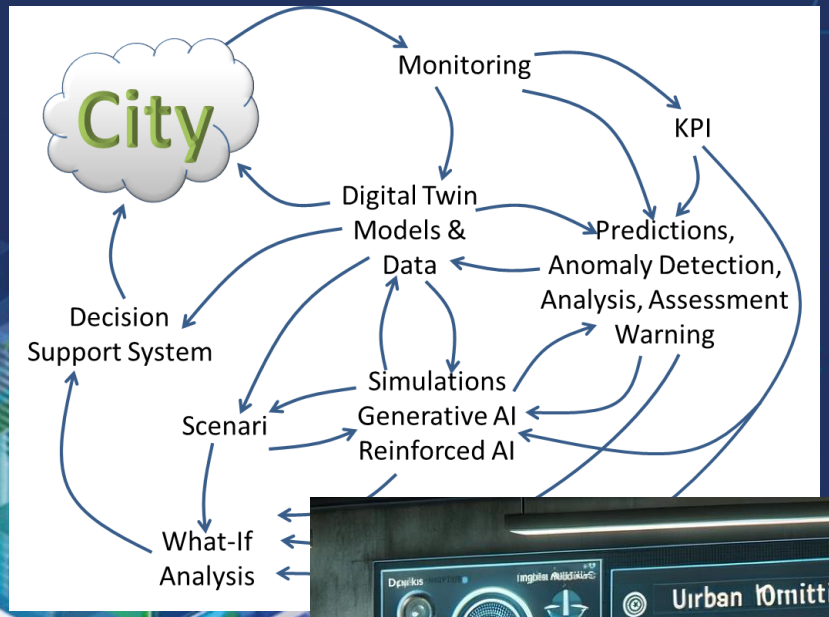
SNAP4CITY

www.snap4city.org
www.snap4solutions.org



KM4CITY

www.km4city.org

Controlling and Planning overview

DIGITAL TWIN SOLUTIONS TO SETUP SUSTAINABLE DECISON SUPPORT SYSTEMS AND BUSINESS INTELLIGENCE

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

BY NC ND
SOME RIGHTS RESERVED

Domains

- Smart City, control room
- Mobility and transport
- Environment, pollutant, waste, water, green, ..
- Energy, light, recharge
- Tourism and People
- Asset management
- Security and Safety
- Social Media

- Big Data, AI/XAI
- Public and private data

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

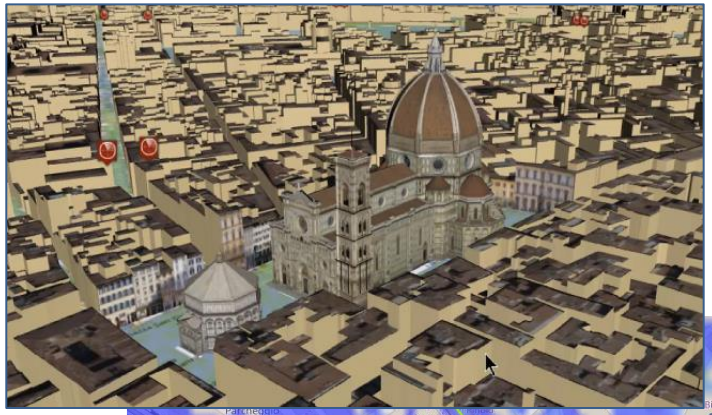
Public Spaces as Critical Infrastructures

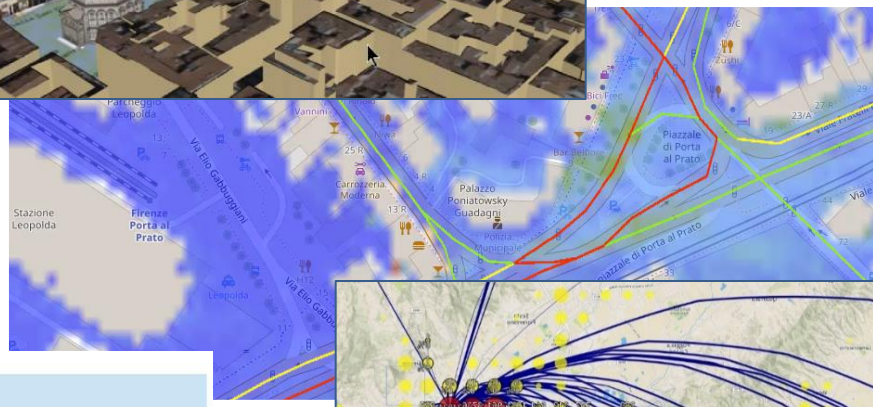
- The City is a system of systems for city users
  - Cascading effects
- **Transport** networks
  - Main means for rescue teams, food, water, etc.
- **Communication**, ICT infrastructure
  - TV cam, switches, cyber,
- **Energy** networks
  - power supply for health, cyber systems, etc.
- **Hospitals**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

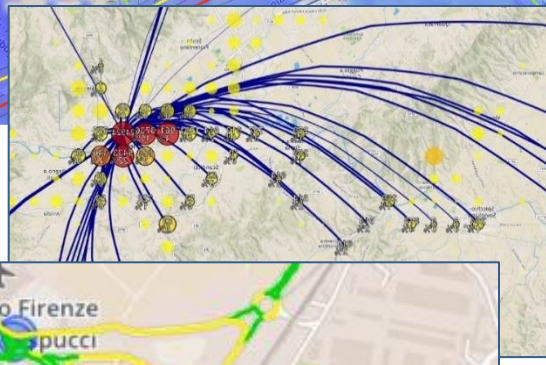
https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf

Main Tasks

- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Computing predictions data from the field and KPI
  - Anomaly detection
  - Early warning on critical conditions
- **Making plan: tactic and strategic, medium and long range**
  - Optimisation: Prescriptions, suggestions
  - Risk assessment
  - What-if analysis on scenarios
    - Simulation and predictions
  - Resilience
- **Be ready for Unexpected Unknows**

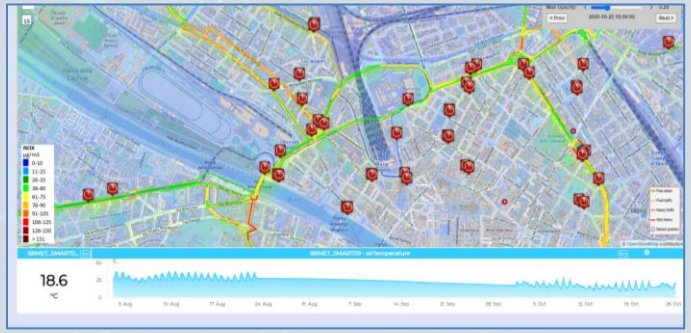


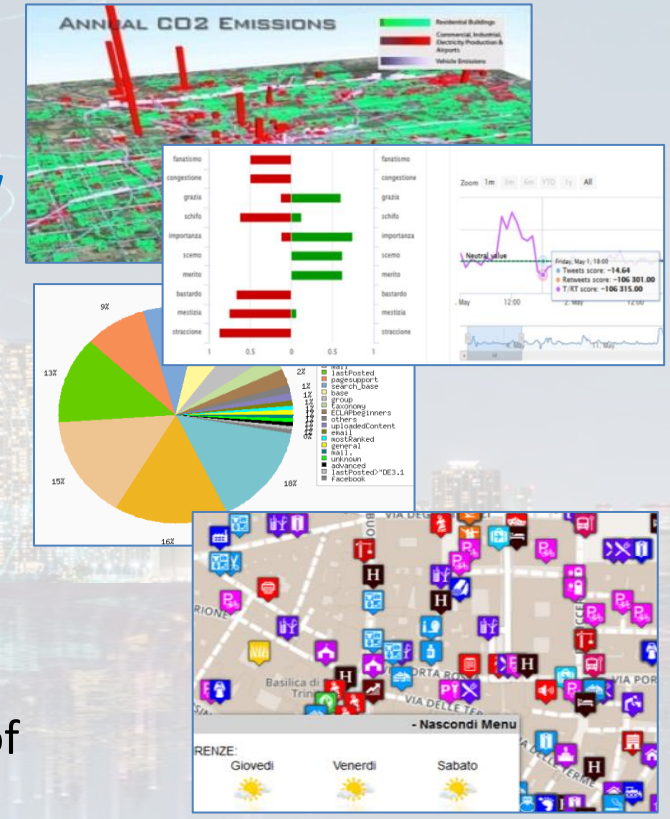


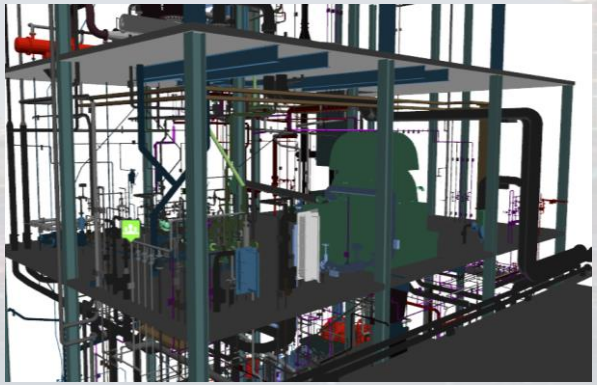


Digital Twin

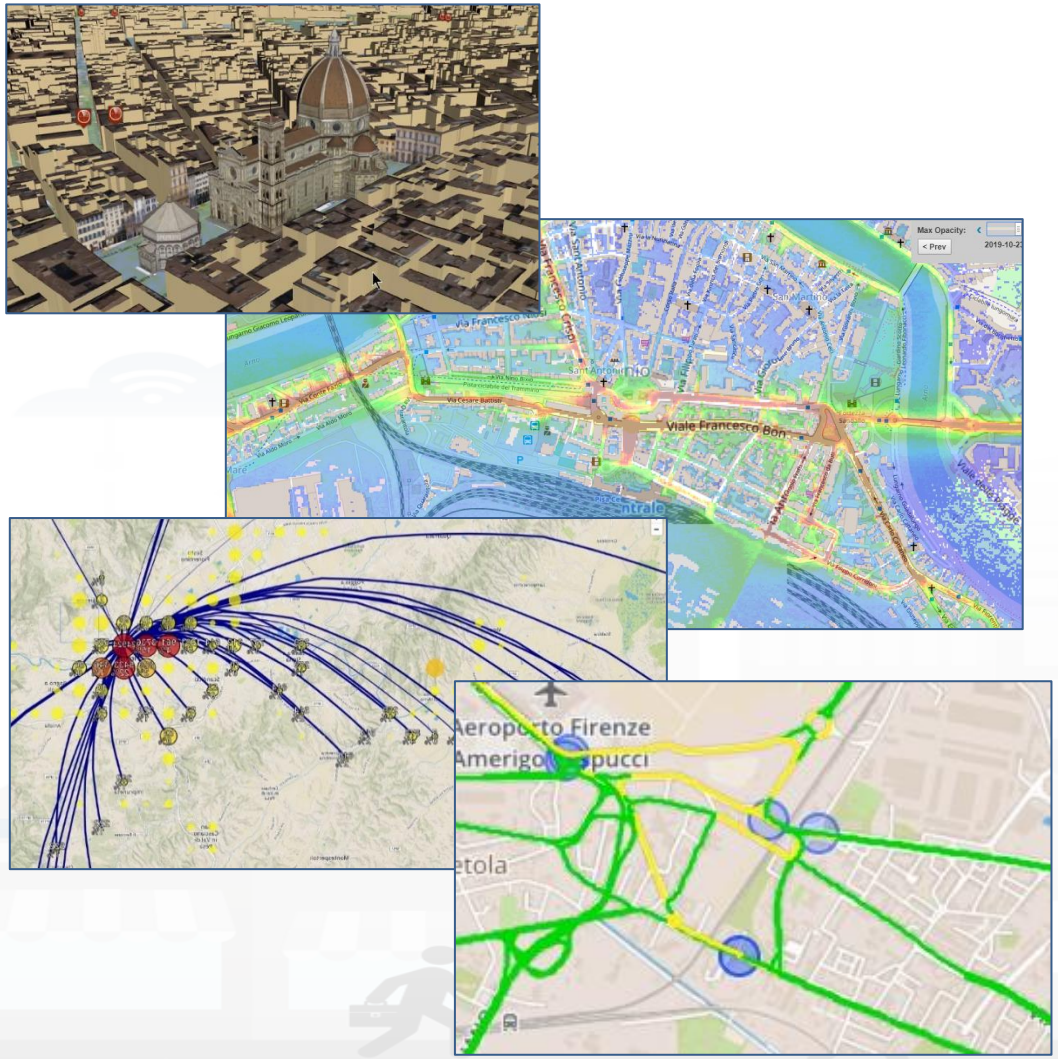
- **Digital Twin**
  - **Connected** with real systems
  - **Modelling** aspects: structural, visual, informative, real time data sensors (context), POI, functional, resources, etc.
  - **Analytics:** AI/XAI techniques, simulations, users' needs, etc.
- **Easier to understand the context, review from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







Smart City Digital Twin



City Digital Model with…

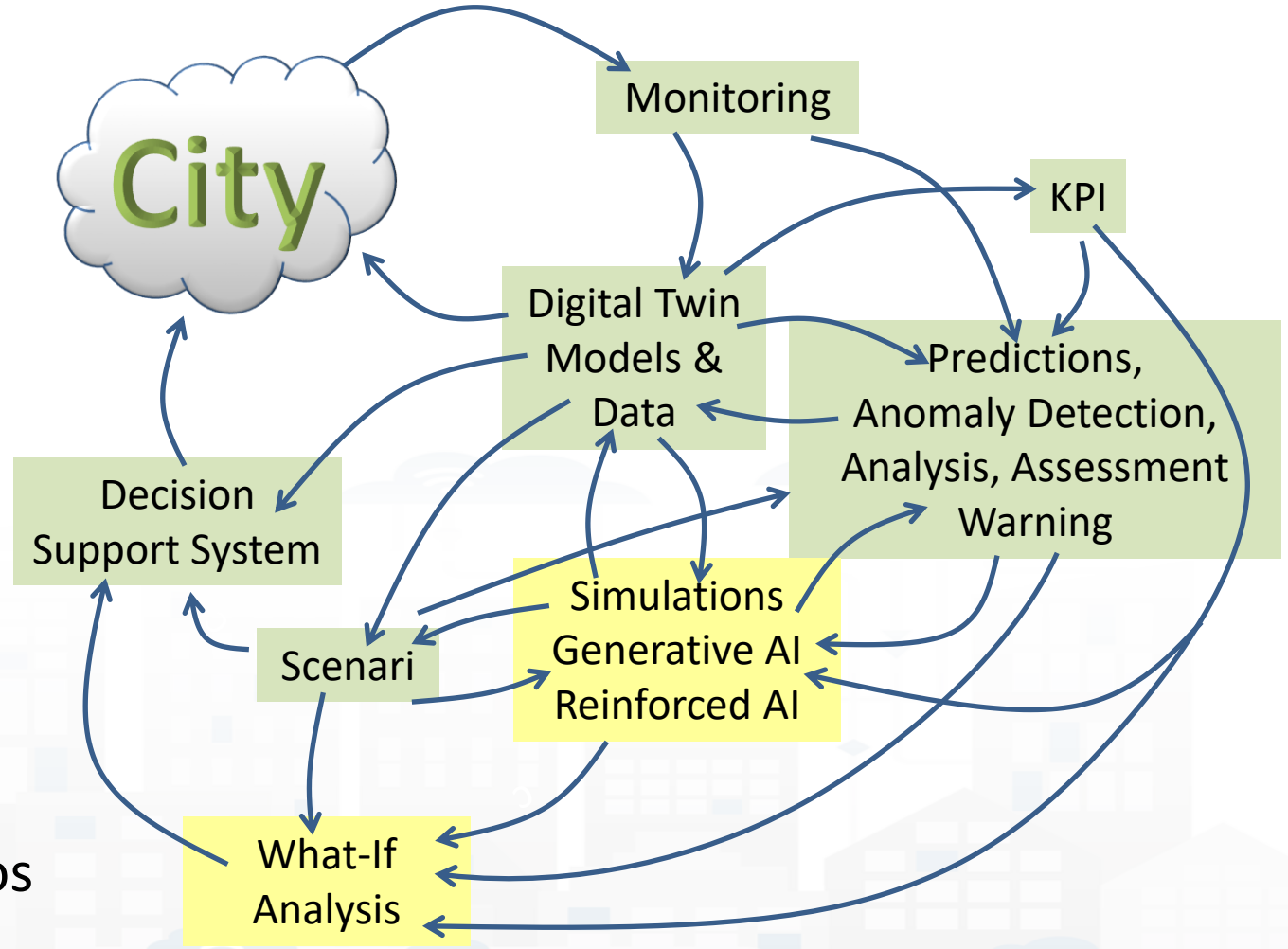
- Intuitive platform
- Any Data TYPE, any data source, any protocol
- Data storage seamless
- Data analytics → artificial intelligence, AI/XAI
- Data Ethics, AI Ethics, GDPR
- Data Representation, any kind
- Key Performance Indicators, any kind
- What-IF analysis – Simulation, prediction, 2D/3D
- Micro,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

Complex and heterogeneous information, interoperability

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

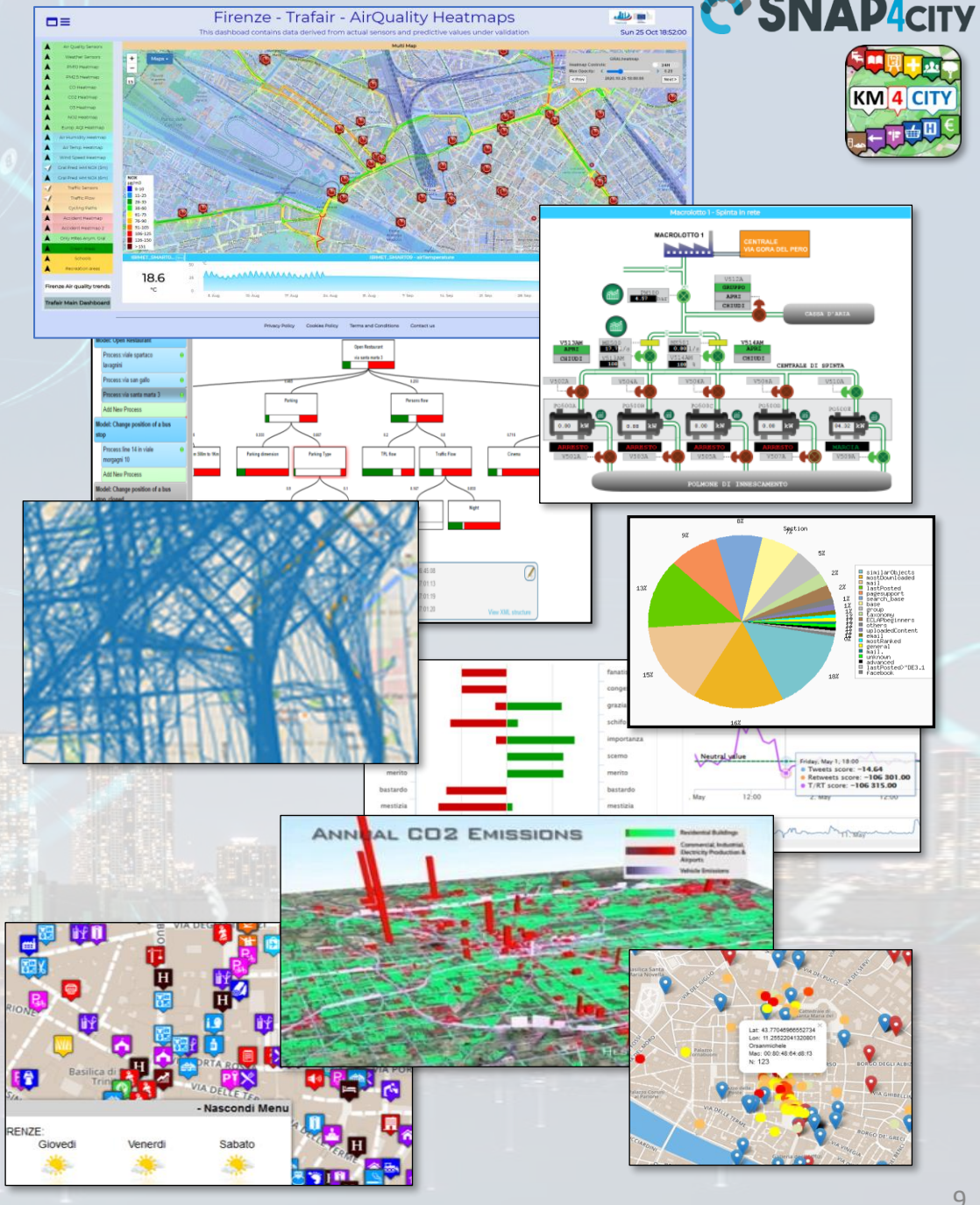
Main tasks

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



Data Driven Decision Support

- Decision Support system
- Assessment / Strategies
- Data Rendering,
  - visual analytics, business intel..
- Data Analytics, ML, AI
- Data aggregation, Storage, indexing
- Data Ingestion



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Snap4City

SNAP4CITY | KM4CITY

Smart Solutions and Decision Support Systems

100% OPEN SOURCE

Powered by FIWARE

FREE TRIAL

PEN Test Passed

EU GDPR COMPLIANT

SNAP4 Appliances and Dockers Installations

EUROPEAN OPEN SCIENCE CLOUD

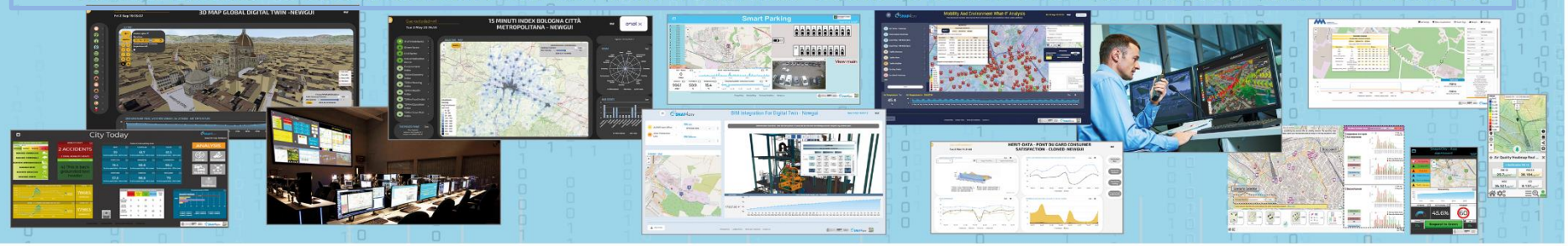
Node-RED

JS Foundation

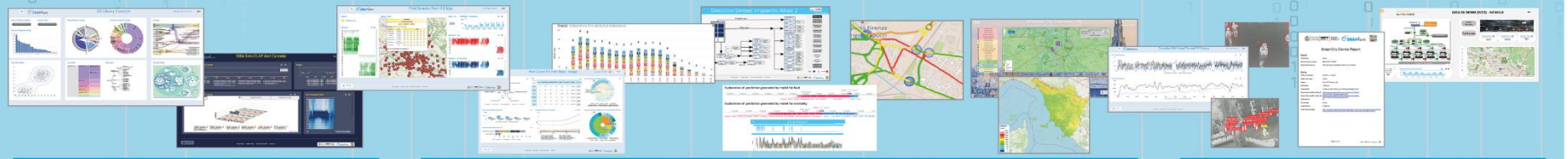
E015 digital ecosystem

NVIDIA

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



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

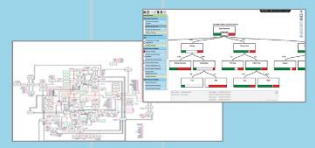


DASHBOARDS, WIDGETS
TEMPLATES

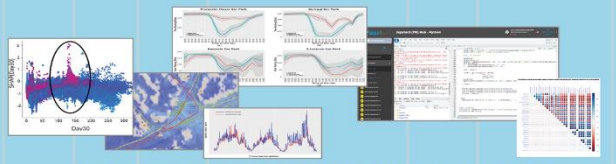
PREDICTION - ANOMALY DETECTION - CLUSTERING - ROUTING - SENTIMENT NLP - TRAFFIC FLOW
PEOPLE FLOWS - SDG - 15 MIN CITY INDEX - KPI - HEATMAPS - ORIGIN DESTINATION - ETC...

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

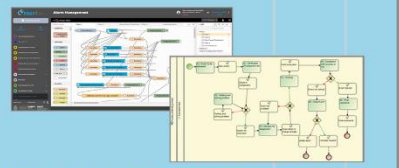
ANY: DATA, BROKER, NETWORK AND VERTICAL



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



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

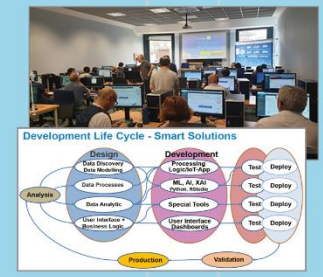


VISUAL PROGRAMMING, ADAPTERS
DATA FLOWS, WORKFLOWS
PARALLEL DISTRIBUTED PROCESSING
EVENT DRIVEN

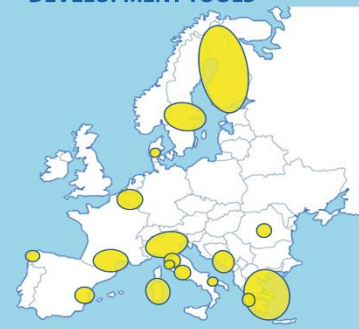
Native and External Smart Applications

- Mobility & Transport
- Light & Energy
- Waste | Environment
- Building | Tourism
- Asset Management
- Security and Safety
- Social Media

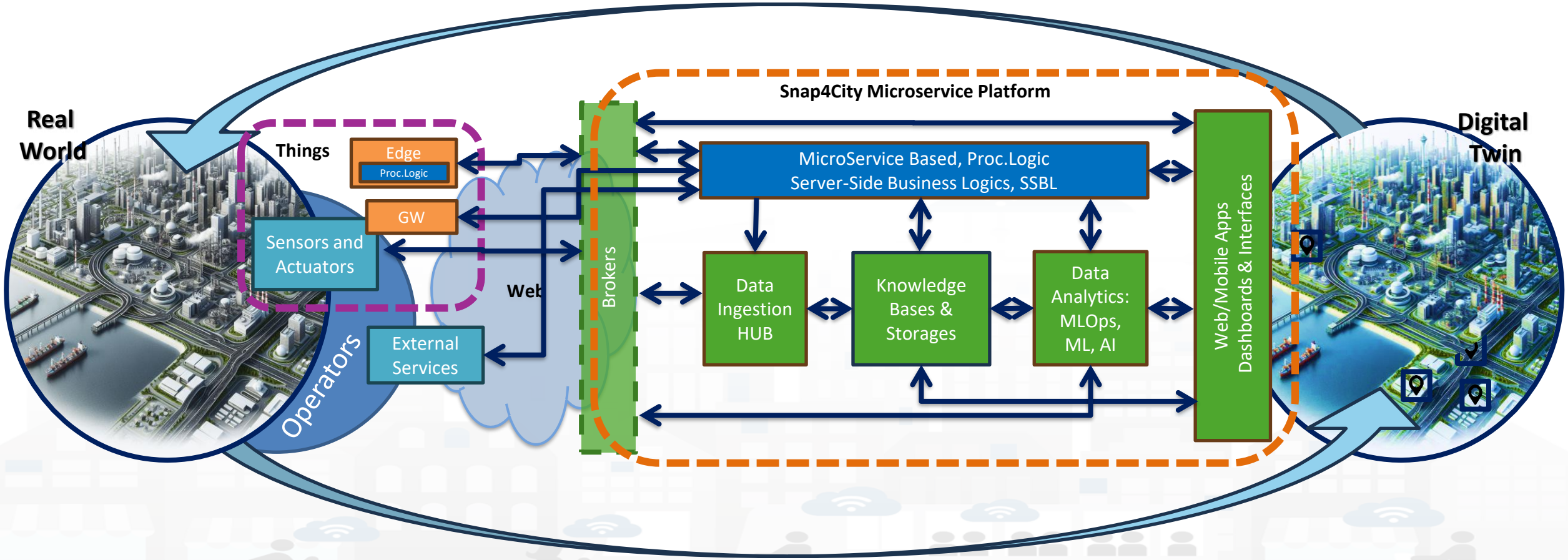
...



METHODOLOGIES
LIVING LABS
COURSES AND COMMUNITY
DEVELOPMENT TOOLS



Digital Twin Development Platform

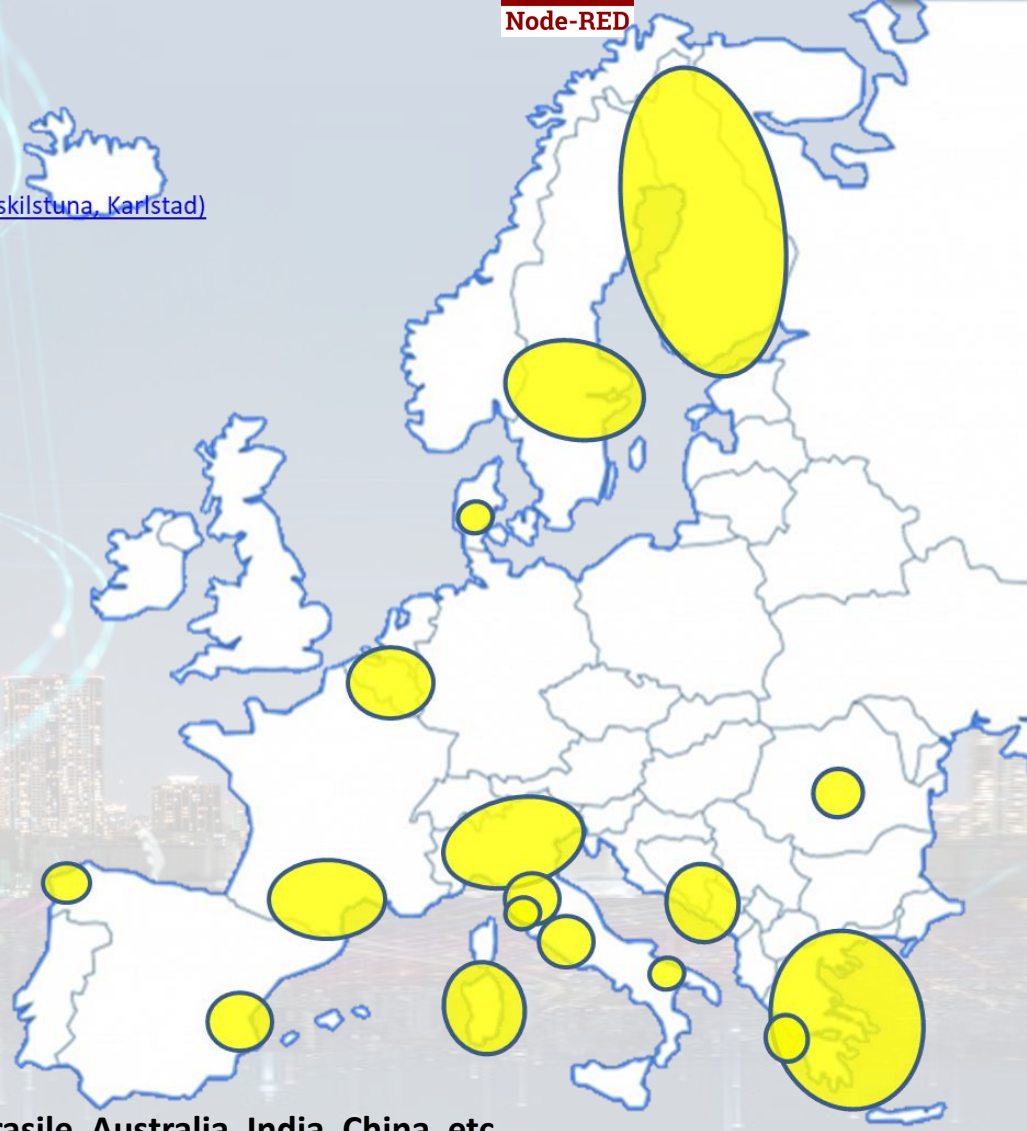


https://www.Snap4City.org

- 11 running installations in Europe
  - Snap4.city.org, Greece, Merano, …
  - Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
  - Altair, Italmatic, Sweden, Romania, ….
- 16 projects, 12 pilots on 10 Countries
  - >40 cities/area
- **Widest MULTI-tenant deploy has**
  - 19 Organizations / tenant
  - > 8000 users on
  - > 1600 Dashboards
  - > 16 mobile Apps
  - **> 2.2 Million of structured data per day**
  - > 520 IoT Applications/node-RED
  - > 700 web pages with training
  - > 70 videos, training videos

Main Organizations/areas

- Antwerp area (Be)
- Bologna (I)
- Brasov (Ro)
- 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)
- Merano (I)
- Modena (I)
- Mostar, Bosnia-Herzegovina
- Oslo & Padova (Impetus)
- Pisa area (I)
- Pistoia (I)
- Pont du Gard, Occitanie (Fr)
- Prato (I)
- Roma (I)
- Santiago de Compostela (S)
- Sardegna Region (I)
- Siena (I)
- SmartBed (multiple)
- Toscana Region (I), SM
- Valencia (S)
- Venezia area (I)
- WestGreece area (Gr)



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

Standards and Interoperability (6/2023)

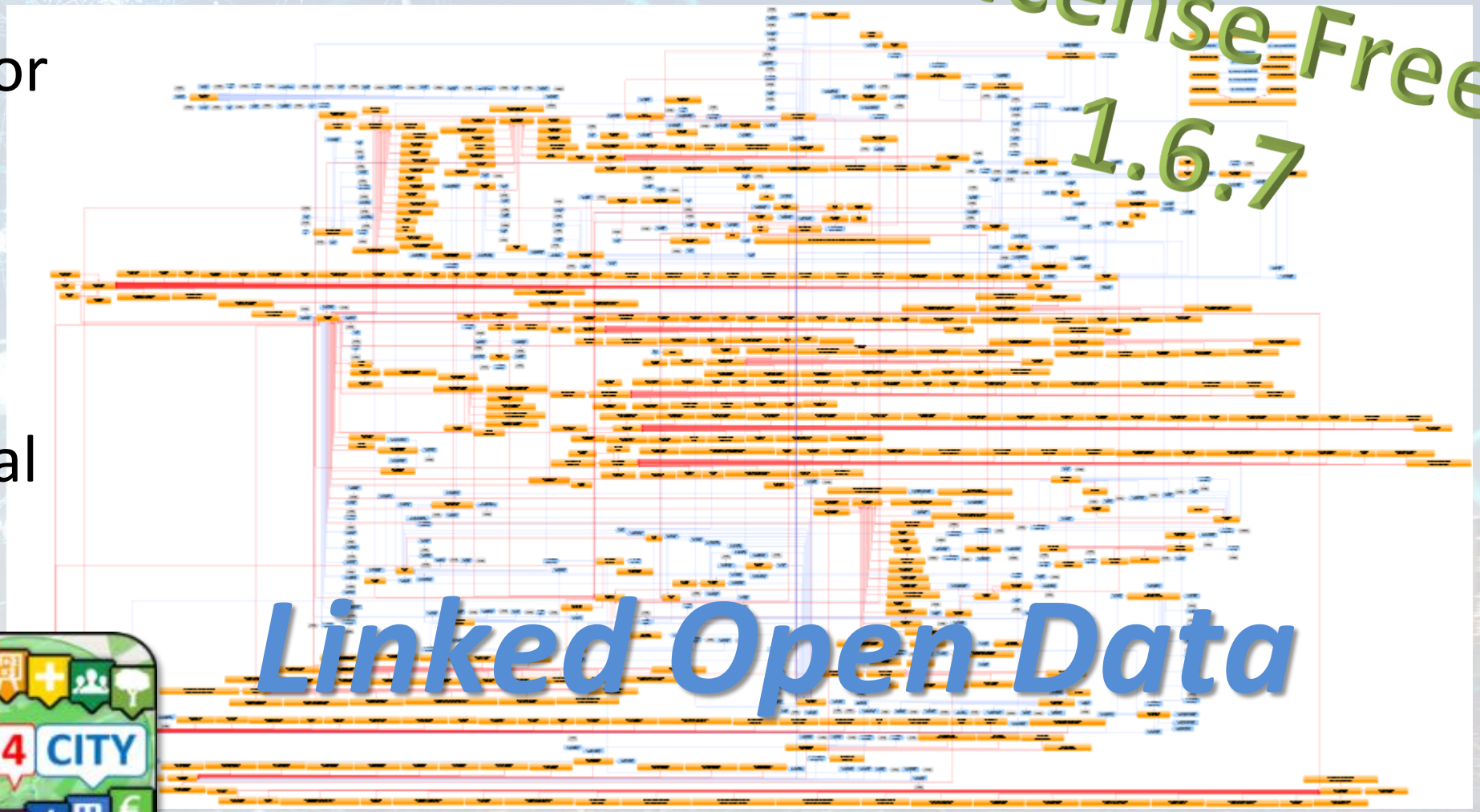
Compliant with:

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

https://www.snap4city.org/65

Expert System semantic queries

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

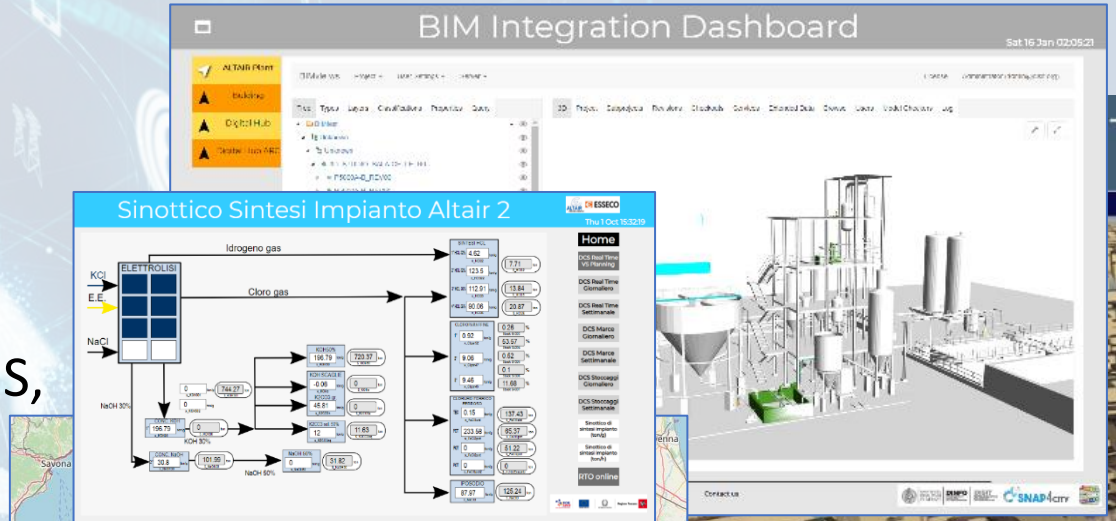


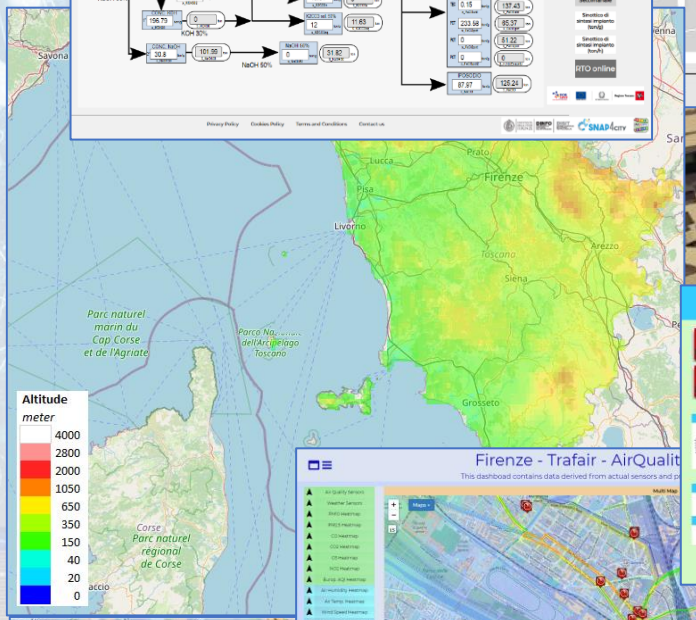
https://www.snap4city.org/19

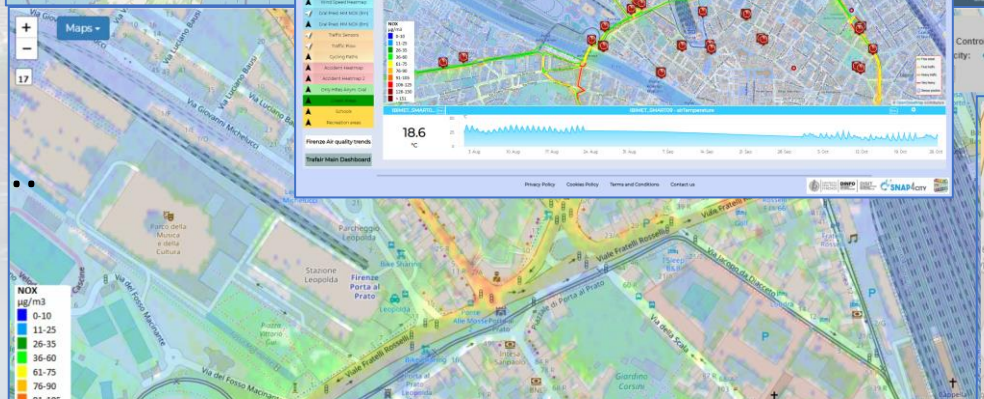
High Level Types

Snap4City (C), June 2024

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

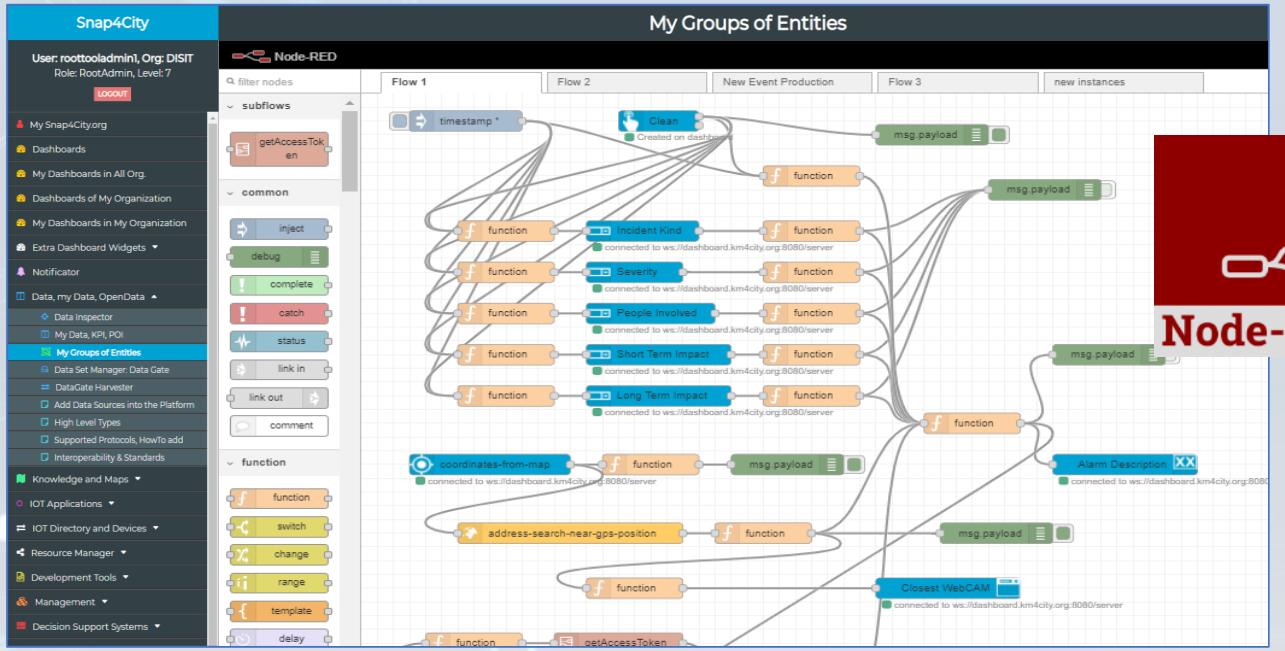


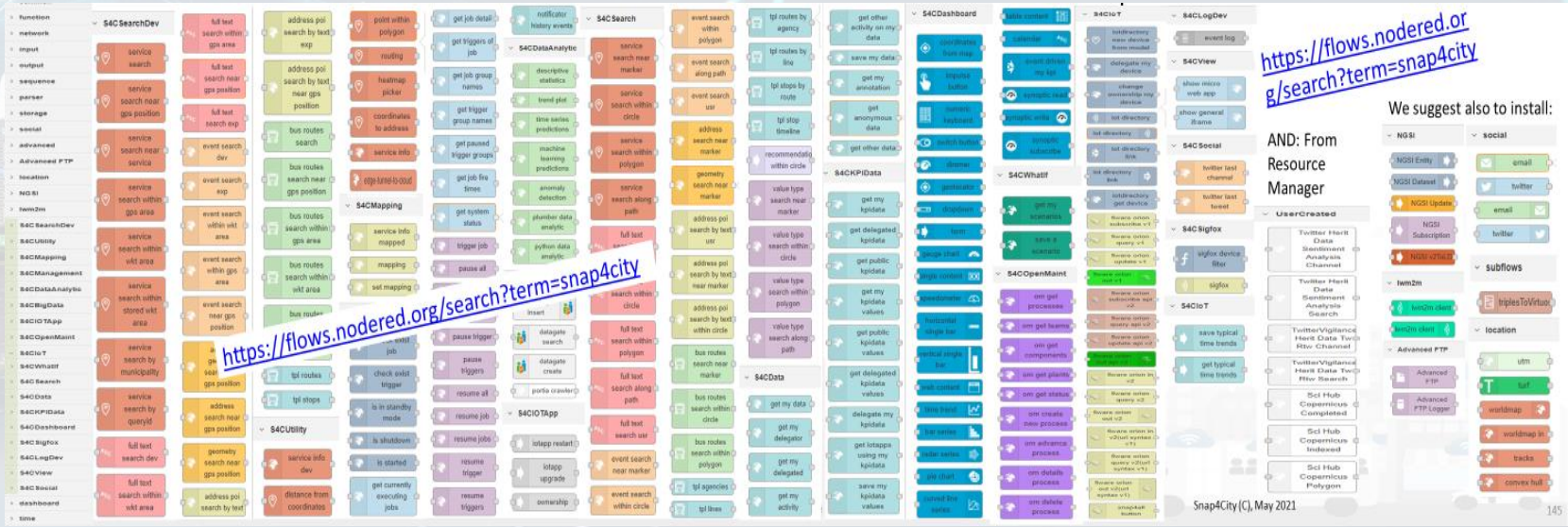




Ingestion, aggreg. → exploitation

- **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

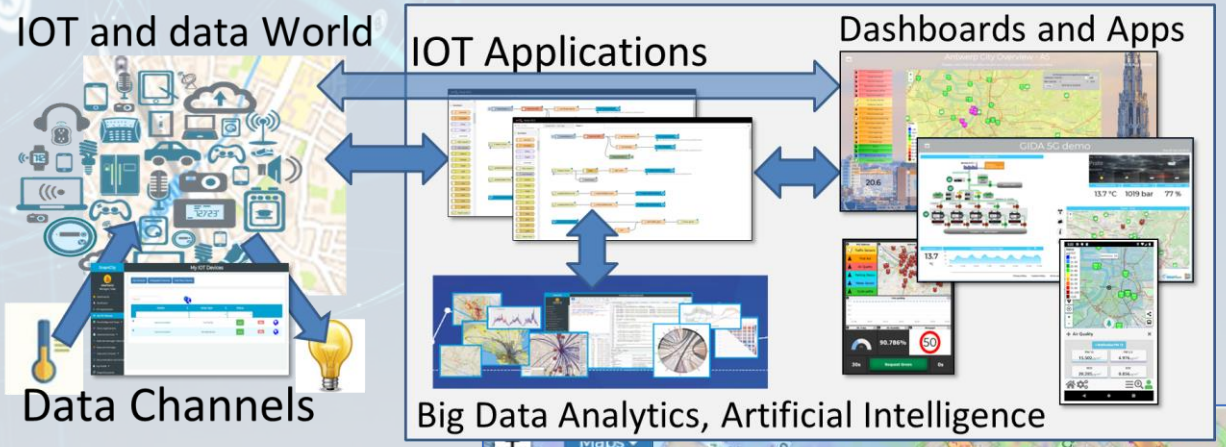


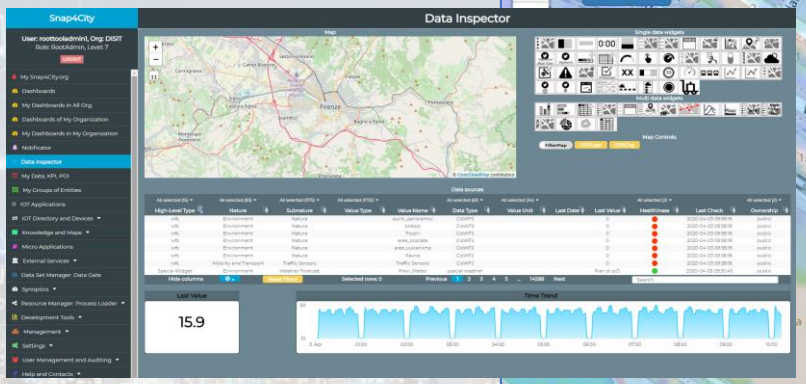


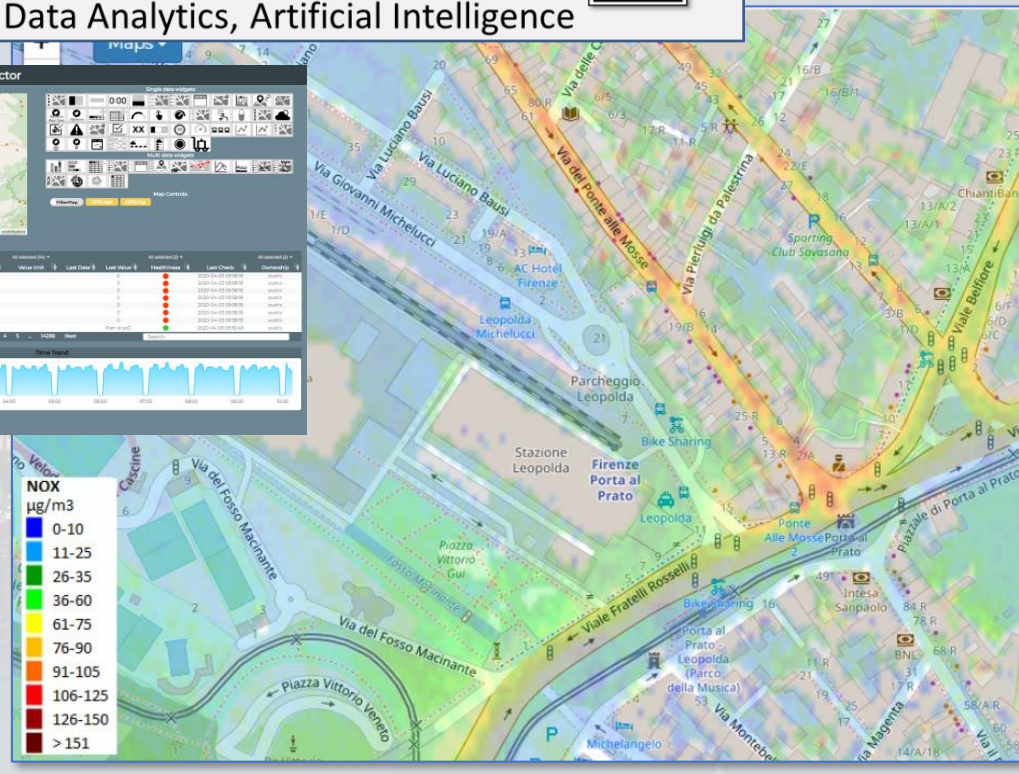
Solutions: reliable, secure and fast to realize

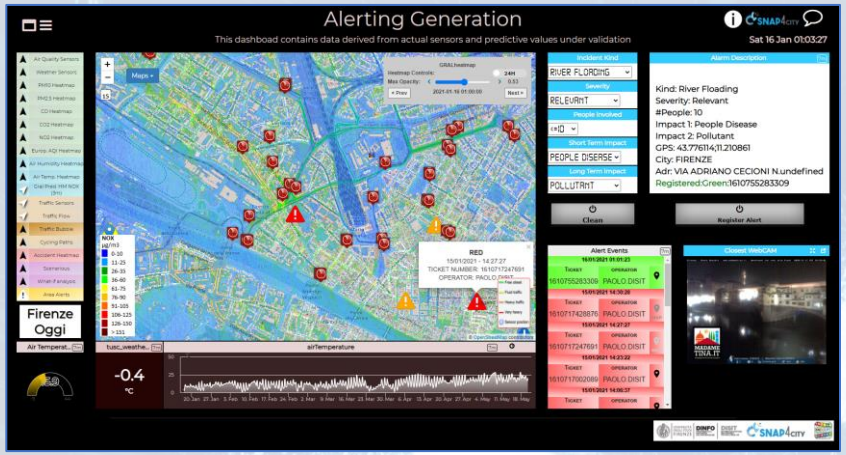
- **Via Snap4City tools**
  - **Dashboard Wizard**
  - **Dashboard Builder**
  - **Data/Visual Analytic**

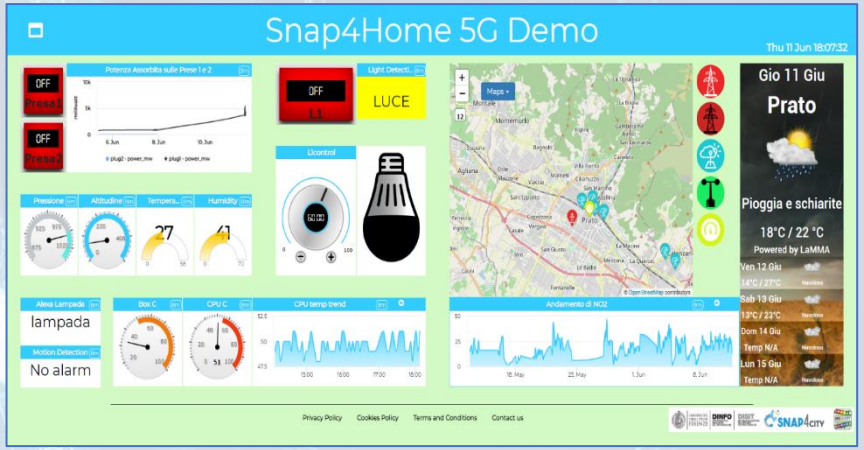
- **Smart Solutions results to be**
  - **Real time data drive**
  - **Secure end-to-end**
  - **GDPR compliant**
  - **Reliable, interoperable**
  - **Auditable, marketable**

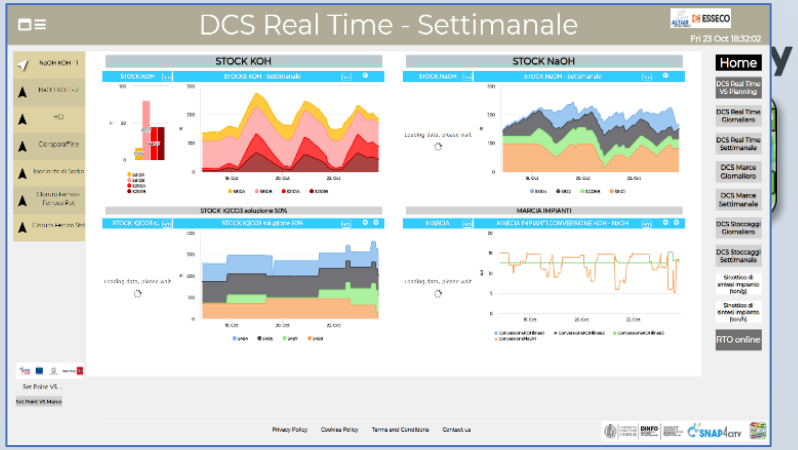


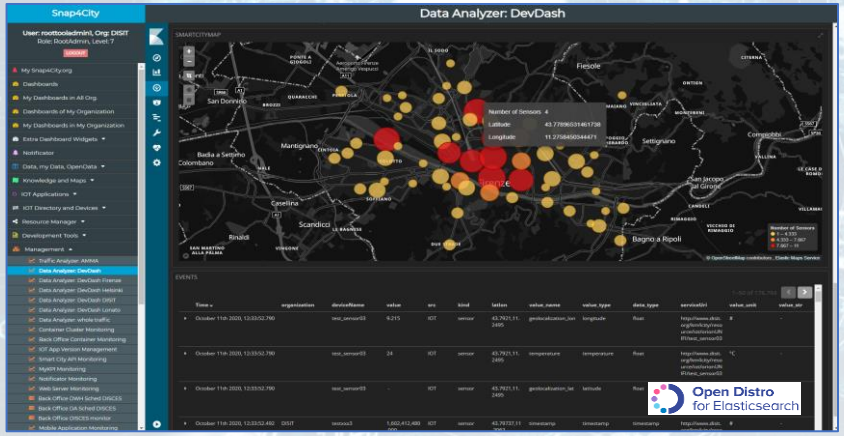


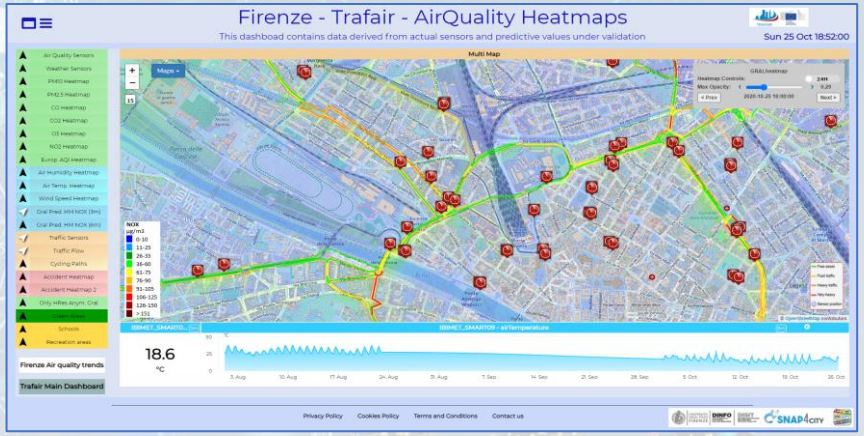


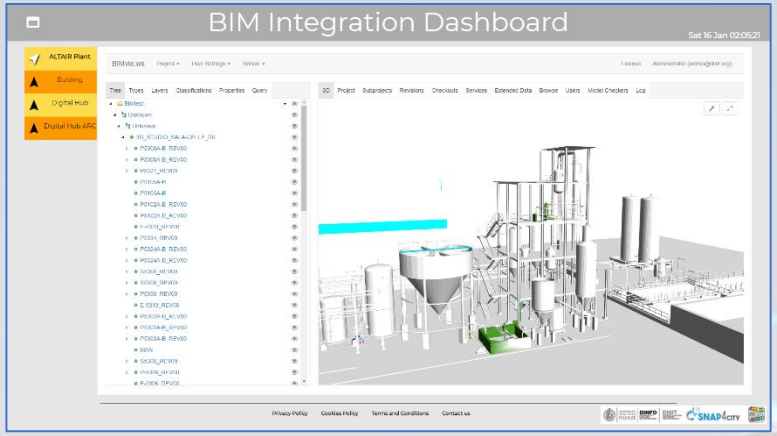

Alerting Generation
This dashboad contains data derived from actual sensors and predictive values under validation
Sat 16 Jan 01:03:27
Firenze Oggi
-0.4


