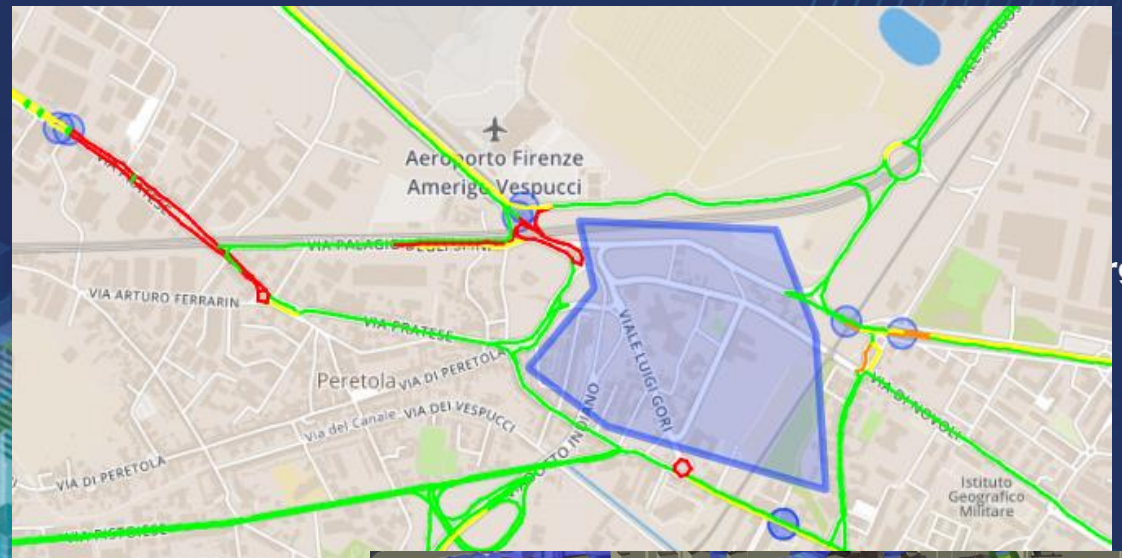
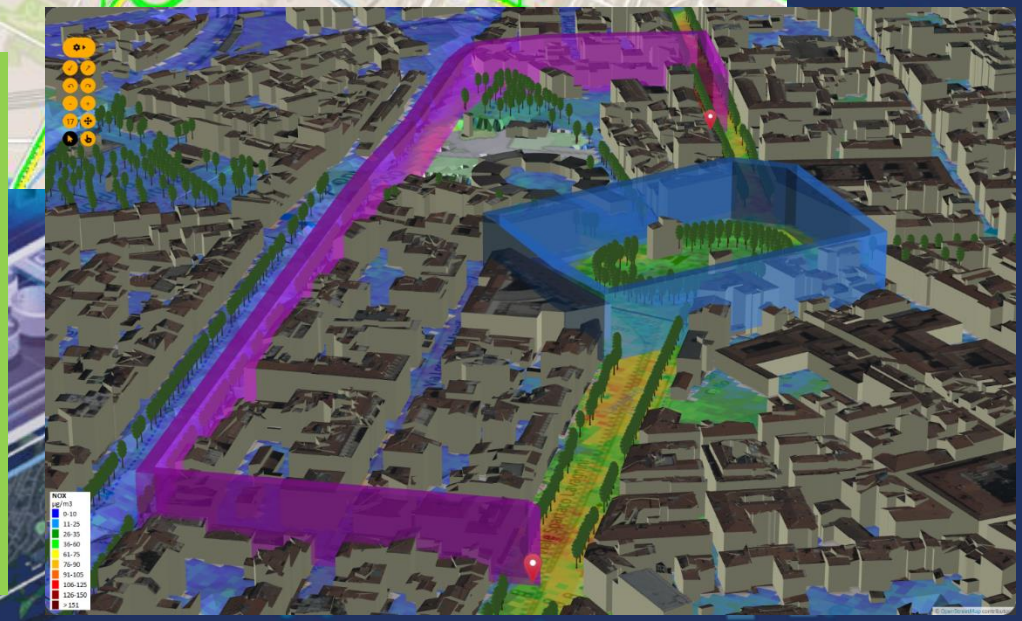
SNAP4CITY

www.snap4city.org
www.snap4solutions.org



Mobility and Transport Operation and Plan Digital Twin



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

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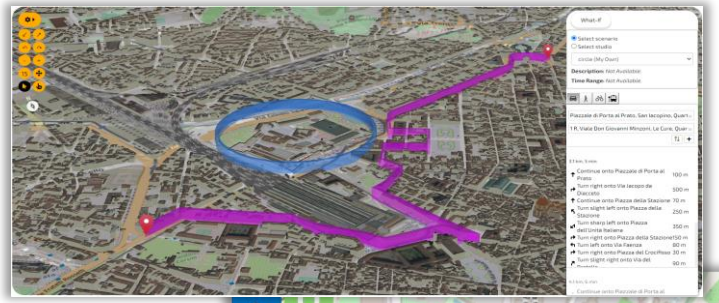
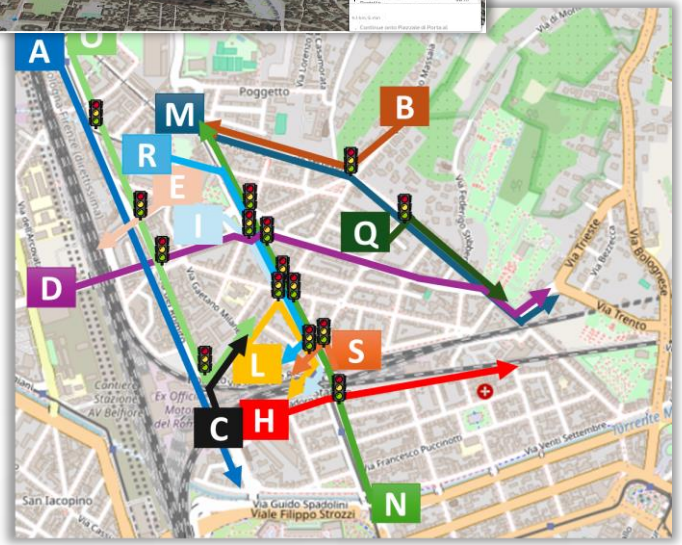
DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

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

Mobility

SNAP4CITY KM4CITY





- **Goals:**
  - Decongestion, Decarbonization, costs reductions
  - Improve Accessibility to services
  - Improve Security/Safety of city users
- **Operation and Plan**:
  - Traffic monitoring, prediction, reconstruction, identification of critical conditions (early warning), fleet management, dynamic routing, multimodal routing, city user behaviour analysis
- **Optimization and what-if analysis traffic light, infrastructure**
  - **Reduction**: travel time, waiting time, stops, CO2 emissions, consume fuel, travel time for tramways
- **Public Transport**: analysis of Mobility Demand vs Offer of Transportation
- **Parking Management:** monitoring, prediction, any payments, on/off-road
- **Sharing / Pooling Management**: eShare and mobile app, bikesharing, smart bike, fleet management
- **KPI:** SUMI/SUMP, travel time, emissions, traffic status, accessibility, ..
- **Mobile App**: final users and operators
  - Info Mobility, traffic reconstruction, charging, participation,
  - Parking, payments, overparking, fine reporting, ..
- **Participatory**: problem reporting, ticketing, etc.
- **Data Integration of any kind: env, weather. Tickets, presences, POI, sat, etc.**

Mobility and Transport

SNAP4CITY

Digital Twin Solutions for Sustainability

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

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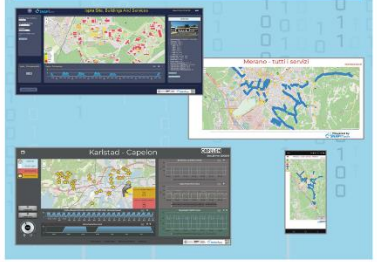
OPERATION AND PLAN - CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS - OPTIMIZATION - APPLICATIONS

CONTROL AND PLAN

MOBILITY AND TRANSPORT

SMART ENERGY AND SMART BUILDING

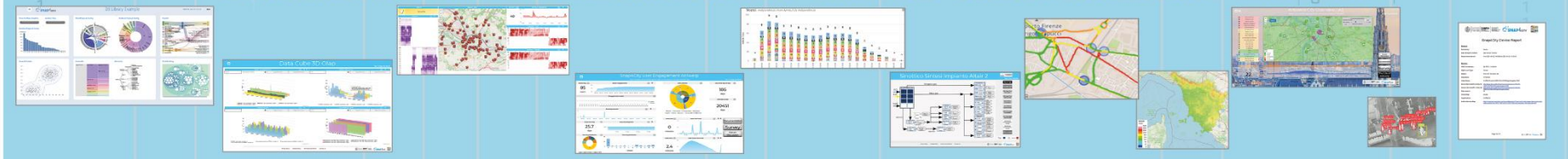


ENVIRONMENT AND WASTE MANAGEMENT

CITY USER'S SERVICES AND TOURISM MANAGEMENT

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

VISUAL ANALYTICS - SYNOPTICS - GRAPHICAL WIDGETS - ANALYTICS - BUSINESS INTELLIGENCE - SIMULATIONS

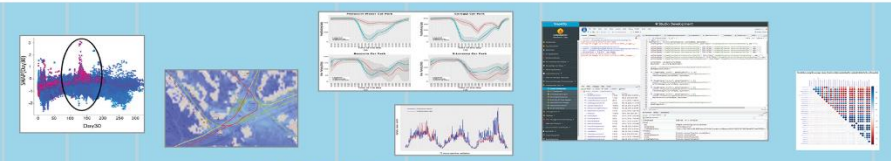


DASHBOARDS, WIDGETS
TEMPLATES

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 ...

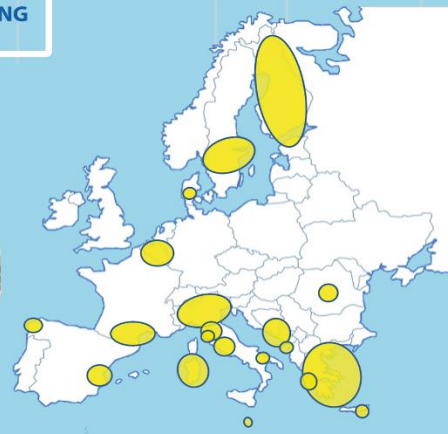
EXPERT SYSTEM, KNOWLEDGE BASE
SEMANTIC REASONING
SMART DATA MODEL
IOT DEVICE MODELS, STORAGE



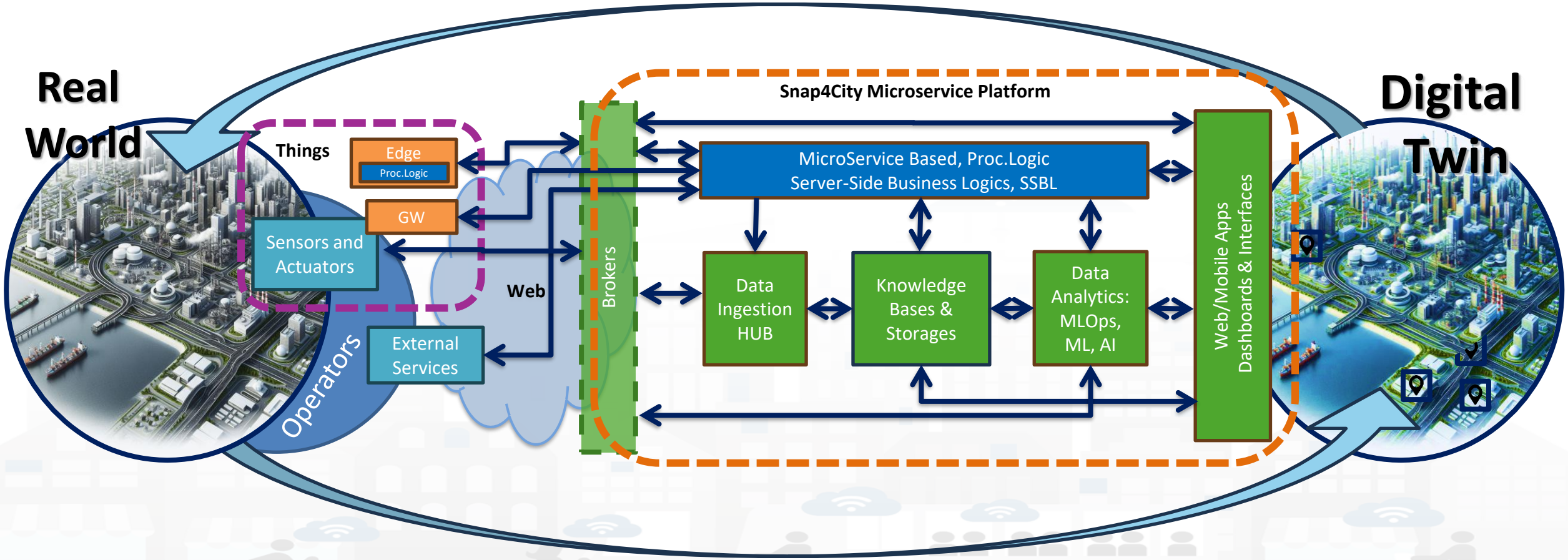
BIG DATA ANALYTICS, ARTIFICIAL INTELLIGENCE
EXPLAINABLE AI, MACHINE LEARNING, GENERATIVE AI
OPERATIVE RESEARCH, STATISTICS

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

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



Digital Twin Development Platform



Standards and Interoperability (6/2023)

Compliant with:

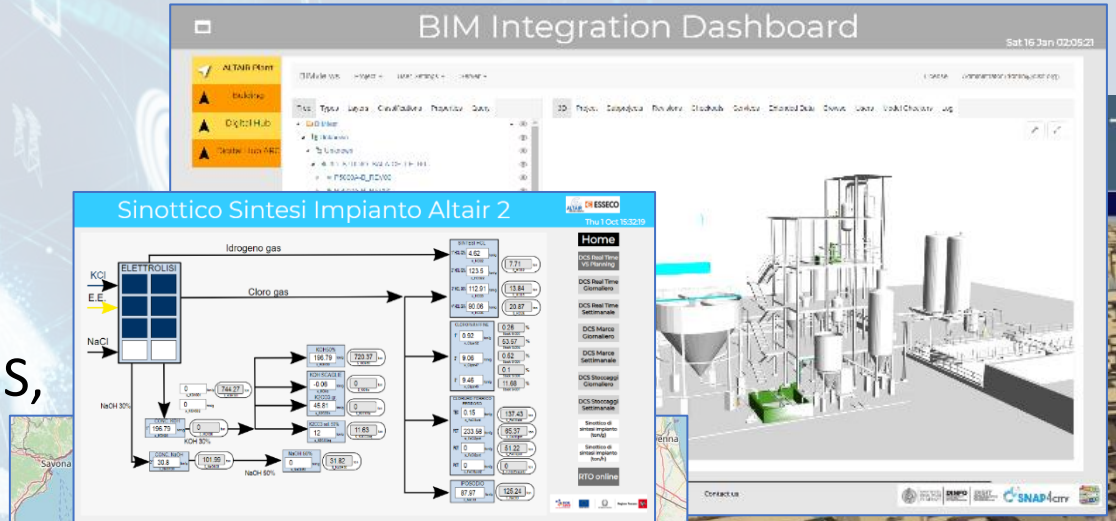
- **IoT:** NGSI V2/LD, LoRa, LoRaWan, MQTT, AMQP, COAP, OneM2M, TheThingsNetwork, SigFOX, Libelium, IBIMET/IBE, Enocean, Zigbee, DALI, ISEMC, Alexa, Sonoff, HUE Philips, Tplink, BACnet, TALQ, Protocol Buffer, KNX, OBD2, Proximus, ..
- **IoT model:** FIWARE Smart Data Model, Snap4City IoT Device Models
- **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.

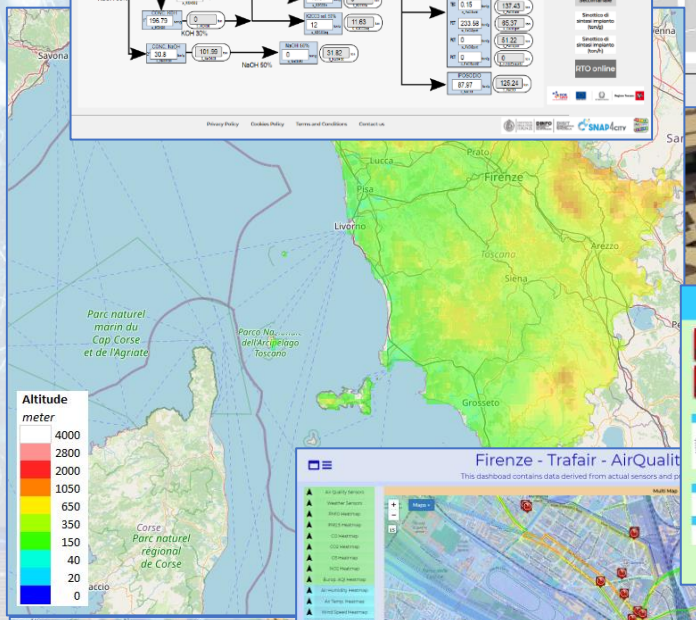
https://www.snap4city.org/65

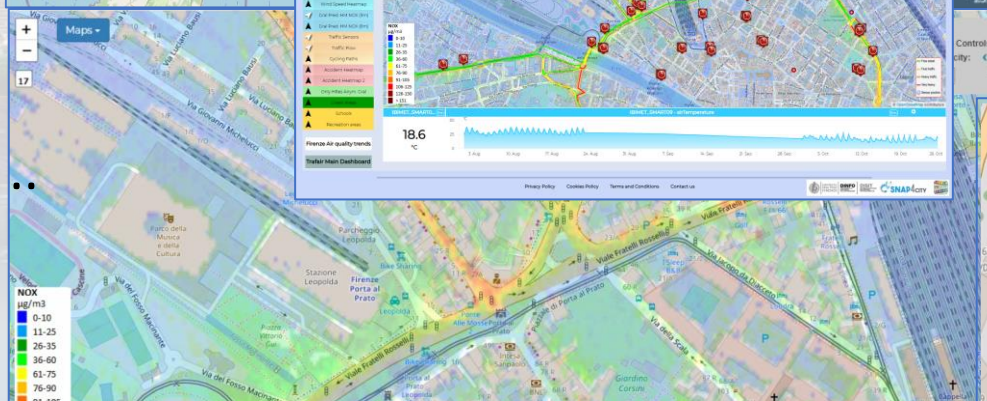
High Level Types

Snap4City (C), August 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.

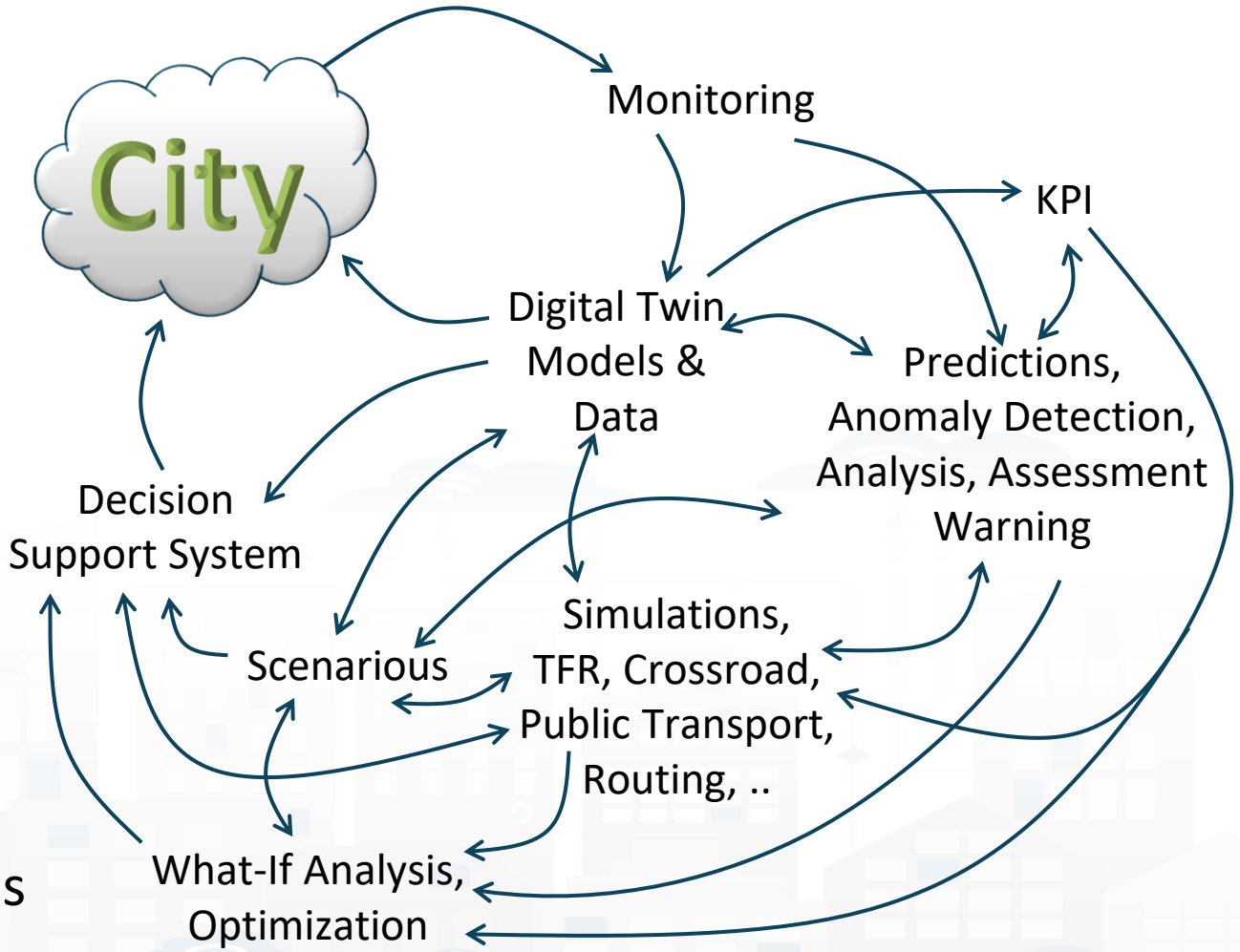






Main tasks

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



City

Monitoring

KPI

Digital Twin
Models &
Data

Predictions,
Anomaly Detection,
Analysis, Assessment
Warning

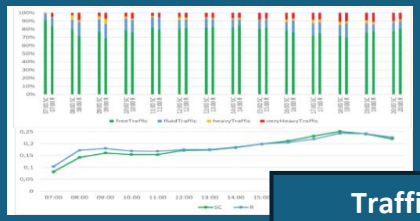
Decision
Support System

Scenarious

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

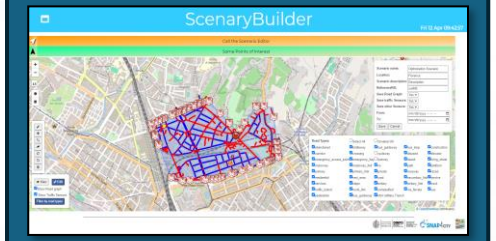
What-If Analysis,
Optimization

KPI, Predictions, ...



