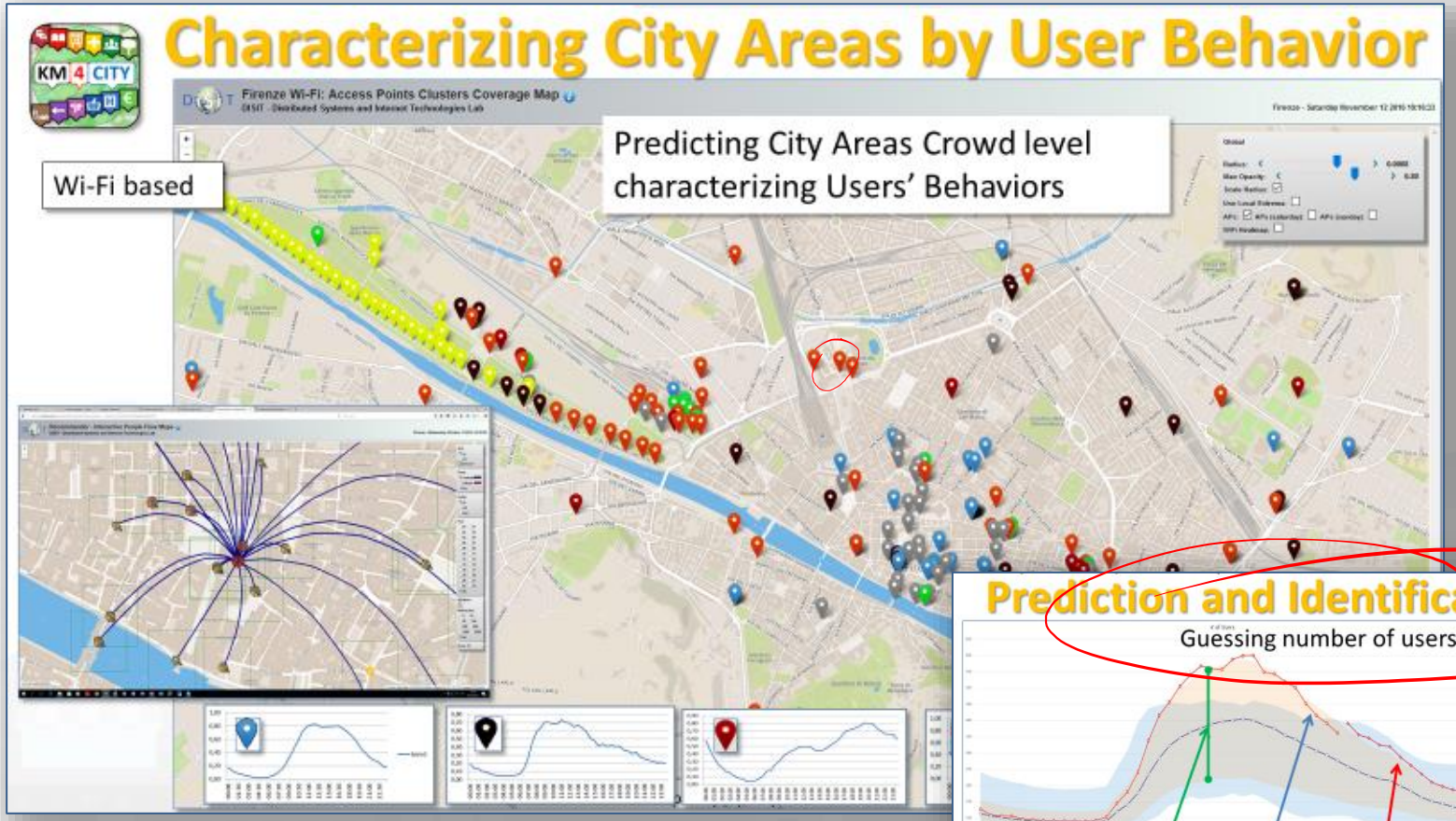
Artificial Intelligence Classification

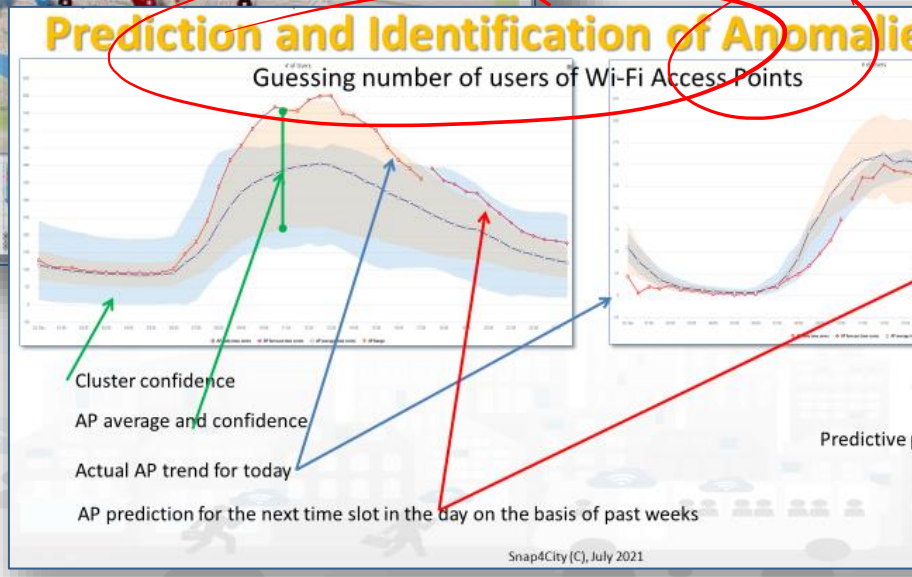
Suggestions



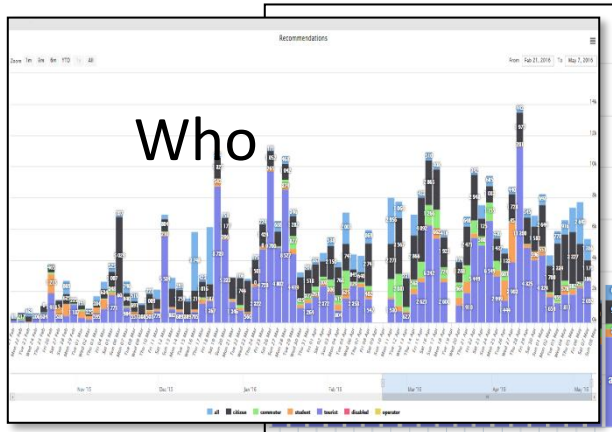
People Flows

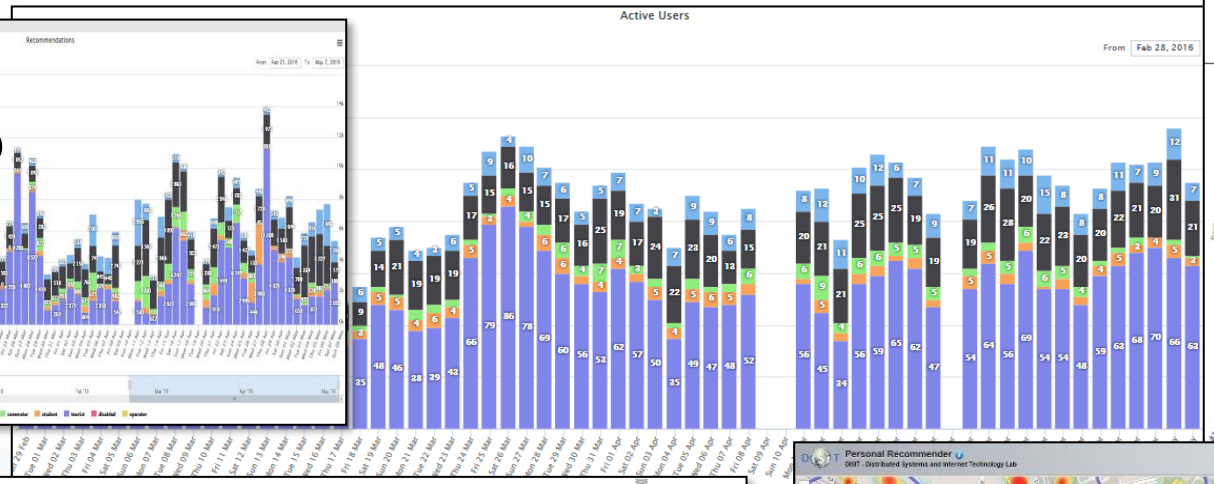
- **Prediction of people flows** on the basis of Wi-Fi data
- **Anomaly** detection
- **Resolute** H2020
- Classification of city areas

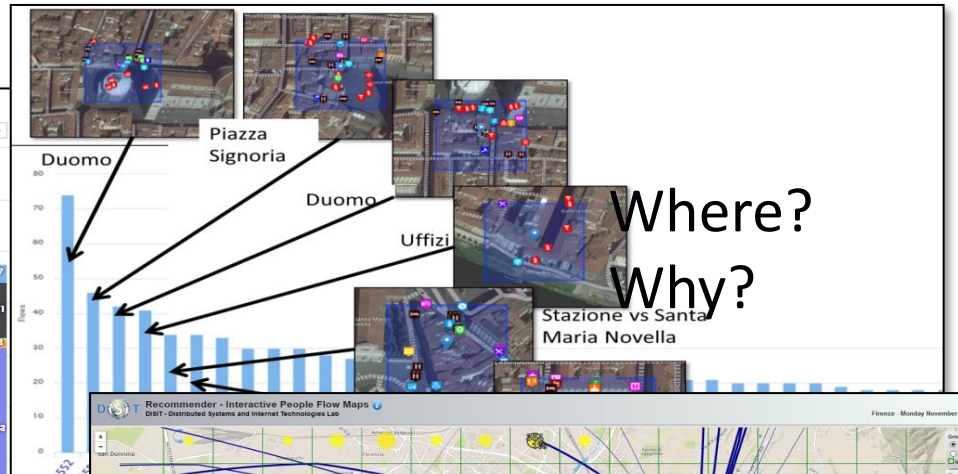


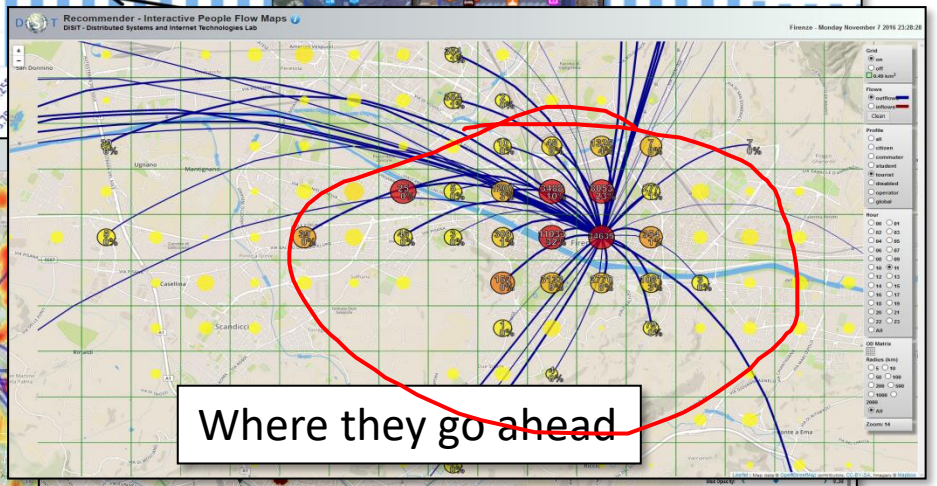


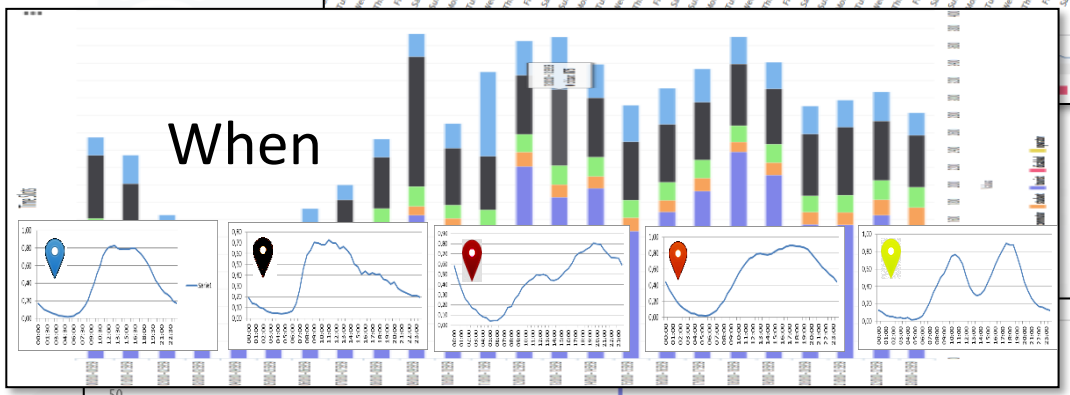
User Behavior Analyser for Collective Profiling

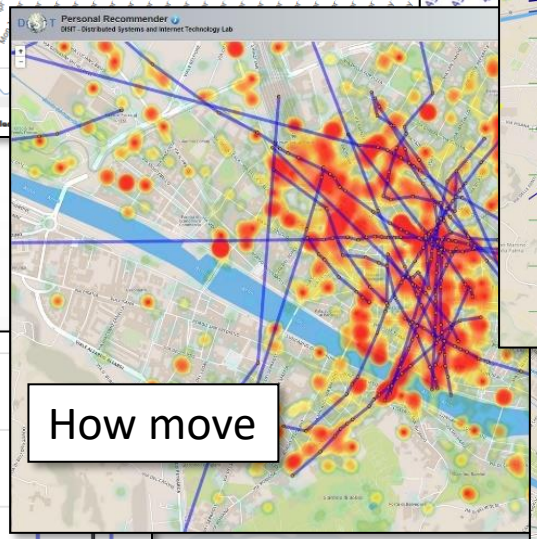


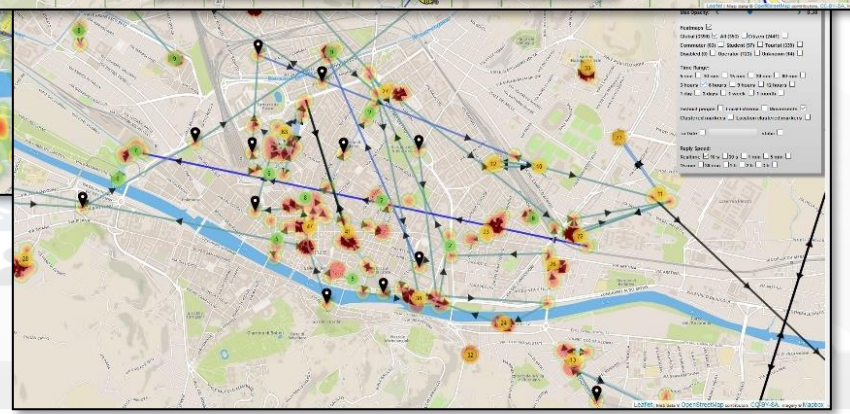


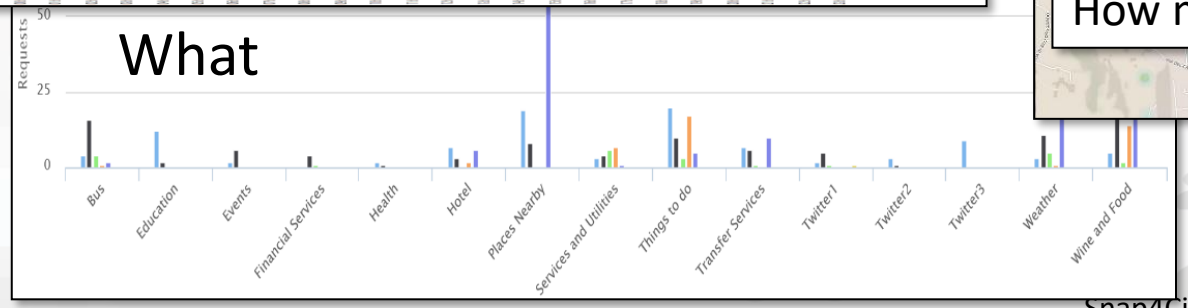




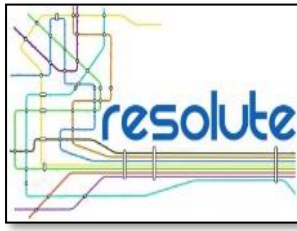








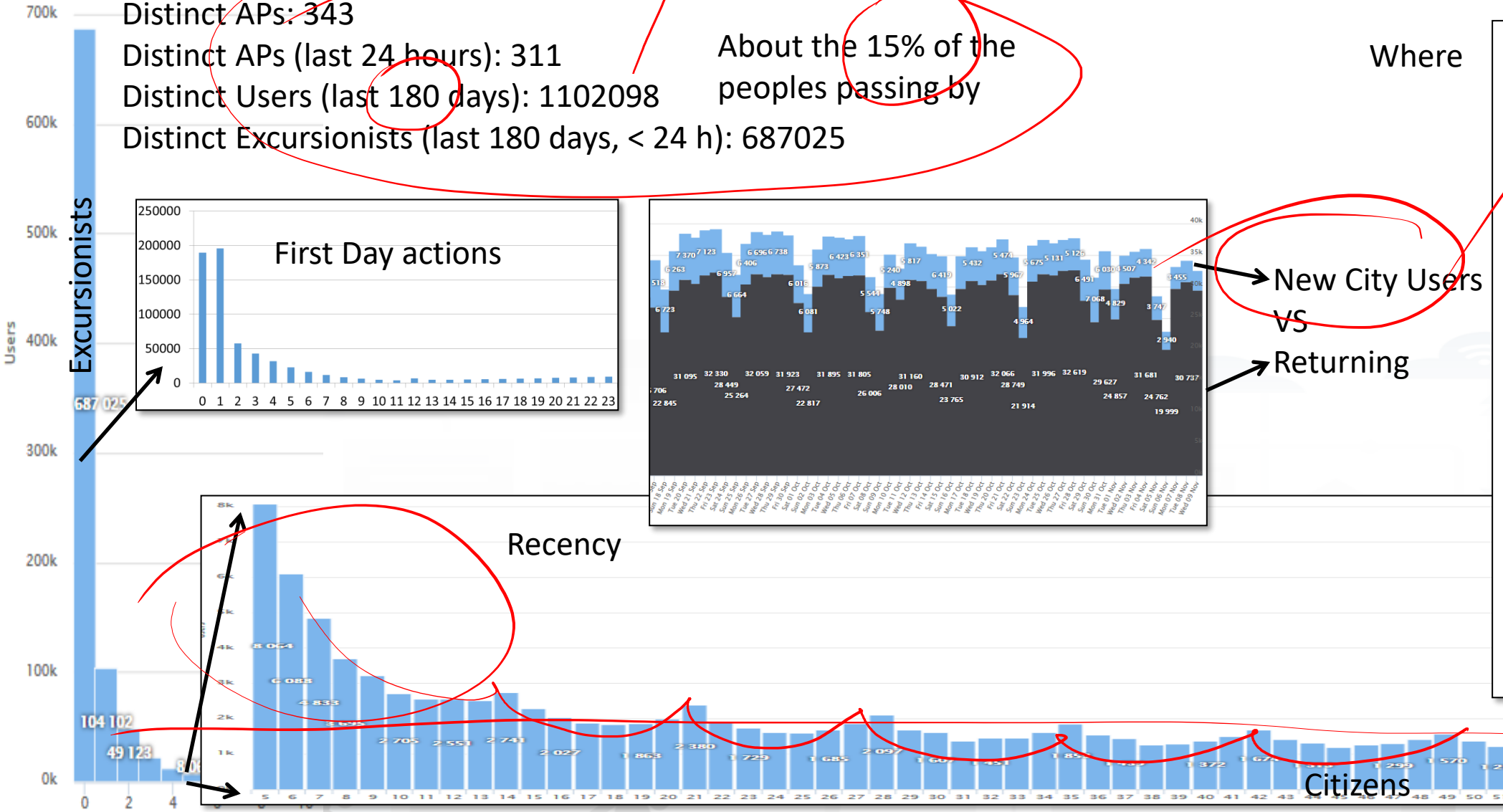
User Behaviour Analysis



Distinct APs: 343
Distinct APs (last 24 hours): 311
Distinct Users (last 180 days): 1102098
Distinct Excursionists (last 180 days, < 24 h): 687025

About the 15% of the peoples passing by

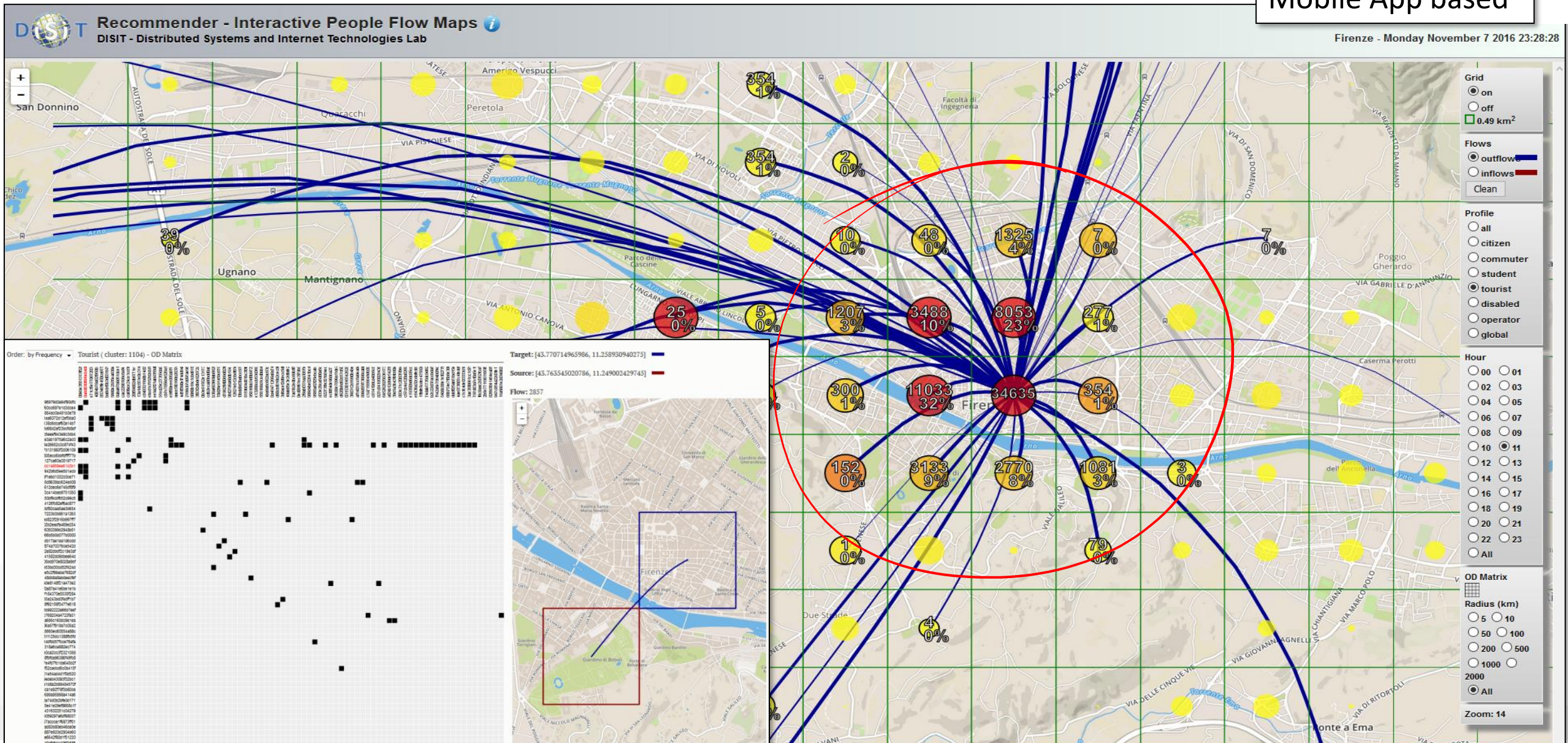
Where



Scalable multiresolution OD matrix

Sii-Mobility

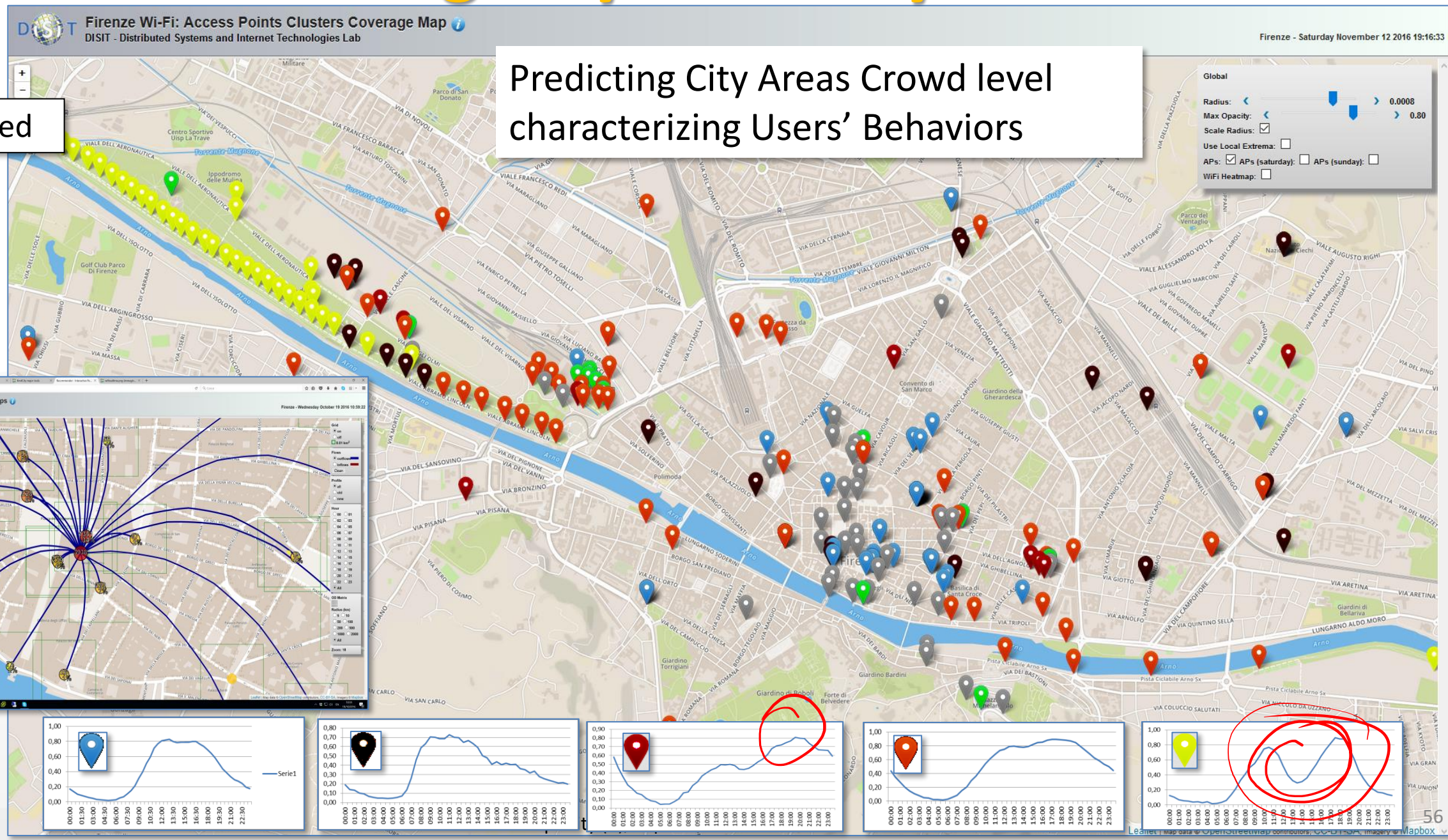
Mobile App based



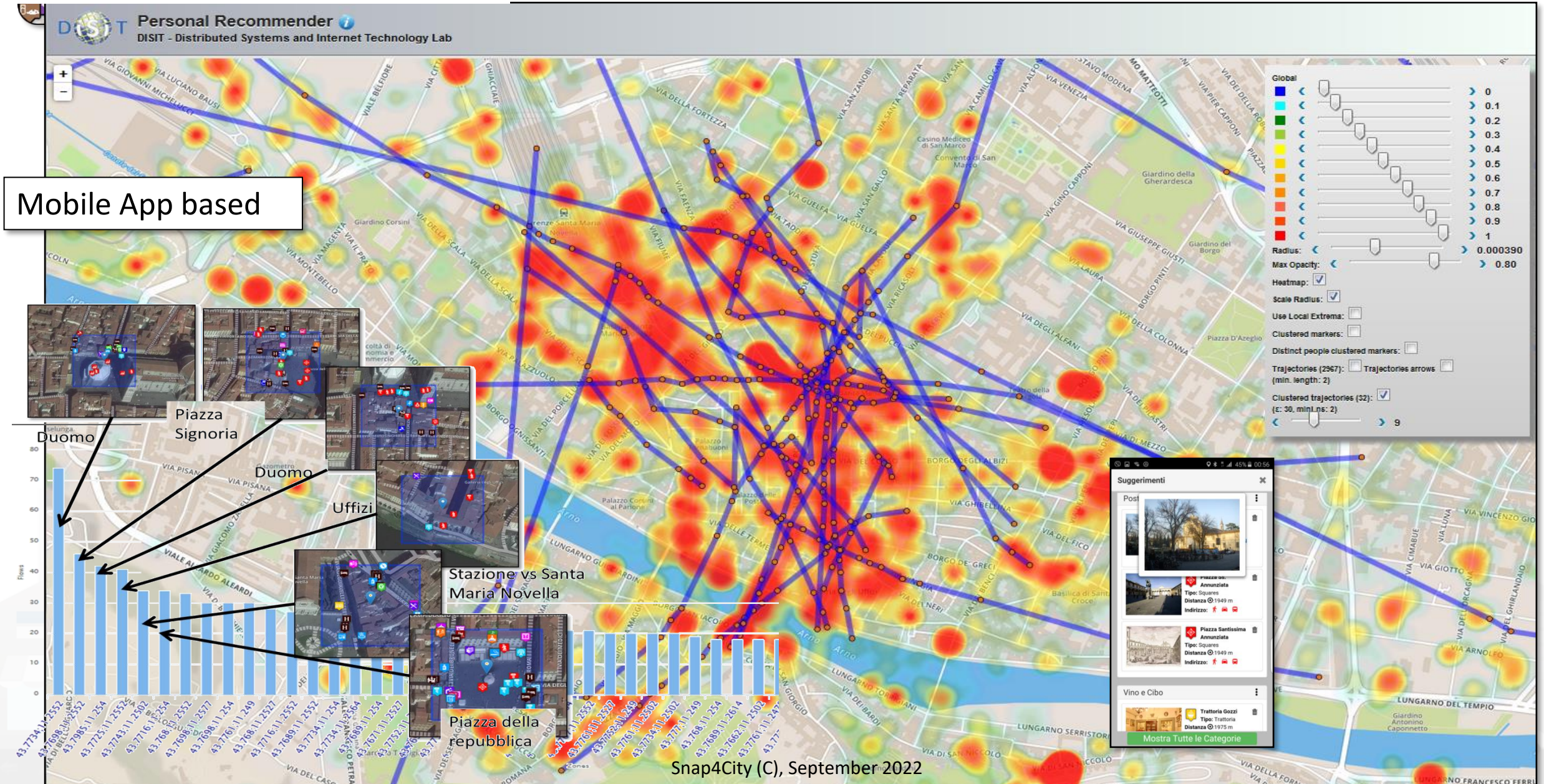
Characterizing City Areas by User Behavior