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

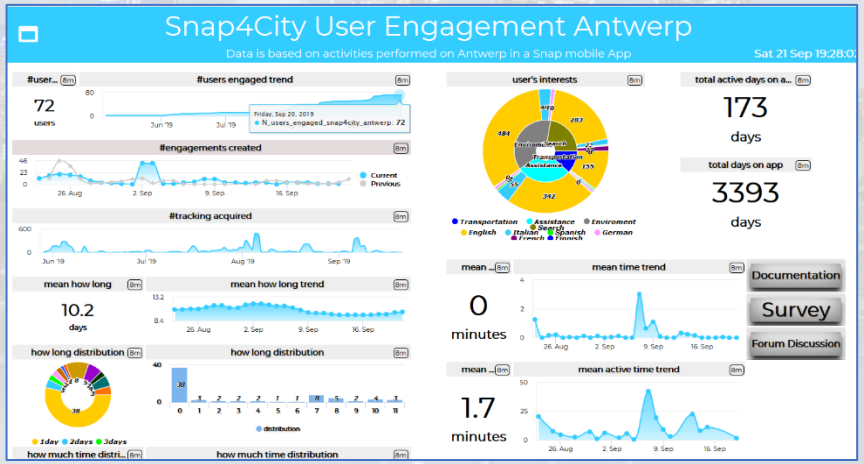

DCS Real Time - Settimanale
Fri 23 Oct 18:32:02
STOCK KOH
STOCK NaOH
Home

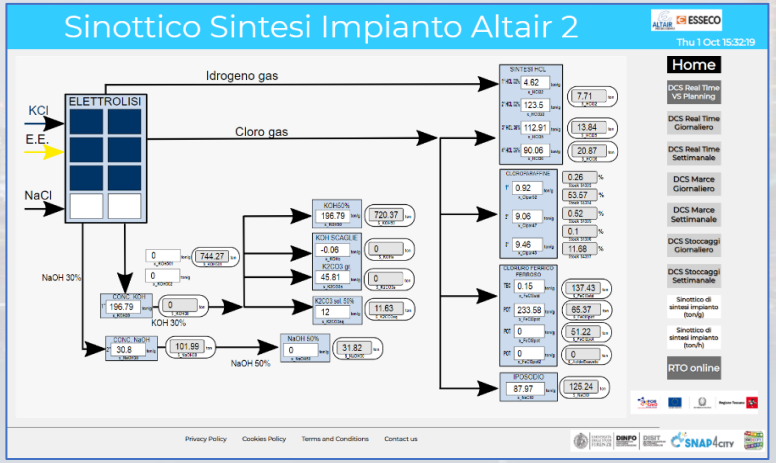

Data Analyzer: DevDash
Open Distro for Elasticsearch


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

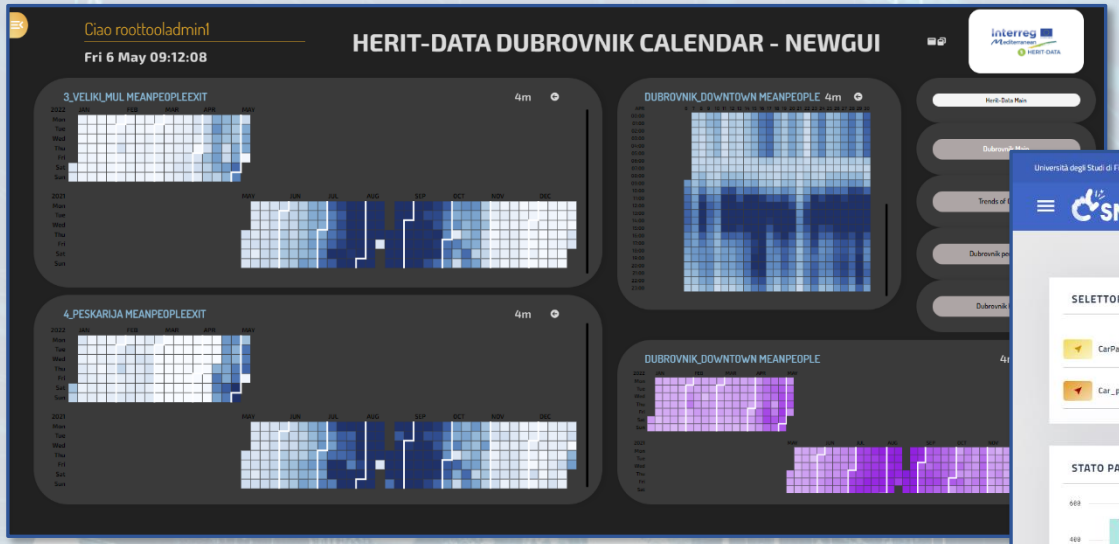

BIM Integration Dashboard
Sat 16 Jan 02:05:21

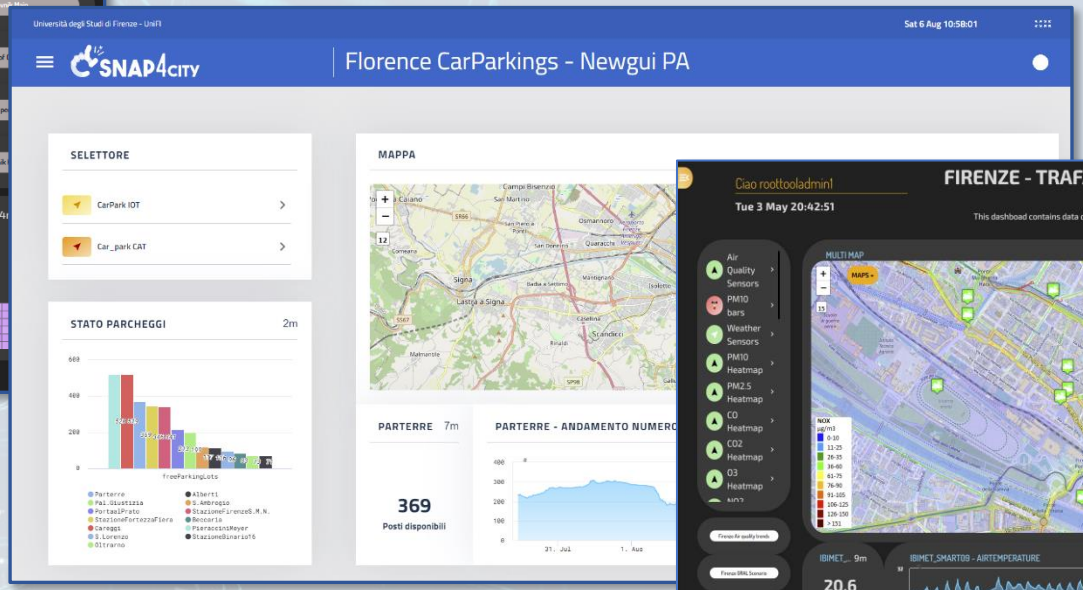
3D Multi Data Map - Digital Twin Global - Firenze
demonstrator
Sun 3 Apr 16:03:52
192

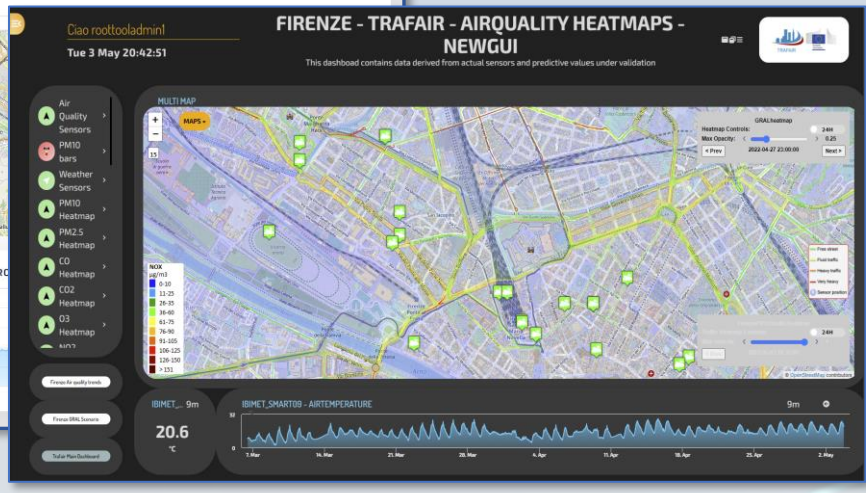

Snap4City User Engagement Antwerp
Data is based on activities performed on Antwerp in a Snap mobile App
Sat 21 Sep 19:28:0
72
users
173
days
3393
days
0
minutes
1.7
minutes
Documentation
Survey
Forum Discussion

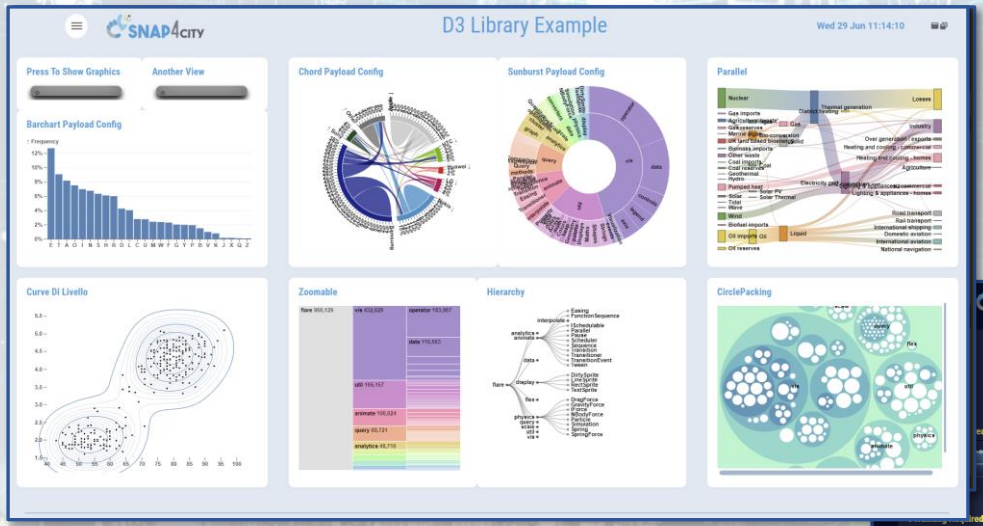

Sinottico Sintesi Impianto Altair 2
Thu 1 Oct 15:32:19
Home
Idrogeno gas
Cloro gas
ELETTROLISI
KCl
E.E.
NaCl
NaOH 30%
KOH 30%
NaOH 50%

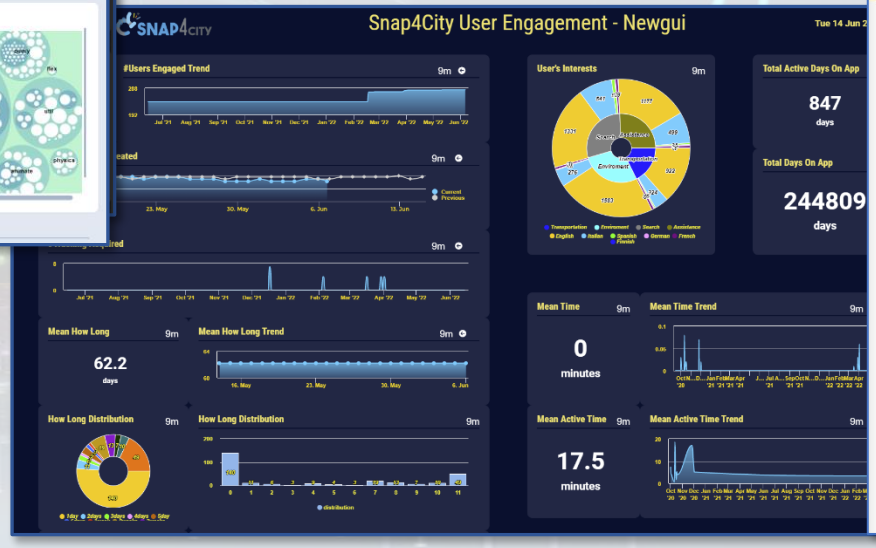
Different Themes

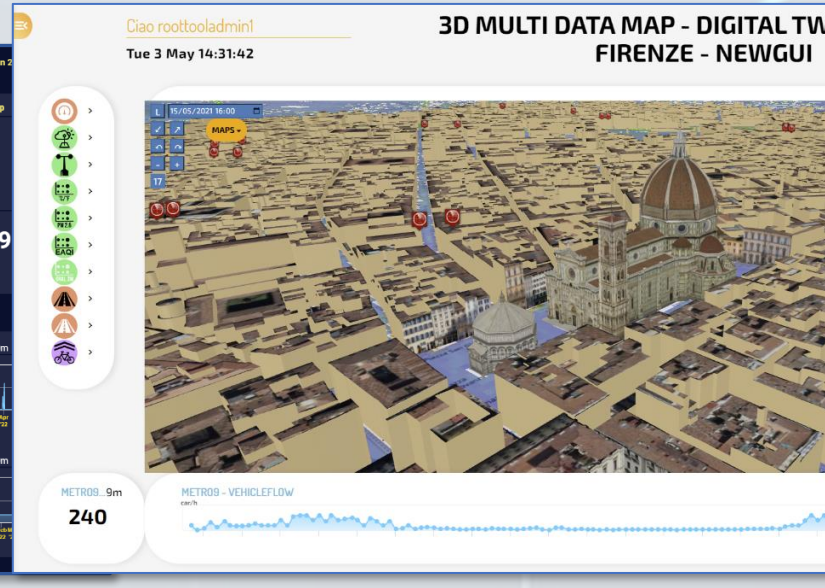












New styles/themes can be developed by specializing a few files from open source

https://www.snap4city.org/793

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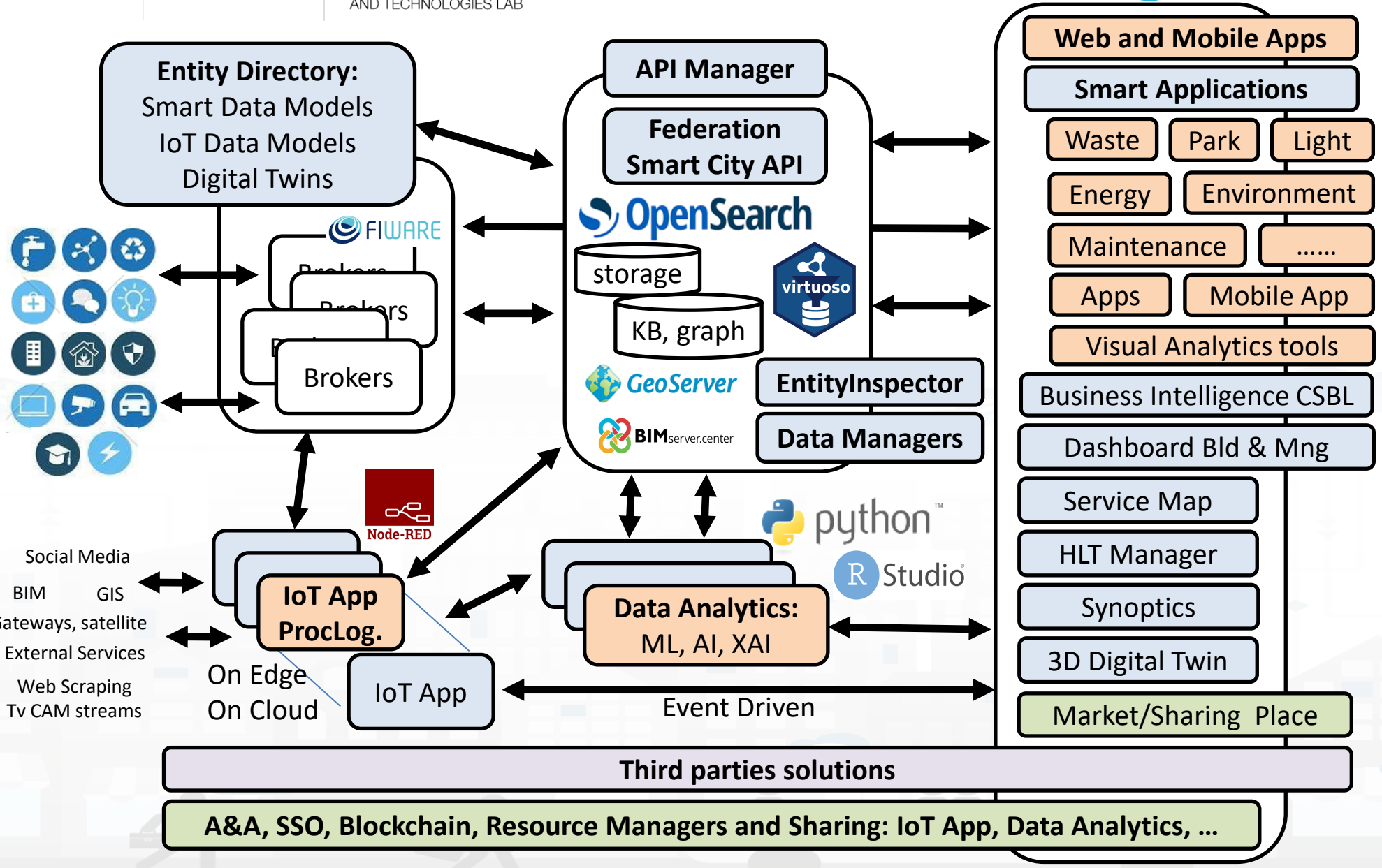
DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB

Tech Arch

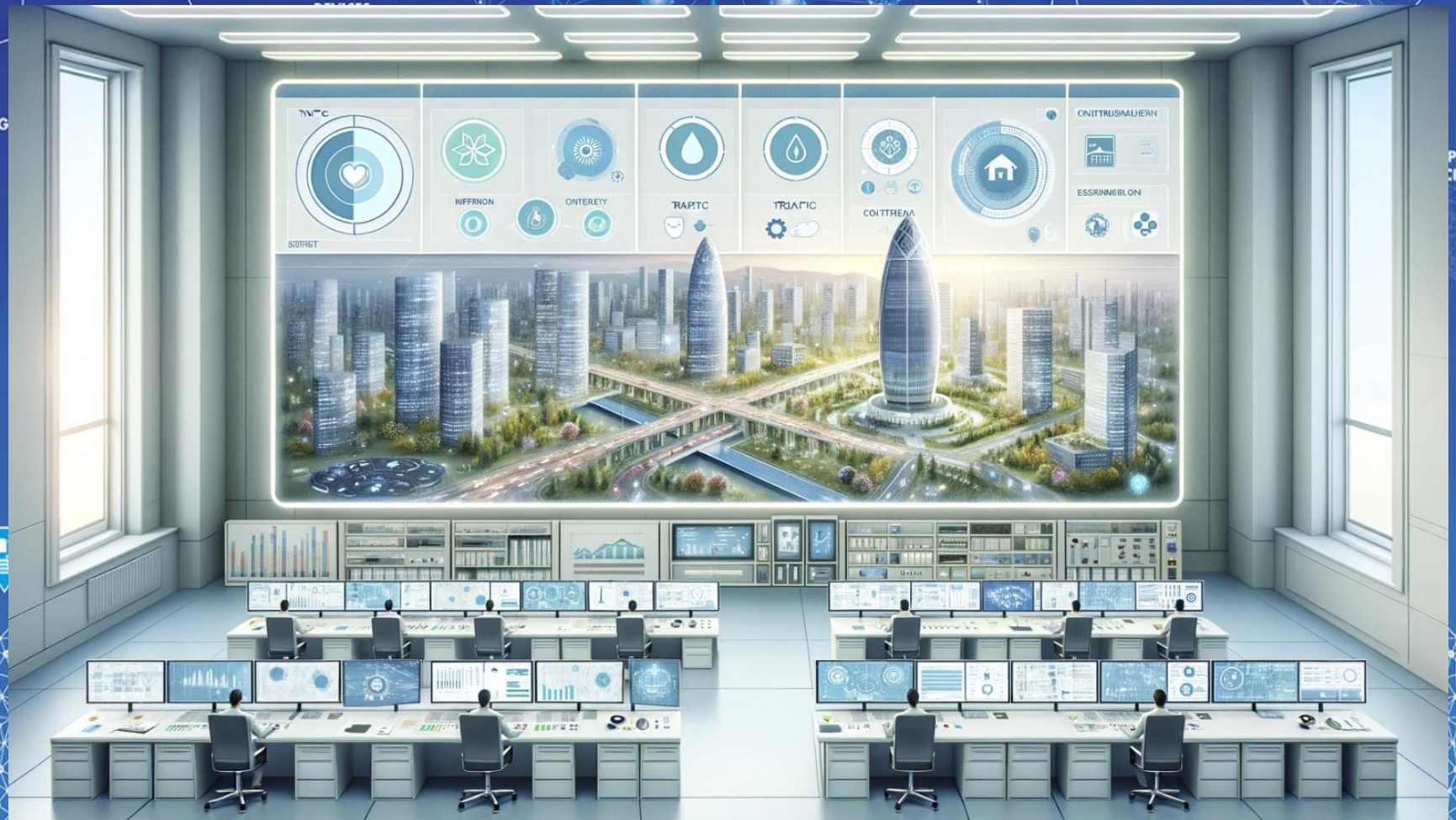
SNAP4CITY

KM4CITY



TOP

Monitoring and control



FROM CITY DASHBOARD TO APPLICATIONS

DATA GATHERING AND CITY DATA KNOWLEDGE MANAGEMENT

IOT APPLICATIONS VS IOT EDGE

TWITTER VIGILANCE: SOCIAL MEDIA ANALYSIS

TO DEVELOPERS AND STAKEHOLDERS

SNAP4CITY AND KM4CITY PROJECTS

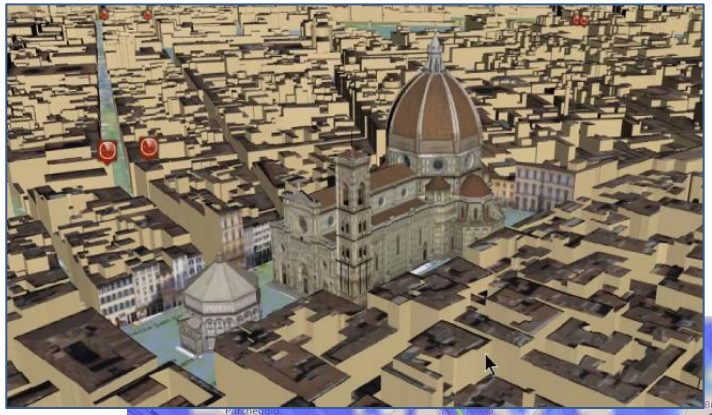
HOW TO ADOPT SNAP4CITY, AND OUR ROADMAP

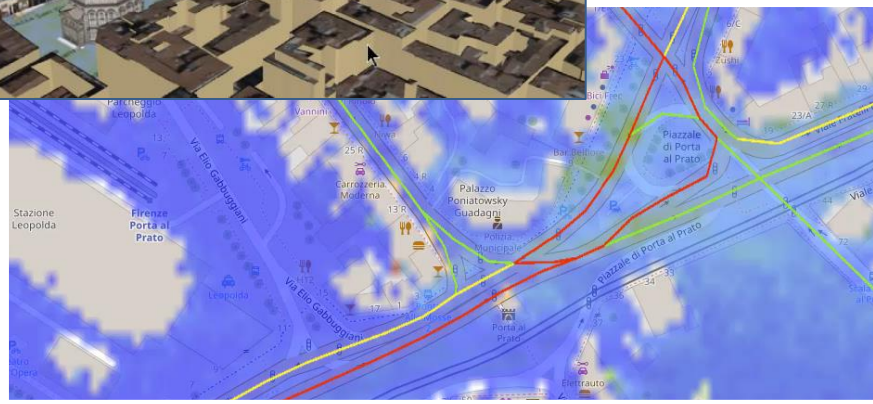
SNAP4CITY THE VIEW OF THE ADMINISTRATORS

100% OPEN SOURCE

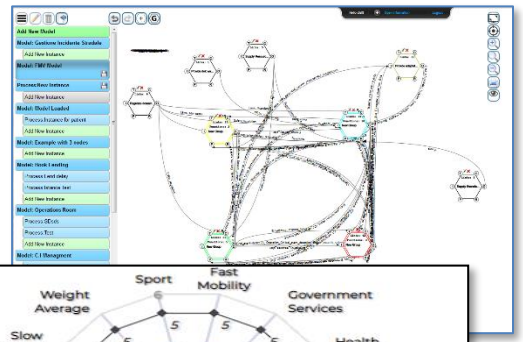
Monitoring

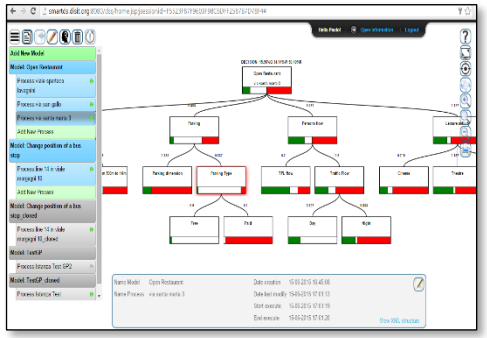
- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Computing predictions and KPI
  - Anomaly detection, Early warning
  - Control Rooms, situation rooms
- **Reacting: Computing in real time**
  - Changing semaphore maps
  - Changing Dynamic signage
  - Real time Info Mobility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

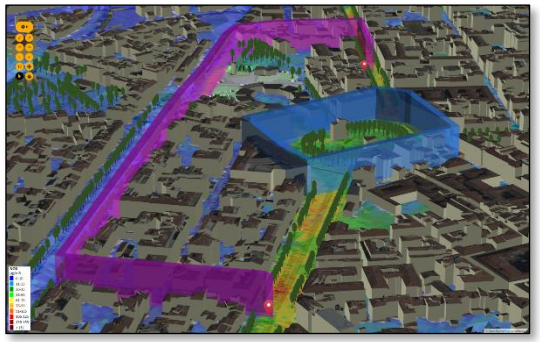


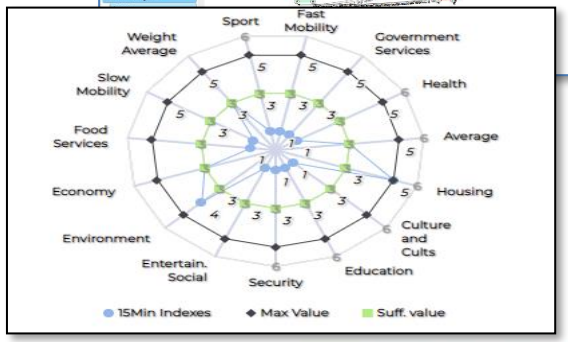


ERMG: European Resilience Management Guide









CRAMSS
Collaborative Resilience Assessment and Management Support System

MONITORING

- Big Data Platform
- IoT/IoE/Open Data
- Real Time Dashboard
- Resilience Control Room
- Data Analytics
- Early Warnings
- Urban Traffic Manager Data Exchenge

LEARNING

- Human Behavior Analysis
- Predictive Analytics
- Urban Transport System Dynamic Analysis
- Resilience Quantification
- Network Analysis

ANTICIPATING

- European Resilience Management Guidelines
- Game Based Training

RESPONDING

- Smart Decision Support Systems (DSS)
- Evacuation Decision Support
- Smart Intelligent Transport Systems
- Emergency Support Smart App
- Resilience DSS

Early Warning, Detection

Issue:

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

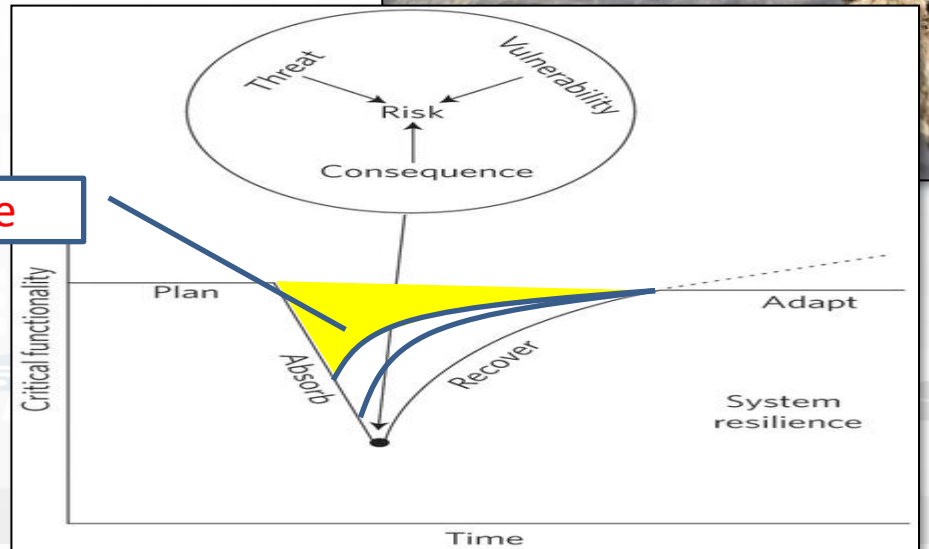
Impact:

- Early warning, faster reaction
- Increased resilience

Several metrics related to:

- Volume of retweets
- Sentiment analysis

Prepare
Absorb
Recover
Adapt



Key Performance Indicators, KPI

Air Quality Directive				WHO guidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
$PM_{2.5}$	One day			25 µg/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	

- **United Nations Sustainable Development Goals, SDGs** (for which cities can do more to achieve some of the 17 SDGs, https://sdgs.un.org/goals);
- **15 minutes cities** (where primary services must be accessible within 15 minutes on foot);
- **objectives of the European Commission** in terms of pollutant emissions for: NO2, PM10, PM2.5 (https://environment.ec.europa.eu/topics/air_en);
- **SUMI: mobility and transport vs env**
  - **https://www.snap4city.org/951**
- **SUMP/PUMS: mobility and transport vs env.**
- **ISO indicators:** city smartness, digitization, tech level.
- **Low Level/Real Time:** global traffic, quality of service, betweenness, centrality, queue, time to travel, etc.

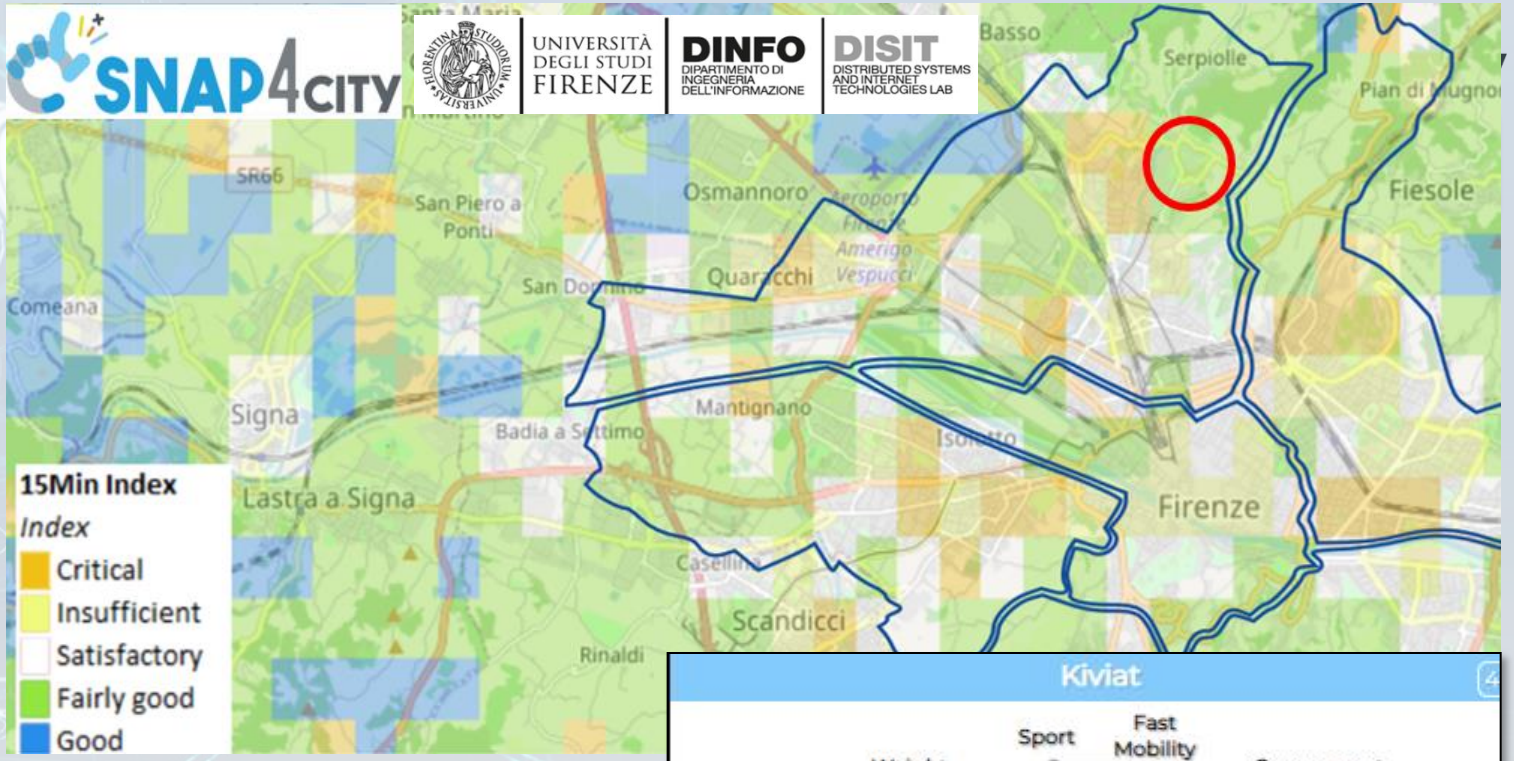
Global & Local

Periodic & Realtime

15MinCityIndex

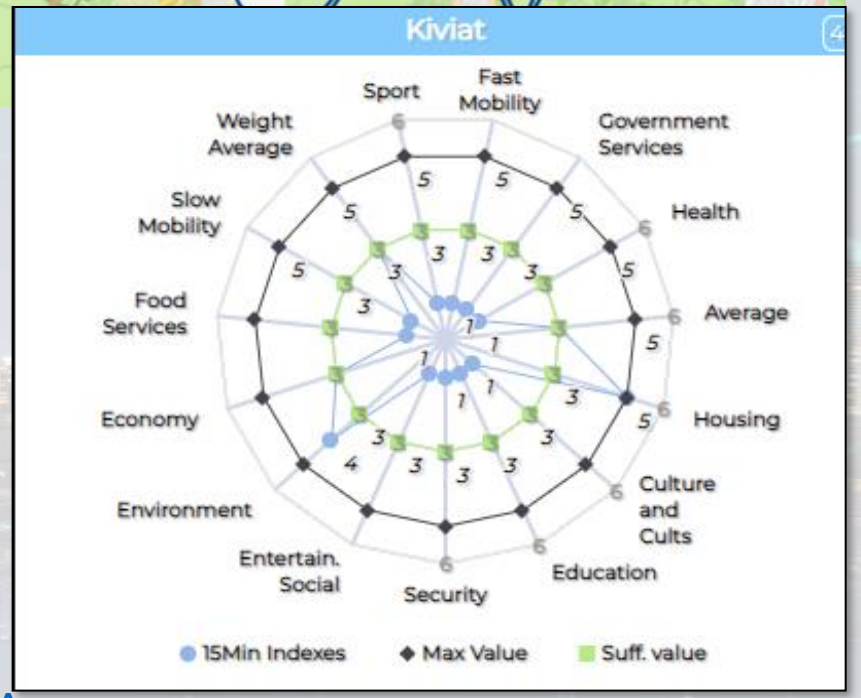
What would support my neighborhood to become a 15-Minute City?

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



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

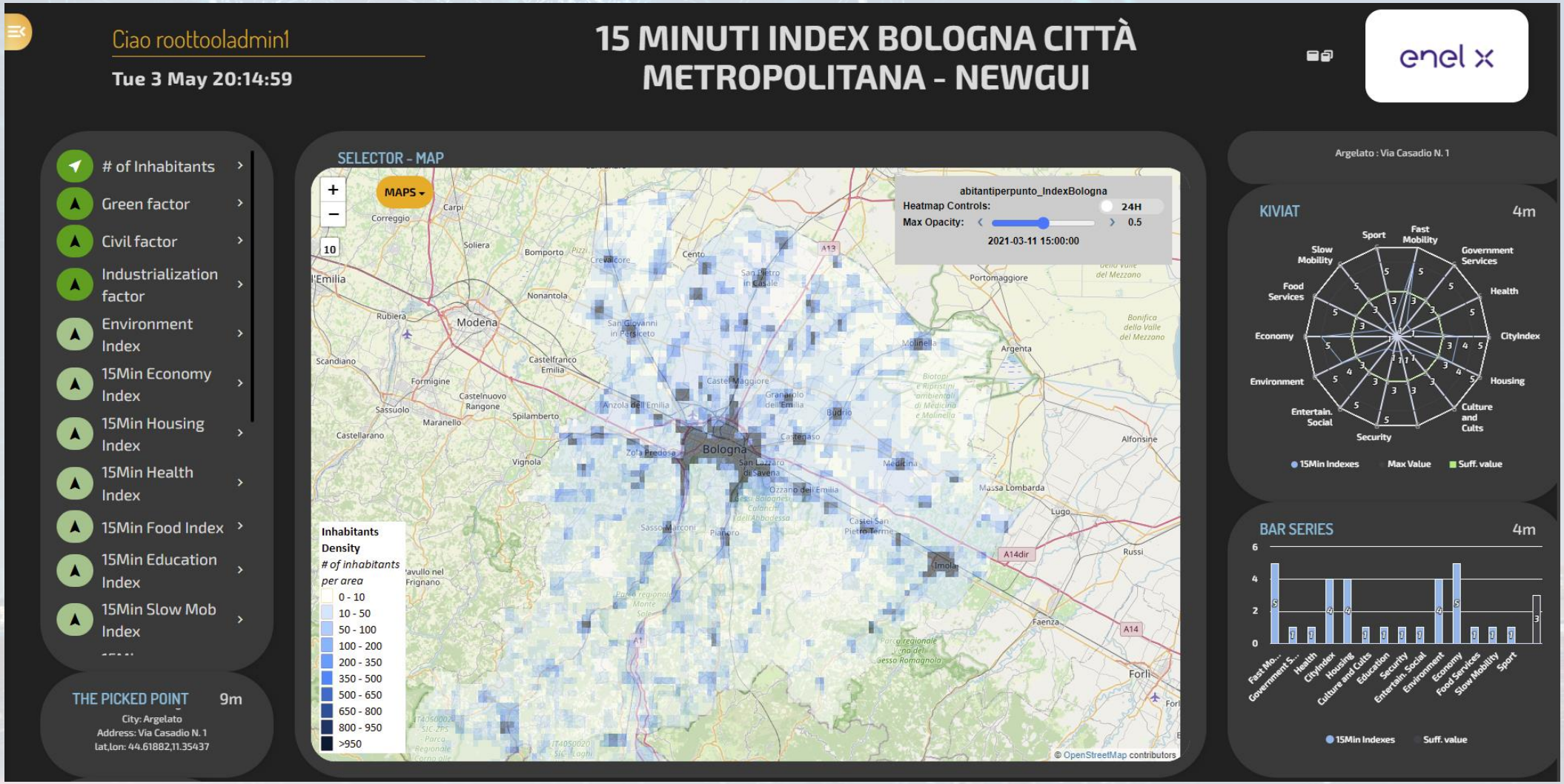
The tool supports the becoming of a 15-Minute city evaluating the service level in various domains.



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==

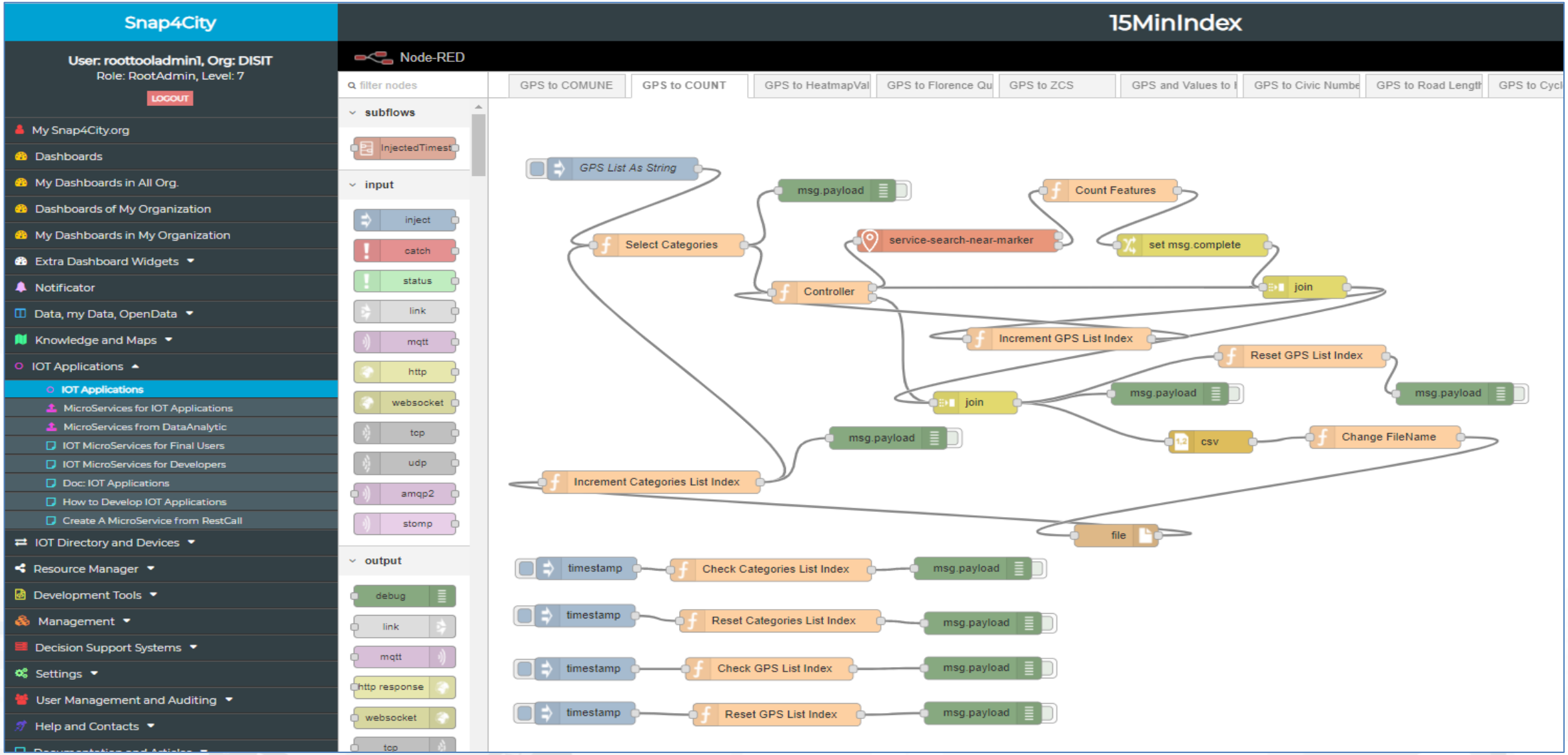
15MinCityIndex on Bologna



1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
7 AFFORDABLE AND CLEAN ENERGY
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
15 LIFE ON LAND

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

IoT App....

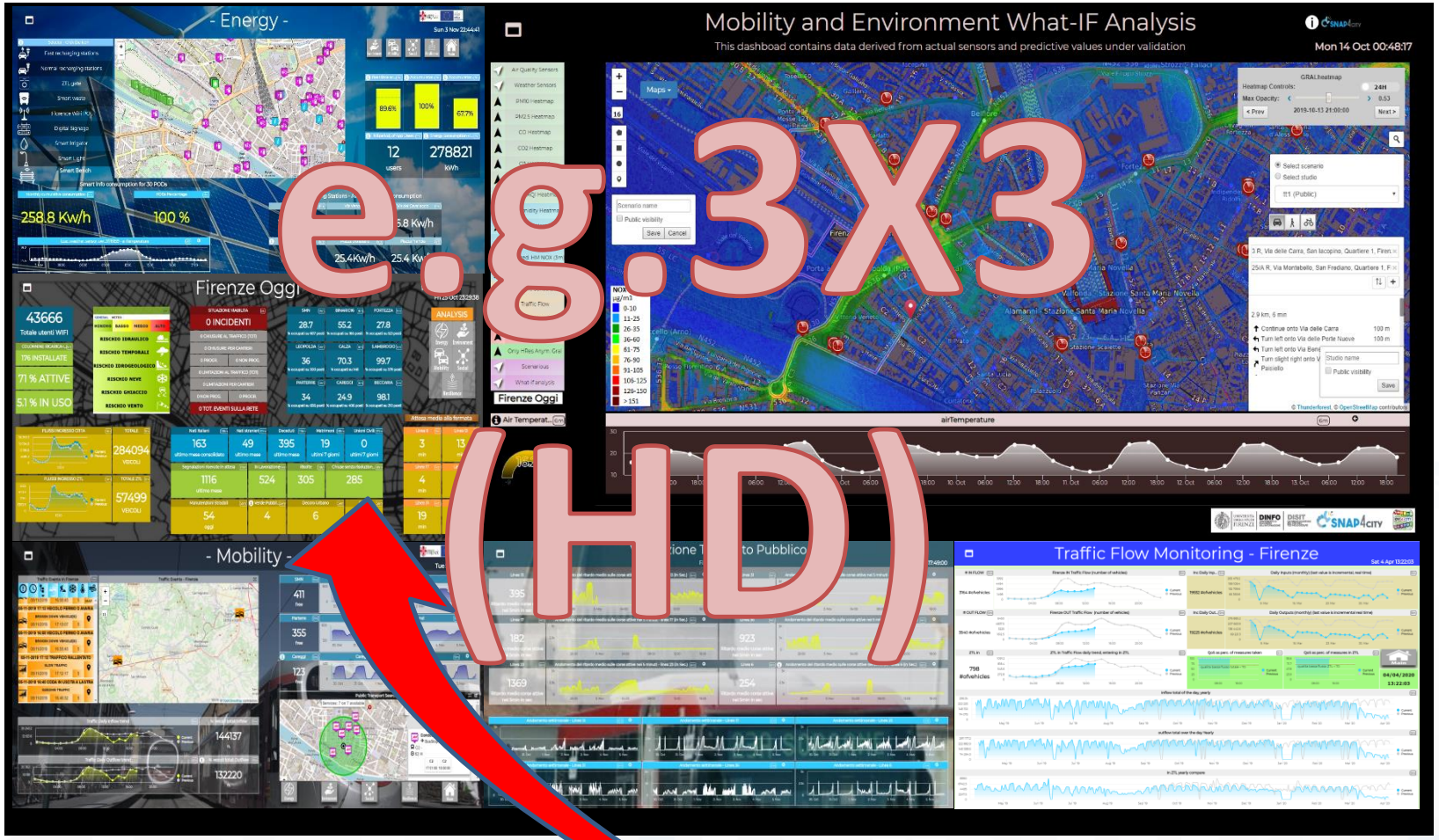

Snap4City
User: roottooladmin1, Org: DISIT
Role: RootAdmin, Level: 7
LOGOUT
My Snap4City.org
Dashboards
My Dashboards in All Org.
Dashboards of My Organization
My Dashboards in My Organization
Extra Dashboard Widgets
Notificator
Data, my Data, OpenData
Knowledge and Maps
IOT Applications
IOT Applications
MicroServices for IOT Applications
MicroServices from DataAnalytic
IOT MicroServices for Final Users
IOT MicroServices for Developers
Doc: IOT Applications
How to Develop IOT Applications
Create A MicroService from RestCall
IOT Directory and Devices
Resource Manager
Development Tools
Management
Decision Support Systems
Settings
User Management and Auditing
Help and Contacts
15MinIndex
Node-RED
filter nodes
subflows
InjectedTimest
input
inject
catch
status
link
mqtt
http
websocket
tcp
udp
amqp2
stomp
output
debug
link
mqtt
http response
websocket
tcp
GPS to COMUNE
GPS to COUNT
GPS to HeatmapVal
GPS to Florence Qu
GPS to ZCS
GPS and Values to
GPS to Civic Numbe
GPS to Road Length
GPS to Cycl
GPS List As String
msg.payload
Count Features
Select Categories
service-search-near-marker
set msg.complete
Controller
join
Increment GPS List Index
Reset GPS List Index
join
msg.payload
msg.payload
msg.payload
csv
Change FileName
Increment Categories List Index
file
timestamp
Check Categories List Index
msg.payload
timestamp
Reset Categories List Index
msg.payload
timestamp
Check GPS List Index
msg.payload
timestamp
Reset GPS List Index
msg.payload

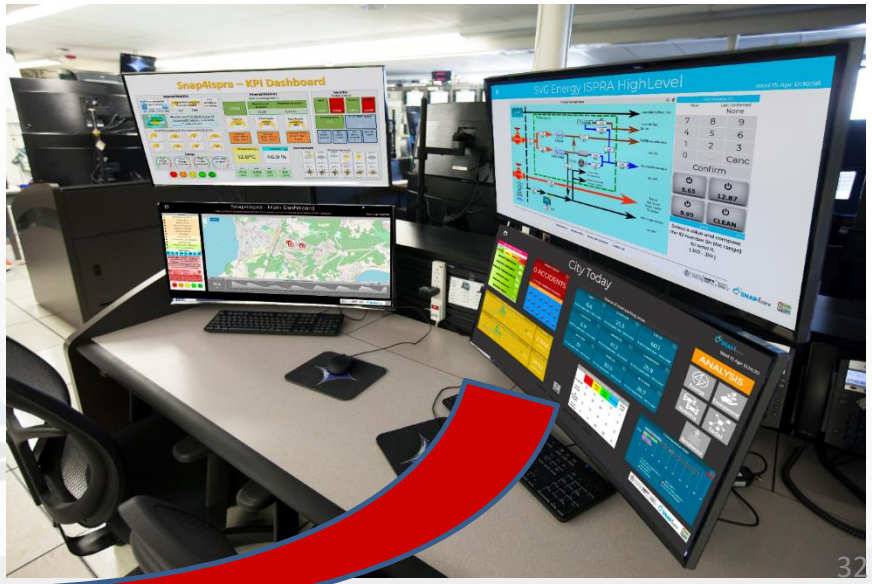
Real Time: control room, monitoring

- **Video Wall:** physical and virtual:
  - control room but also distributed control room: web and mobile views
- **Many Decision Makers** that have to
  - Early Warning: receiving real time notifications in push, telegram, etc.
  - share the same view monitoring a specific situation
    - may be located in multiple places
    - may be connected by using multiple kind of devices
  - Chatting privately on the same context
  - Receiving in real time the same changes and events

Control Room

Video Wall





From Consolle Operator to the Video Wall

SNAP4CITY
3D Global Digital Twin - 2023bt
KM 4 CITY
°C/°F
PM 2.5
EAQI
GRAL 3M
Free street
Fluid traffic
Heavy traffic
Very heavy
Sensor position
Air Quality FI-BASSI - NO2
New York
Paris
Rome
Tokyo

Smart City Control Room
Florence Metropolitan City

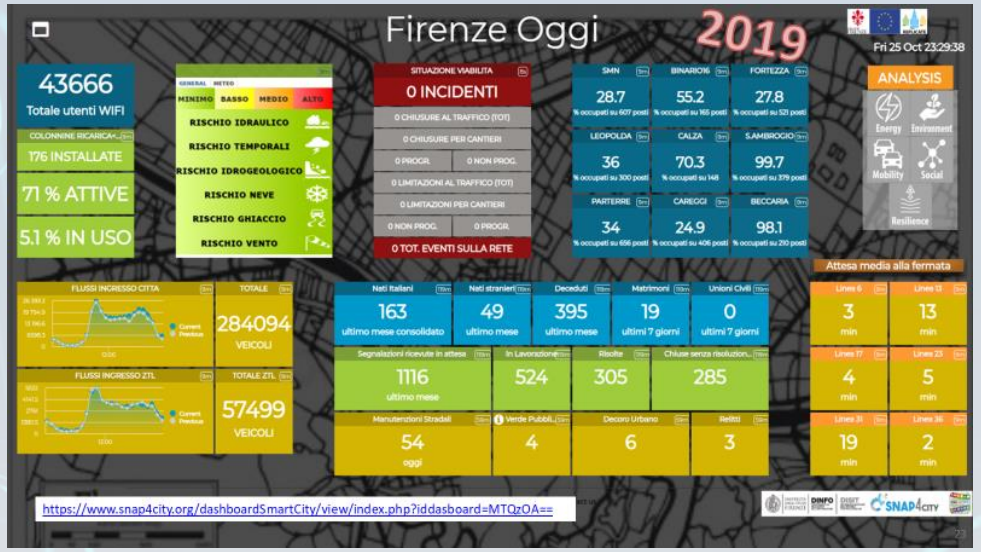
COMUNE DI FIRENZE

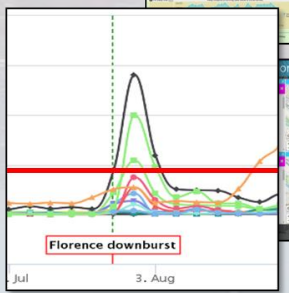
reference

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

Snap4City
Dashboard Management Syst
Dashboard Management Syst
Nuova scheda
snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTQzOA==
Ospite
Firenze Oggi
Mon 16 May 12:59:27
20991
COLONNINE
SITUAZIONE VIABILI
0 INCIDENTI
0 CHIUSURE AL TRAFFICO (TOT)
0 CHIUSURE PER CANTIERI
0 PROGR.
0 NON PROG.
0 LIMITAZIONI AL TRAFFICO (TOT)
0 LIMITAZIONI PER CANTIERI
0 NON PROG.
0 PROGR.
0 TOT. EVENTI SULLA RETE
SMN
42.2
BINA...
54.5
FORT...
23.2
LEOP...
37.3
CALZA...
48
S.AM...
58.6
PART...
55
CARE...
13.8
BECC...
77.6
ANALYSIS
Energy
Environment
Mobility
Social
Resilience
FLUSSI INGRESSO CIT
TOTA...
92207
FLUSSI INGRESSO ZTL
TOTA...
15964
Nati italiani
175
Nati s...
48
Dece...
499
Matri...
72
Unio...
2
Manutenzioni Strad...
19
Verd...
18
Decoro Urba...
3
Reiti...
5
Indicatore Rt per la provincia di
Rt
0.94
Linea...
Linea...
Linea...
Linea...
Linea...
Linea...
The European House
Ambrosetti

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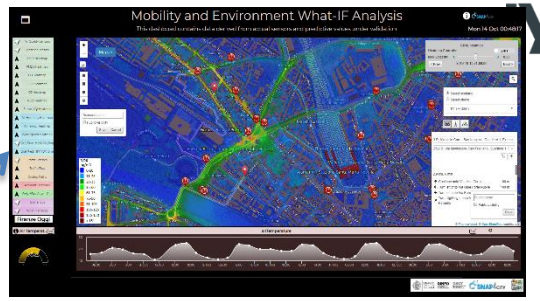
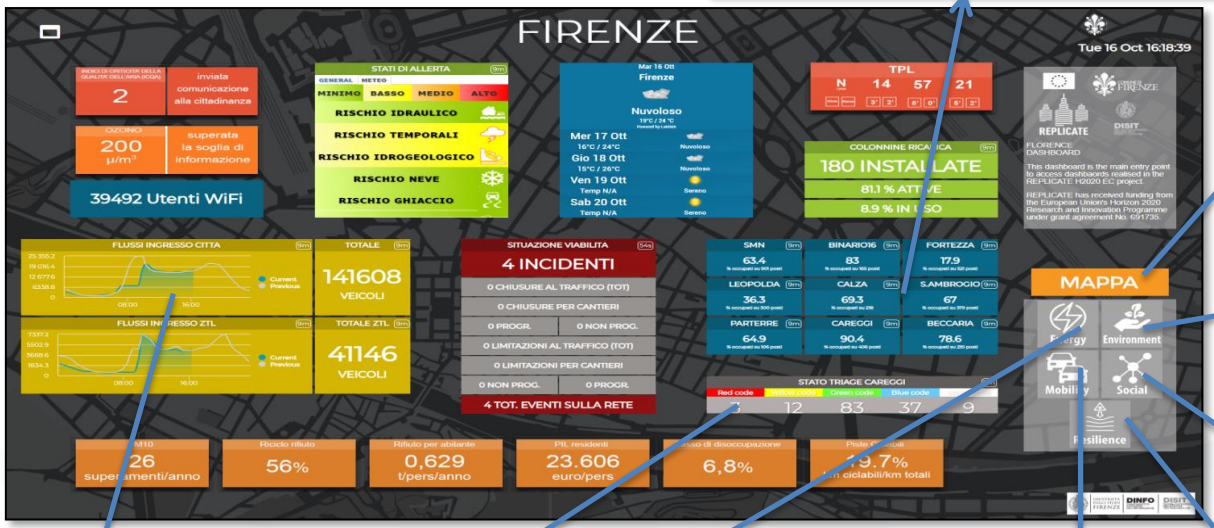
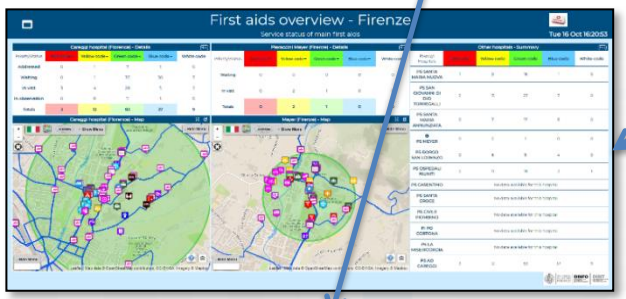
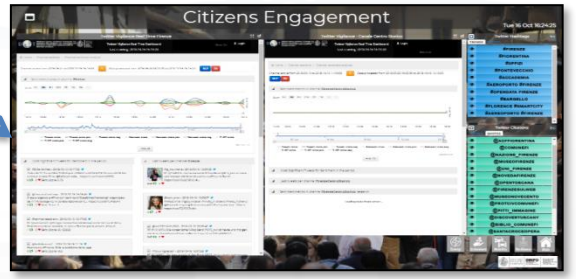
REPLICATE

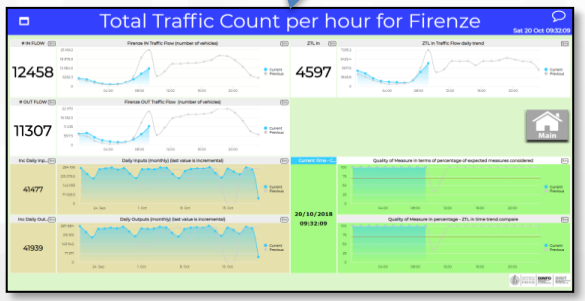
KM4CITY

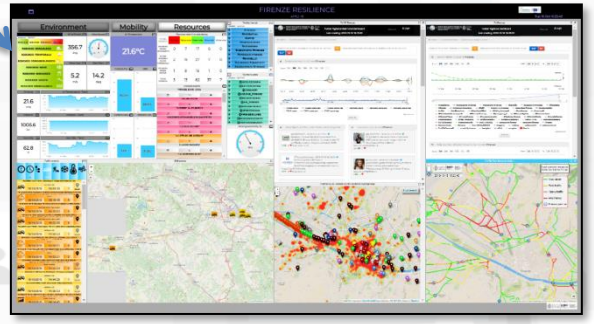












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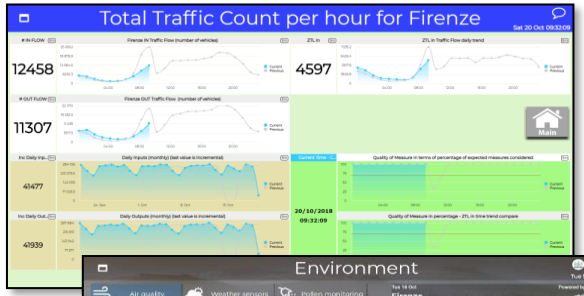
Florence Case