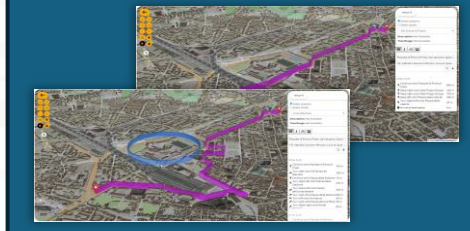
Traffic Reconstruction

Scenario Editor

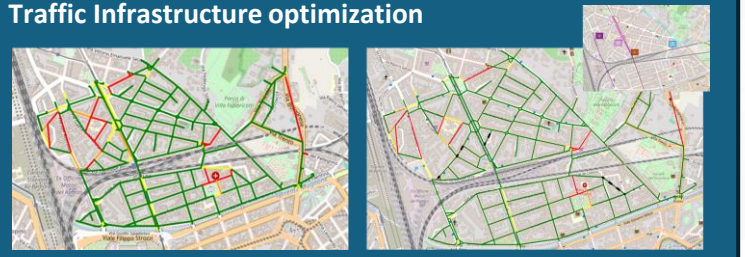


Traffic Light Plan optimization

Routing / Dynamic Routing



Traffic Infrastructure optimization



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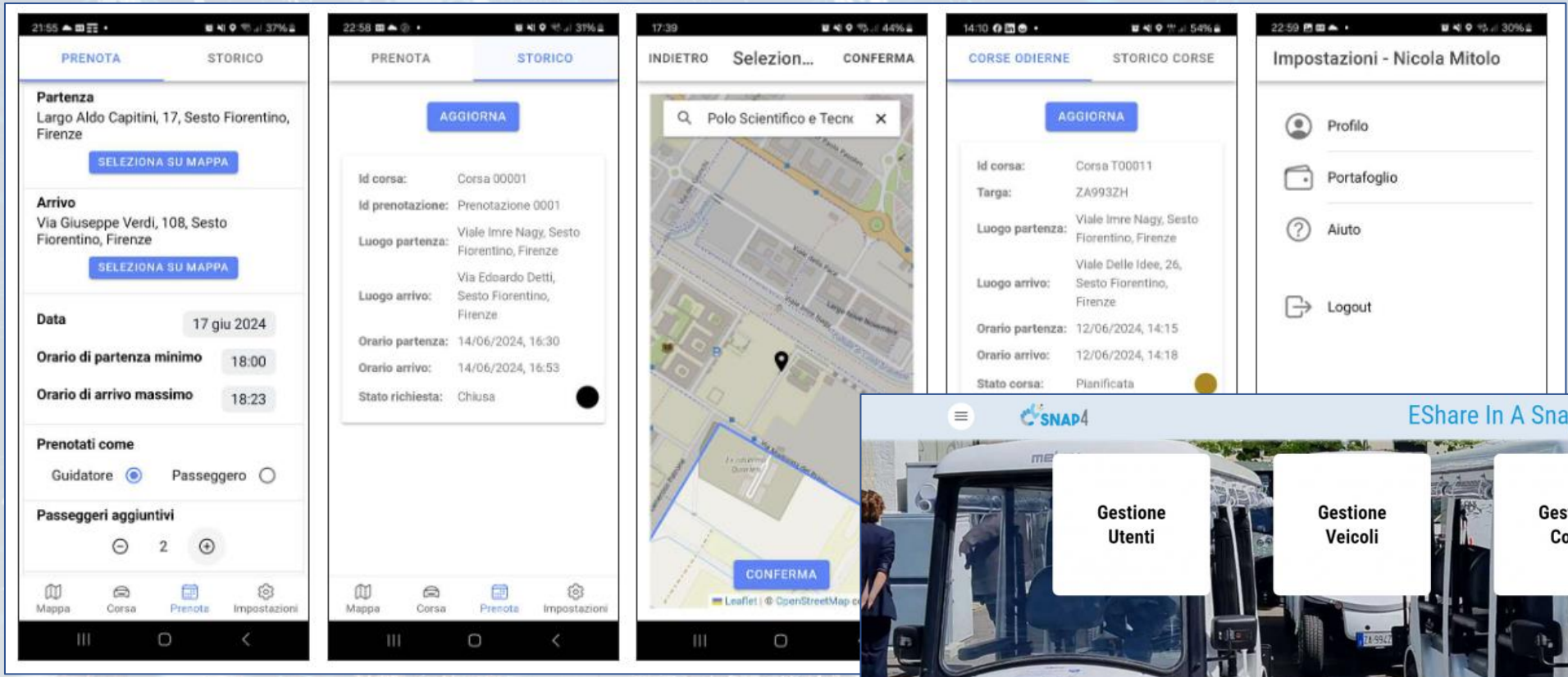
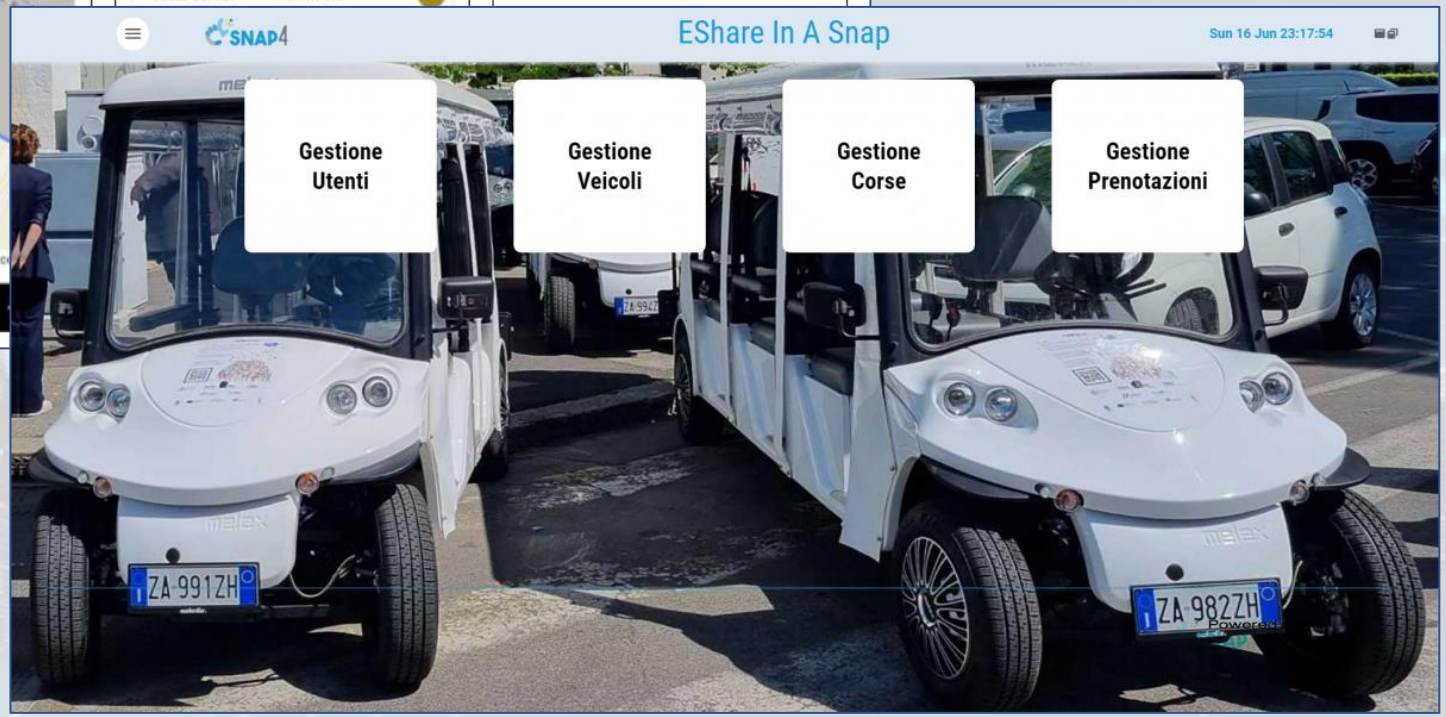
KM4CITY

Application: eSharing and Pooling

eShare in a Snap, by Snap4 s.r.l.

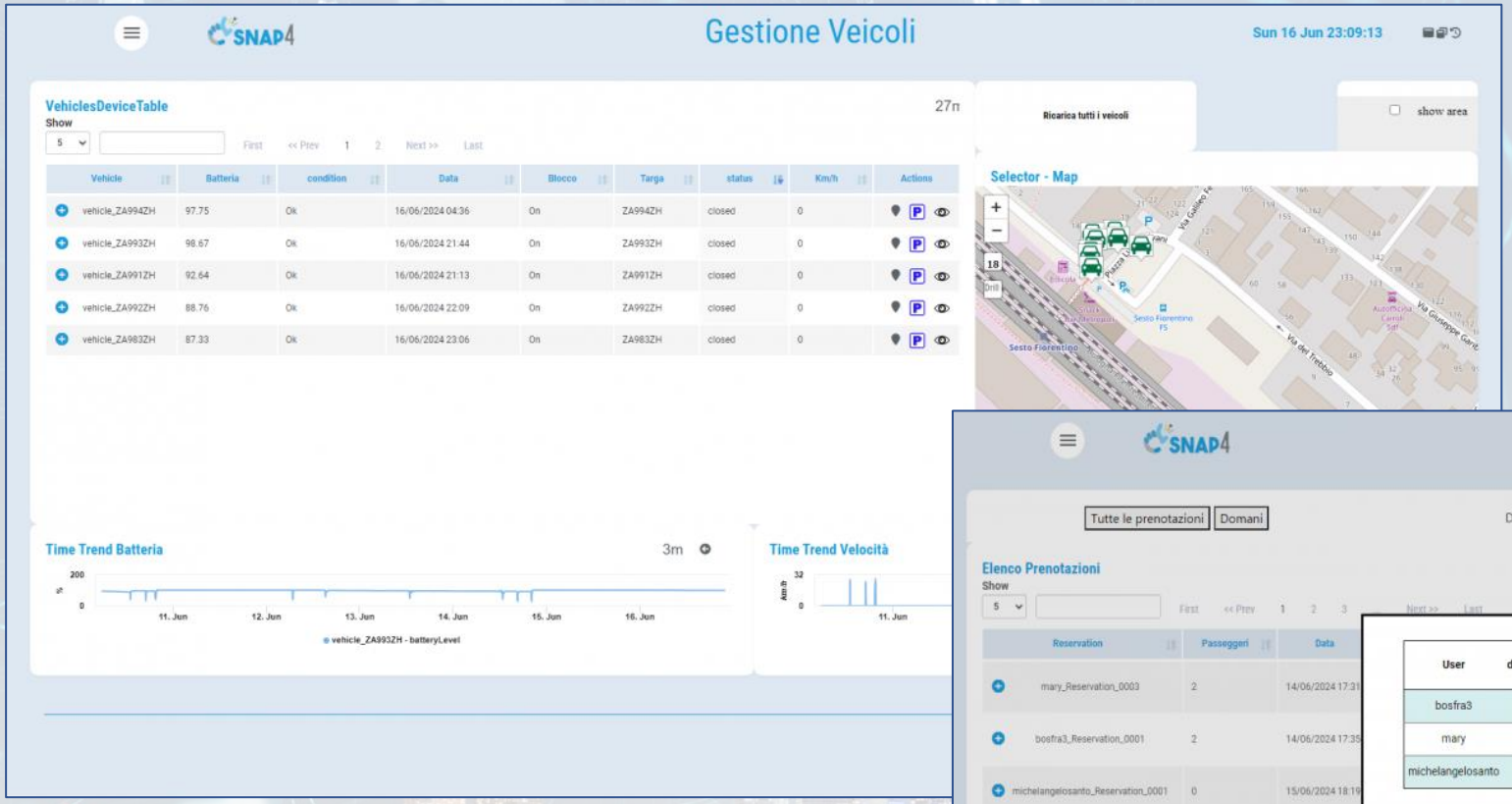
eShare in a Snap, by Snap4





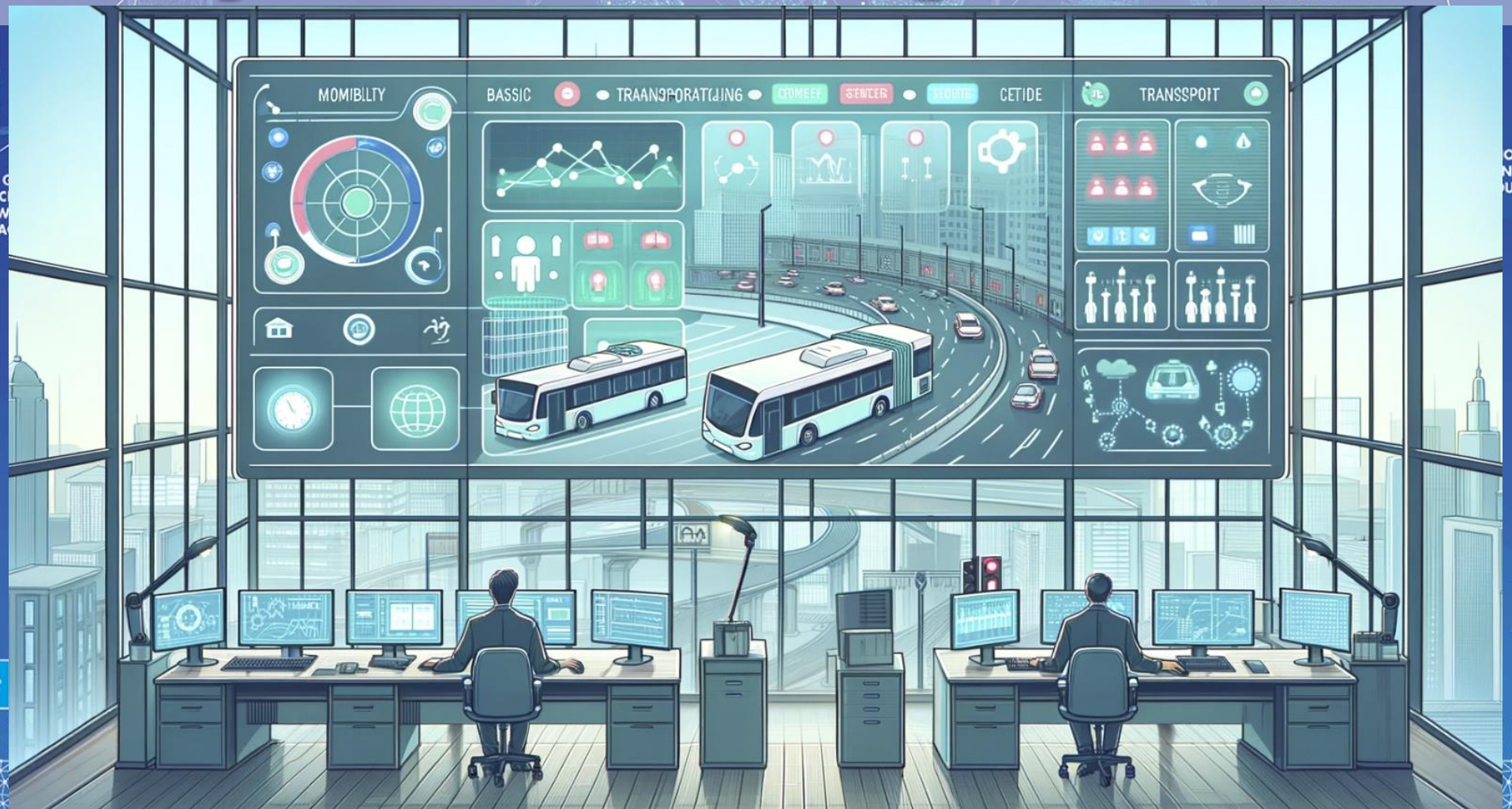
Integrated car sharing and pooling
Multiple drivers on the same means
Dynamic pooling and e-sharing

eShare in a Snap, by Snap4



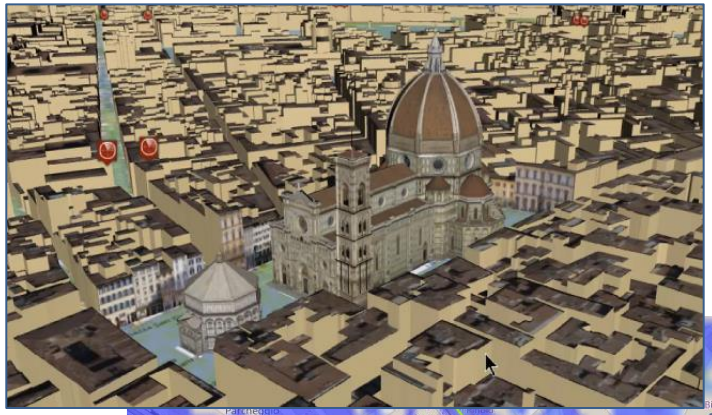
Integrated car sharing and pooling
Multiple drivers on the same means
Dynamic pooling and e-sharing

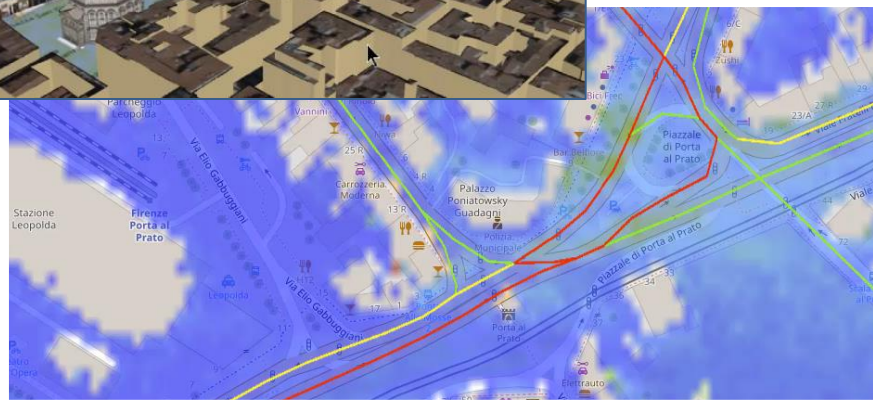
Mobility Monitoring and Control



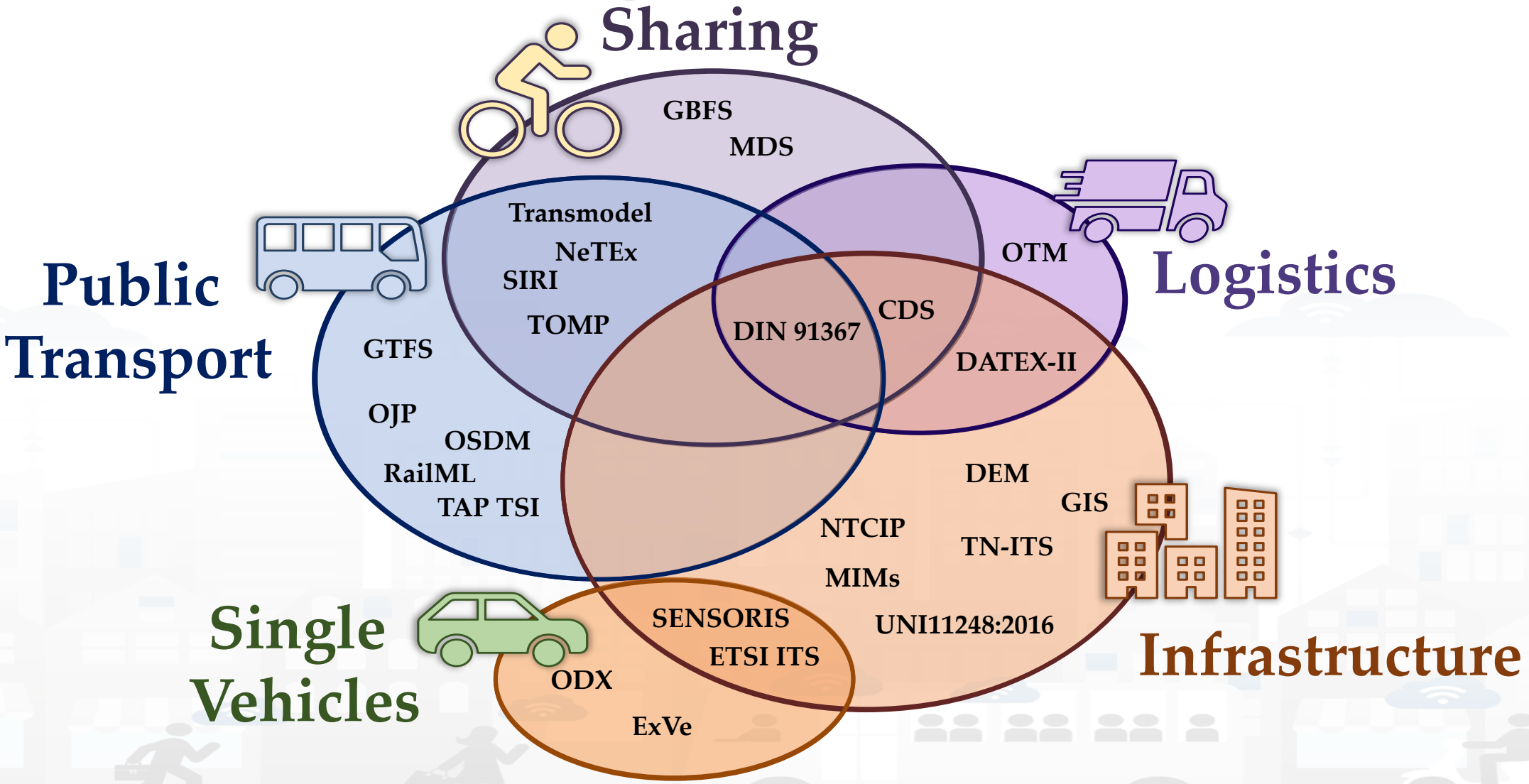
Monitoring

- **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.,





Mobility data formats



Data and standards	Temporal domain			Mobility Domain					Mobility Subdomain													Format															
	Static	Historic	Real-time	Infrastructure	Logistic	Sharing	Public Transport (PT)	Single Vehicles	Census	Road network	Urban elements	Traffic Signals	POI	Buildings	Terrain	Weather	Pollution	PT Urban: Bus, Tram, ...	PT: Railways	Journey Planning	User notification	Vehicle Status / Diagnosis	Excel	SDMX	XML	CSV	JSON	GeoJSON	Protocol Buffers (PBF)	Esri Shapefiles	SVG	SQLite	RDF	PNG	GeoTIFF	Esri grid ASCII (ASC)	ASN.1
Statistical data	X	X		X	X	X	X	X	X														X	X		X	X										
GIS data (governemnt)	X			X						X	X		X	X														X		X							
GIS data (OSM)	X			X						X	X	X		X	X														X	X	X	X	X		X			
TN-ITS	X		X							X															X												
DEM (DTM, DSM)	X													X	X																			X	X	X	
CDS	X	X	X	X	X	X				X	X																X	X									
GTFS	X						X											X											X								
GTFS-RT			X				X											X											X								
NeTEx	X					X	X											X	X						X												
SIRI			X			X	X											X	X						X												
Transmodel	X		X			X	X											X	X	X																	
OJP			X				X											X	X	X					X												
TAP TSI	X		X				X												X	X					X												
RailML	X		X				X												X	X					X												
OSDM	X						X												X	X							X										
GBFS	X		X			X																					X										
MDS	X	X	X			X																					X										
DIN SPEC 91367			X	X	X	X	X			X	X		X					X	X	X					X	X											
OTM			X		X																				X		X										
IoT/IoE Sensors - TV Cam			X	X						X			X			X	X								X		X										
DATEX-II			X	X	X					X	X	X	X												X												
NTCIP			X	X								X													X												
UNI11248:2016			X	X							X																										
TOMP	X		X			X	X											X	X	X							X										
ETSI ITS			X	X				X		X											X	X															X
SENSORIS		X	X	X				X		X											X								X								
ExVe			X					X														X			X		X										
ODX			X					X														X			X												

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

- ***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.
- Community of Energy, planning energy plant