Wi-Fi based

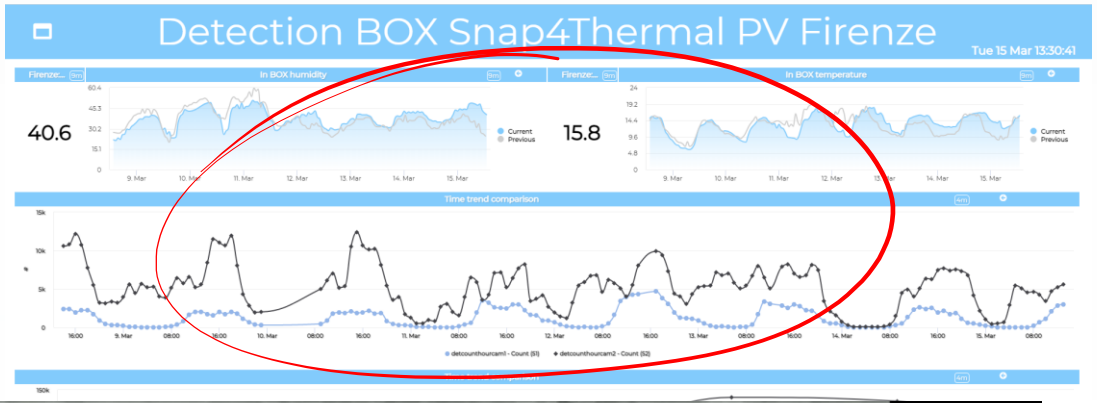
Predicting City Areas Crowd level characterizing Users' Behaviors

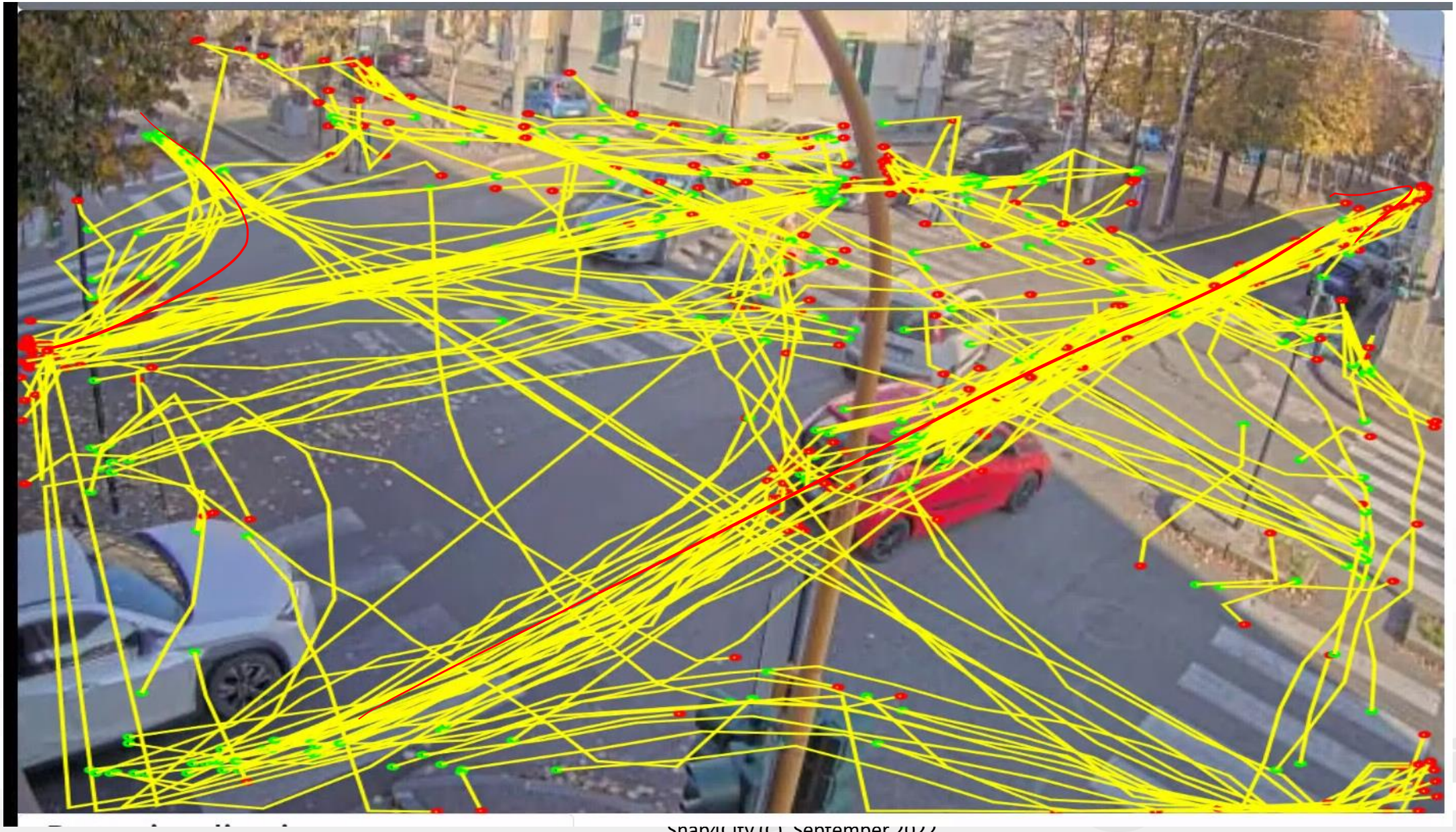


User Behavior Analyzer

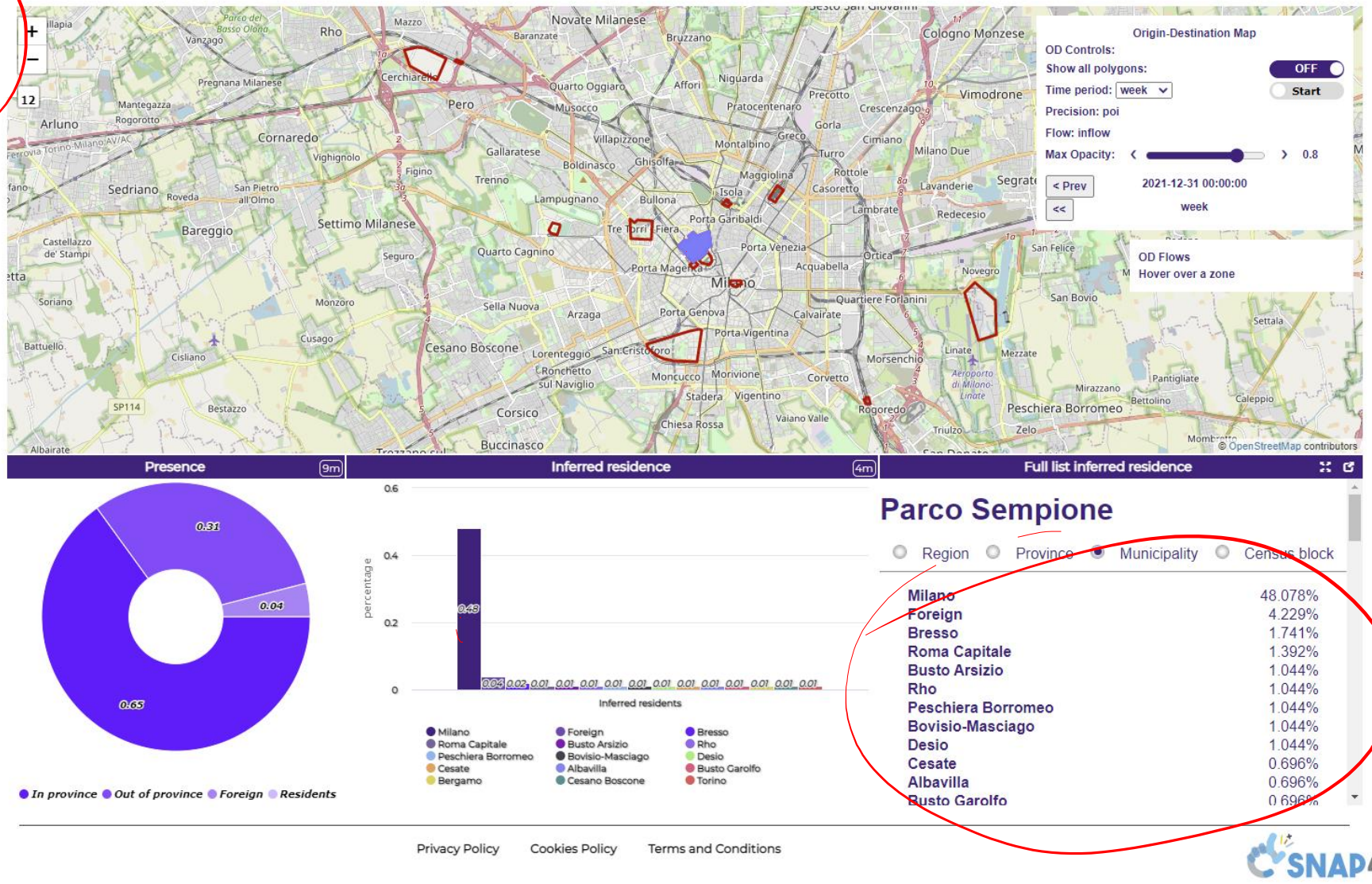


A view and data from the Thermal Camera





ODM Visual Analytic on Milan Area

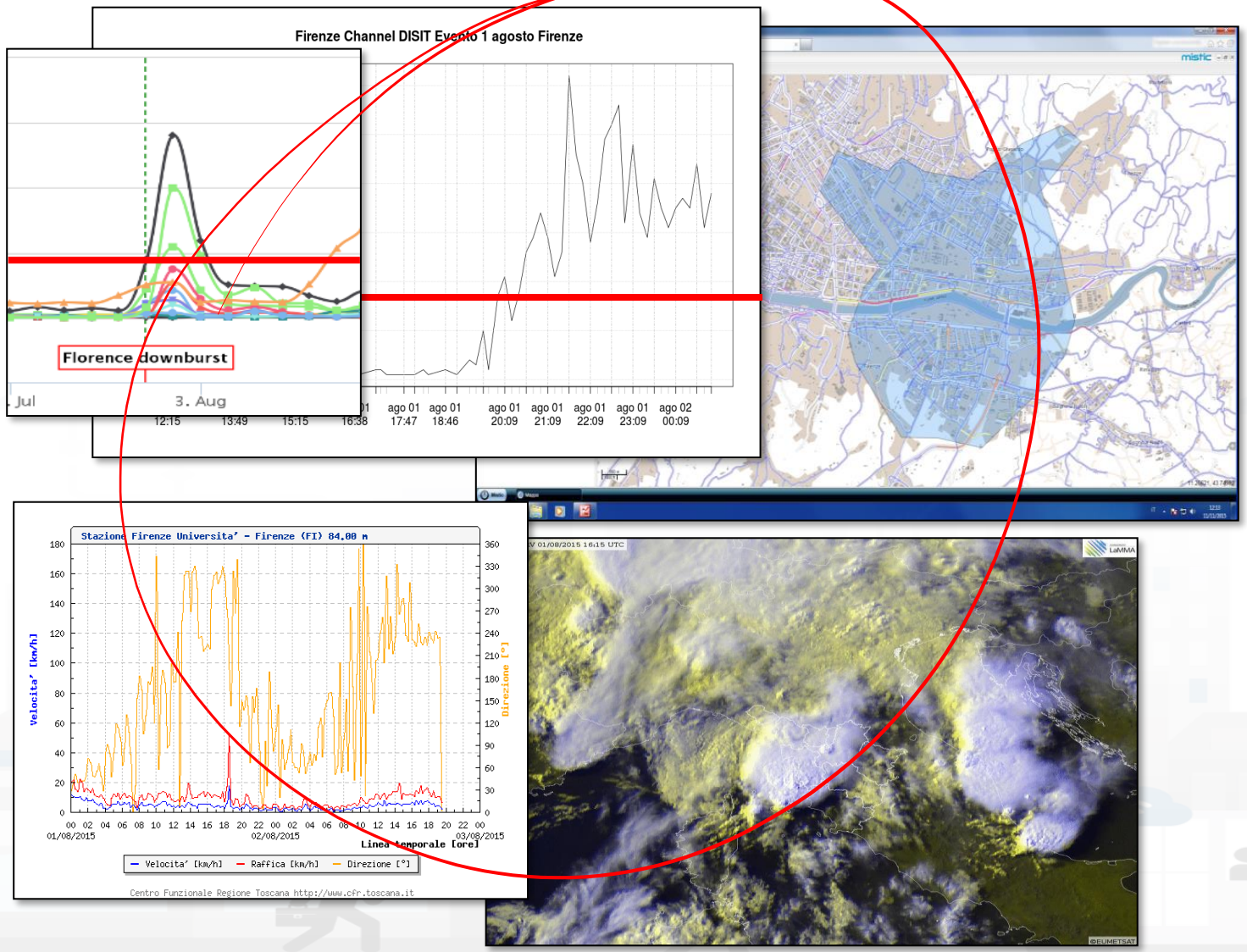


Available DATA ANALYTICS (2b)

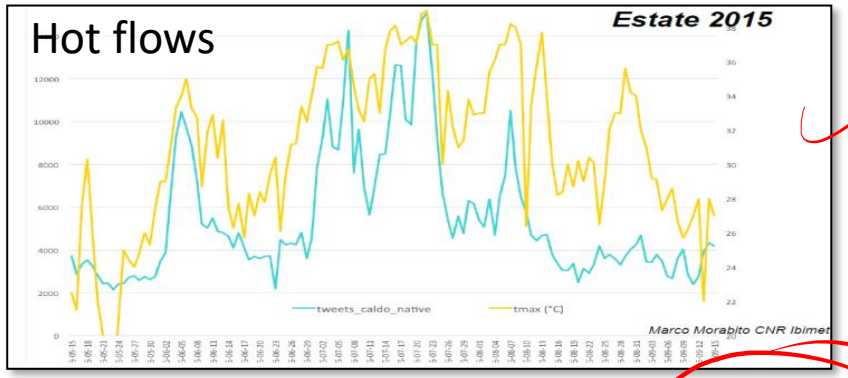
- **City Users and Social**
  - Social media analysis on specific channel, specific keywords: see Twitter Vigilance,
    - Reputation, service assessment: MultiLingual NLP and Sentiment Analysis, SA
    - Tweet proneness, retweet-ability of tweets, impact guessing
    - Audience predictions on TV channels and physical events, locations
    - Prediction and estimation of presences/tickets
    - Prediction/assessment of reputation as Trip Advisor
    - Anomaly detection

Twitter Vigilance

Early Warning



Predictive models



Attendance at long lasting events: EXPO2015

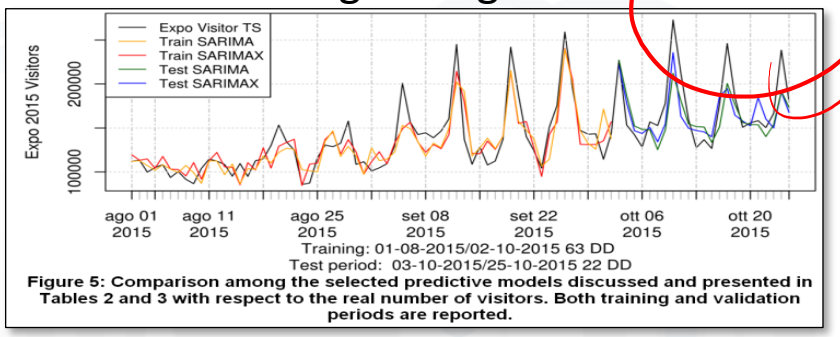
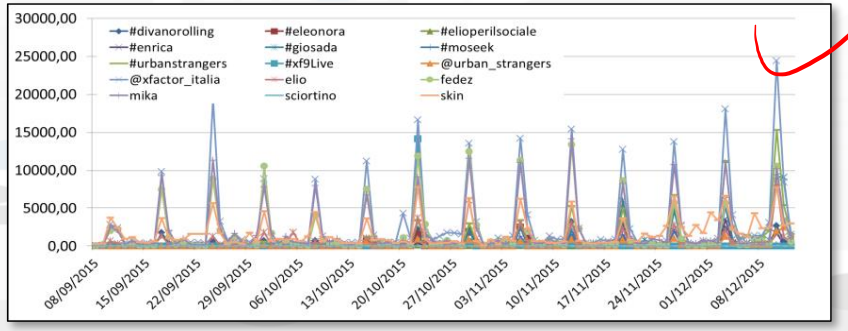


Figure 5: Comparison among the selected predictive models discussed and presented in Tables 2 and 3 with respect to the real number of visitors. Both training and validation periods are reported.

Attendance at recurrent events: TV, footbal



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

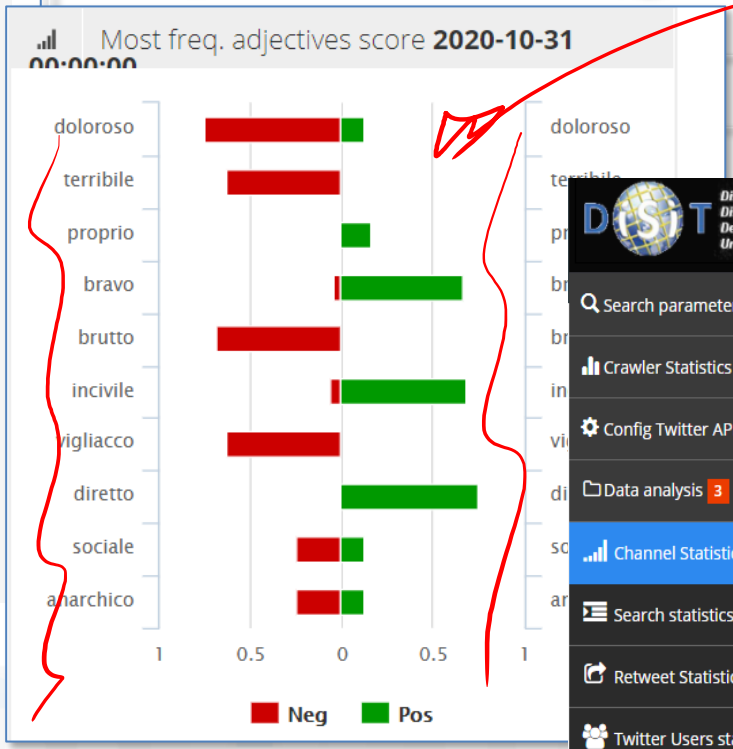
SNAP4CITY | KM 4 CITY

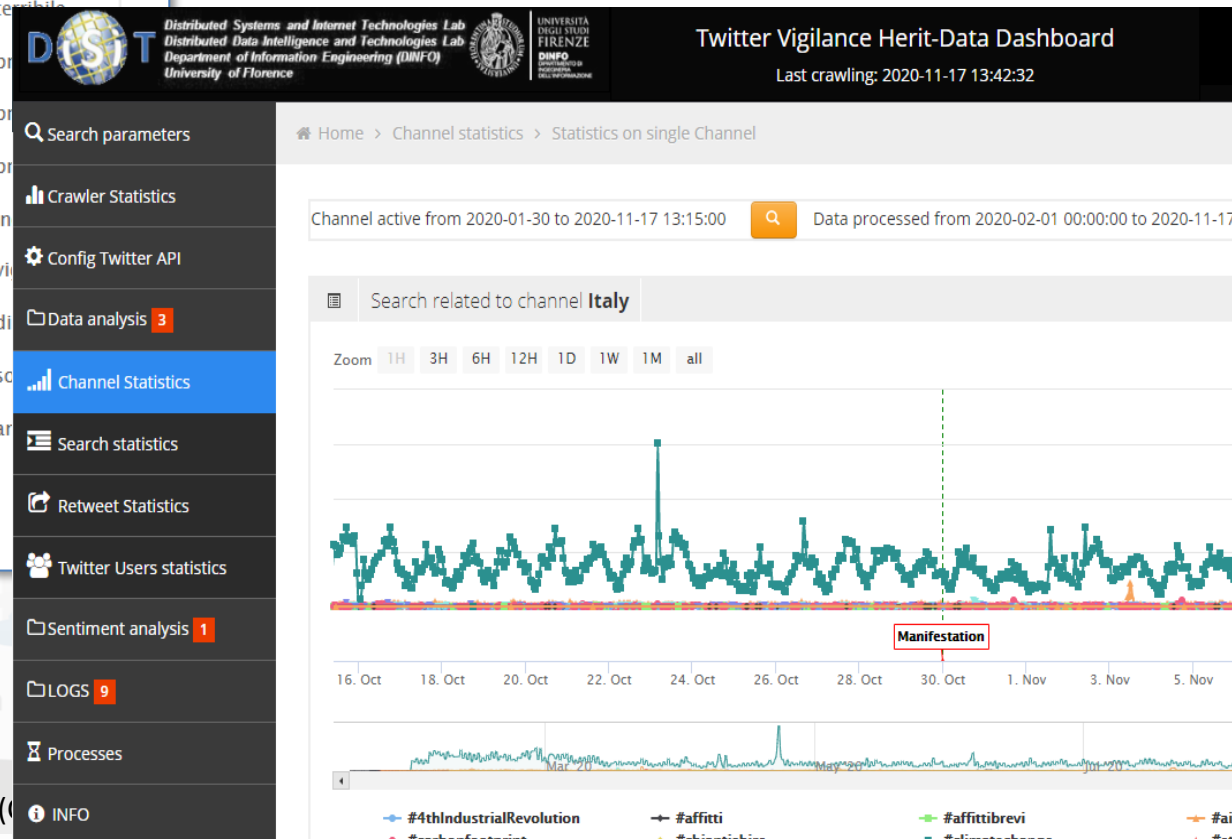
TV on Florence

#4thIndustrialRevolution #affitti #affittibrevi #airbnb
#airbnbfication #carbonfootprint #chiantishire #climatechange
#ethicaltourism #fairbnb #gentrification #gentrificazione
#grandinavi #greentourism #home-sharing #iperturismo
#locazioni #locazionituristiche #marketingTerritoriale #Outlet
#overtourism #responsibletravel #sharingEconomy
#socialtourism #SustainableDevelopmentGoals
#sustainabletourism #Tourism4SDGs #turismoEnogastronomico
#turismoEsperenziale #turismoetico #turismoSmart
#turismosostenibile #turismoverde #voluntourism

Interreg Mediterranean HERIT-DATA

Twitter Vigilance





Event: clashes between police and demonstrators in Florence, during an unauthorized demonstration against the restrictions of Covid-19 government measures (on 30th October 2020 night).

Italy: Protests flare in Florence over restrictions

31 Oct, 2020

Facebook Twitter Mi piace 655 Tweet

Florence mayor condemns violence and vandalism in historic centre in "surreal, terrible and painful night" for Tuscan city.

Protesters clashed with police in central Florence last night during an unauthorised protest over Italy's latest restrictions aimed at curbing the spread of covid-19.

In partnership with la Repubblica FIRENZE.it

Oct. 30 Protest Devastates Florence

10/31/2020

During the unauthorized evening demonstration against recent social lockdown pandemic measures lasting four hours in downtown Florence on the evening of October 30 saw

TOP NEWS STORIES

Oct. 30 Protest Devastates Florence
During the unauthorized evening demonstration against recent social lockdown pandemic measures lasting four hours in downtown Florence [...]

COVID Demonstrations Hit Florence
Unlike the U.S. protesters in Italy reserve public space for peaceful demonstrations which are organized to communicate a [...]