SNAP4CITY | KM4CITY

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

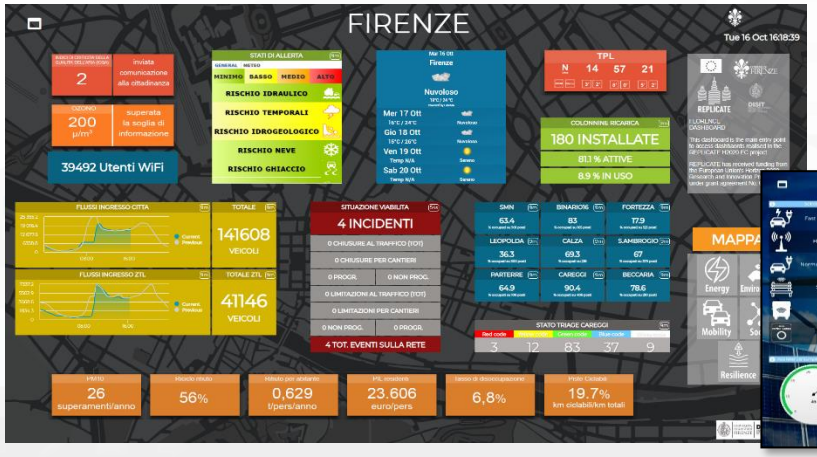


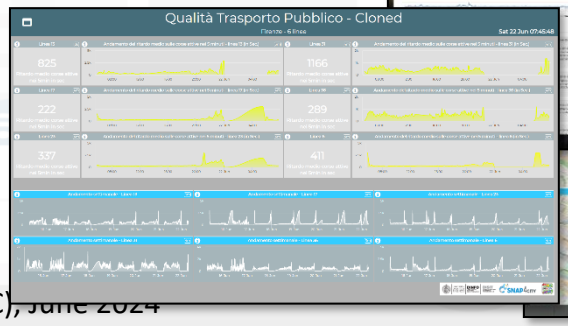
- **Mobility**:
  - quality of public transportation service (mean delay on bus-stops)
  - public transport operators schedule and paths, routing, multimodal routing
  - traffic flow reconstruction
  - Smart parking: predictions
  - Accidents and events, Log, heatmaps
- **Environment**:
  - smart irrigators
  - 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

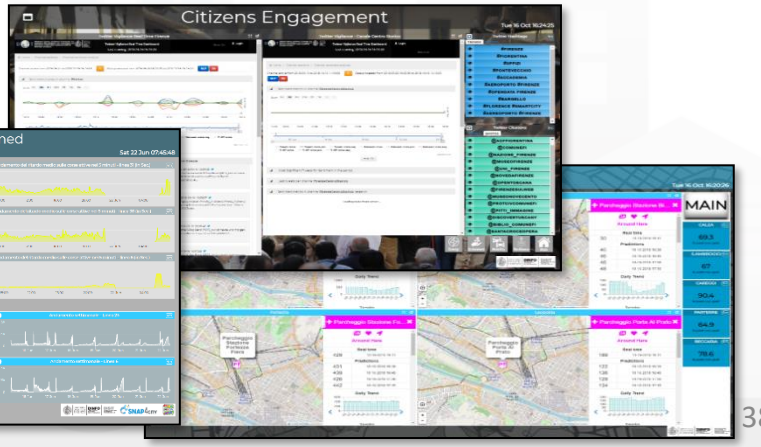
- **Social**:
  - smart benches
  - Twitter monitoring, Sentiment analysis, NLP text
  - TV camera streams
- **People Flows**:
  - Wi-Fi, people flow
  - Origin destination matrices
- **Governmental and Communications**:
  - KPI of the City
  - Digital Signage
  - Civil protection, Resilience (Resolute)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

Analysis:

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





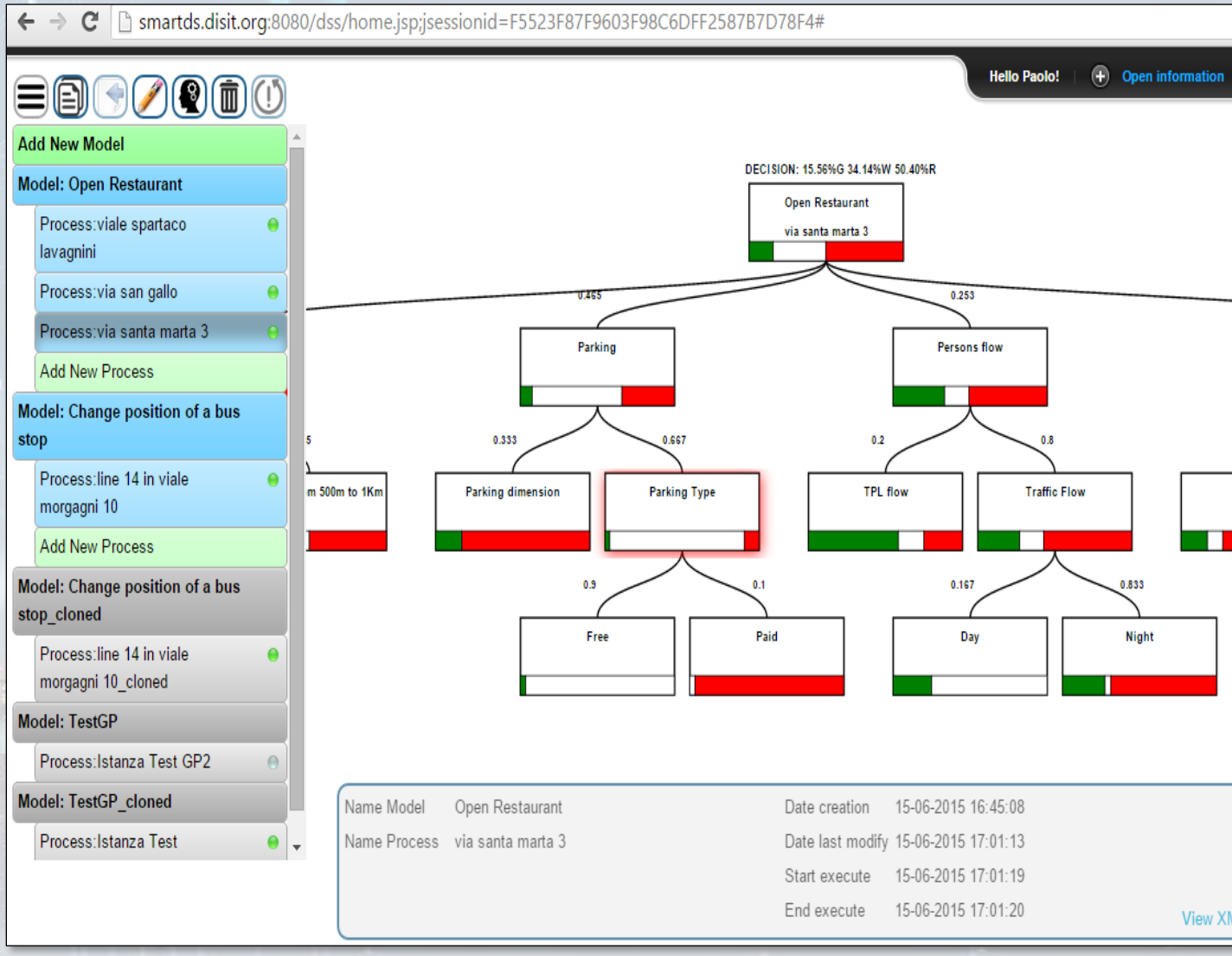


Dashboard System for Operators and Control Room

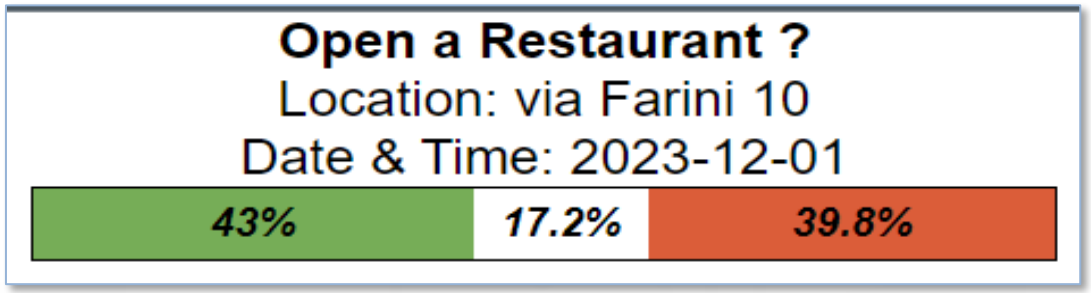
- **Management of video wall** on the basis of events and operators monitors
- Definition of **connections among the dashboards** and business intelligence tools
  - Dashboards with parameters
  - Actions Urls
  - Urls on Widgets
  - CSBL: full custom
- Definition of **Virtual Private Chat Rooms** attached to the dashboards
- Generation of **QR for direct mobile** access

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, …



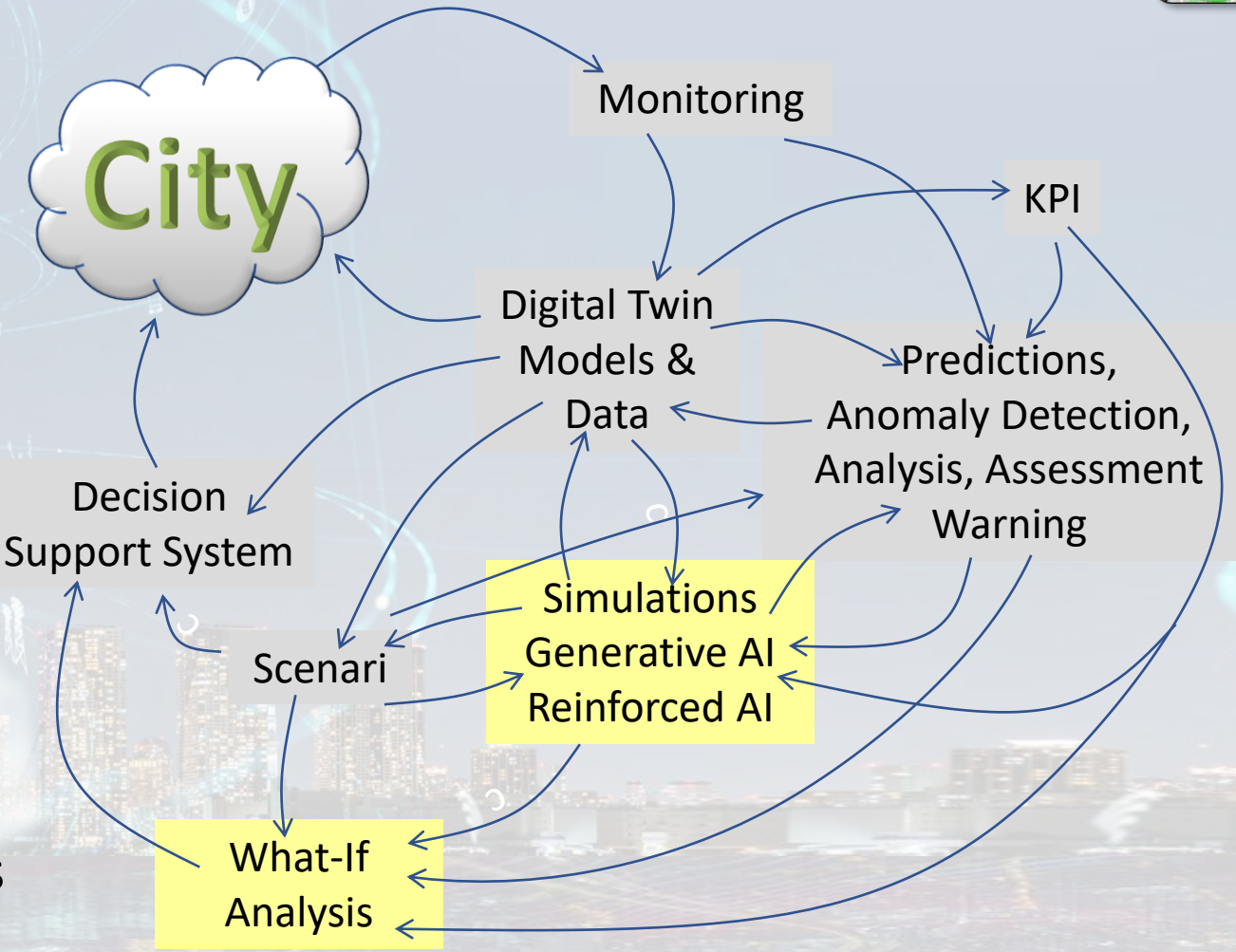
- Supports the definition of the **Decision Tree Model, DTM**, in terms of System Thinking, with Italian Flag and combinations
- Allows the **statistic composition** of subDecisions probabilities
- **Generating a DTM as an IoT App,**
- **IoT Apps with DTM can**
  - **be customized**
  - **compute root values in real time in** any context: location, parameters, etc.
    - Single DTM root value can be produced on Dashboard
    - Several DRM root values can be represented on dashboard as heatmaps for Green/White/Red values



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

From What-If to Decision Support System

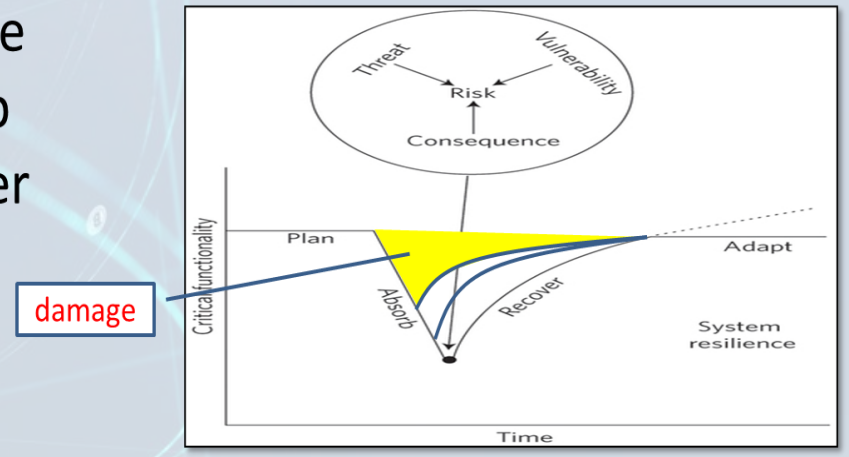
- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Computing predictions vs KPI
  - Anomaly detection
  - Neuro-Symbolic analysis
  - Risk assessment
  - Early warning on critical conditions
- **Making plan: tactic and strategic, medium and long range, micro/macro**
  -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



Snap4City What-If

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

Prepare
Absorb
Recover
Adapt



Data Analytics

System Modeling and Simulation

Knowledge Models

Scenarious

Short Term **Predictions**

Long Term **Predictions**, Typical trends

Recommendations & Prescriptions

What-if Analysis

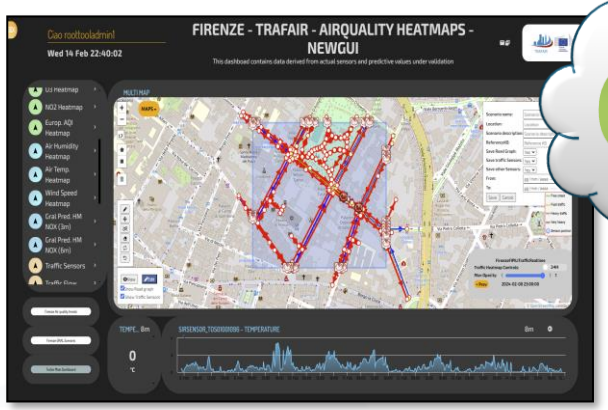
Anomaly Detection Early Warning

Disaster Recovery

Strategies and Plans

Partial graph

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



City

Monitoring

KPI

Digital Twin Models & Data

Predictions, Anomaly Detection, Analysis, Assessment Warning

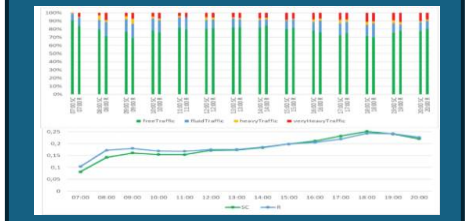
Decision Support System

Scenarious

Simulations, TFR, Crossroad, Public Transport, Routing, ..

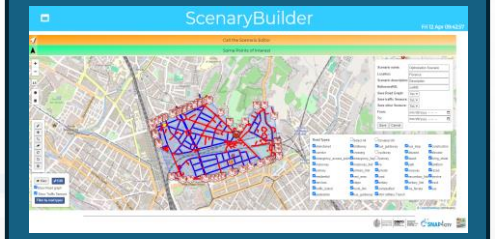
What-If Analysis, Optimization

KPI



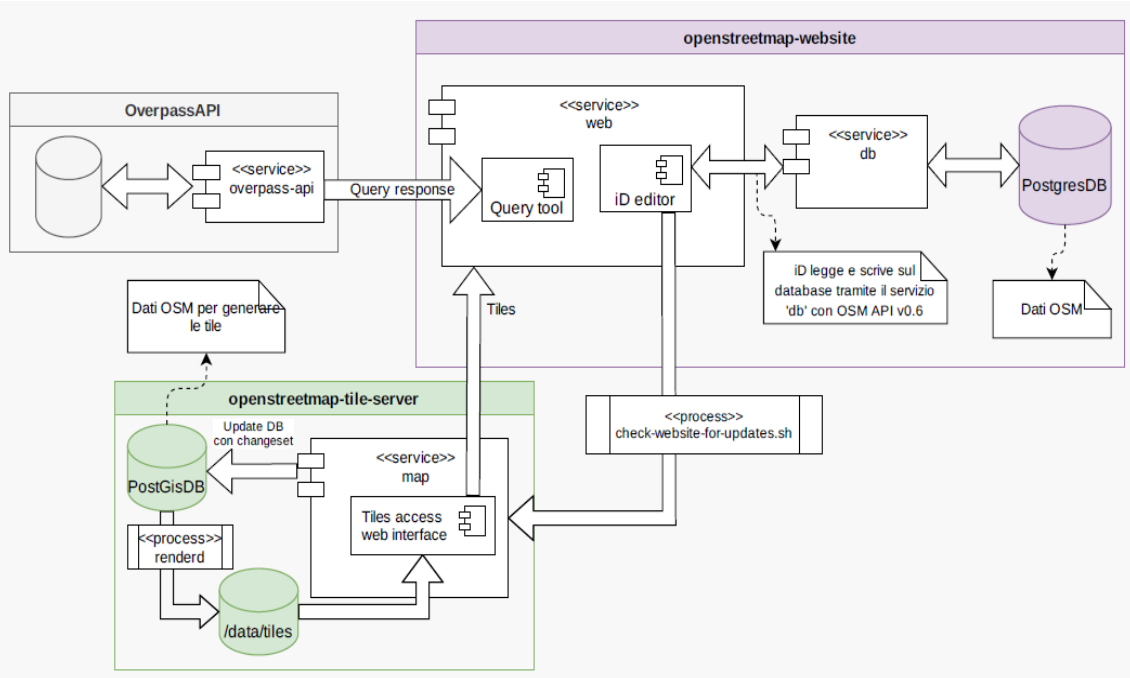
Traffic Lights plan optimization

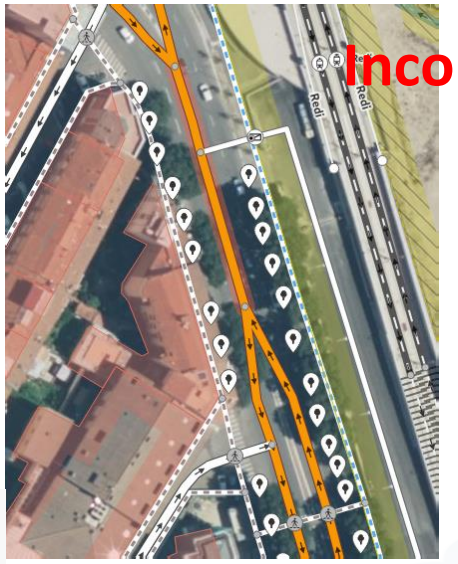
Scenario Editor

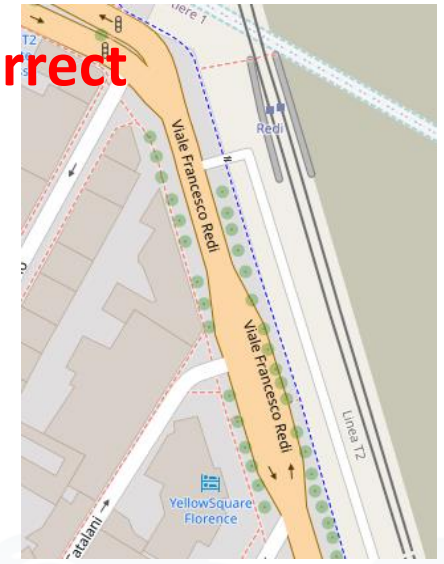


Traffic Reconstruction

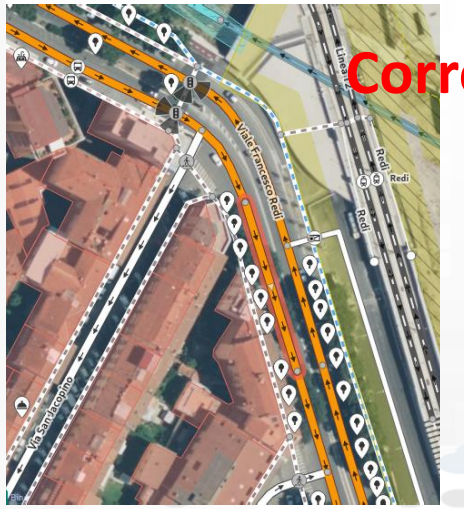
Correcting road graphs from OSM

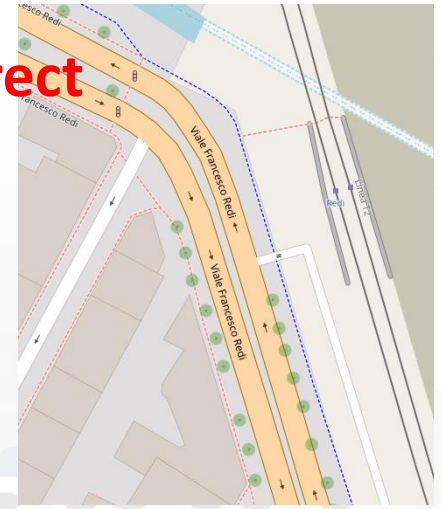






OSM data with non clear double bidirection lane on Viale Redi, Florence.
Editing OSM data and present Tiles





After Corretion of OSM data defining a clear double bidirection lane on Viale Redi, Florence.
Regeneration of the TILEs for the maps

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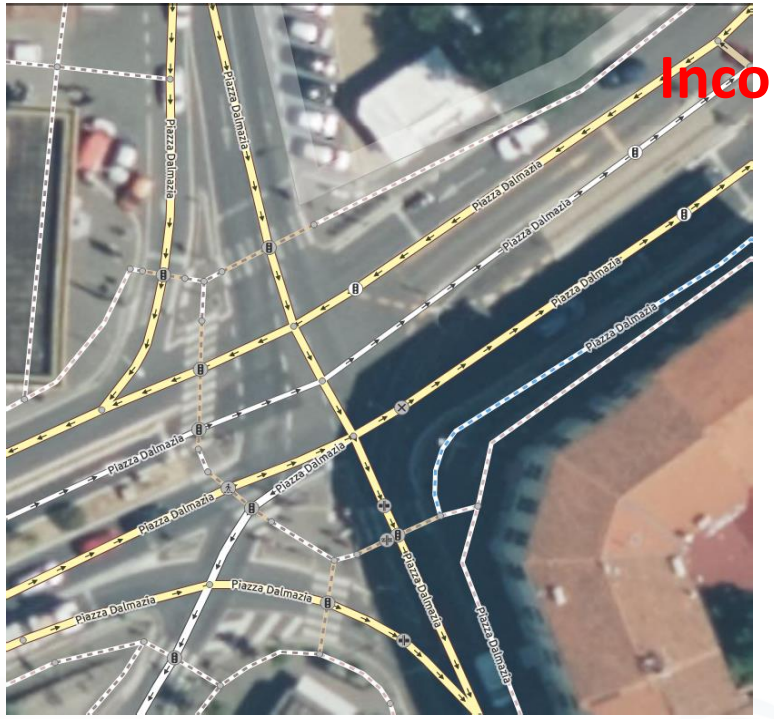
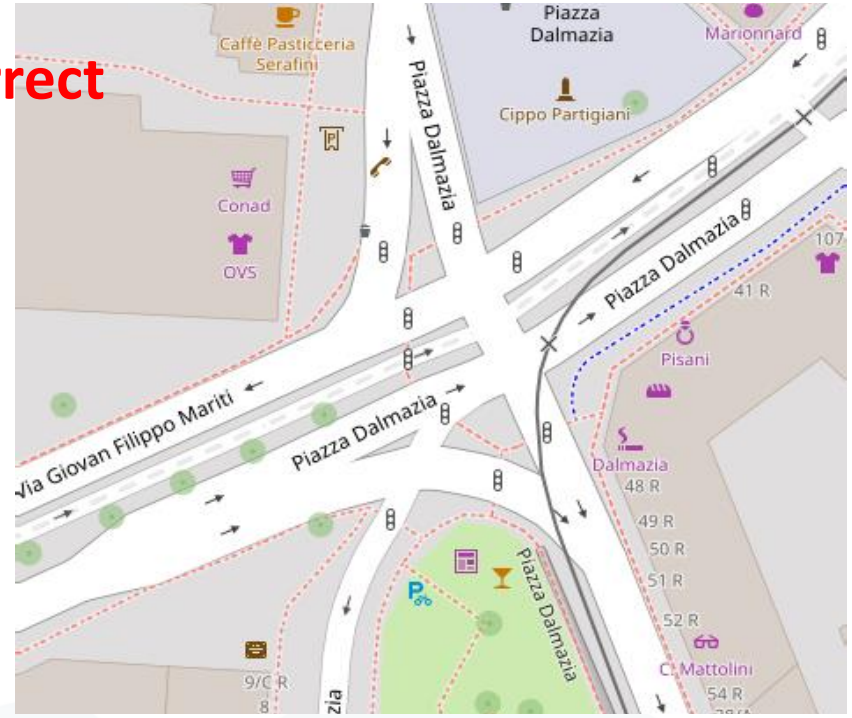
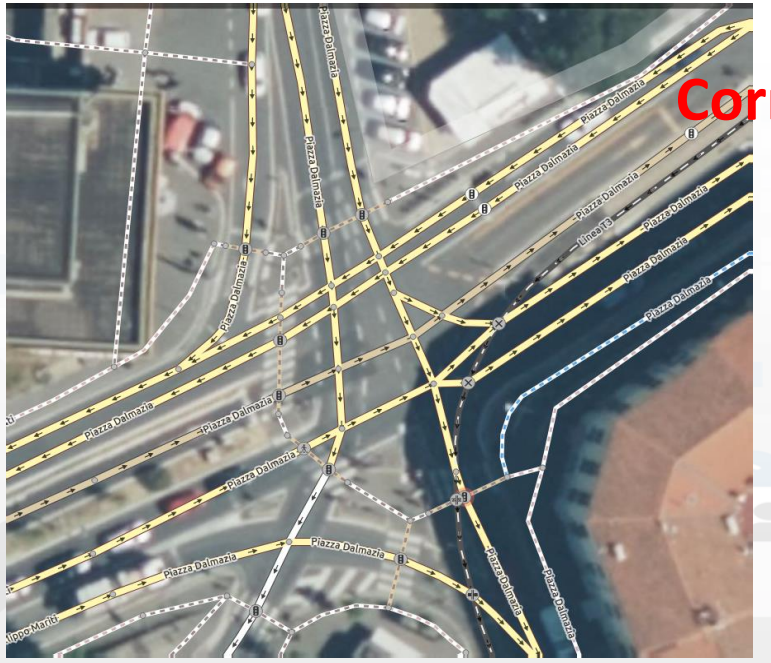
OSM data with non correct viability in Piazza Dalmazia, Firenze



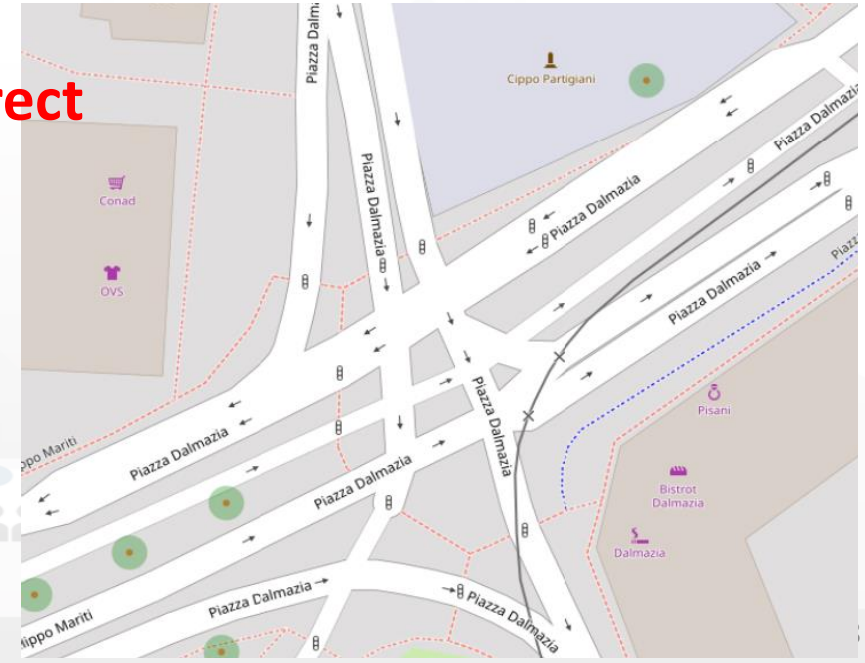
Incorrect



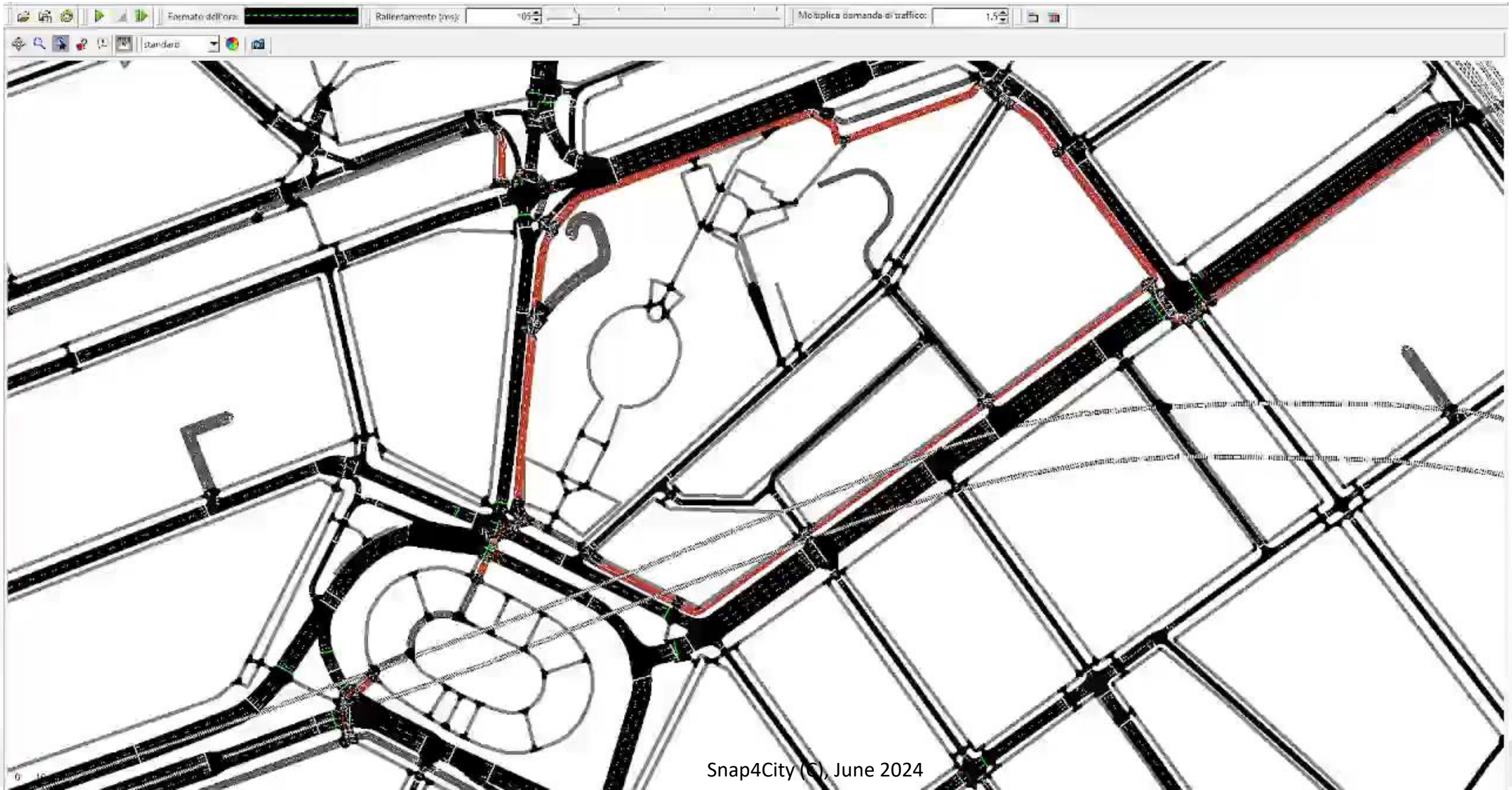
After Correction of OSM data defining a correct viability of Piazza Dalmazia, Florence. Regeneration of the TILEs for the maps



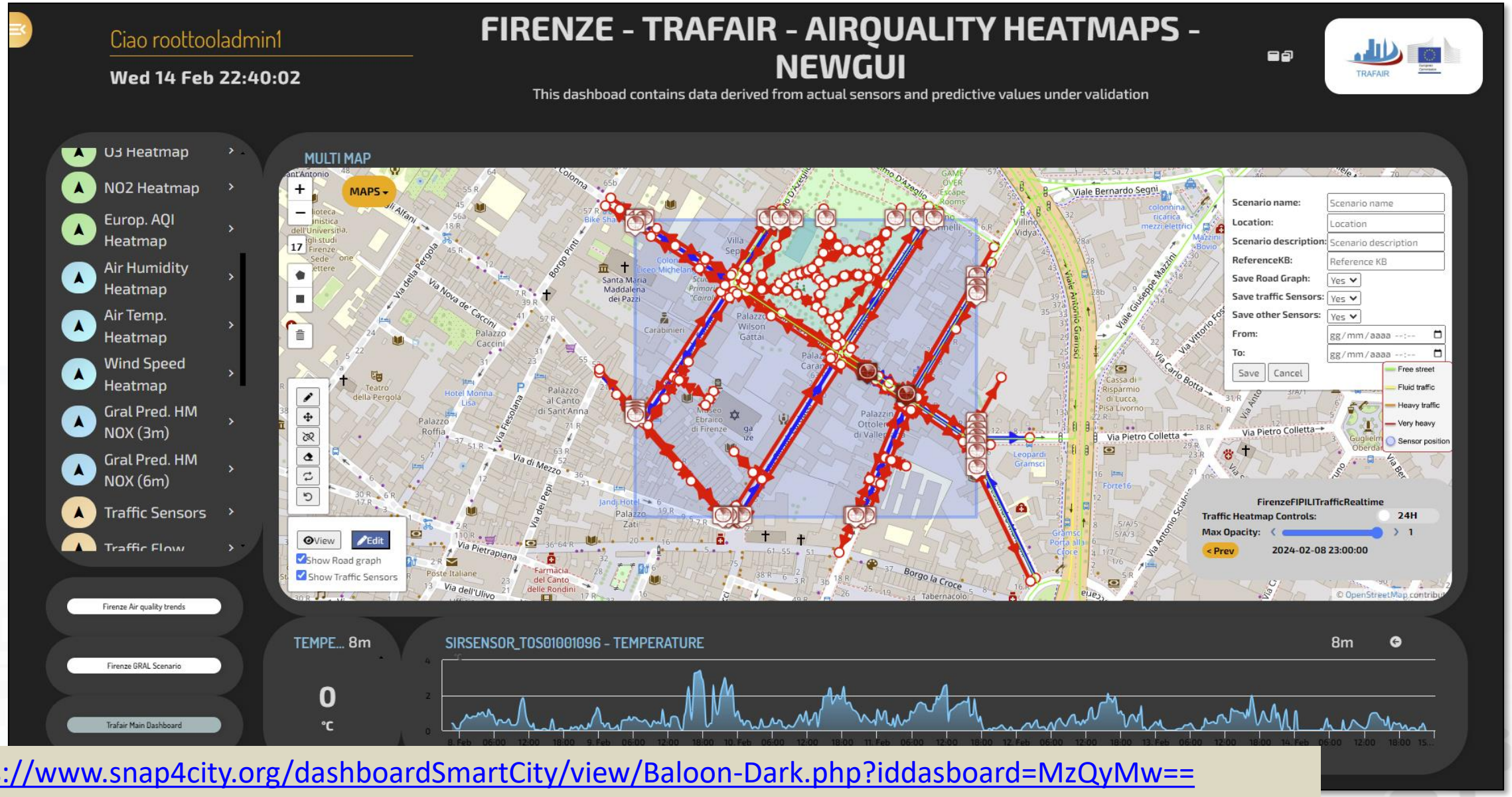
Correct



Micro Simulation

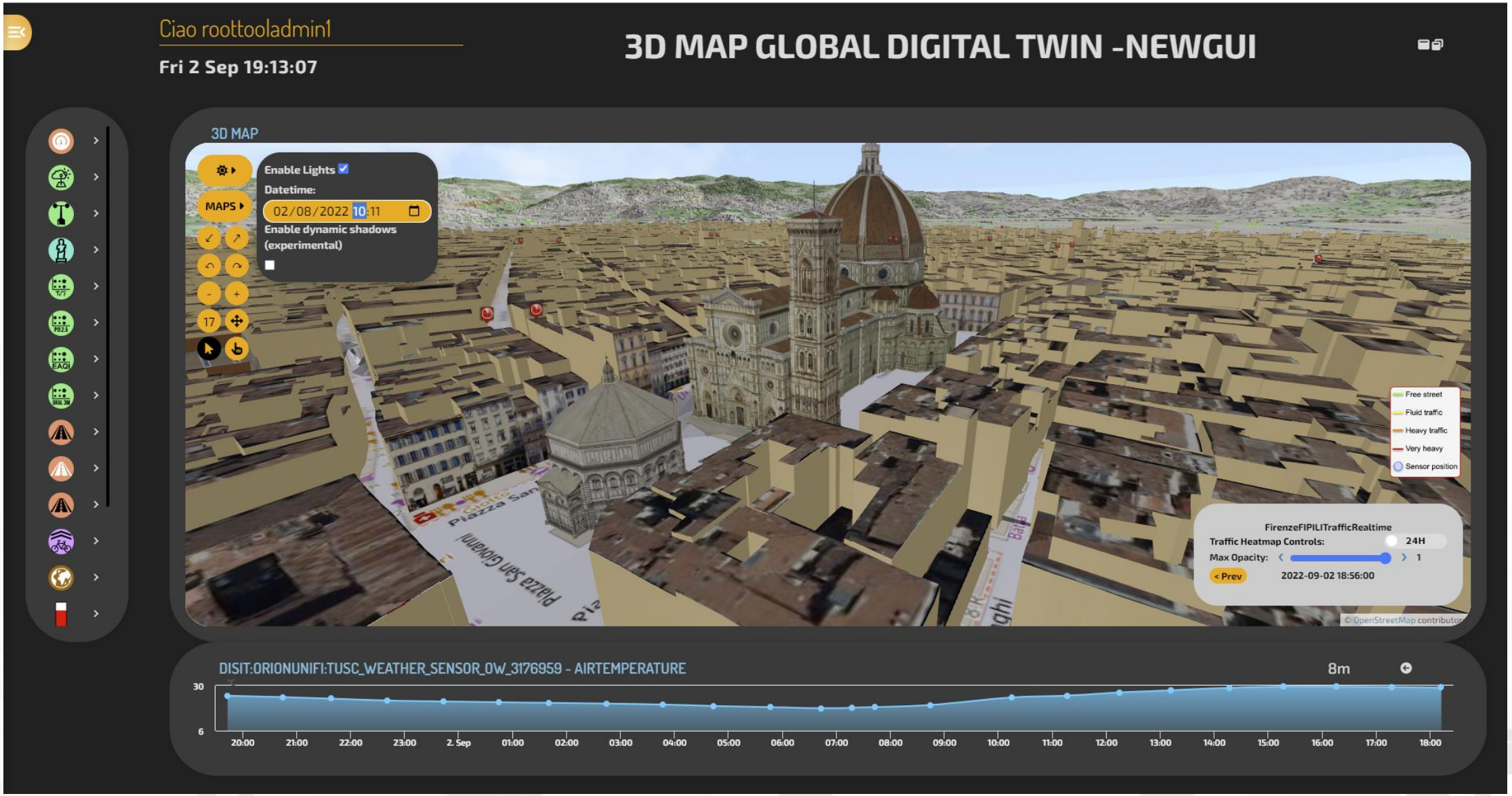


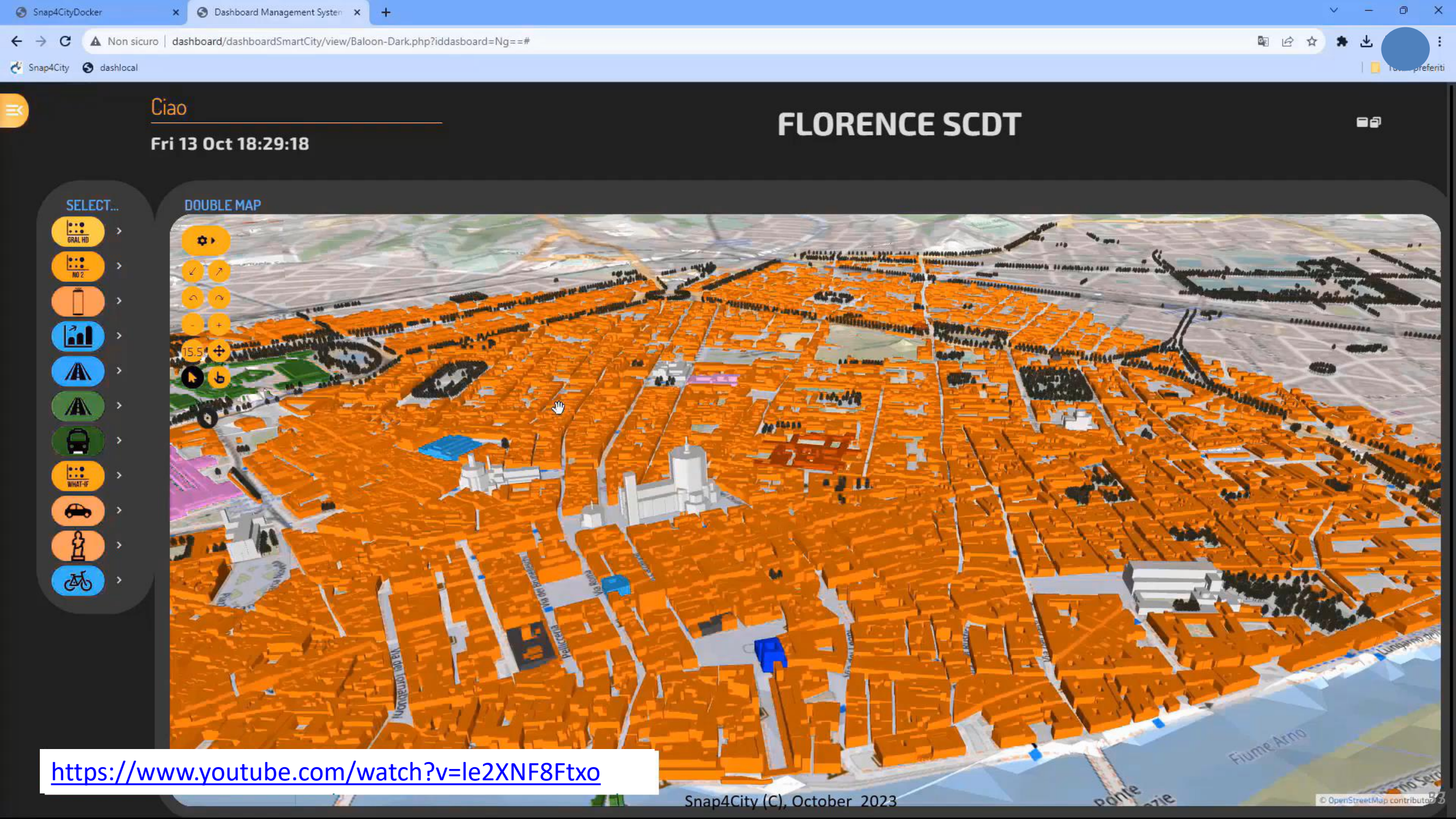
Trial:



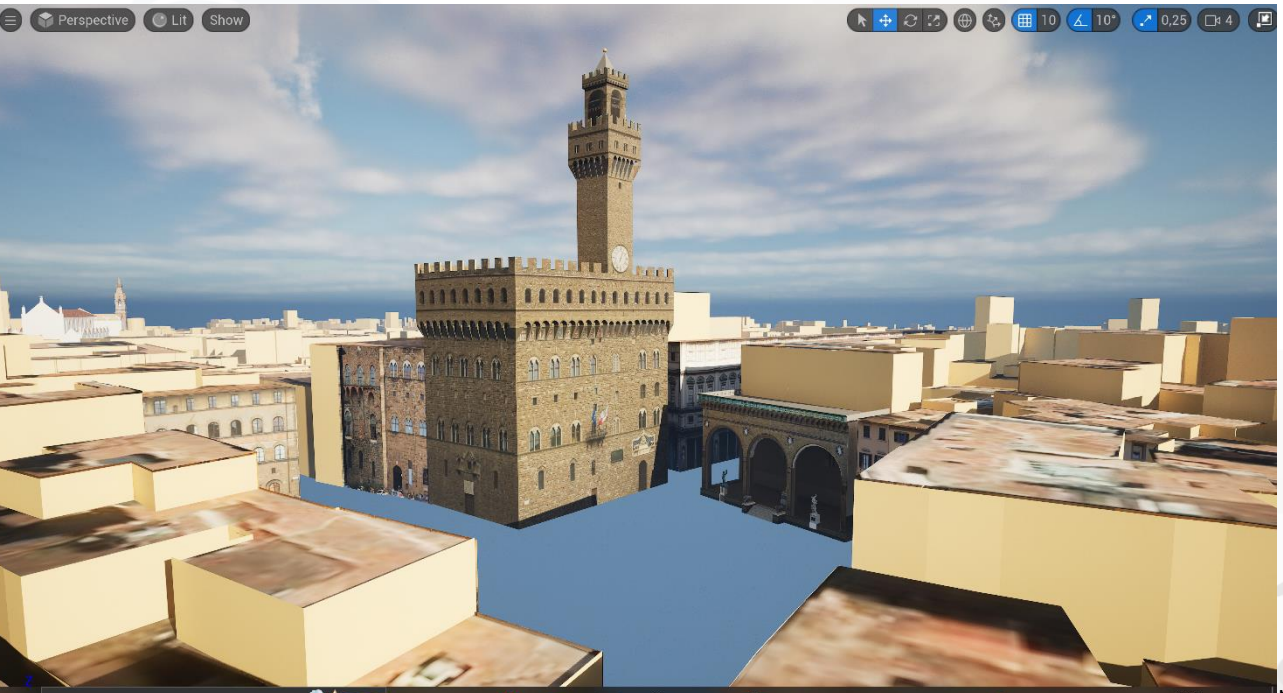
https://www.snap4city.org/dashboardSmartCity/view/Baloon-Dark.php?iddasboard=MzQyMw==

3D Digital Twin




Snap4CityDocker
Dashboard Management Syster
Non sicuro | dashboard/dashboardSmartCity/view/Baloon-Dark.php?iddasboard=Ng==#
Snap4City
dashlocal
Ciao
Fri 13 Oct 18:29:18
FLORENCE SCDT
SELECT...
DOUBLE MAP
GRAL HD
NO 2
WHAT-IF
Fiume Arno
Snap4City (C), October 2023
https://www.youtube.com/watch?v=le2XNF8Ftxo

OCULUS


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

Perspective
Lit
Show

OCULUS

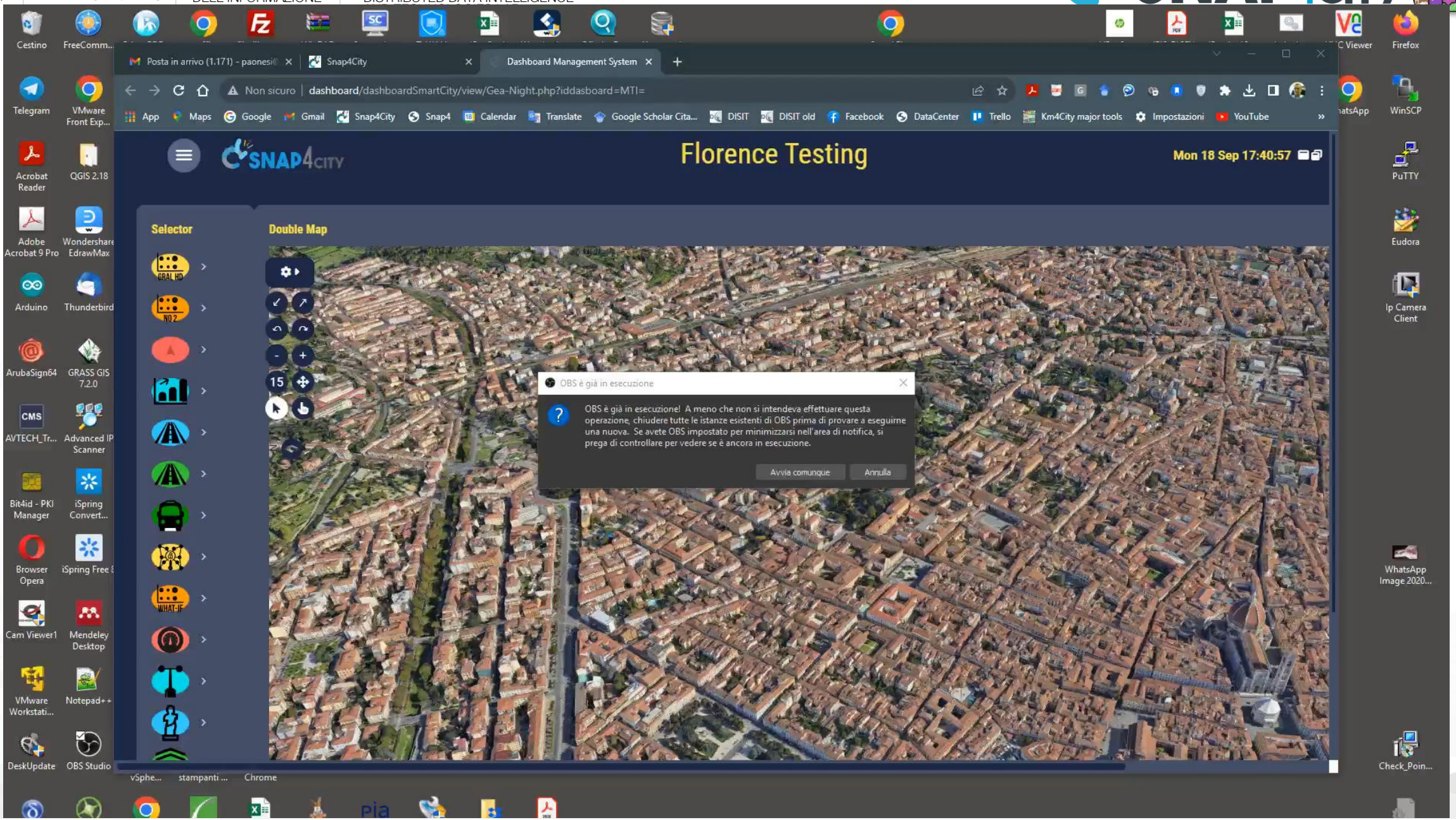
https://www.youtube.com/watch?v=Rcf_B2_GOio

Exploiting Google API with Snap4City engine

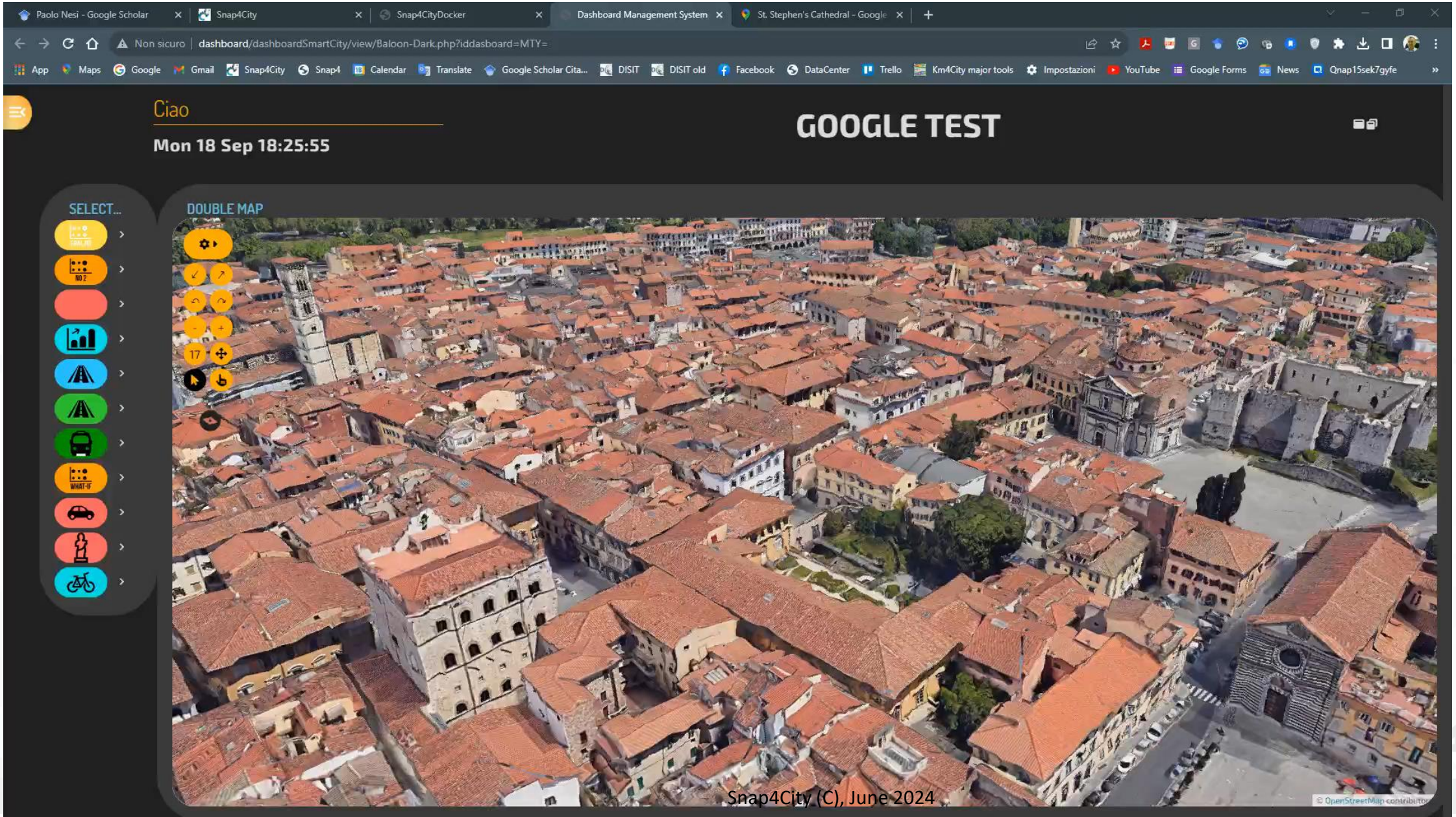
- Select any city/locality and see if 3D Representation of your city is Available
- Snap4City redendering and distribution engine allows to
  - Optimize distribution of data
  - Integrate any kind of data on Digital Twin with 3D tileds of Google
    - PIN, IoT Data
    - Traffic Flows
    - Cycling paths
    - 3D shapes superimposed
    - Etc.