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

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

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

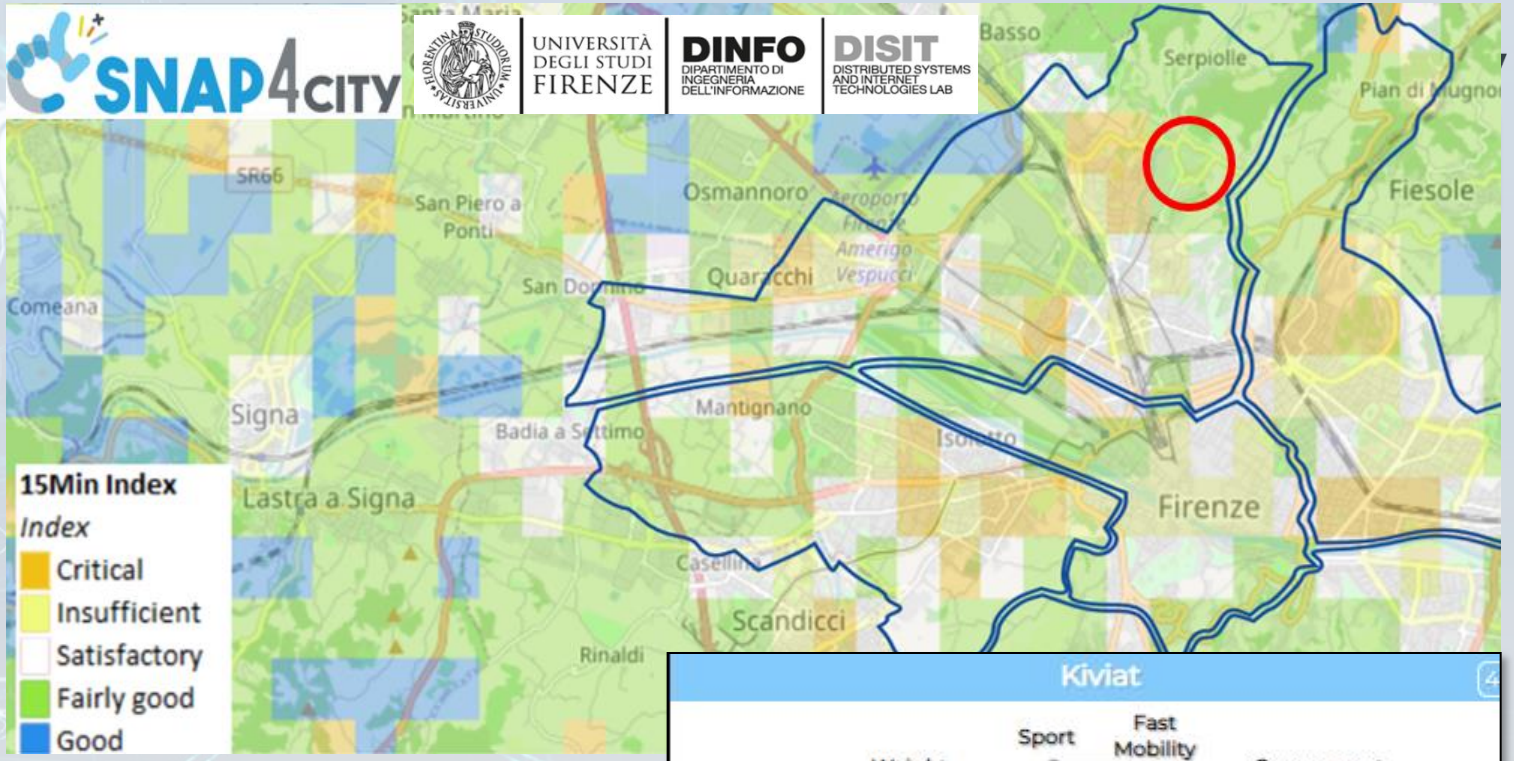
- Monitoring and Predicting: NO2, NOX, CO2, Traffic flow, pollutant, landslide, waste, etc.
- Traffic flow reconstruction
- Demand vs Offer of Mobility analysis

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

15MinCityIndex

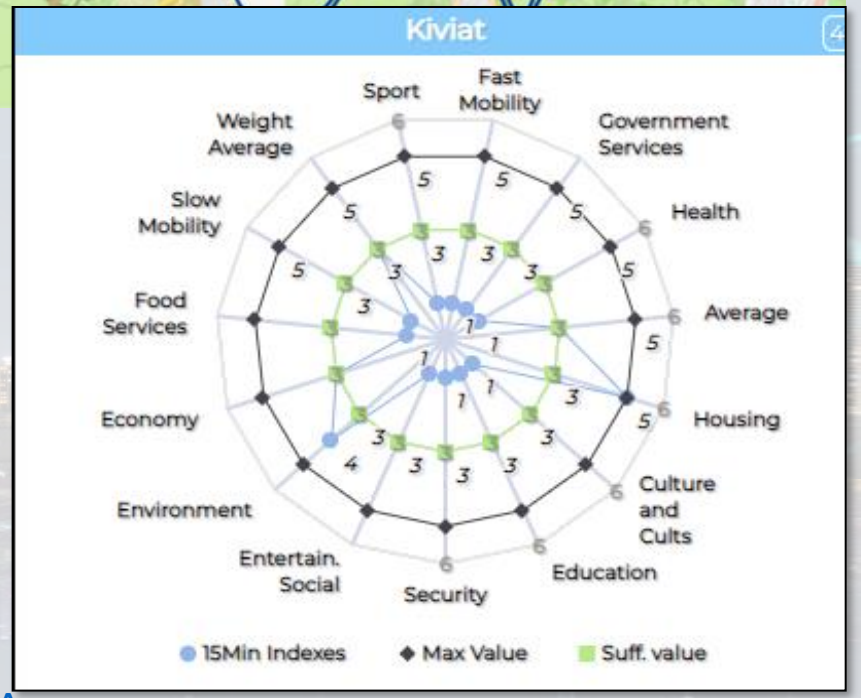
What would support my neighborhood to become a 15-Minute City?

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



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

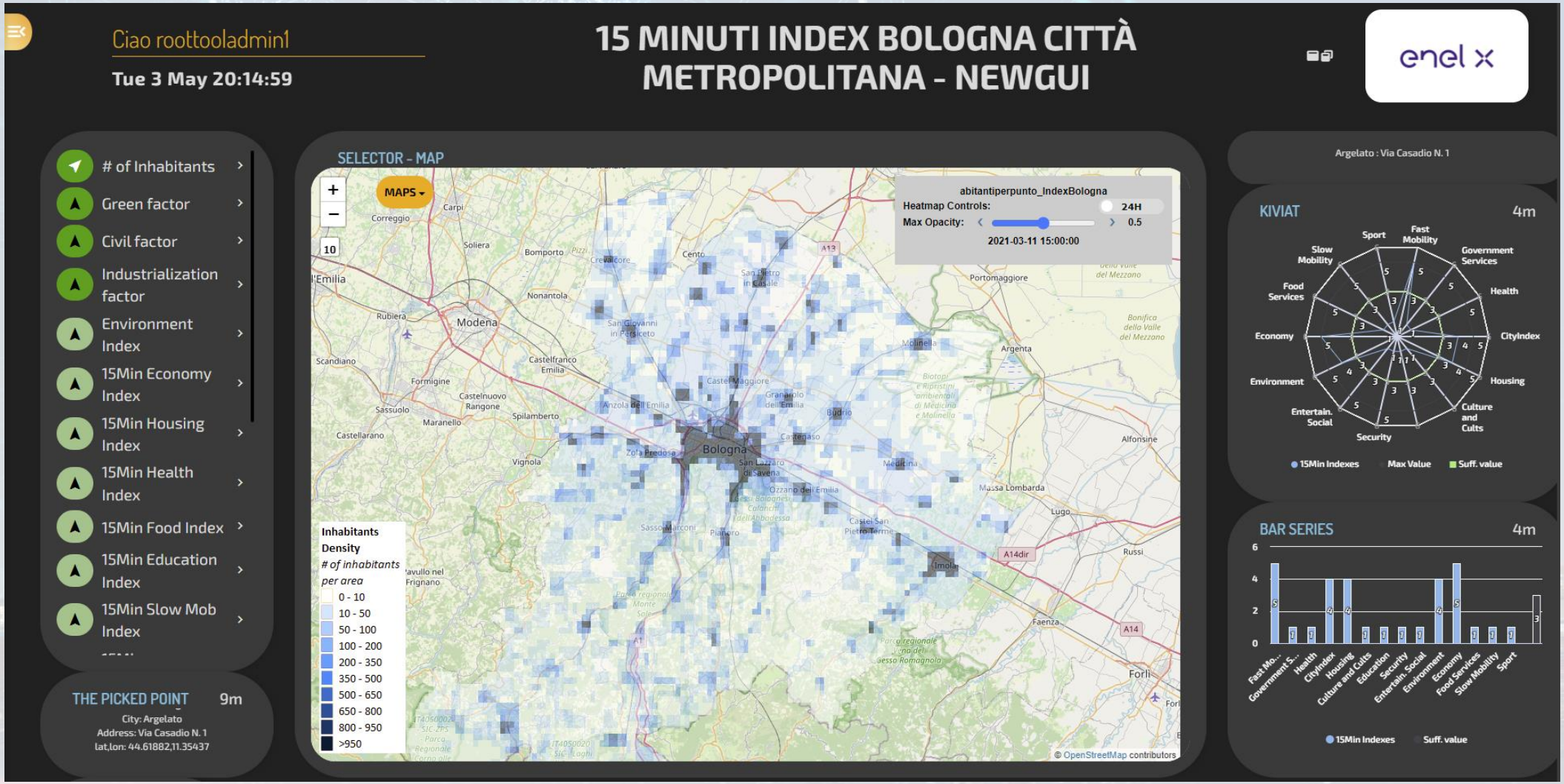
The tool supports the becoming of a 15-Minute city evaluating the service level in various domains.



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

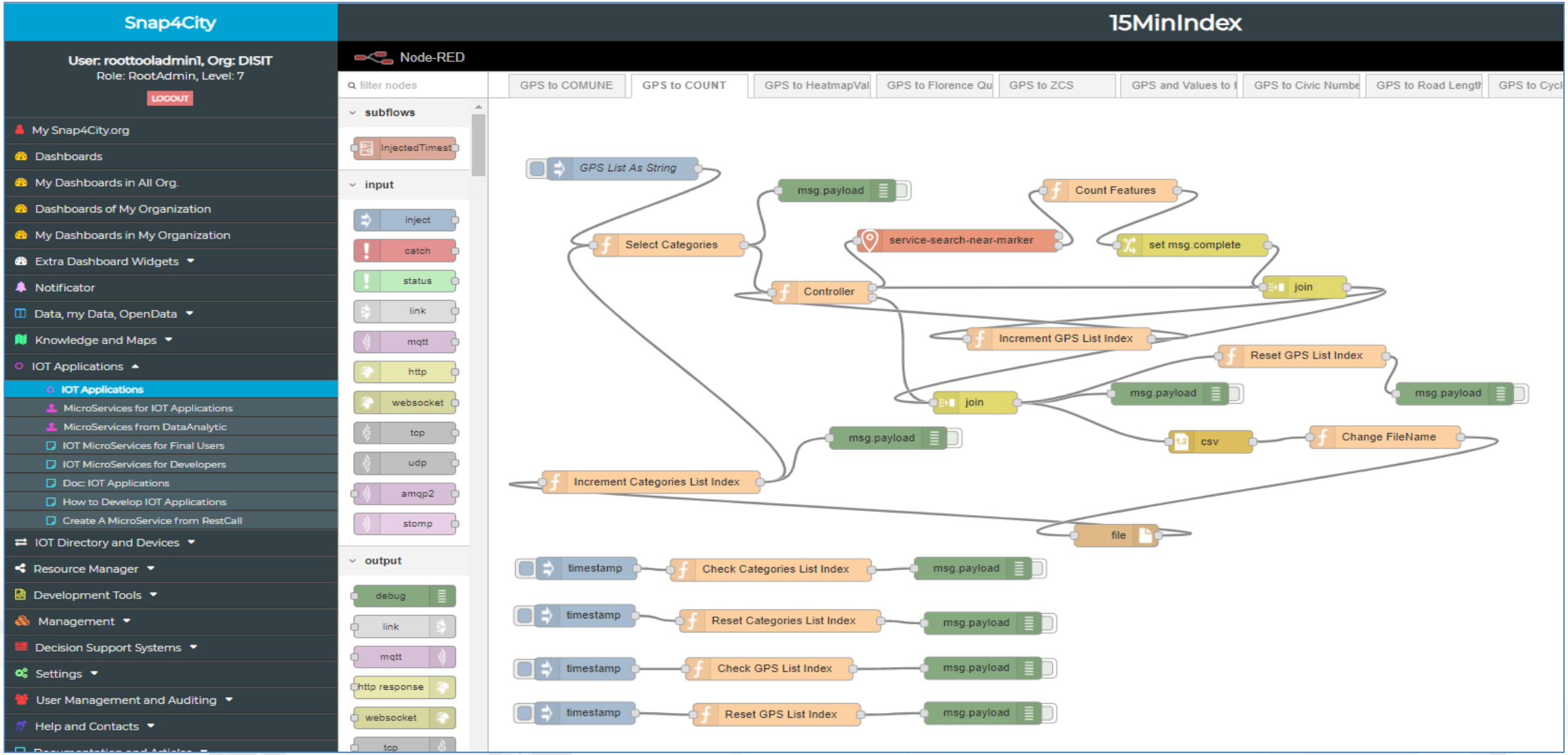
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjkzOA==

15MinCityIndex on Bologna



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

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

Smart City Control Room
Florence Metropolitan City

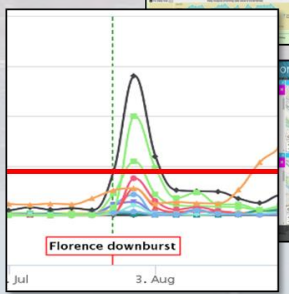
COMUNE DI FIRENZE

reference

SNAP4CITY

KM 4 CITY

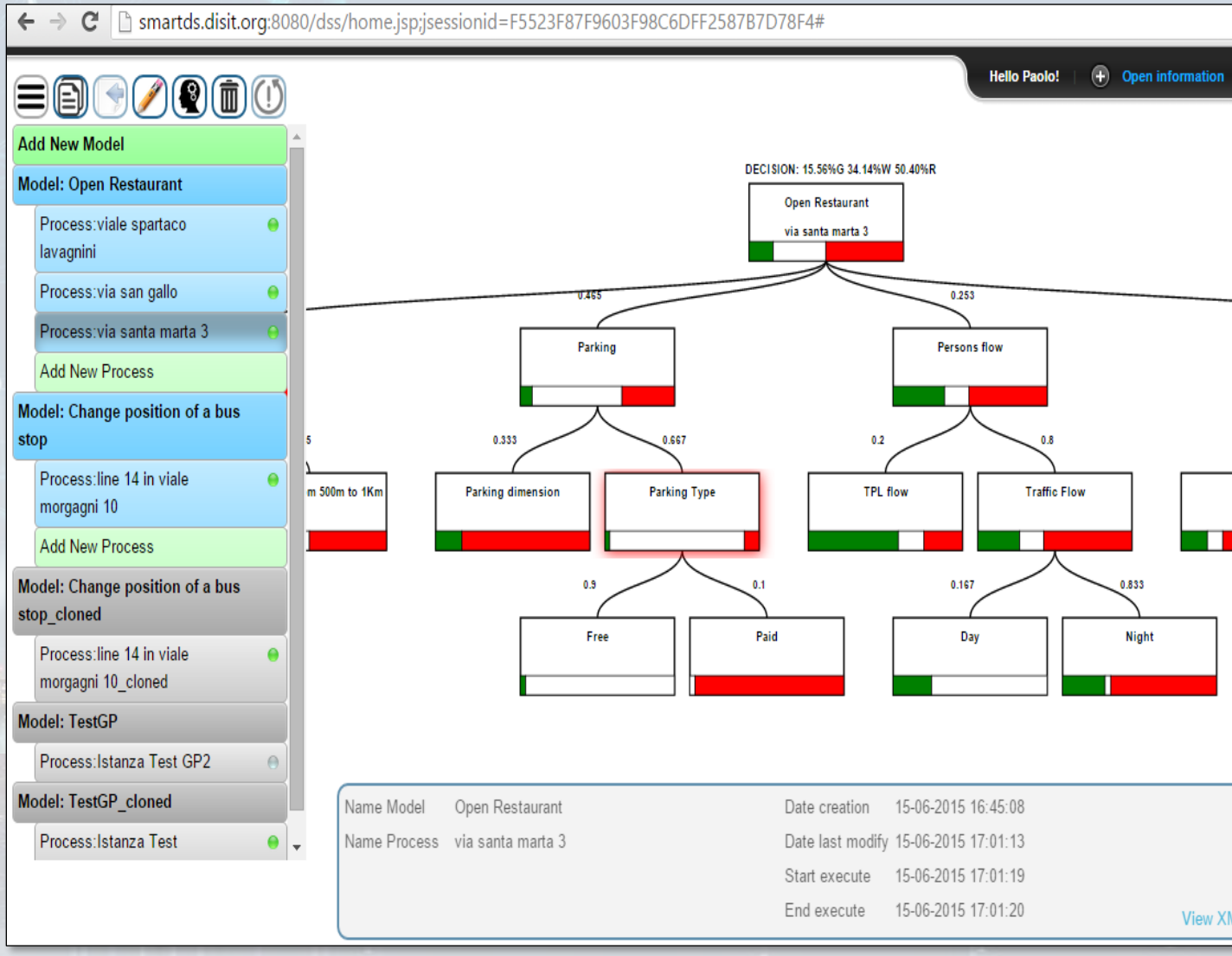
- **Multiple Domain Data**
  - Thousands of Open/Private data, POI, IOT, etc.
  - ***mobility and transport***: accidents, public transport, parking, traffic flow, Traffic Reconstruction, KPI, …
  - ***AND***: environment, civil protection, gov KPI, covid-19, social & social media, people flow, tourism,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



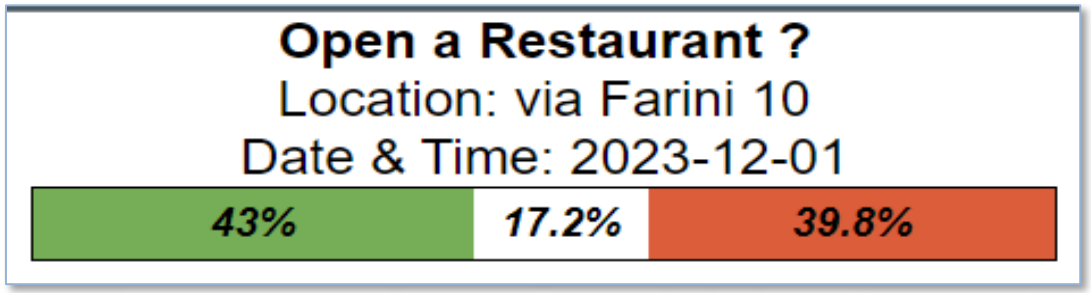
https://www.snap4city.org/747

Smart Decision Support , system thinking

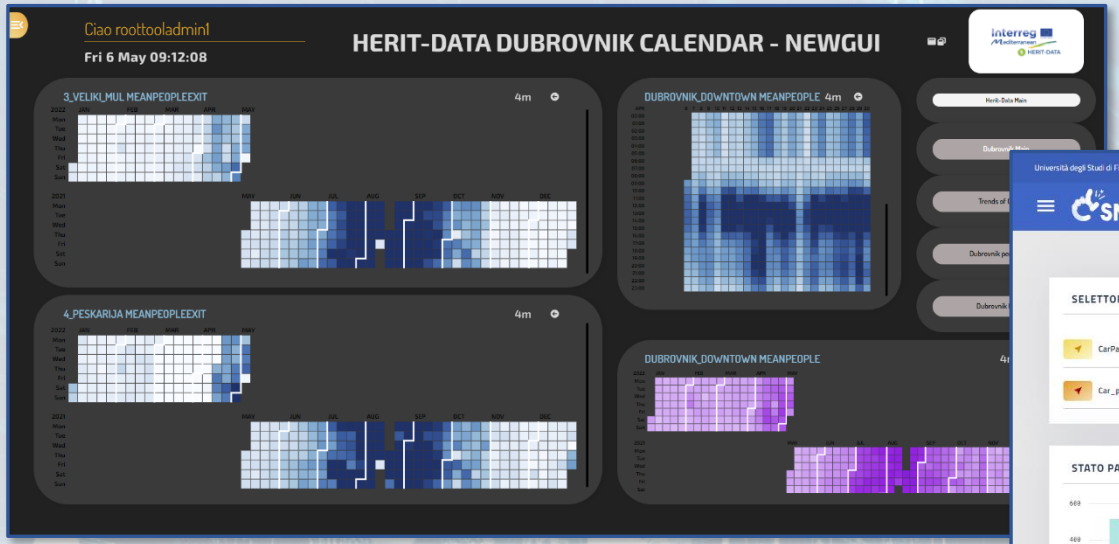
- **Smart Decision Support System** based on System Thinking plus
- Actions to city reaction, resilience, smartness, ...
- Enforcing Mathematical model for propagation of decision confidence..
- Collaborative work, …
- Processes connected to city data: DB, RDF Store, Twitter, etc.
- Production of alerts/alarms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

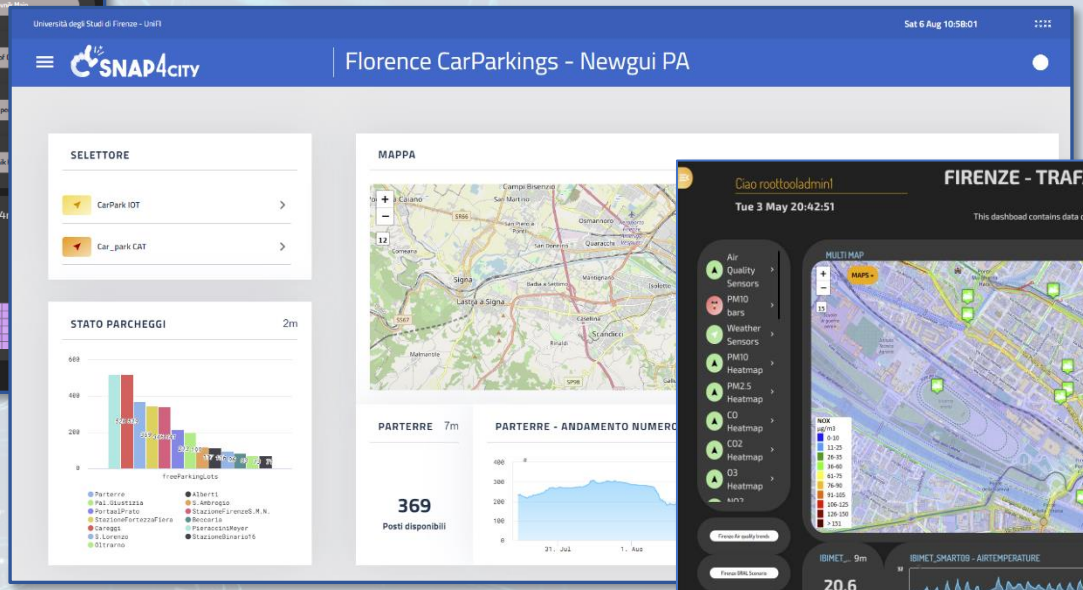


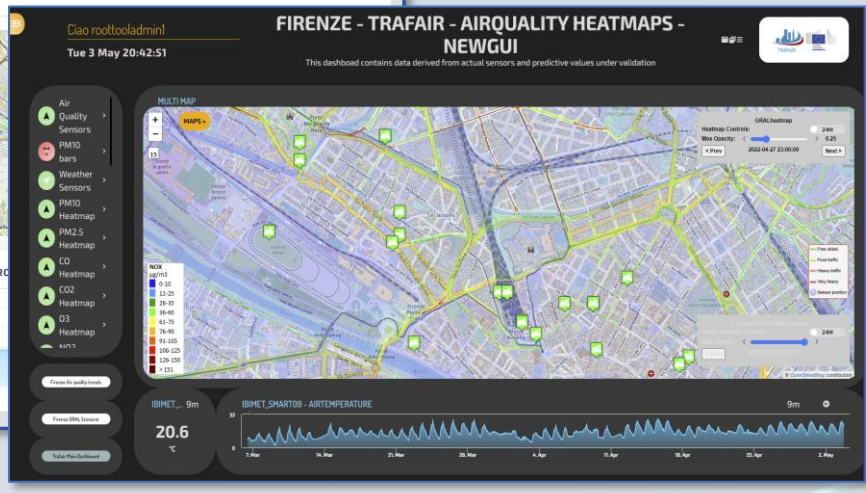
- Supports the definition of the **Decision Tree Model, DTM**, in terms of System Thinking, with Italian Flag and combinations
- Allows the **statistic composition** of subDecisions probabilities
- **Generating a DTM as an IoT App,**
- **IoT Apps with DTM can**
  - **be customized**
  - **compute root 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