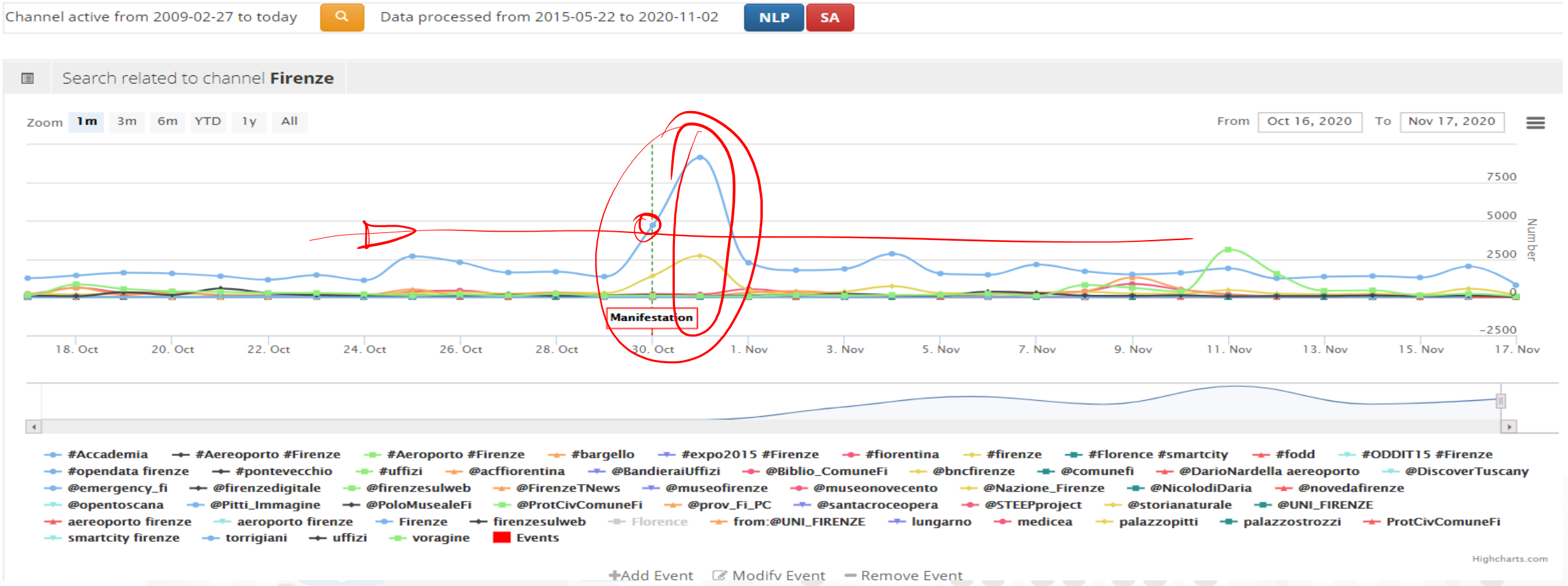
New Anti-Covid Regulations: Dos & Dont's
Given the upswing in Coronavirus infections and consequent hospital admissions since the beginning of October, Italian Prime Minister [...]

New Pandemic Regulations in Italy
In the face of the rise of Coronavirus infections, the Italian government has extended the national state [...]

LA COMPAGNIA
Original Language Movies
International Film Festivals

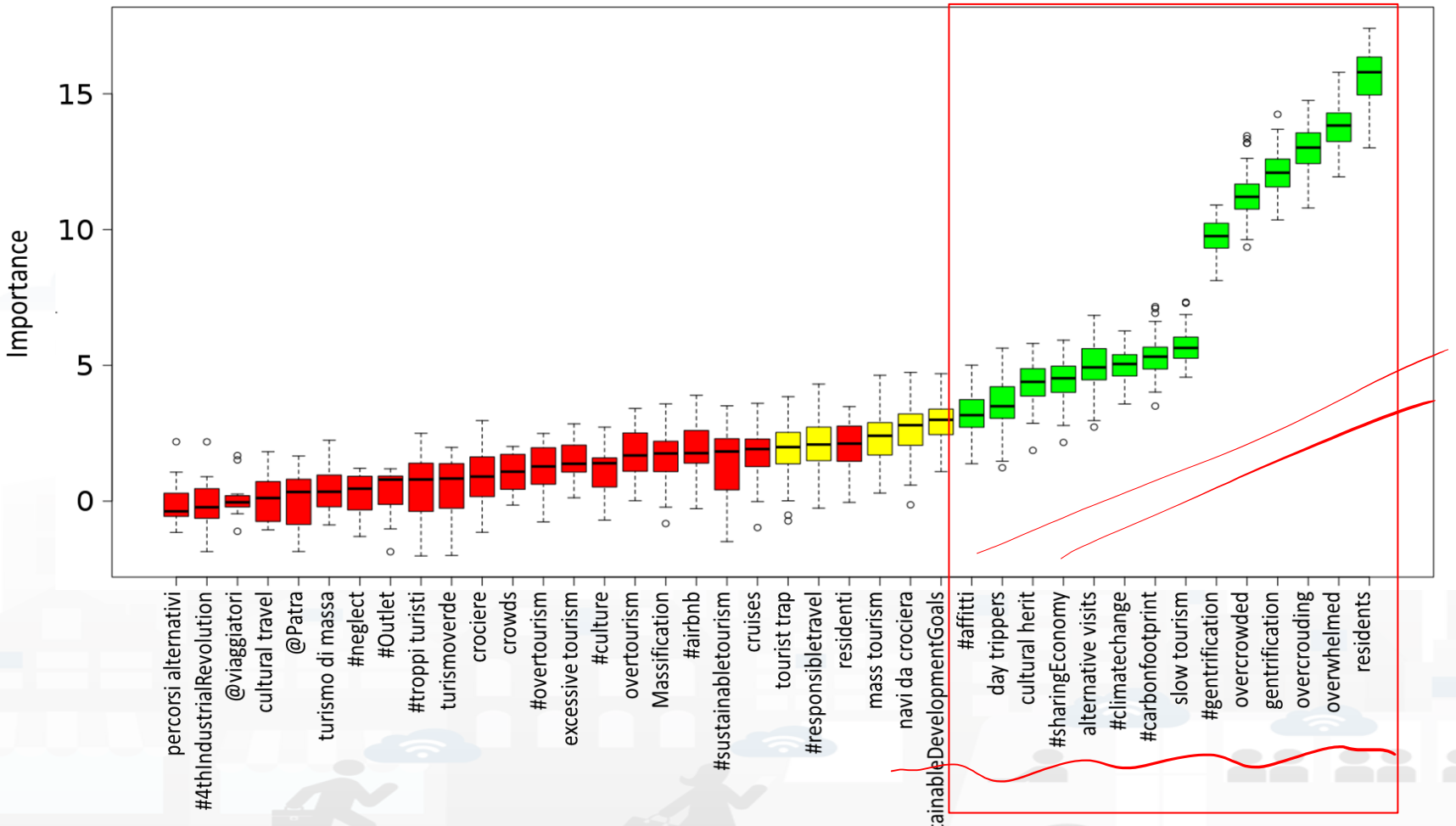
ORCHESTRA DELLA TOSCANA

30 October Manifestation



Twitter Vigilance

Relevant Feature Selection - Italy



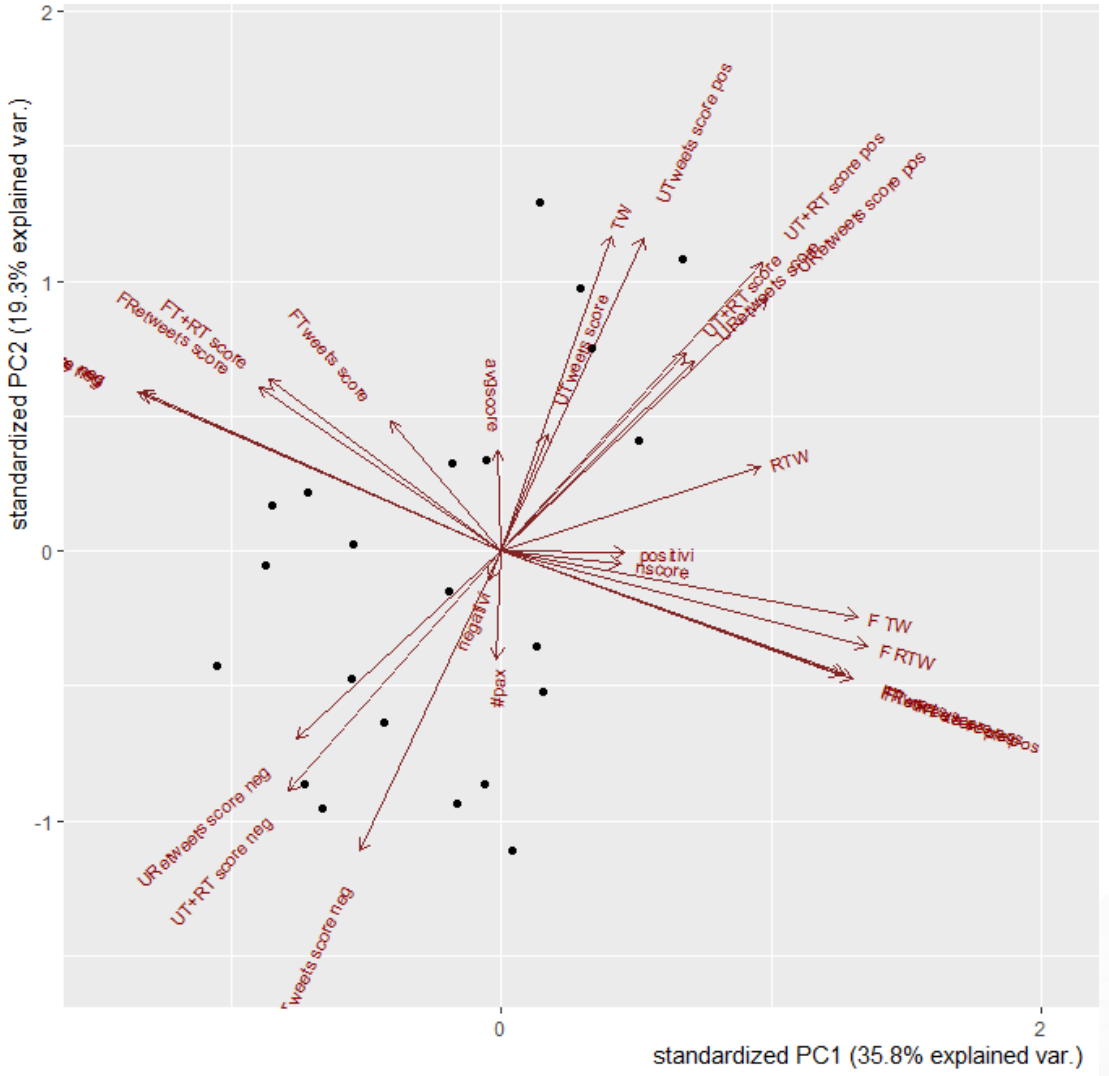
Random Forest Model Results expoiting the *confirmed* keys:

- Accuracy = 0.90
- Kappa index = 0.81

Twitter Vigilance

Reputation

- Prediction/estimation of **Average Score of Trip Advisor** as a function of *Twitter Vigilance Metrics + other information*
- Prediction/estimation of **Negative Scores on specific Museum** or service as a function *of Twitter Vigilance Metrics + other information*



Twitter Vigilance

Environmental

Available DATA ANALYTICS (3)

- **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

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 ($PM_{2.5}$)	0-10	10-20	20-25	25-50	50-800
Particles less than 10 µm (PM_{10})	0-20	20-35	35-50	50-100	100-1200
Nitrogen dioxide (NO_2)	0-40	40-100	100-200	200-400	400-1000
Ozone (O_3)	0-80	80-120	120-180	180-240	240-600
Sulphur dioxide (SO_2)	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.**

Common Air Quality Index **CAQI**

http://www.airqualitynow.eu

Qualitative name	Index or sub-index	Pollutant (hourly) density in µg/m³			
		NO_2	PM_{10}	O_3	$PM_{2.5}$(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

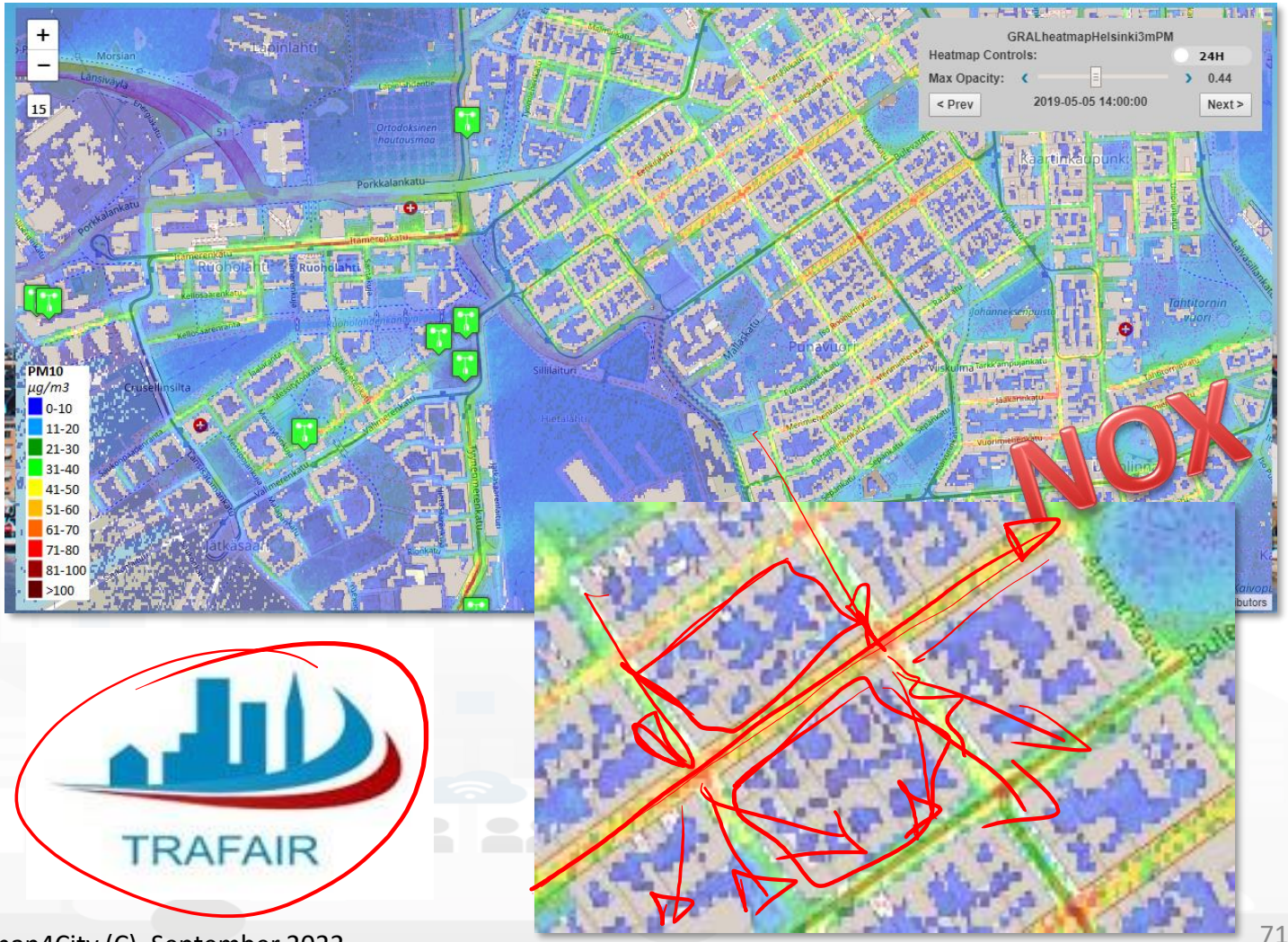
The index is defined away from roads (a "background" index). **CAQI** is computed on the basis of **NO_2, $PM_{2,5}$, PM_{10}** and **O_3**.

Legend of Environmental data:

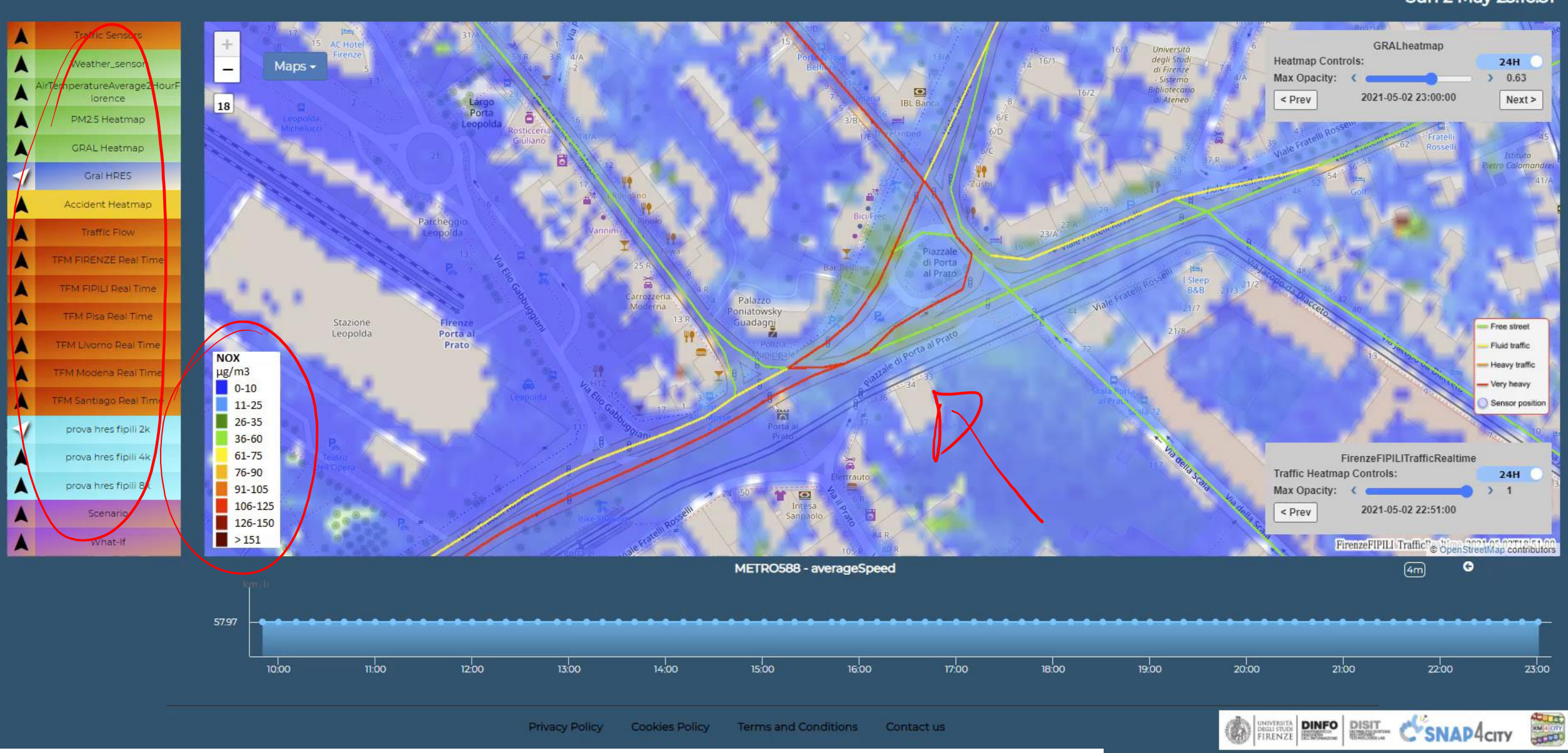
https://www.snap4city.org/435

NOX and PM10 prediction particles flows

- **GRAL predictions: PM10, NOX, ….**
  - **Comparison wrt real time values in actual value of Sensors**
  - Graz Lagrangian Model.
- GRAL model takes into account:
  - pollution sources (for example the vehicles, their distribution on the streets, the about of pollution they produce according to their distribution over time and space, etc.),
  - structure of the city (streets and shape 3D of the buildings),
  - weather forecast (wind intensity and direction), etc.
- GRAL can be applied on NOX, PM10, PM2.5, … or any other particles



Traffic Flow Manager on multiple cities



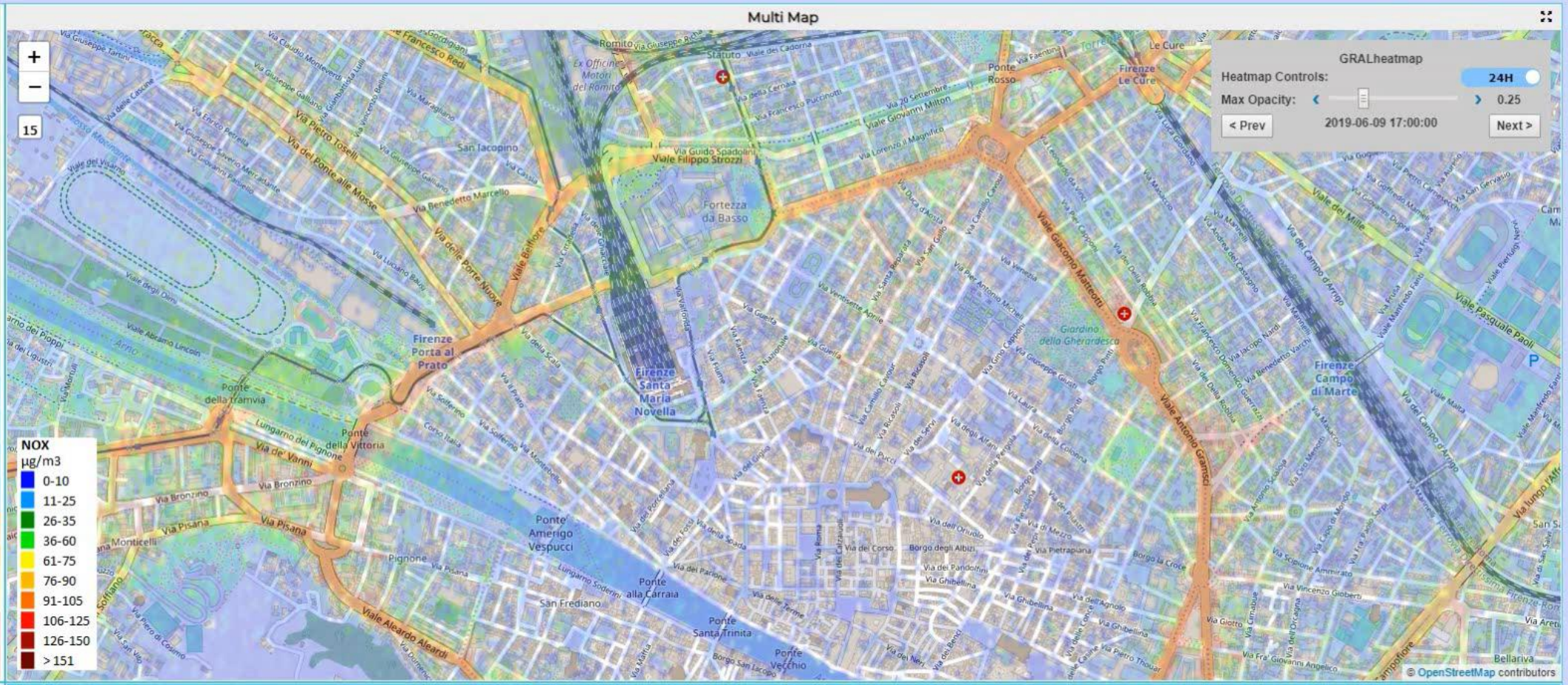
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzEyNg==

Firenze - Trafair - AirQuality Heatmaps

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

Sun 9 Jun 17:41:58

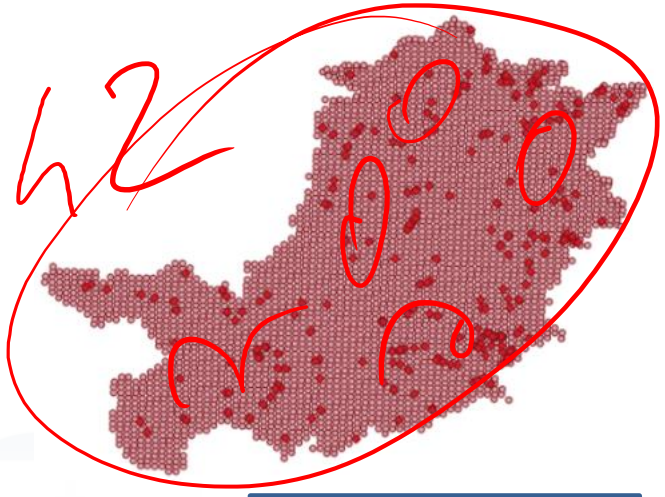
- Air Quality Sensors
- PM10 Heatmap
- PM2.5 Heatmap
- CO Heatmap
- CO2 Heatmap
- SO2 Heatmap
- O3 Heatmap
- NO2 Heatmap
- Benzene Heatmap
- H2S Heatmap
- Air Humidity Heatmap
- Air Temp. Heatmap
- Wind Speed Heatmap
- Gral Pred. HM NOX (3m)
- Gral Pred. HM NOX (6m)
- Traffic Sensors
- Traffic Flow
- Cycling Paths
- Accident Heatmap
- Accident Heatmap 2