Snap4City Digital Twin Engine and data + 3D Google Data

Firenze


Florence Testing
Mon 18 Sep 17:40:57
Selector
Double Map
OBS è già in esecuzione
OBS è già in esecuzione! A meno che non si intendeva effettuare questa operazione, chiudere tutte le istanze esistenti di OBS prima di provare a eseguirne una nuova. Se avete OBS impostato per minimizzarsi nell'area di notifica, si prega di controllare per vedere se è ancora in esecuzione.
Avvia comunque
Annulla

Prato


Paolo Nesi - Google Scholar
Snap4City
Snap4CityDocker
Dashboard Management System
St. Stephen's Cathedral - Google
Non sicuro
dashboard/dashboardSmartCity/view/Baloon-Dark.php?iddasboard=MTY=
App
Maps
Google
Gmail
Snap4City
Snap4
Calendar
Translate
Google Scholar Cita...
DISIT
DISIT old
Facebook
DataCenter
Trello
Km4City major tools
Impostazioni
YouTube
Google Forms
News
Qnap15sek7gyfe
Ciao
Mon 18 Sep 18:25:55
GOOGLE TEST
SELECT...
DOUBLE MAP
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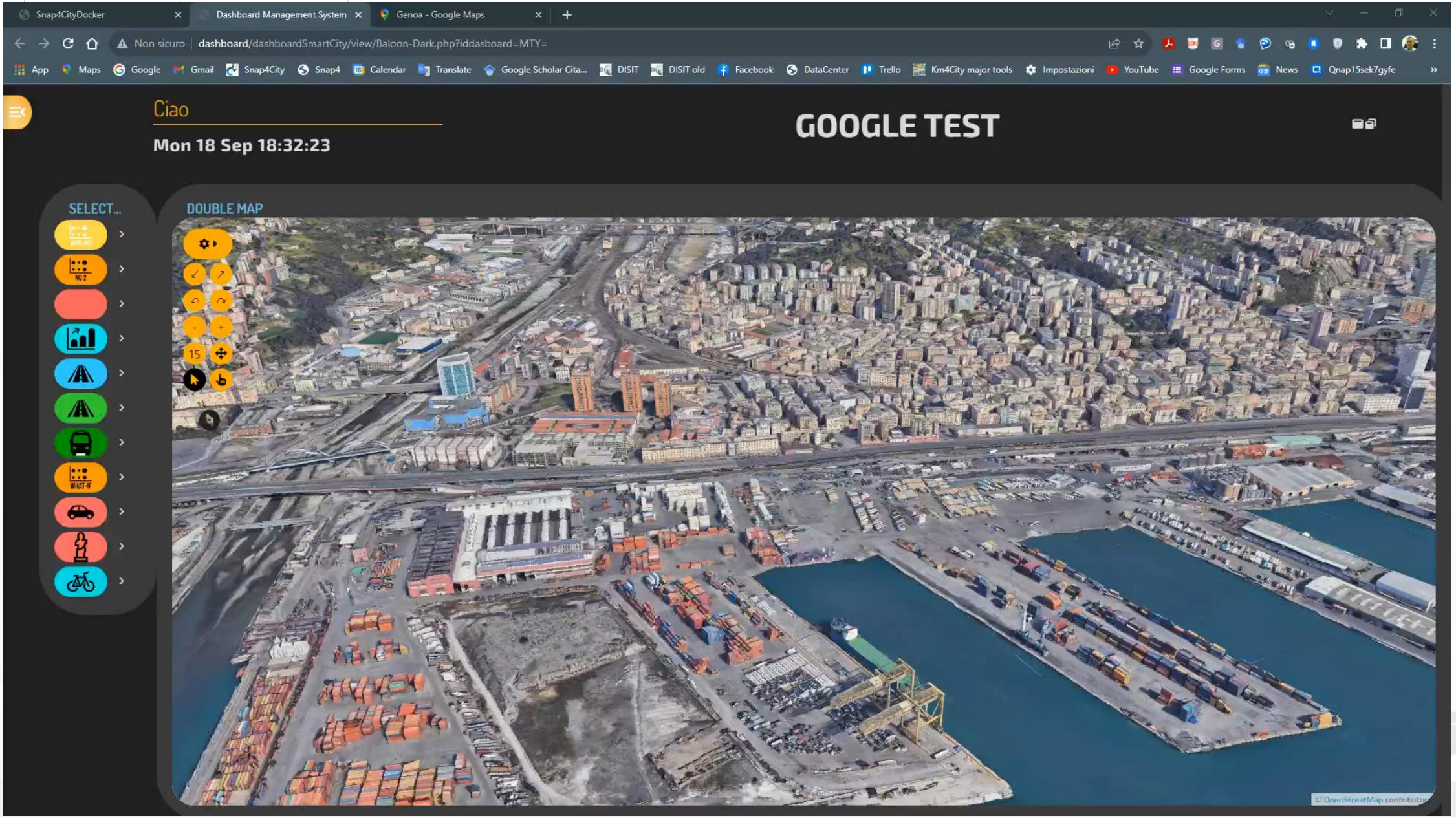
Genova

SNAP4CITY KM4CITY



Local Digital Twin vs BIM

Snap4City | Dashboard Management System | Nuova scheda

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

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

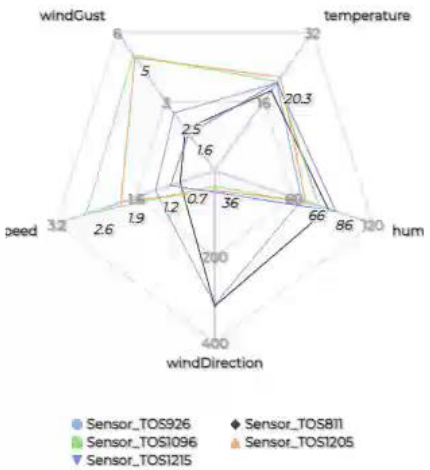
BIM Airport

Thu 25 May 18:16:22

Select the view of interest

- Airport Building 1
- Airport Heatmap dash
- Terminal Heatmap

Sensor Data 4m



Last Value	Time Trend Chart
No data	

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Tour Again
www.snap4solutions.org
ダッシュボード
Dashboards (Public)
My Dashboards in All Org.
Dashboards of My Organization
My Dashboards in My Organization
My Data Dashboard Dev Kibana
My Data Dashboard Kibana
Extra Dashboard Widgets
Notificator
Data Management, HLT
Knowledge and Maps
Processing Logics / IOT App
Entity Directory and Devices
Resource Manager
Development Tools
Management
Decision Support Systems
Deploy and Installation

Snap4City: Smart aNalytic APp builder for sentient Cities and IOT

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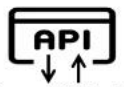

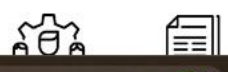

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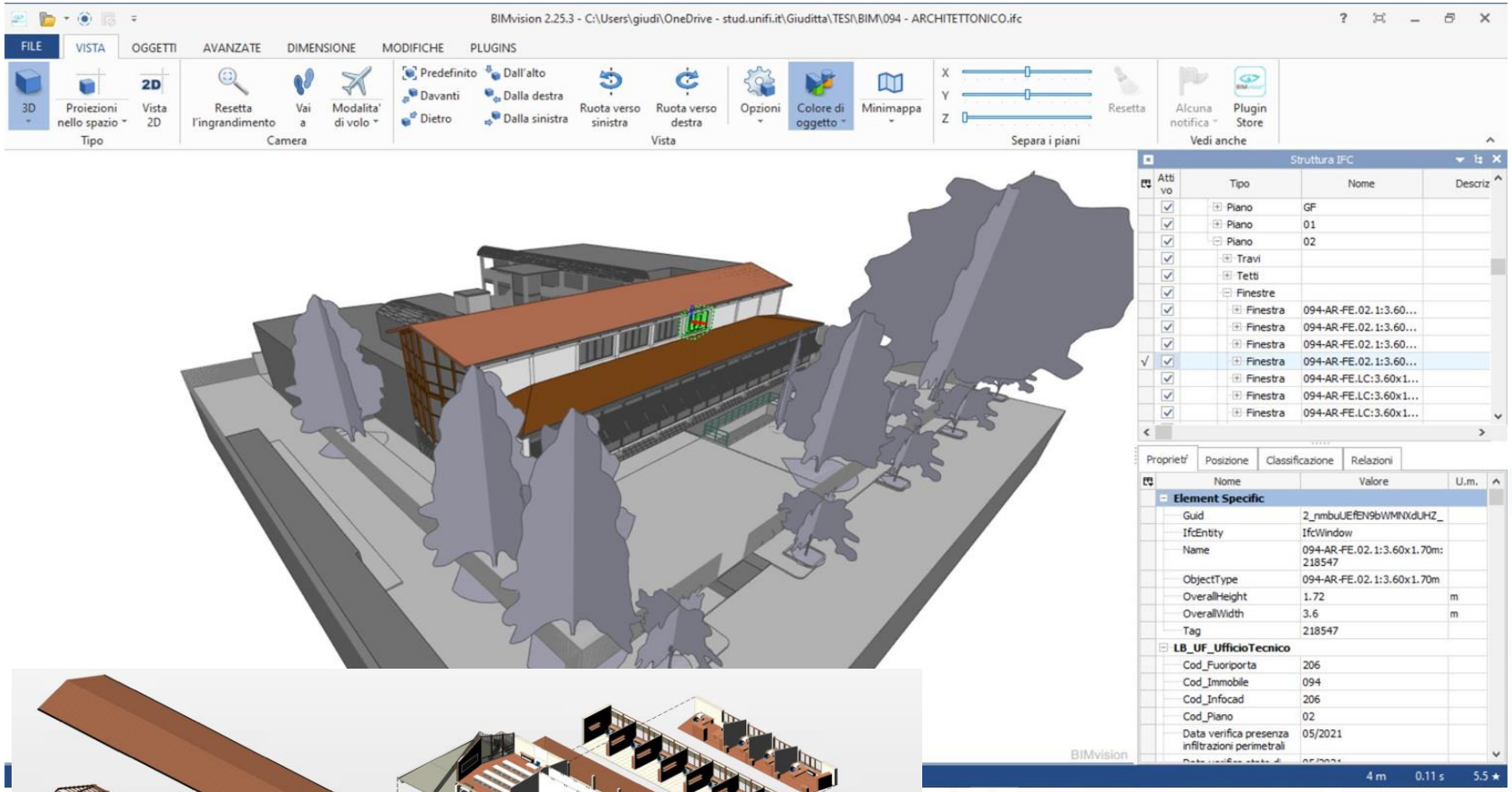
Search

Search

-Any-

Who's online

.IFC



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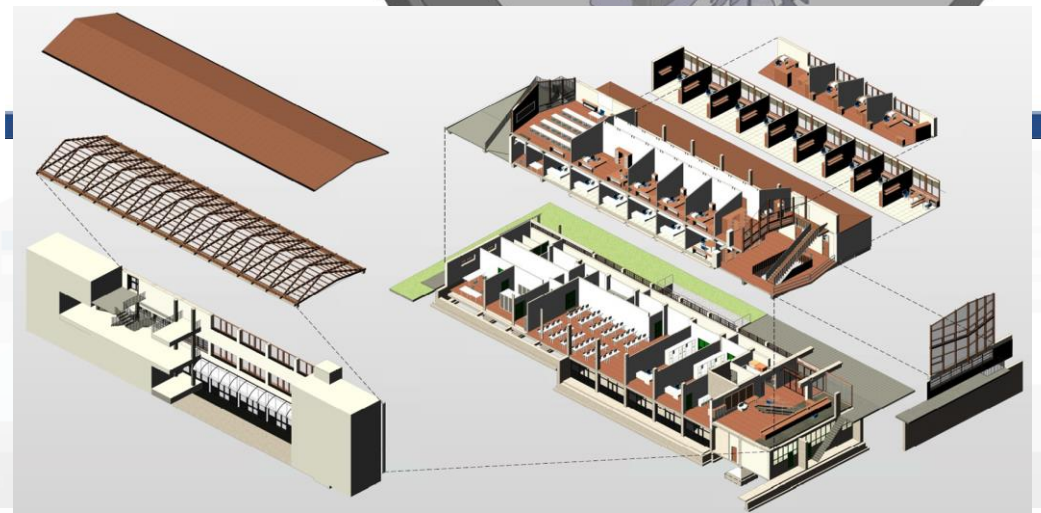
LB_UF_UfficioTecnico		
Cod_Fuoriporta	122	
Cod_Immobile	094	
Cod_Infocad	122	
Cod_Piano	01	
Data verifica presenza infiltrazioni perimetrali	05/2021	
Data verifica stato di conservazione, fissaggio, funzionalità, stabilità e tenuta superfici vetrate	05/2021	
Descrizione	Facciata continua con telaio in legno, finestre apribili e avvolgibili	
Immagine	Immagine raster: IMG_7428.JPG	
Immagine tipo	Immagine raster: IMG_7428.JPG	
Periodicità verifica presenza infiltrazioni perimetrali	A chiamata	
Periodicità verifica stato di conservazione, fissaggio, funzionalità, stabilità e tenuta di superfici vetrate	A chiamata	
Verifica presenza infiltrazioni perimetrali	Si	
Verifica stato di conservazione, fissaggio, funzionalità, stabilità e tenuta di superfici vetrate	Si	



TOP

Data Analytic Artificial Intelligence, XAI, Machine and Deep Learning

Available AI Solutions on Snap4City

https://www.snap4city.org/997

More than 80 Available Solutions & 300 AI applic.

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

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

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

SUSTAINABLE DEVELOPMENT GOALS

- ***15 Minute City Index:***
  - 13 subindexes: energy, slow mobility, fast mobility, housing, economy education, culture and cults, health, entertainment, gov, food, security…

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

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

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

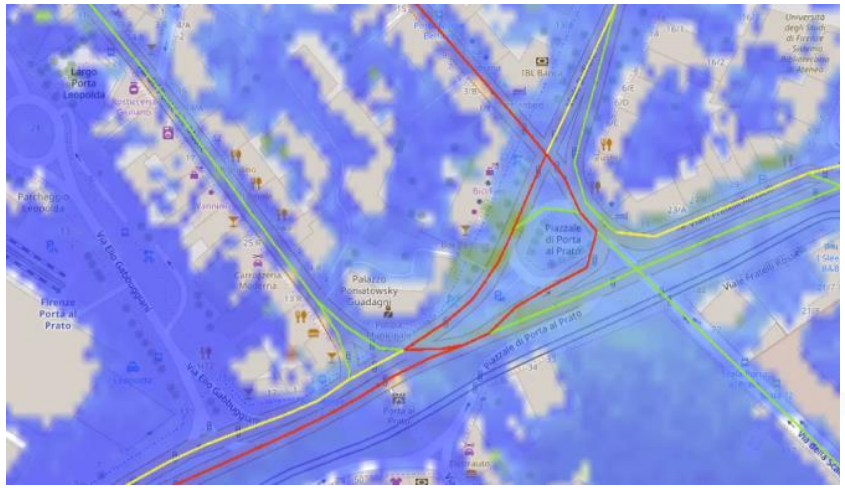
- business intelligence tools for decision makers
- Reduction production costs
- Monitoring resource consumption
- Optimization of Waste Collection

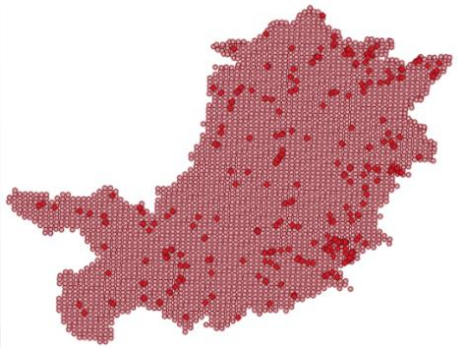
- Monitoring and Predicting: NO2, NOX, CO2, Traffic flow, pollutant, landslide, waste, etc.
- Traffic flow reconstruction
- Demand vs Offer of Mobility analysis

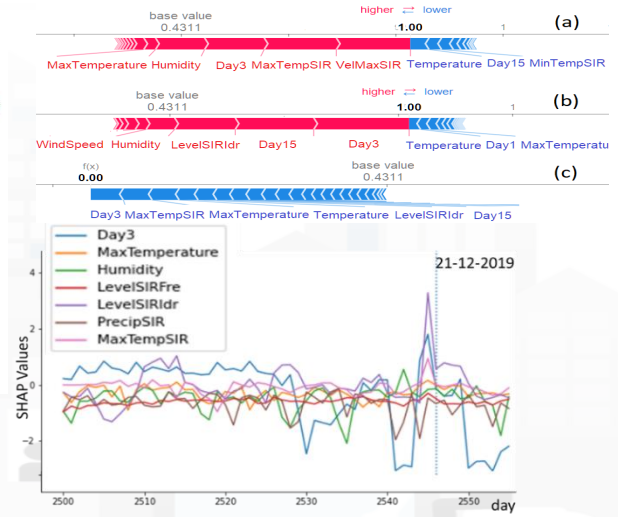
- Shortening justice time
- Anonymization and indexing legal docs.
- Prediction of mediation proneness
- Ethical Explainable Artificial Intelligence

The difference is on computational models

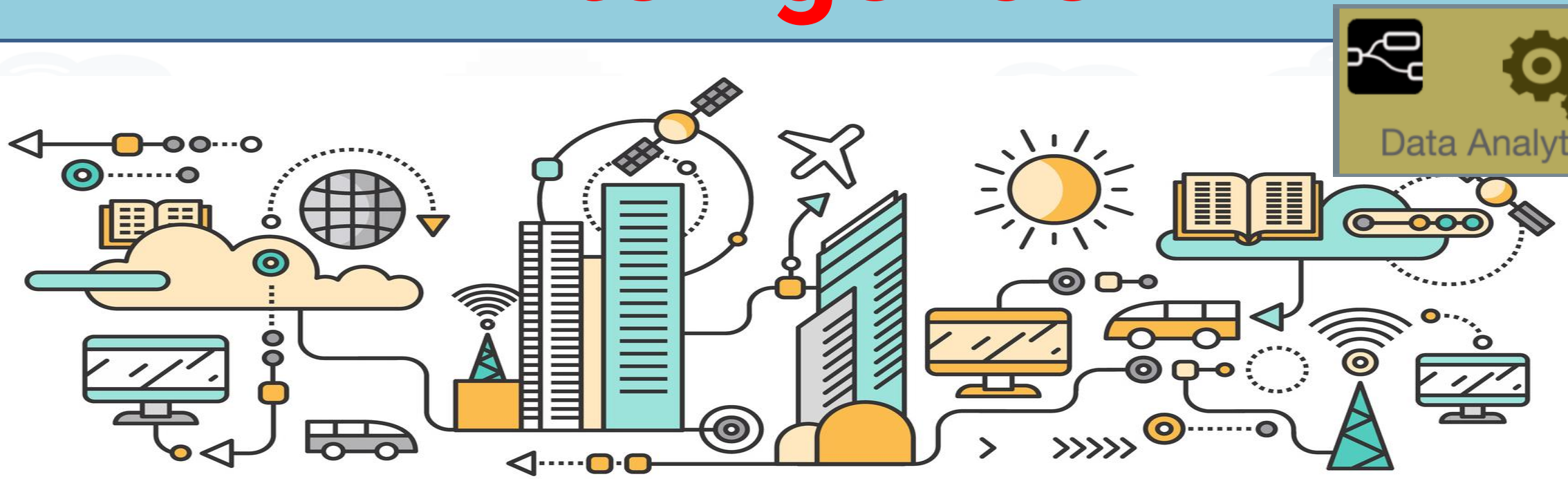
- **Simulation models,**
- **statistics and operations research techniques**
- Machine Learning and Artificial Intelligence techniques
  - exploitation of heterogeneous data, **BIG DATA**
    - Predictions, Early Warning, Anomaly Detection, …
    - **What-If Analysis** integrating predictive models and simulations
  - **Explainable AI, XAI, providing to the decision-maker**
    - **detailed explanations** on the motivations behind the suggestions provided, so that the decision maker can understand the process and the motivations
    - **evidence of compliance with ethical aspects with confidence**
  - ***To be able to use the systems as a trusted expert system.***





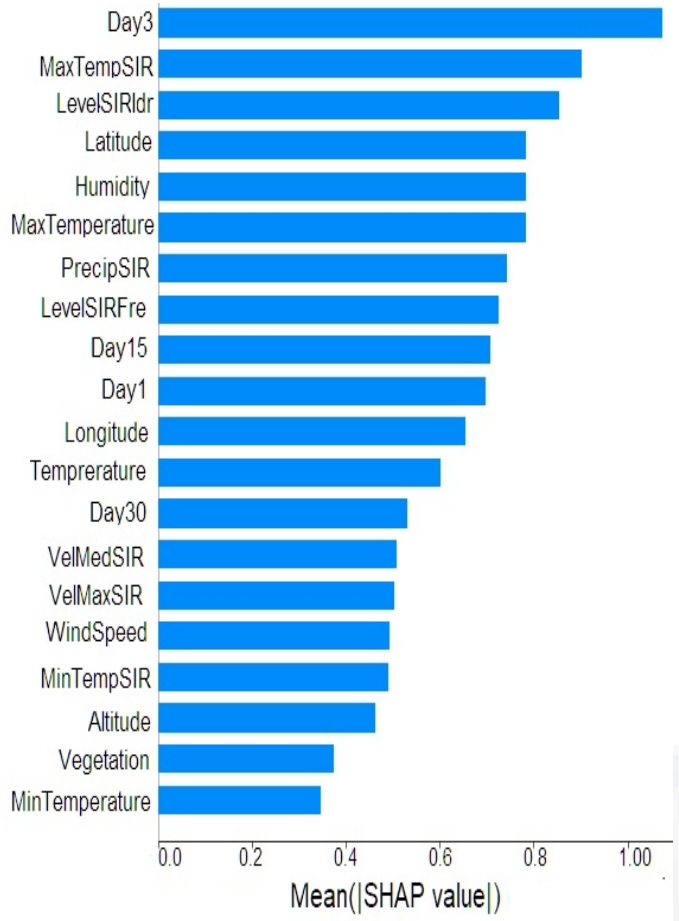


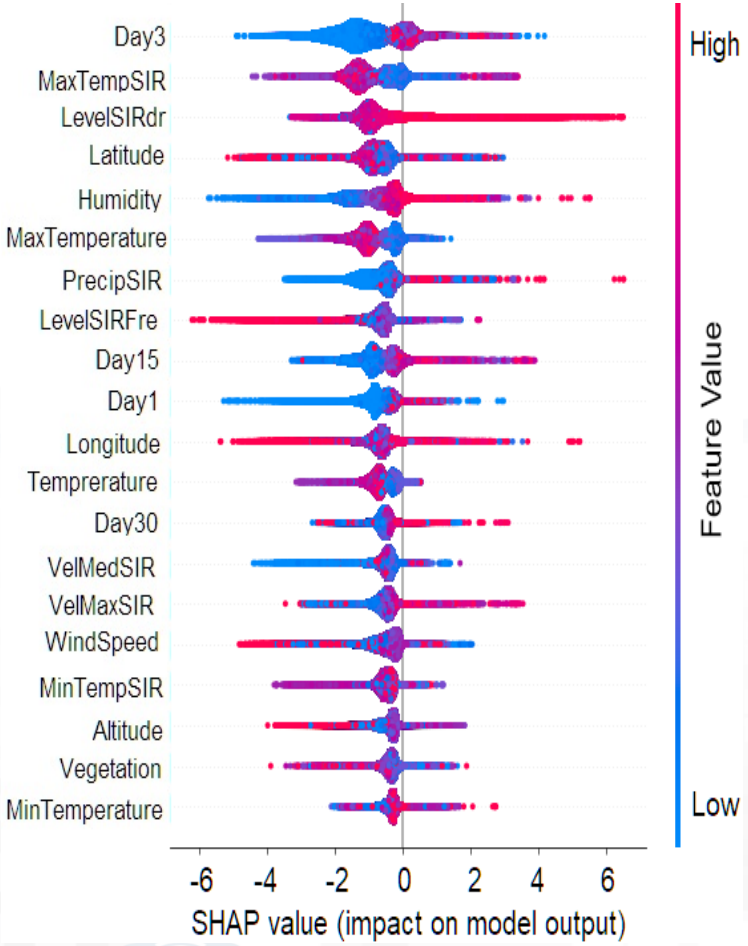
XAI: Explainable artificial intelligence



SHAP Global interpretability

```
with tf.device('/device:GPU:0'):
    explainer = shap.TreeExplainer(MODEL)
    shap_values = explainer.shap_values(X_train)
```





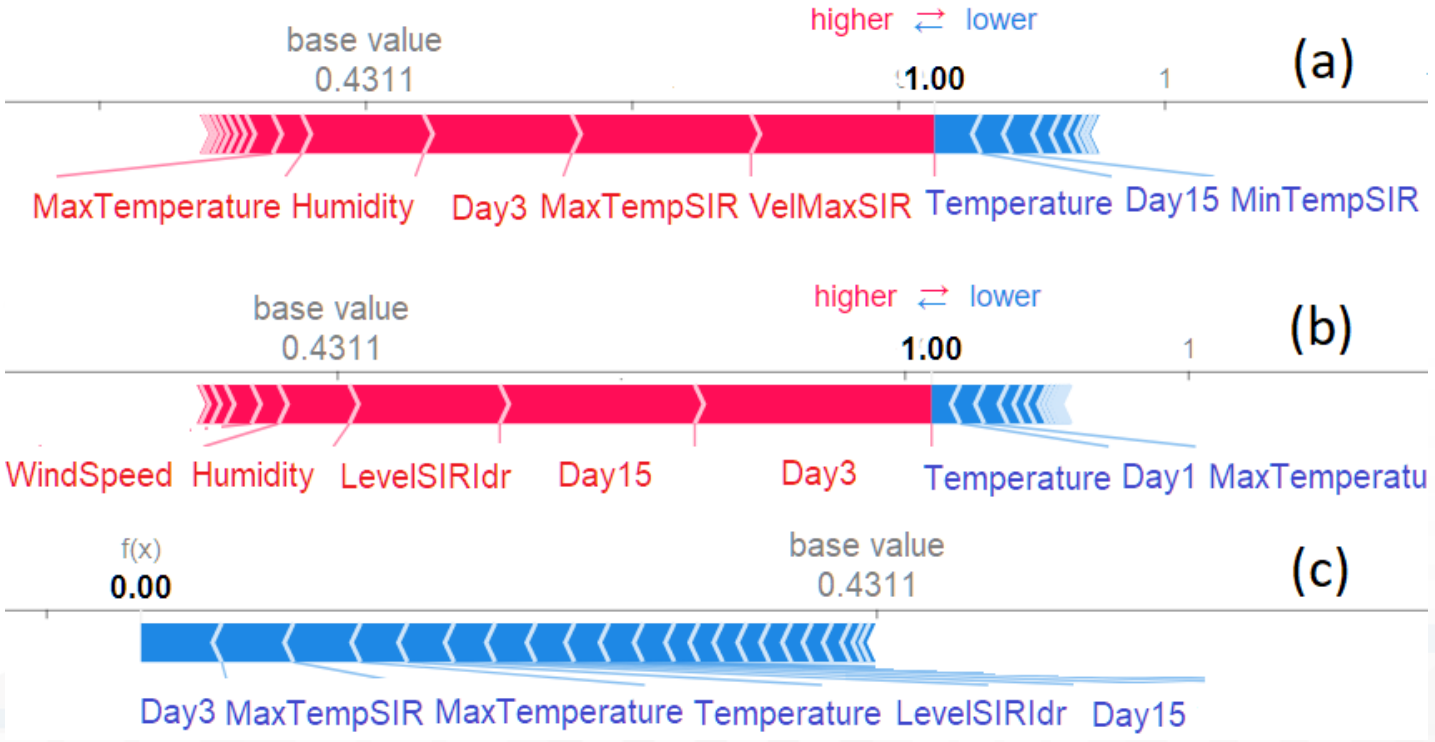
- ***Feature importance:*** Variables are ranked in descending order.
- ***Impact:*** The horizontal location shows whether the effect of that value *is associated with a higher or lower prediction*.
- ***Original value:*** Color shows whether that variable is high (in red) or low (in blue) for that observation.
- ***Correlation:*** A *high* level of "Day3" or "PrecipiSIR" content has a high and *positive* impact on the classification. The "high" comes from the red color, and the "positive" impact is shown on the X-axis.

```
shap.summary_plot(shap_values, features_names, plot_type="bar")
```

```
shap.summary_plot(shap_values, X_train,features_names)
```

SHAP: Local interpretability

```
with tf.device('/device:GPU:0'):
    explainer = shap.TreeExplainer(MODEL)
    shap_values = explainer.shap_values(X_train)
```




```
shap.force_plot(explainer.expected_value,
shap_values[7,:],fields)
```

The ability to explain each prediction, is a very important promise in an explainable AI.

(a) value of VelMaxSIR, MaxTempSIR, Day3 and Humidity contributed significantly to the classification of the observation as a landslide event.

(b) values related to rainfall in the last days, LevelSIRIdr and Humidity given a relevant contribution to the landslide event prediction.

(c) the value of features: Day3, MaxTempSIR, MaxTemperature, Temperature and LevelSIRdr have been determinant for the classification of the observation into a no landslide event.

SCALABLE SMART ANALYTIC APPLICATION BUILDER FOR SENTIENT CITIES

SNAP4CITY

KM4CITY

Mobility and Transport

Mobility and Transport Domain (2024)

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

Tools for Mobility and Transport (2024)

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

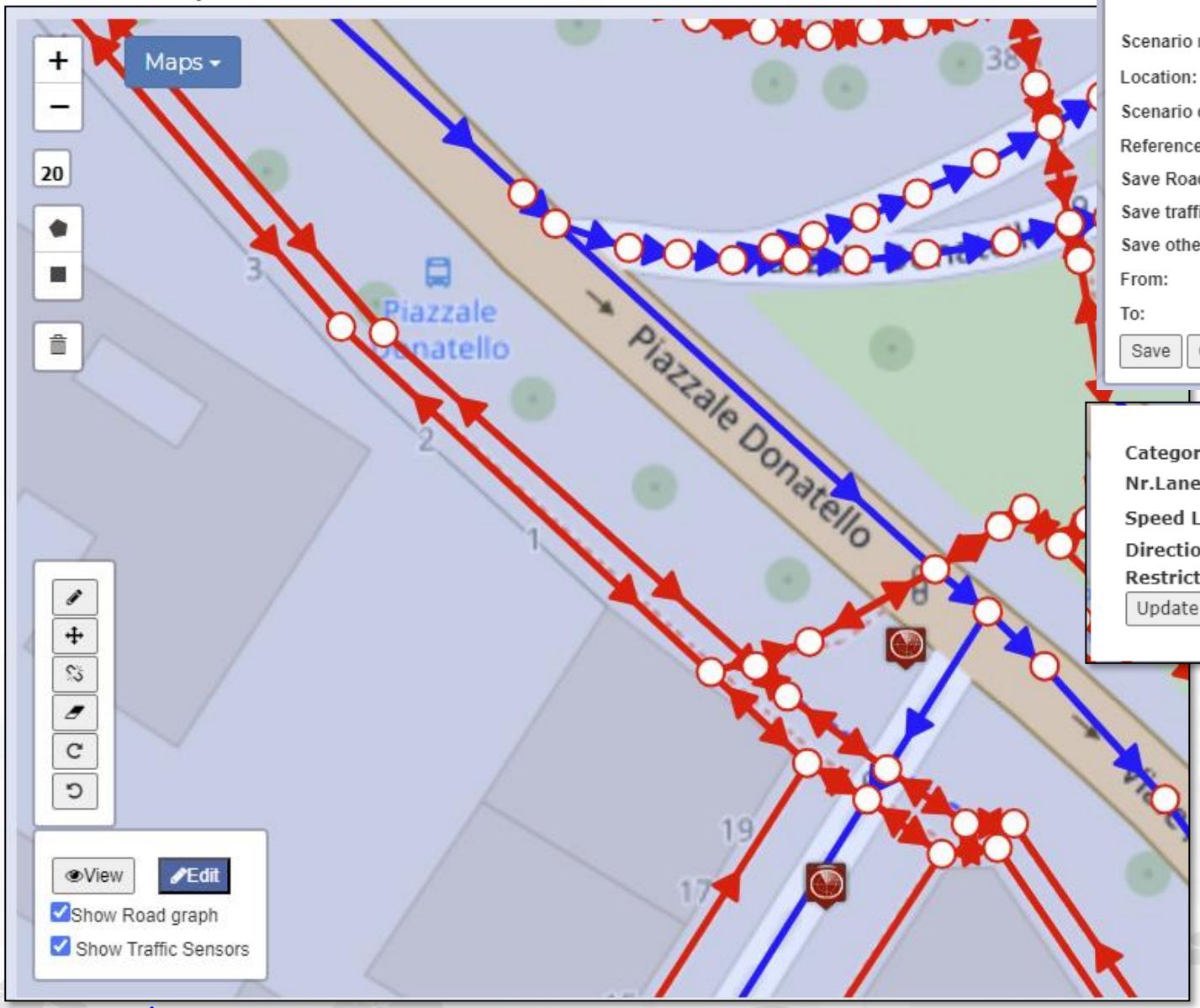
For example:

Select map

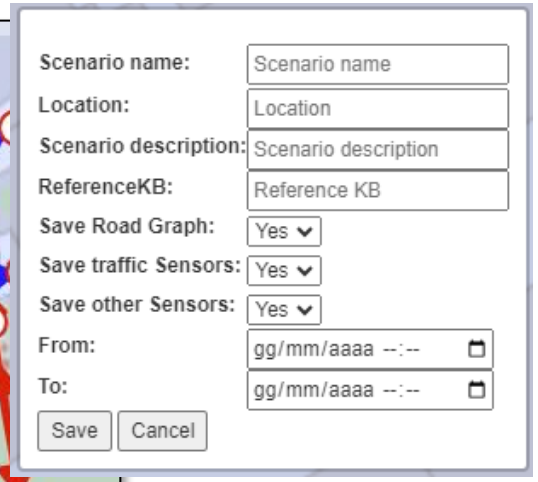
Zoom

New Scenario

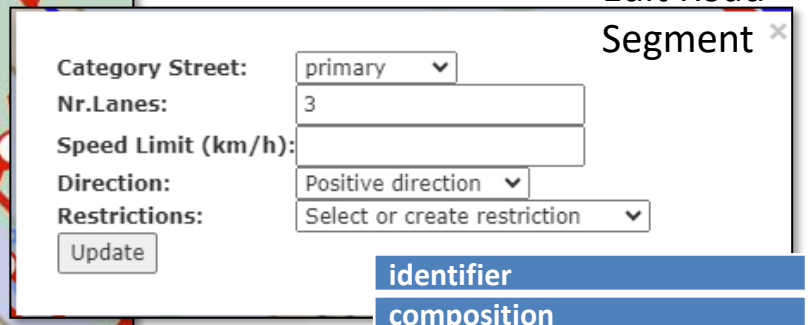
Editing
Drag & drop
Split & Join
Delete
Do and Undo



Save



Edit Road Segment



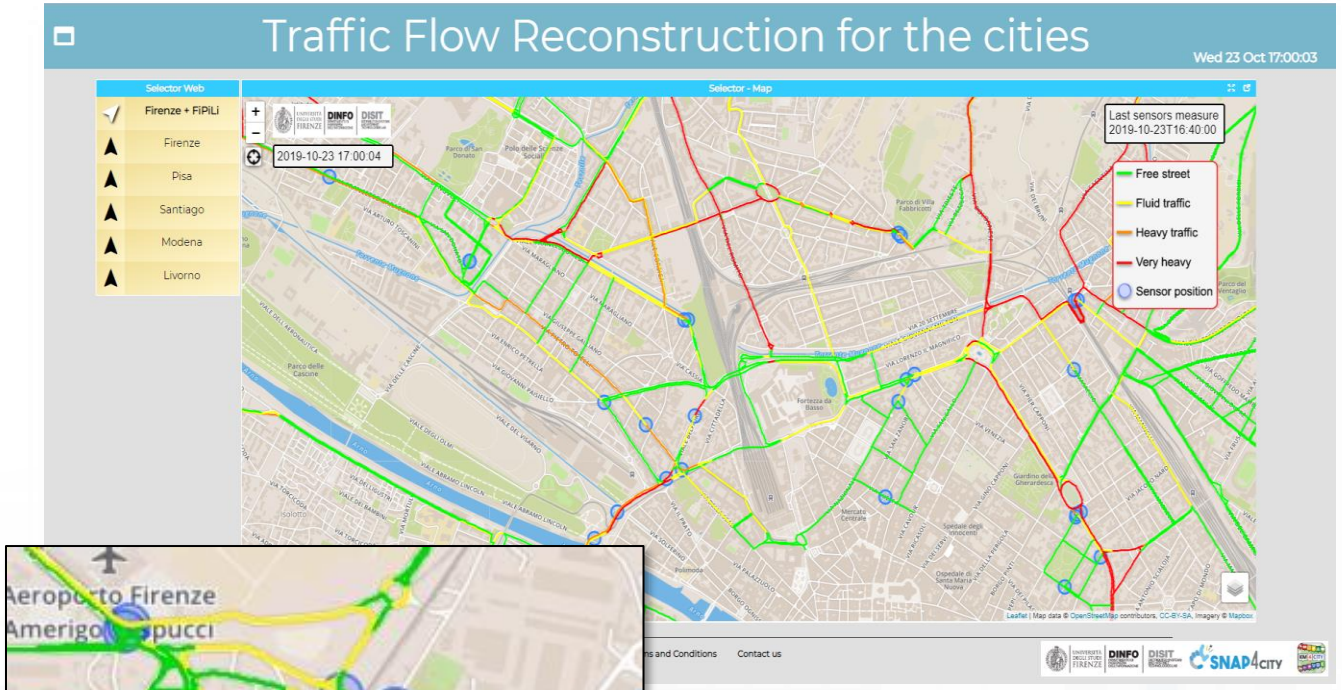
- identifier
- composition
- elemLocation
- elementClass
- elementType
- length
- operatingStatus
- speedLimit
- trafficDir
- width
- highwayType
- route

Properties of Road Elements

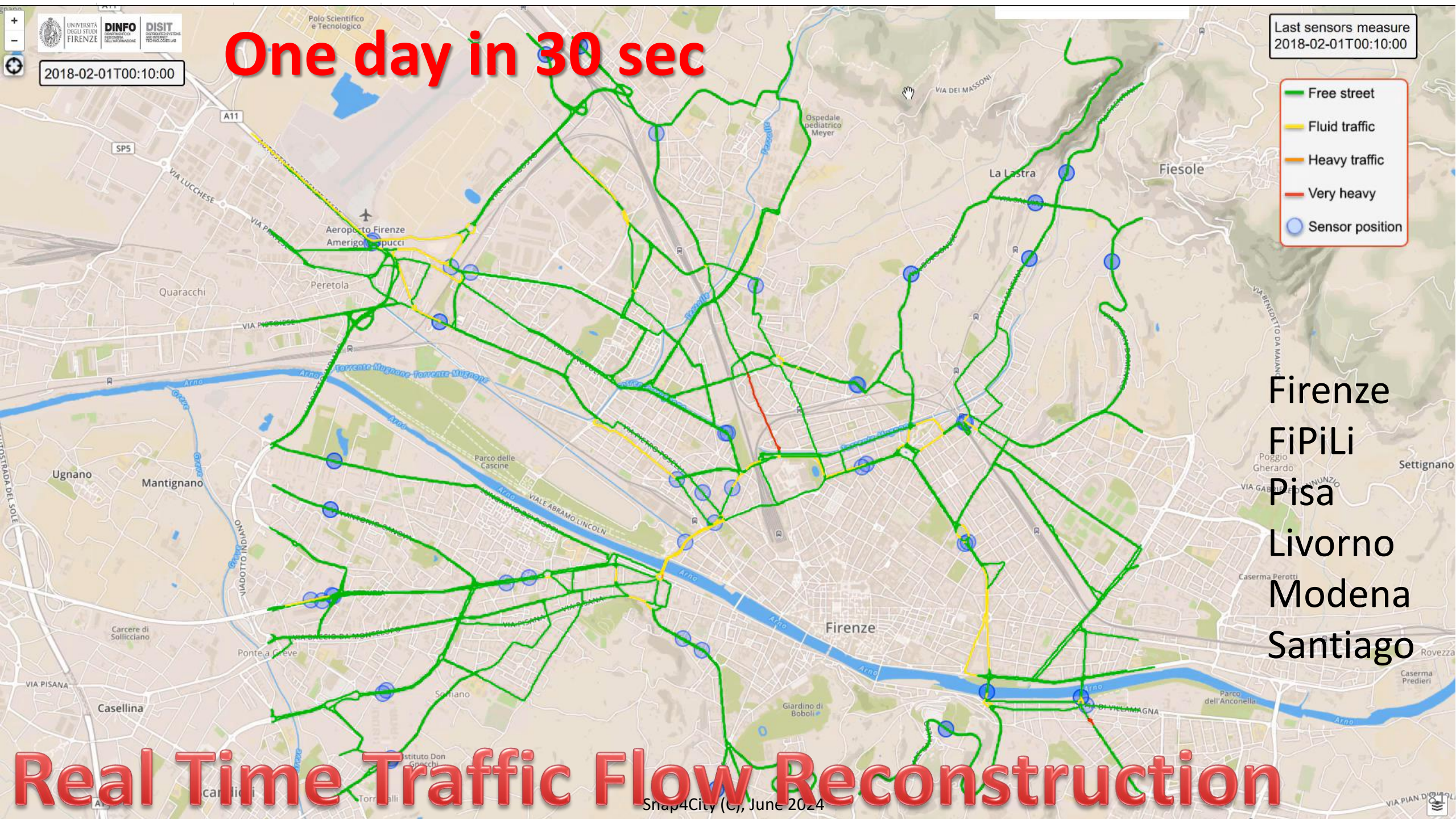
https://www.snap4city.org/976

Why Dense Traffic Flow Reconstruction ?

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

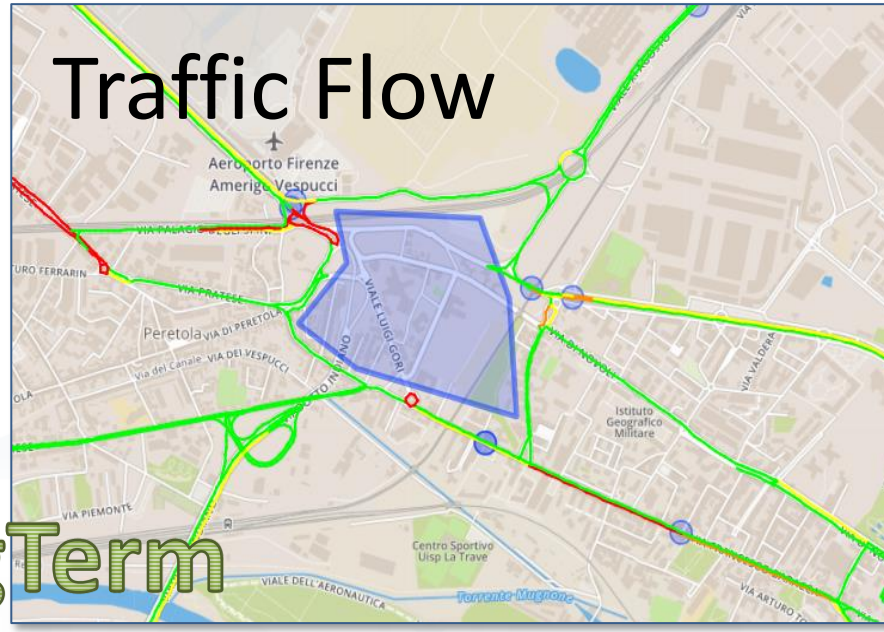


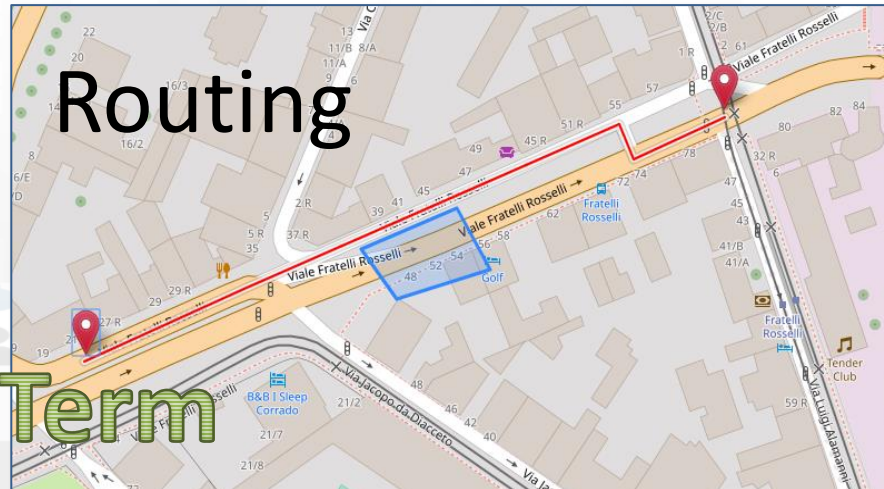
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc5NQ==


One day in 30 sec
2018-02-01T00:10:00
Last sensors measure
2018-02-01T00:10:00
Free street
Fluid traffic
Heavy traffic
Very heavy
Sensor position
Firenze
FiPiLi
Pisa
Livorno
Modena
Santiago
Real Time Traffic Flow Reconstruction

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

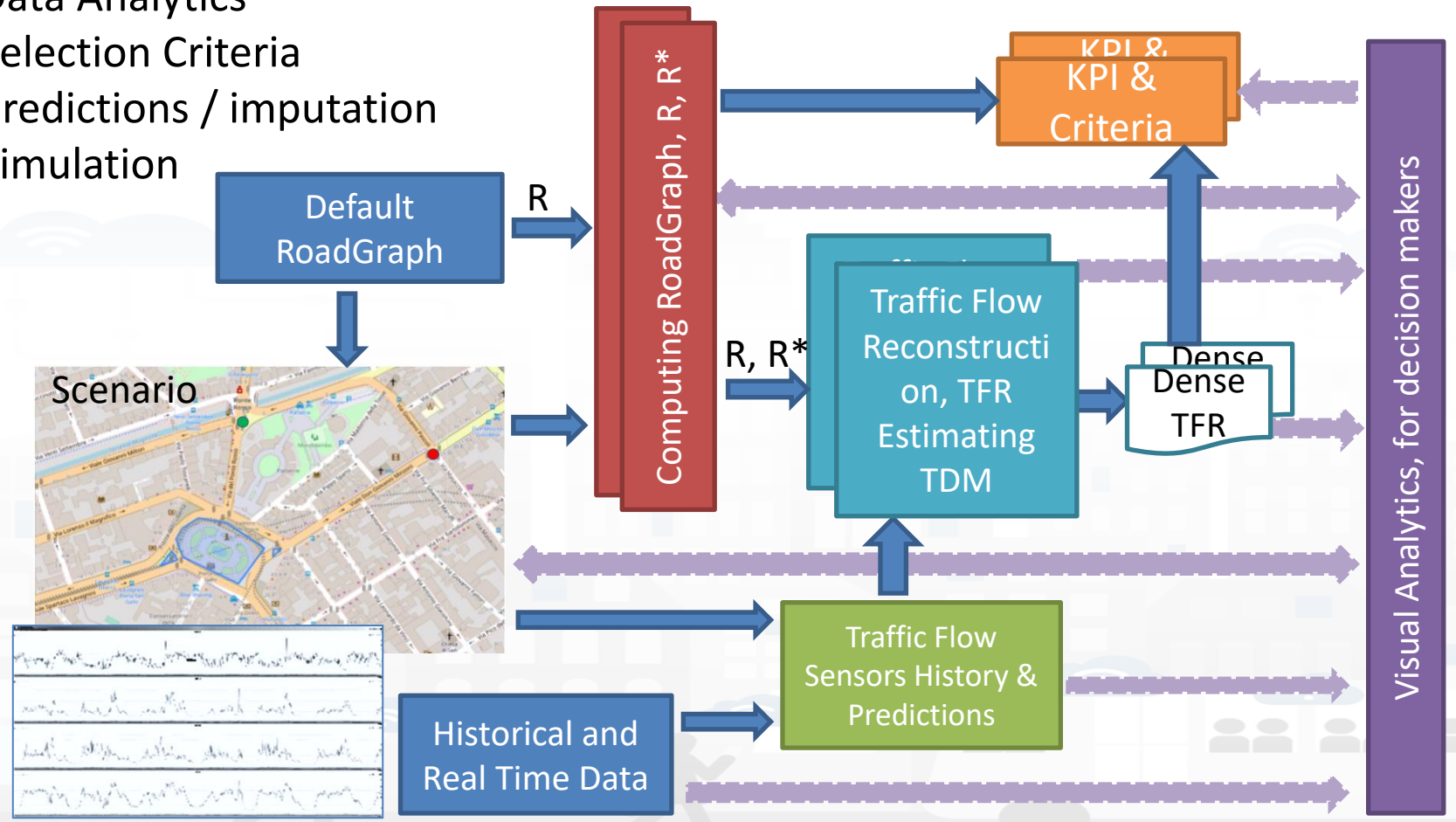




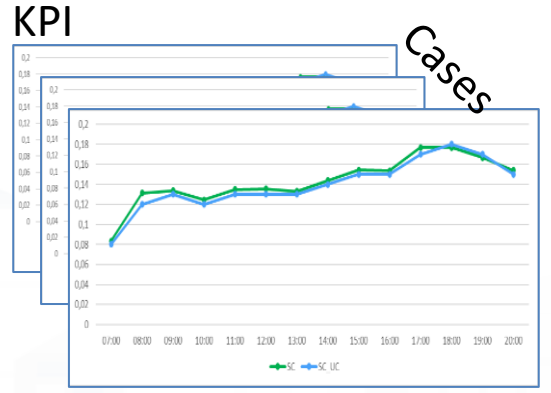
What-if: Simulation for Traffic Flow

At the same color corresponds the same area:

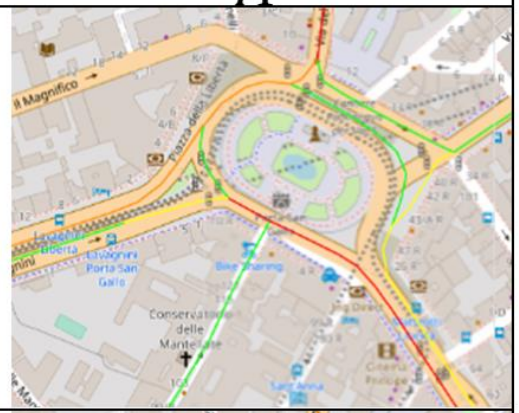
- Data / information
- Data Analytics
- Selection Criteria
- Predictions / imputation
- Simulation

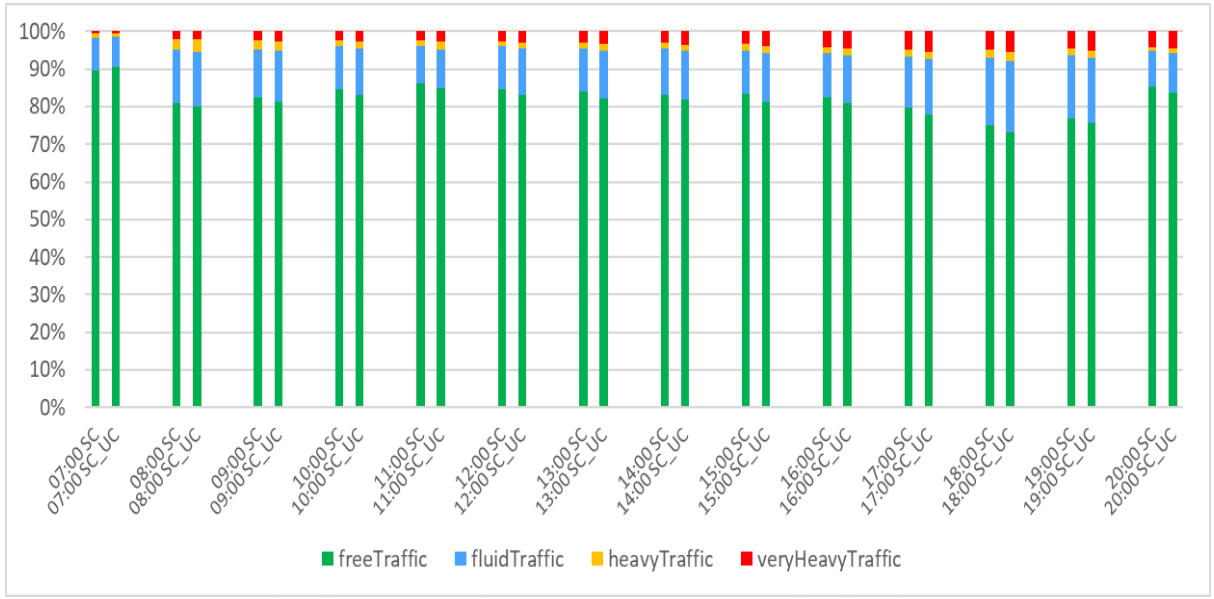


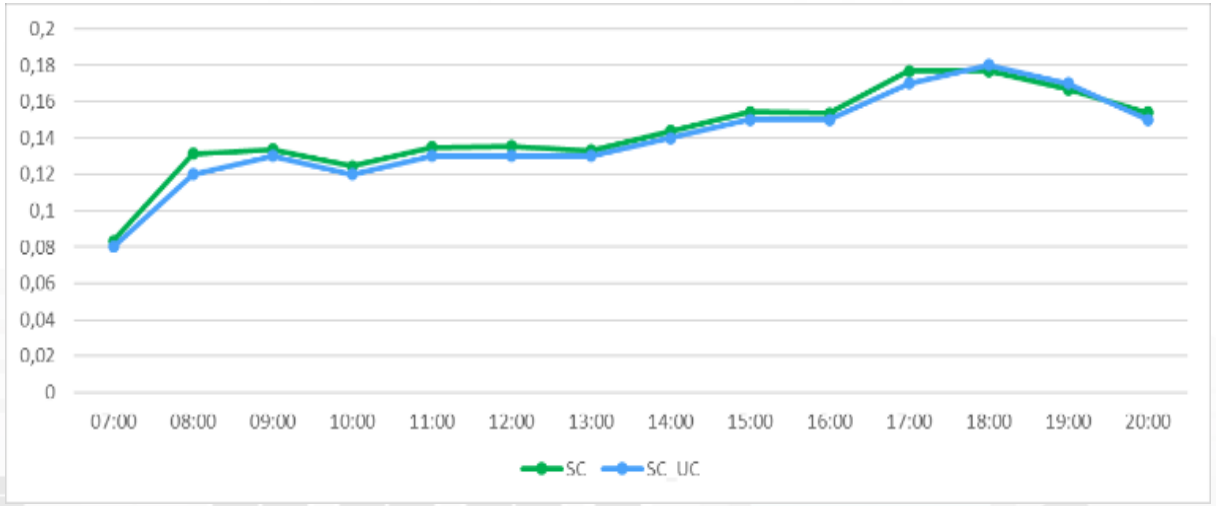
Data Driven Decision



What-if

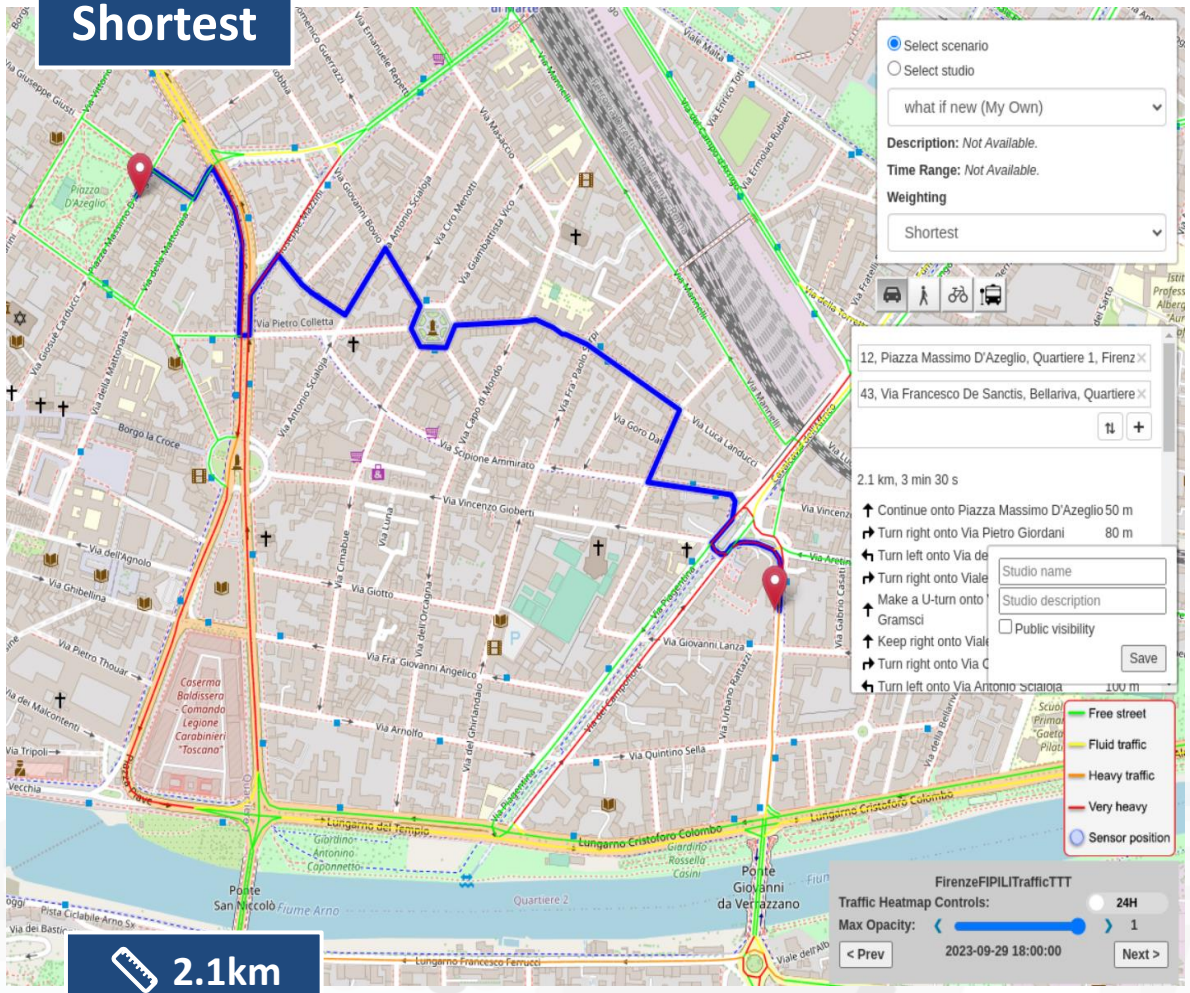
	analysis results of $SC_{i,\hat{T}}$	Actual Traffic Flow results of $R_{\hat{T}1}$
09:00		
15:00		





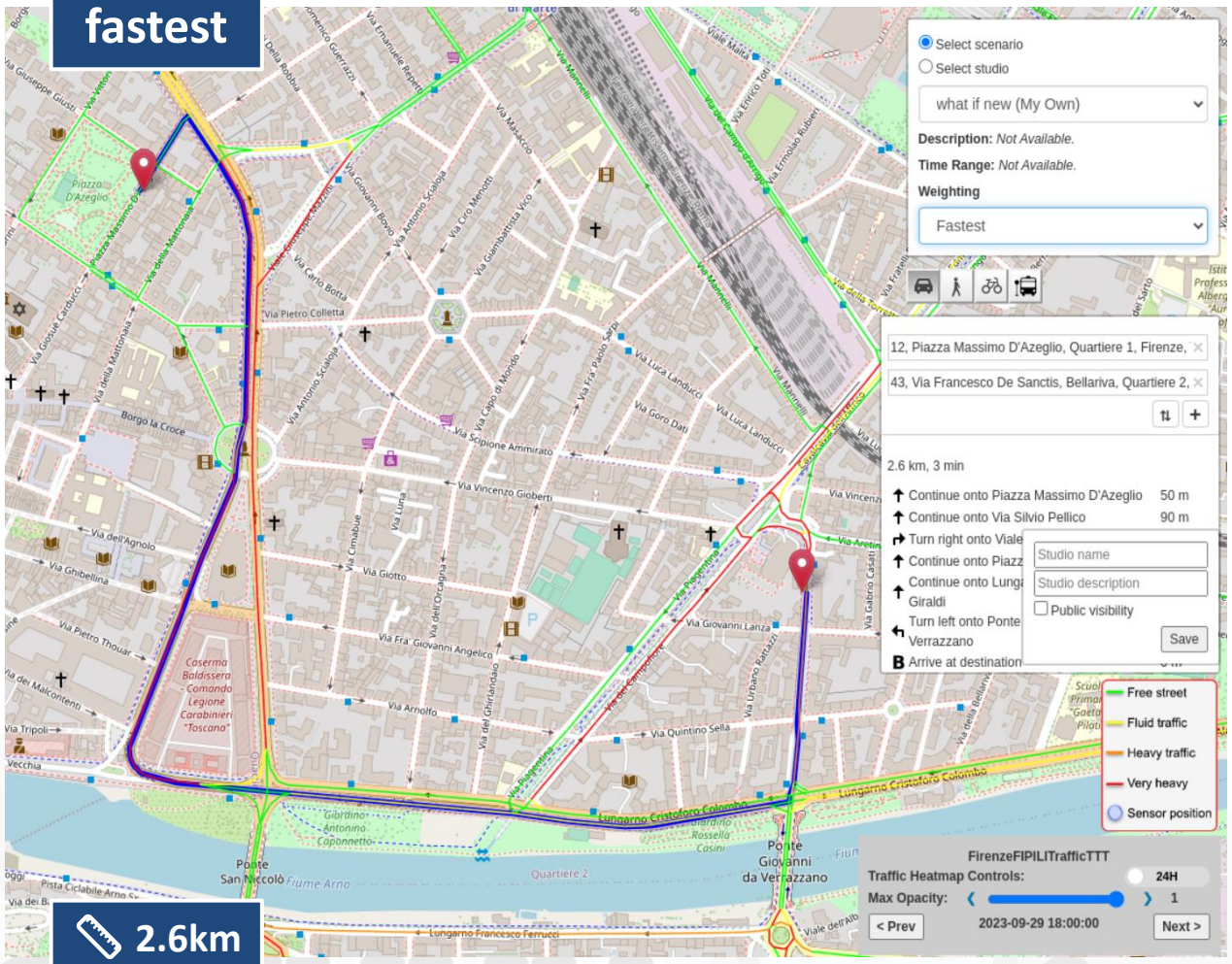
Constrained Dynamic Routing: Traffic Flow