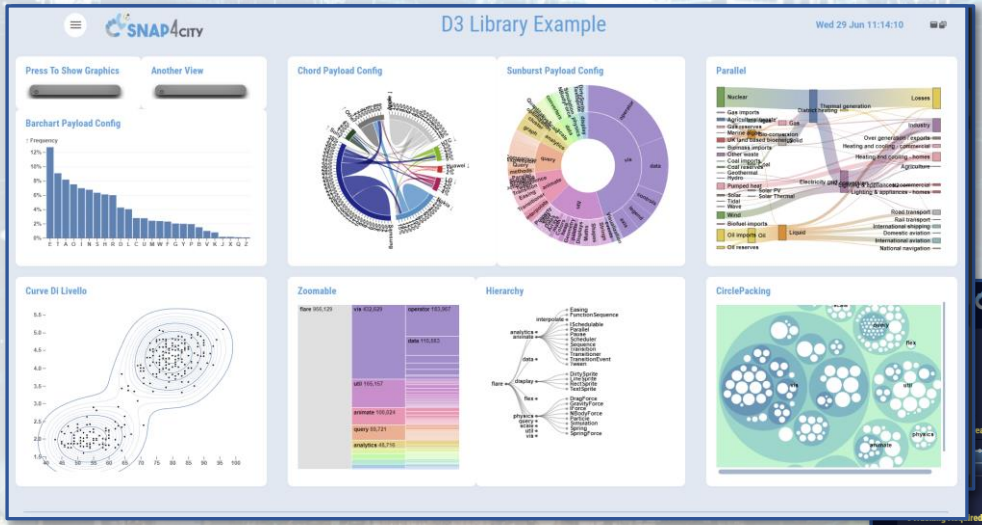


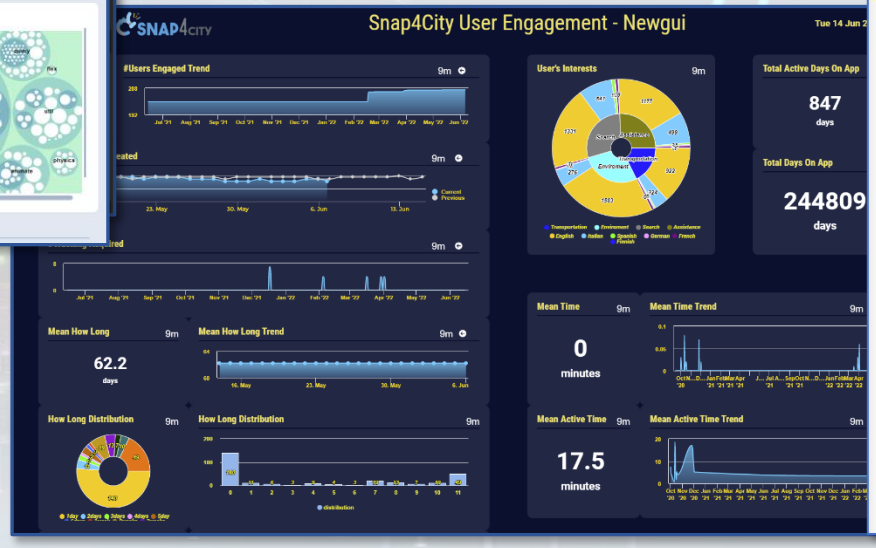
Different Themes

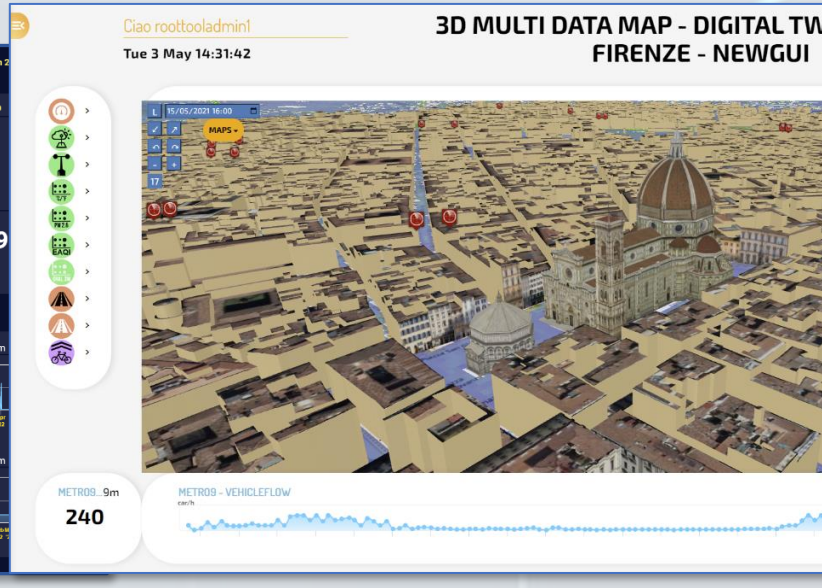








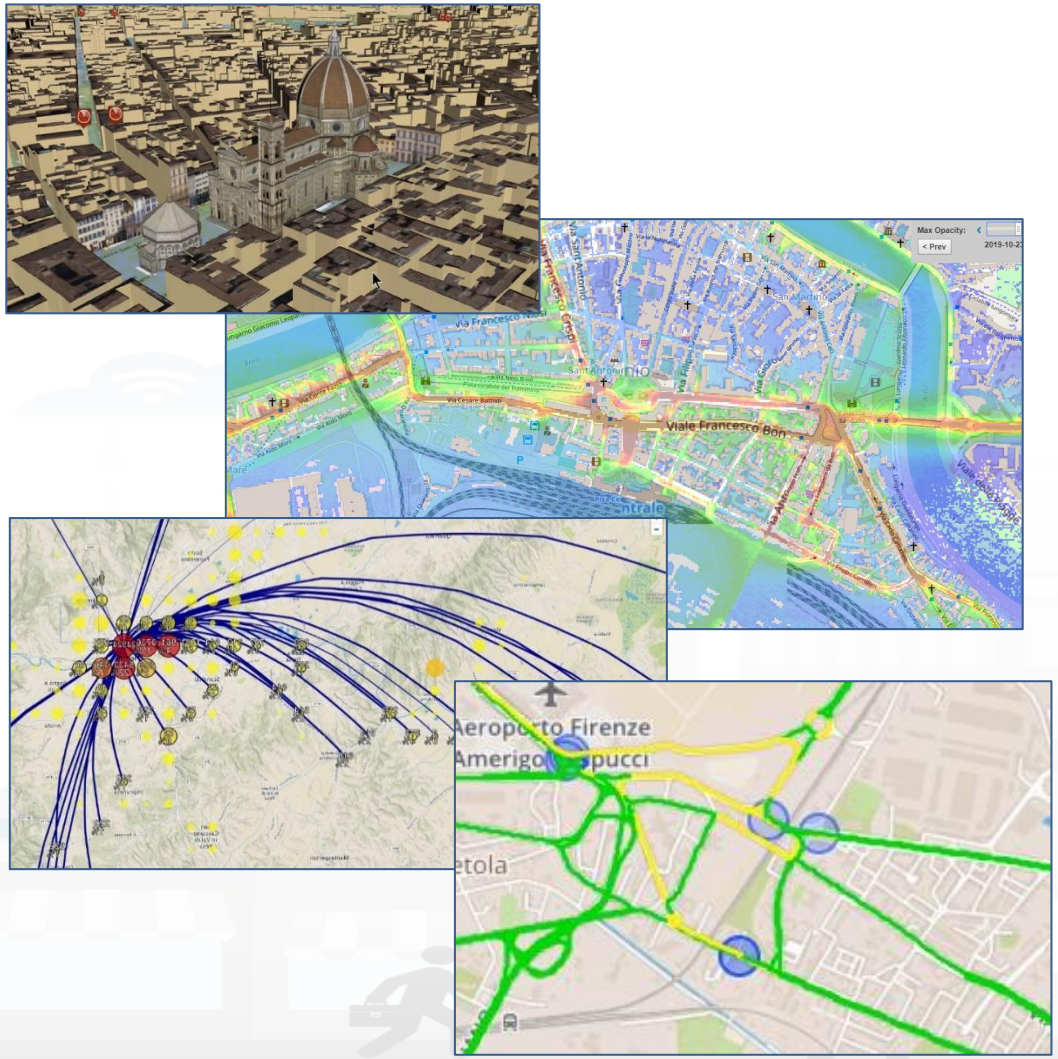




New styles/themes can be developed by specializing a few files from open source

https://www.snap4city.org/793

Smart City Digital Twin



City Digital Model with…

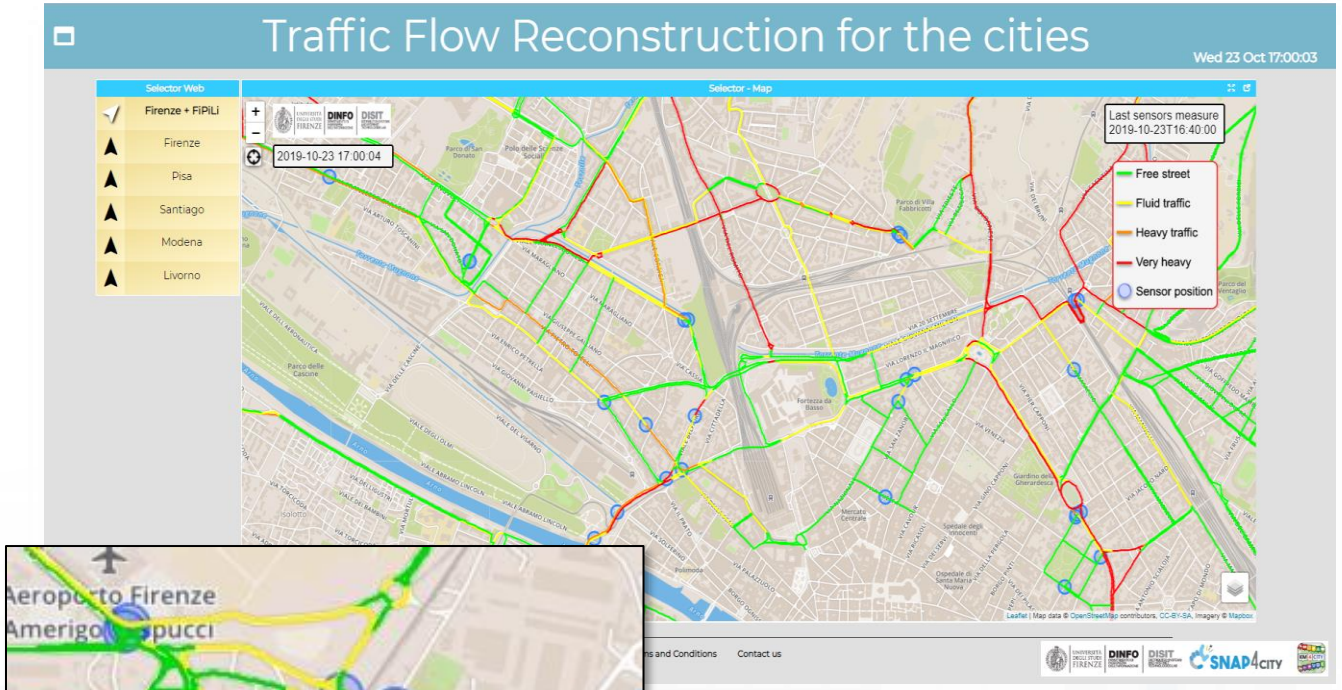
- Intuitive platform
- Any Data TYPE, any data source, any protocol
- Data storage seamless
- Data analytics → artificial intelligence, AI/XAI
- Data Ethics, AI Ethics, GDPR
- Interactive Data Representation, any kind
- Key Performance Indicators, any kind
- What-IF analysis – Simulation, prediction,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

Complex and heterogeneous information, interoperability

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

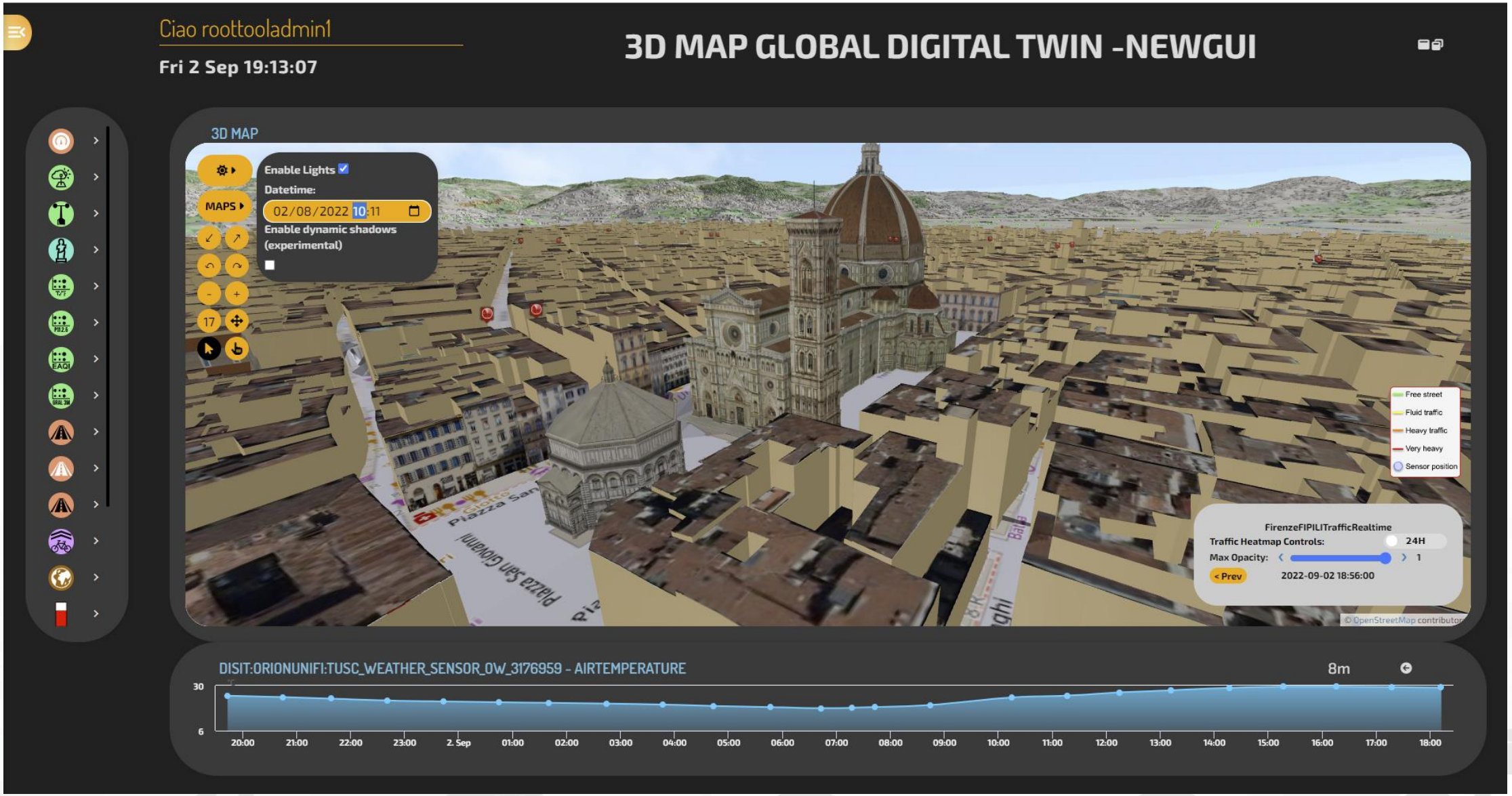
Why Dense Traffic Flow Reconstruction ?

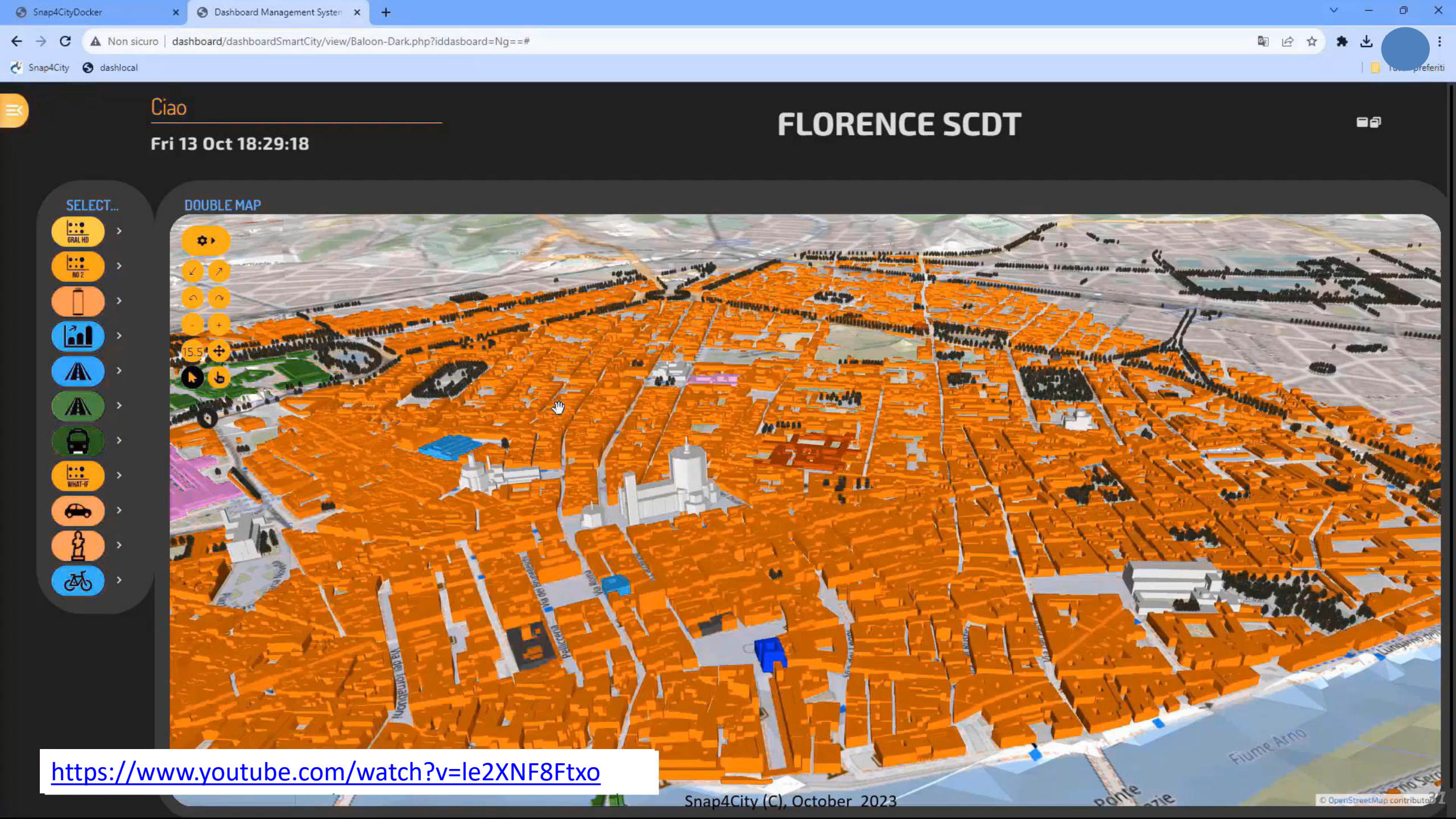
- Making decision on mobility and transport solutions → what if analysis
- Controlling pollution
- Dynamic Routing for Firebrigade, Ambulances, general public
- Planning Public Transportation routing



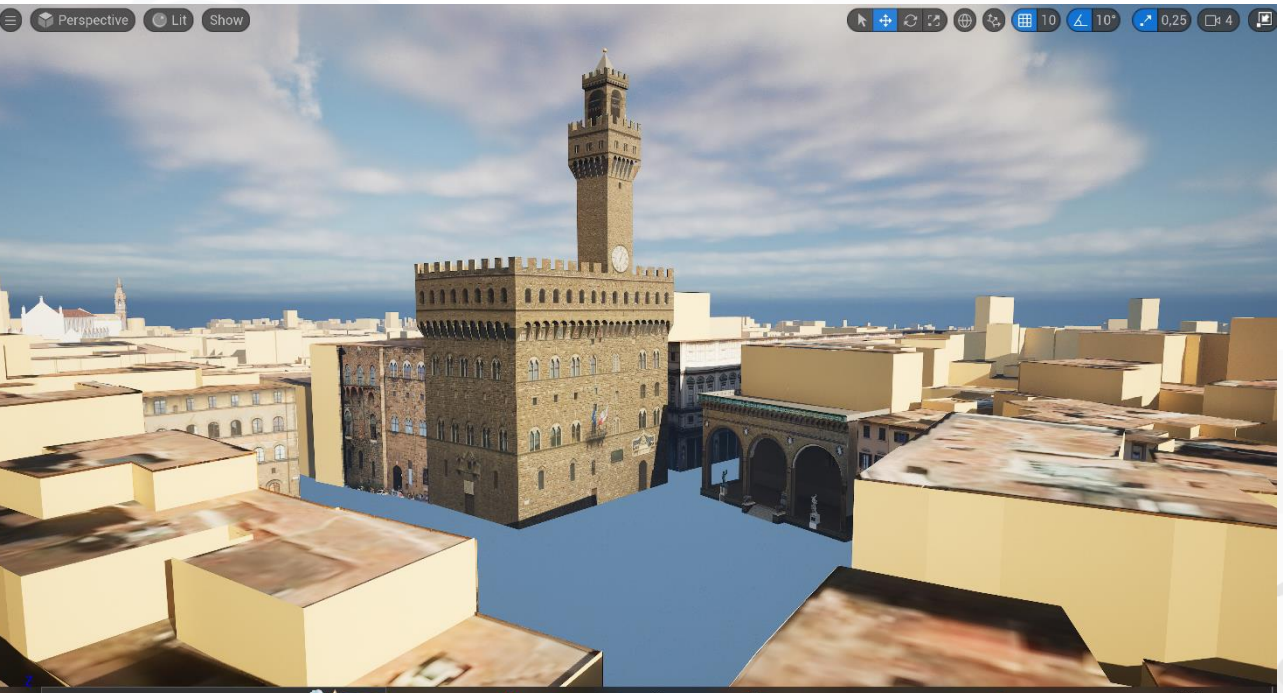
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc5NQ==