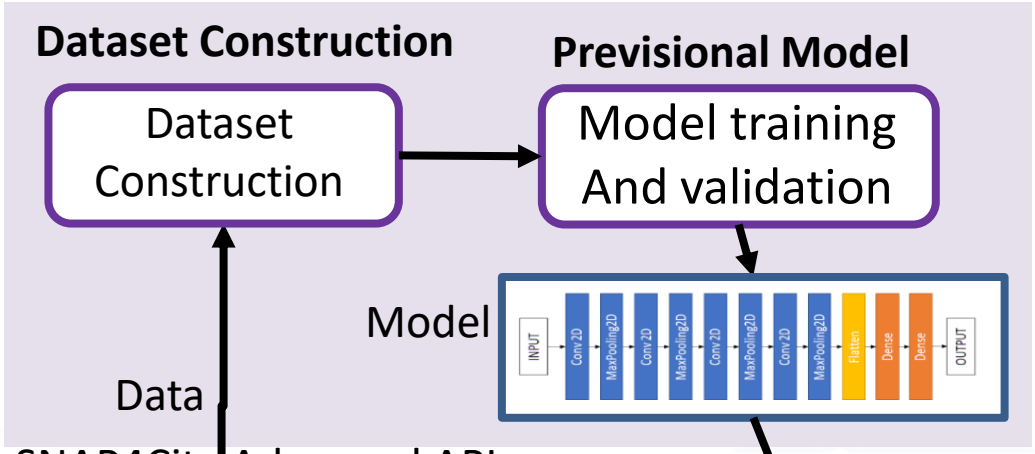


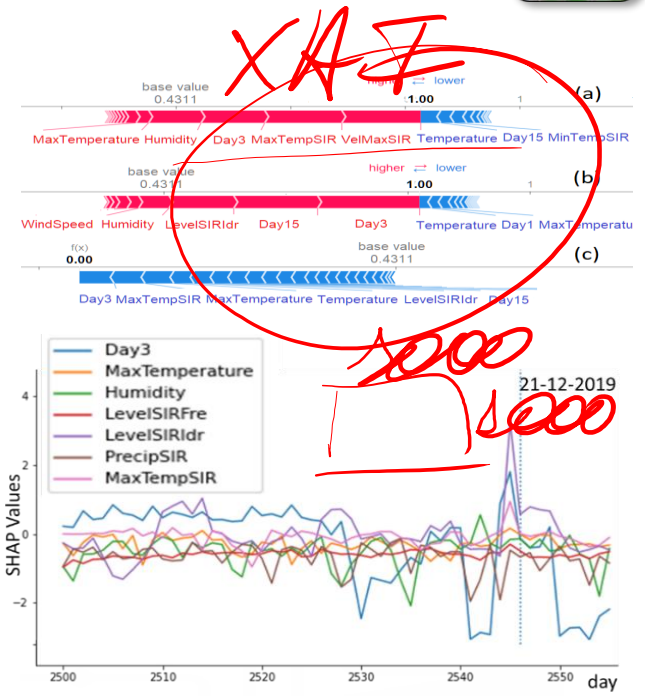
Air Temperature Bolognese 7m

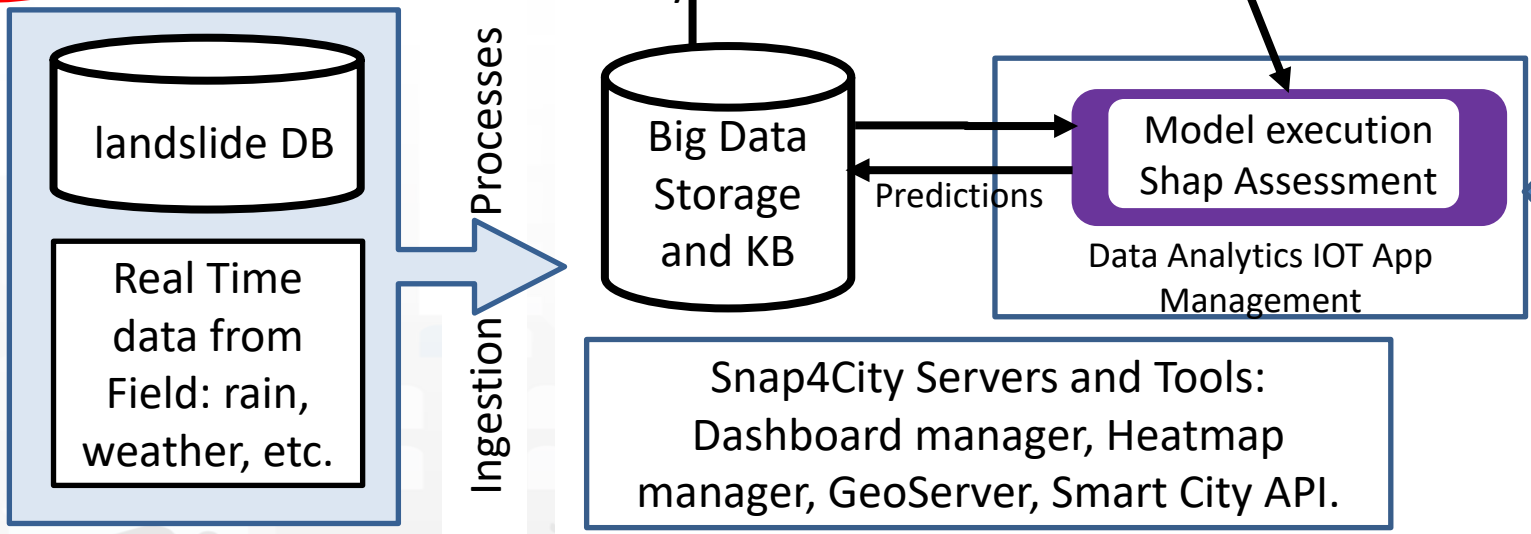
SIRSensor_TOS01001095 - airTemperature 7m

Predicting Land slides



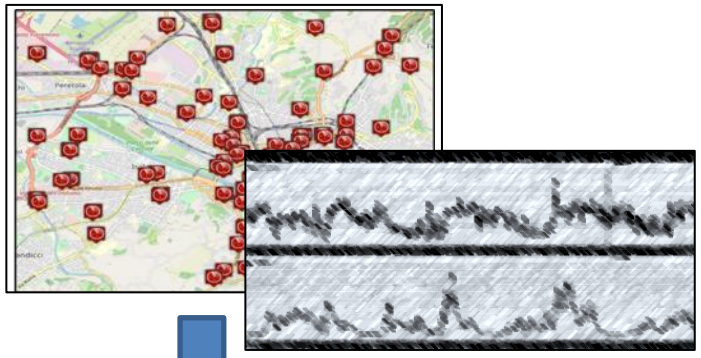






E. Collini, L. A. I. Palesi, P. Nesi, G. Pantaleo, N. Nocentini and A. Rosi, "Predicting and Understanding Landslide Events with Explainable AI," in *IEEE Access*, doi: 10.1109/ACCESS.2022.3158328.
https://ieeexplore.ieee.org/abstract/document/9732490

Estimating City Local CO2 from Traffic Flow Data



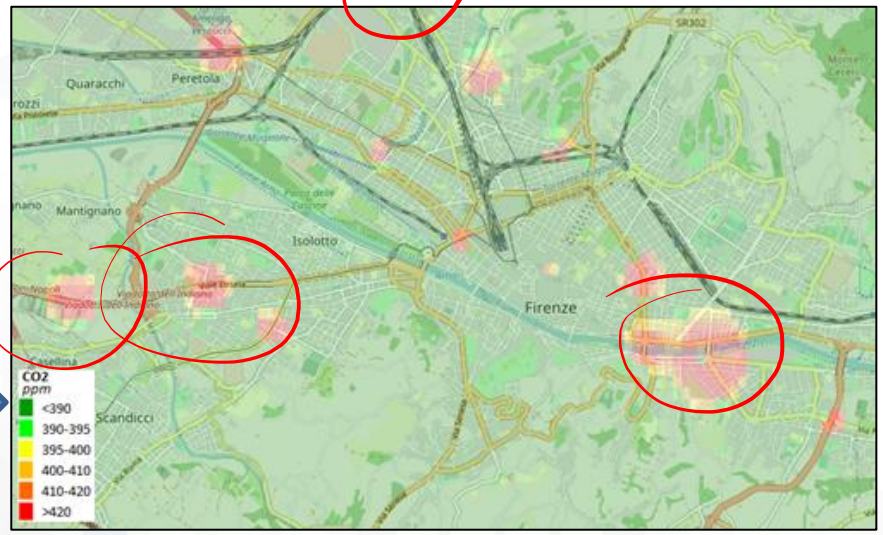
Computing Traffic Flow into CO2 sensor area

Traffic Flow data

- Traffic Flow is one the main source of CO2
- **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

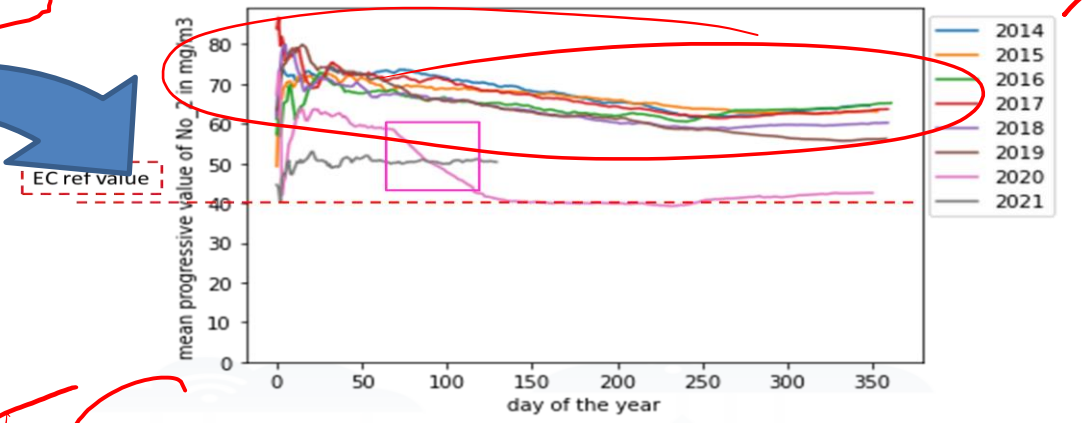
Detailed CO2 estimation



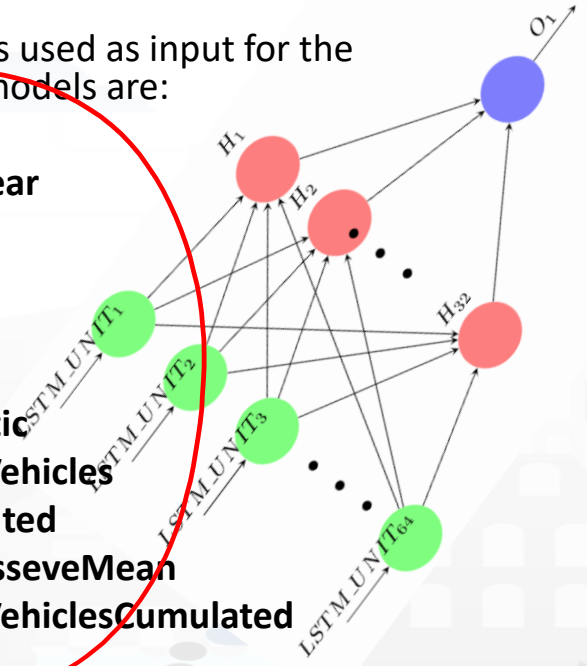
S. Bilotta, P. Nesi, "Estimating CO2 Emissions from IoT Traffic Flow Sensors and Reconstruction", Sensors, MDPI, 2022. https://www.mdpi.com/1424-8220/22/9/3382/

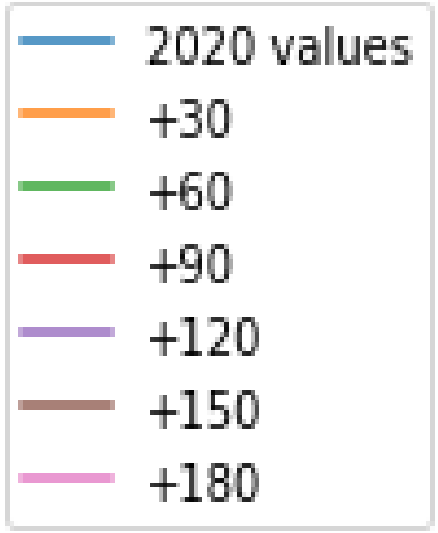
Predicting EC's KPI on NO2 months in advance

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**





EC

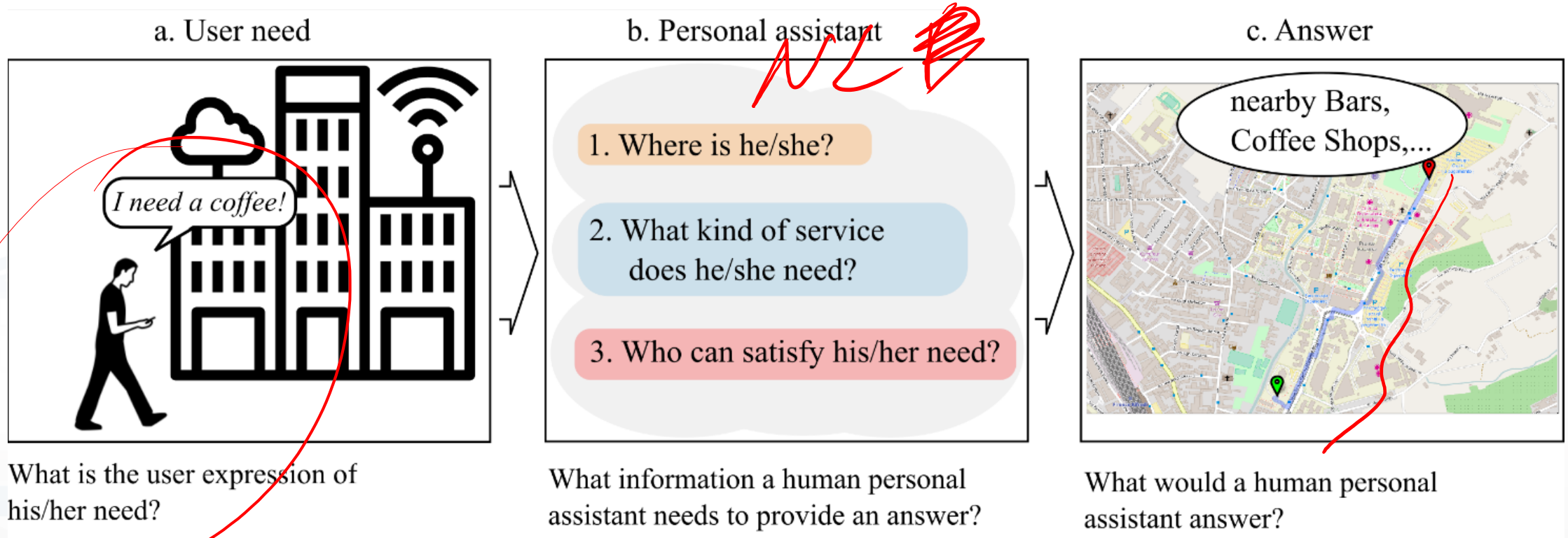
	Air Quality Directive			WHO guidelines	
Pollutant	**Averaging period**	**Objective and legal nature and concentration**	**Comments**	**Concentration**	**Comments**
$PM_{2.5}$	One day			25 µg/m³ (*)	99th percentile (3 days/year)
$PM_{2.5}$	Calendar year	Target value, 25 µg/m³	The target value has become a limit value since 1 January 2015	10 µg/m³	
PM_{10}	One day	Limit value, 50 µg/m³	Not to be exceeded on more than 35 days per year.	50 µg/m³ (*)	99th percentile (3 days/year)
PM_{10}	Calendar year	Limit value, 40 µg/m³ (*)		20 µg/m³	
O_3	Maximum daily 8-hour mean	Target value, 120 µg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³	
NO_2	One hour	Limit value, 200 µg/m³ (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m³ (*)	
NO_2	Calendar year	Limit value, 40 µg/m³		40 µg/m³	

Semantic reasoning, NLP

Available DATA ANALYTICS (4)

- **Time Series**
  - Time Series Anomaly detection
  - **Data quality** assessment and control
  - short and long term **prediction**
  - **Interpolation** of Data on regular grid for calibrated heatmaps
- **Semantic Reasoning**
  - **Ontology Modelling** and integration, expert system construction
  - **Knowledge modelling** and reasoning on RDF stores: spatial, temporal, relational
  - Virtual Assistant for tourism guidance
- **Matrices, Images, Maps and 3D Digital Models**
  - Conversion of **Satellite data images** into regular ground images
  - **Extraction information** from **Orthomaps, LIDAR**, etc., regarding city structures
  - **3D Digital Twin** of Cities and Objects: pattern extraction, 3D model reconstruction

Location Aware Virtual Assistant



Massai, P. Nesi, G. Pantaleo, "PAVAL: A location-aware virtual personal assistant for re-trieving geolocated points of interest and location-based services", Journal Engineering Applications of Artificial Intelligence, Elsevier, https://www.sciencedirect.com/science/article/pii/S0952197618301994

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

SNAP4CITY | KM4CITY

PAVAL - Km4City Semantic Service Search

www.disit.org

Home

Query: ho voglia di un caffè in piazza del Duomo Submit

Lingua impostata: ITA

Query Results:

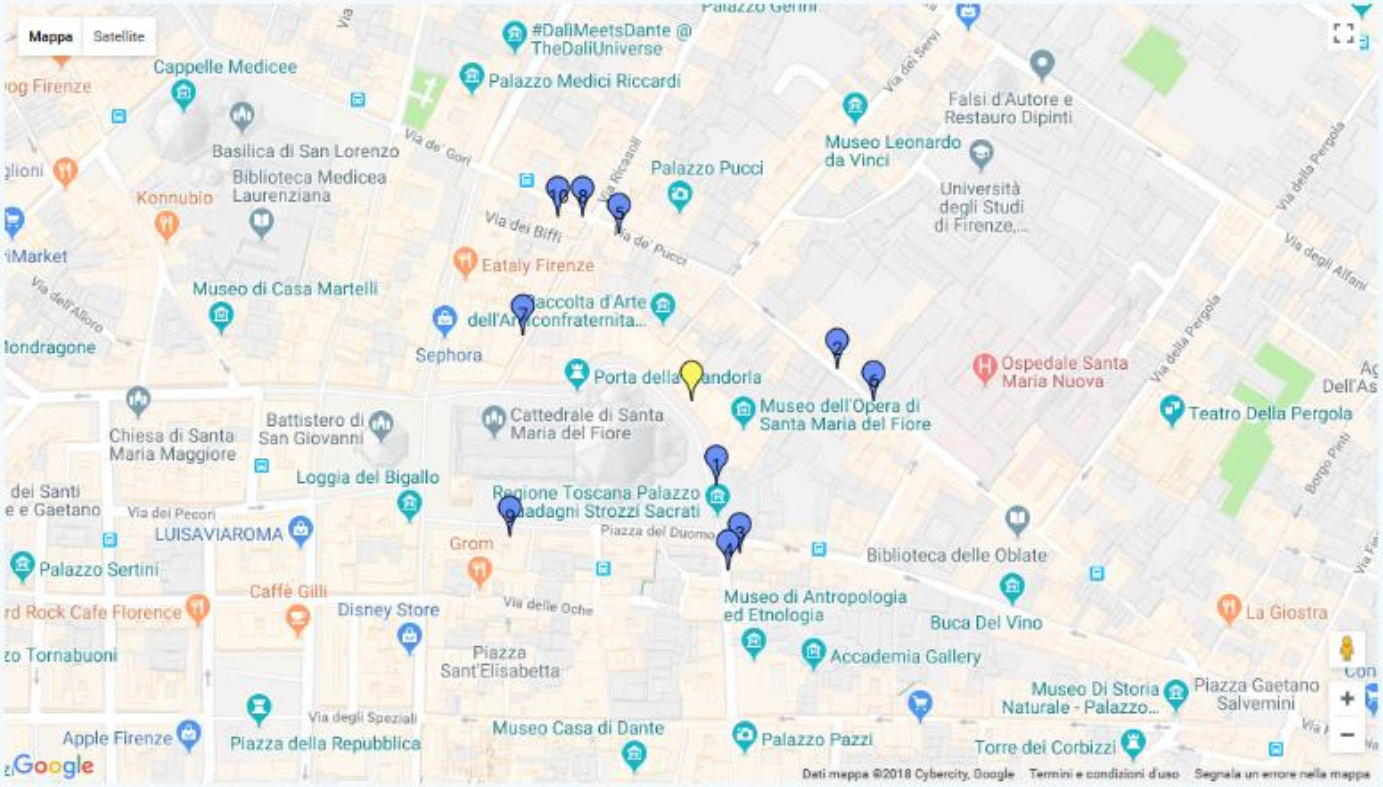
1.
Nome : [redacted]
Distanza : 0.0578798 Km
Indirizzo : PIAZZA DEL DUOMO
n° : [redacted]
CAP : 50122
Comune : FIRENZE
Prov : FIRENZE
Descrizione :
Settore : Bar

User Rating: ☆ ☆ ☆ ☆ ☆

2.
Nome : [redacted]
Distanza : 0.0988314 Km
Indirizzo : VIA MAURIZIO BUFALINI
n° : [redacted]
CAP : 50100
Comune : FIRENZE
Prov : FIRENZE
Descrizione :
Settore : Bar

User Rating: ☆ ☆ ☆ ☆ ☆

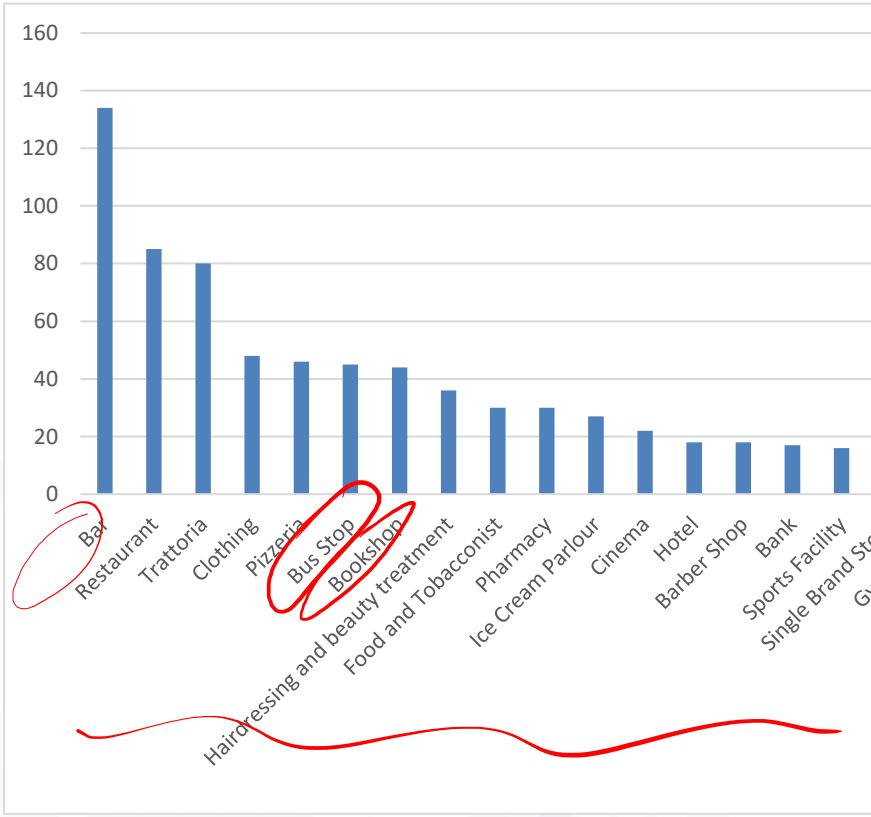
3.
Nome : [redacted]



Riferimento Geografico rilevato nella query: PIAZZA DEL DUOMO - LAT.: [redacted], LONG.: [redacted]
Dall'analisi della query risulta che sei interessato a trovare aziende e servizi relativi a: BAR nei dintorni della posizione rilevata.

Assessment

Class	Definition of the class	Tot.
Type 1	Direct request of a full or partial Km4City service category label. i.e. “I need a restaurant”, “Bed and breakfast around me”	25.60 %
Type 2	Direct request of the name of a precise local business i.e. “Take me to ‘Da Mario’”	2.93 %
Type 3	Queries not exhibiting the service name as the user need i.e. “I want to eat spaghetti”, “My stomach hurts”	74.40 %
Type 4	Presence of precise geographical reference i.e. “I need a restaurant in via dell’Oriuolo”, “Hotels in Piazza del Carmine”	35.12 %
Type 5	Presence of partial or misspelled geographical reference i.e. “Eat in Piazza del Dpomo”, “Bar near piazza P. Leopoldo”	16.32 %
Type 6	Presence of multiple geographical references i.e. “I want to read a newspaper near via Dante Alighieri in Pisa”	5.24 %
Type 7	Presence of geographical references i.e. “Find a place to eat near …”, “I want to drink something in via …”	59.16 %
Type 8	Queries inside Florence municipality i.e. “Museums near piazza della Signoria”	69.71 %
Type 9	GPS localization allowed i.e. Given authorization from the browser: “I need a restaurant nearby”	100 %
Type 10	Not transactional queries i.e. “When did Garibaldi die?”, “Find a video on YouTube”	2.31 %



ITA

Personal Assistant	Precision	Recall	F-Measure
Paval	79.28%	99.61%	88.74%
Google Assistant	77.74%	28.34%	40.75%
Apple Siri	60.07%	64.42%	62.29%
Microsoft Cortana	63.51%	14.43%	22.92%

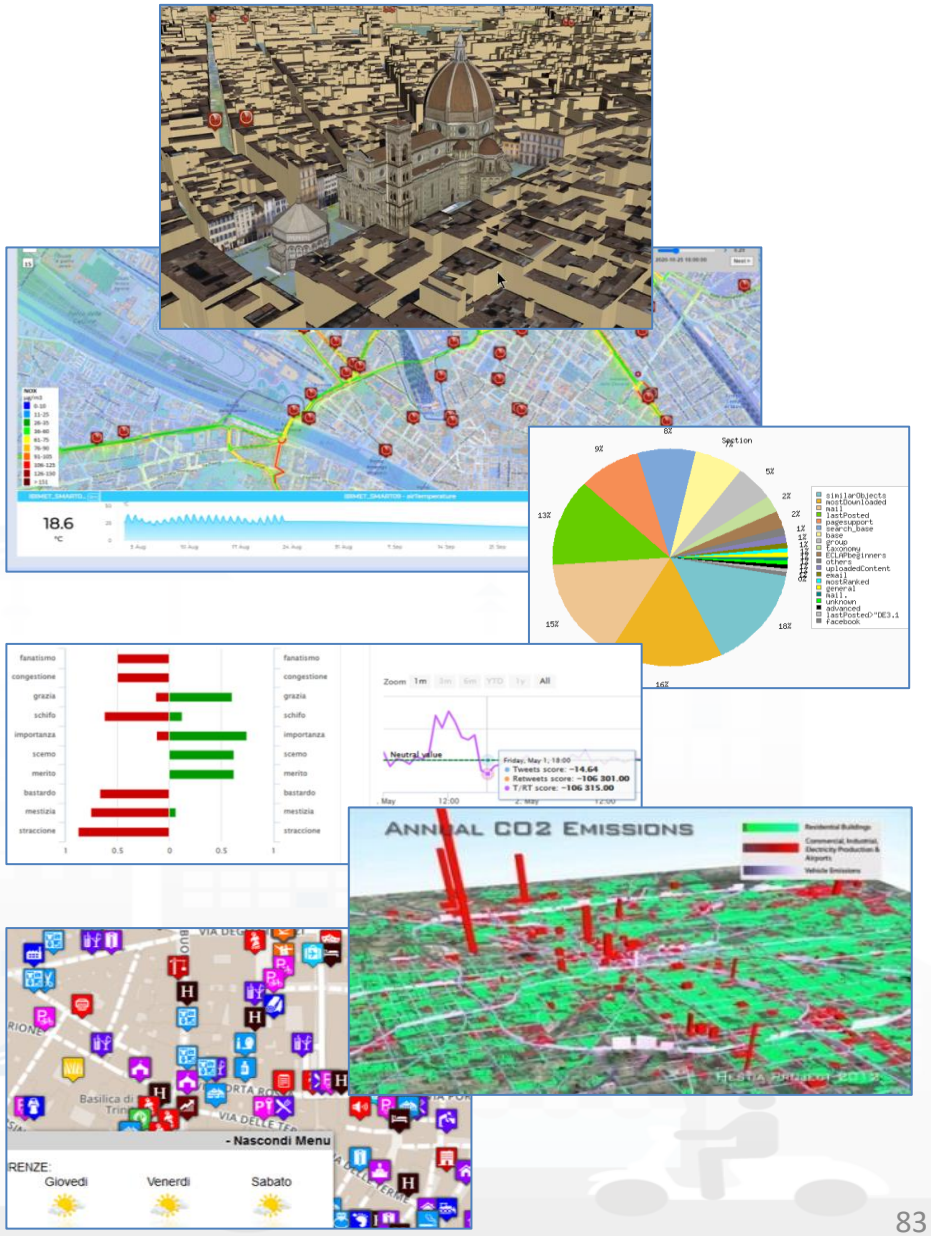
ENG

Personal Assistant	Precision	Recall	F-Measure
Paval	74.67%	96.24%	84.57%
Google Assistant	75.24%	48.92%	58.77%
Apple Siri	72.28%	70.65%	71.45%
Microsoft Cortana	66.81%	27.53%	38.36%