Shortest



2.1km
3min 30s

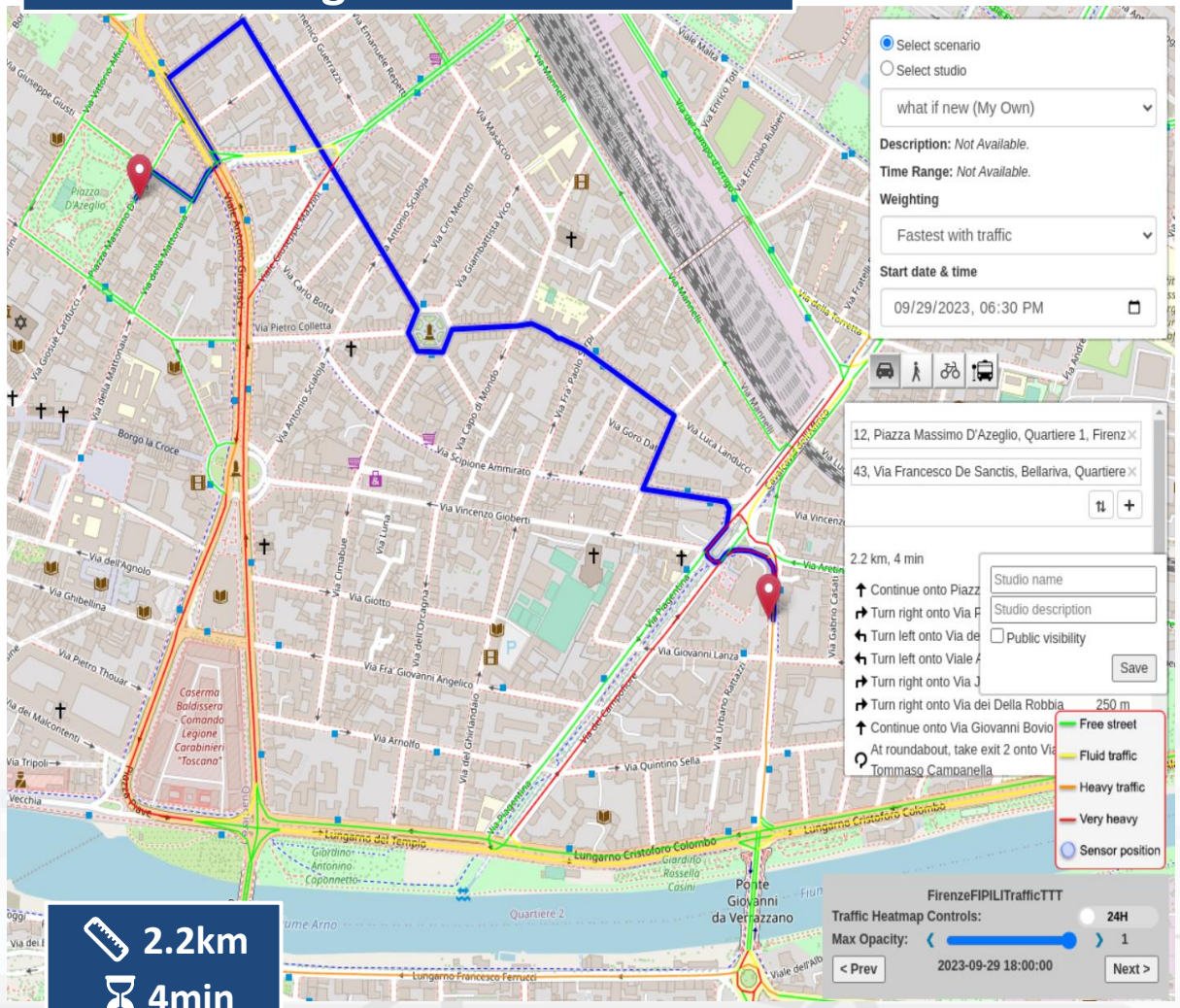
fastest



2.6km
3min

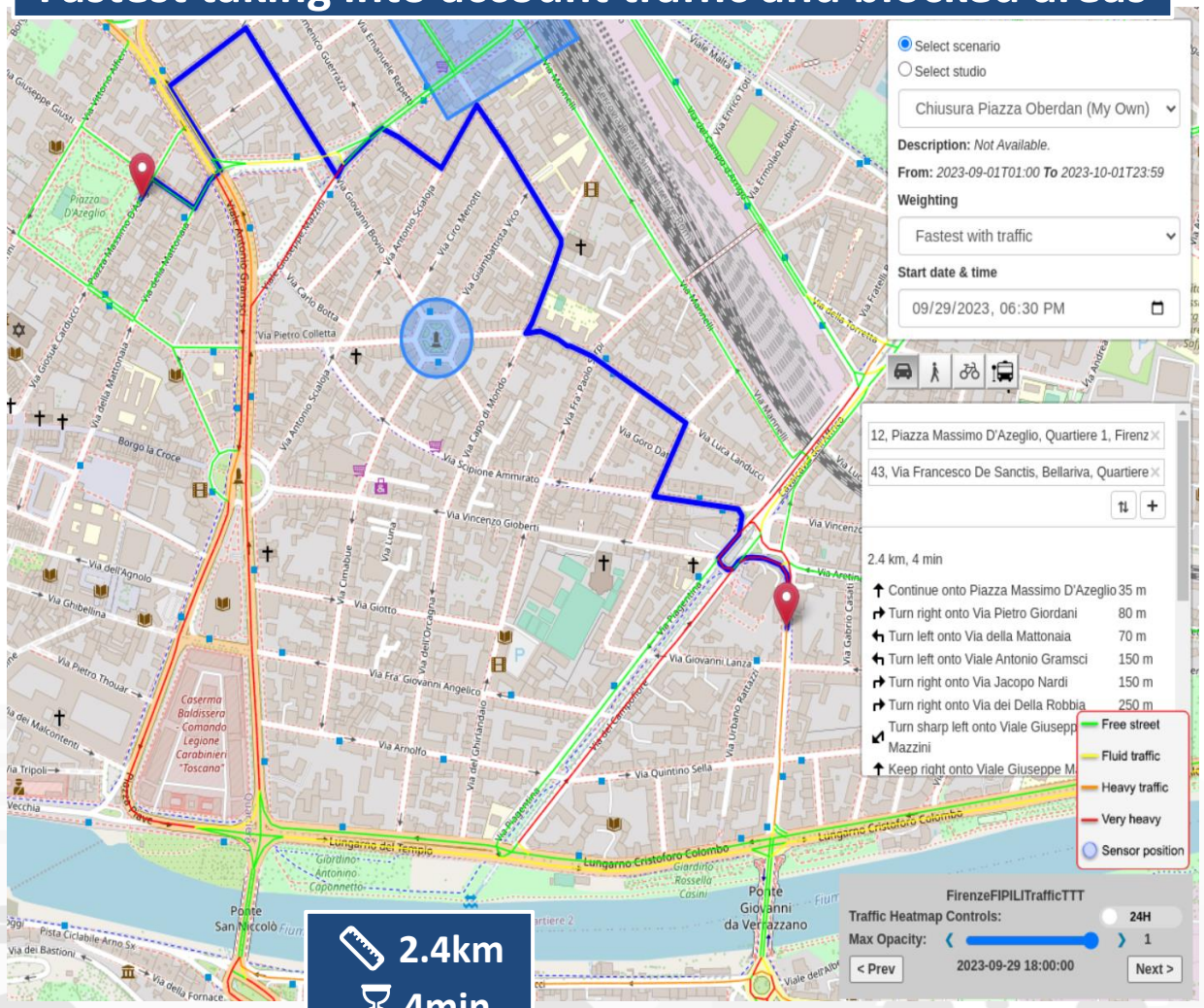
Constrained Dynamic Routing: Traffic Flow

Fastest taking into account traffic



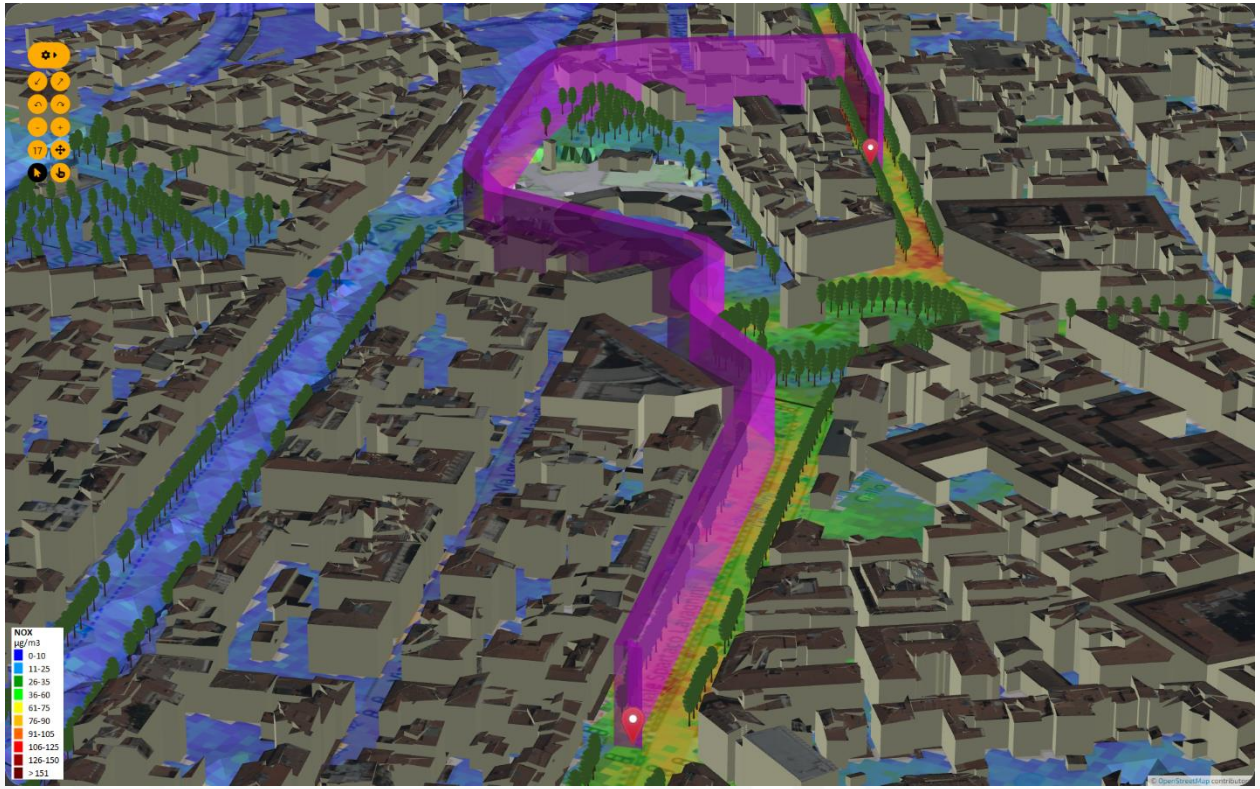
2.2km
4min

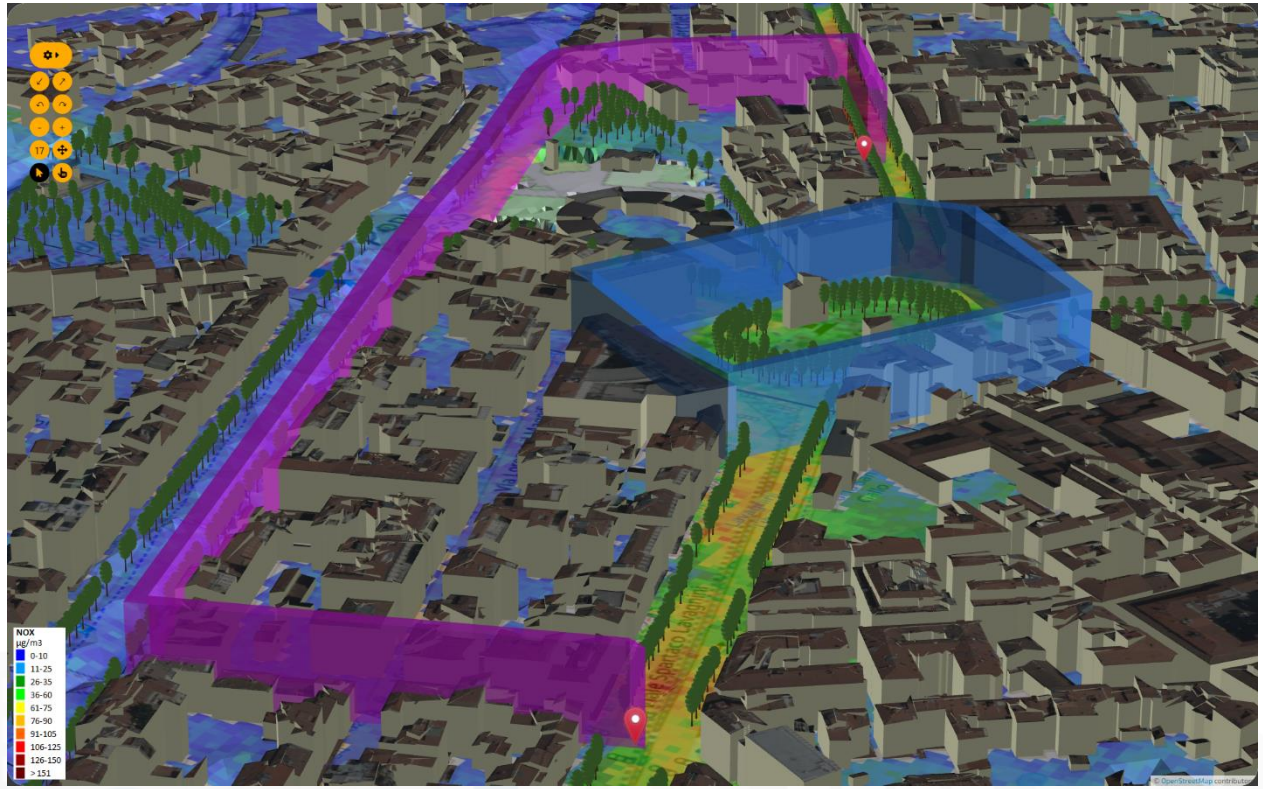
Fastest taking into account traffic and blocked areas



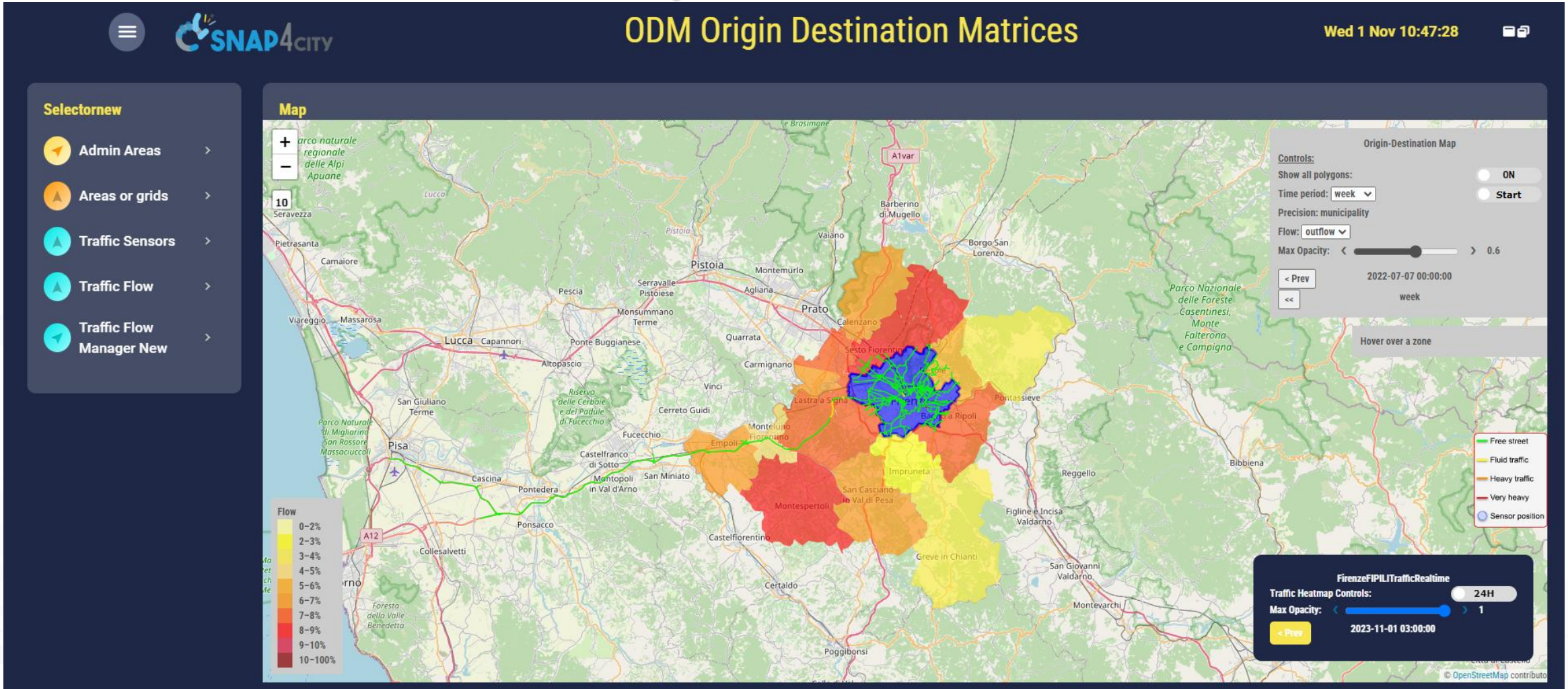
2.4km
4min

Dyamic Routing in 3D space





ODM, Traffic Flow

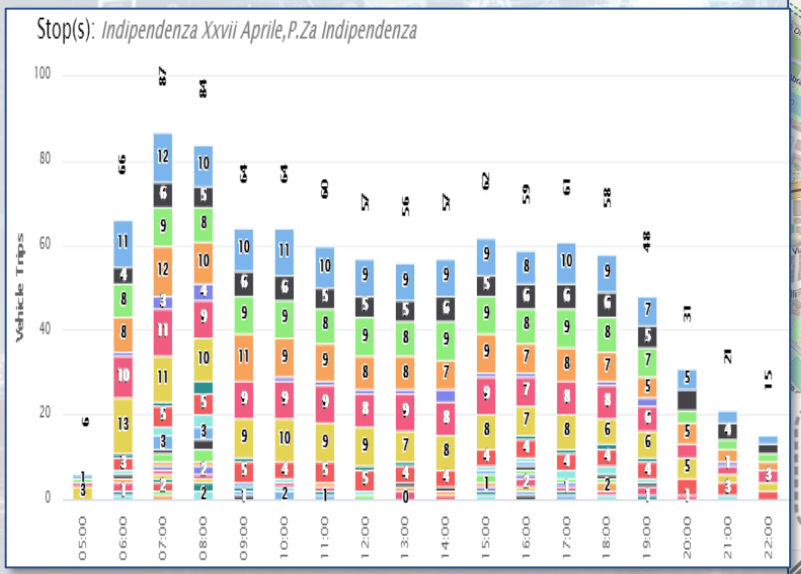


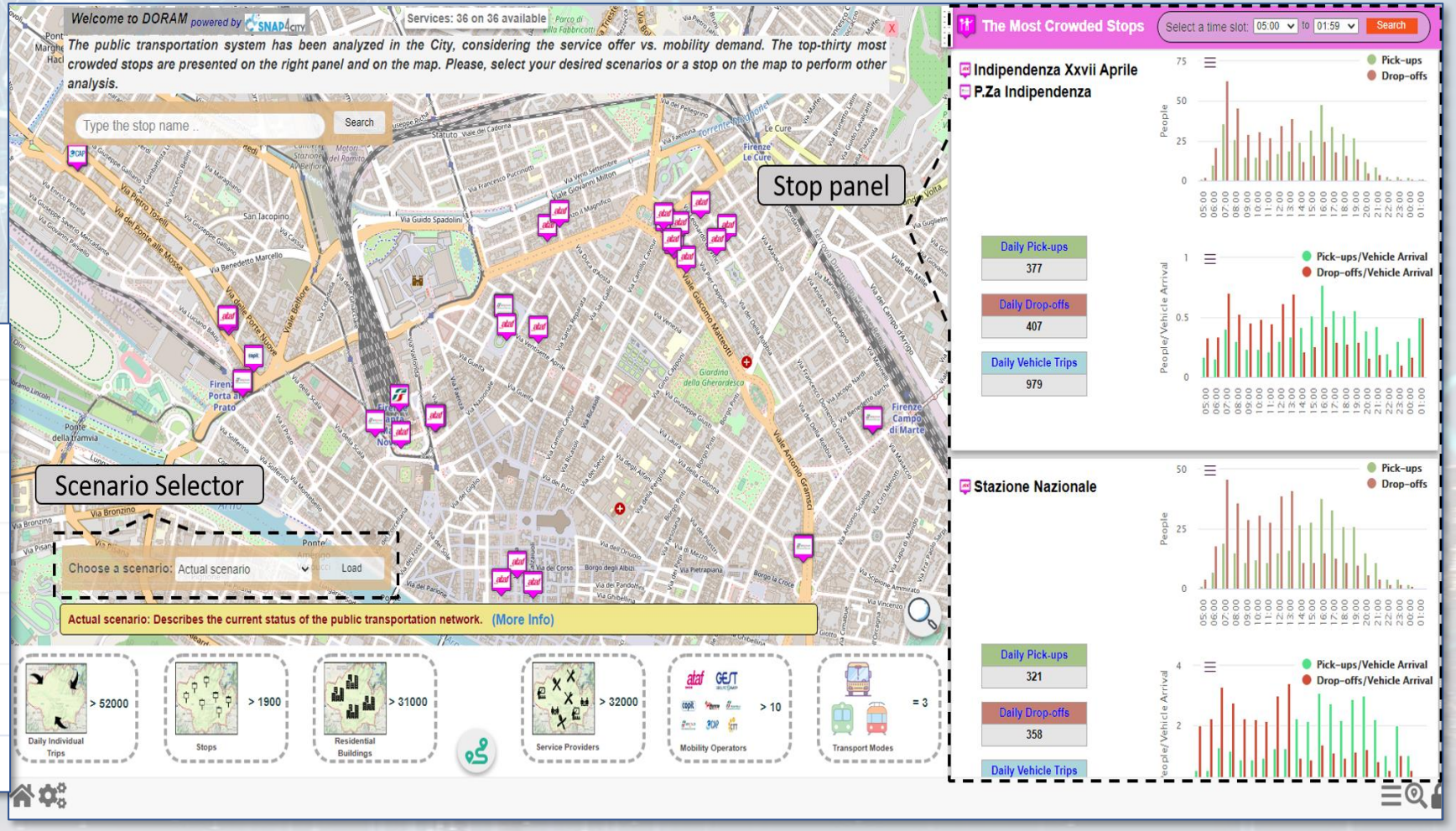
https://www.snap4city.org/dashboardSmartCity/view/Gea-Night.php?iddasboard=Mzk3Nw==

What-if Analysis on Pub Transport

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

Public Services

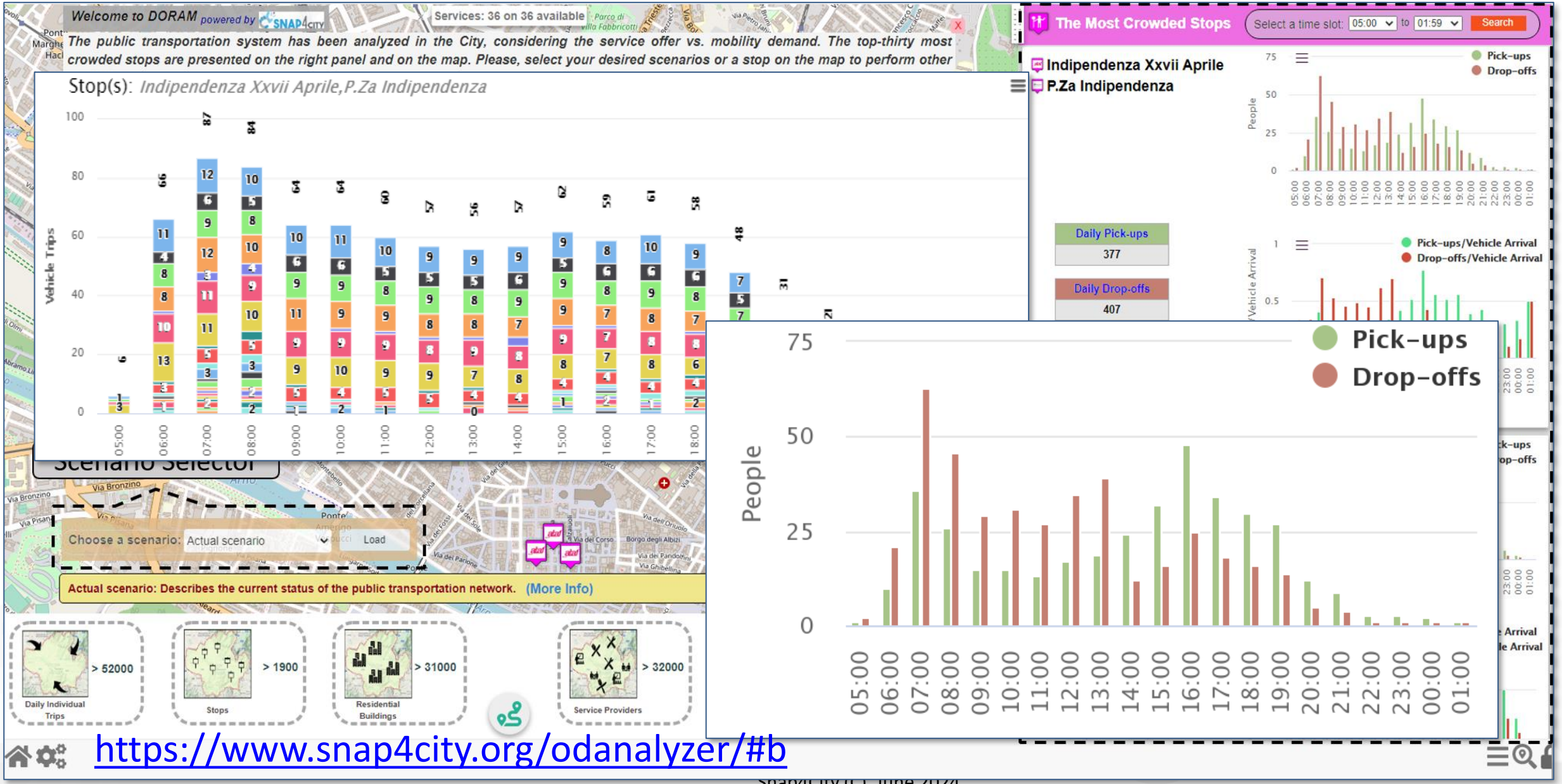




UNIVERSITÀ DEGLI STUDI FIRENZE | DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE | DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

DORAM

SNAP4CITY | KM 4 CITY



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

DORAM

Action based using Snap4City Knowledge Base

Citizen Mobility demand and habits, real time traffic

Service offer (GTFS)

DORAM - Demand OfeR Analyzer for Mobility

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

City Mobility Operator(s)

analysis of the offer vs demand (DORAM)

GTFS variation to improve the efficiency of the service

Planned Bus/Tram/Train/ etc. stops/trips and timetables (GTFS)

What can produce the Analysis tool by KPI

- Identification of critical Bus Stops over time
- Identification of critical courses of bus lines, over day and week
- Effects of changing the position of Bus Stops, courses and line schedules, bus size, etc.
- Effects of changing the contextual conditions:
  - The opening of shopping centers, cinemas, schools, etc..
  - Changes on city structure and paths
  - Size of the buses

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

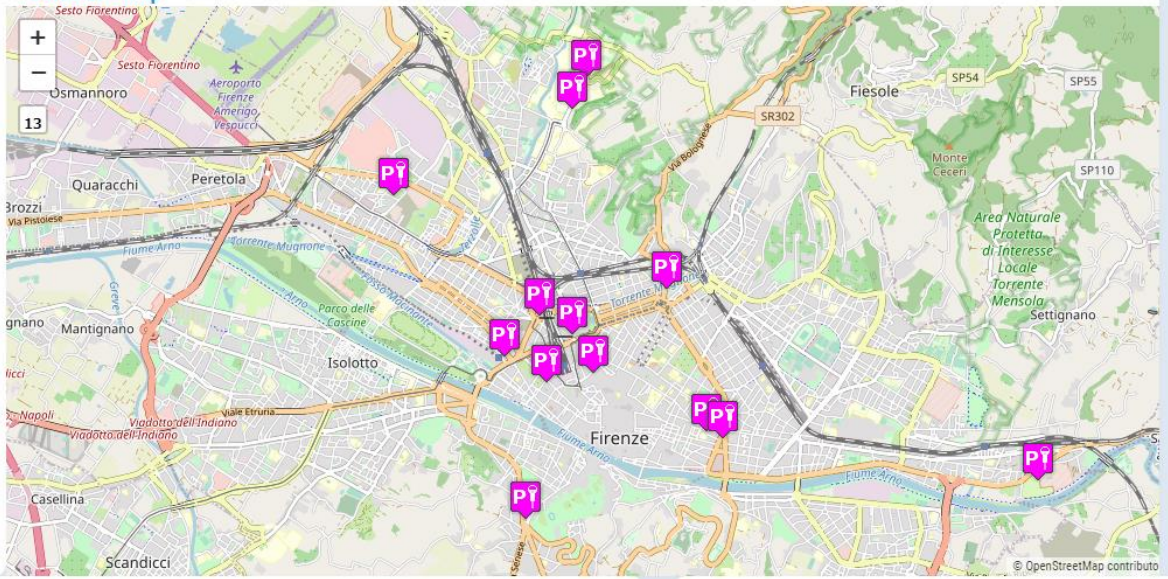
Monitoraggio Parcheggi

Sat 13 May 23:26:20

Selector

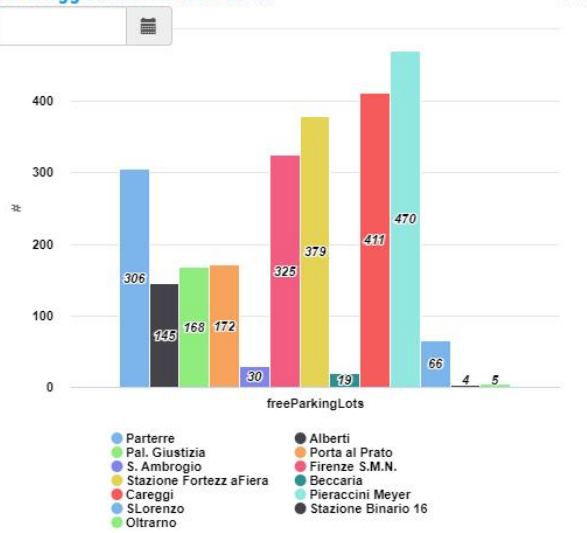
- Parterre
- Piazza Alberti
- Palazzo di.Giustizia
- Porta al Prato
- S. Ambrogio
- Stazione Firenze S.M.N.
- Stazione Fortezza Fiera
- Piazza Beccaria

Selector - Map



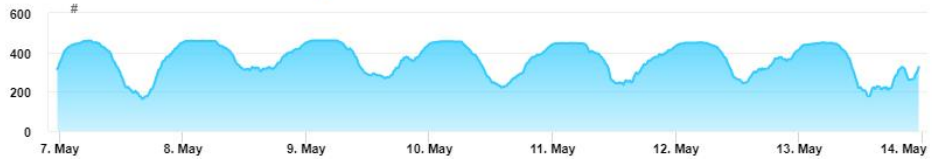
Parcheggi: Numero Posti Liberi

4m



StazioneFirenzeS.M.N. - FreeParkingLots

9m



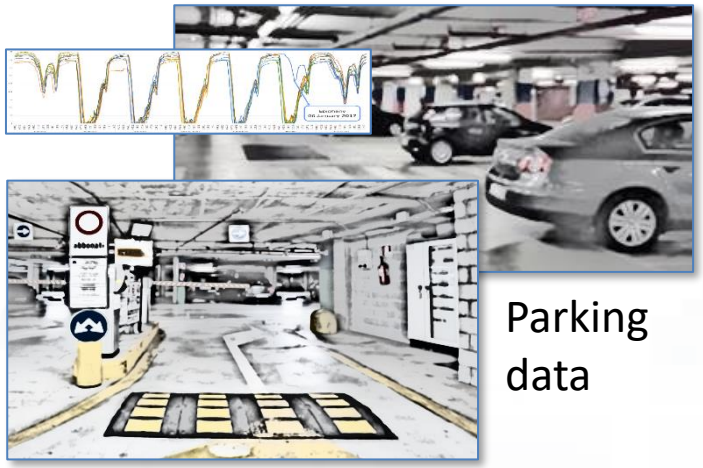
Andamento Posti Occupati

4m

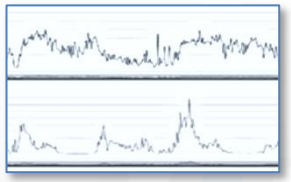
My Profile

Privacy Policy Cookies Policy Terms and Conditions Contact us

Deep Learning AI to surely Park!

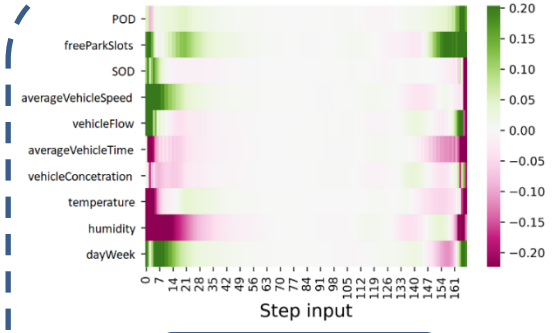


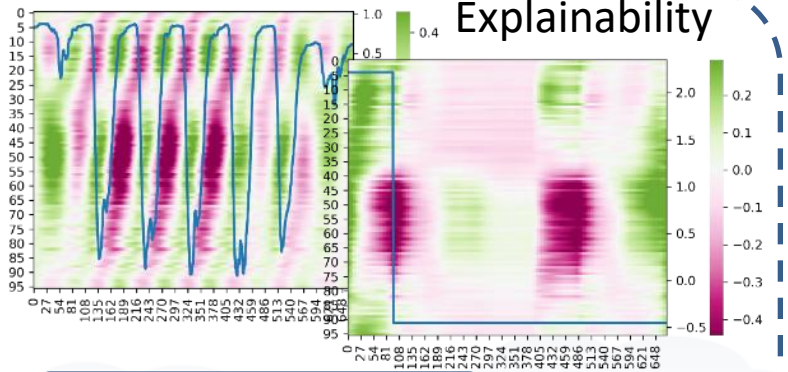
Parking data



Traffic sensors data

Weather Features

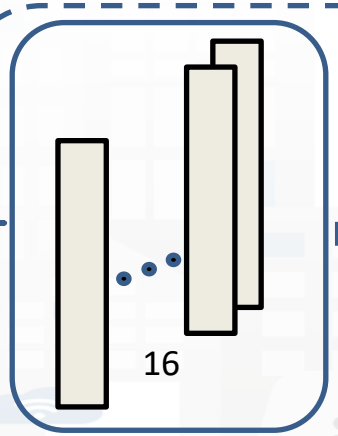


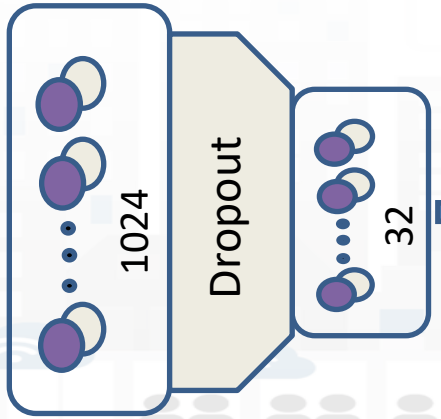


Explainability

Gradient

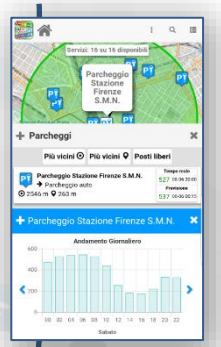
Integrated Gradient





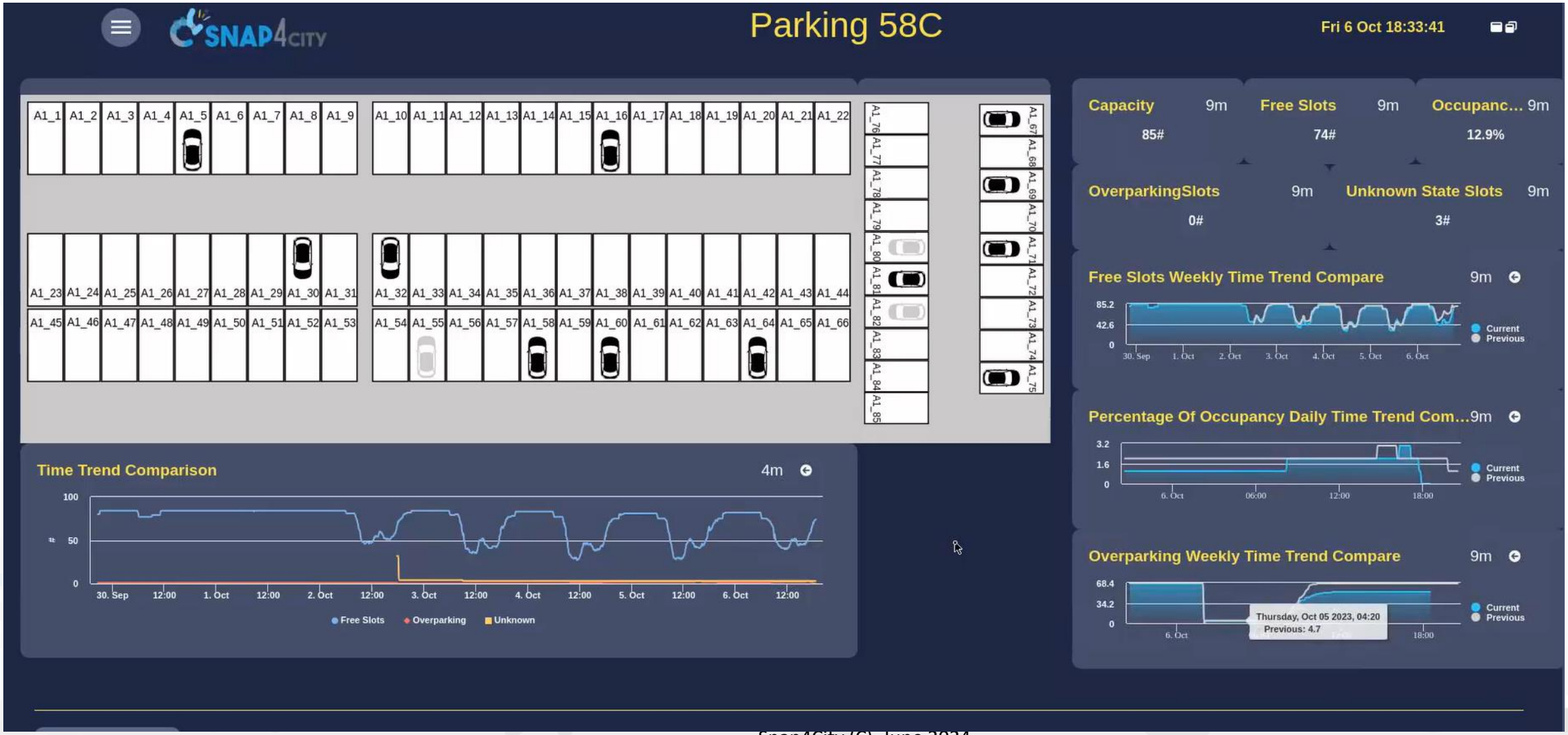
Dropout

Multi-step Predictions



Conv1D+AvPooling1D BI-LSTM BI-LSTM Dense

Snap4ISPRA Parking: ISPRA JRC



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SNAP4CITY | KM4CITY

Human Behavior, security

City Users Domain (2024)

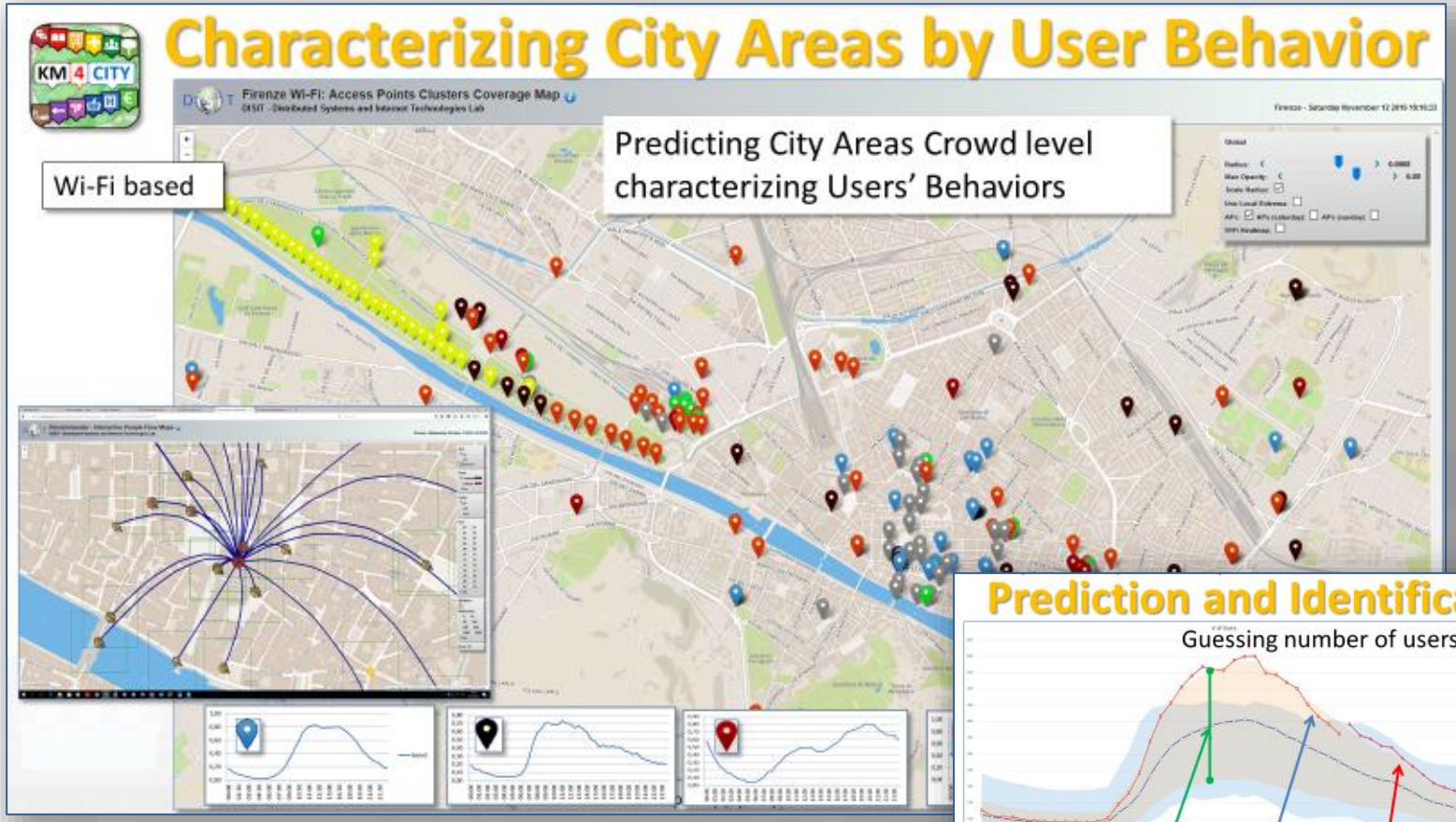
- Goals:
  - Quality of Life, quality of services
  - Costs reduction of services
  - Accessibility to services: citizens, Tourists, commuters, etc.
  - Security/Safety of city users
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring services: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

City Users Behaviour, Safety, Security and Social Analysis

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

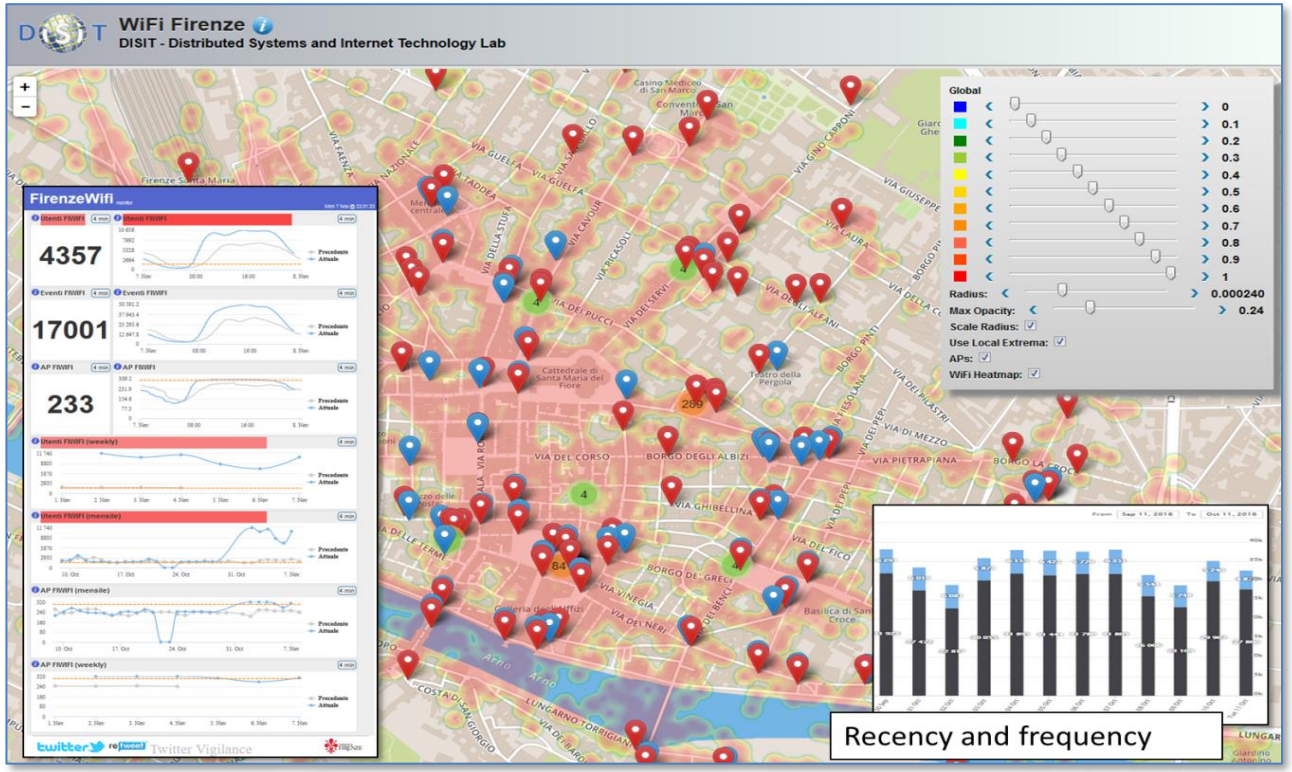
People Flows

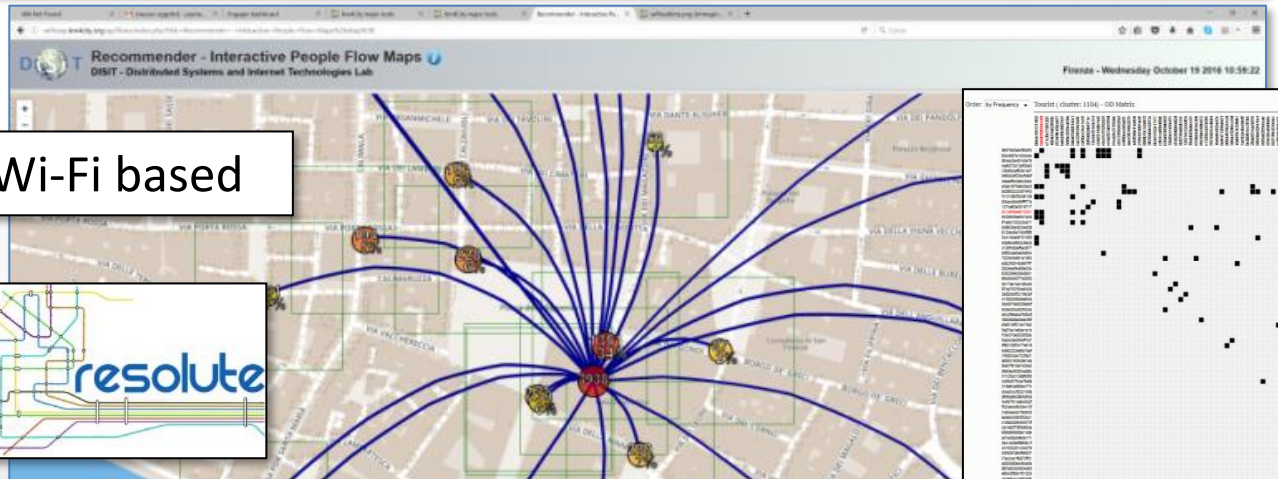
- **Prediction of people flows** on the basis of Wi-Fi data
- **Anomaly** detection
- **Resolute** H2020
- Classification of city areas



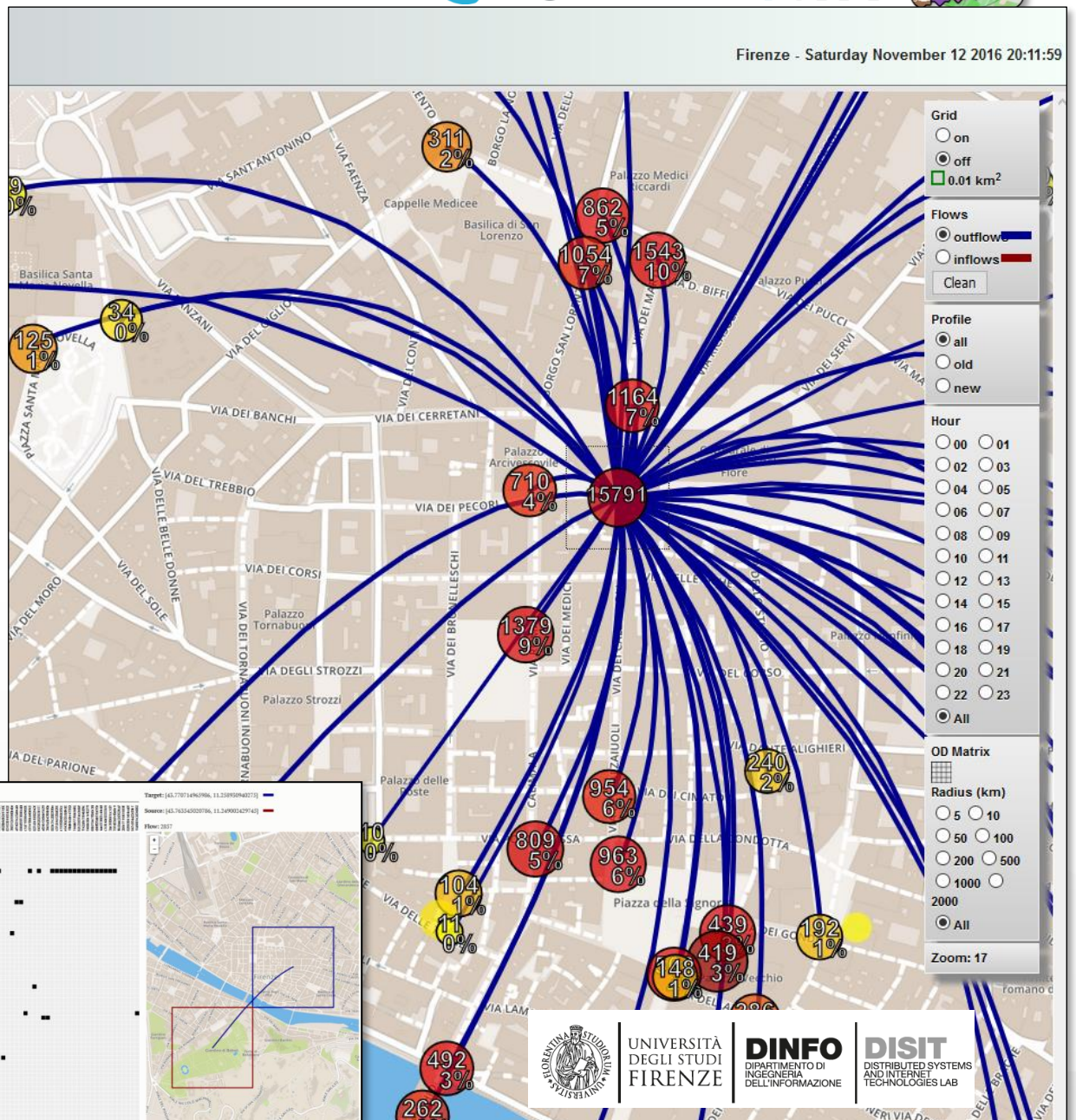
11 SUSTAINABLE CITIES AND COMMUNITIES

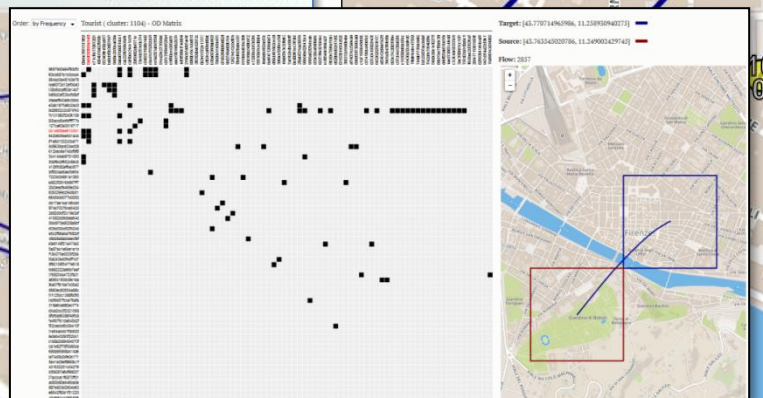
Origin Destination Matrix Estimation





Wi-Fi based





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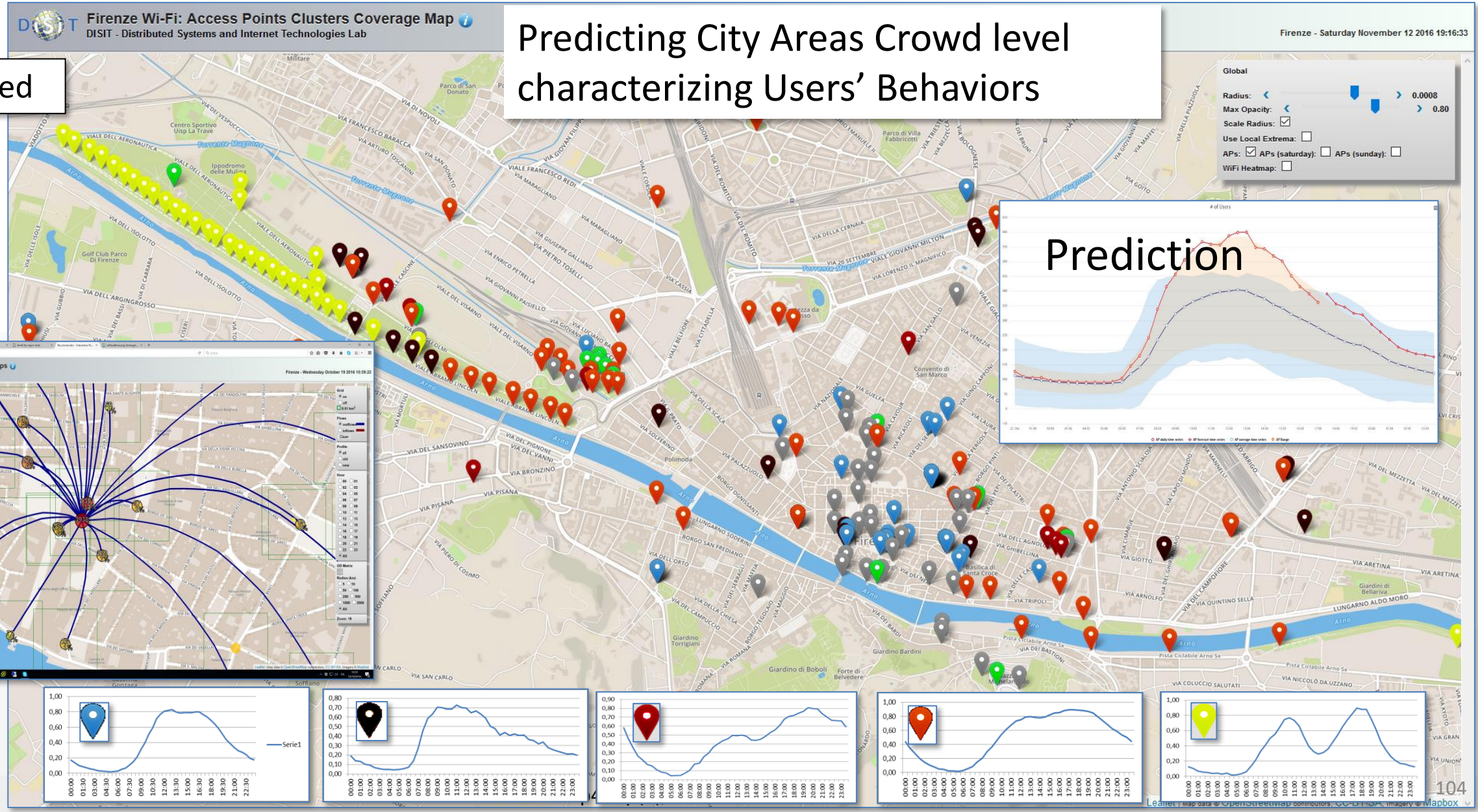
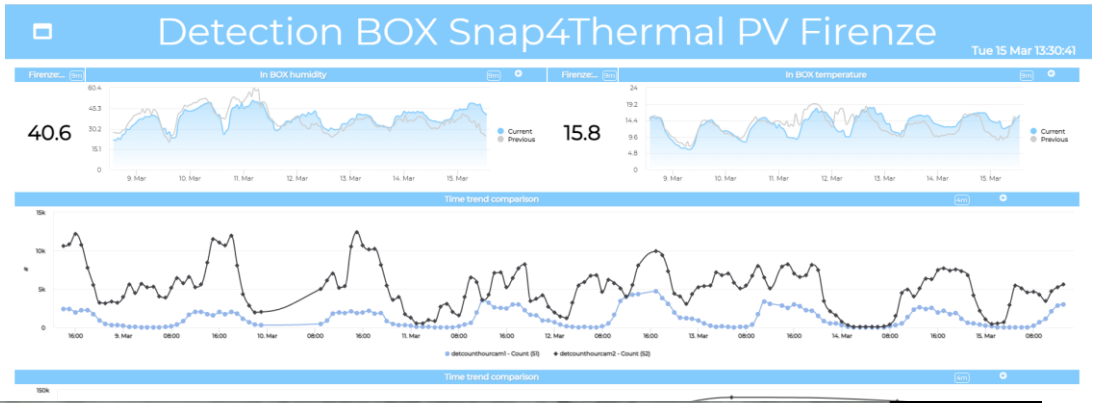
Characterizing City Areas