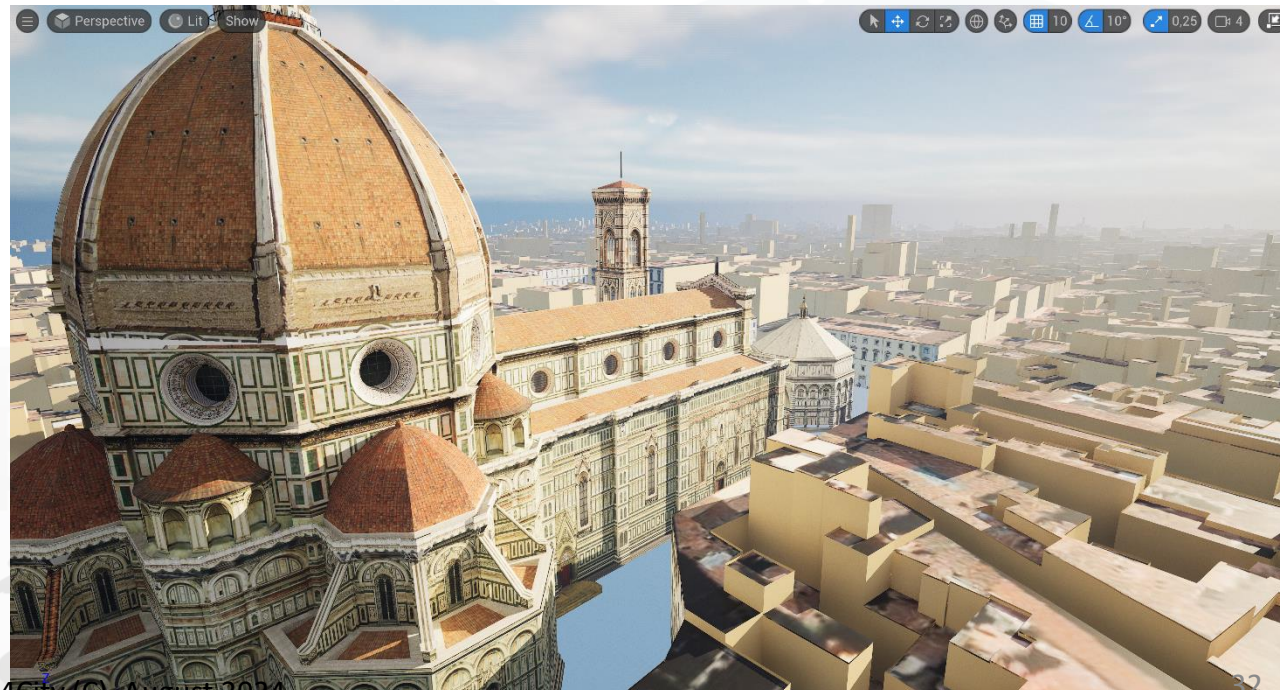
3D Digital Twin




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
© OpenStreetMap contributors
https://www.youtube.com/watch?v=le2XNF8Ftxo
Snap4City (C), October 2023
31

OCULUS


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


Perspective
Lit
Show

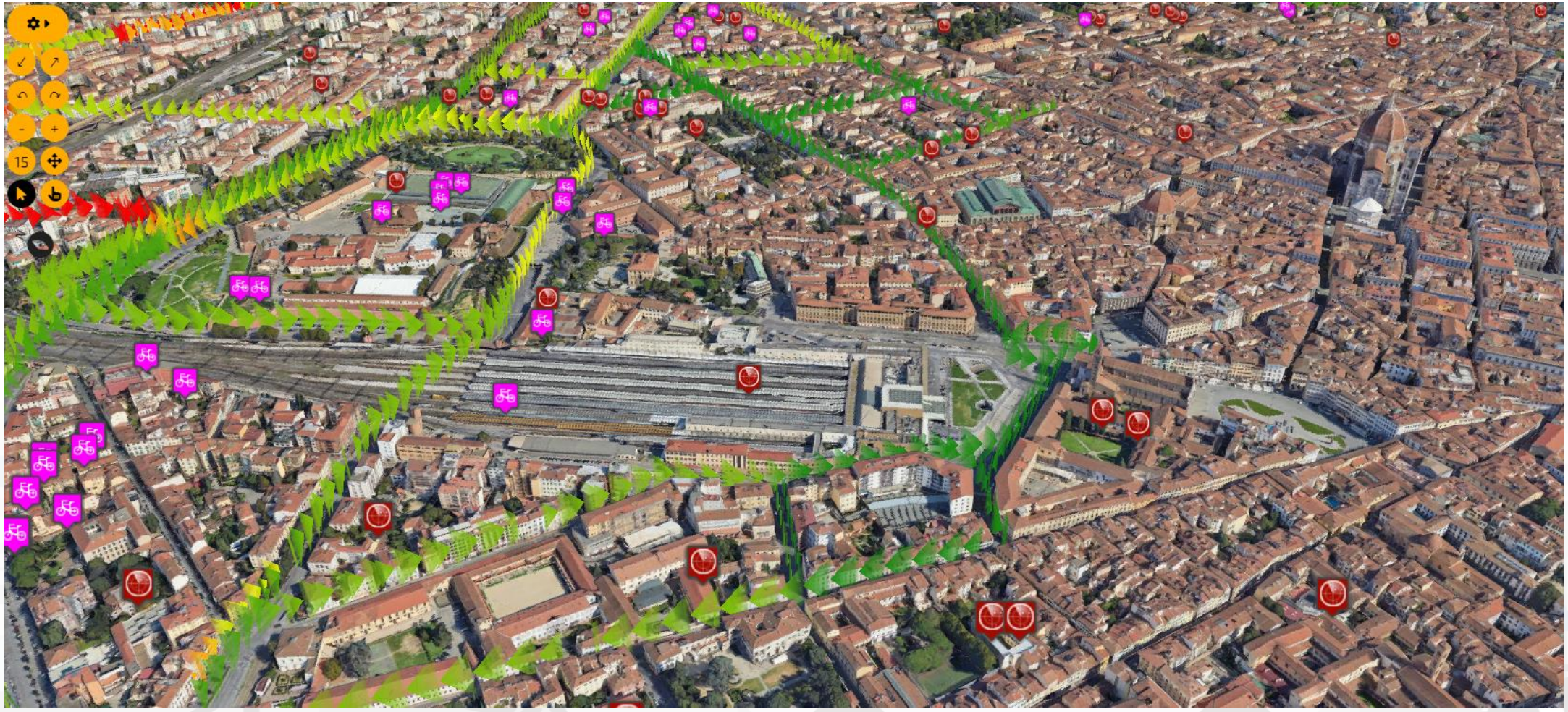
OCULUS

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

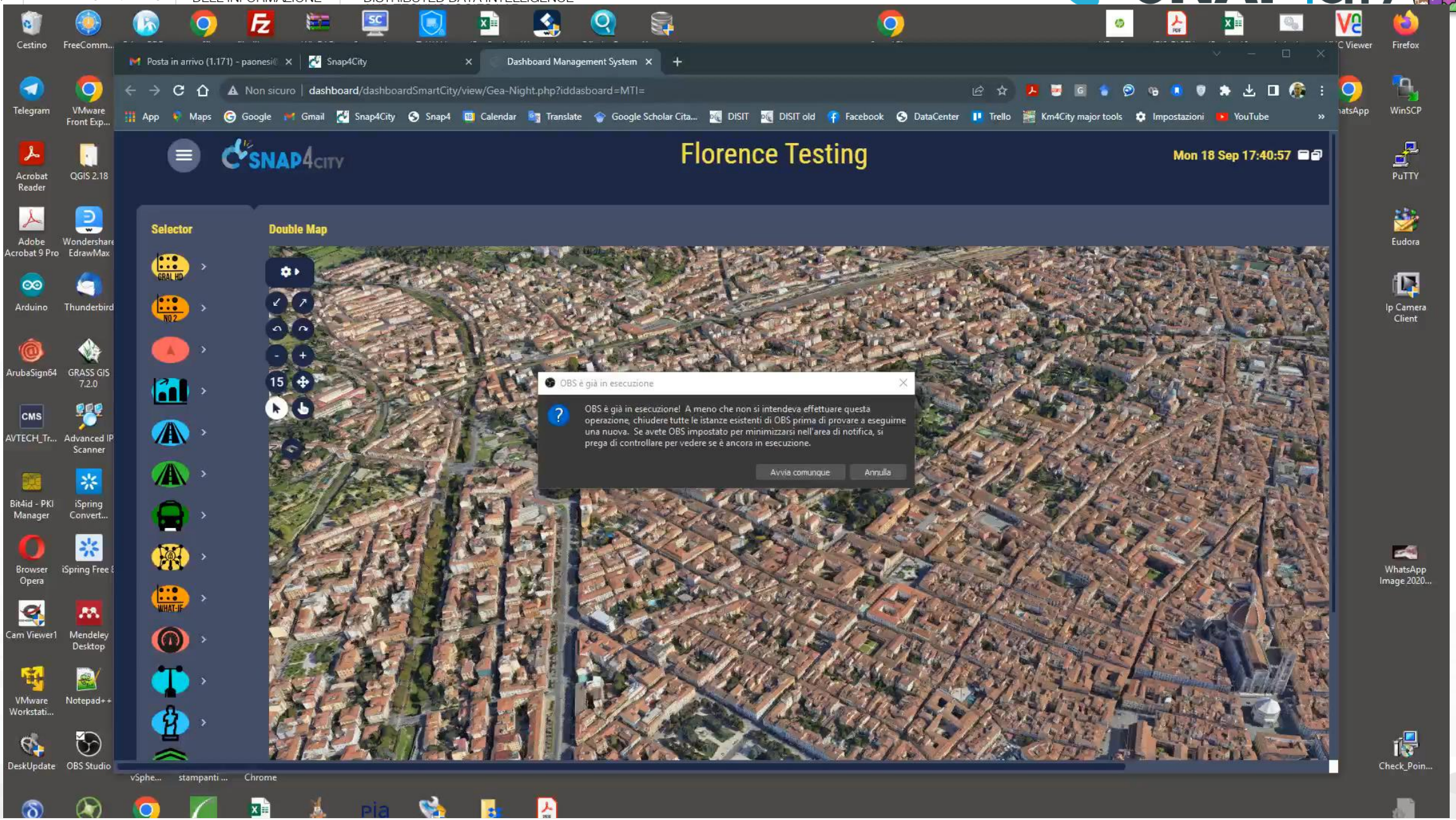
Exploiting Google API with Snap4City engine

- 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


Posta in arrivo (1.171) - paonesi@
Snap4City
Dashboard Management System
Non sicuro | dashboard/dashboardSmartCity/view/Gea-Night.php?iddasboard=MTI=
App Maps Google Gmail Snap4City Snap4 Calendar Translate Google Scholar Cita... DISIT DISIT old Facebook DataCenter Trello Km4City major tools Impostazioni YouTube
SNAP4CITY
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
Cestino
FreeComm...
Telegram
VMware Front Exp...
Acrobat Reader
QGIS 2.18
Adobe Acrobat 9 Pro
Wondershare EdrawMax
Arduino
Thunderbird
ArubaSign64
GRASS GIS 7.2.0
AVTECH_Tr...
Advanced IP Scanner
Bit4id - PKI Manager
iSpring Convert...
Browser Opera
iSpring Free
Cam Viewer1
Mendeley Desktop
VMware Workstati...
Notepad++
DeskUpdate
OBS Studio
Firefox
WinSCP
PuTTY
Eudora
Ip Camera Client
WhatsApp Image 2020...
Check_Poin...
vSphe...
stampanti ...
Chrome

UNIVERSITÀ DEGLI STUDI FIRENZE

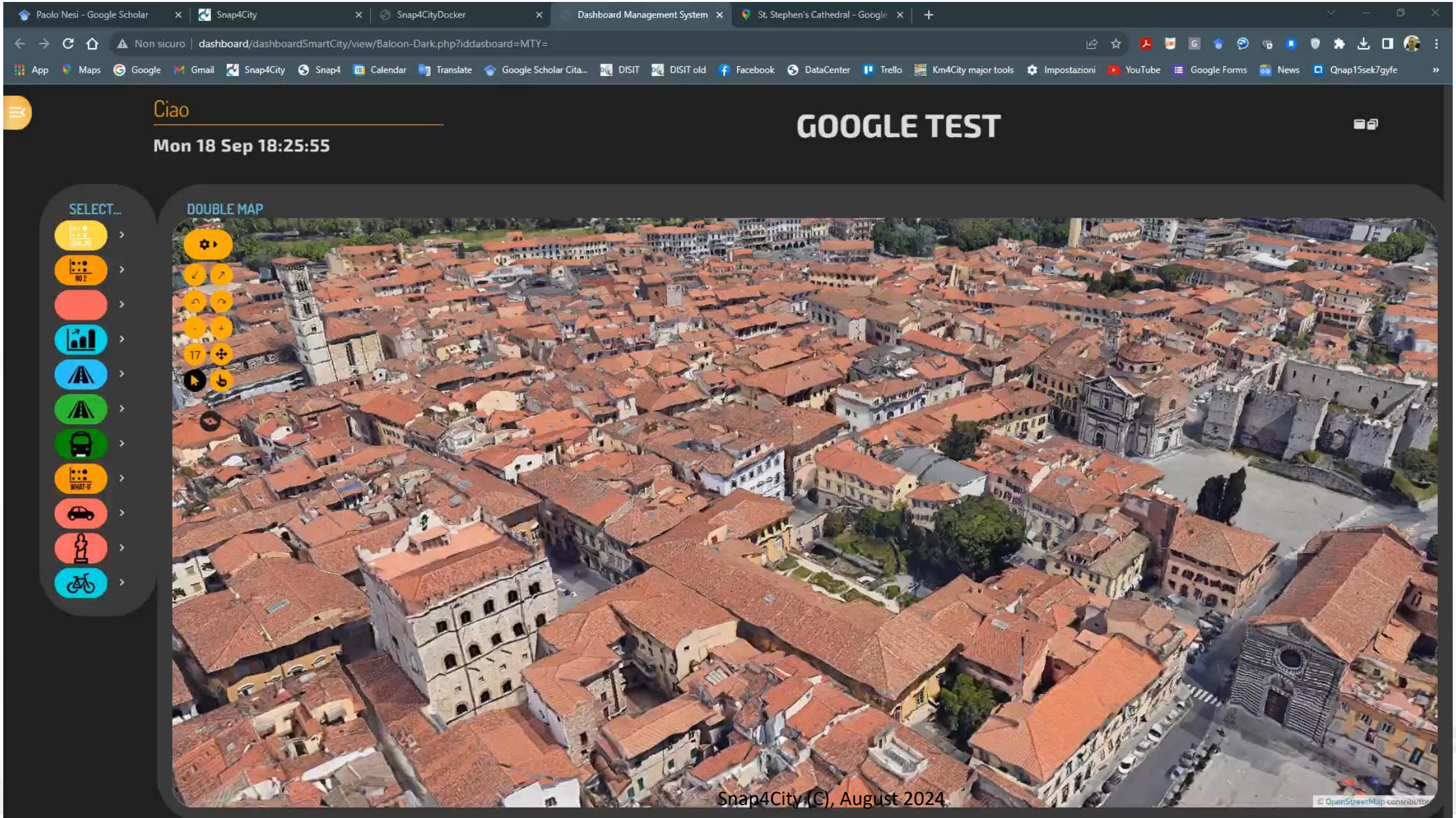
DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

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

Prato

SNAP4CITY

KM4CITY



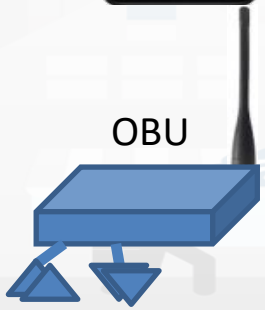
MyKPI: Tracking of Devices and Mobiles

- Real Time Trajectories for
  - Mobile Phone
  - Moving IOT Devices
  - OBU, Vehicular Kits
  - Multiple tracks
  - Day by day
- Micro Application