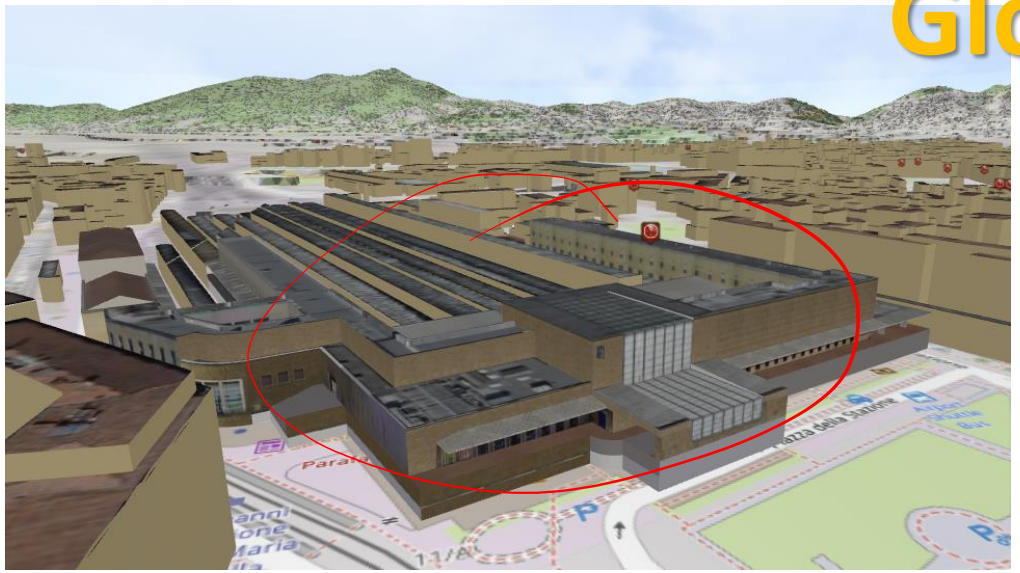
Digital Twin Construction

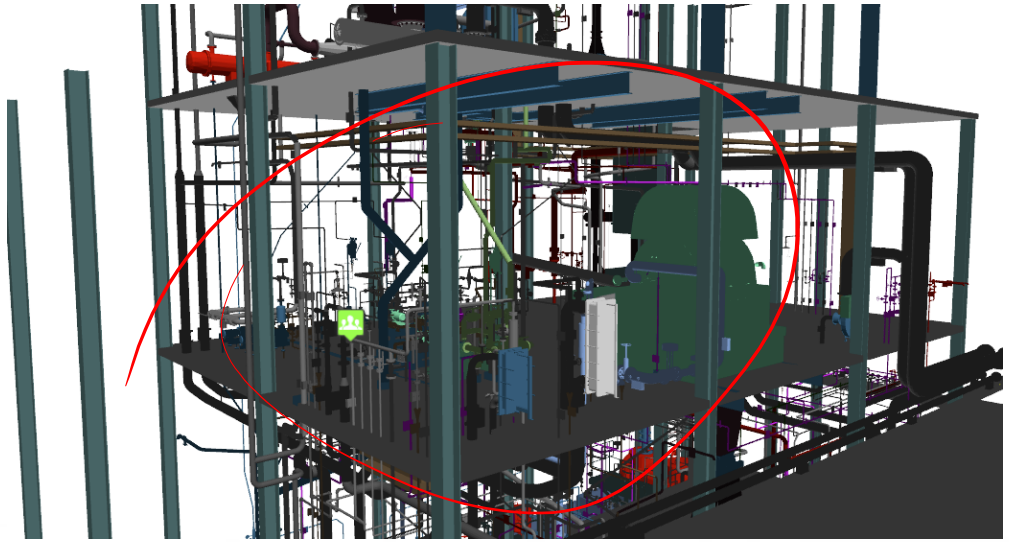
Digital Twin

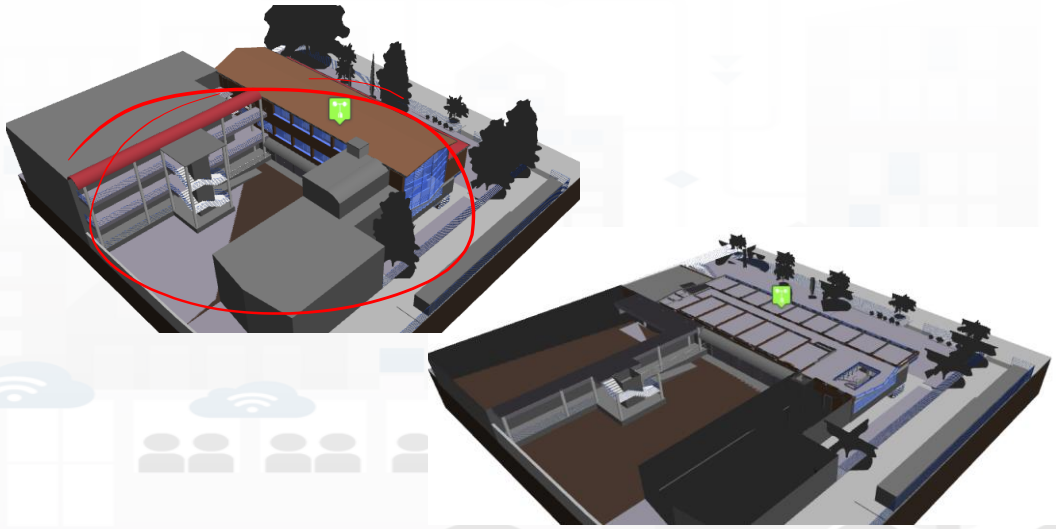
- **Digital Twin**
  - **Connected** with real physical systems
  - **Modelling aspects**: structural, visual, informative, real time data sensors (context), POI, functional, resource managements, etc.
  - **Integration of** AI/XAI techniques with simulations and modelling
- **Easier to understand the 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



Digital Twin
Global vs Local





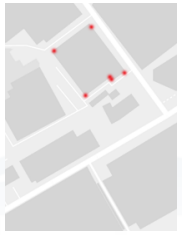


3D City Construction

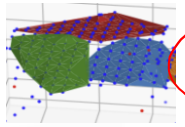
Multiple images from several points of views

Raw Facades pictures

GIS orthomap


GIS Building plant shapes and positions

Building heights (at the eaves)


Lidar Data

Sky Pattern

Terrain (DTM)

Heatmaps, Traffic flow, Pins, IOT, POI, RT data, ...

Events on back office

3D design of High Value Buildings, HVB

Facades patterns extraction

Roof patterns extraction

Create 3D building with flat roofs (by extrusion)

Create 3D buildings with 3D roofs' shapes

Integrated view of HVB + building with roofs and facades

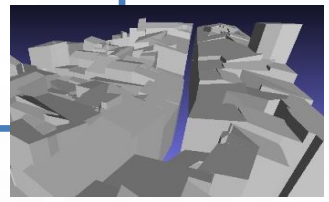
Generate 3D city representation

3D City Digital Twin on Dash

HVB model with patterns

Facades' patterns

Roof patterns



Create 3D building with photorealistic texture

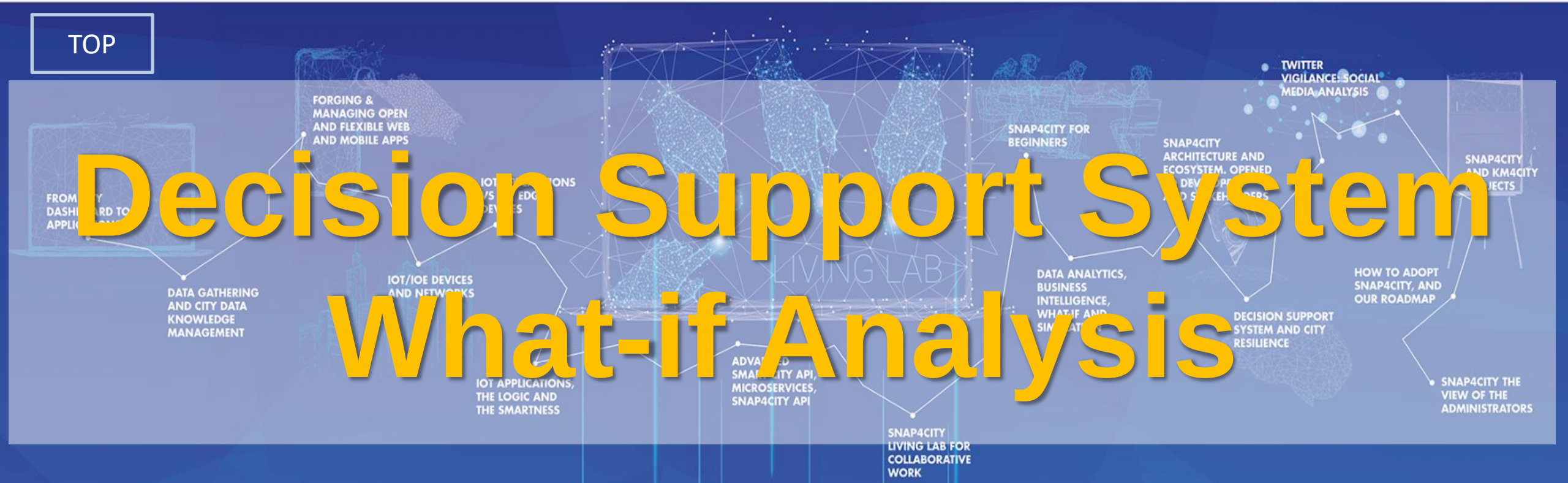
3D buildings with roof and facade patterns

Extruded building with picking functionality

Orientation, Position, Light, zoom, view point, etc.

TOP

Decision Support System
What-if Analysis

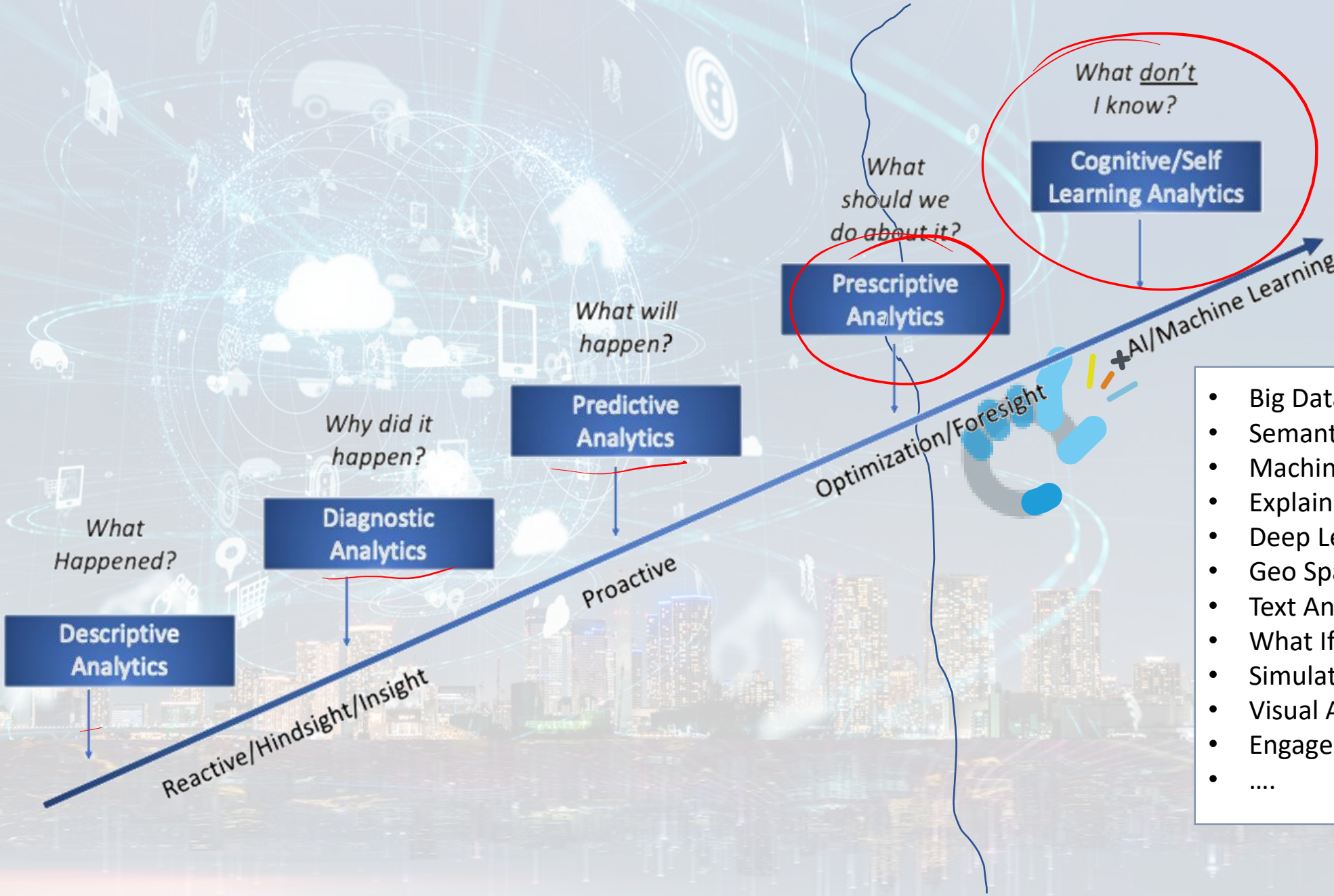


100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

Available DATA ANALYTICS (5)

- **Management and strategies**
  - What-if analysis, dynamic routing, origin destination matrices production from a large range of sources
  - Early warning computation
  - Estimation of KPI and local indexes for: quality of life (15MinCityIndex)
  - Production Optimization
  - Planning and Monitoring renovation works via objective KPIs
  - Managing Maintenance and teams
  - Predictive Maintenance and costs predictions: chemical plant, vehicles, boats
- **Resilience and Risks Analysis**
  - Resilience analysis wrt European Guidelines on Resilience of critical infrastructure, and transport systems
  - Risk analysis: natural and non natural disaster



Sentient and active processes

- Big Data Analytics
- Semantic Computing
- Machine Learning
- Explainable Artificial Intelligence
- Deep Learning
- Geo Spatial Reasoning
- Text Analysis, Sentiment Analysis
- What If Analysis
- Simulations
- Visual Analytics
- Engagement Analysis
- ….

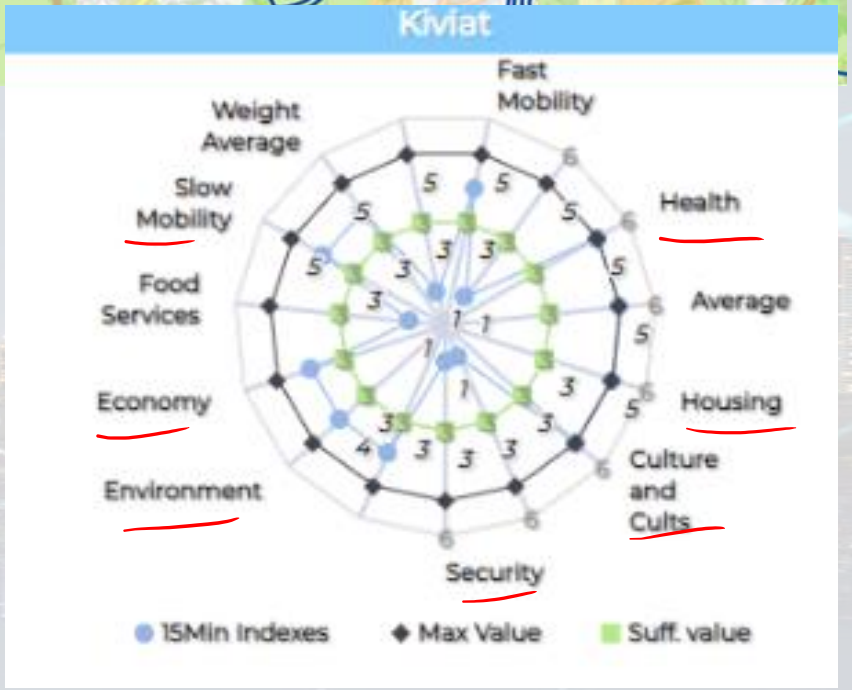
15MinCityIndex

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.

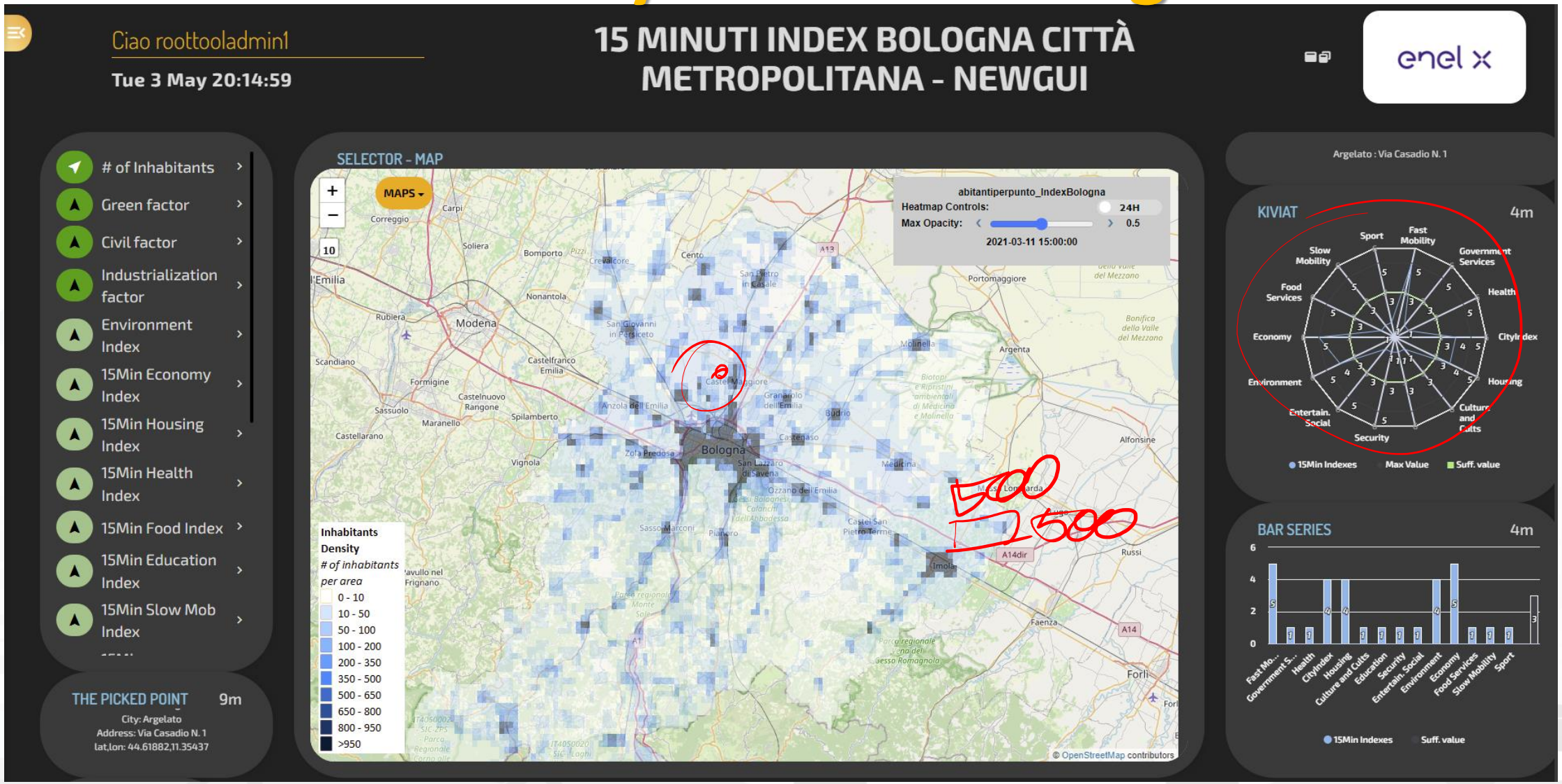
The tool supports the becoming of a 15-Minute city evaluating the service level in various domains.



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==

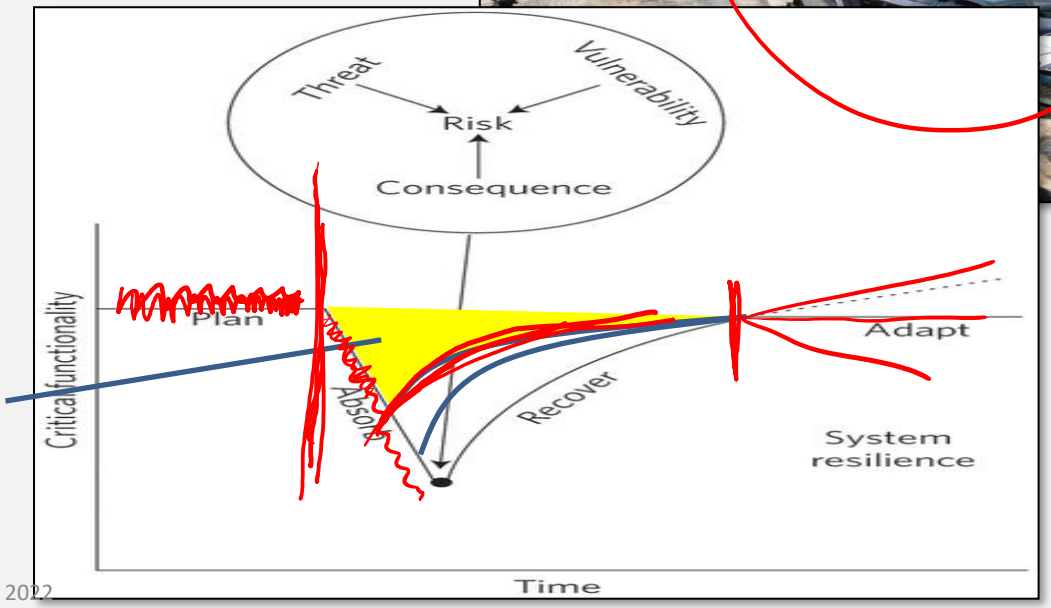
Early warning, detection

resolute

City Resilience

- **Issue:**
  - **Detection of critical condition**
  - **Not easily detected with other means**
- **Impact:**
  - **Early warning, faster reaction**
  - **Increased resilience**
- **Several metrics related to**
  - **Volume of retweets**
  - **Sentiment analysis**

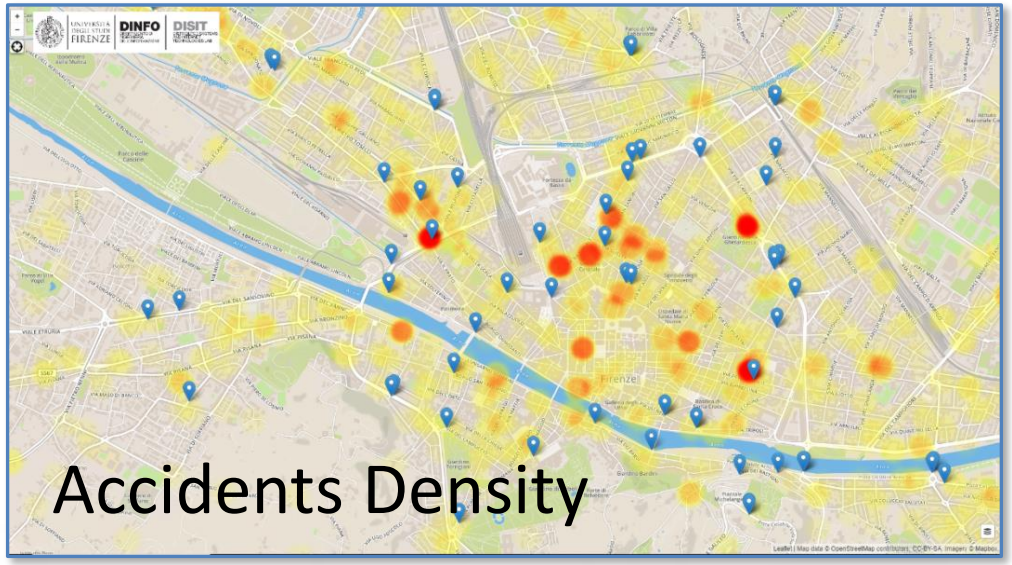
Prepare
Absorb
Recover
Adapt

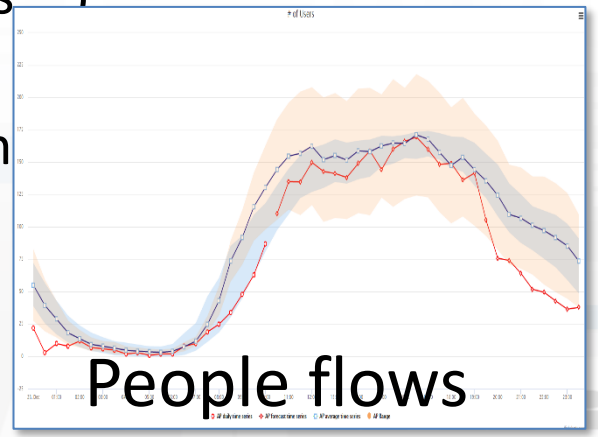


damage

Anomaly Detections

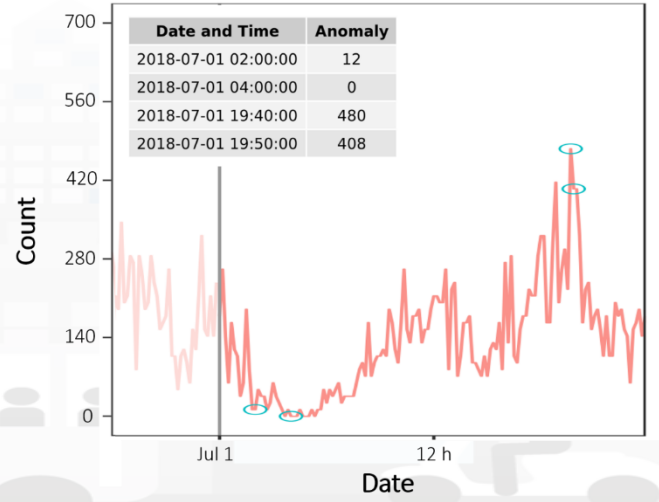
- About the IoT Devices status
  - Eventual problems on IoT Devices, connections, etc.
- About People Flows and Density
  - Early warning of the ineption of critical events
- About traffic flow
  - Early warning on eventual incidents, or on the inception of critical conditions on the traffic (e.g., a reduction in viability, a broken bus)
- About….
  - Early warning, early detection of problem
- Recurrence analysis
- Causal Analysis





METRO 705

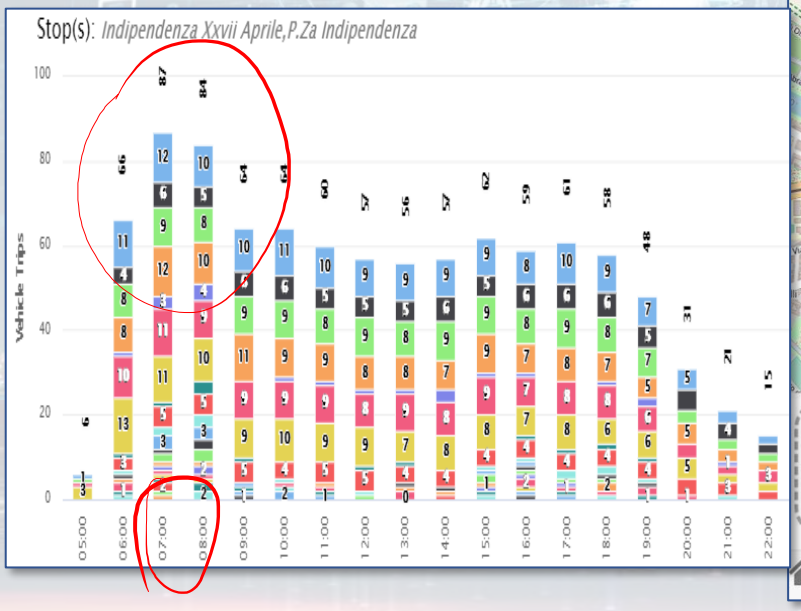
Date and Time	Anomaly
2018-07-01 02:00:00	12
2018-07-01 04:00:00	0
2018-07-01 19:40:00	480
2018-07-01 19:50:00	408