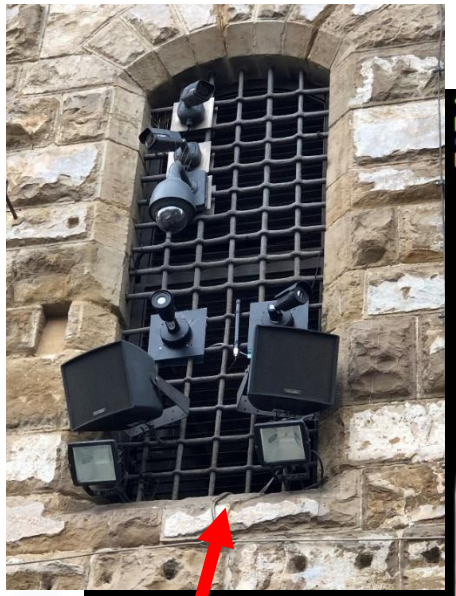
Wi-Fi based

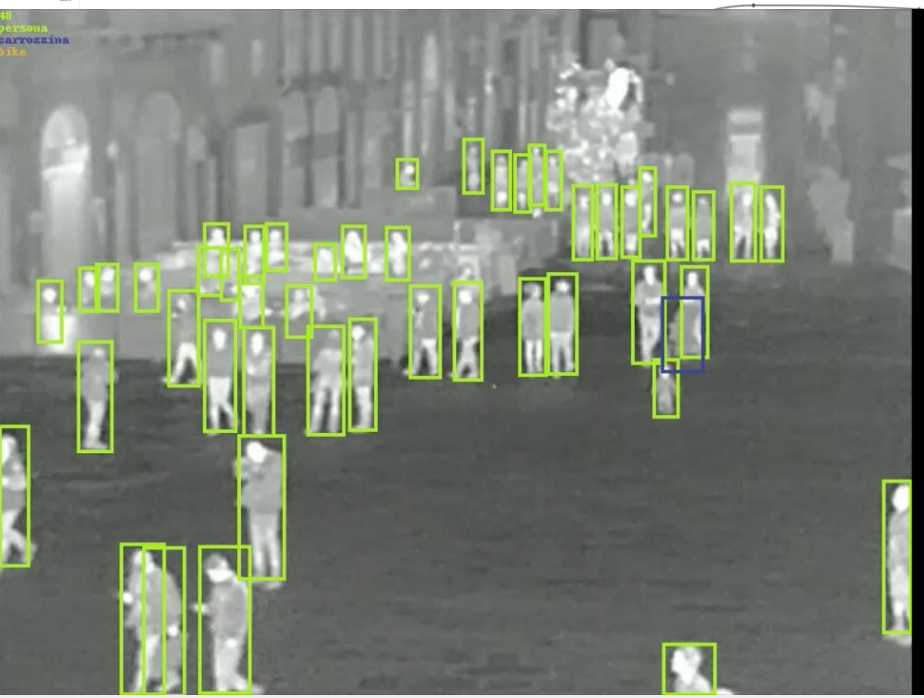
Predicting City Areas Crowd level characterizing Users' Behaviors

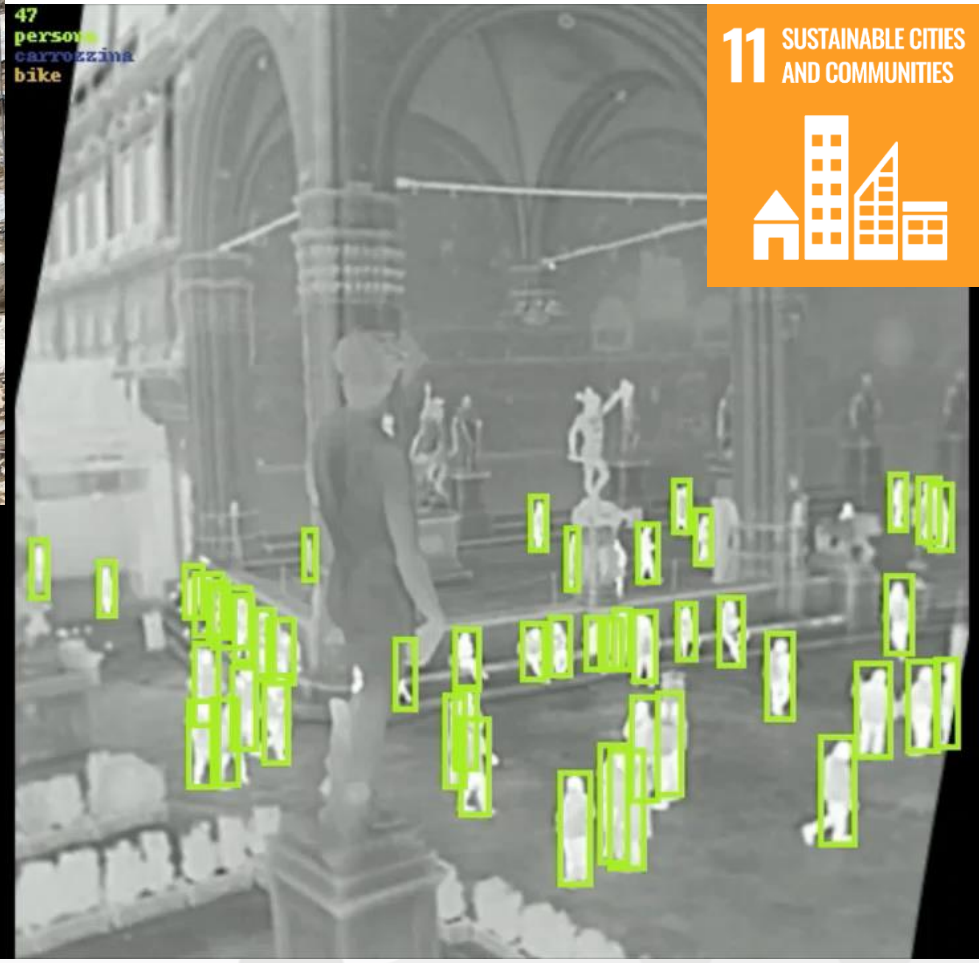


A view and data from the Thermal Camera









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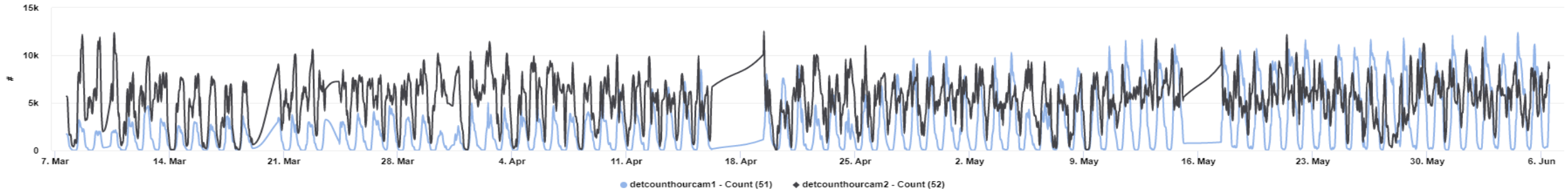
People Counting

https://www.snap4city.org/dashboardSmartCity/view/Gea.php?iddasboard=MzM3Ng==

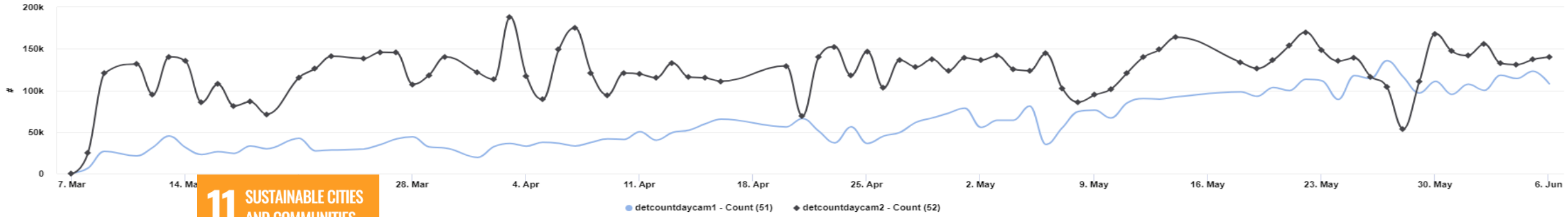
Detection BOX Snap4Thermal PV Firenze

Thu 30 Mar 23:55:16

Time Trend Comparison



Time Trend Comparison



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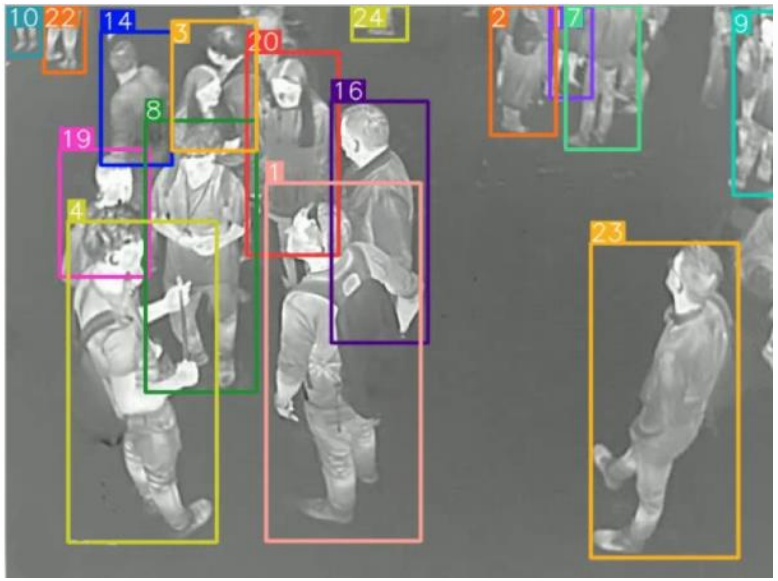
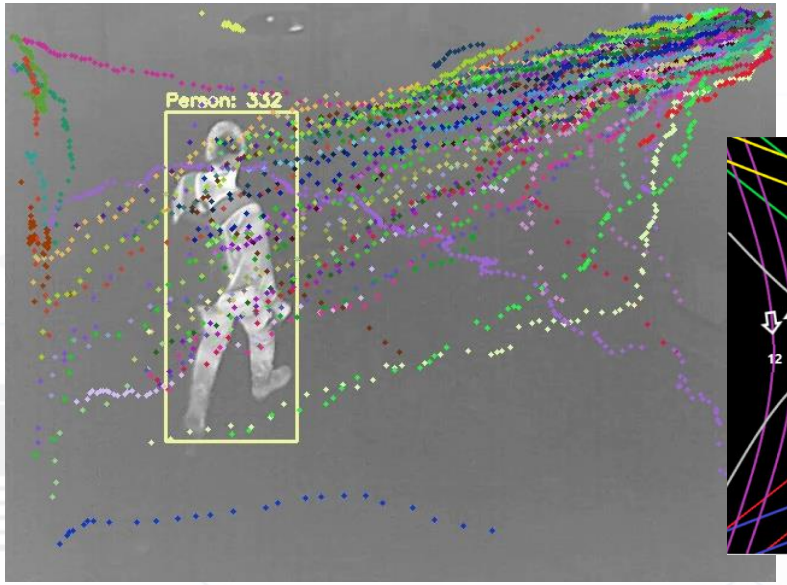
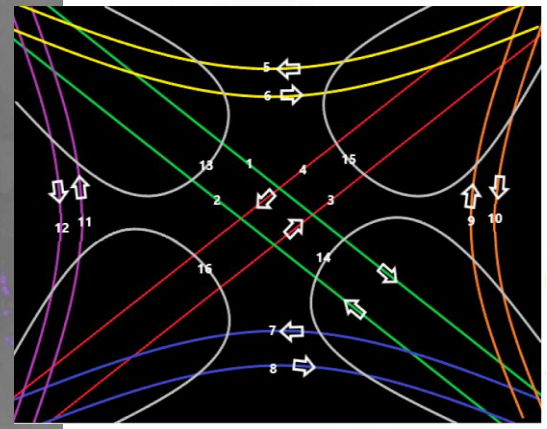
People Counting and Tracking







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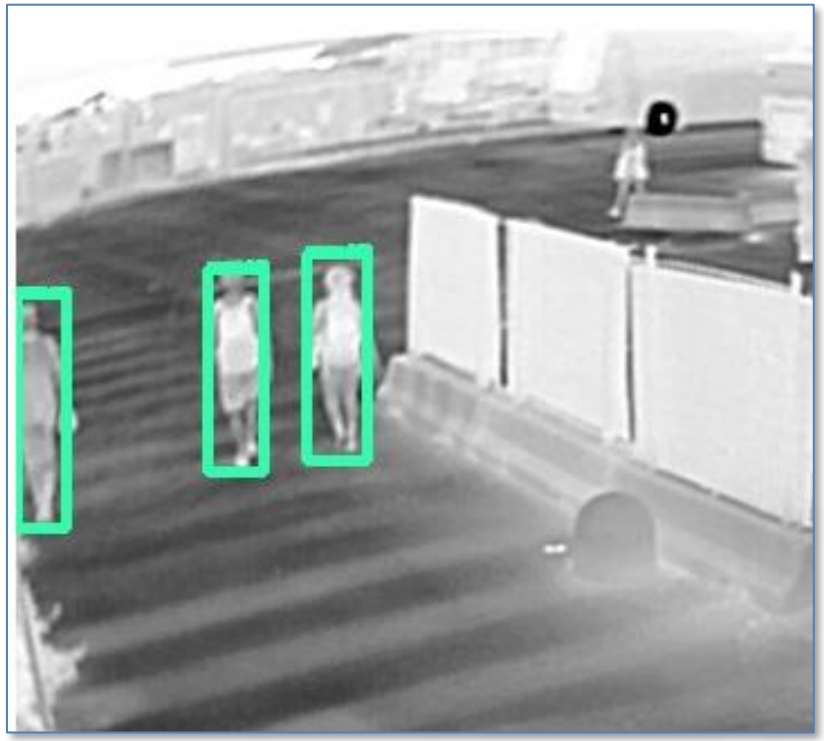
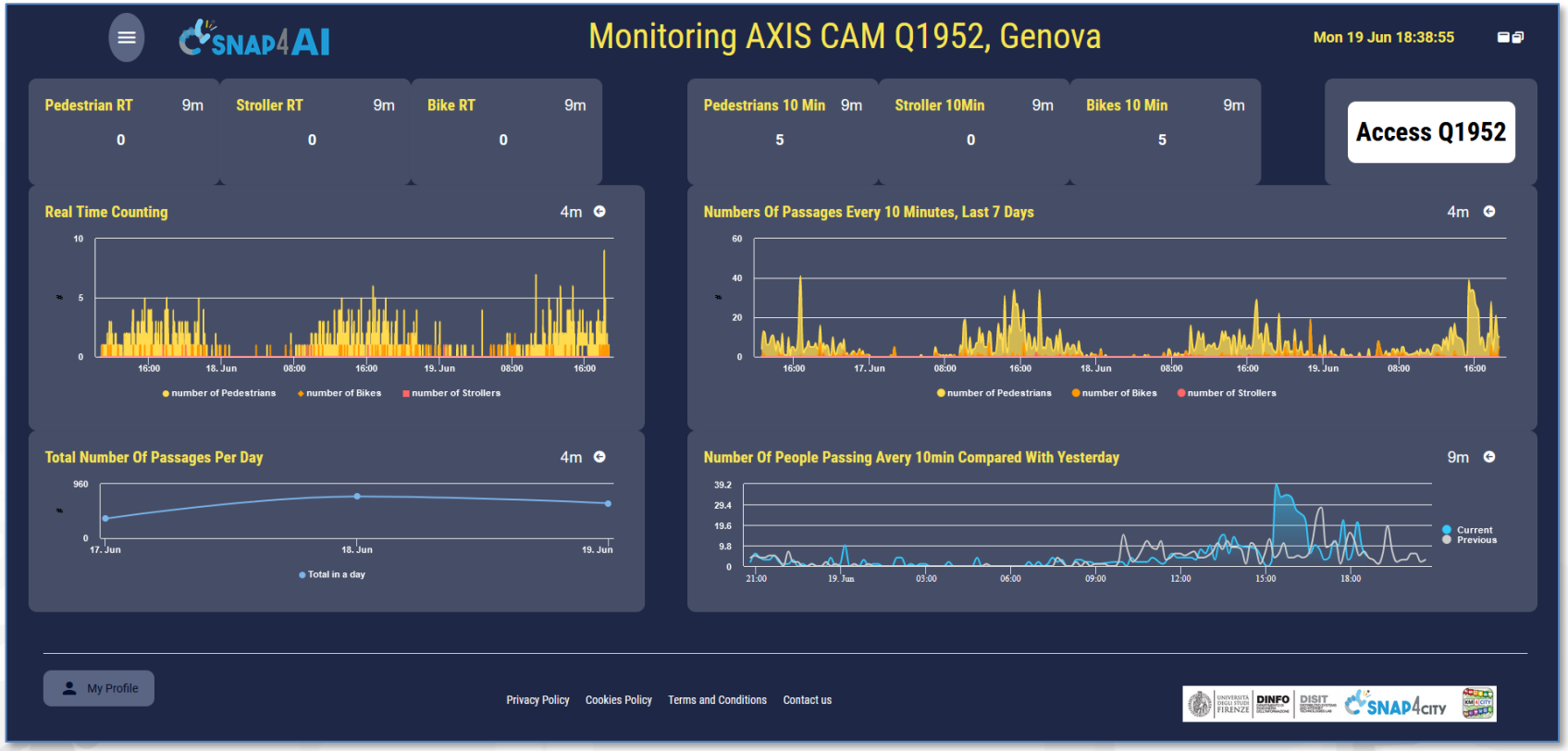
3X



Monitoring Passages AXIS Q1952

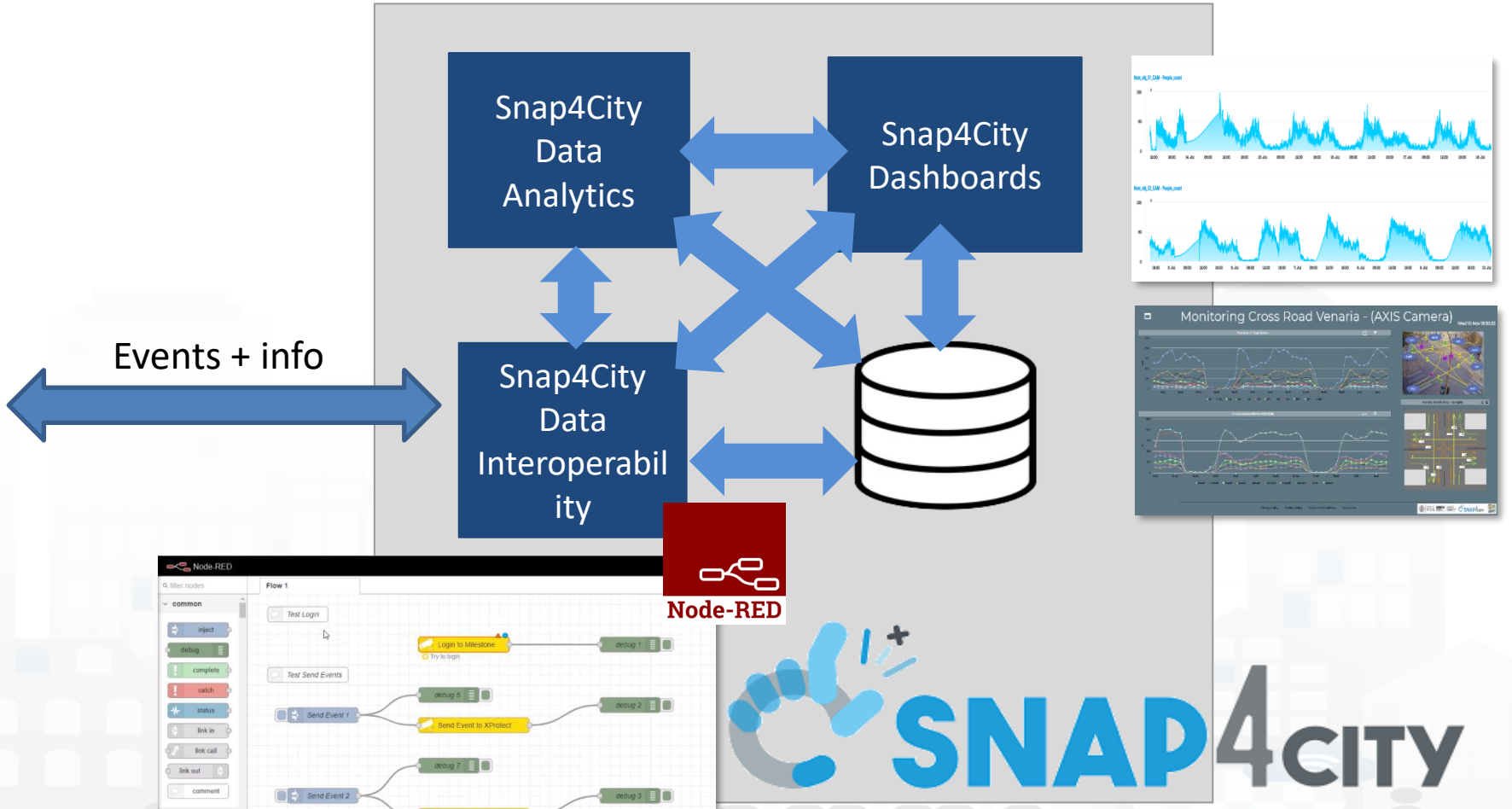
- Genova: Ocean Race, 2023

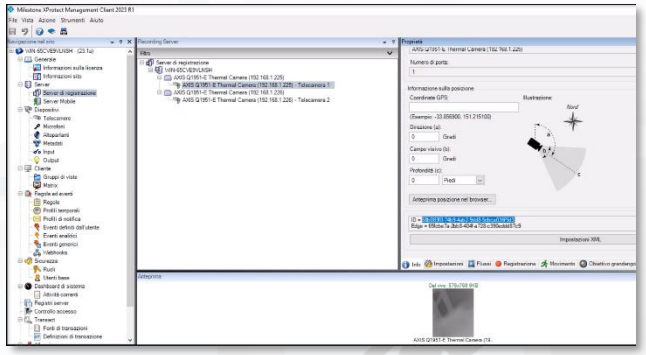


11 SUSTAINABLE CITIES AND COMMUNITIES

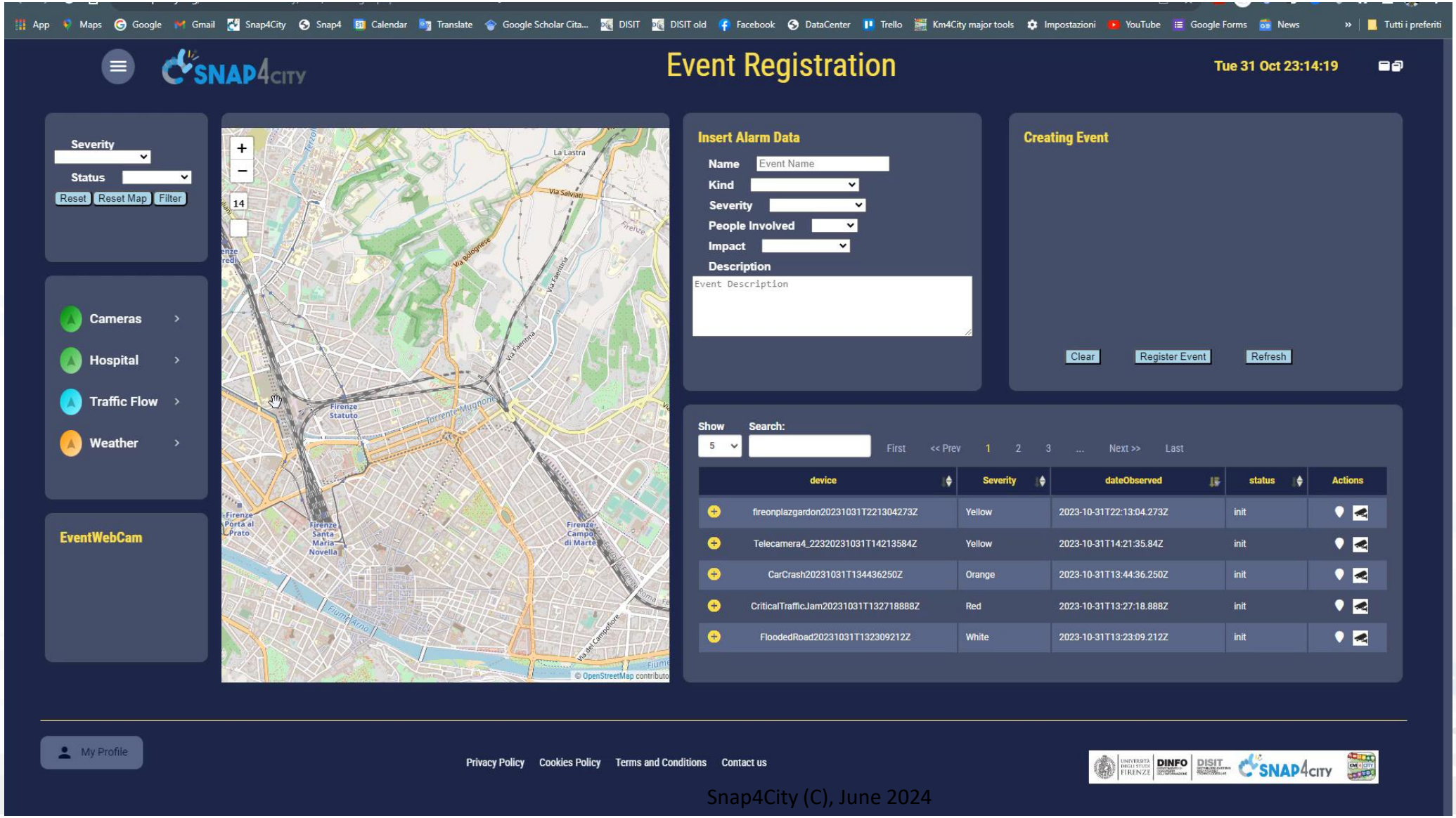
VMS vs Snap4City: sending and getting events, AI solutions

Events + info





Event Management



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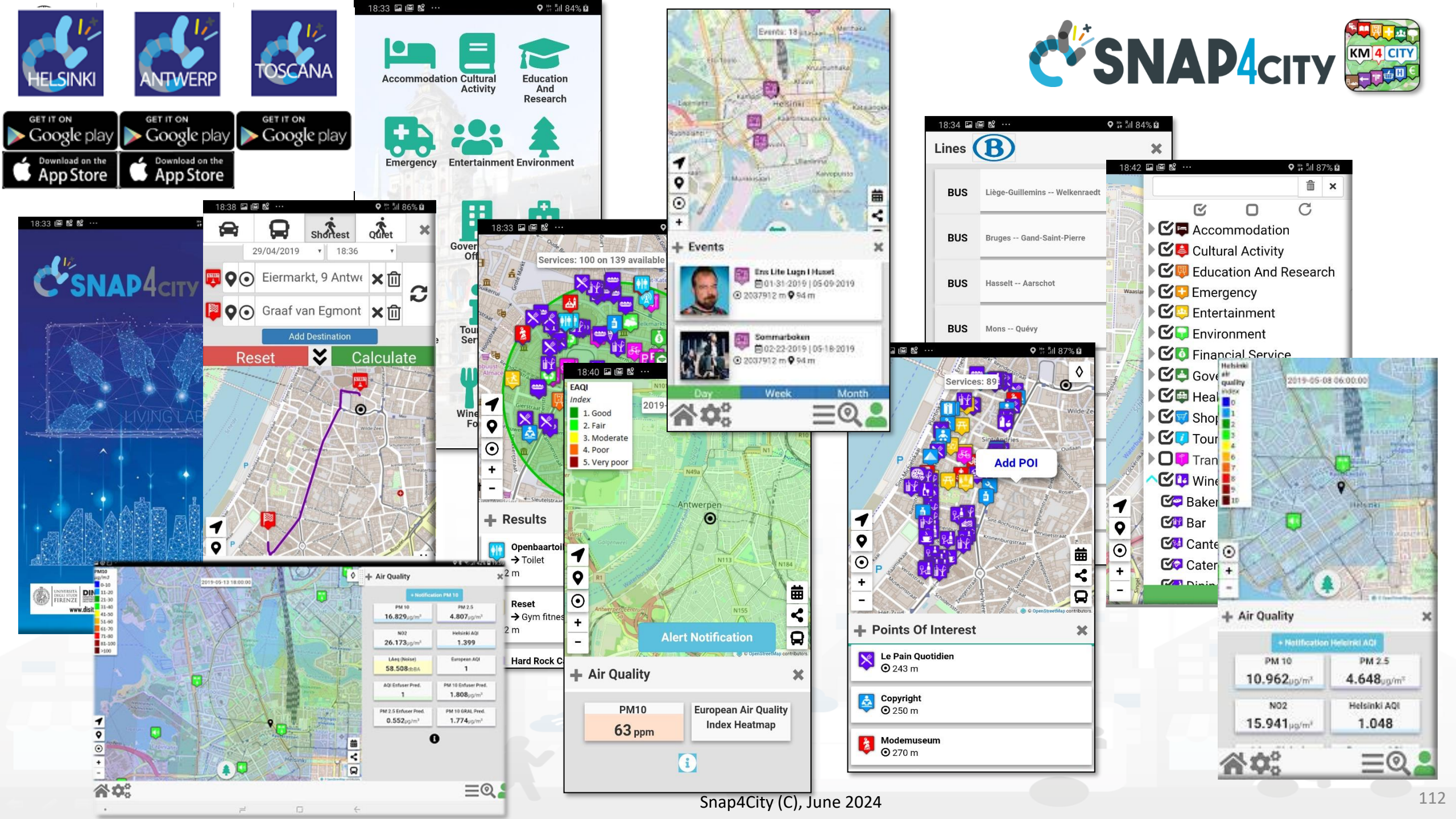
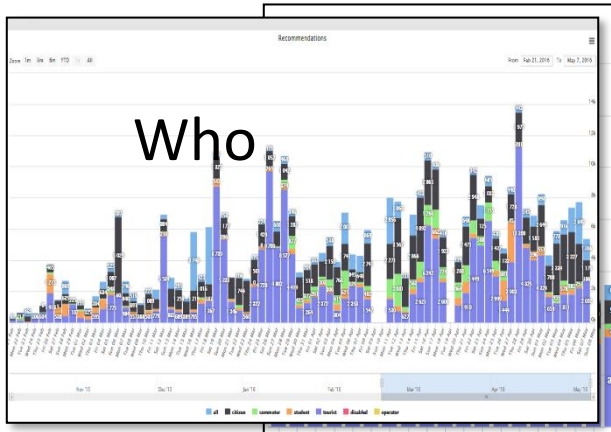
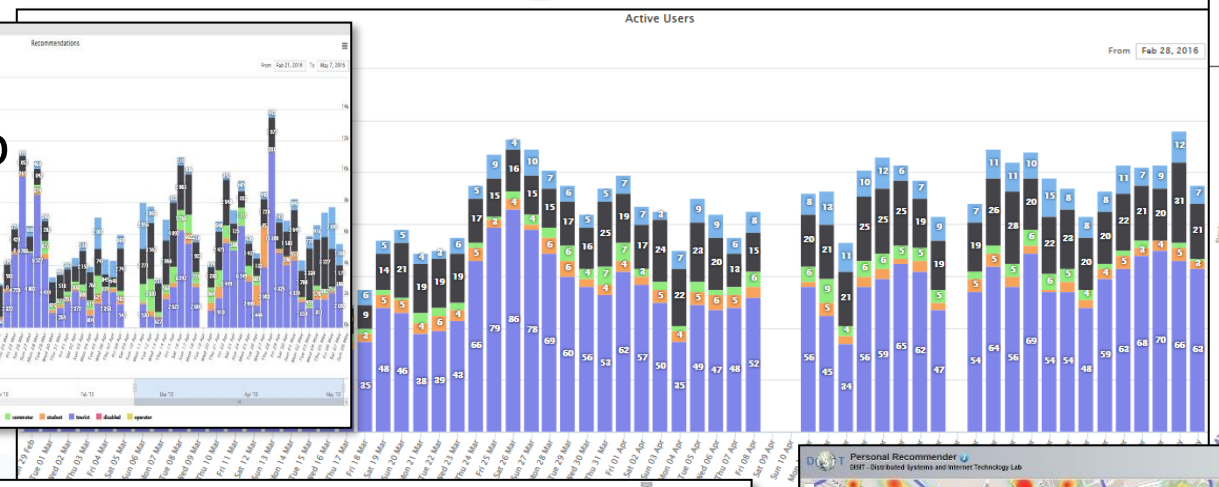
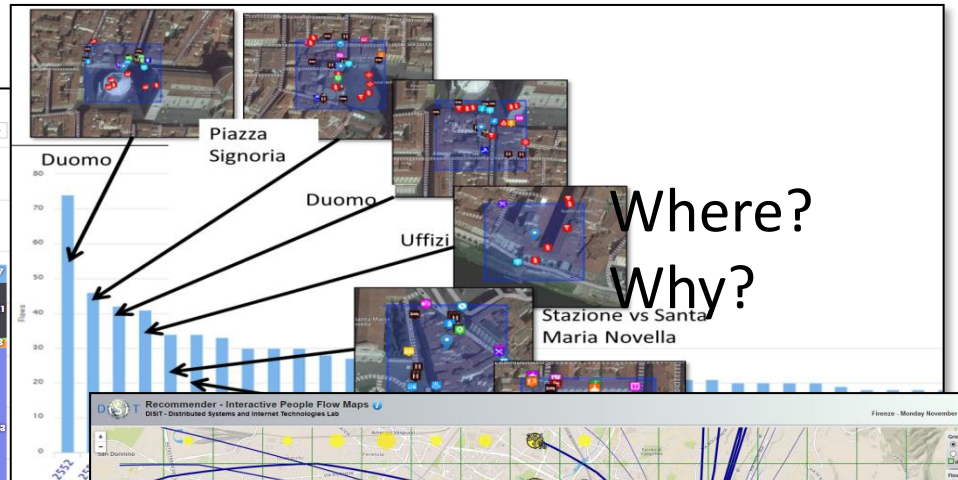
Engaging via Mobile Apps

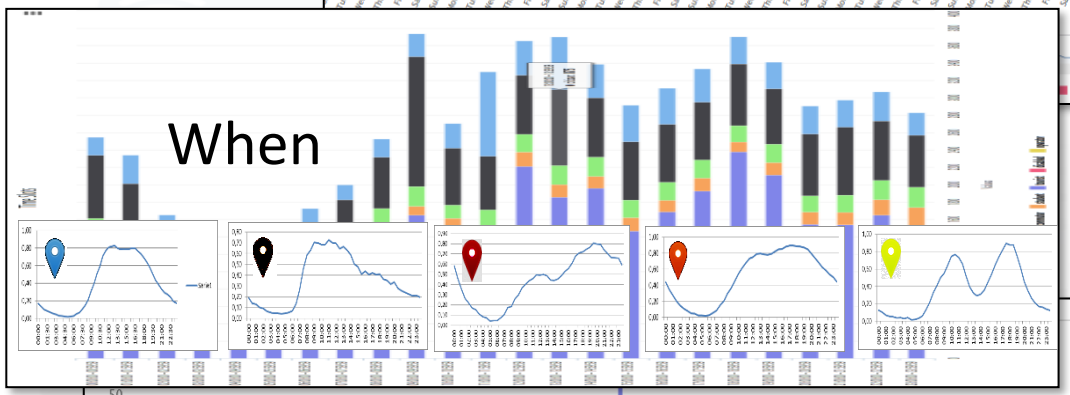

HELSINKI
ANTWERP
TOSCANA
GET IT ON Google play
Download on the App Store
SNAP4CITY
KM 4 CITY
Accommodation
Cultural Activity
Education And Research
Emergency
Entertainment
Environment
Shortest
Quiet
Add Destination
Reset
Calculate
Events
Day
Week
Month
Services: 100 on 139 available
EAQI
Index
1. Good
2. Fair
3. Moderate
4. Poor
5. Very poor
Results
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

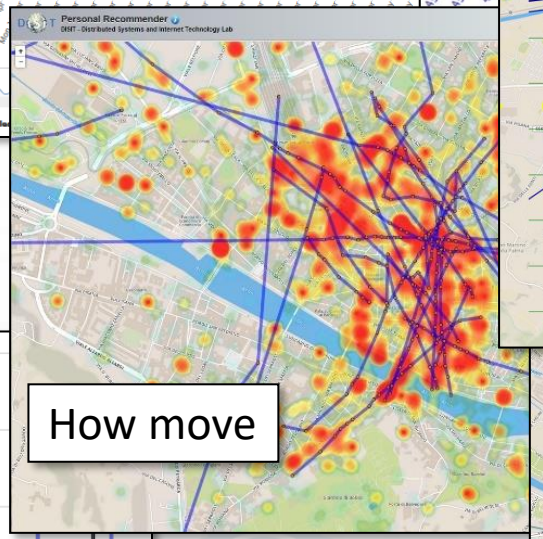
User Behavior Analyser for Collective Profiling

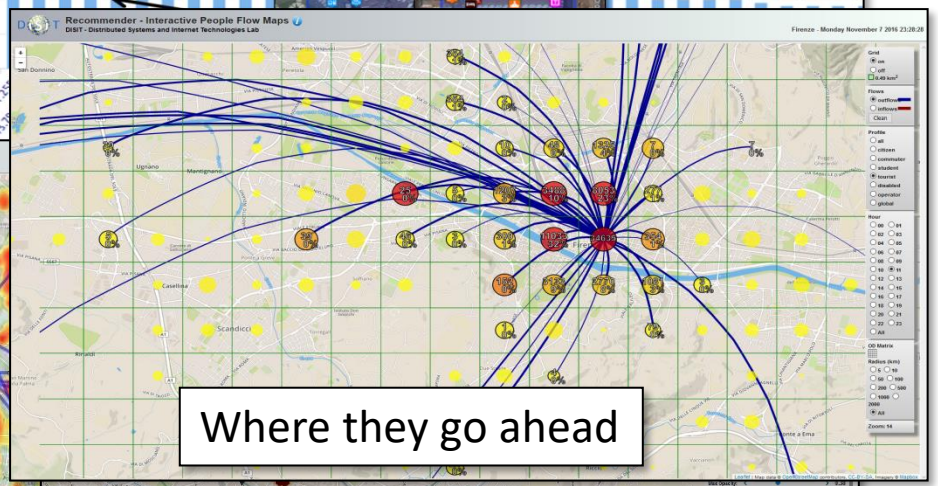


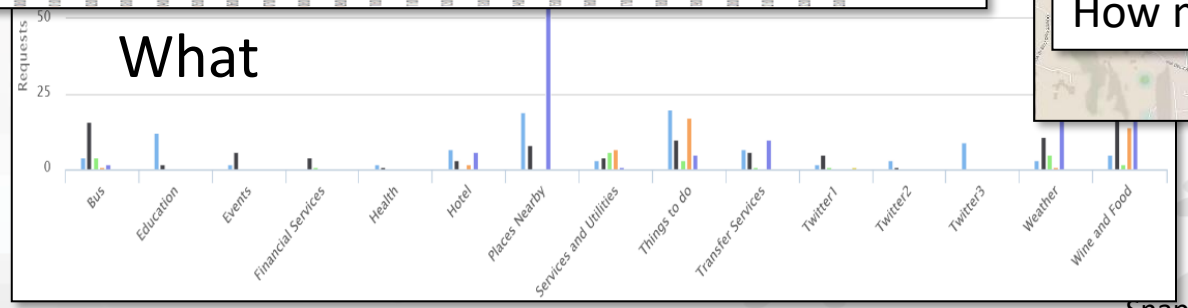


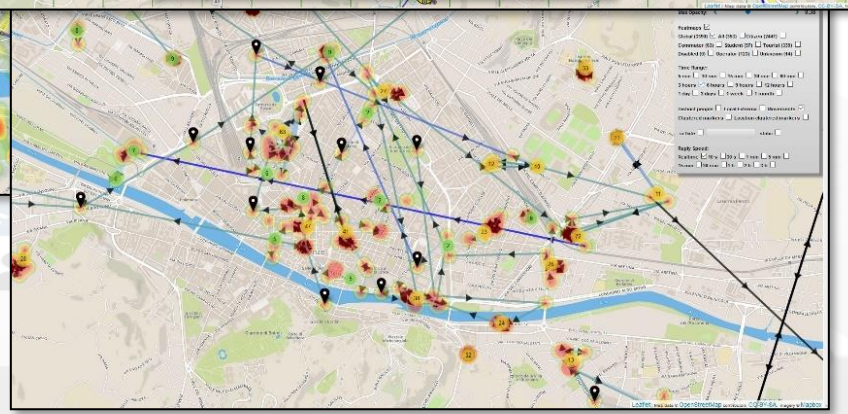




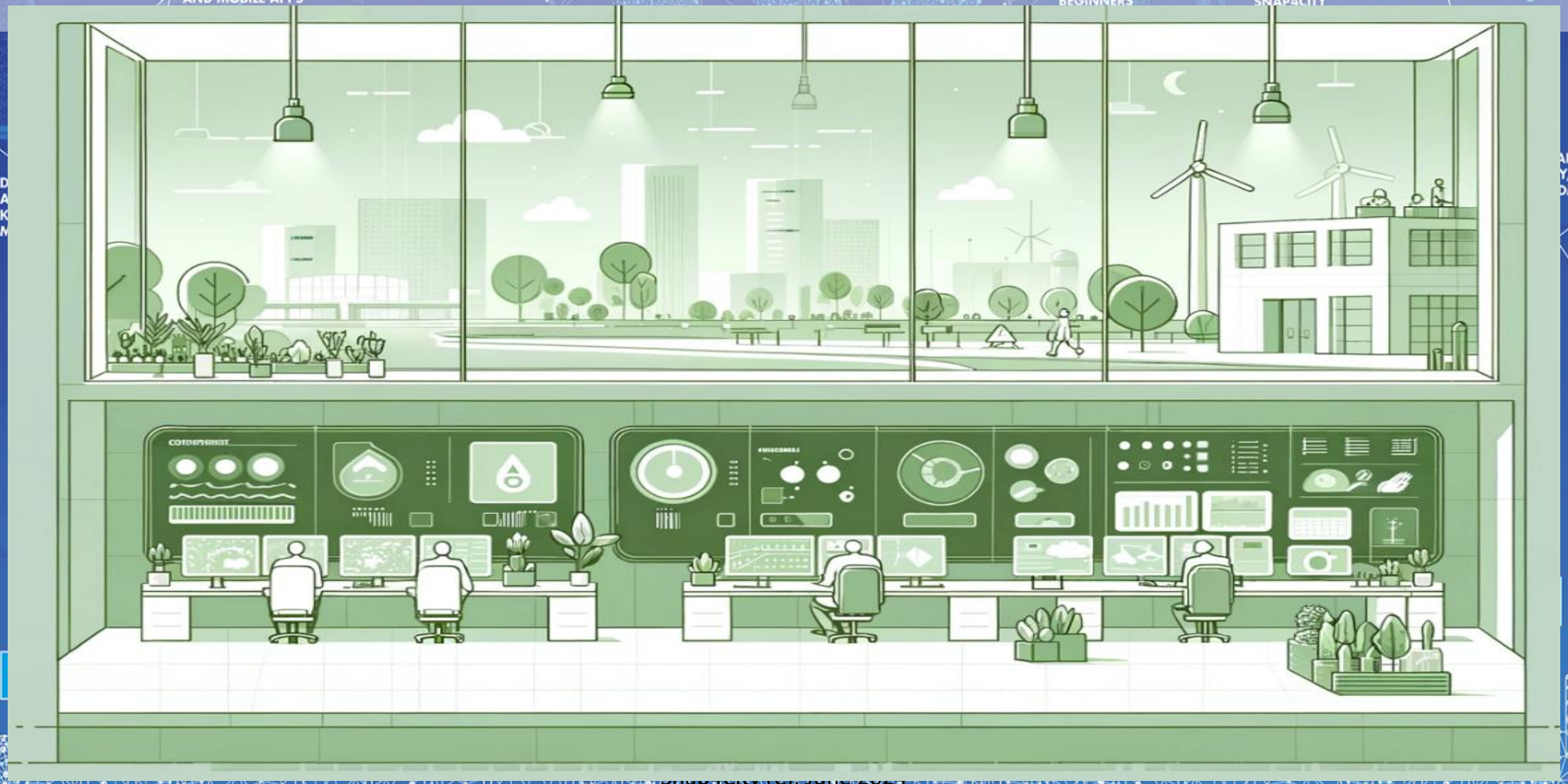








Environmental Domain

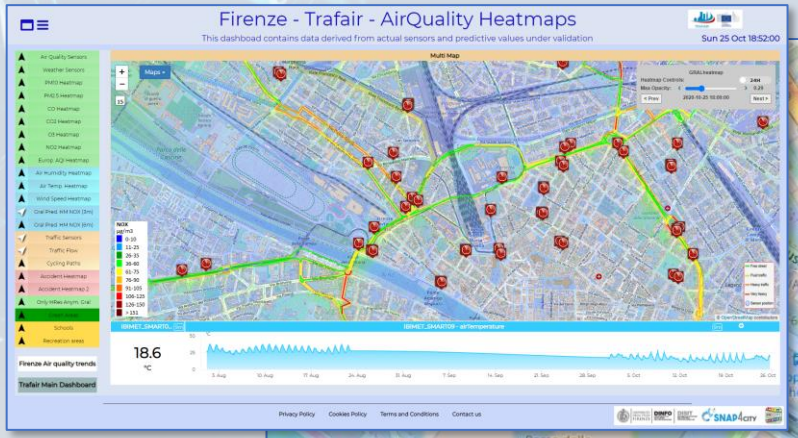


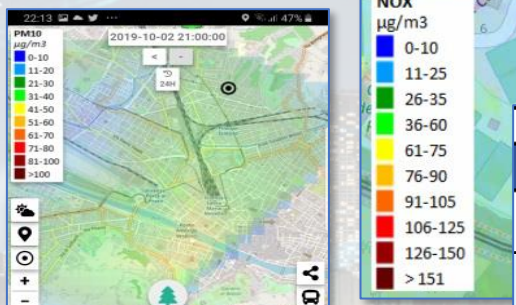
Environment and Quality of Life
Air Quality Predictions

Cities of: Firenze, Pisa, Livorno

reference

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





		Air Quality Directive		WHO guidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
$PM_{2.5}$	One day			25 µg/m³ (*)	99th percentile (3 days/year)
$PM_{2.5}$	Calendar year	Target value, 25 µg/m³	The targe… …come a …value …ry 2015	10 µg/m³	
PM_{10}	One day	Limit …e, 50 µ…	…t to be e…ed on more …han 35 d…s per year.	50 µg/m³ (*)	99th percentile (3 days/year)
PM_{10}	Calend…	…va… 40 µg/m… (*)		20 µg/m³	
O_3	Maximum …ly 8-hour m…n	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	

KPI of EC

Environment, waste, land, etc., Domain (2024)

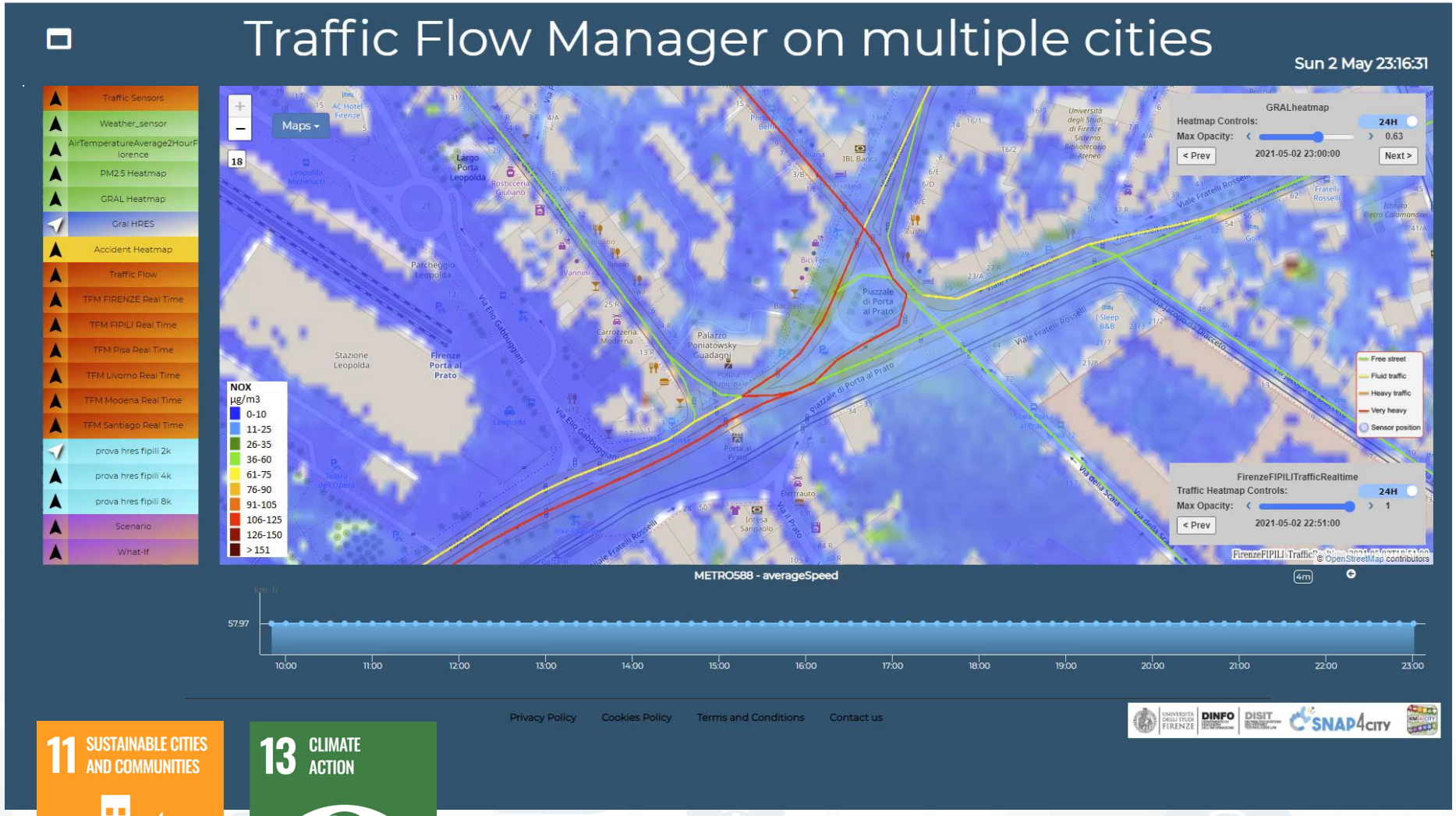
- Goals:
  - Reduction of pollutant emissions and EC taxations
  - Cost Reduction for waste collection, reduction of waste collection impact on mobility
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring emissions, weather, waste, water, etc.: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

Tools: Environment and Weather (2024)

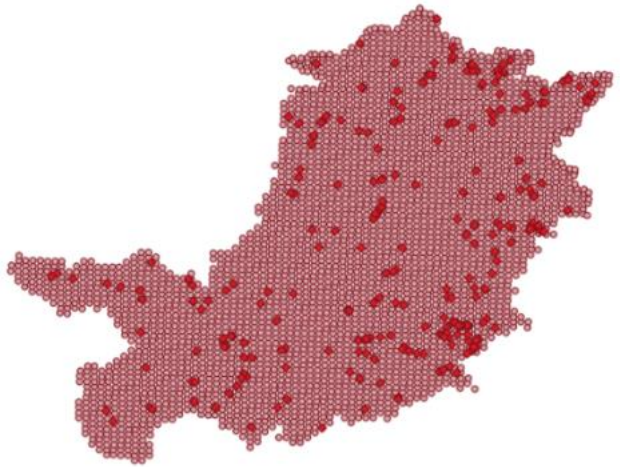
- **Pollutant Predictions: short, long and very long term** European Commission KPIs
  - NOX, PM10 pollution on the basis of traffic flow, 48 hours (ML, AI, DL)
  - Cumulated NO2 average value over the year, ……. (ML, AI, DL)
- **Computation of CO2** on the basis of traffic flows (DP), computing emission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

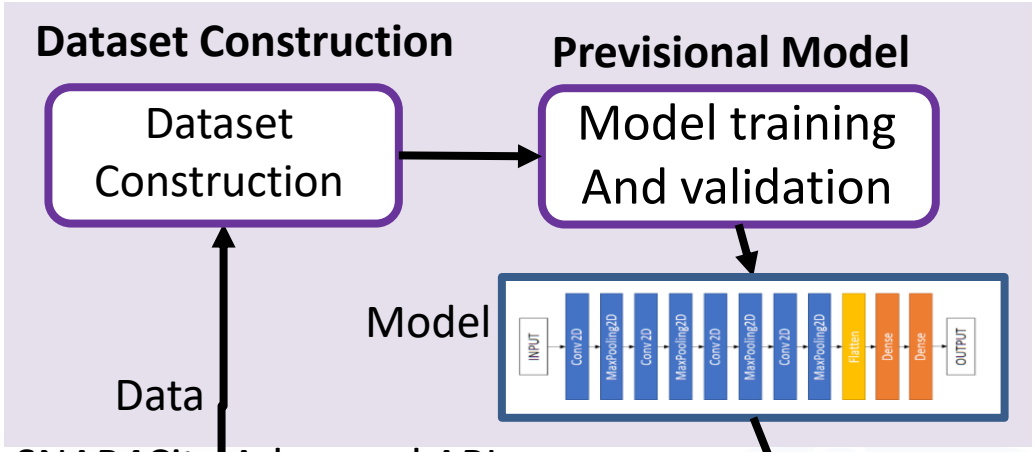
Environment

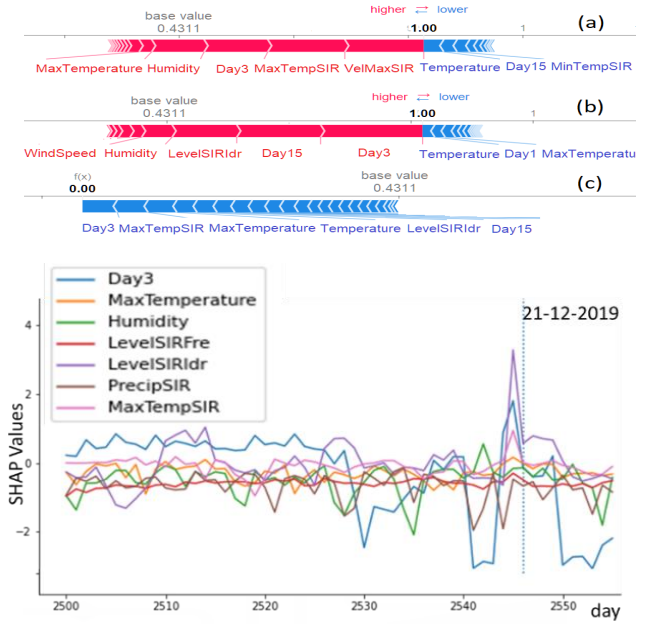
- **Prediction**
  - **NOX Pollutant** diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
  - **NO2 progressive average** (Long term)
- **Project:**
  - **Trafair** CEF EC
  - Mixed solutions of Fluidinamics modeling and AI



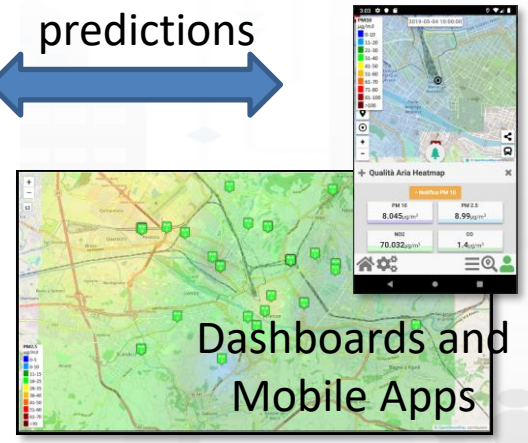
Predicting Land slides





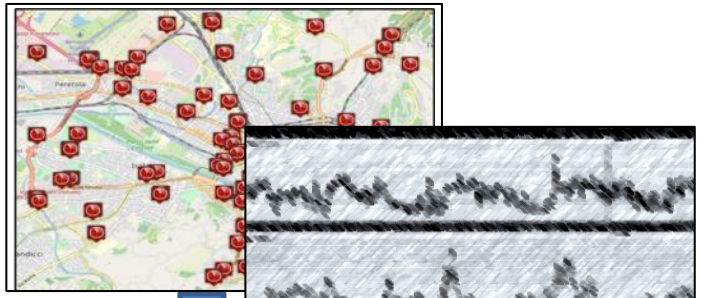


predictions



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 **(ton of CO2 x Km x Vehicle)**
  - **K1: Fluid Flow**
  - **K2: Stop and Go**
- **Dense estimation of CO2 into the city** is very useful to know to target EC's KPIs

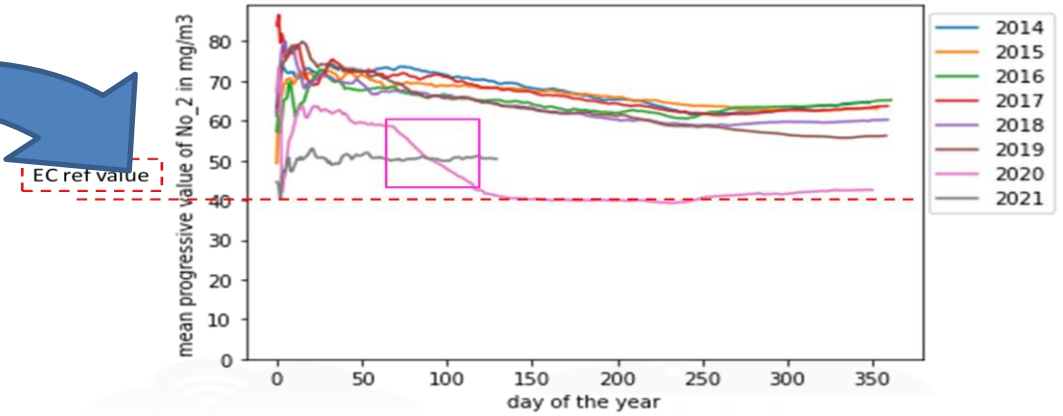
Computing CO2 on the basis of traffic flow data