Mobile
PAX Counter

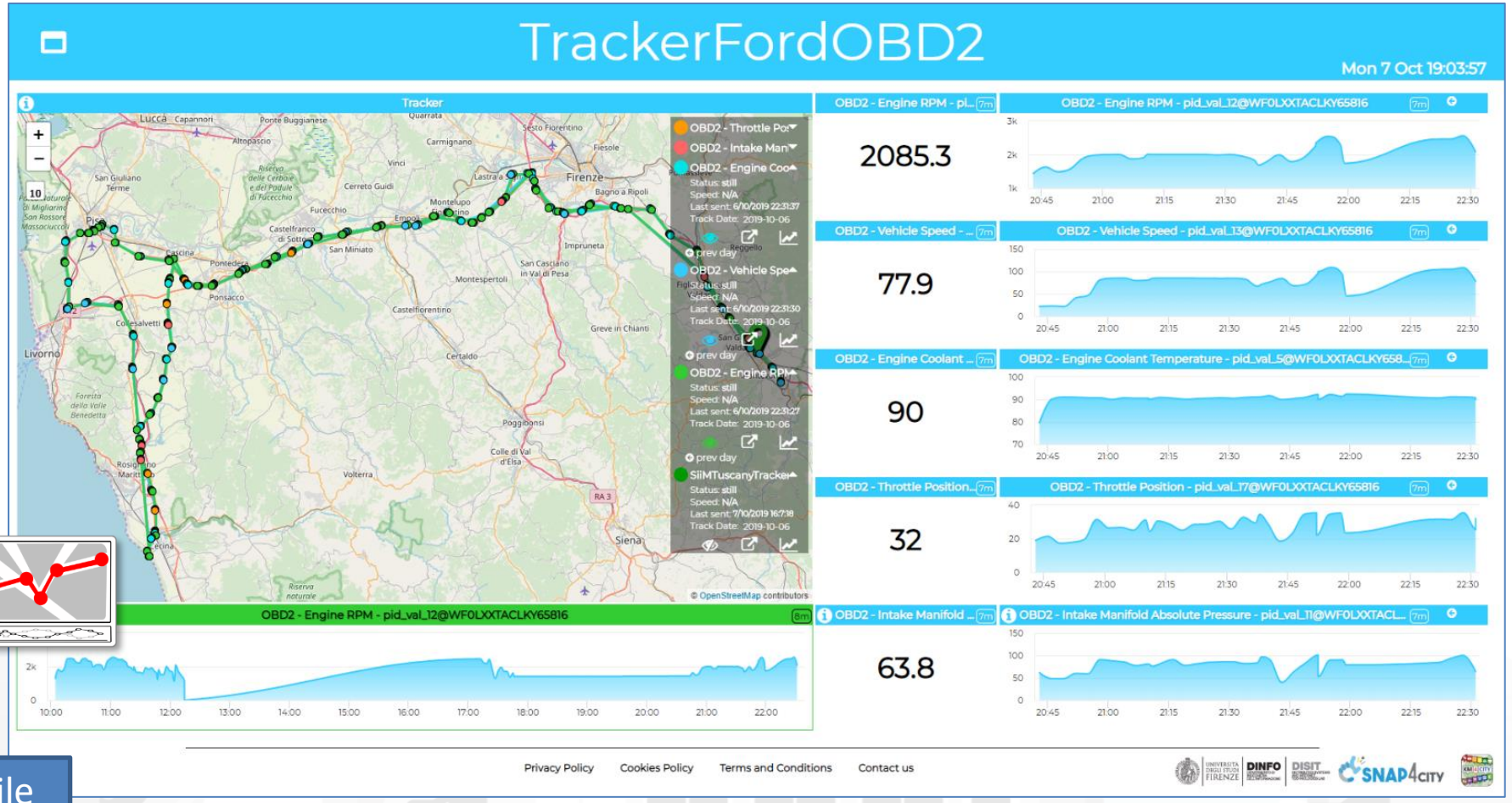
Apps

OBD2

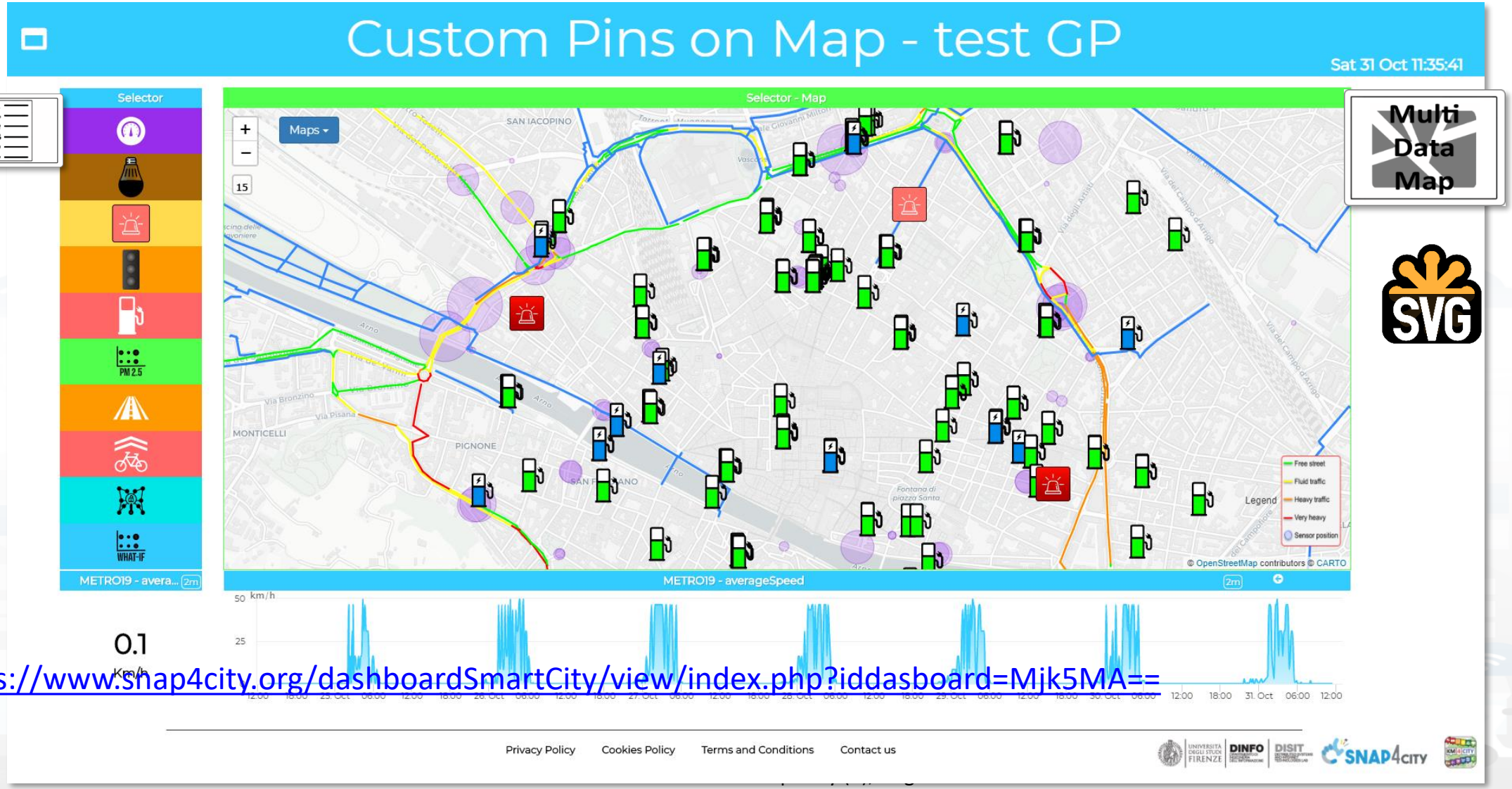


OBU

Mobile sensors

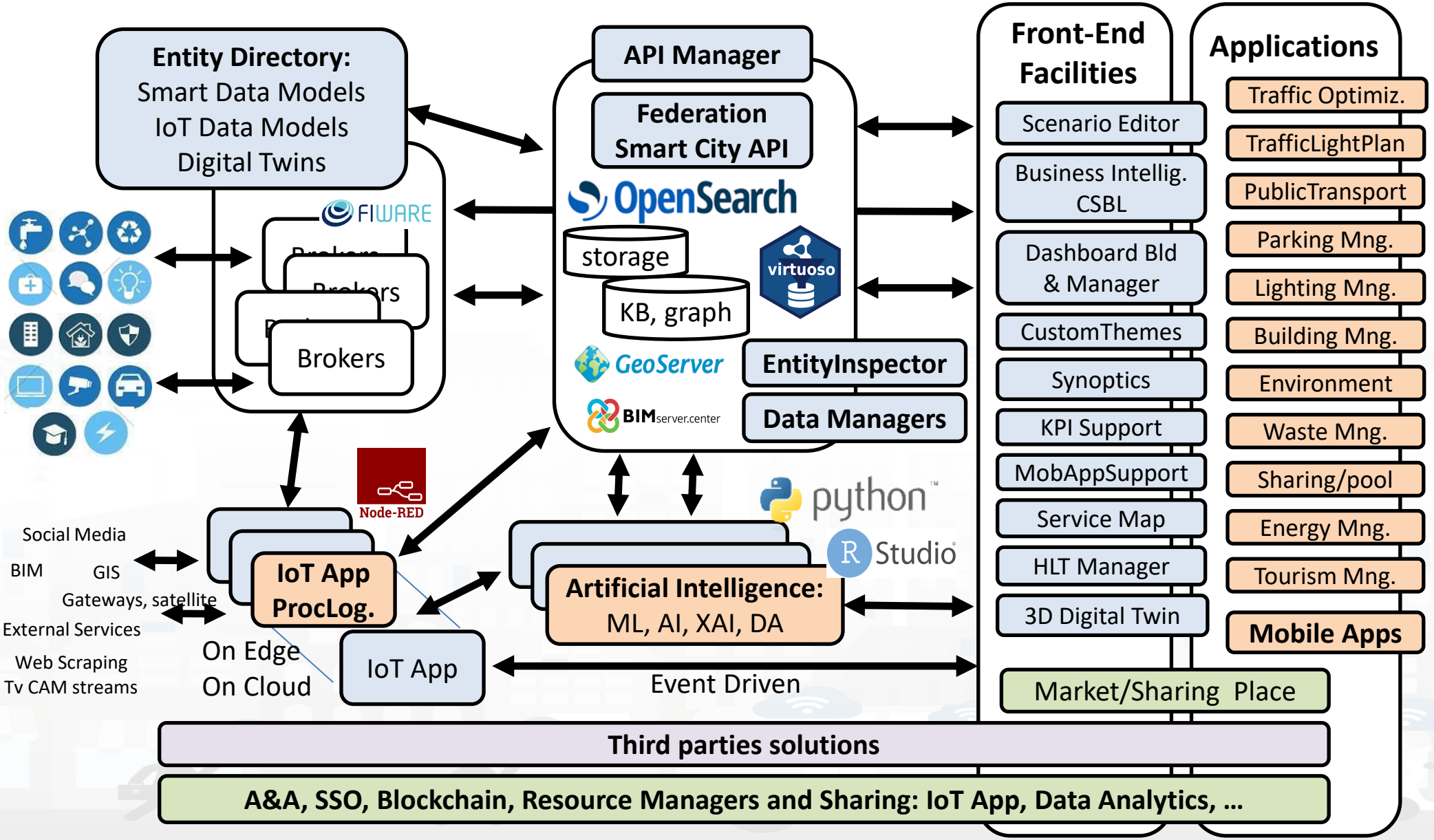


Custom Dynamic Pins



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=Mjk5MA==

Tech Arch


Entity Directory:
Smart Data Models
IoT Data Models
Digital Twins
FIWARE
Brokers
Brokers
Brokers
API Manager
Federation
Smart City API
OpenSearch
storage
KB, graph
virtuoso
GeoServer
BIMserver.center
EntityInspector
Data Managers
Node-RED
python
R Studio
Social Media
BIM
GIS
Gateways, satellite
External Services
Web Scraping
Tv CAM streams
IoT App
ProcLog.
On Edge
On Cloud
IoT App
Artificial Intelligence:
ML, AI, XAI, DA
Event Driven
Front-End
Facilities
Scenario Editor
Business Intellig.
CSBL
Dashboard Bld
& Manager
CustomThemes
Synoptics
KPI Support
MobAppSupport
Service Map
HLT Manager
3D Digital Twin
Applications
Traffic Optimiz.
TrafficLightPlan
PublicTransport
Parking Mng.
Lighting Mng.
Building Mng.
Environment
Waste Mng.
Sharing/pool
Energy Mng.
Tourism Mng.
Mobile Apps
Market/Sharing Place
Third parties solutions
A&A, SSO, Blockchain, Resource Managers and Sharing: IoT App, Data Analytics, …

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

City

Monitoring

KPI

Digital Twin Models & Data

Predictions, Anomaly Detection, Analysis, Assessment Warning

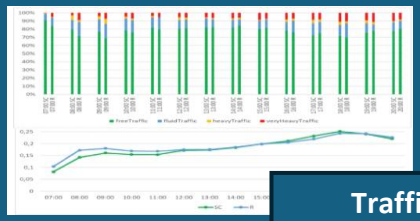
Decision Support System

Scenarious

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

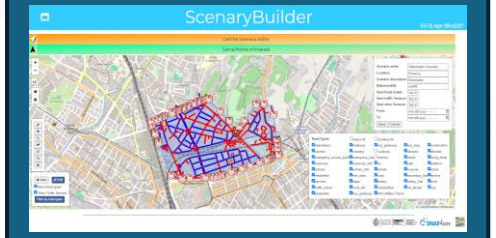
What-If Analysis, Optimization

KPI, Predictions, ...



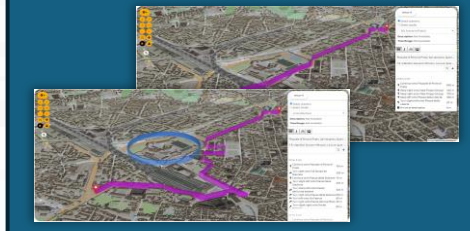
Traffic Reconstruction

Scenario Editor

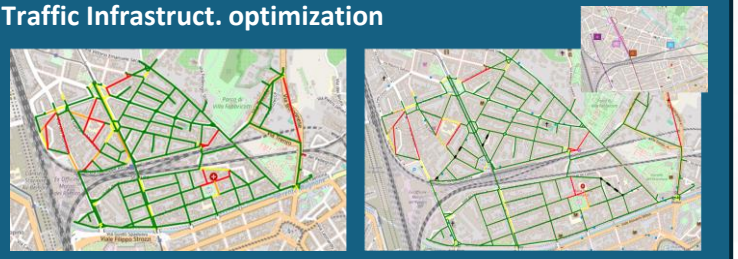


Traffic Light Plan optimization

Routing / Dynamic Routing



Traffic Infrastruct. optimization



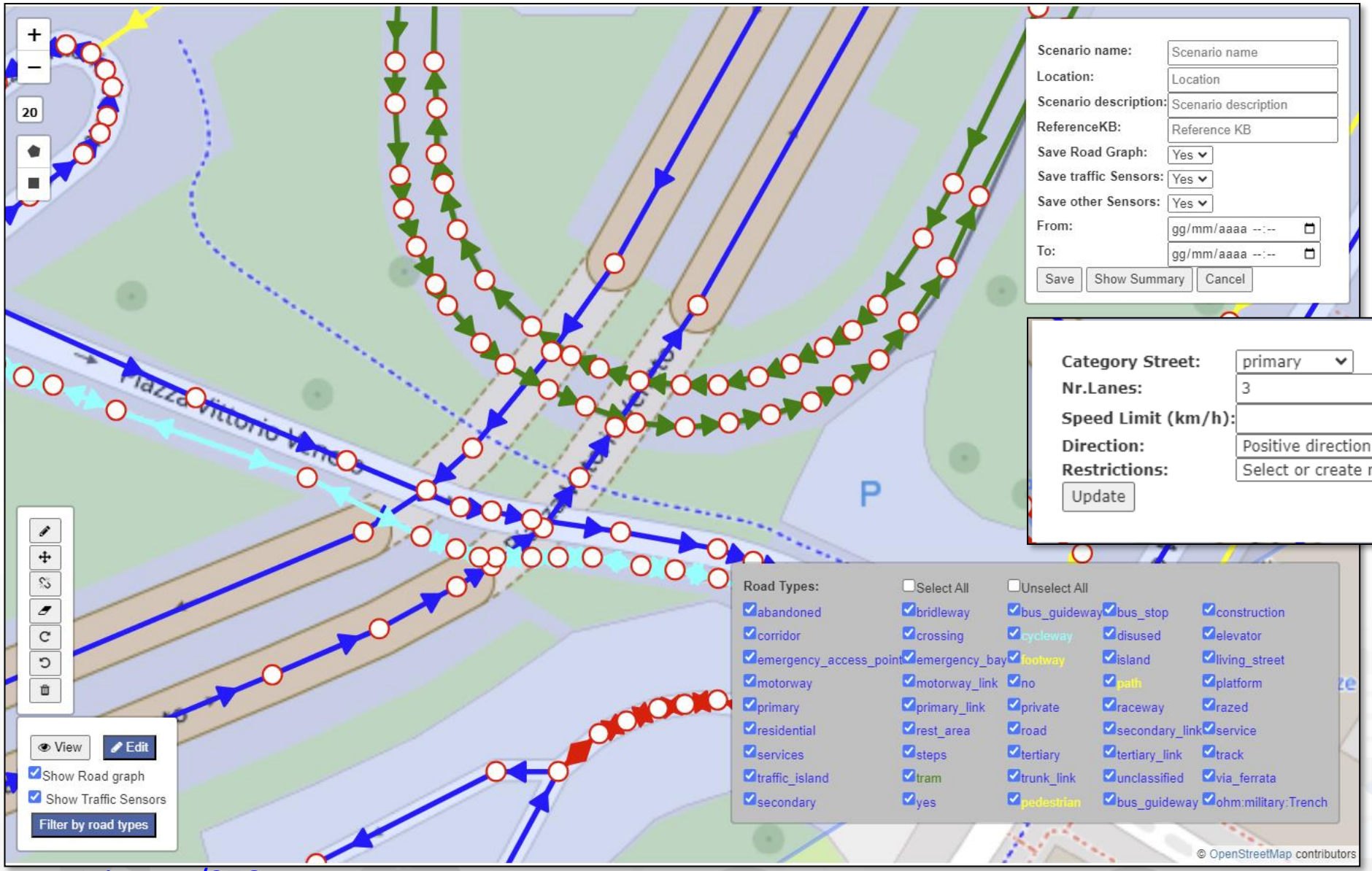
Scenario Editor

Select map

Zoom

New Scenario

Editing
Drag & drop
Split & Join
Delete
Do and Undo



Edit Road Segment

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

Properties of Road Elements

https://www.snap4city.org/976

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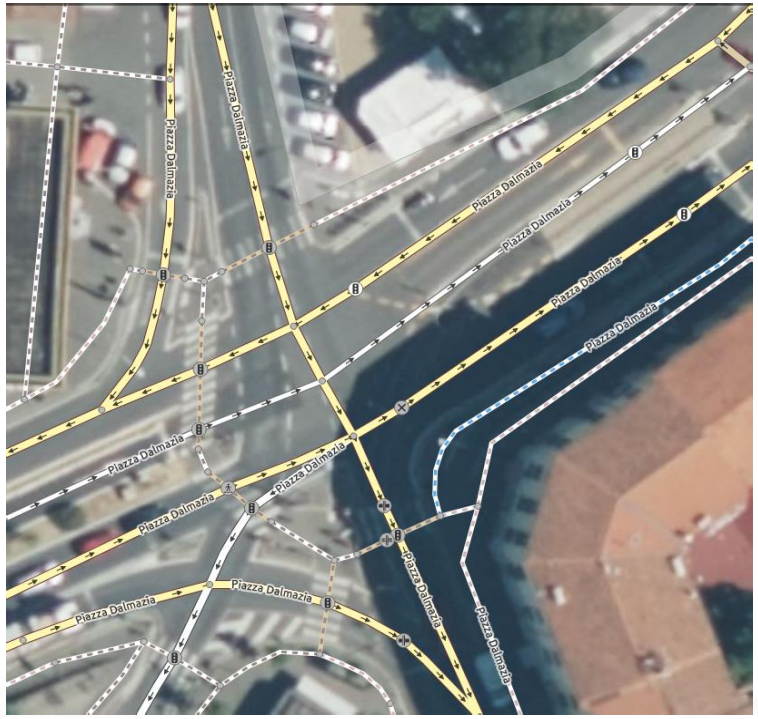
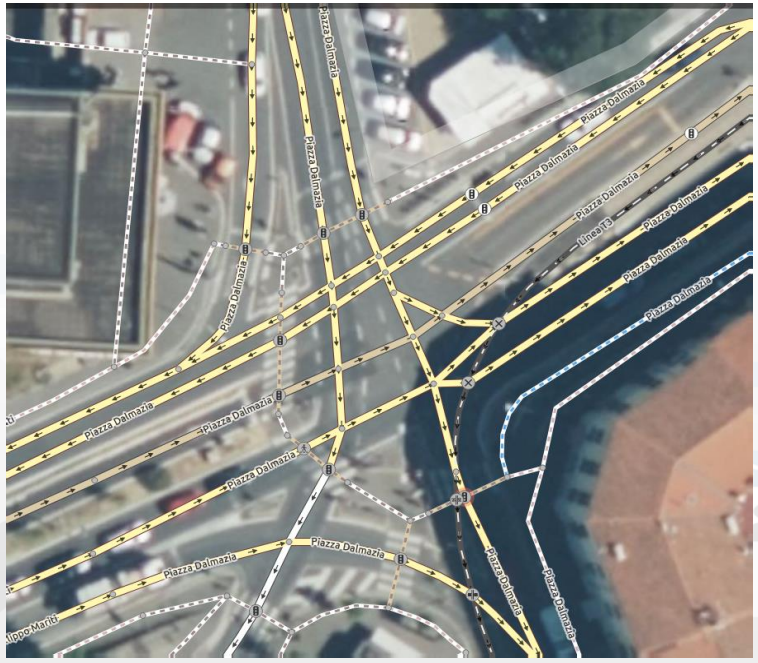
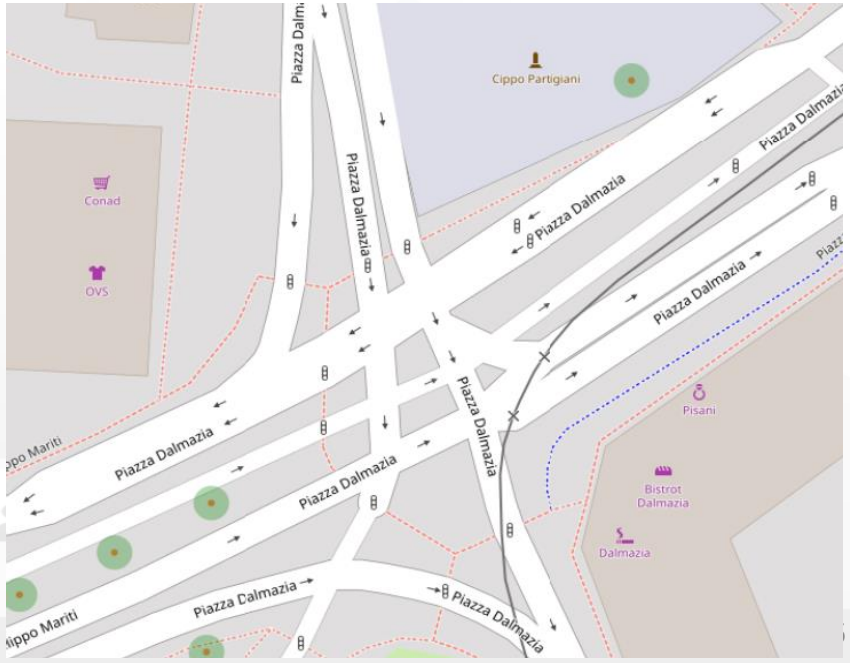
OSM data with non correct viability in Piazza Dalmazia, Firenze

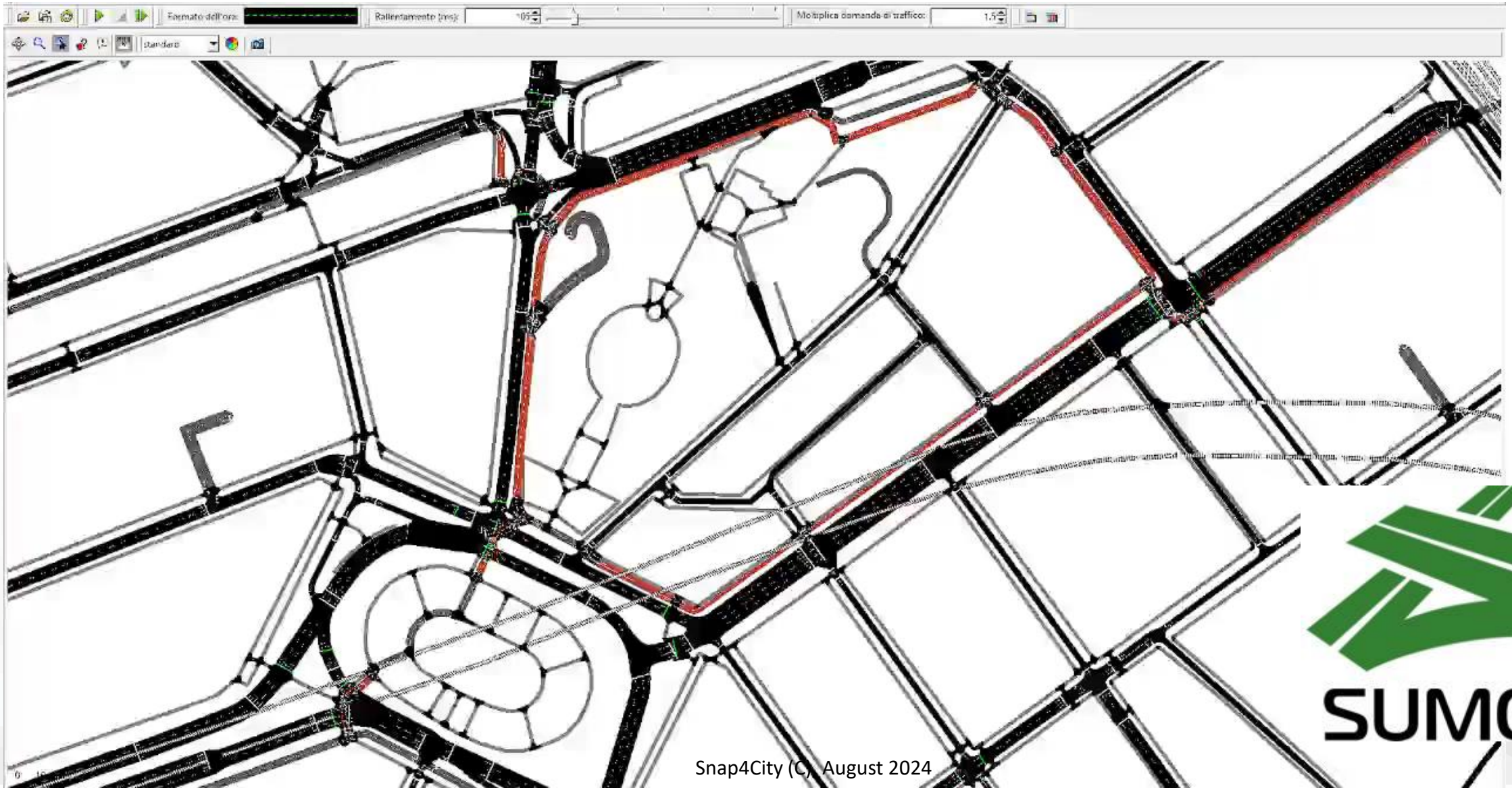


After Correction of OSM data defining a correct viability of Piazza Dalmazia, Florence. Regeneration of the TILEs for the maps