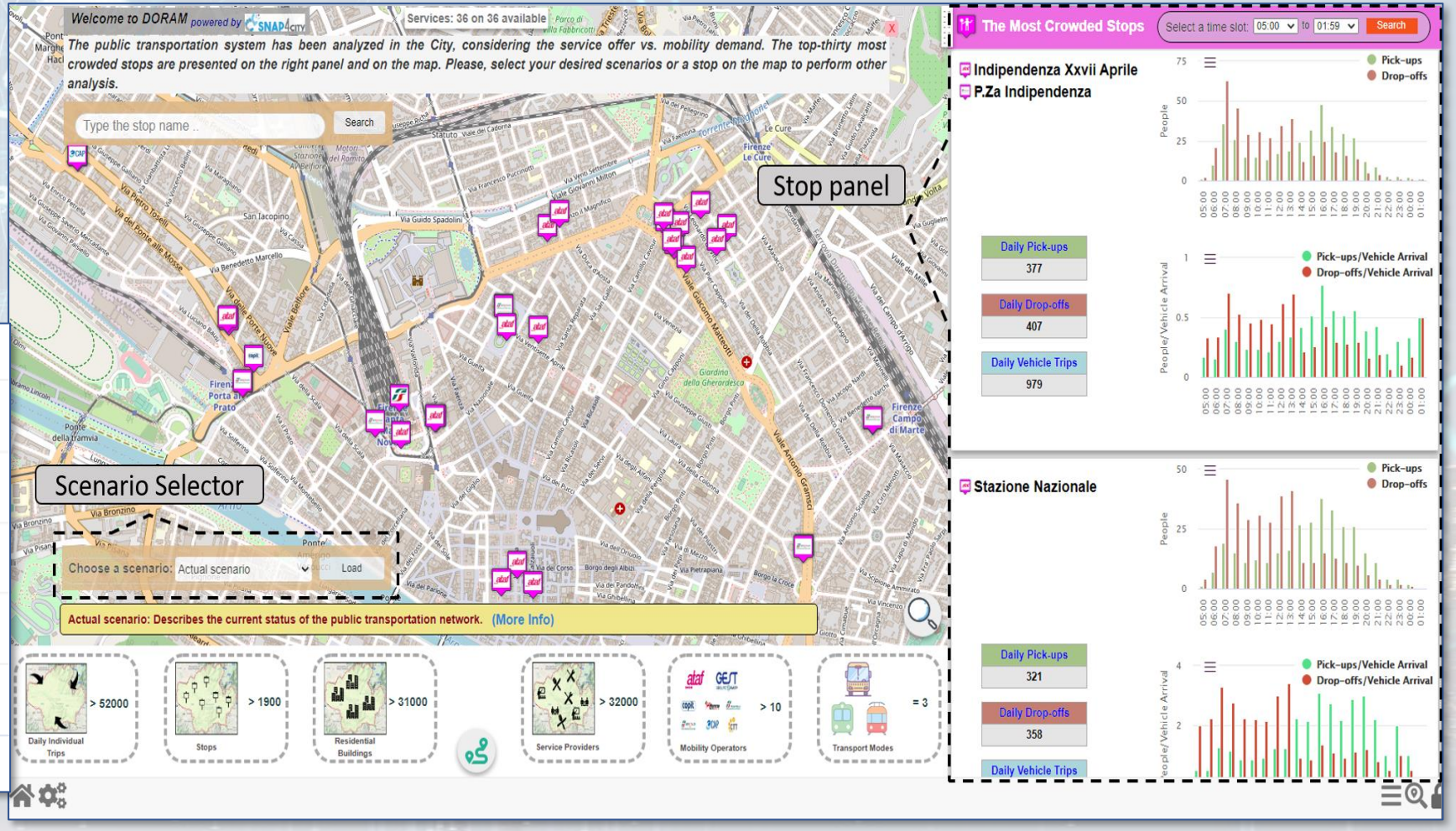


What-if Analysis on Pub Transport

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

Public Services





DORAM

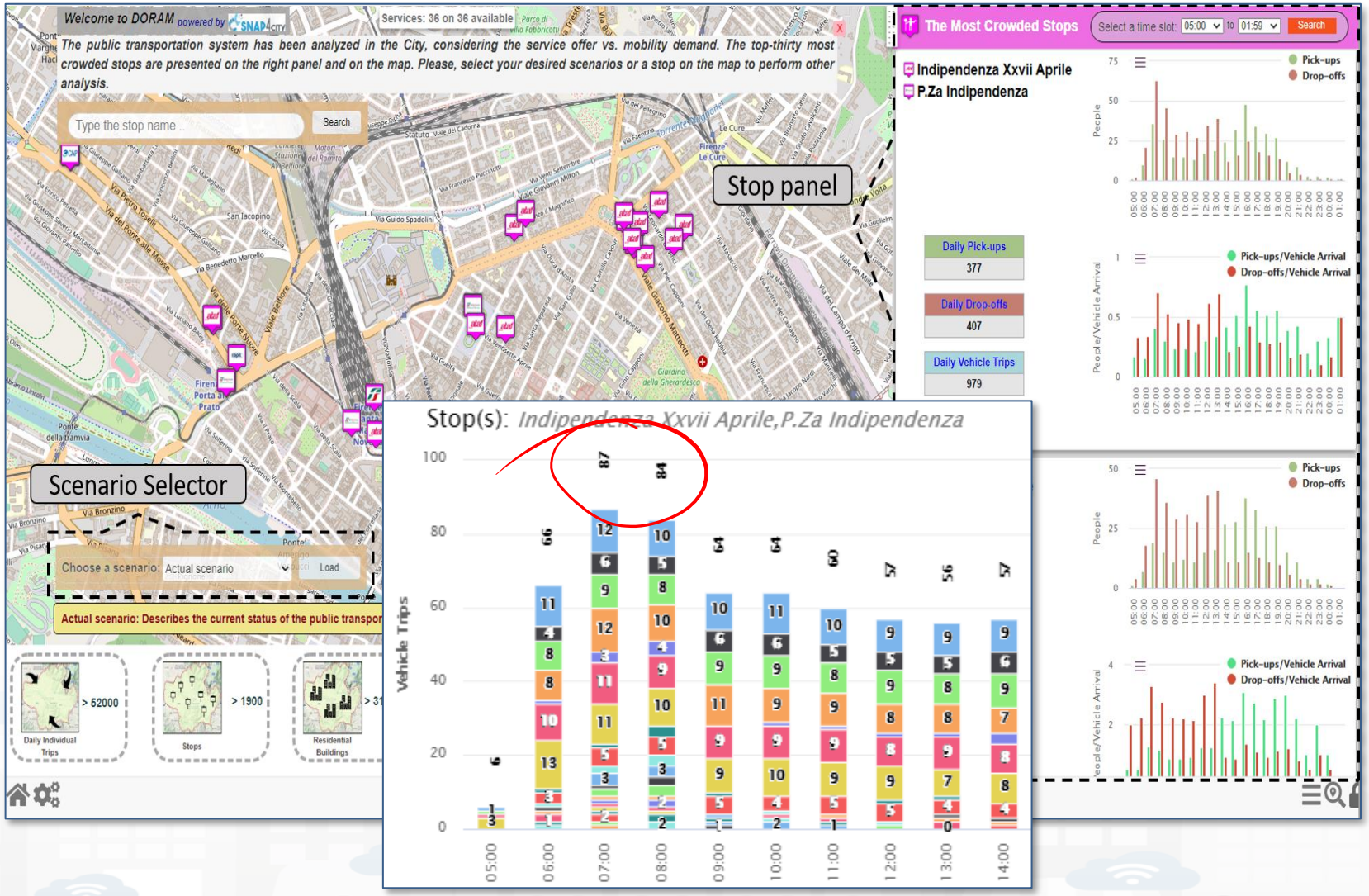
Analysis of

- **Demand** of Mobility
  - Via OD matrices
  - POI, city structure, etc.

With respect to

- **Offert** of Transportation:
  - Public services
  - Private services
  - Multiple agencies
  - GTFS

Critical Busses, bus-stops, paths, rides, etc.

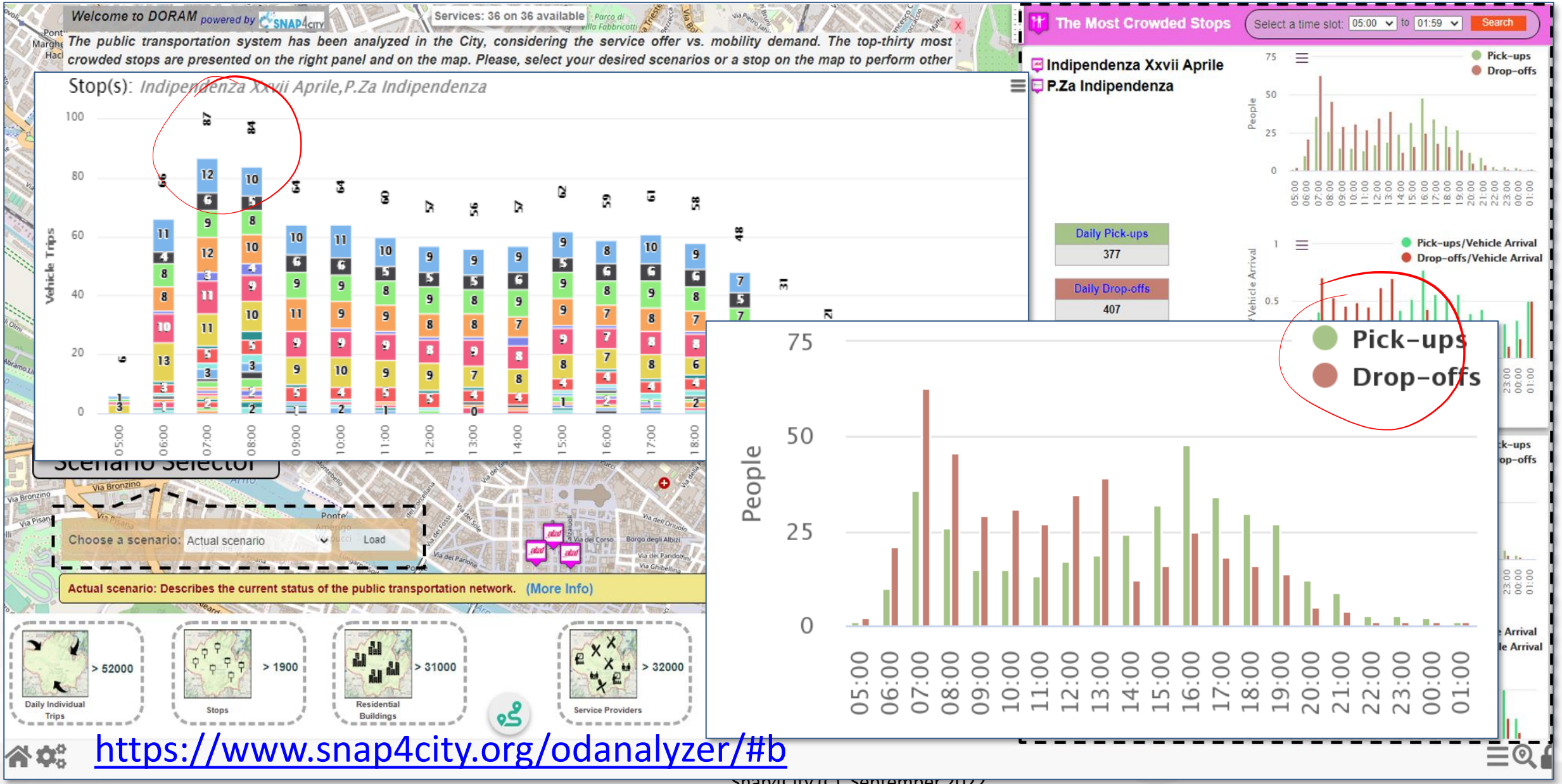


https://www.snap4city.org/odanalyzer/#b

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

DORAM

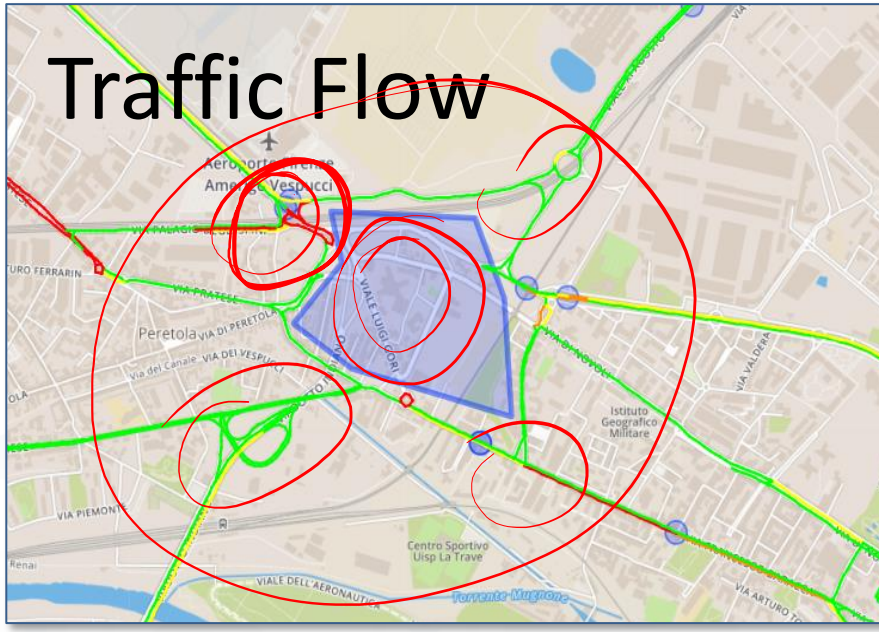
SNAP4CITY | KM 4 CITY

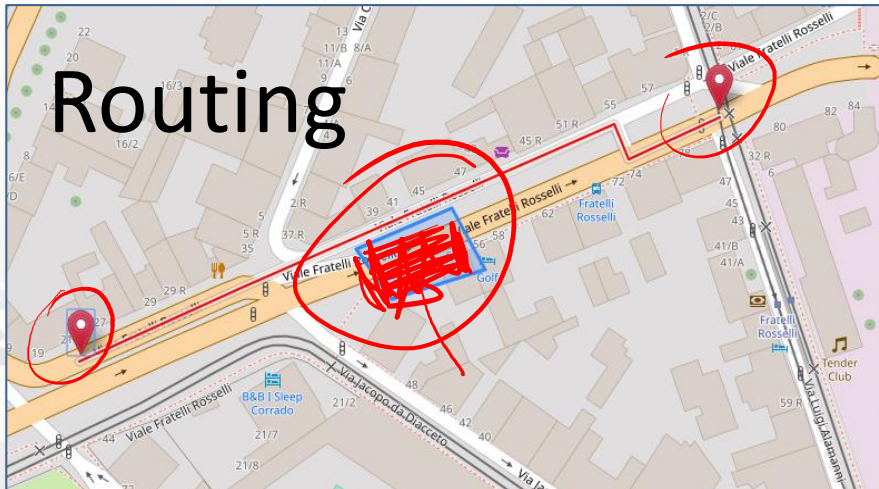


https://www.snap4city.org/odanalyzer/#b

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





Early Warning, Detection

Issue:

- Detection of critical condition
- Not easily detected with other means

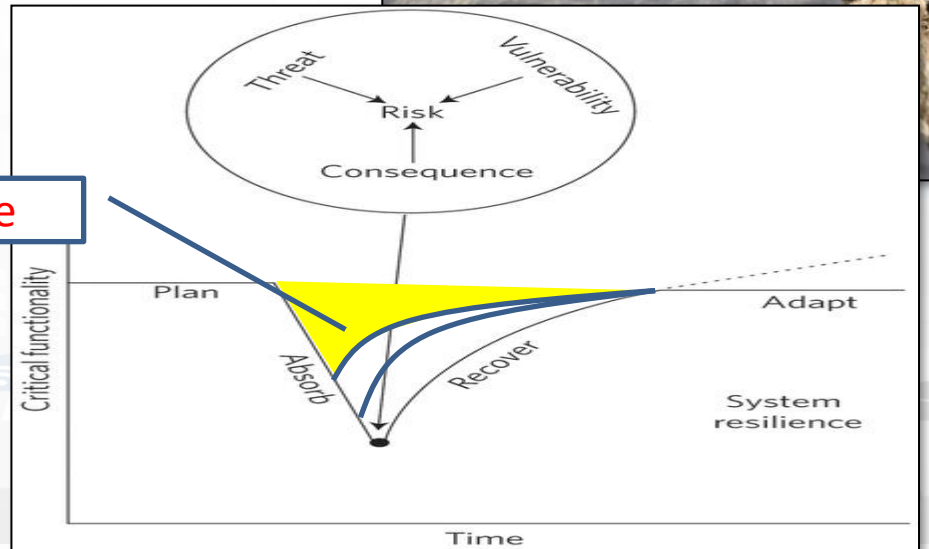
Impact:

- Early warning, faster reaction
- Increased resilience

Several metrics related to:

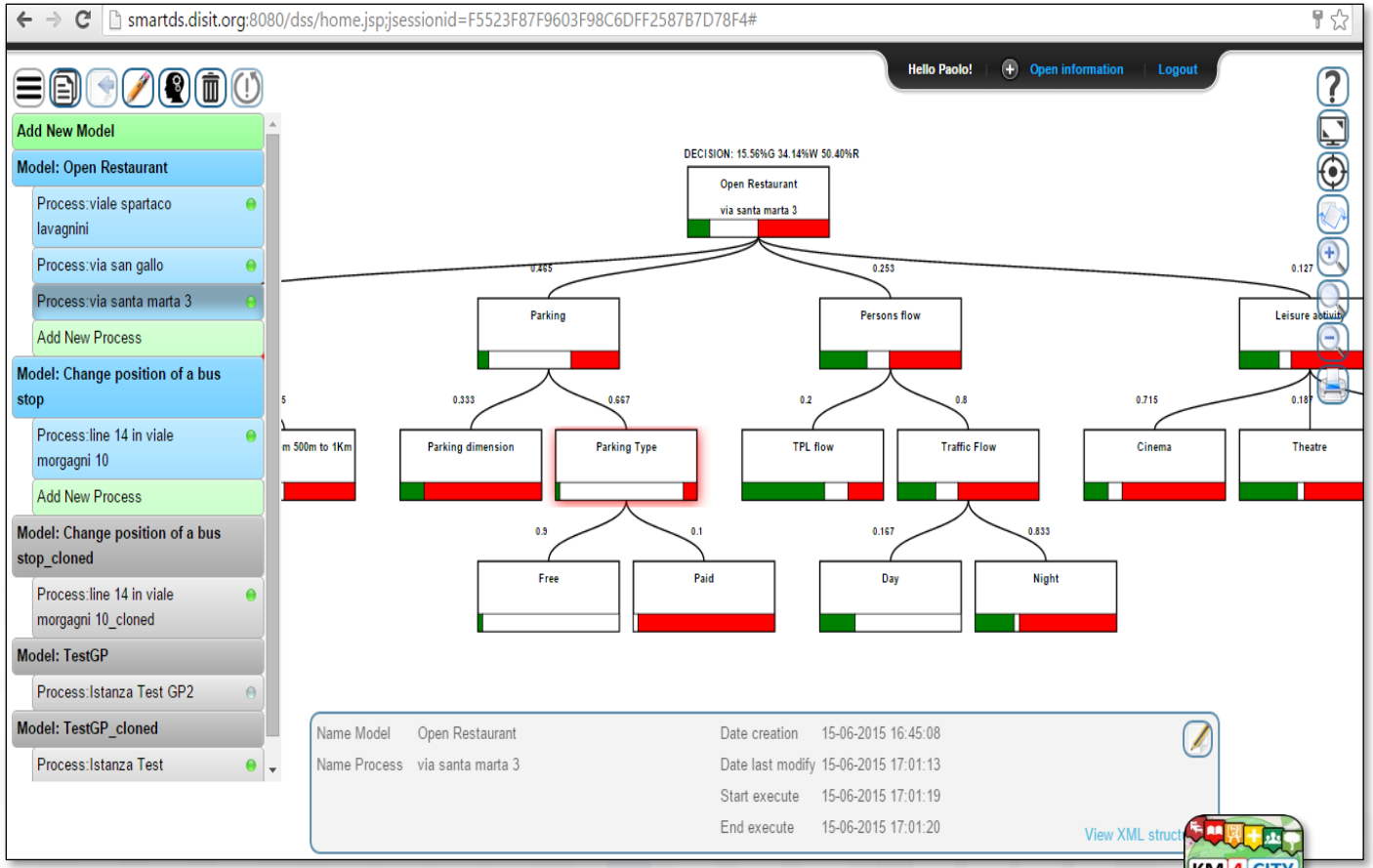
- Volume of retweets
- Sentiment analysis

Prepare
Absorb
Recover
Adapt



Smart Decision Support , system thinking

- **Smart Decision Support System** based on System Thinking plus
- Actions to city reaction, resilience, smartness, …
- Enforcing Mathematical model for propagation of decision confidence..
- Collaborative work, …
- Processes connected to city data: DB, RDF Store, Twitter, etc.
- Production of alerts/alarms
- Data analytics process
- Twitter Processes
- reuse, copy past, …