CO2 estimation

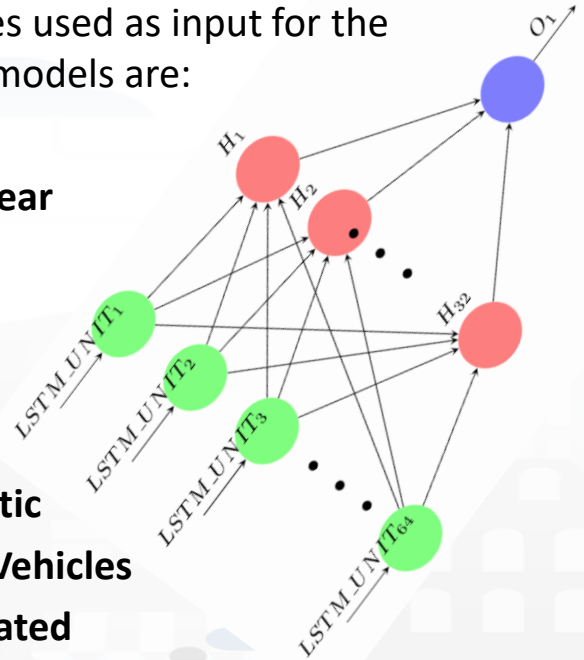
S. Bilotta, P. Nesi, "Estimating CO2 Emissions from IoT Traffic Flow Sensors and Reconstruction", Sensors, MDPI, 2022. https://www.mdpi.com/1424-8220/22/9/3382/

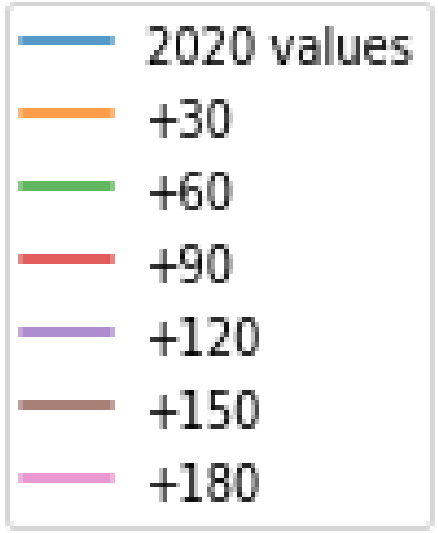
Predicting EC's KPI on NO2 months in advance

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**





	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	

Smart Energy /Building

Energy Domain (2024)

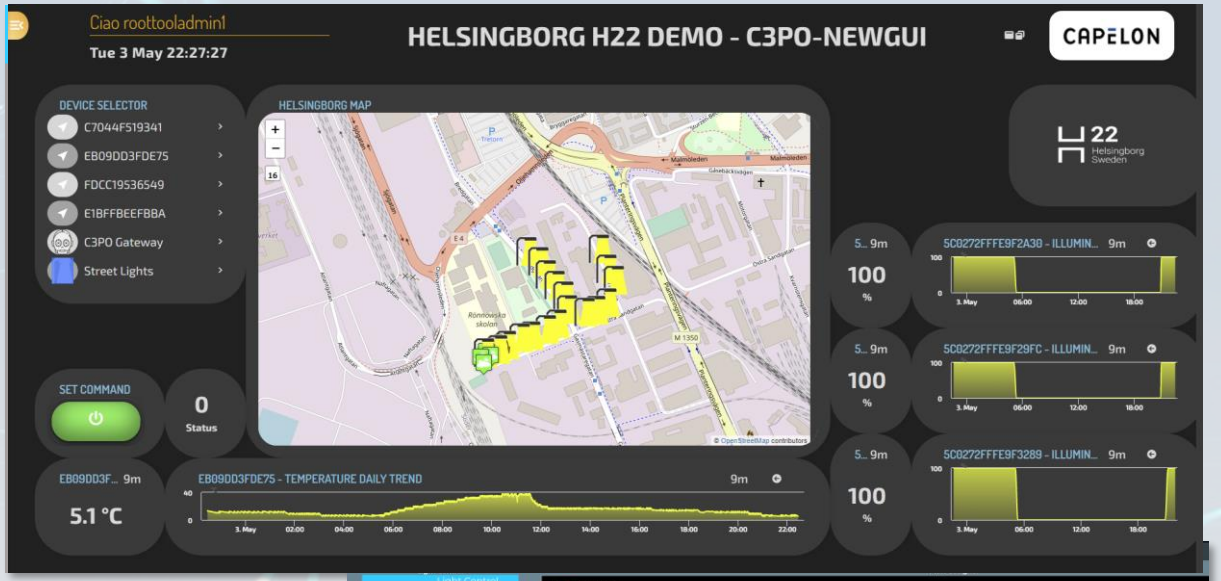
- Goals:
  - Efficiency, costs
  - Accessibility to services
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring energy consumption (heating, cooling, prod.,..), conditions, charging stations, etc.
  - Managing Smart Light for city: dimering,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

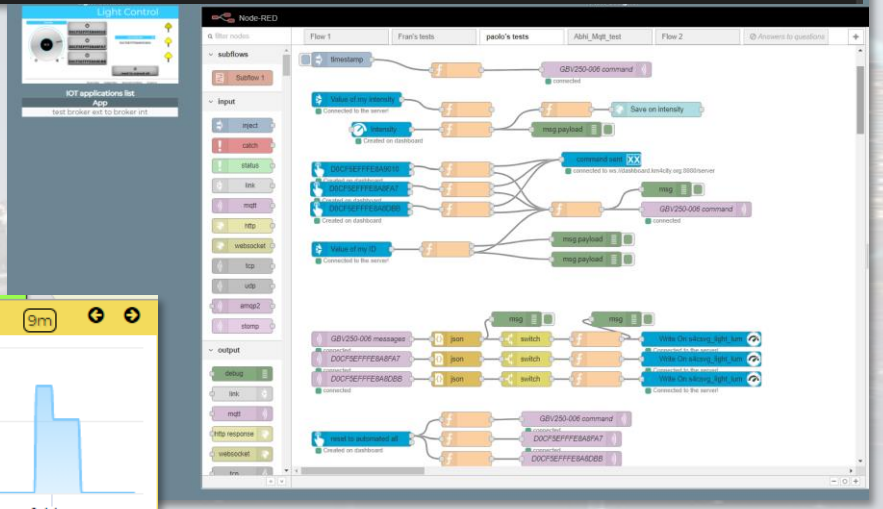
Tools: Energy Domain (2024)

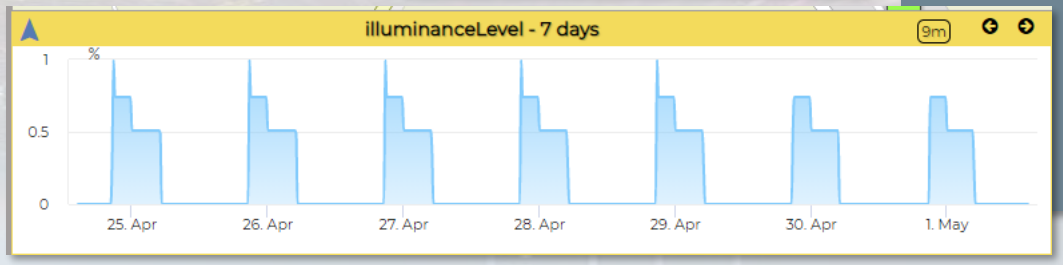
- Monitoring Energy Consumption in single building, area and per zone
- Matching Energy consumption with respect to the actual usage
- Computing Roof orientation for Photovoltaic installations
- Optimisation of Photovoltaicc installations to identify the best parameters of size and storage
- Smart Light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

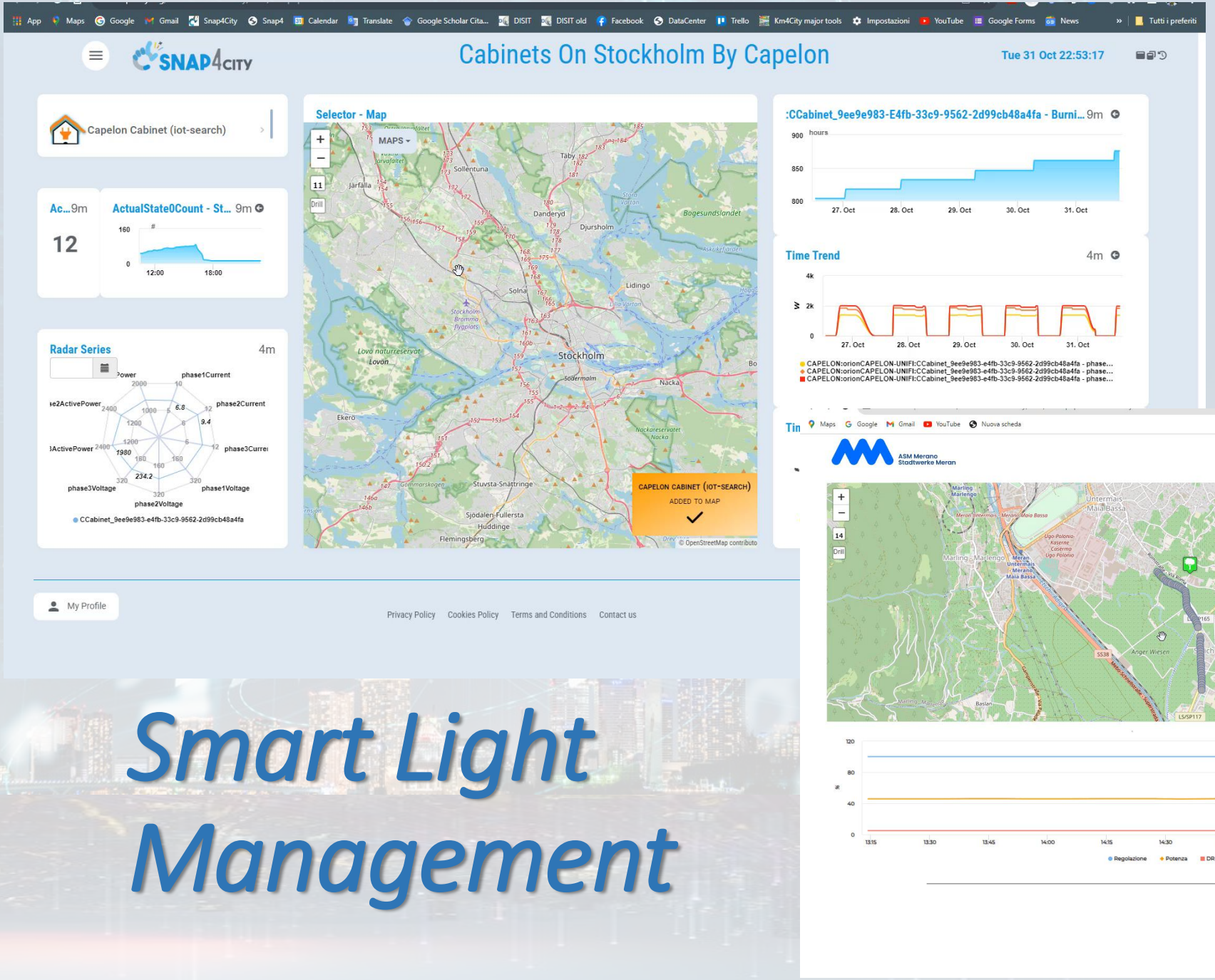
Smart Light Control of CAPELON *reference*

- **Energy Domain**
  - Smart Light, MQTT, ….
  - IoT Orion Broker FIWARE
- **Dashboards**
  - Map coverage on Sweden
  - Monitoring and real time control
  - Energy control, analytics
  - Direct control
- **Historical and Real Time data**
- **Services Exploited on:**
  - Multiple Levels, API
  - Dashboards
- **Since 2020**









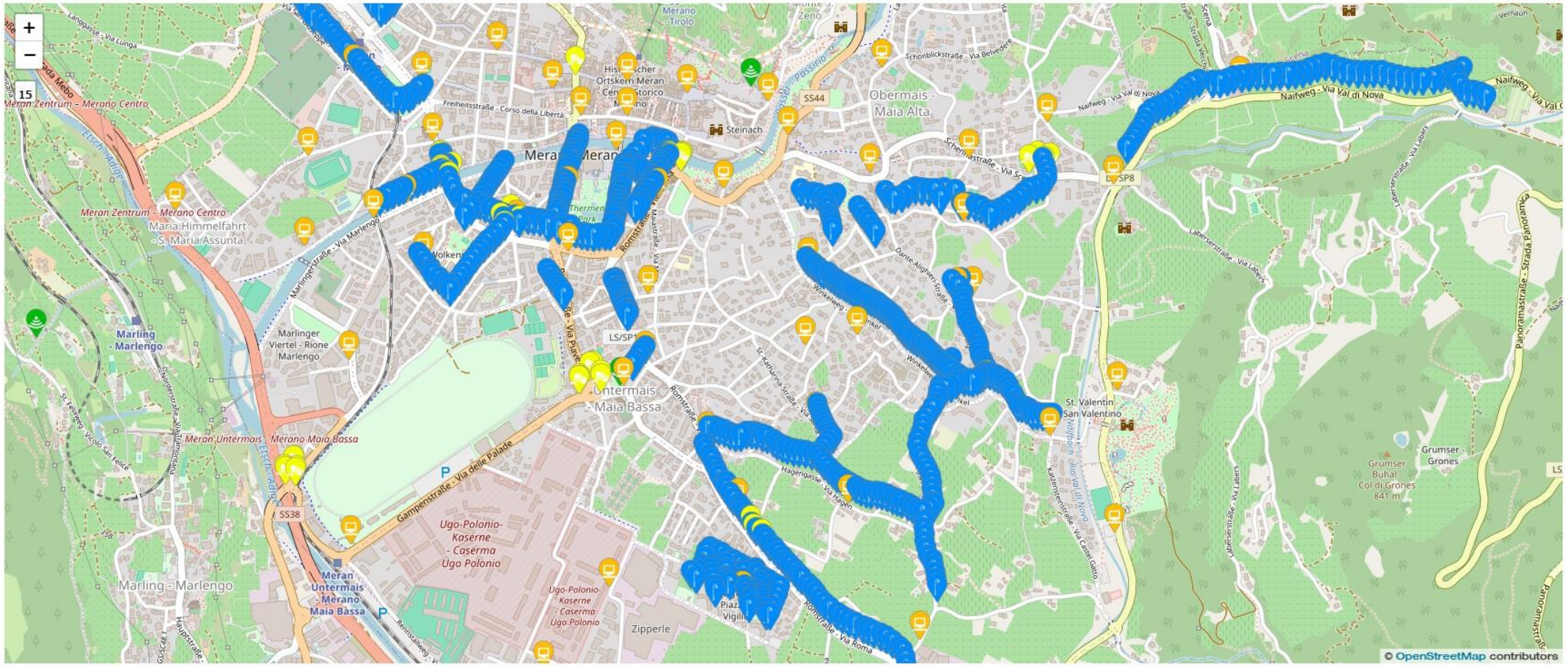
Smart Light Management

Smart Light in Merano

ASM Merano
Stadtwerke Meran

Merano - tutti i servizi

Wed 13 Dec 15:34:57



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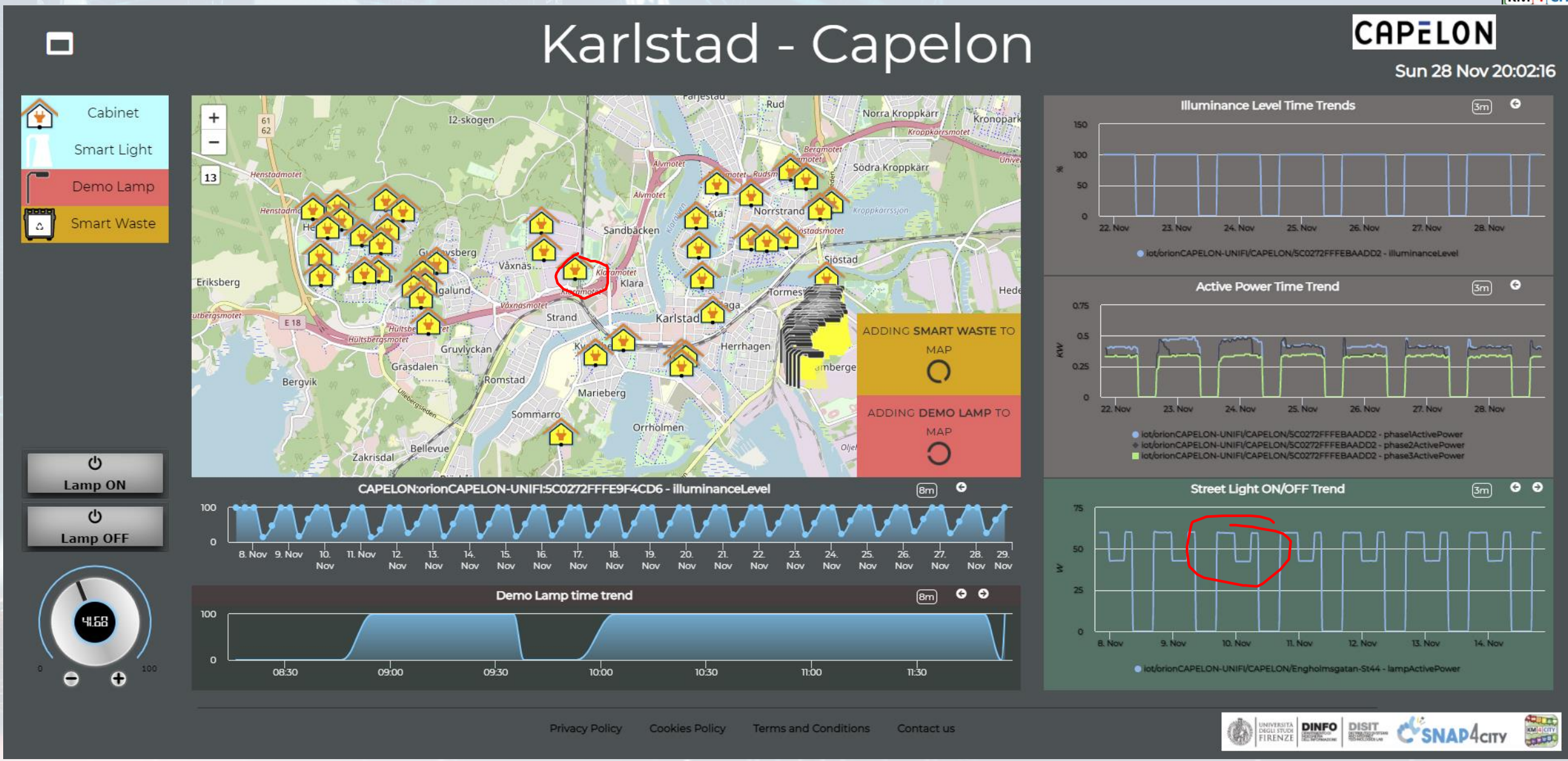
Karlstad Street Lights



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

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SNAP4CITY KM4CITY

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

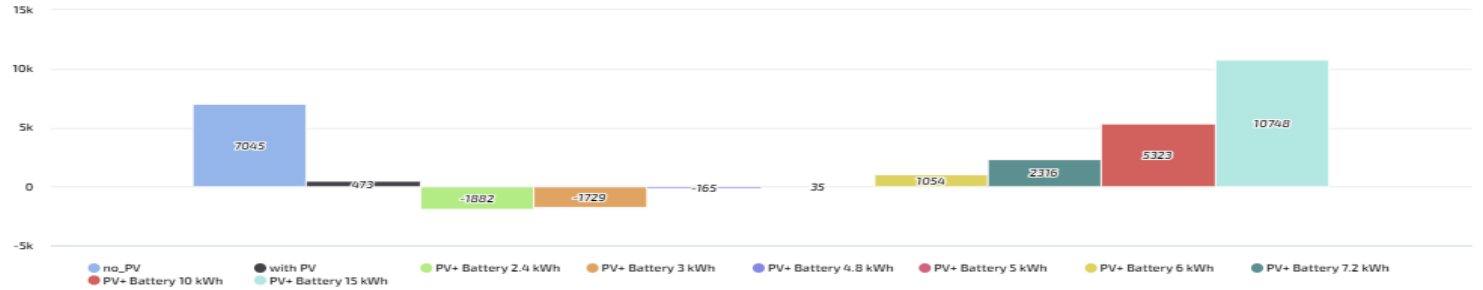
Ciao roottooladmin1

Sat 11 Nov 17:26:28

ONLINE PHOTOVOLTAIC SYSTEM SIMULATOR

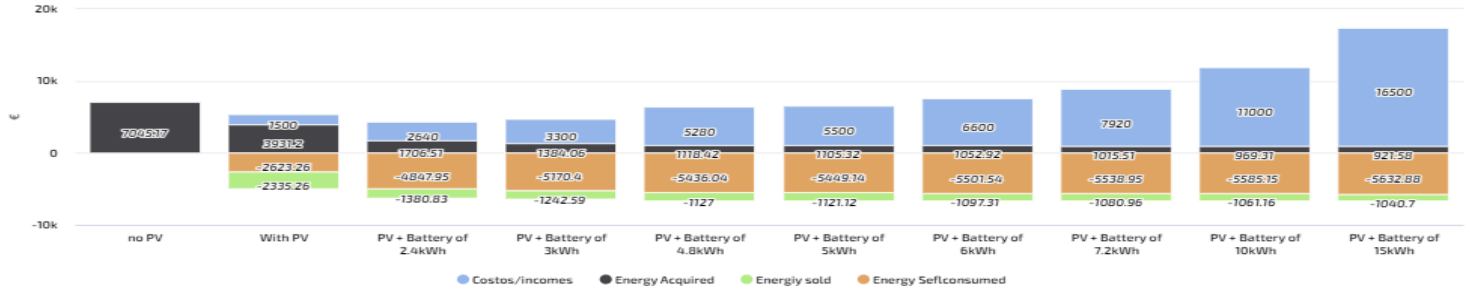
TOTAL COSTS OVER THE INVESTMENT YEARS

599m



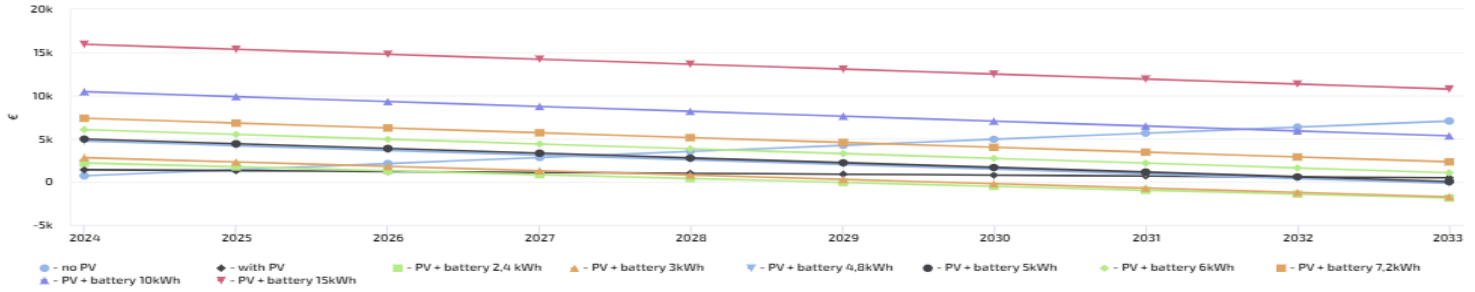
TOTAL COSTS OVER YEARS DECOMPOSED IN COSTS AND INCOMES

599m



BREAK EVEN TREND FOR THE DIFFERENT KIND OF PLANTS

599m



User Manual

Italian Version

PARAMETERS OF YOUR PV PLANT

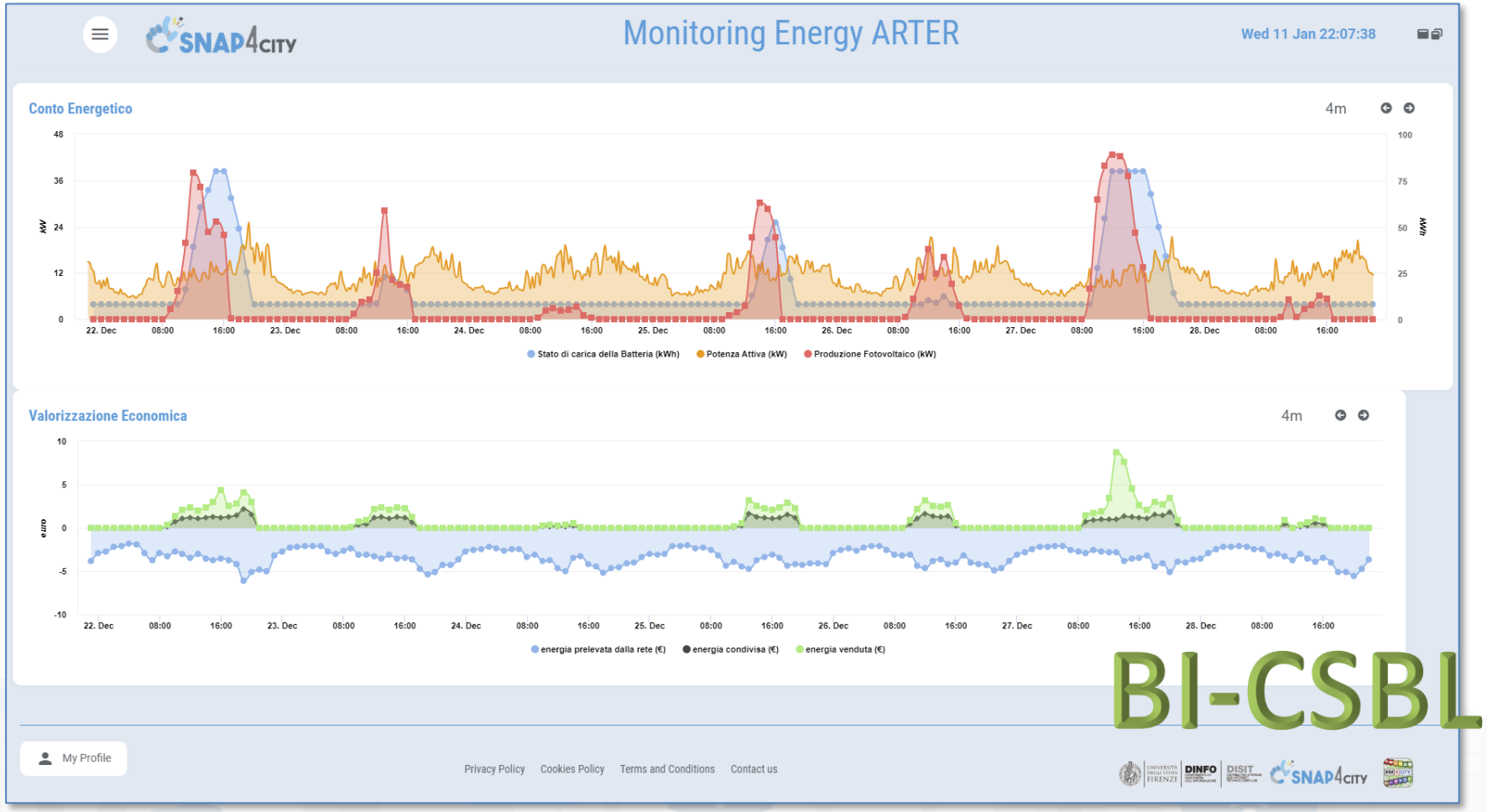
We suggest you PV plus battery of 2.4 kWh

Annual Consumption	2000 kWh
Price of energy sold (€/kWh)	0,15
Price of Energy Acquired (€/kWh)	0,35
Years of Investiment	10
Months for typical trends	Gennaio

Compute

7 AFFORDABLE AND CLEAN ENERGY

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



BI-CSBL

https://www.selfuser.it

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SNAP4CITY | KM4CITY

SELF USER

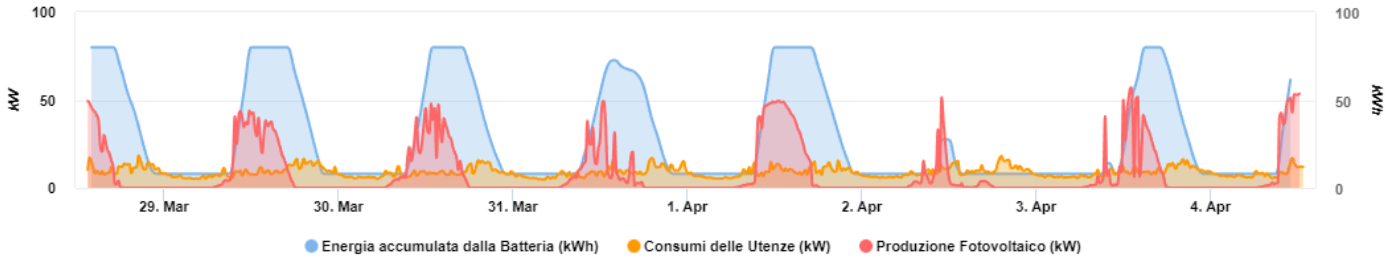
Monitoraggio in tempo reale della comunità energetica condominiale

Tue 4 Apr 13:20:04

SELF USER

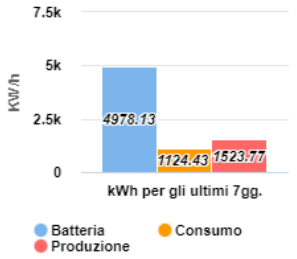
Conto Energetico

4m



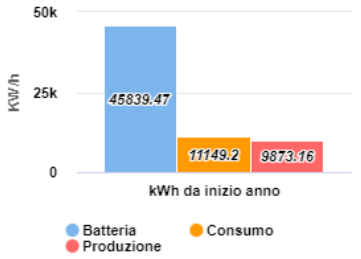
KWh Ultimi 7 Gg.

4m



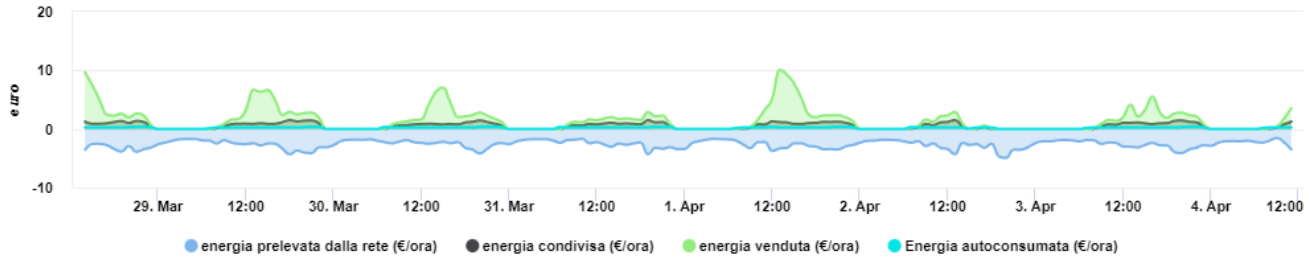
KWh Da Inizio Anno

4m



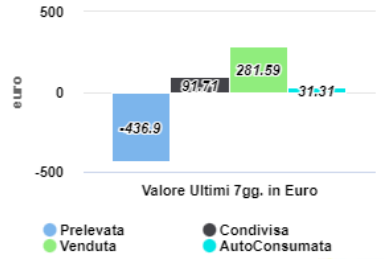
Valorizzazione Economica

4m



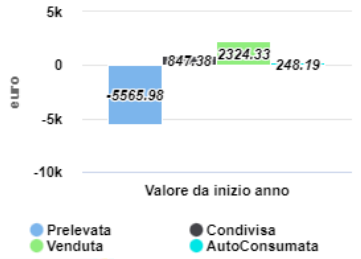
Valore Ultimi 7gg.

4m



Valore Da Inizio Anno

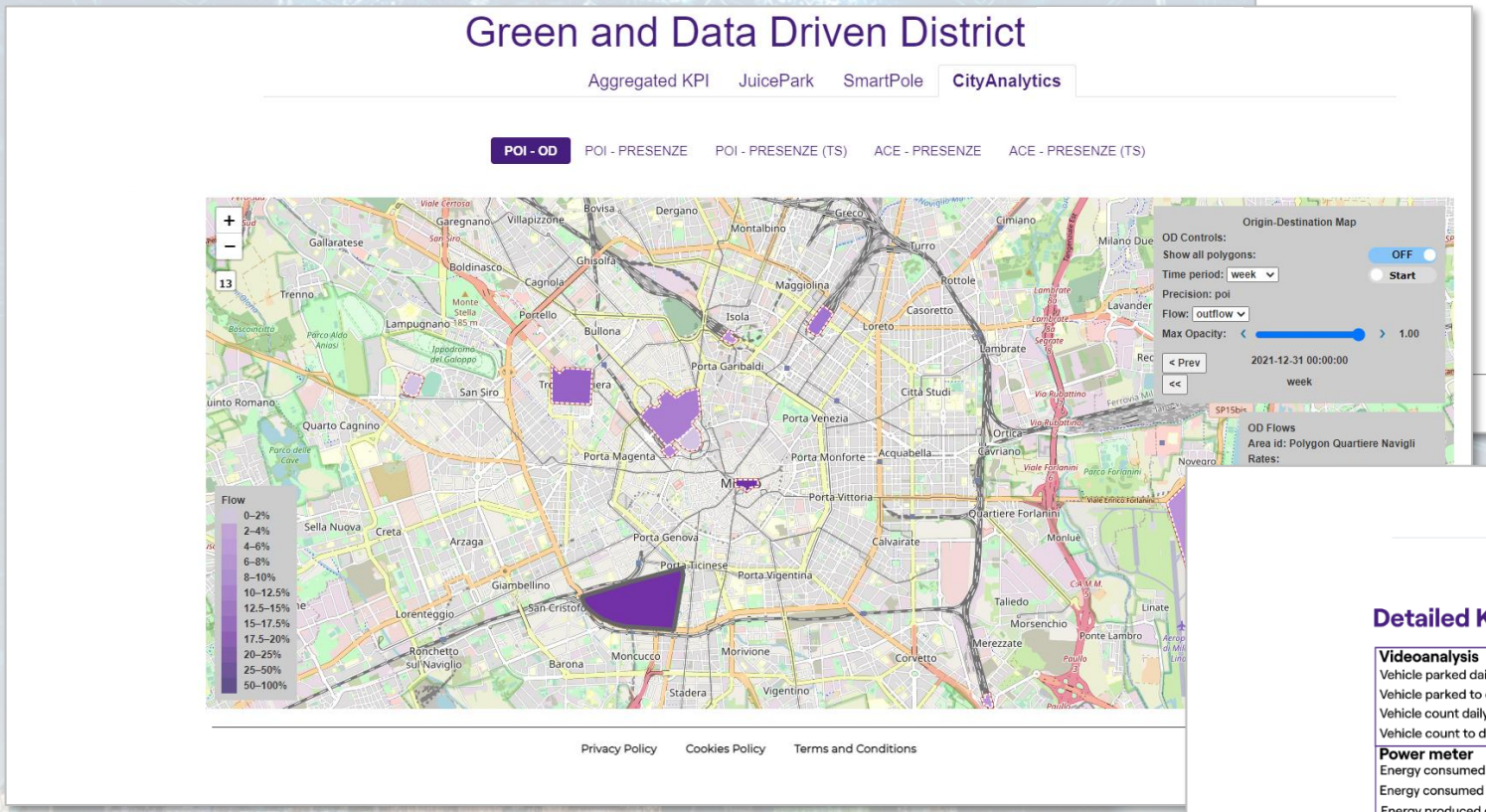
4m

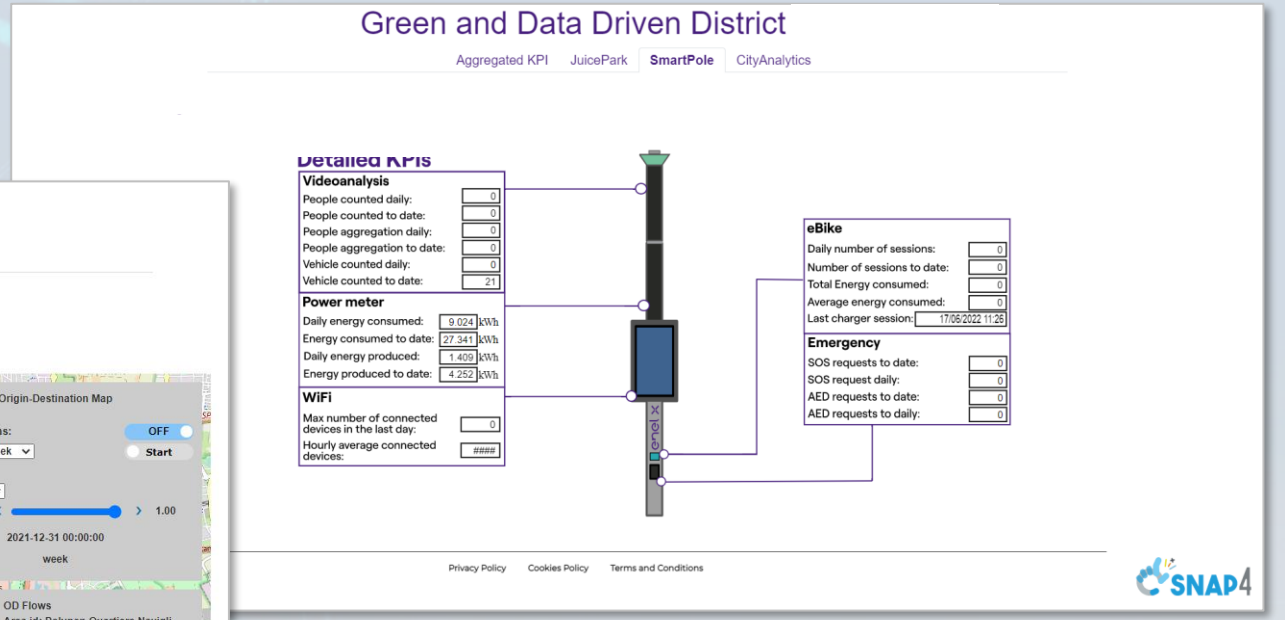


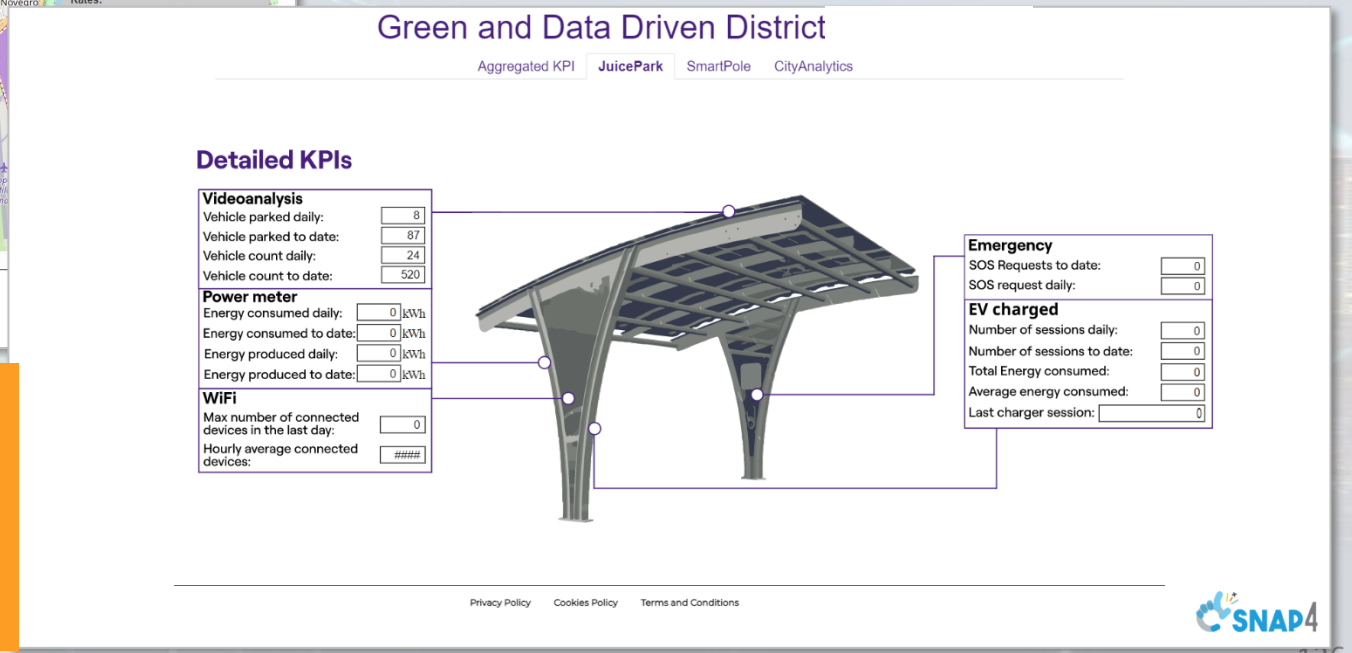
Regione Emilia-Romagna | ART-ER | ACER | Alma Mater Studiorum Università di Bologna | ENEA | enel x

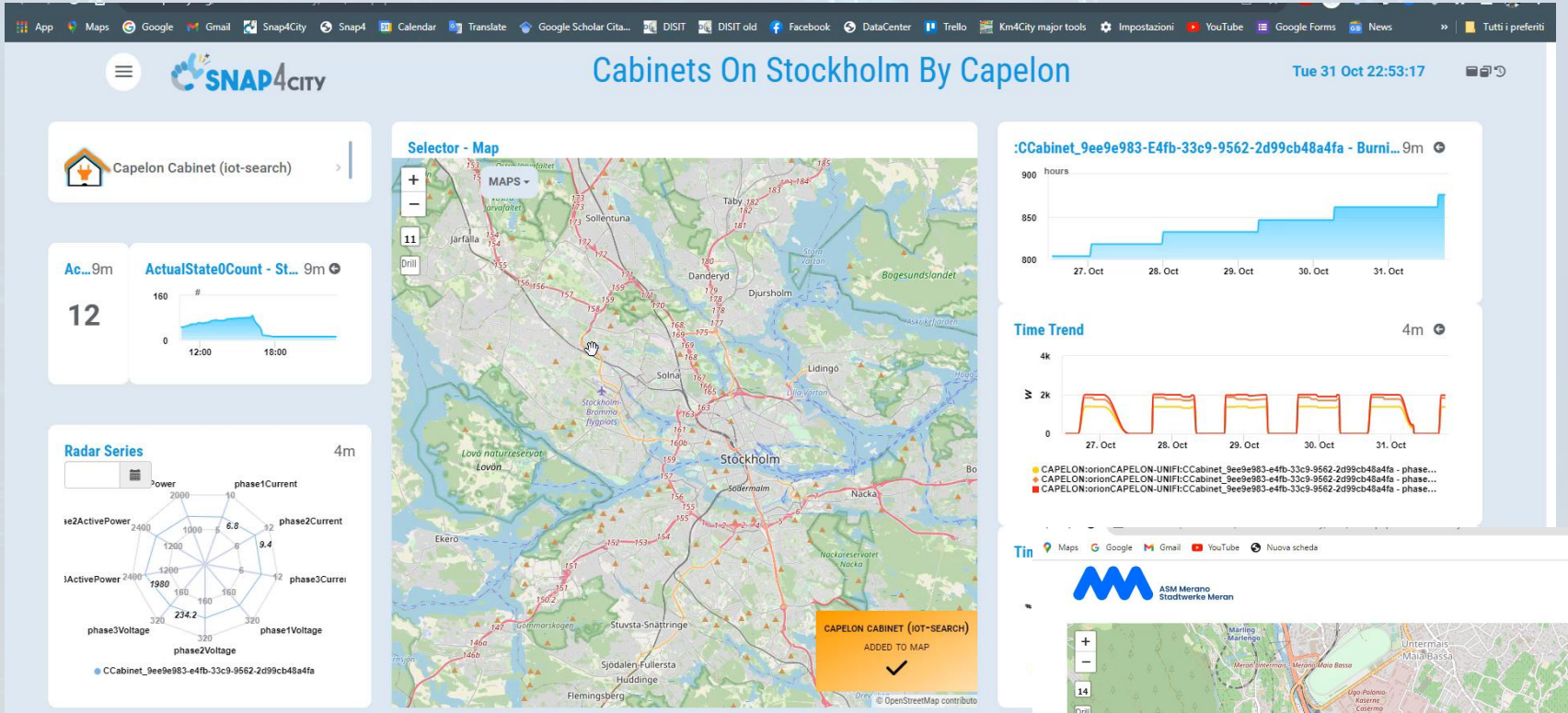
7 AFFORDABLE AND CLEAN ENERGY

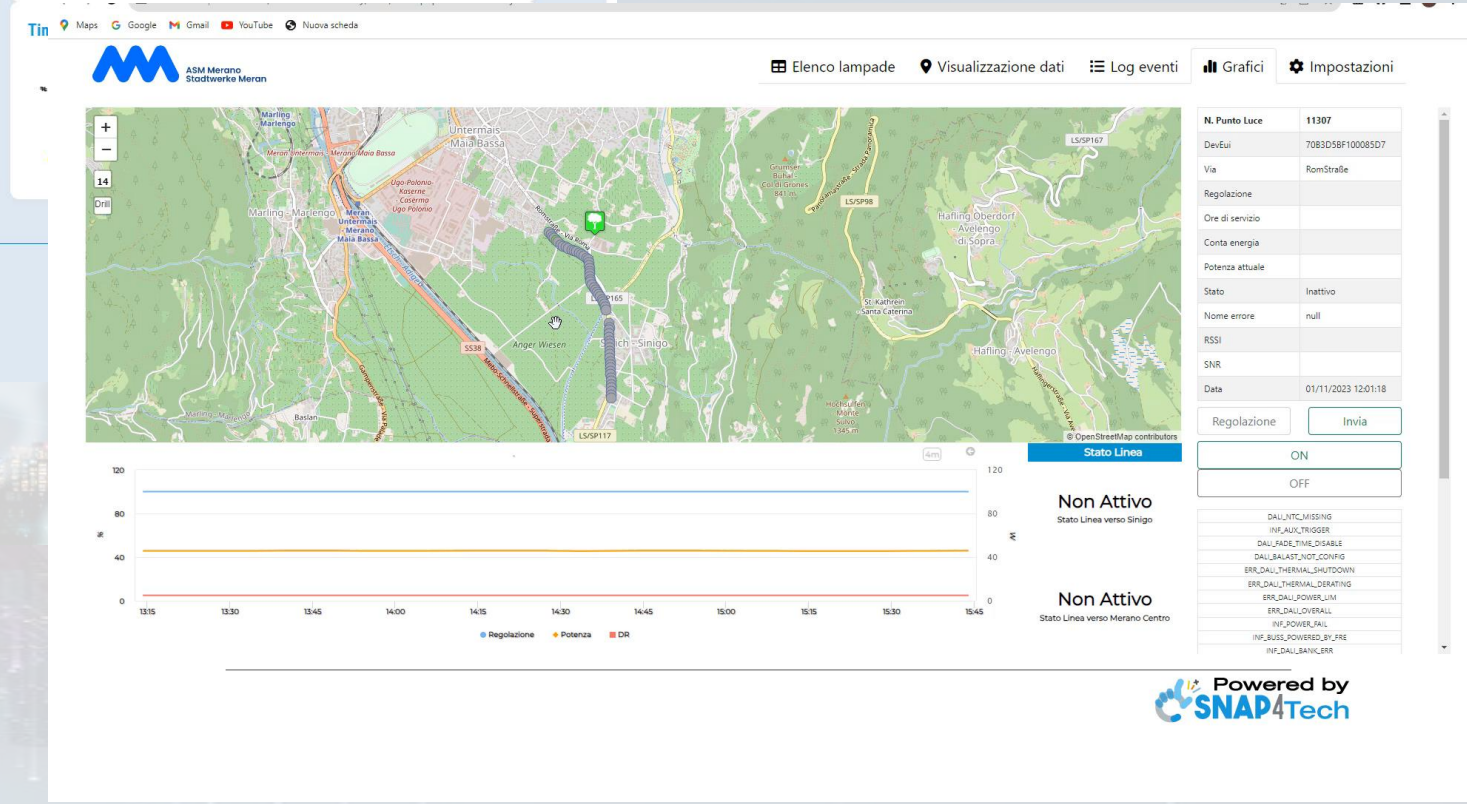
Energy monitoring and business intelligence











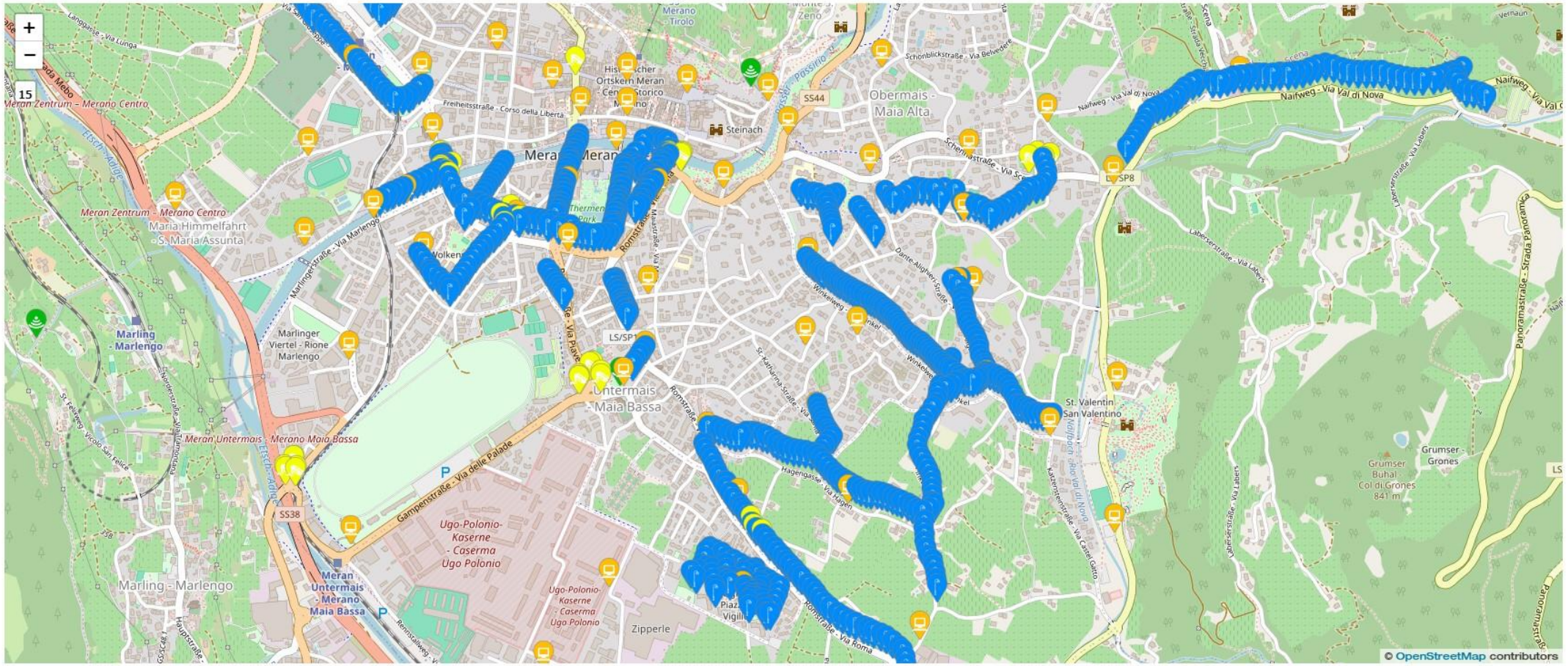
Smart Light Management

Smart Light in Merano

ASM Merano Stadtwerke Meran

Merano - tutti i servizi

Wed 13 Dec 15:34:57



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Assets Quality Control Domain (2024)

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

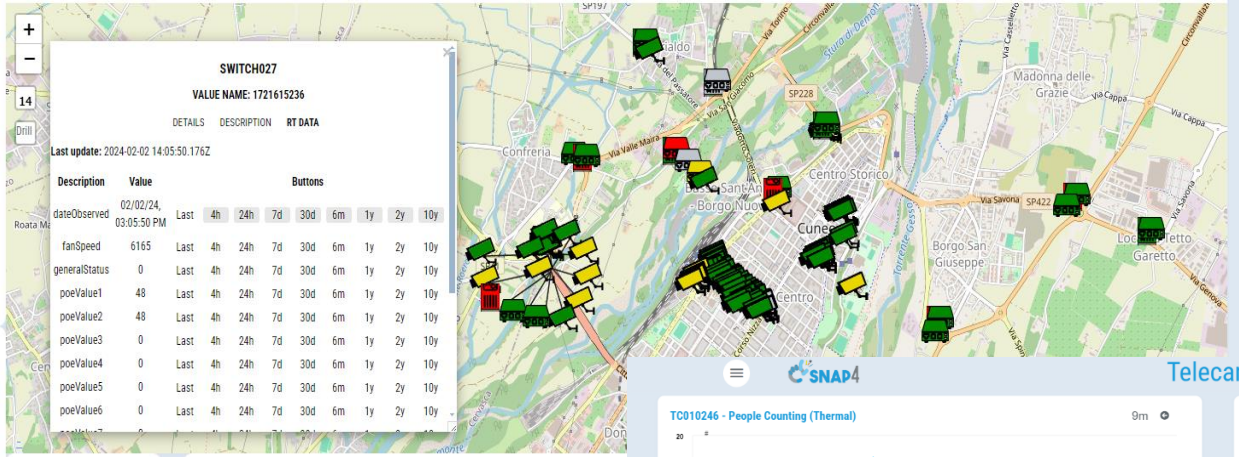
Monitoraggio Generale

Fri 2 Feb 17:08:24

- CameraModelP1448-LE
- UpsModelRiello
- UpsModelSeltec
- SwitchModelMicrosense
- SwitchModelNetonix

Legenda

GENERAL STATUS		
Valore	Significato	Simbolo
0	Buono stato	
1	Non raggiungibile	
2	Raggiungibile, dati non disponibili	
3	Identificata anomalia	



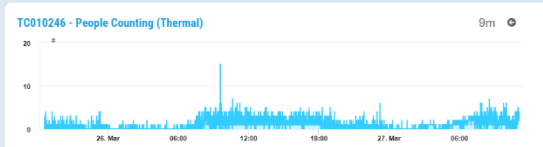
Stato Attuale 9m

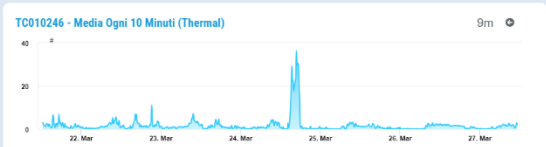
0

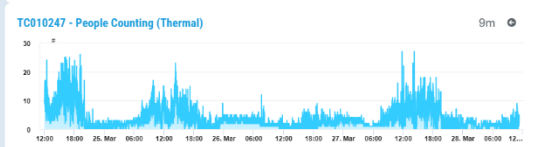
1721612145 - GeneralStatus - Andamento Settimanale

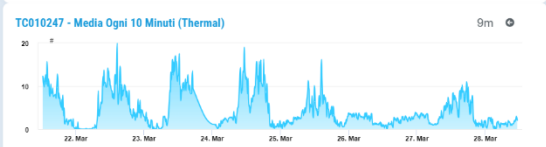
Telecamere Cuneo

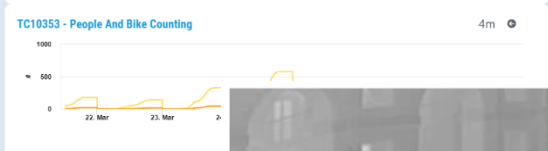
Thu 28 Mar 11:18:02



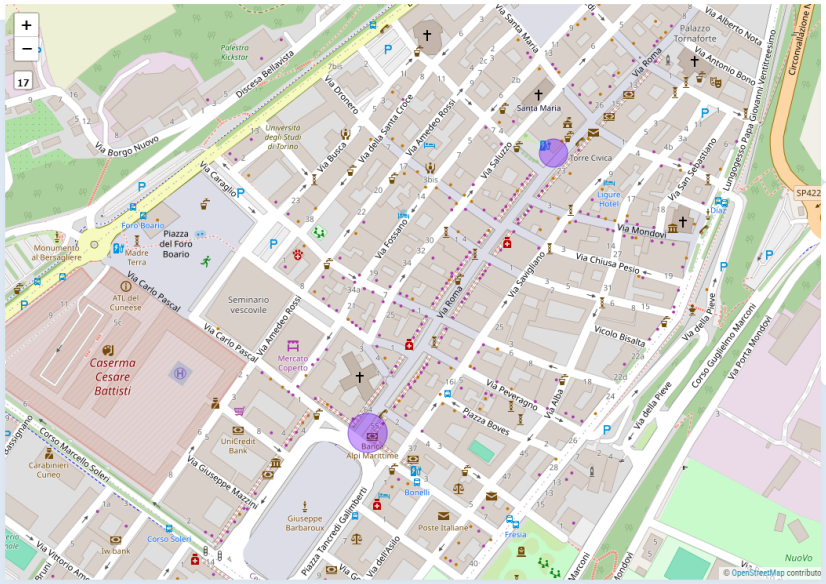








Conteggi Telecamere


Caserma Cesare Battisti
Piazza del Foro Boario
Seminario vescovile
Santa Maria
Torre Civica
Bar Alpi Marittime
Poste Italiane
Fresia
Bonelli
UniCredit Bank
Mercato Coperto
Ligure Hotel
Dior
Carabinieri Cuneo
Iw bank
Corso Soleri
Via Roma
Via Mondovì
Via Chiusa Pesio
Via Savigliano
Via Fossano
Via Amedeo Rossi
Via Carlo Pascal
Via Caraglio
Via Borgo Nuovo
Via Giuseppe Mazzini
Piazza Boves
Vicolo Bisalta
Via della Pieve
Corso Guglielmo Marconi
Via Porta Mondovì
Via Peveragno
Via Alba
Via Torino
Via Vittorio Amedeo
Via Alberto Nota
Via Antonio Bono
Via Roma
Via Santa Maria
Via Amedeo Rossi
Via della Santa Croce
Via Bisalta
Via Bongioanni
Via Cuneo
Via Vecchia
Via Cavour
Via Cacciatori delle Alpi
Via Giovanni Giolitti
Via Giuseppe Garibaldi
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Via Roma
Via Mondovì
Via Chiusa Pesio
Via Savigliano
Via Fossano
Via della Pieve
Corso Guglielmo Marconi
Via Porta Mondovì
Via Peveragno
Via Alba
Via Torino

Smart Building

FROM CITY DASHBOARD TO APPLICATIONS

100% OPEN SOURCE

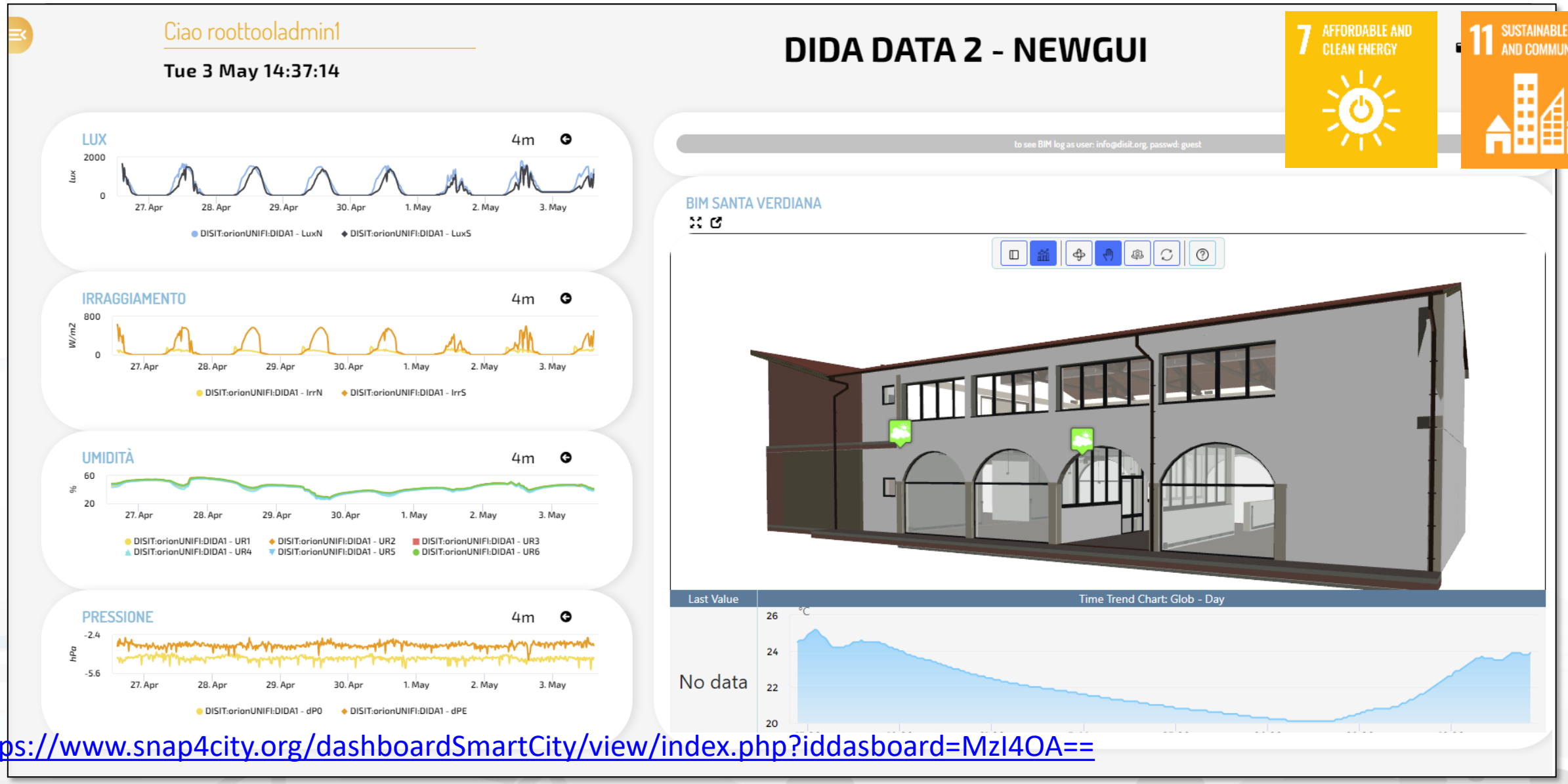
Snap4Building Domain (2024)

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

Tools: Smart Buildings, Snap4Building (2024)

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

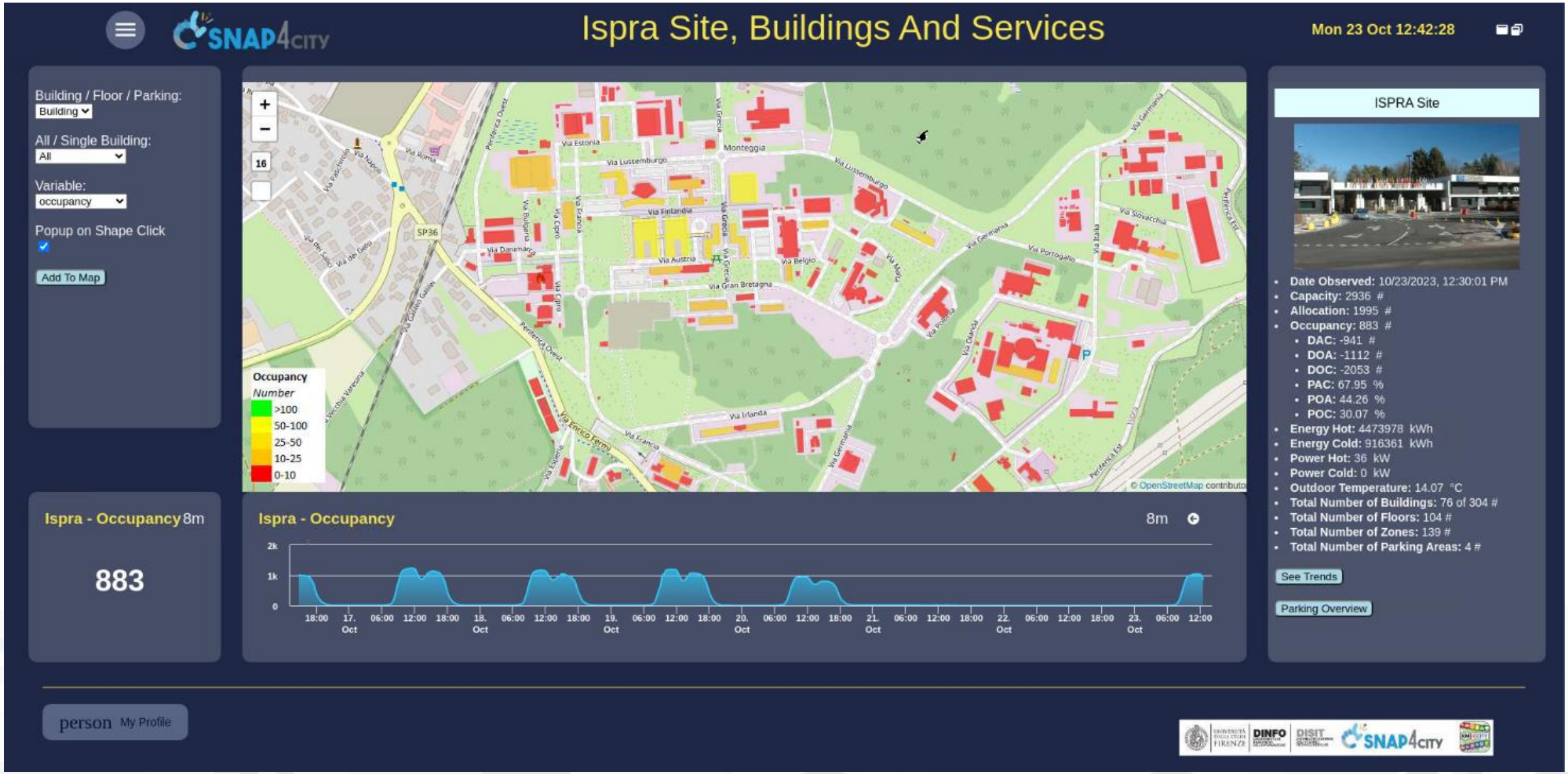
Smart Building



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

Snap4ISPRA POC

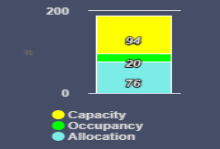
- **Set up a Snap4Ispra demonstration** to:
  - Enable the analysis at level of building, floors/zones for Zones' Occupancy vs Energy consumption
  - Enable the analysis of parking areas
  - Conformance with EU Login
  - Exploiting heterogenous data coming from multiple sources


SNAP4CITY
Ispra Site, Buildings And Services
Mon 23 Oct 12:42:28
Building / Floor / Parking:
Building
All / Single Building:
All
Variable:
occupancy
Popup on Shape Click
Add To Map
Occupancy
Number
>100
50-100
25-50
10-25
0-10
© OpenStreetMap contributo
ISPRA Site
Date Observed: 10/23/2023, 12:30:01 PM
Capacity: 2936 #
Allocation: 1995 #
Occupancy: 883 #
DAC: -941 #
DOA: -1112 #
DOC: -2053 #
PAC: 67.95 %
POA: 44.26 %
POC: 30.07 %
Energy Hot: 4473978 kWh
Energy Cold: 916361 kWh
Power Hot: 36 kW
Power Cold: 0 kW
Outdoor Temperature: 14.07 °C
Total Number of Buildings: 76 of 304 #
Total Number of Floors: 104 #
Total Number of Zones: 139 #
Total Number of Parking Areas: 4 #
See Trends
Parking Overview
Ispra - Occupancy 8m
883
Ispra - Occupancy
8m
2k
1k
0
18:00 17. Oct 06:00 12:00 18:00 18. Oct 06:00 12:00 18:00 19. Oct 06:00 12:00 18:00 20. Oct 06:00 12:00 18:00 21. Oct 06:00 12:00 18:00 22. Oct 06:00 12:00 18:00 23. Oct 06:00 12:00
person My Profile

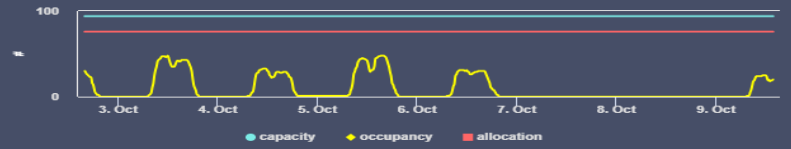
Building 27B Trends

Mon 9 Oct 13:47:14

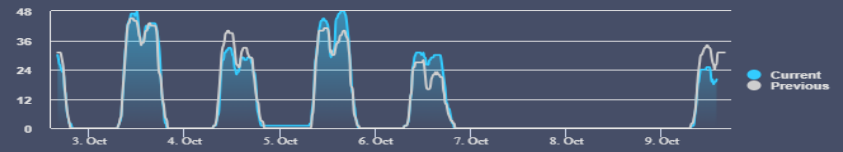
Actual 4m



Capacity - Allocation - Occupancy 4m



Occupancy Weekly Time Trend Compare 9m



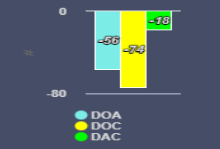
Office Mq 9m

803.9
m2

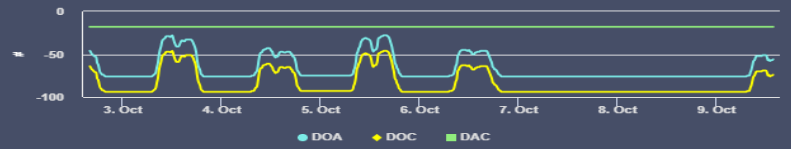
Temp. 9m

20.6
°C

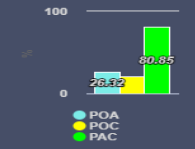
Difference 4m



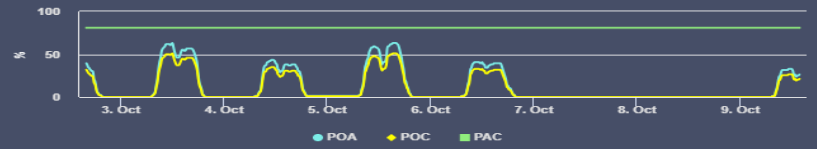
DOA - DOC - DAC 4m



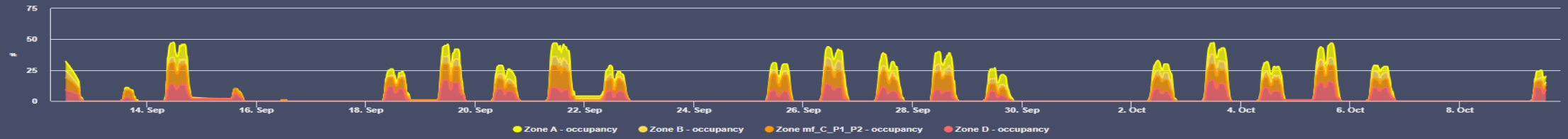
Percentage 4m



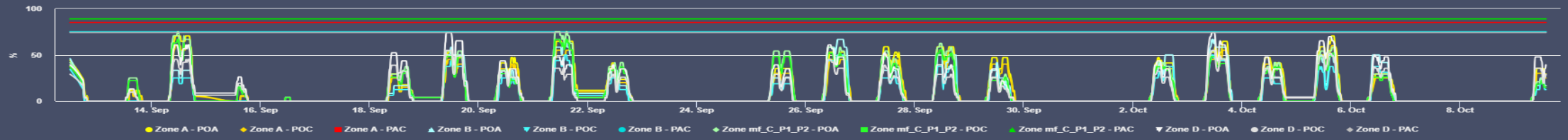
POA - POC - PAC 4m



Occupancy Per Zones - Monthly Time Trend Comparison Stacked 4m



Percentage Per Zones - Monthly Time Trend Comparison 4m



Heat Power 9m

0 kW

Heat Energy 9m

1931279 kWh

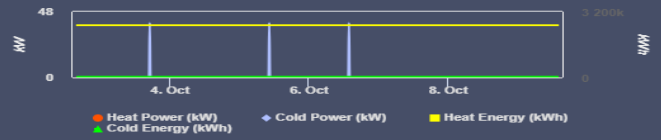
Cold Power 9m

0 kW

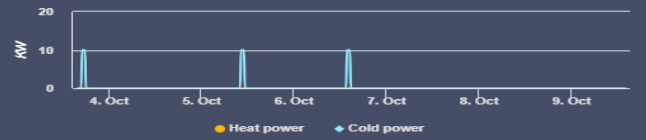
Cold Energy 9m

888311 kWh

Energy Trends 4m



Average Hourly Power 4m



En./Mq 9m

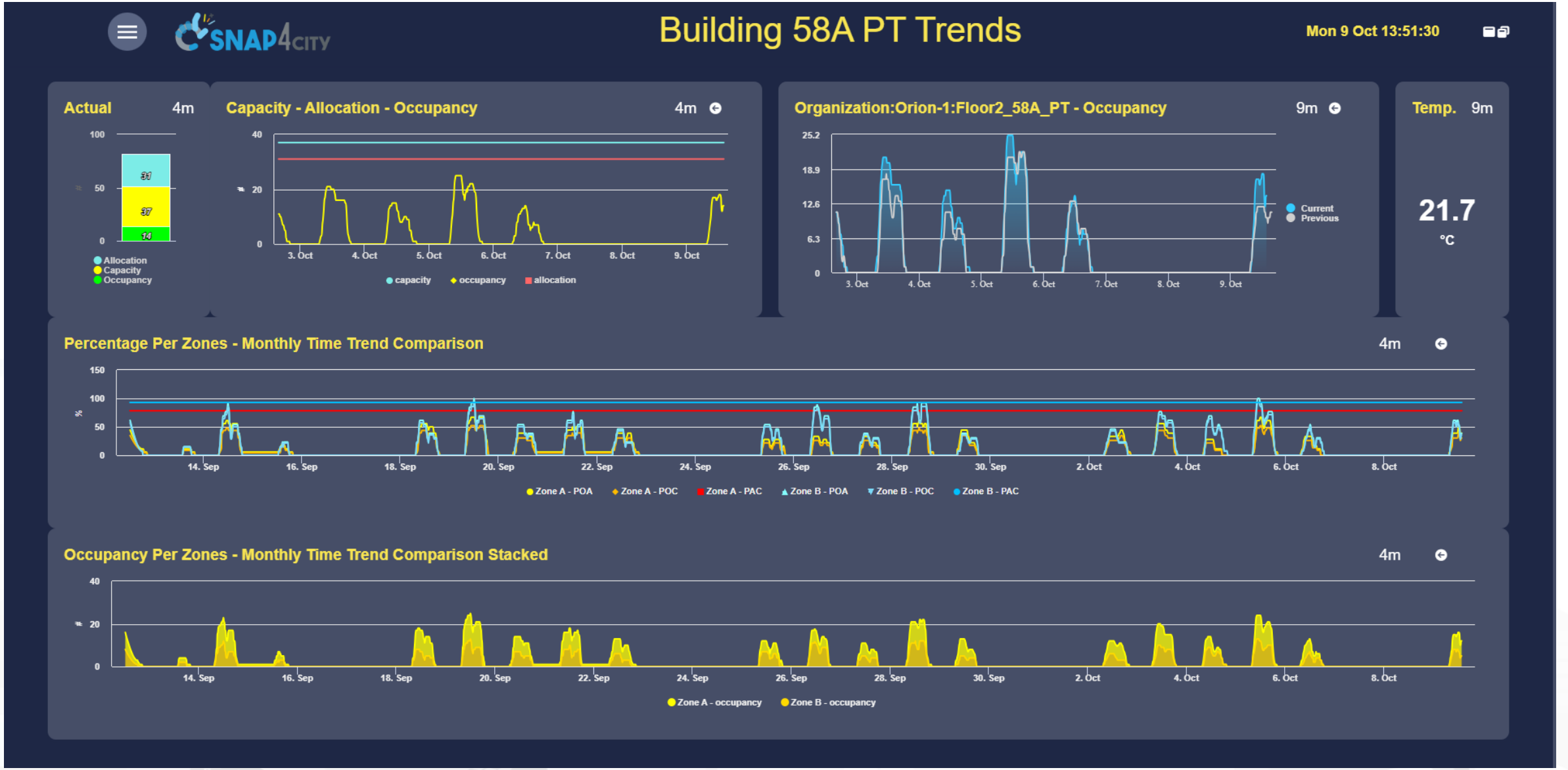
0 kWh

En./Pax 9m

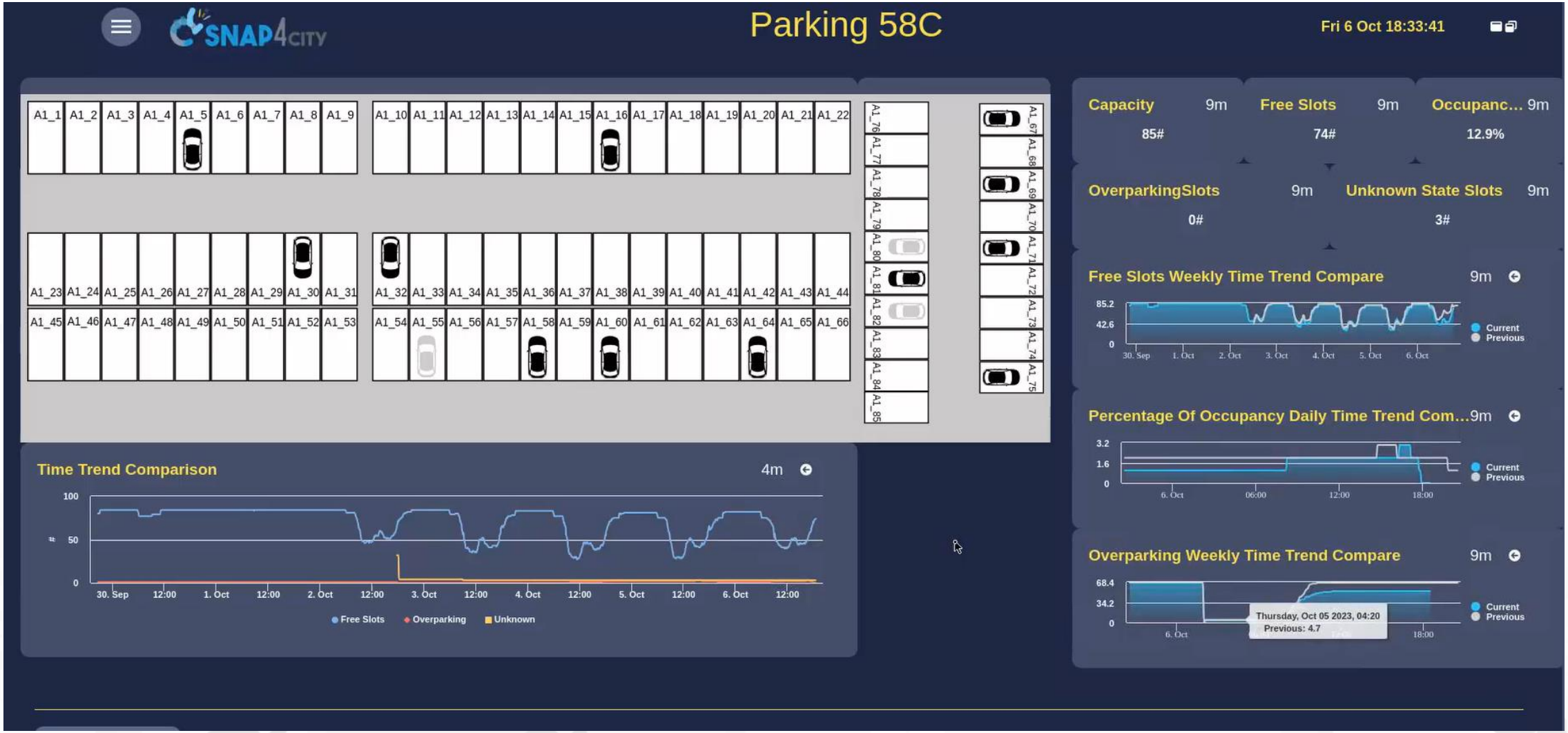
0 kWh

person My Profile

Floor Details


Building 58A PT Trends
Mon 9 Oct 13:51:30
Actual 4m
Allocation
Capacity
Occupancy
Capacity - Allocation - Occupancy 4m
capacity
occupancy
allocation
Organization:Orion-1:Floor2_58A_PT - Occupancy 9m
Current
Previous
Temp. 9m
21.7
°C
Percentage Per Zones - Monthly Time Trend Comparison 4m
Zone A - POA
Zone A - POC
Zone A - PAC
Zone B - POA
Zone B - POC
Zone B - PAC
Occupancy Per Zones - Monthly Time Trend Comparison Stacked 4m
Zone A - occupancy
Zone B - occupancy

Parking


Parking 58C
Fri 6 Oct 18:33:41
Capacity 9m
85#
Free Slots 9m
74#
Occupanc... 9m
12.9%
OverparkingSlots 9m
0#
Unknown State Slots 9m
3#
Free Slots Weekly Time Trend Compare 9m
Current
Previous
Percentage Of Occupancy Daily Time Trend Com... 9m
Overparking Weekly Time Trend Compare 9m
Thursday, Oct 05 2023, 04:20
Previous: 4.7
Time Trend Comparison 4m
Free Slots
Overparking
Unknown

TOP

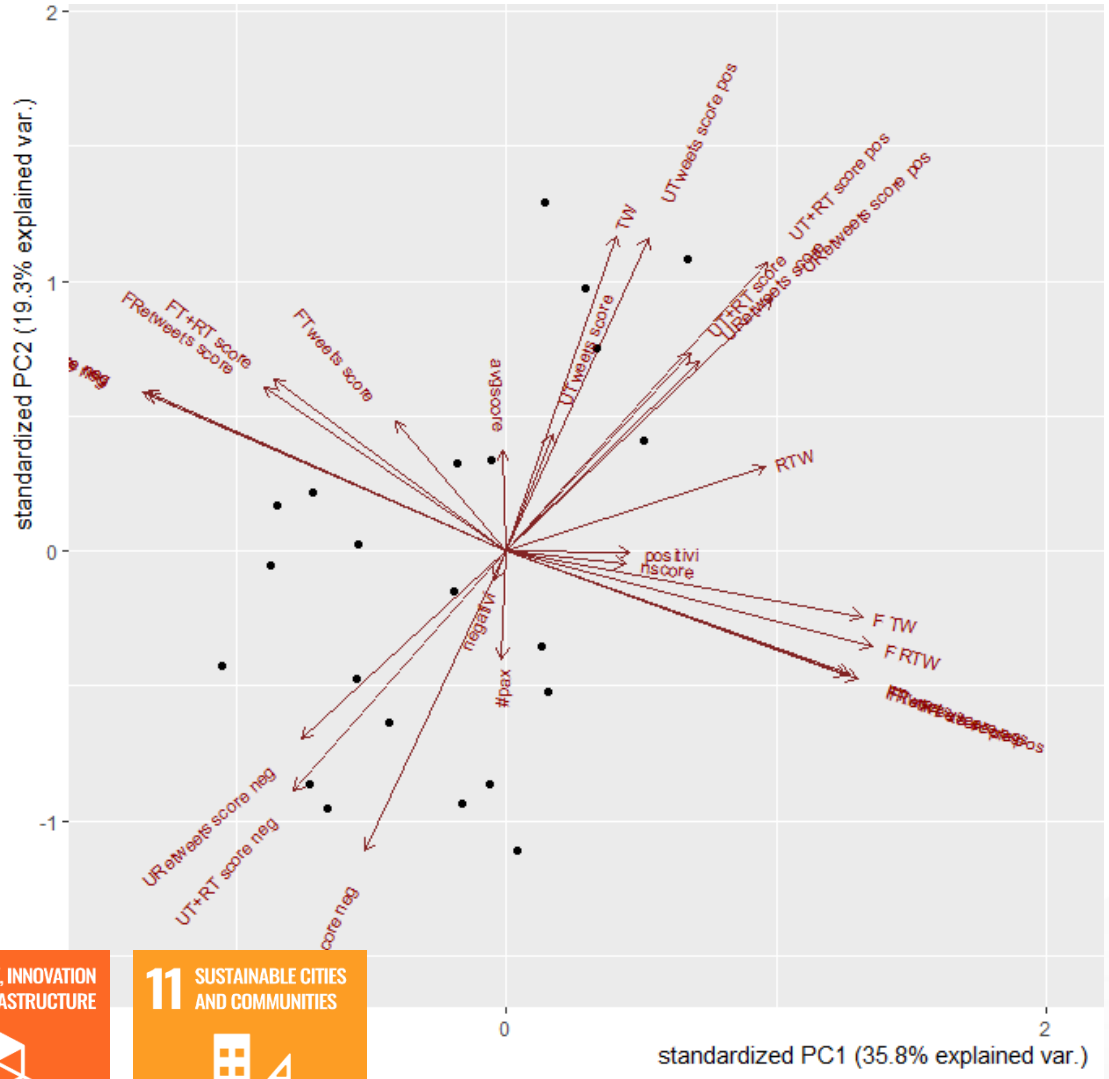
Tourism Domain

100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

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*



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

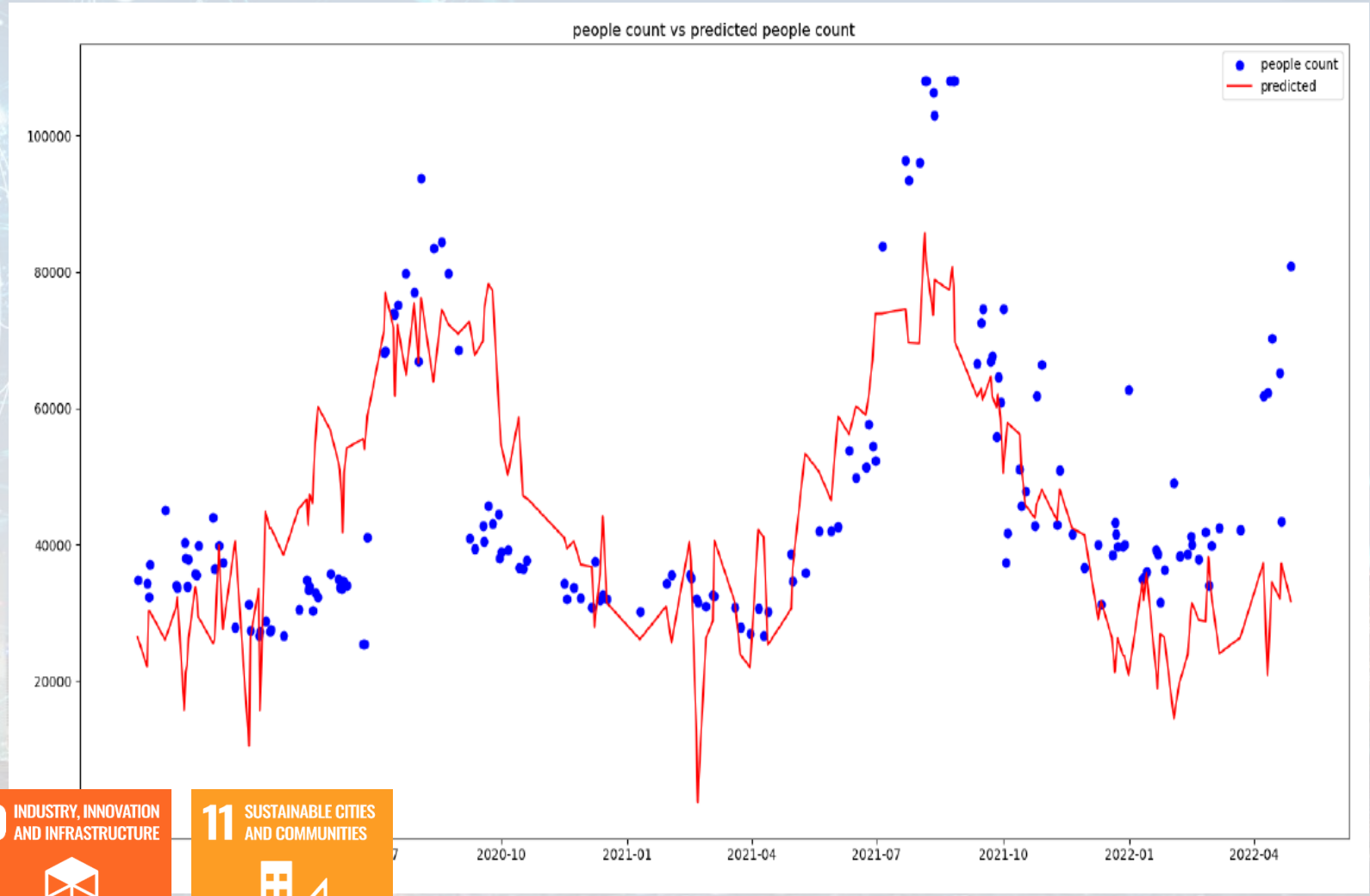
11 SUSTAINABLE CITIES AND COMMUNITIES

Twitter Vigilance

Dubrovnik: Data Analytics

- Assessing impact of advertising

- Prediction of presences on the basis of
  - Social Media Twitter Vigilance
  - weather conditions
  - Historical data



Twitter Vigilance

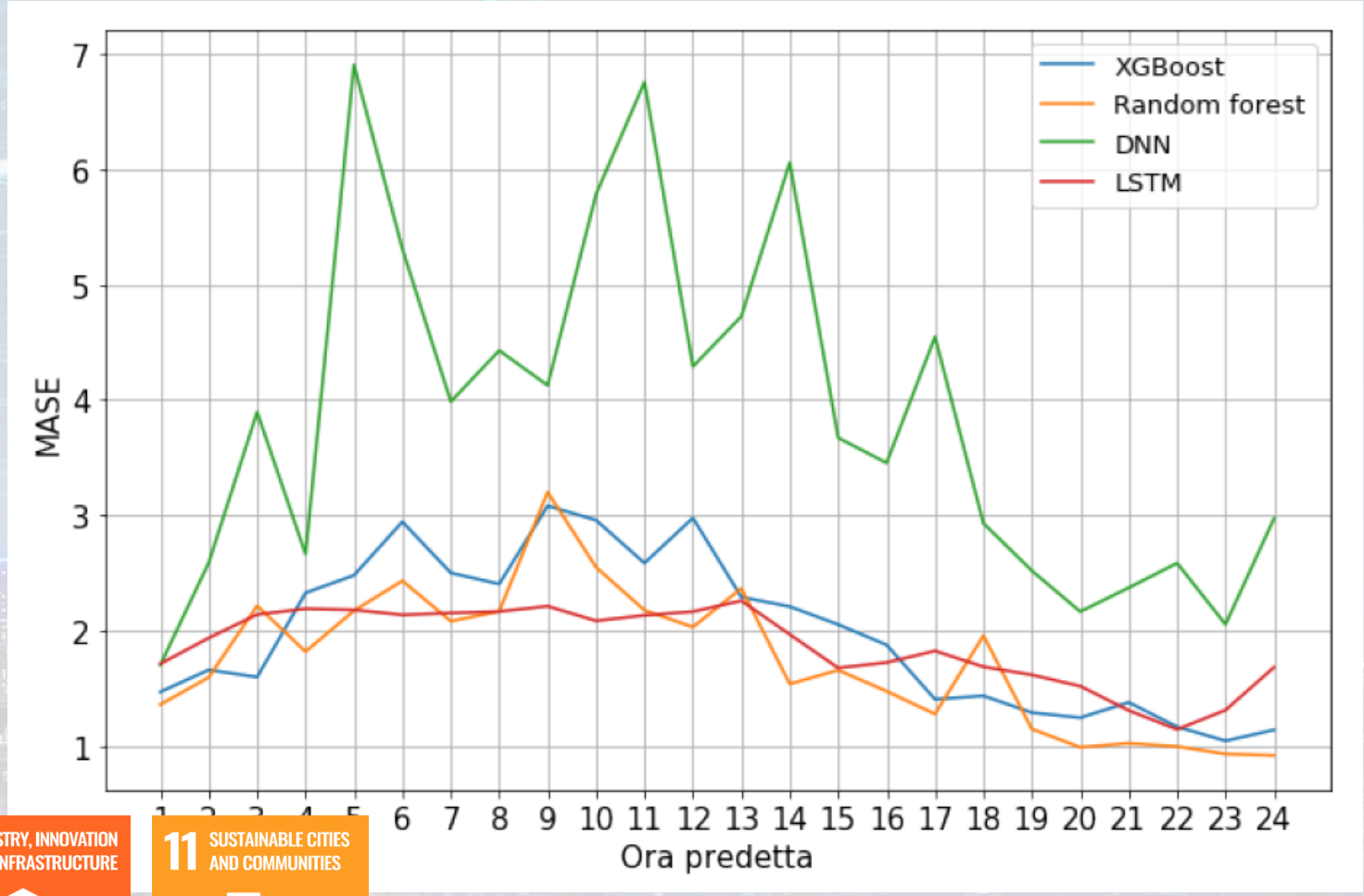
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

Pont du Gard: data analytics

- Prediction of the number of sold tickets 24 hours in advance

- Using:
  - Historical data
  - Weather conditions
  - Social Media



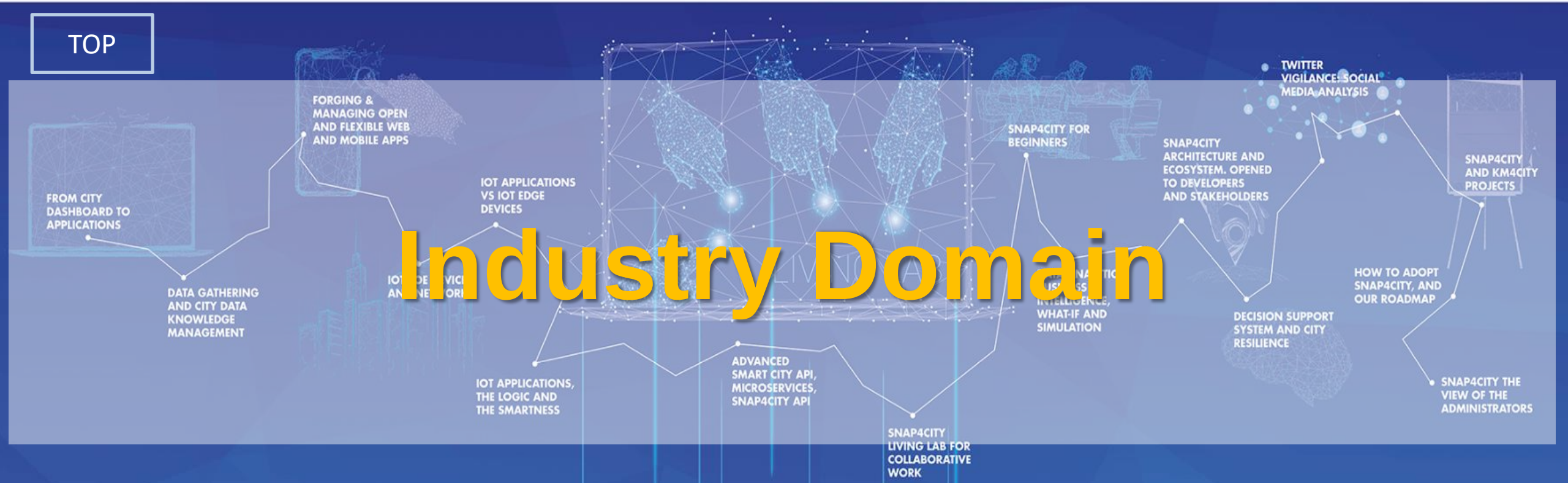
Twitter Vigilance

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

TOP

Industry Domain



100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

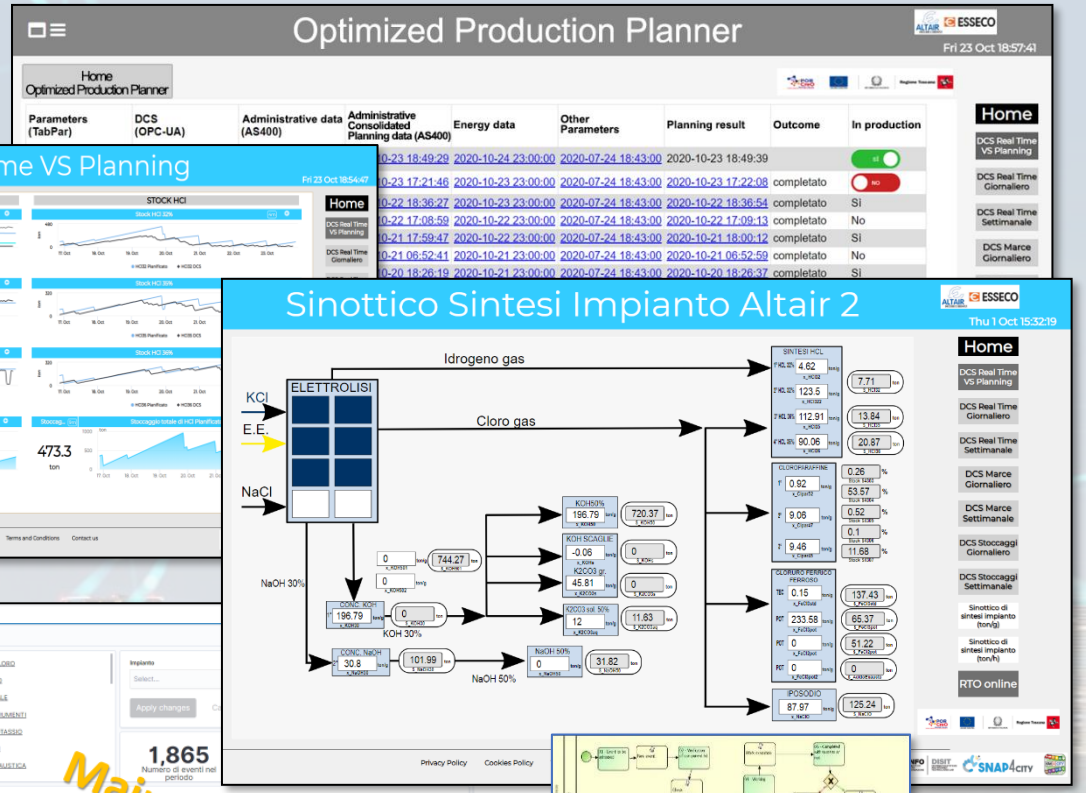
Industry production Domain (2024)

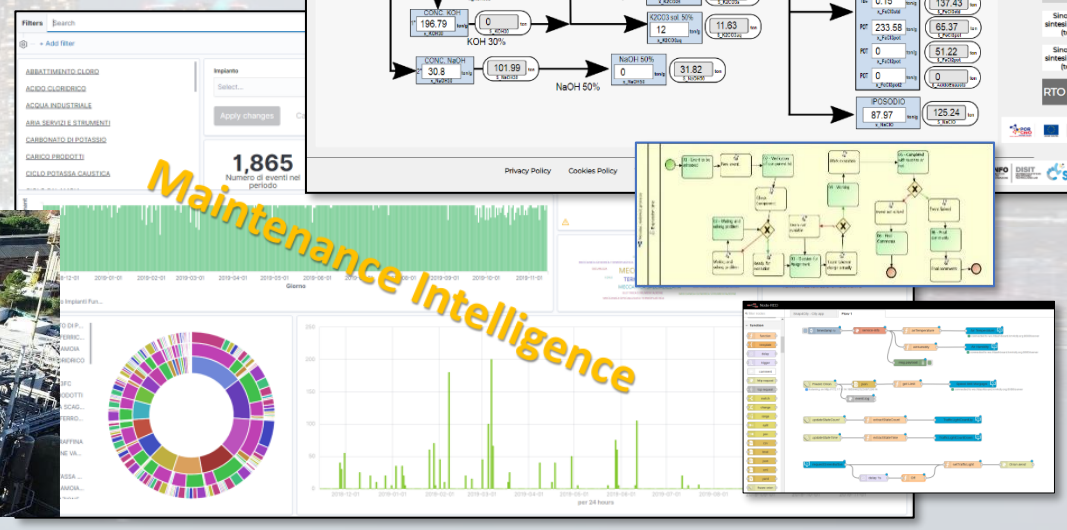
- Goals:
  - Efficiency, costs
  - Production optimisation
  - Quality Level
- Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)
  - Monitoring KPI: administration, production, commercial, faults, etc.
  - Early detection/warning, alarm, of critical conditions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

Snap4Altair Decision Support supervision and control, Industry 4.0

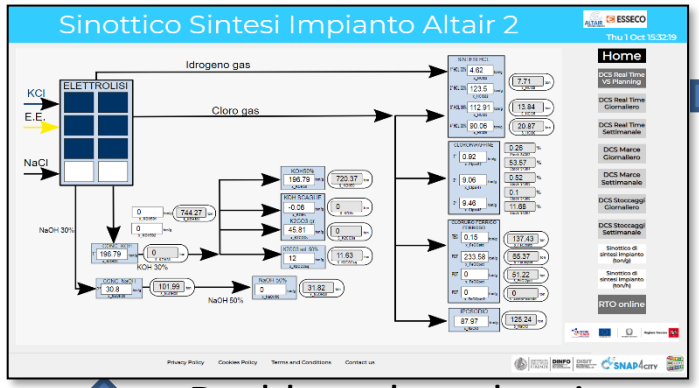
reference

- **Multiple Domain Data**
  - Distributed Control System: energy, flows, storage, chemical data, settings, ..
  - Cost of energy, Orders,
  - Production Parameters
  - Maintenance data
- **Multiple Levels & Decision Makers**
  - Optimized planning on chemical model
  - Business Intelligence on Maintenance data
- **Historical and Real Time data**
  - Billions of Data
- **Services Exploited on:**
  - Multiple Levels, Mobile Apps, API
- **Since 2020**



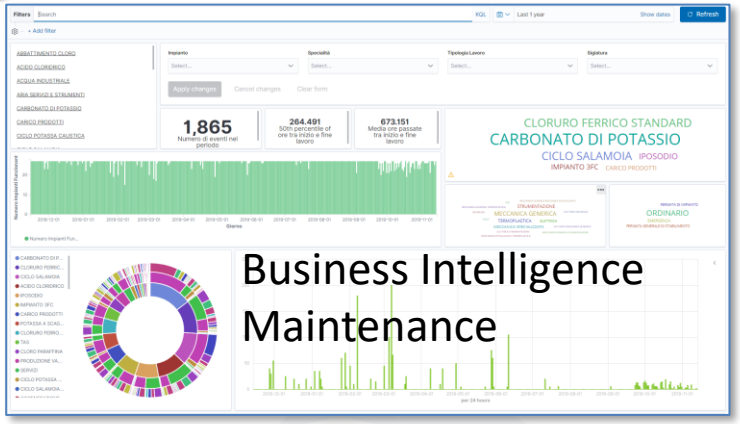


Workflow for Ticket management

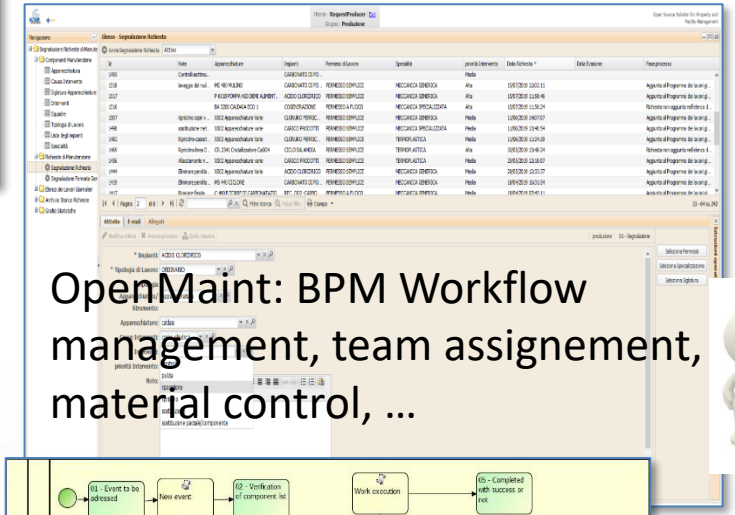


Dashboards and actions

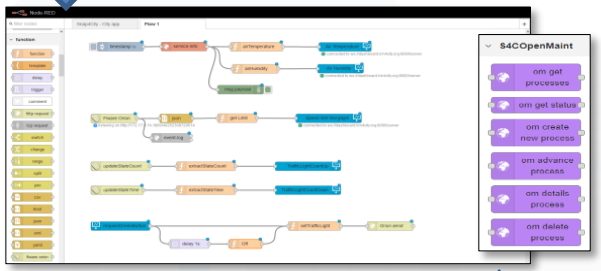
Consumptions/productions

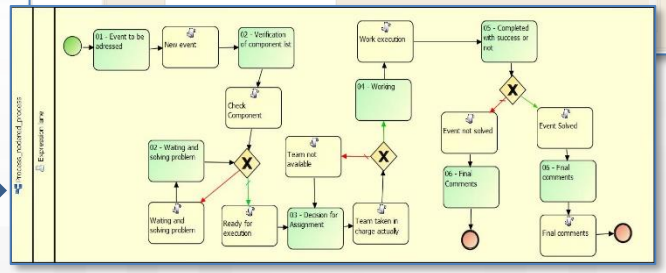


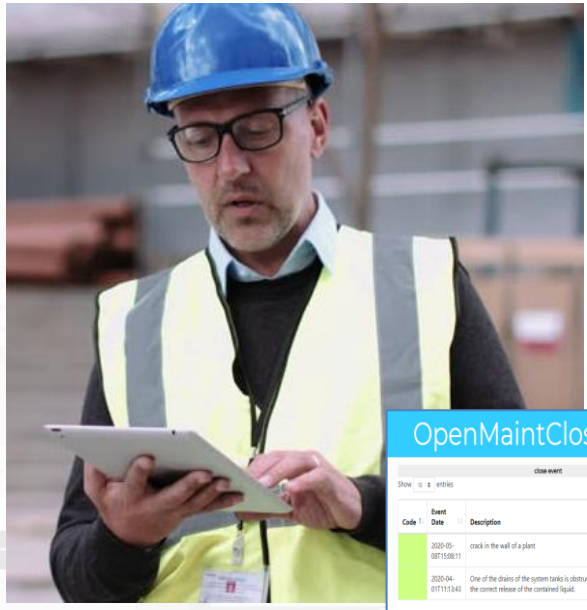
Events/actions

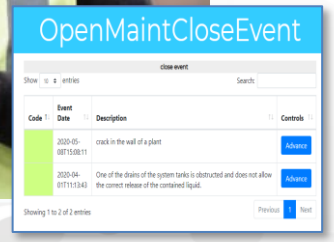


OpenMaint: BPM Workflow management, team assignement, material control, …









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

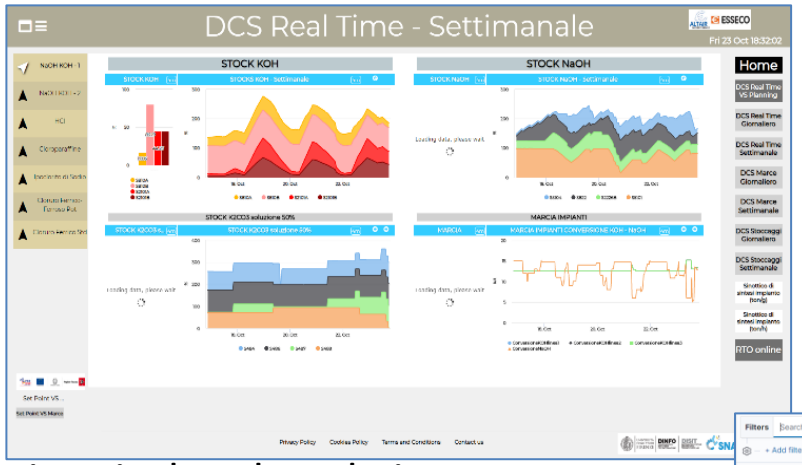
UNIVERSITÀ DEGLI STUDI FIRENZE

DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

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

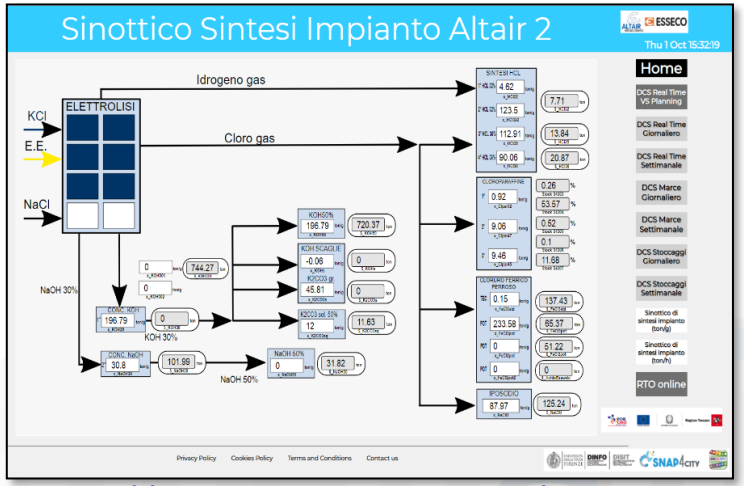
Closing the loop

SNAP4CITY KM4CITY



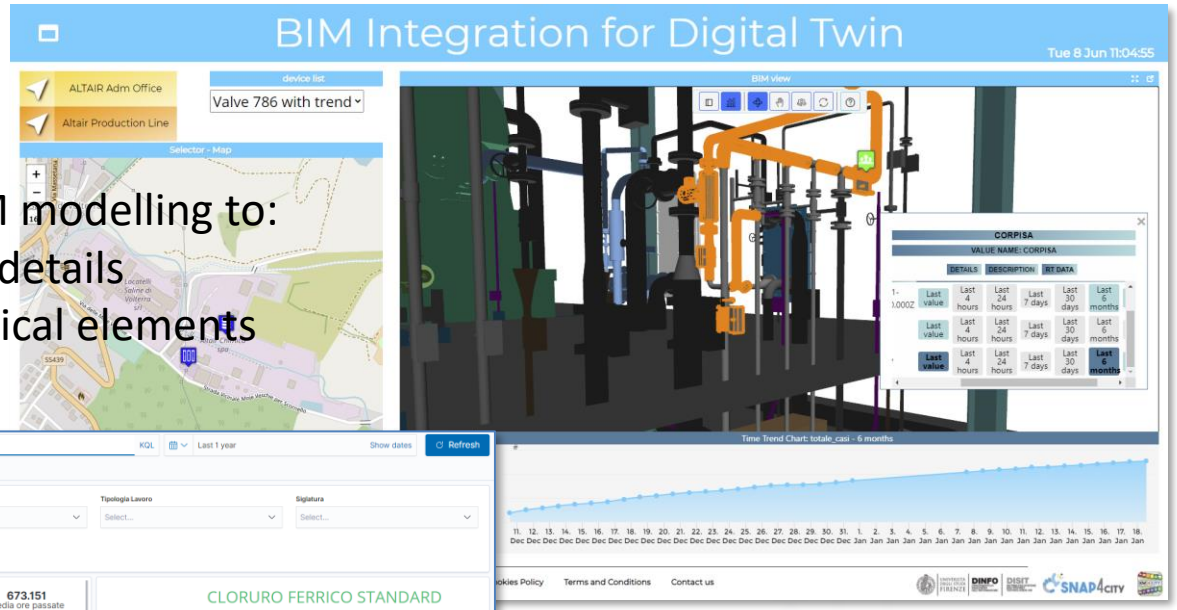
Historical and Real Time Data

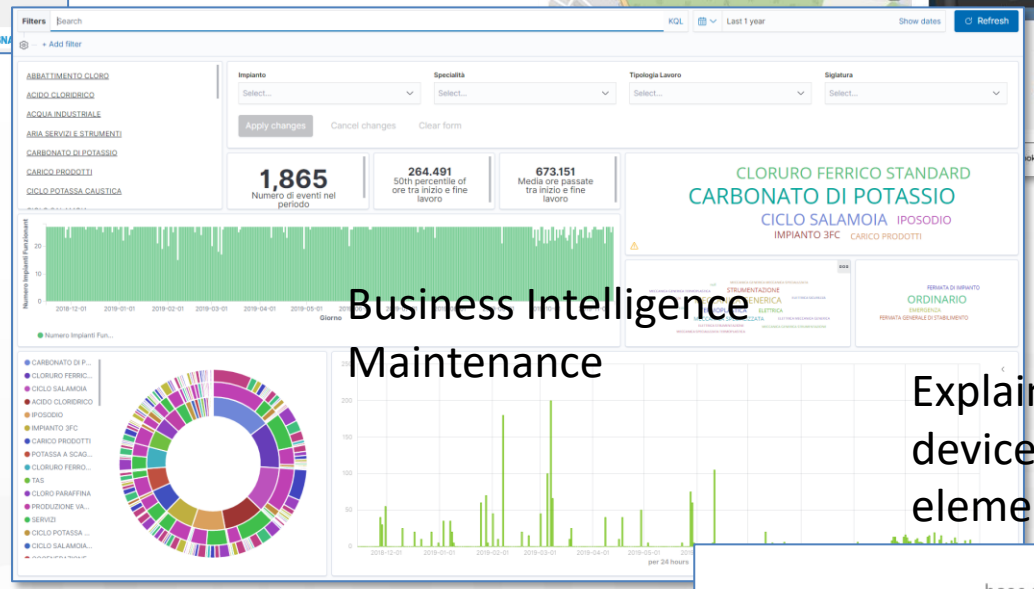
Synoptics for real time monitoring



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

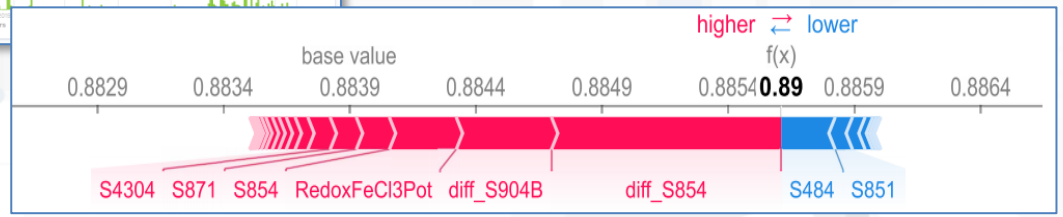
Map and 3D BIM modelling to:
-- represent the details
-- associate physical elements with data





Business Intelligence Maintenance

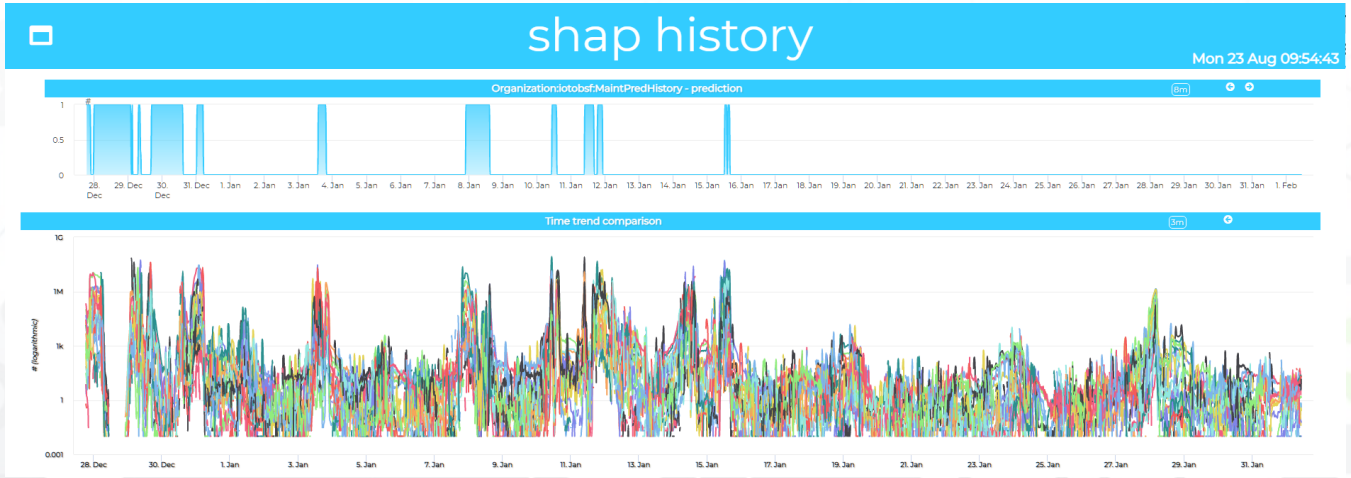
Explainable AI to map critical values of devices and detection to physical elements in the plant



Explainable/XAI - CNN-LSTM (SHAP)

Explanation of prediction generated by model for fault

Explanation of prediction generated by model for normality



TOP

References

FROM CITY DASHBOARD TO APPLICATIONS

DATA GATHERING AND CITY DATA KNOWLEDGE MANAGEMENT

FORGING & MANAGING OPEN AND FLEXIBLE WEB AND MOBILE APPS

IOT/IOE DEVICES AND NETWORKS

IOT APPLICATIONS VS IOT EDGE DEVICES

IOT APPLICATIONS, THE LOGIC AND THE SMARTNESS

ADVANCED SMART CITY API, MICROSERVICES, SNAP4CITY API

SNAP4CITY LIVING LAB FOR COLLABORATIVE WORK

SNAP4CITY FOR BEGINNERS

DATA ANALYTICS, BUSINESS INTELLIGENCE, WHAT-IF AND SIMULATION

SNAP4CITY ARCHITECTURE AND ECOSYSTEM. OPENED TO DEVELOPERS AND STAKEHOLDERS

TWITTER VIGILANCE: SOCIAL MEDIA ANALYSIS

DECISION SUPPORT SYSTEM AND CITY RESILIENCE

HOW TO ADOPT SNAP4CITY, AND OUR ROADMAP

SNAP4CITY AND KM4CITY PROJECTS

SNAP4CITY THE VIEW OF THE ADMINISTRATORS

100% OPEN SOURCE

SNAP4 Appliances and Dockers **Installations**

2023 booklets

- Smart City

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

- Industry

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

- Artificial Intelligence

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

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) MIUR

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

E0l5 digital ecosystem (Powered by EXPO MILANO 2015)

(2016-19) MIUR 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

5G (2018-21)

- 5G tech
- Energy
- Industry 4.0
- Synoptics

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)

SIRIUS

TRAFAIR CEF (2018-21)

- Traffic and Mobility Impact on Pollution
- NOX predictions

2019
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

Winner of Select4Cities PCP

SNAP4CITY roadmap

2020

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

- Smart Mobility
- PISA, PUMS
- Living lab

Km4City 1.6.7

2021

Smart Ambulance (2021-22)

Sii-Mobility

Contract

Contract

PC4City (2020-21) Monitoring Terrain

Winner of Open Data Challenge of

- Smart Light
- Sweden

Enterprise (2021-22) Industry 4.0

Almafluida Industry 4.0 (2021-22)

AMPERE (2021-22) Industry 4.0

SYN-RG-AI SmartCity

Industry 4.0

SmartCity, 2021-23

AXIS collab SmartCity

2022

Asymmetrica Smart City, 2022-23

Italferr, Smart City

2023

Contract, 2022-23

Contract, 2022-23

2022-2023

Contract, 15min

Security and Risk

Contract, 2024-25

CN MOST, 2022-26

EI THE, 2022-26

G. Agile, 2021-23

2023-26

Merano, smart light

OceanRace, Genova, AWS

Cuneo, smart city

2024

TOURISMO

ELLIE IA 2024-2027

SASUAM

CAI4DSA

Rhodes, smart city

eShare UNIFI TUSS

AMMIRARE

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