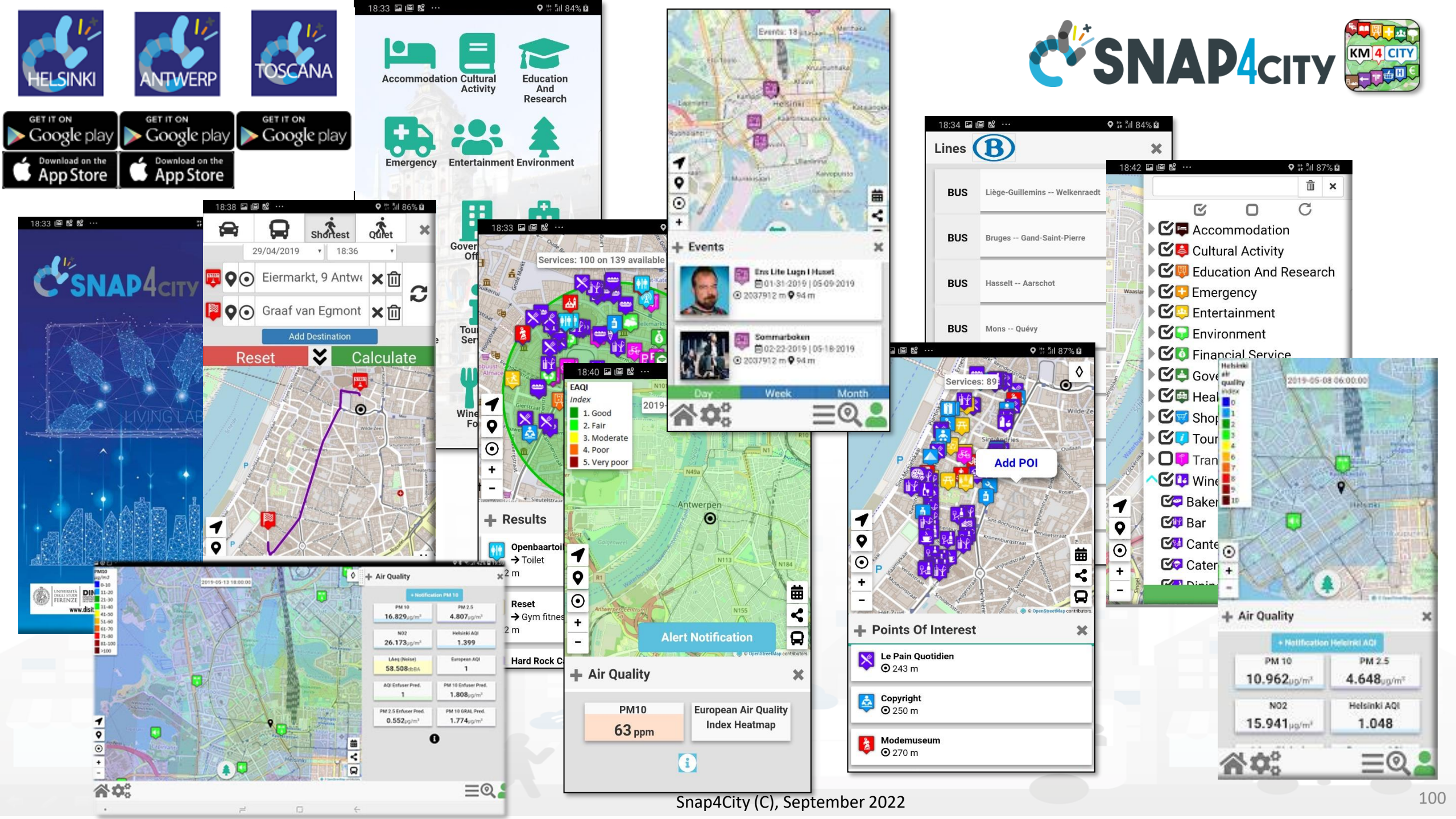
http://smartds.km4city.org

TOP

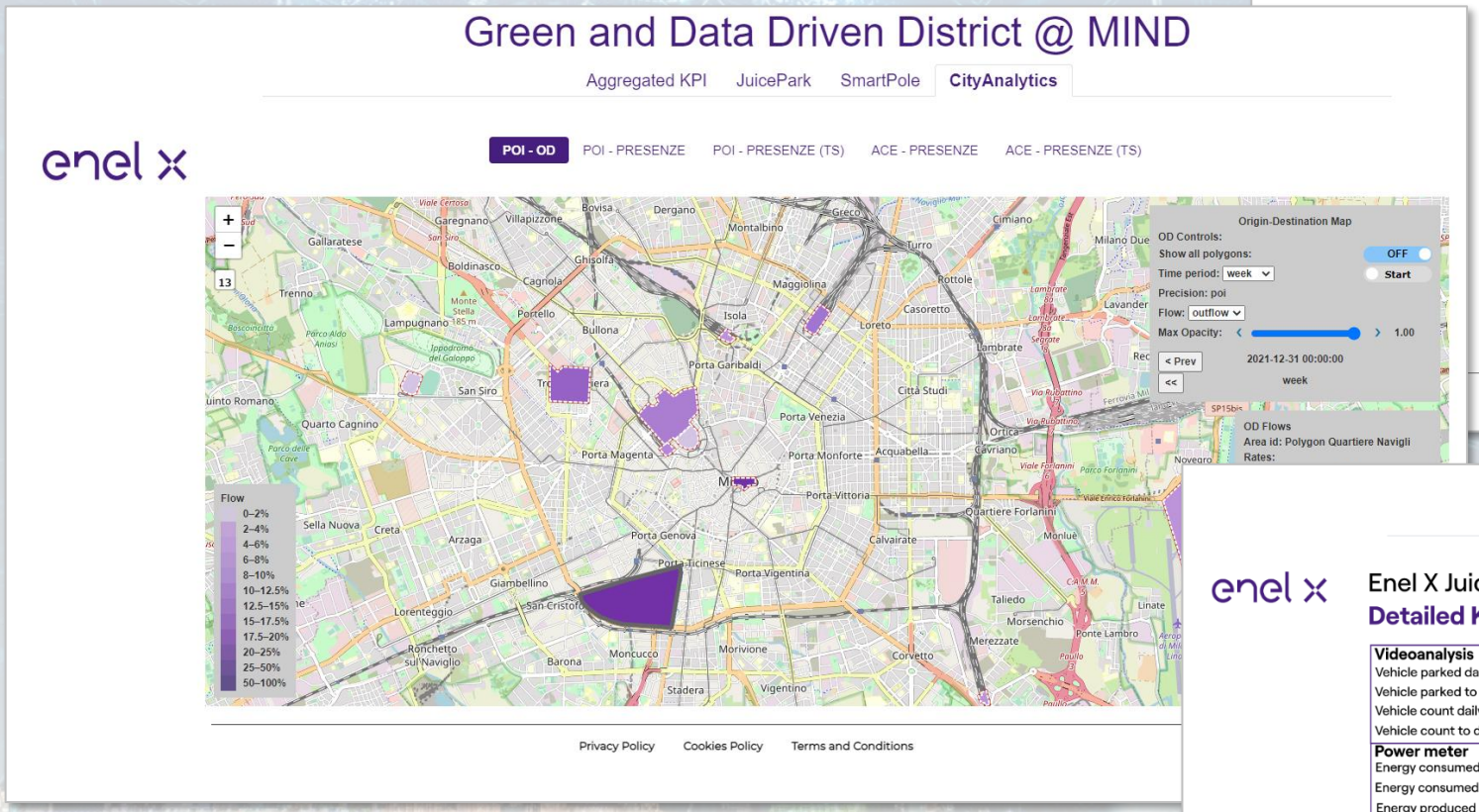
Other cases

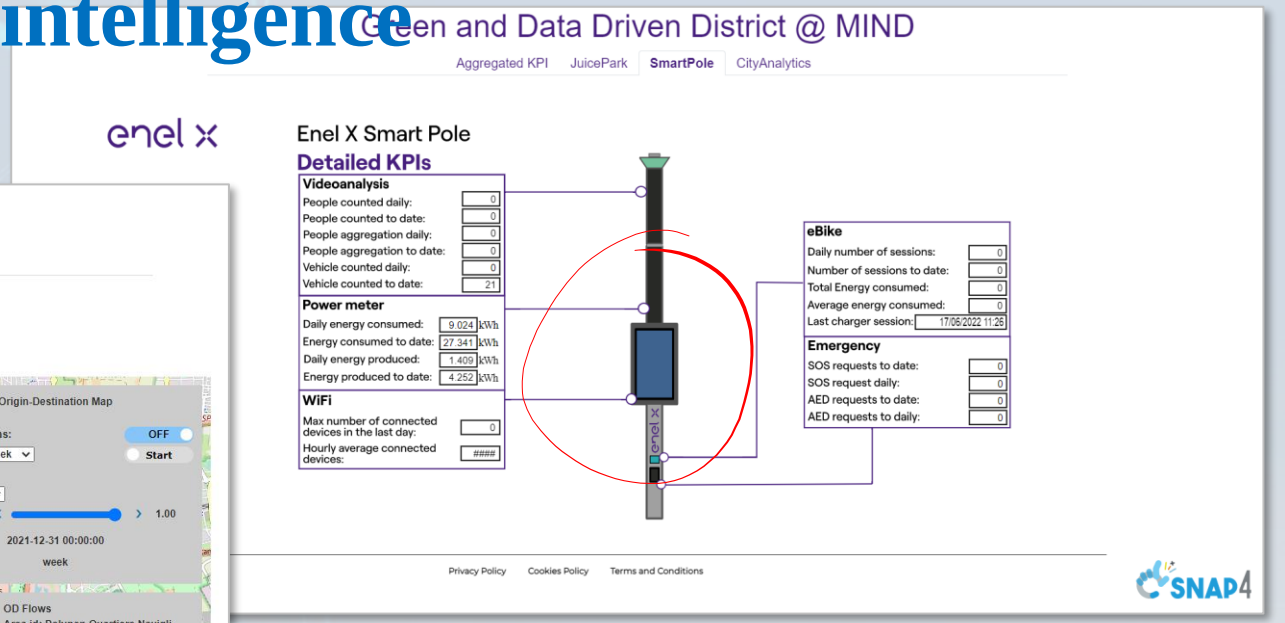
100% OPEN SOURCE

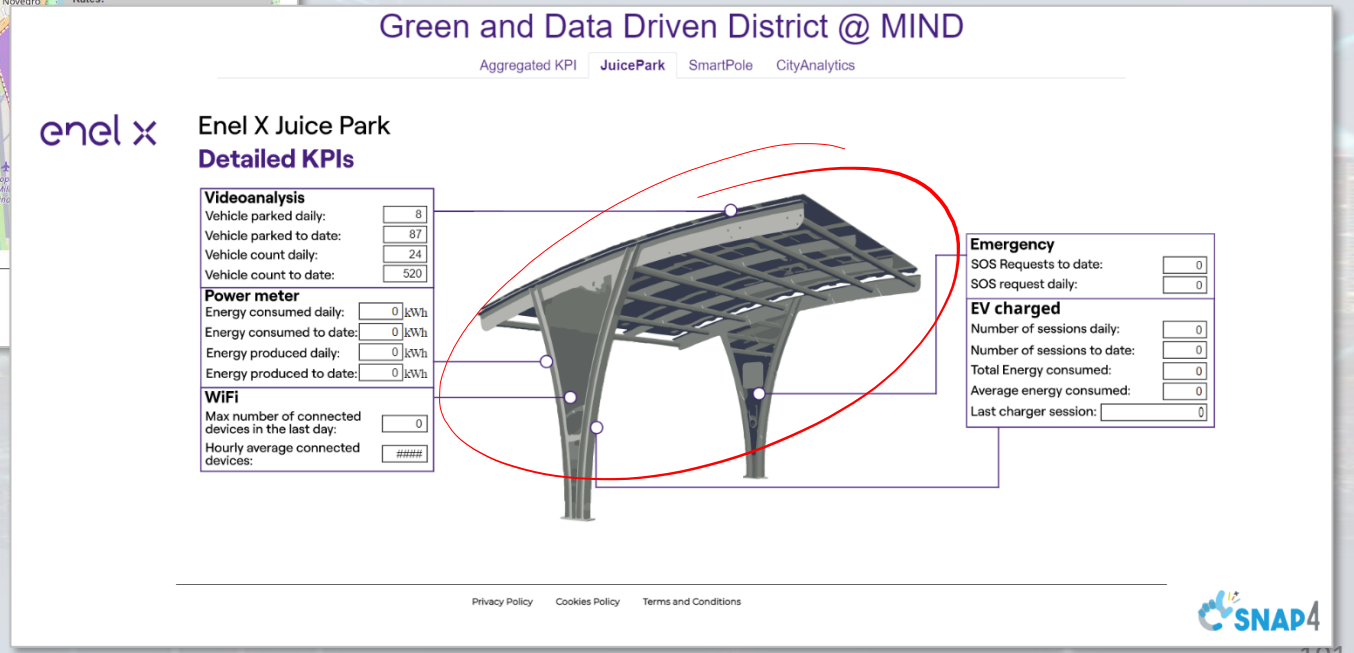
SNAP4 Appliances and Dockers **Installations**


HELSINKI
ANTWERP
TOSCANA
GET IT ON Google play
Download on the App Store
SNAP4CITY
KM 4 CITY
Accommodation
Cultural Activity
Education And Research
Emergency
Entertainment
Environment
Shortest
Quiet
Add Destination
Reset
Calculate
Events
Day
Week
Month
Services: 100 on 139 available
EAQI
Index
1. Good
2. Fair
3. Moderate
4. Poor
5. Very poor
Results
Antwerpen
Alert Notification
Air Quality
PM10
63 ppm
European Air Quality Index Heatmap
Lines
BUS
Liège-Guillemins -- Welkenraedt
Bruges -- Gand-Saint-Pierre
Hasselt -- Aarschot
Mons -- Quévy
Add POI
Points Of Interest
Le Pain Quotidien
243 m
Copyright
250 m
Modemuseum
270 m
Financial Service
Bar
Air Quality
PM 10
10.962
PM 2.5
4.648
NO2
15.941
Helsinki AQI
1.048

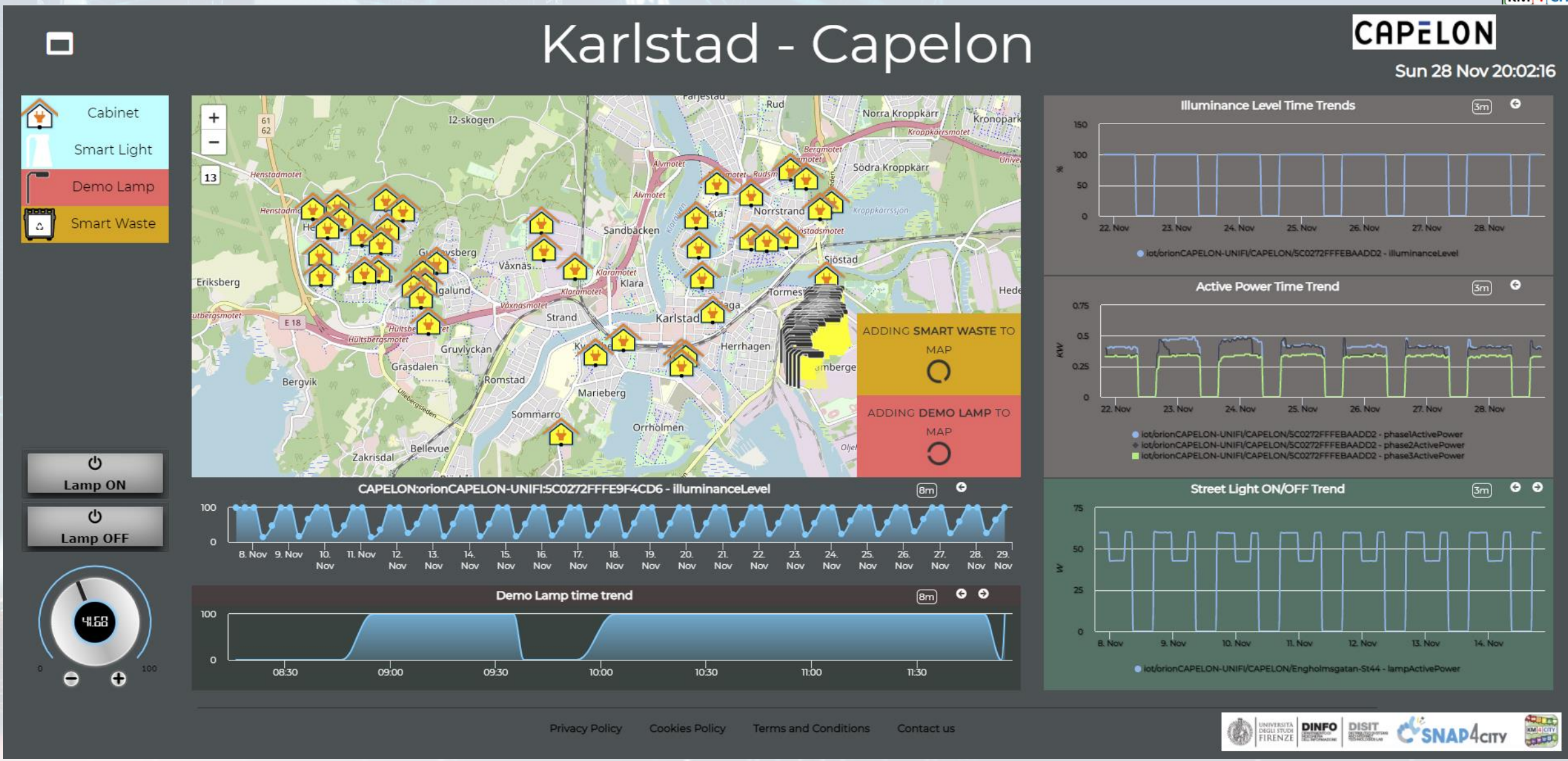
Energy monitoring and business intelligence







Karlstad Street Lights



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzI5NQ==

Herit-Data Twitter Vigilance

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

Twitter Vigilance Herit-Data: *Some Numbers*

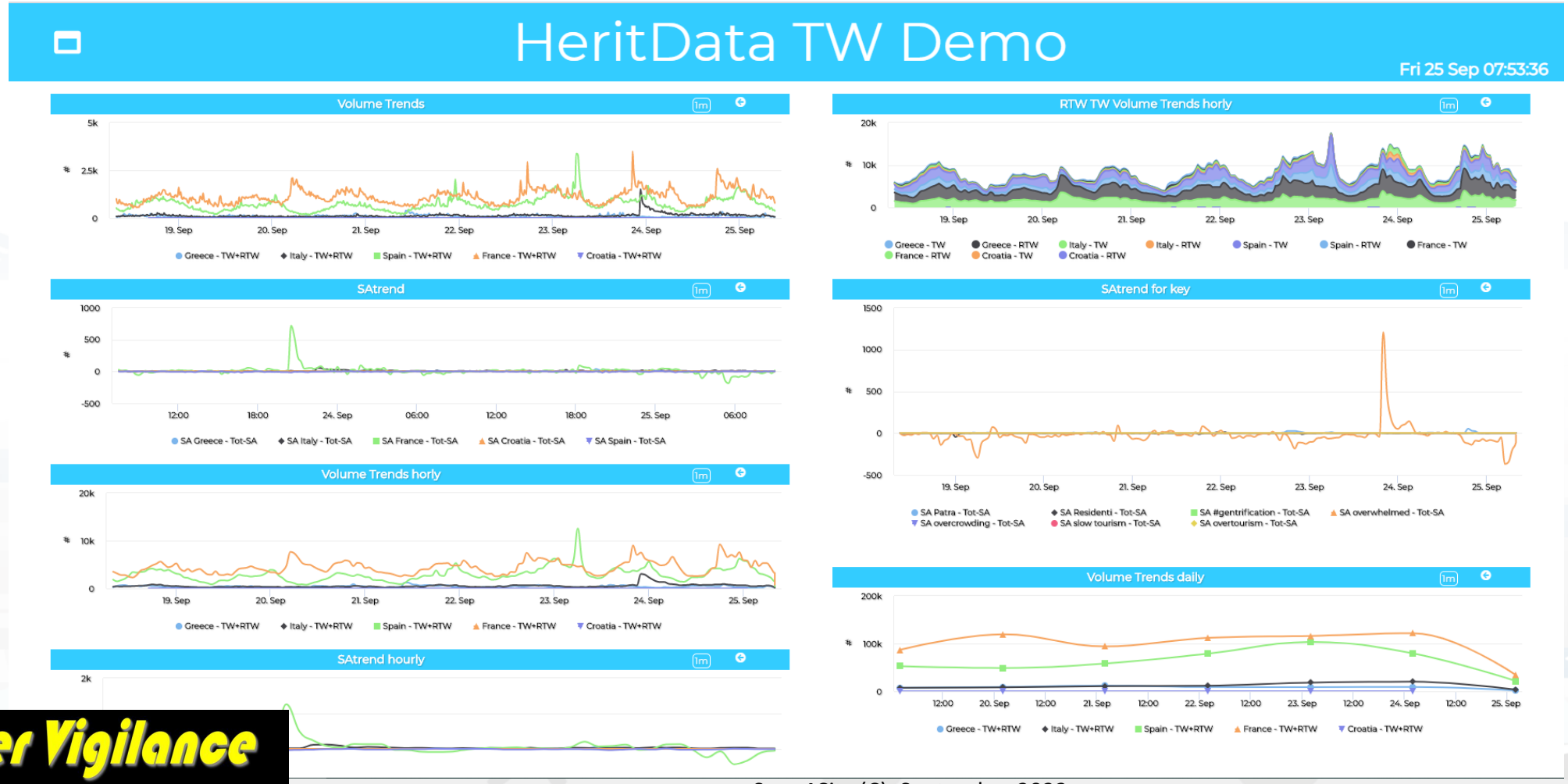
Channel Name	Total Number of Collected TW+RTW	Number of Collected Tweets	Number of Collected Retweets	Twitter Volume Processing Time Range	NLP & Sentiment Analysis Processing Time Range	NLP & Sentiment Analysis Languages
Spain	113.7 Millions	40.99 Millions	72.49 Millions	From 30-01-2020 to current datetime	From 01-02-2020 to current datetime	English, Spanish
France	50,1 Millions	16.0 Millions	34.1 Millions	From 30-01-2020 to current datetime	From 01-02-2020 to current datetime	Italian, English, French
Greece	12.3 Millions	4.2 Millions	8.1 Millions	From 30-01-2020 to current datetime	From 01-02-2020 to current datetime	English
Italy	2.97 Millions	1.0 Million	1.9 Millions	From 30-01-2020 to current datetime	From 01-02-2020 to current datetime	Italian, English
Croatia	35.8 Thousands	15.5 Thousands	19,8 Thousands	From 30-01-2020 to current datetime	From 01-02-2020 to current datetime	English

Updated: Dec. 2021

Twitter Vigilance

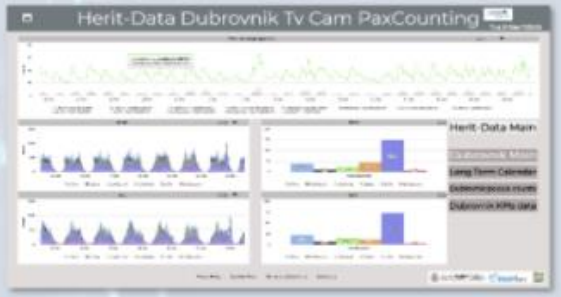
Twitter Vigilance Data on Dashboards trought IoT-App

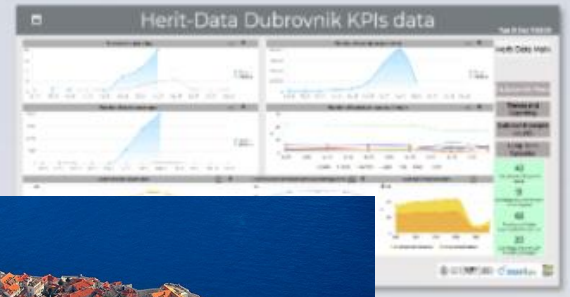
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=Mjc3NQ==

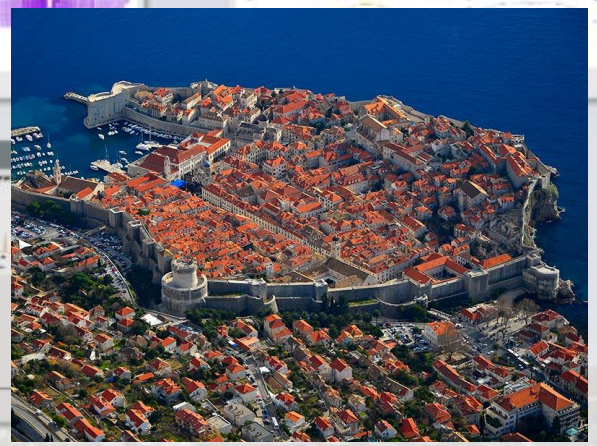


Dubrovnik

- **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**







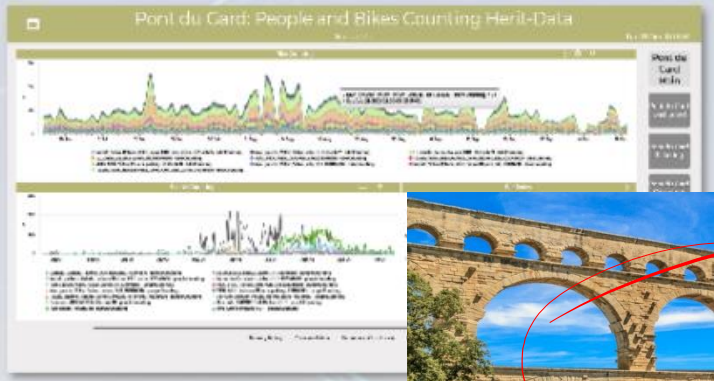
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzE0Ng==

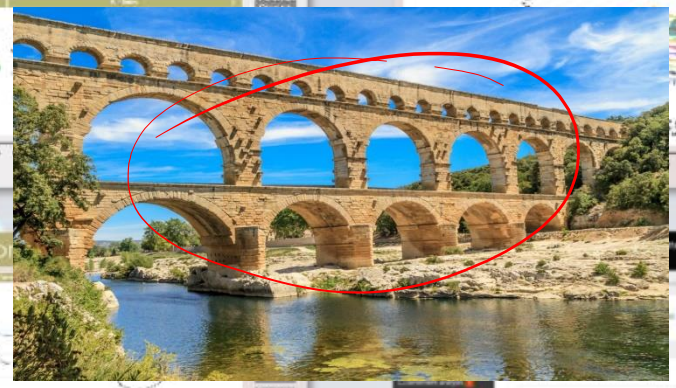
Dubrovnik: Data Analytics

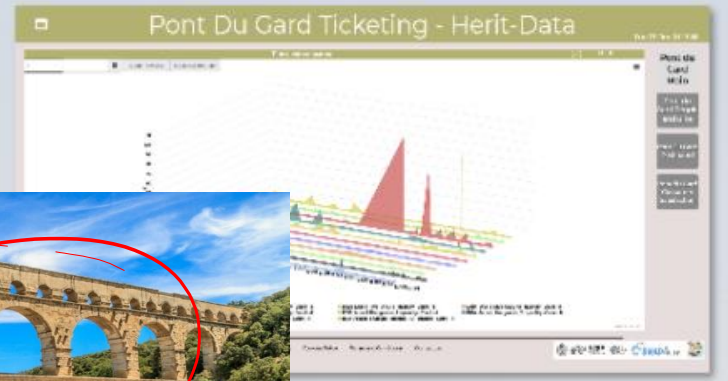
- Prediction of presences on the basis of ……
- Effects of advertising via Social Media
- Effect of weather conditions

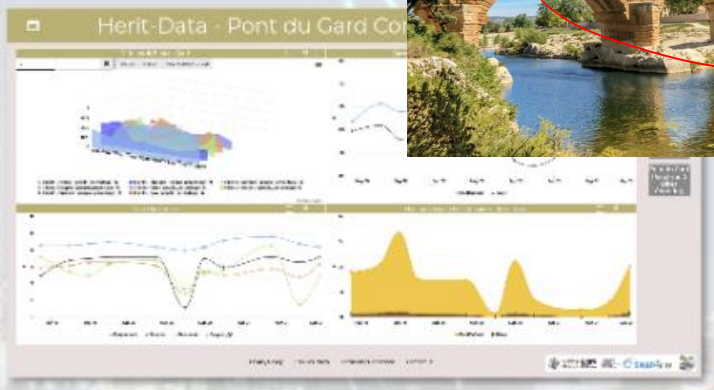
Pont du Gard

- **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**





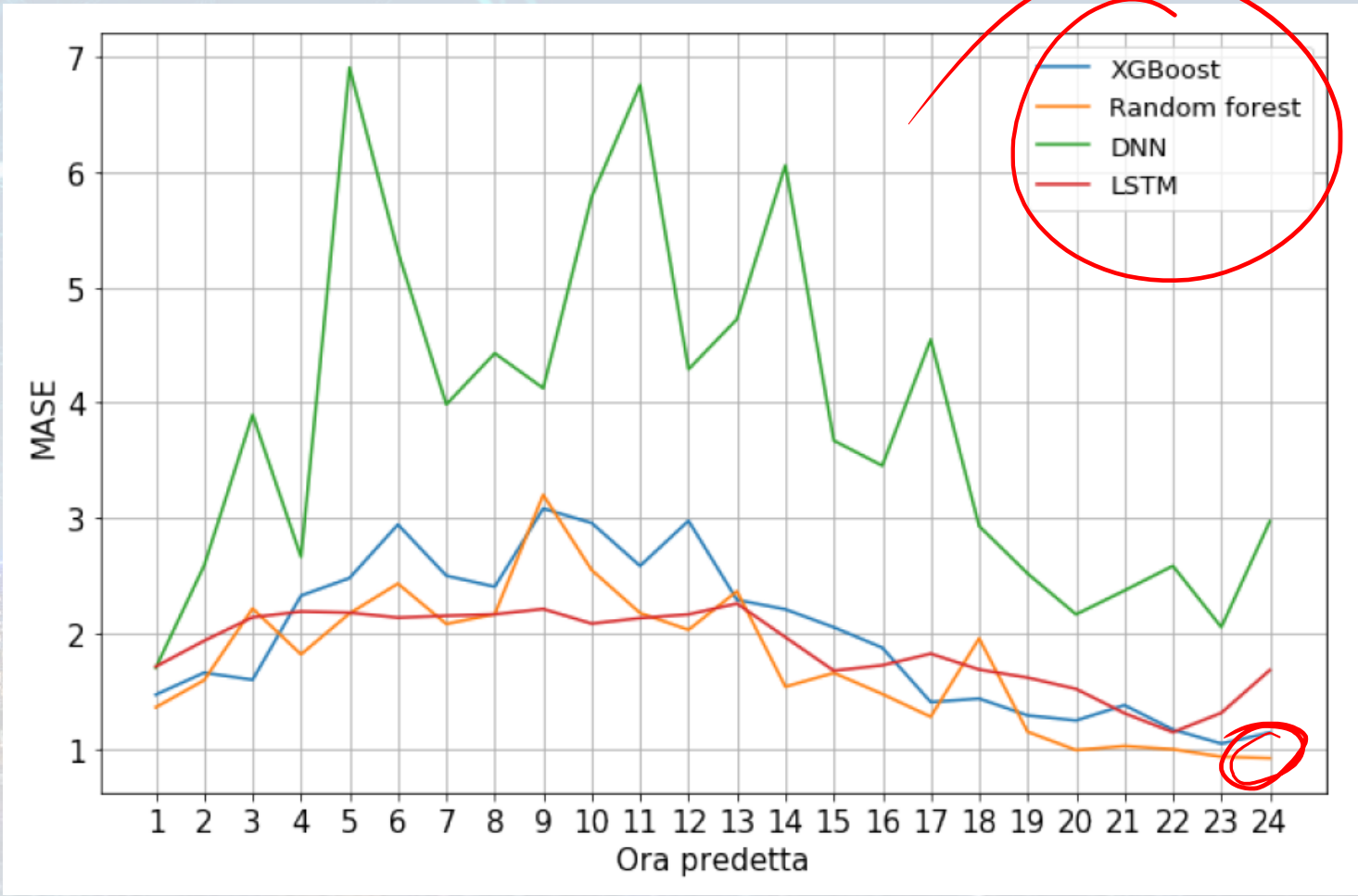




https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzE1Mw==

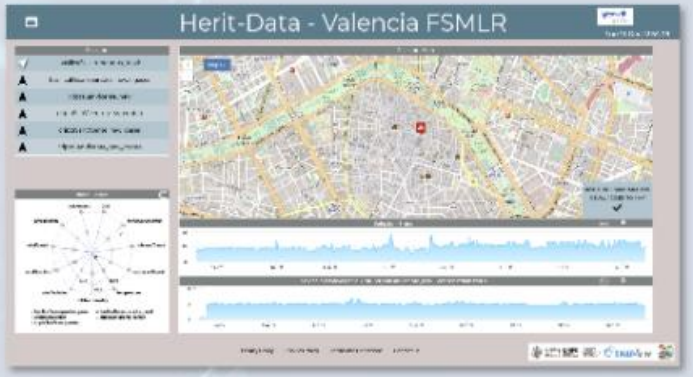
Pont du Gard: data analytics

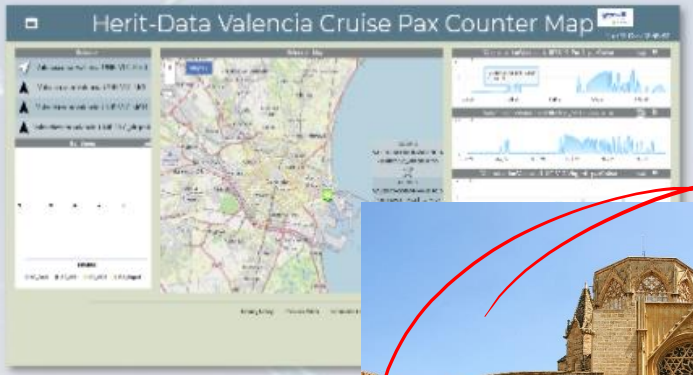
- Prediction of the number of sold tickets 24 hours in advance
- As a function of …….

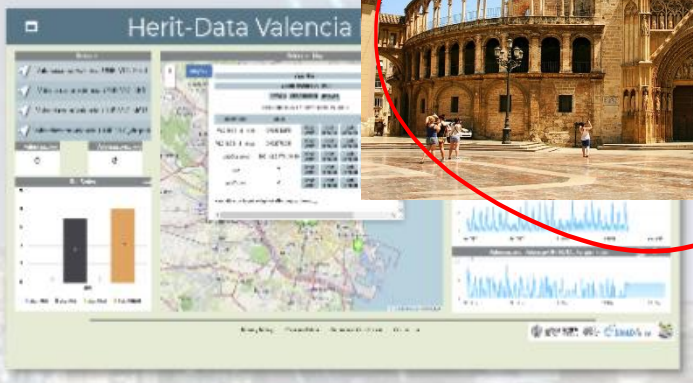


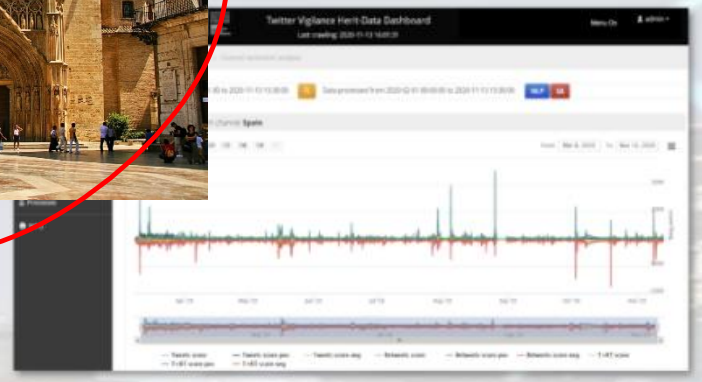
Valencia, FSMLR

- **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**





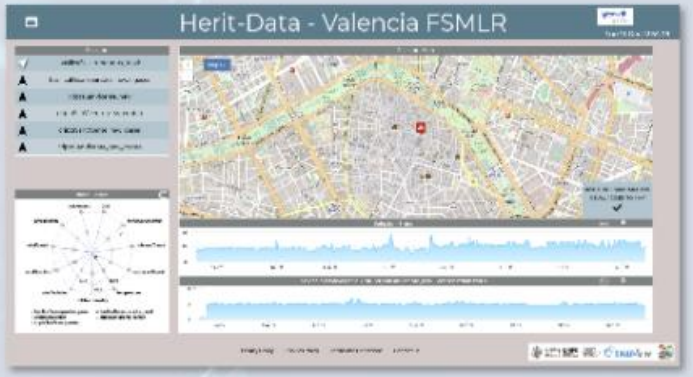


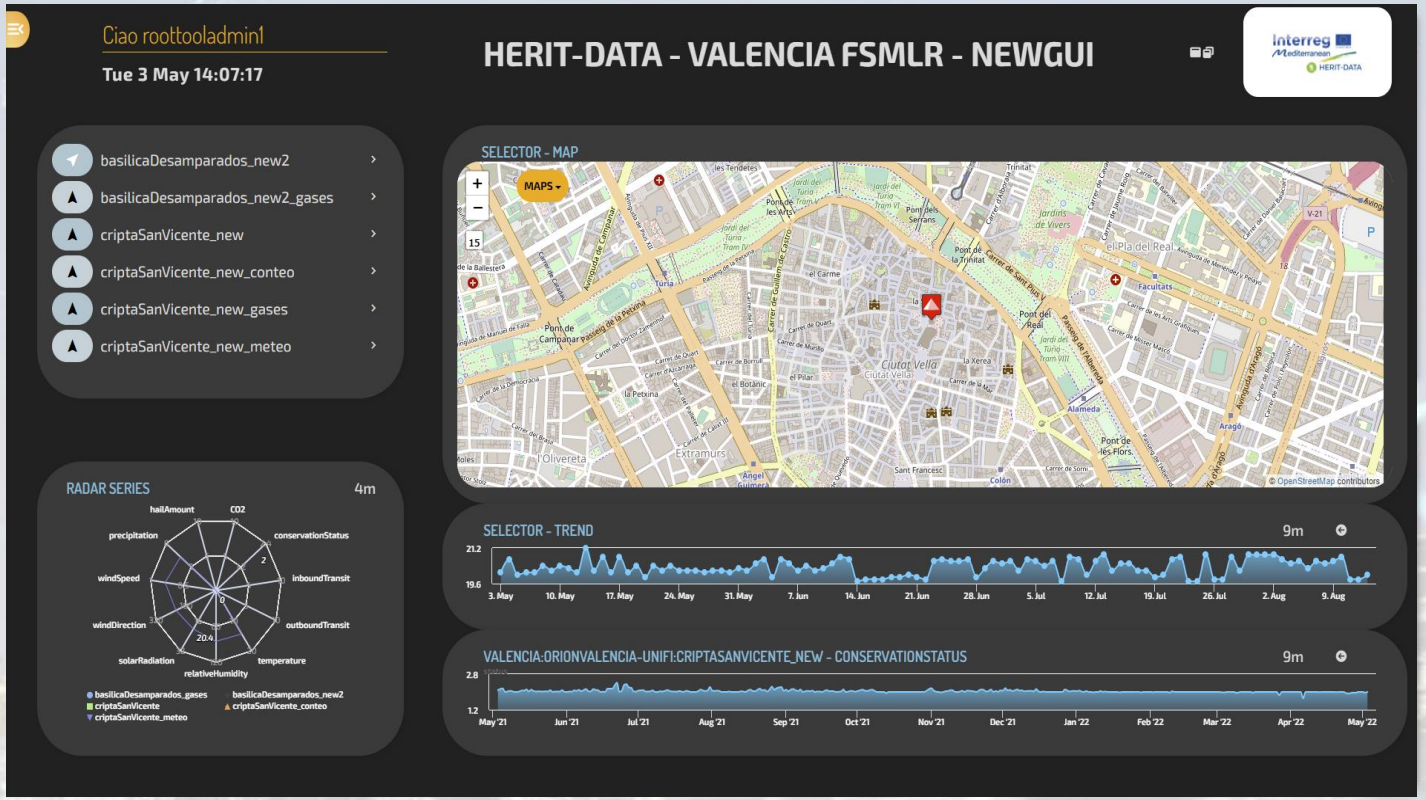


https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzE1MA==

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**

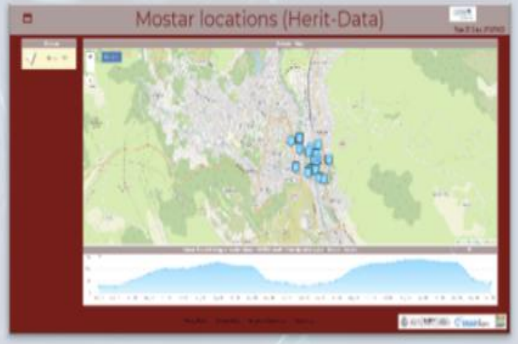


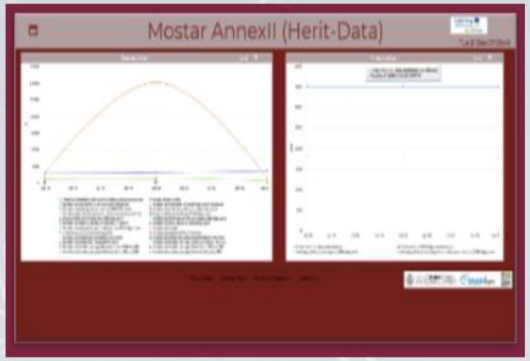


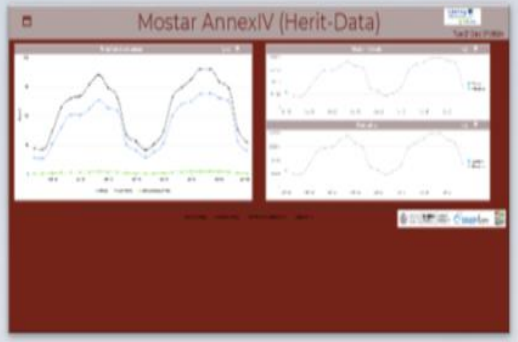
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzE1MA==

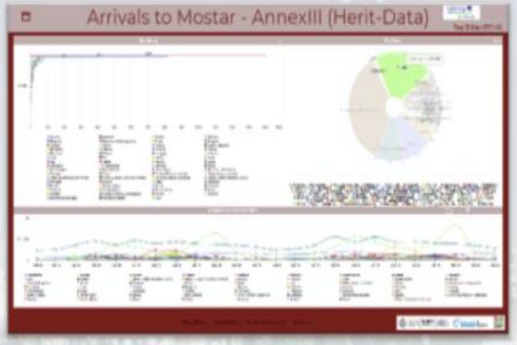
Mostar, Bosnia Herzegovina

- **Tourism Domain**
  - KPI: business, house prices, investments, stay duration, etc.
  - Profiled POI, Point of Interests
  - People flows: arrivals, overhights
- **Dashboards**
  - Monitoring KPI
  - POI, flows
- **Historical and updated data**
- **Services Exploited on:**
  - Dashboard
- **Since 2020**





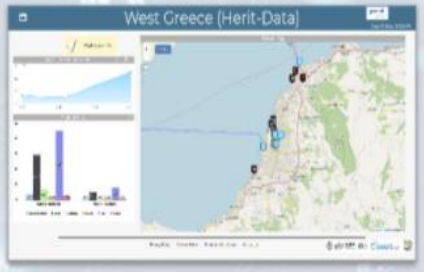


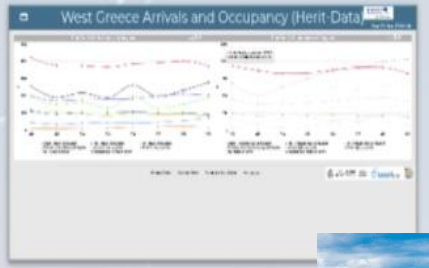


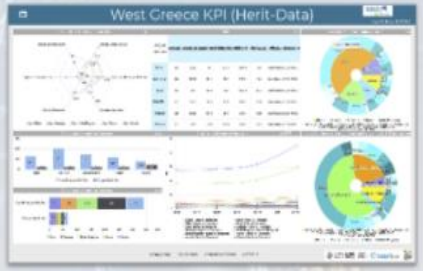
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzE0OQ==

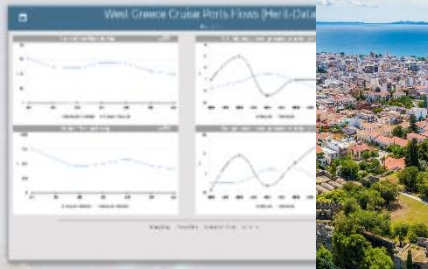
West Greece

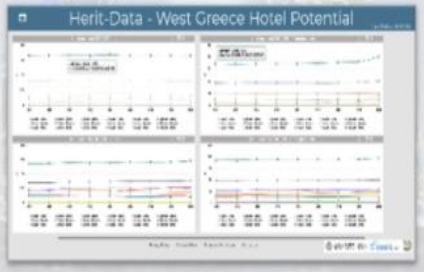
- **Tourism Domain**
  - KPIs: ODM, Flows, …
  - Social Media
  - People Flows
- **Dashboards**
  - Monitoring KPI
  - People flows
  - Twitter Vigilance
- **Historical and updated data**
- **Services Exploited on:**
  - Dashboard
- **Since 2020**











https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzE1NA==

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

TOP

Get other info on……

100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

Using from Cloud or Installing on Premise

- **Cloud «as a service»:** a number of installations are in place
  - The largest https://www.snap4city.org
    - 20 tenants/organizations, Billions of data
    - 1 hour deploy new organization, devices, data, dashboards
- **Installations on public or private cloud, or on private servers**
  - A number of ready to use configurations from 1VM to multiple scalable solutions: https://www.snap4city.org/471
    - VM: Appliances ready to use
    - Docker compose, Tool for generating and downloading the docker compose files
      - Micro X version can be installed and tested in 4 hours.

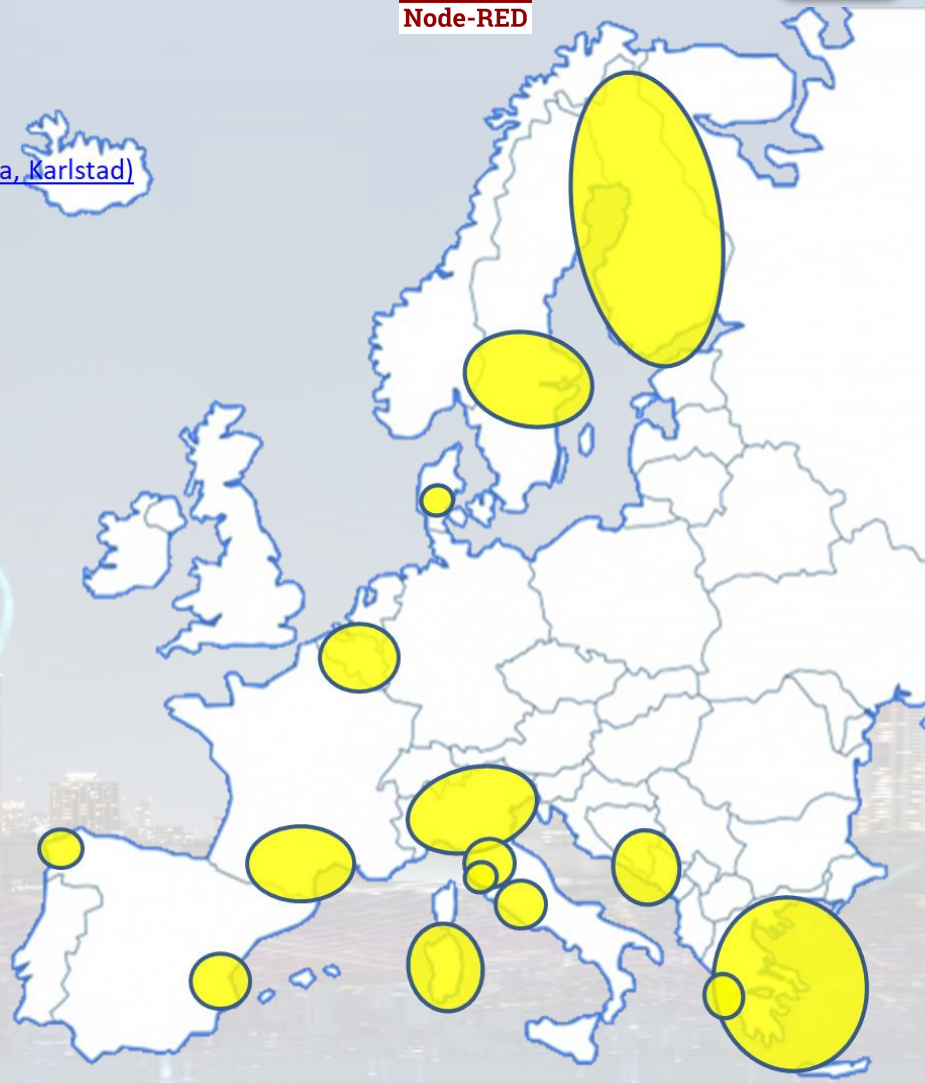
https://www.Snap4City.org

https://www.snap4city.org/download/video/cov/

- > 7 running installations
  - Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
  - Altair, Italmatic, ….
- 13 actions, 12 pilots on 10 Countries
  - >40 cities/areas
- **Wide MULTI-tenant deploy, e.g.,**
  - 19 Tenants / Organizations
  - > 7700 users on
  - > 1400 Dashboards
  - > 16 mobile Apps
  - **> 2 Million of structured data per day**
  - > 520 IoT Applications/node-RED
  - > 700 web pages with training
  - > 75 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)



- **Trials in Israel, Colombia, Australia, India, etc……**

DISIT lab roadmap vs model and tools' usage

2013
Km4City Ontology 1.1

- Tuscany, Road Graph
- Mobility
- culture, tourism
- Events
- Parking
- Services
- Linked open graph

2014
- Weather Forecast
- Real Time Wi-Fi
- Entertainment
- LOD

- Twitter Vigilance
- Social Media Analytics, Sentiment Analysis

Km4City 1.4

2015
Km4City 1.5

- Resilience Decision Support
- Smart First Aid
- User Behaviour Analysis, predictions
- Risk Analysis

ckan, resolute

H2020 (2015-18)

2016
(2016-21) H2020 REPLICATE

Km4City 1.6.4

- Smart Energy
- Sustainable Mobility
- Control Room
- Dashboard

Km4City 1.6.2

Sii-Mobility (2016-21)

SII-MOBILITY SCN

- Infomobility
- Mobile App
- Routing
- Multimodality

FIWARE

Km4City 1.5

- Resilience Decision Support
- Smart First Aid
- User Behaviour Analysis, predictions
- Risk Analysis

2017
Sii-Mobility

- Origin-Destination and trajectories
- Traffic Reconstruction
- Offer Analysis
- OBU, smart devices

E0I5 digital ecosystem (Powered by EXPO MILANO 2015)

(2016-19) GHOST SIR

- Sardinia Region Smart City Strategies and plan

GREEN IMPACT C.A.P.A.C.I.T.Y.

GREEN IMPACT
POR FESR 2014-2020

- Industry 4.0
- Critical Plant
- Monitoring

- IOT/IOE, IOT App
- Living Lab
- Maker Support
- IOT Edge
- Smart City IOT
- GDPR,
- Privacy & Security

life weee (2017-20)

- Smart Waste

2018
MOSAiC MObility 4.0 for SmArt (i) City (2018-20)

- Mobility Demand / Offer Analytics and Strategy

Sii-Mobility

- User engagement
- Bike Sharing
- Data Analytics ++
- Social Predictions
- OBD2

IOT/IOE

Km4City 1.6.6

Node-RED

SNAP4CITY SELECT for Cities H2020 (2017-19)

2019
5G (2018-21)

- 5G tech
- Energy
- Industry 4.0
- Synoptics

TRAFAIR CEF (2018-21)

- Traffic and Mobility Impact on Pollution
- NOX predictions

EUROPEAN OPEN SCIENCE CLOUD

LAID Smart Bed

- Smart Health

GREEN FIELD PEAS Soda4.0 Optimization and Automated Decision System 4.0

- Industry 4.0

bee smart city

- Smart Lonato

Reverberi Enetec Gruppo MPES

SNAP4CITY KM4CITY

Winner of Select4Cities PCP

SNAP4CITY roadmap

SODA

2020

JRC EUROPEAN COMMISSION

Interreg Mediterranean HERIT-DATA

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

Interreg MARITTIMO-IT FR-MARITIME MOBI MART

- Smart Mobility
- PISA, PUMS
- Living lab

smartGARDAlake

2021

JRC EUROPEAN COMMISSION

PC4City (2020-21)
Monitoring Terrain

Winner of Open Data Challenge of enel x

CAPELON

- Smart Light
- Sweden

Km4City 1.6.7

enel x
Contract

Smart Ambulance
(2021-22)

Enterprise
(2021-22)
Industry 4.0

Almafluida
Industry 4.0
(2021-22)

AMPERE (2021-22)
Industry 4.0

SYN-RG-AI
SmartCity

Smartea

IMPETUS
Security and Risk

ITALFERR GRUPPO FERROVIE DELLO STATO ITALIANE
Smart City

ASYMMETRICA URBAN TECHNOLOGY
Smart City

2022

AXIS COMMUNICATIONS
SmartCity

uni.systems
SmartCity

GRUPPO PRETTO
Industry 4.0

enel x
Contract

Filippi
Contract

ART-ER ATTRATTIVITÀ RICERCA TERRITORIO
Contract

Some agreements

https://www.snap4city.org/4

Scenarious

- 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

- 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

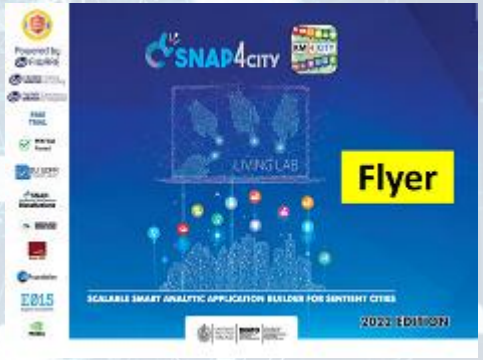
https://www.snap4city.org/577

On Line Training Material (free of charge)

	1st part (*)	2nd part (*)	3rd part (*)	4th part (*)	5th part (*)	6th part (*)	7th part (*)
what	General	Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App
PDF							
Inter active							
Video1							
Video2							
Video3							
Video4				none		none	none
duration	2:55	3:16	3:41	2:00	2:48	2:35	1:47

2022 booklets

- Snap4City



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

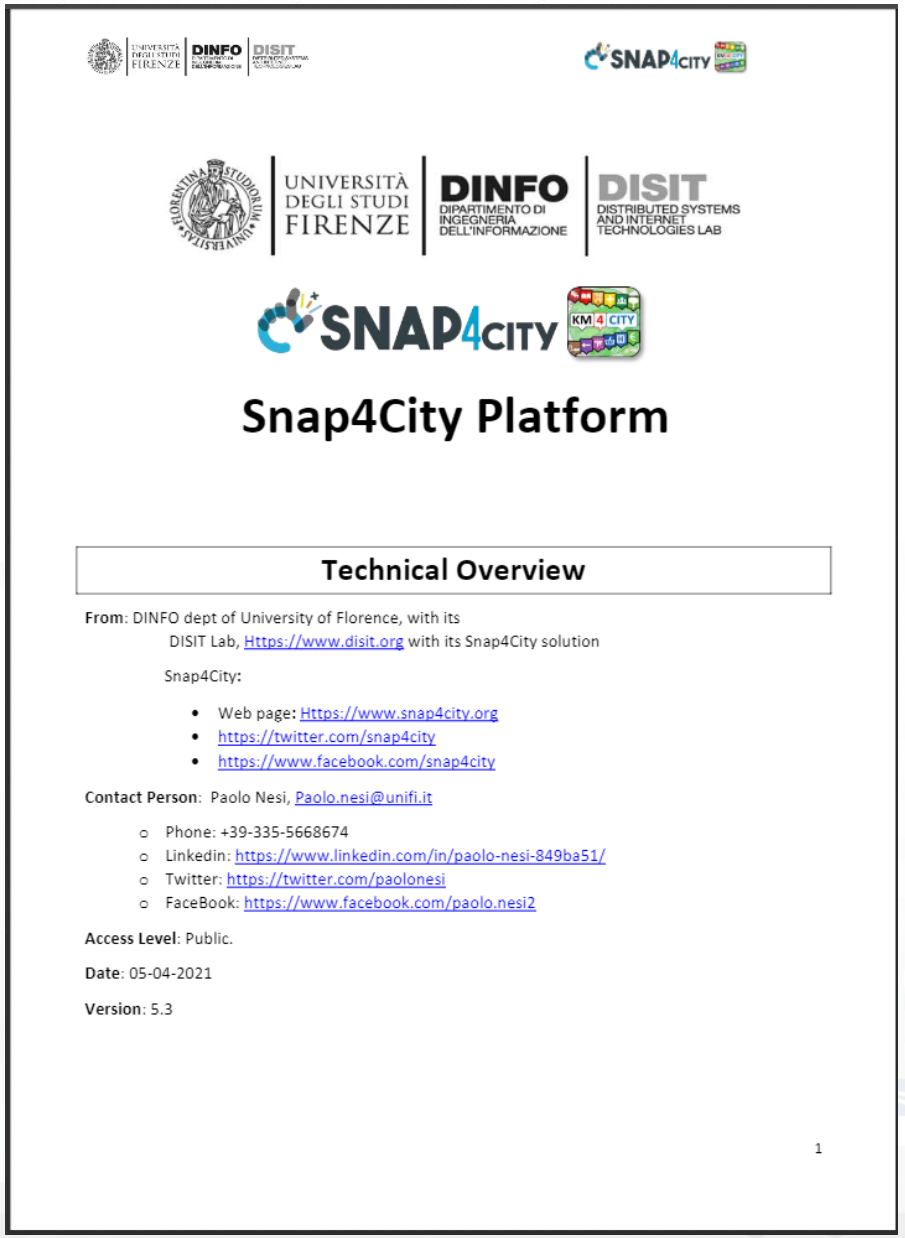
- Snap4Industry

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

Overview

- https://fiware-foundation.medium.com/snap4city-fiware-powered-smart-app-builder-for-sentient-cities-acfe24df49d5
- https://www.snap4city.org/drupal/sites/default/files/files/FF_ImpactStories_Snap4City.pdf

Overview



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

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

Access Level: Public.

Date: 05-04-2021

Version: 5.3

1

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

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

legenda

SNAP4CITY | KM 4 CITY

Presentation: Control Room, Widgets, Mobile Apps, Visual Analytics Applications, Telegram Bot, …

Dashboard Builder | Dashboard Mng | Synoptics | Dashboard Wizard | Data Inspector, Digital Twin

External Interoperability: Smart City API, Federated, API Accounting/Billing

Super | ASCAPI | kafka | WebSocket

Operation:

Reporting | Simulation | Heatmap Mng | Traffic Flows | Tip. Time Trend | OD Mng | TVCam Mng | .....

RStudio | python | ..... | docker

Analysis | WorkFlow Tickets BPM | Sentiment Analysis | ..... | Open to any module and subsystem | .....

Data Analytics | Predictions | Anomaly detection | Statistics | Artificial Intelligence | Routing | Internal GIS GeoServer | ckan | openMAINT | BIMserver.center | .....

Internal Interoperability: API, MicroServices

Snap4City Node-red Libraries | ASCAPI | WebSocket | FIWARE

Data Storage and Reasoning: data storage, noSQL, aggregation, semantic modeling, city entities, normalization, knowledge base

Service Map | nifi | OpenSearch | virtuoso

NGSI V1, V2 FIWARE | Linked Data triples

Data Collection: data mining, harvesting, integration, transformation, data models, …

IoT Directory | Data Manager | IoT Brokers | FIWARE | Node-RED

Any protocol and format | Any protocol and format

Connectivity: wired, wireless (Lora, 5G, 4G, 3G, Wi-Fi, etc…), IoT Edge, etc. | Node-RED

Any protocol and format | Any protocol and format

Device Layer

GIS | BIM | Gateways | External Services | Web Scraping | Social Media

External Third Party Services

Platform Management: docker | SNAP4CITY

IoT Applications Data Flow Logic | Node-RED

Authentication and Authorization: GDPR compliant | KEYCLOAK | OpenLDAP | SNAP4CITY

TOP

SNAP4CITY

KM 4 CITY

Be smart in a SNAP!

SNAP4
Appliances and Dockers
Installations

CONTACT

DISIT Lab, DINFO: Department of Information Engineering
Università degli Studi di Firenze - School of Engineering

Via S. Marta, 3 - 50139 Firenze, ITALY
https://www.disit.org

www.snap4city.org

Email: snap4city@disit.org

Office: +39-055-2758-515 / 517
Cell: +39-335-566-86-74
Fax.: +39-055-2758570

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