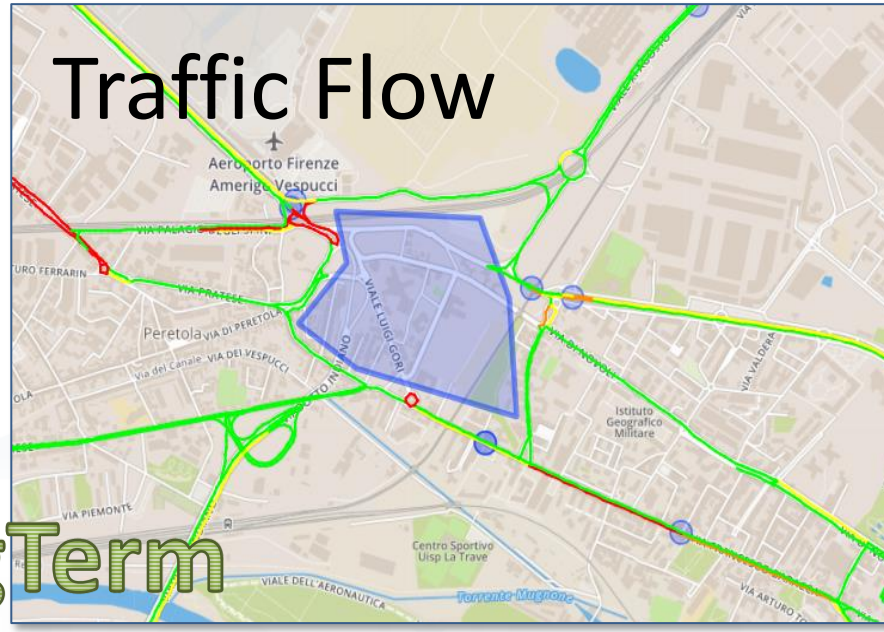
Micro Simulation

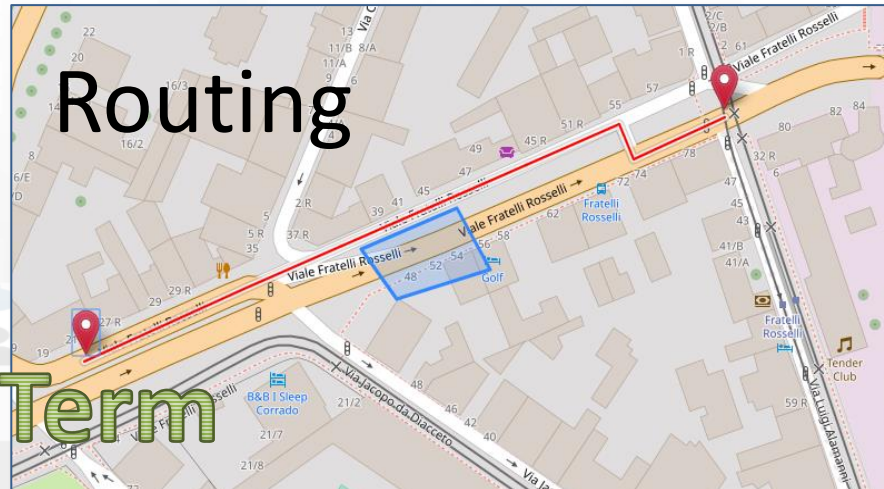


SUMO

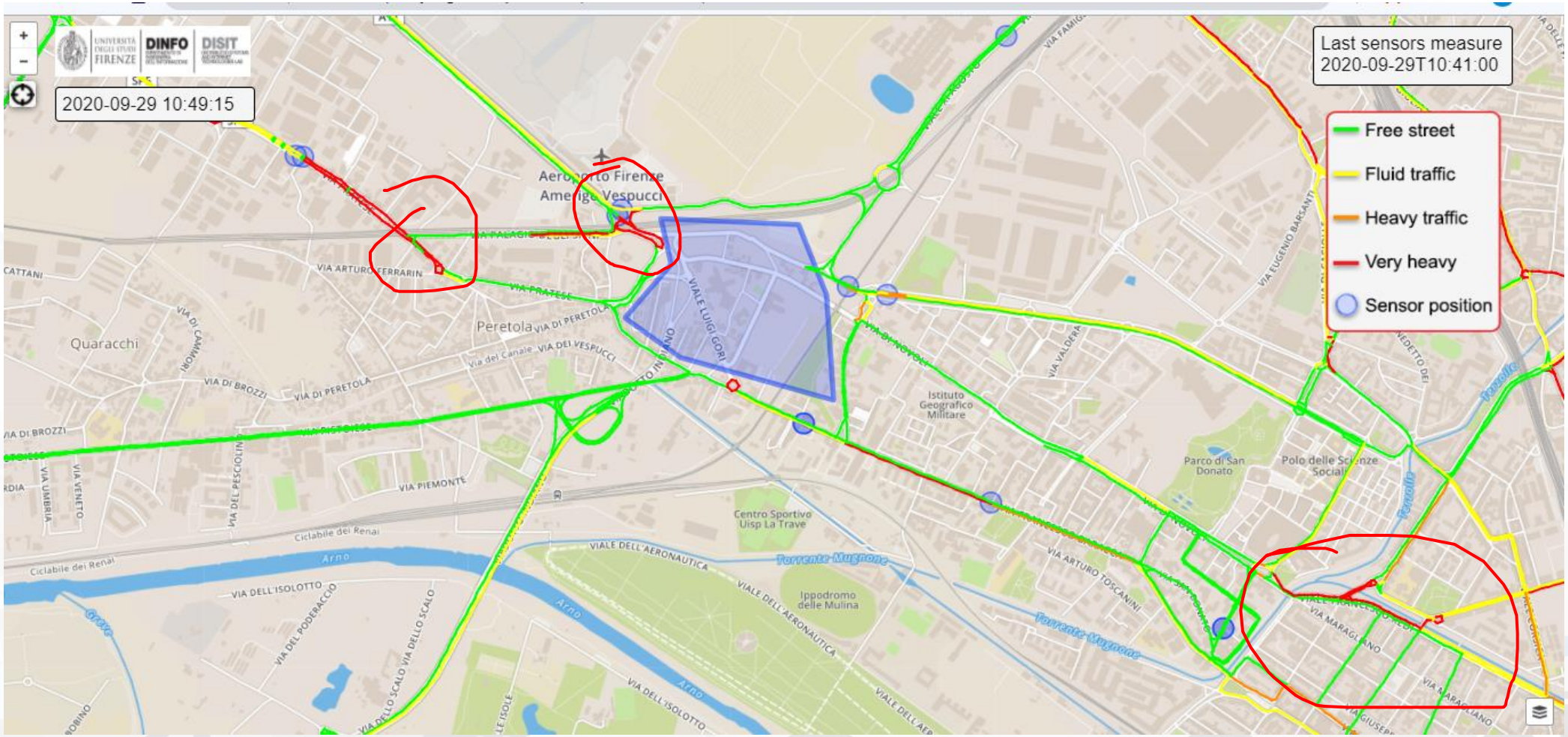
Decision Support Systems, What-if

- **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

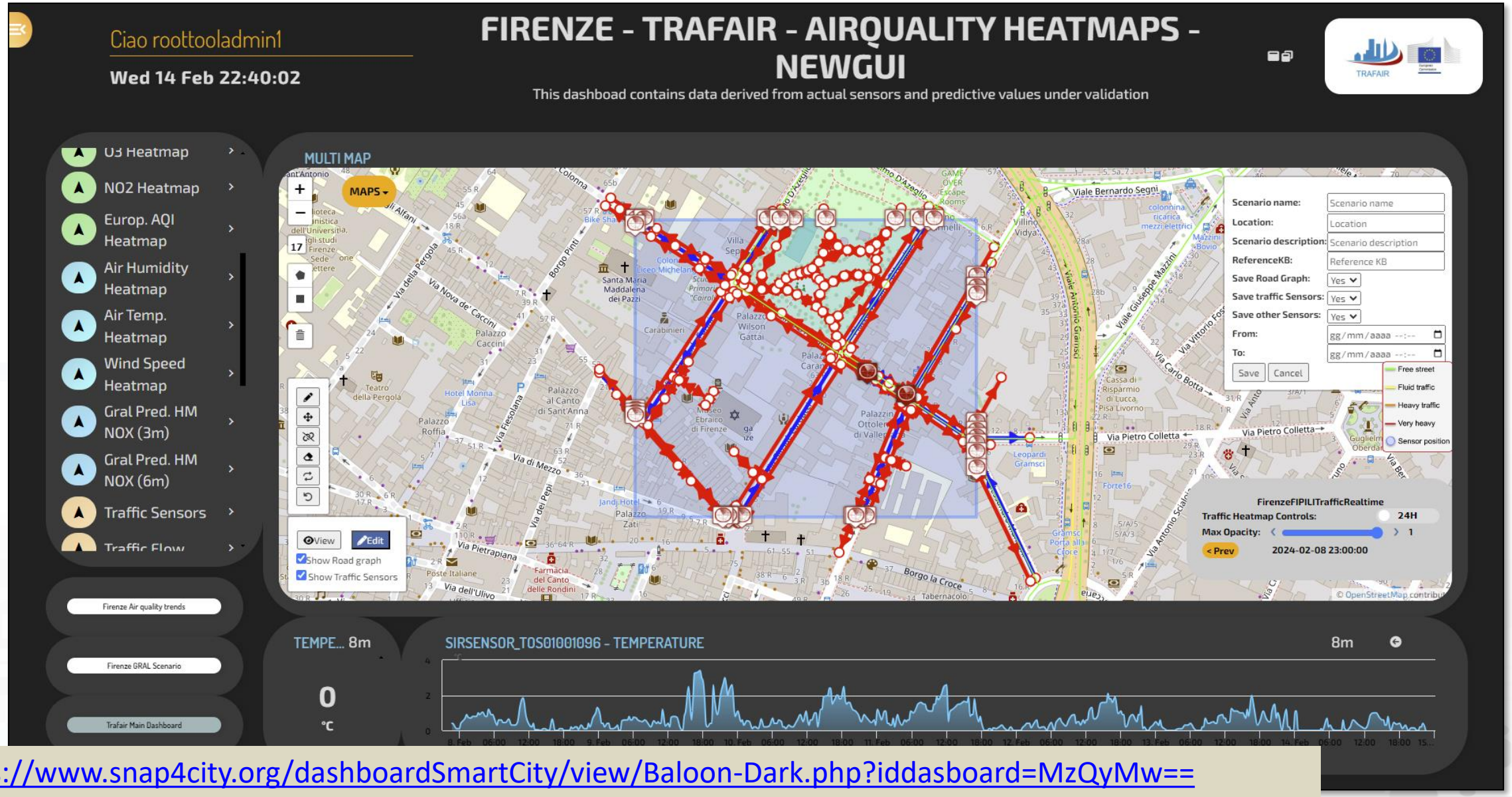




Computation of Traffic Flow Evolution, cascade effects

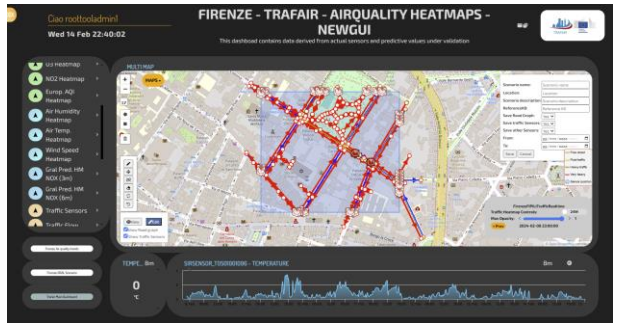


Scenarious Editor



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

The actual Scenario Exploitation

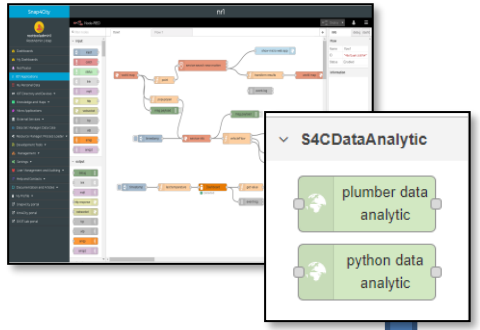


Defining Context via Editing Scenario:

- Select area and data
- Editing roads, POI, IoT entities, ..
- Save/load, share
- Change status

A Scenario includes:

- Metadata
- Status and versions, date time
- Period of validity
- Road graphs, cycling, pedestrian seg.
- List of data, sensors
- Etc.

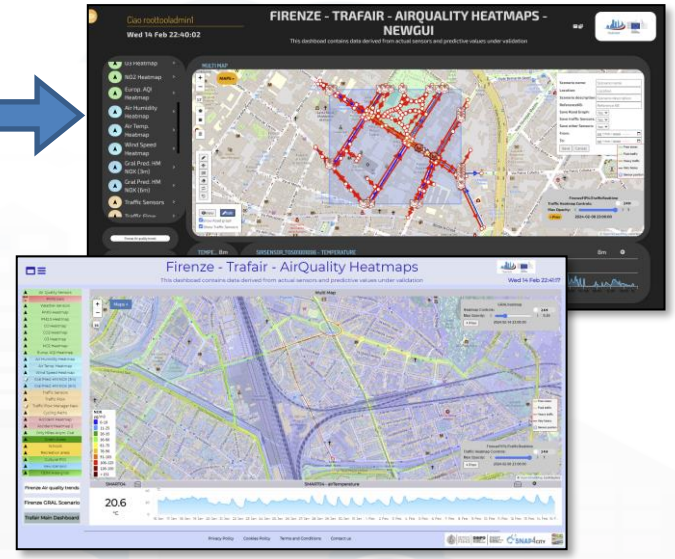


Computing in the Scenario Context as:

- KPI, Metrics, SUMI, SUMP, 15MinCity Index
- Heatmaps
- OD Matrices
- Traffic Flow reconstructions
- Predictions
- Routing, constrained routing
- Early Warnings
- Etc.

ReLoading Scenario in JavaScript

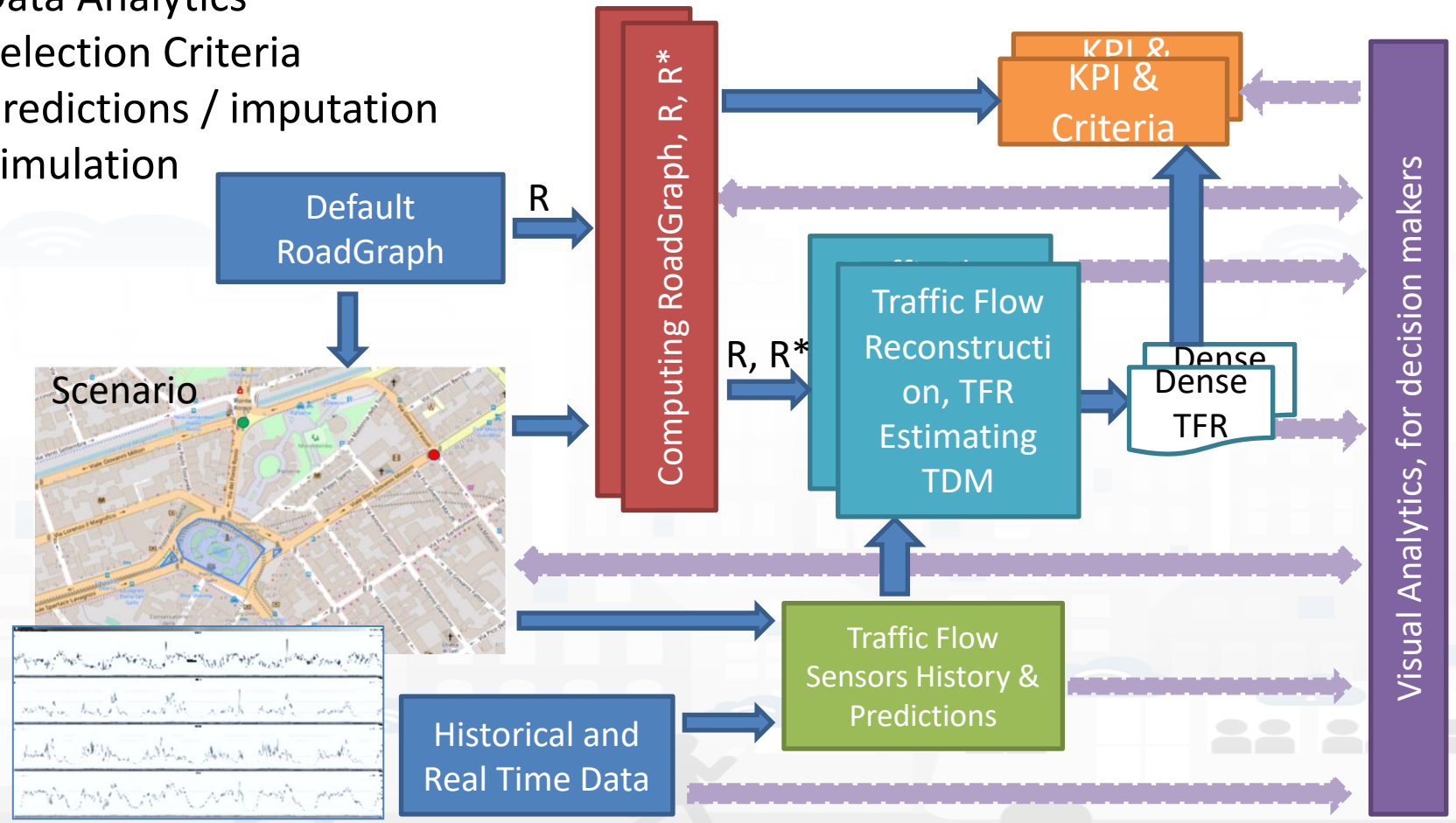
- Evolve Scenarios
- Use Scenario to context the Data Analytics: R Studio, Python for computing



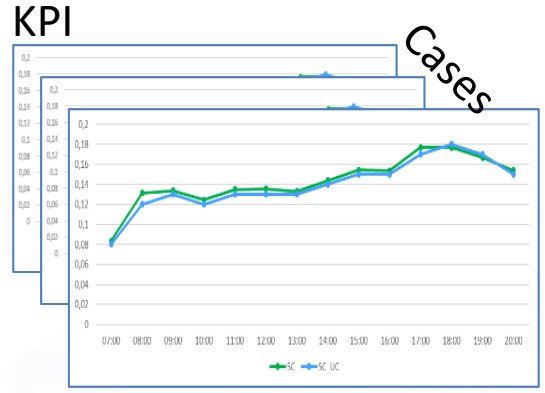
What-if: Simulation for Traffic Flow

At the same color corresponds the same area:

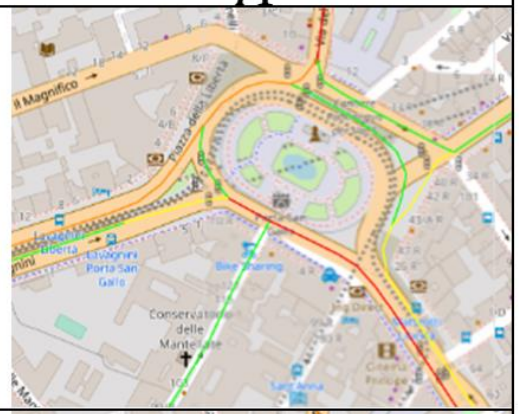
- Data / information
- Data Analytics
- Selection Criteria
- Predictions / imputation
- Simulation

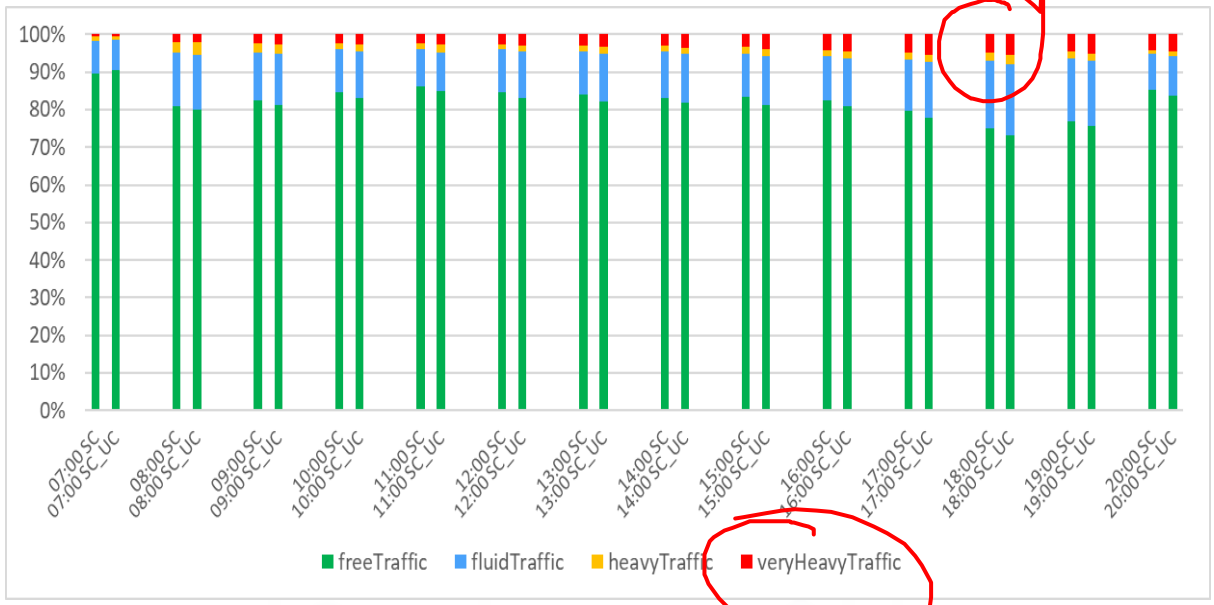


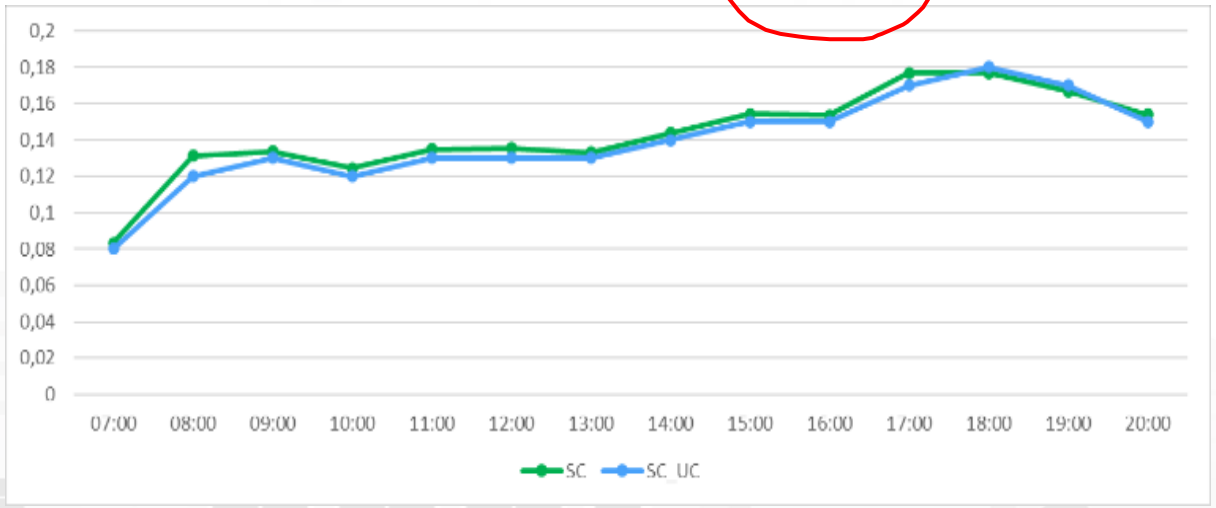
Data Driven Decision



What-if

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





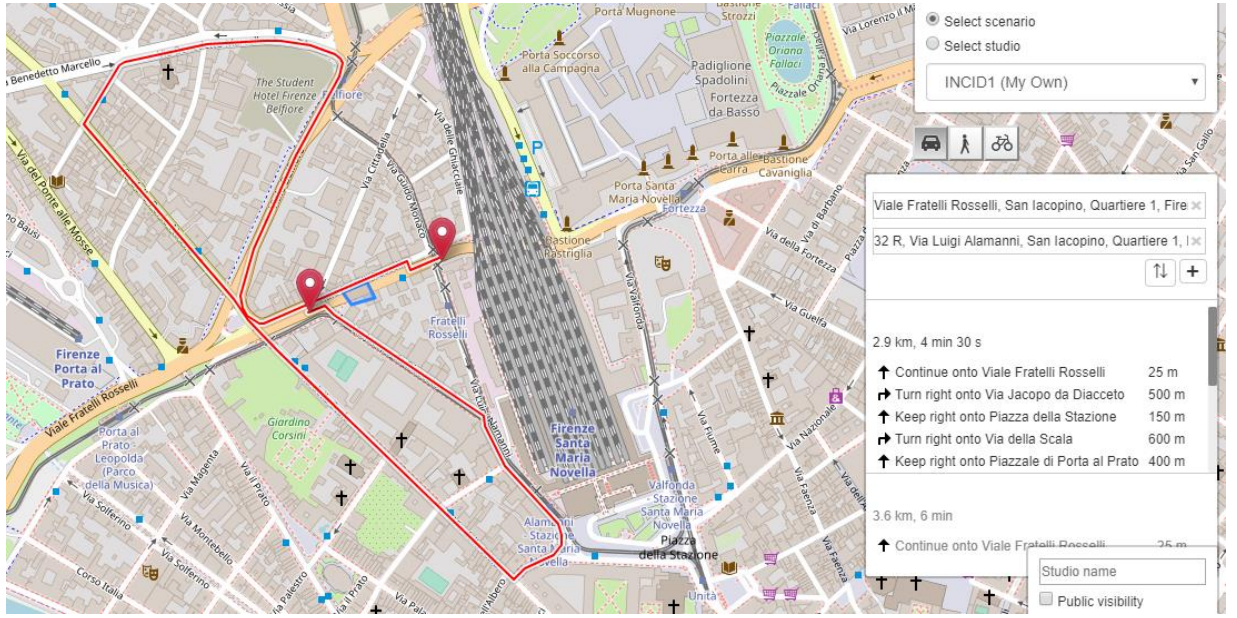
What-If Analysis

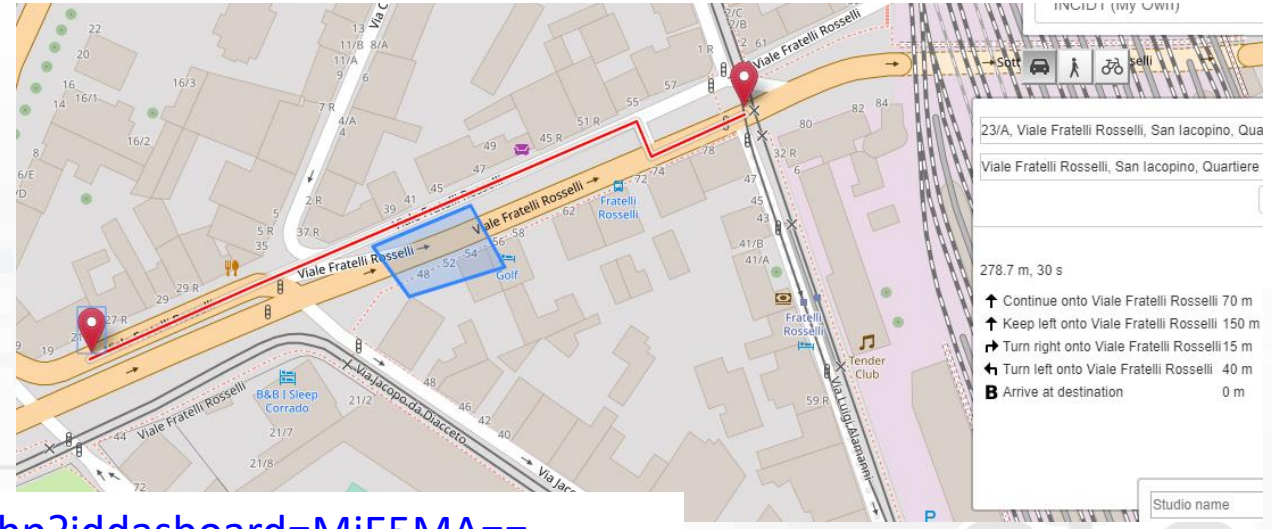
Accidents and elements blocking Points and Shapes taken into account for:

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

Assessment on the basis of changes:

- Mobility demand assessment
- Mobility Offer assessment

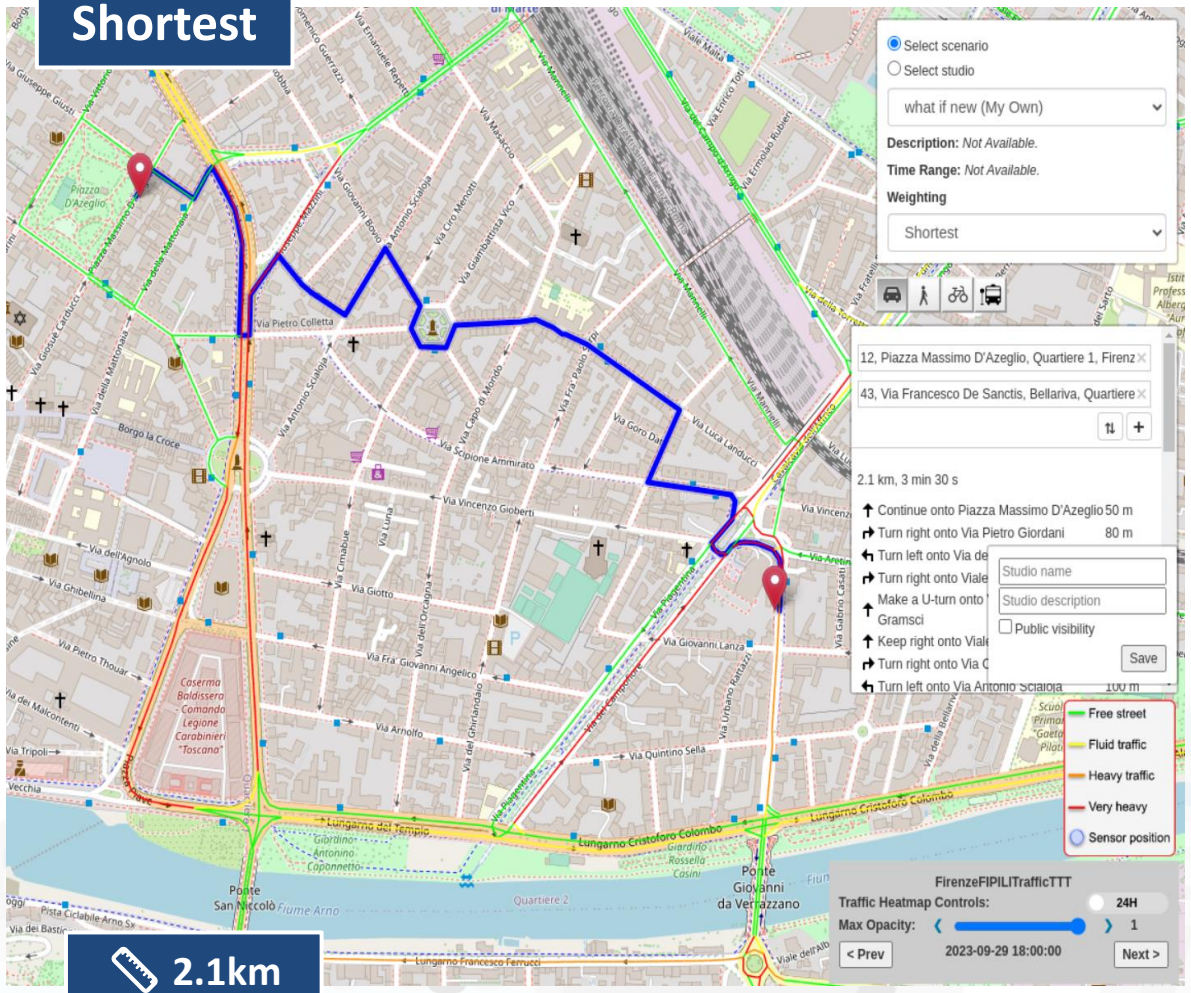




https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjE5MA==

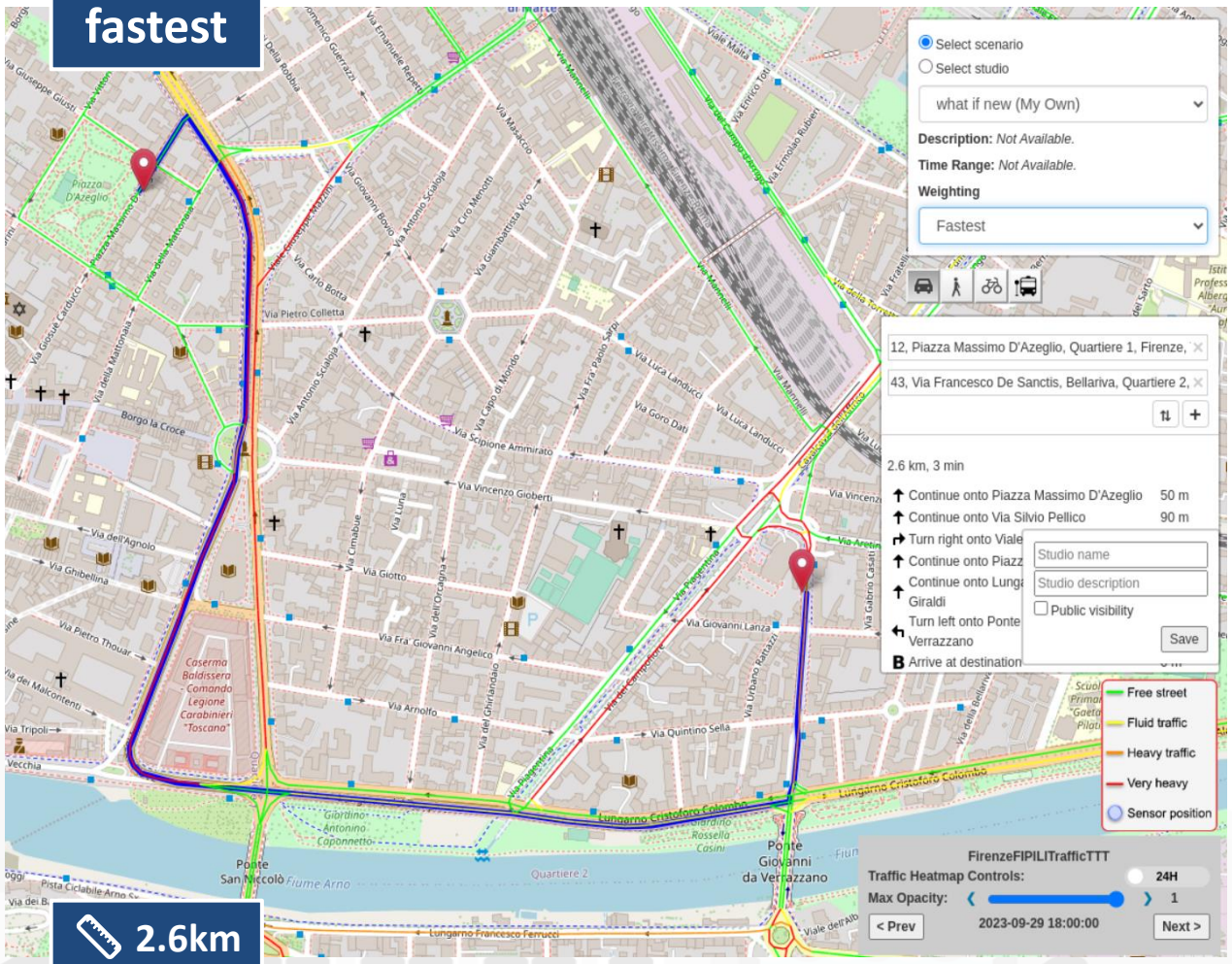
Constrained Dynamic Routing: Traffic Flow

Shortest



2.1km
3min 30s

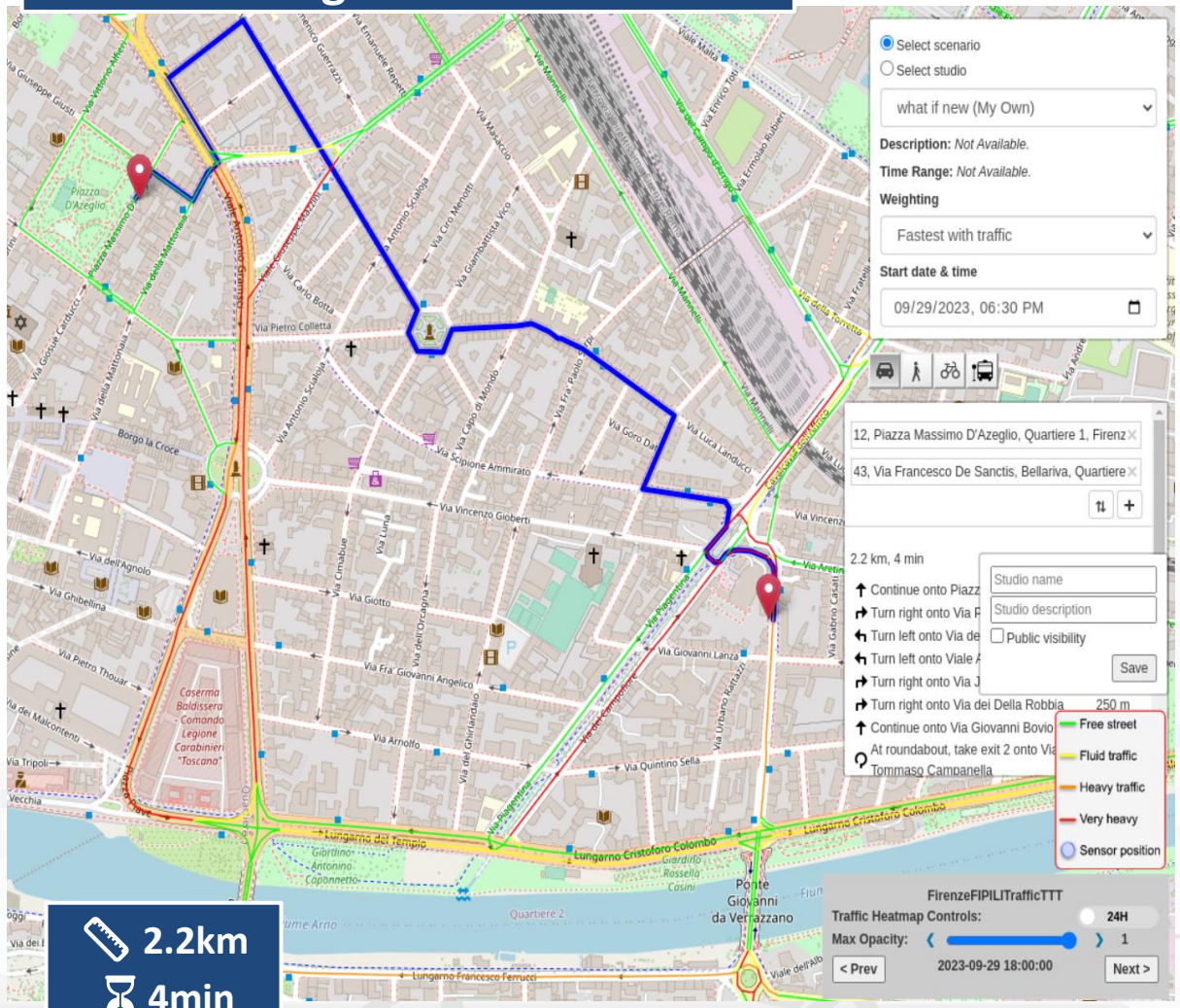
fastest



2.6km
3min

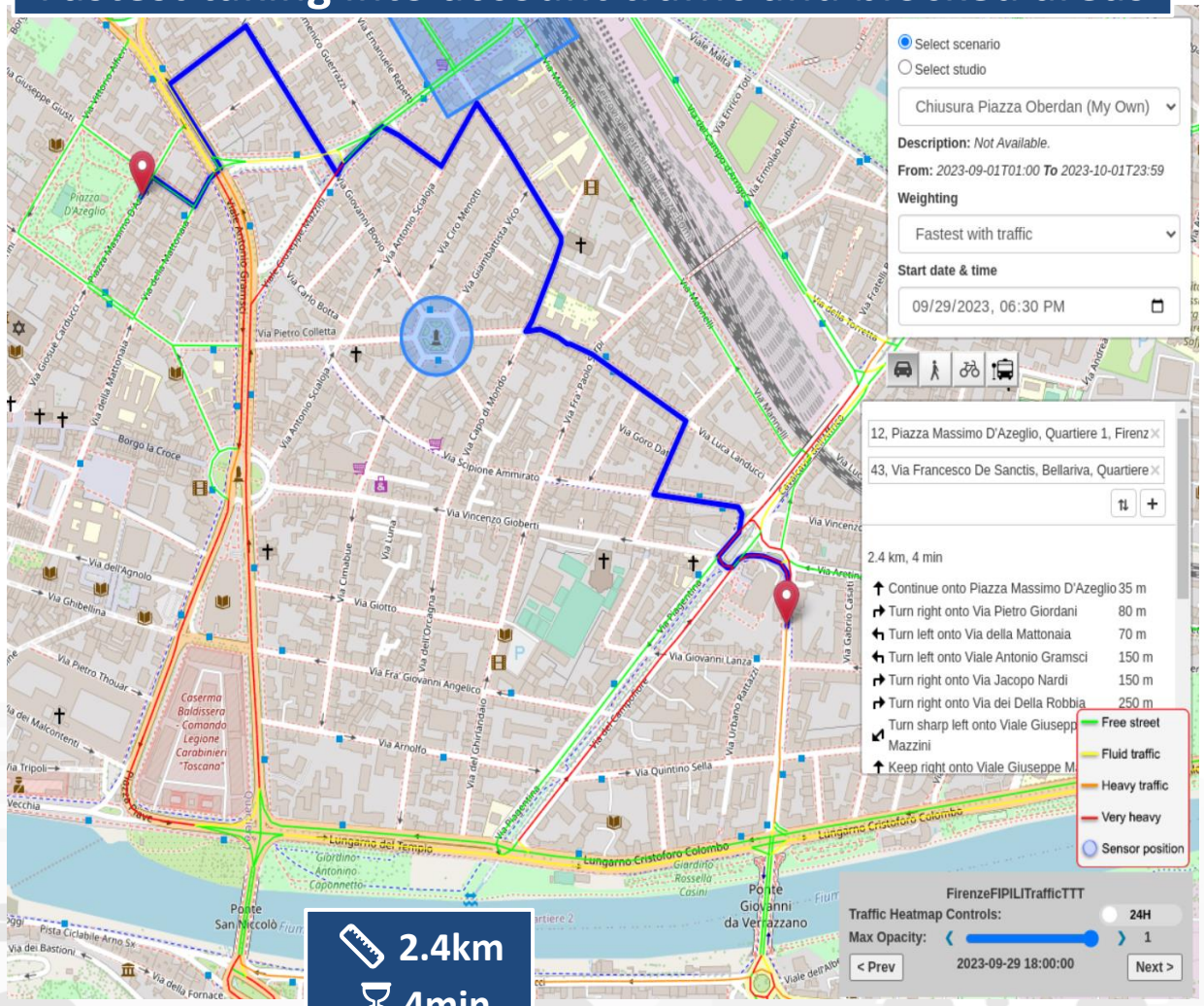
Constrained Dynamic Routing: Traffic Flow

Fastest taking into account traffic



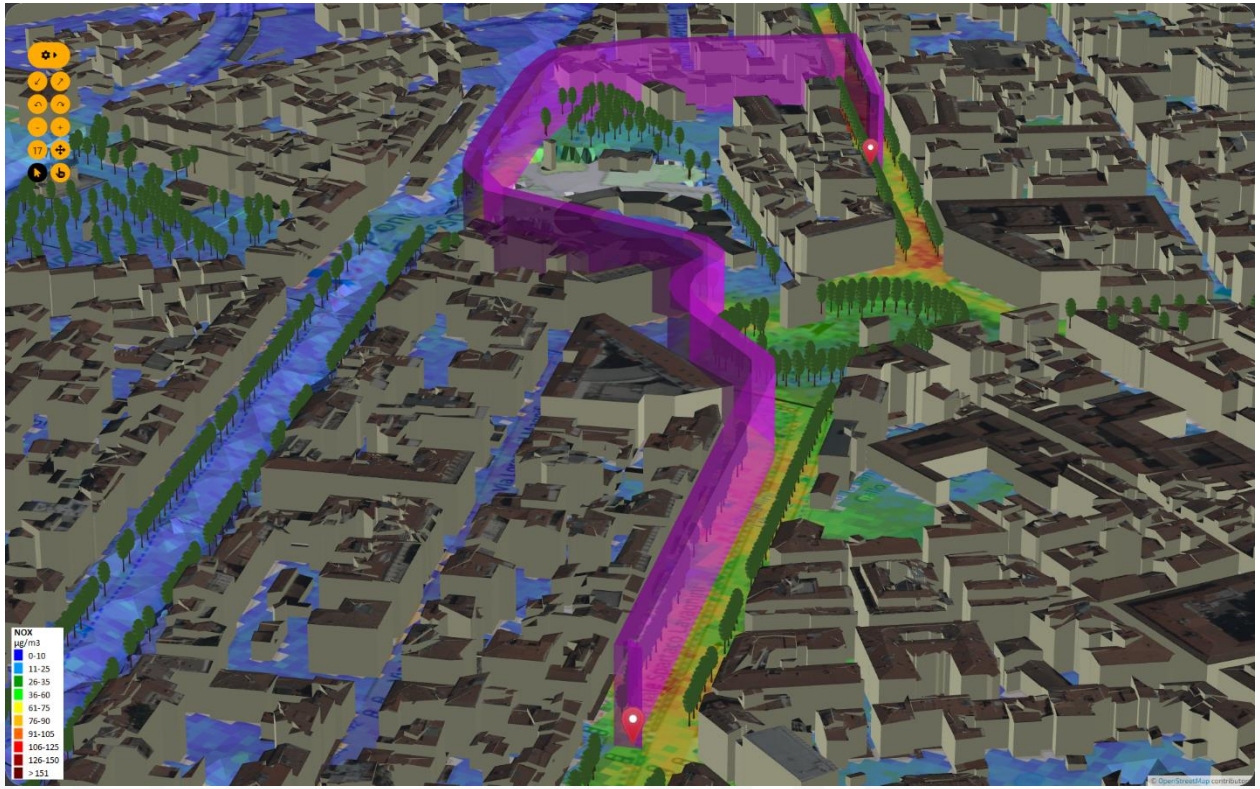
2.2km
4min

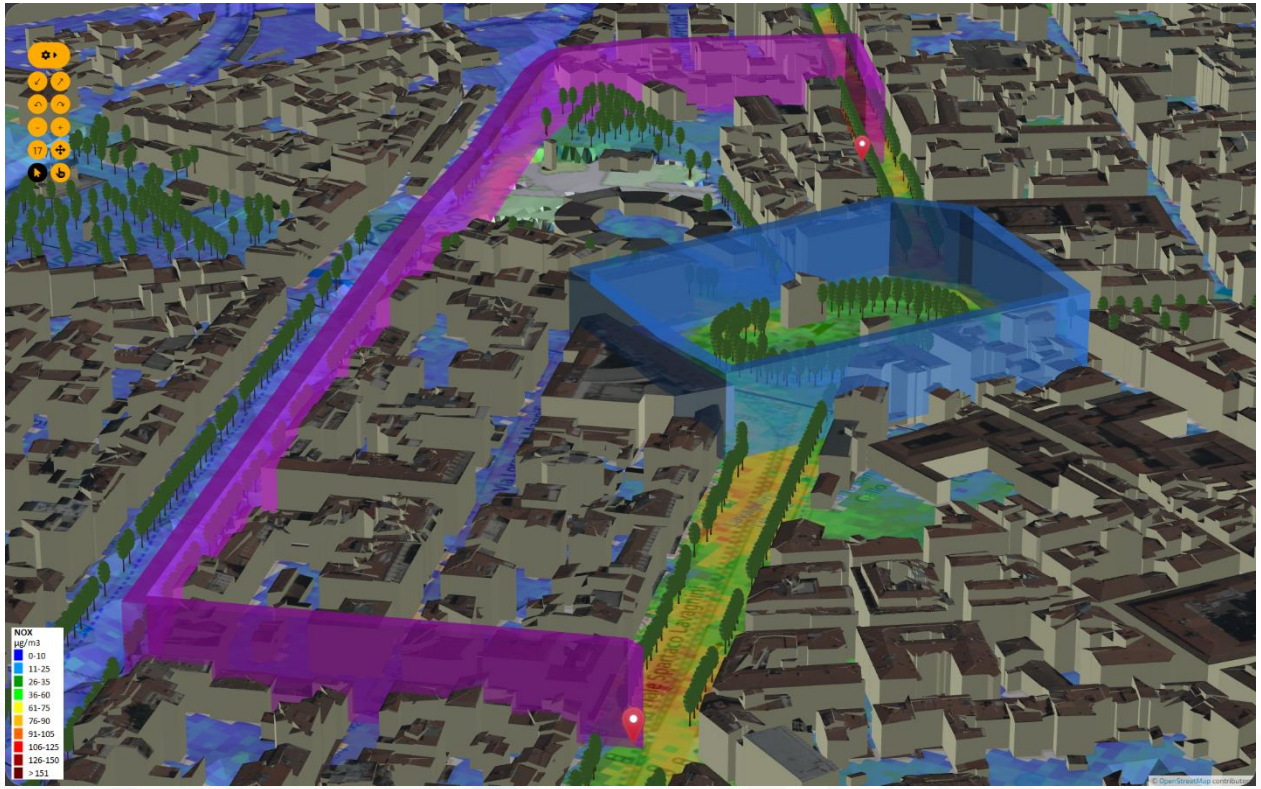
Fastest taking into account traffic and blocked areas



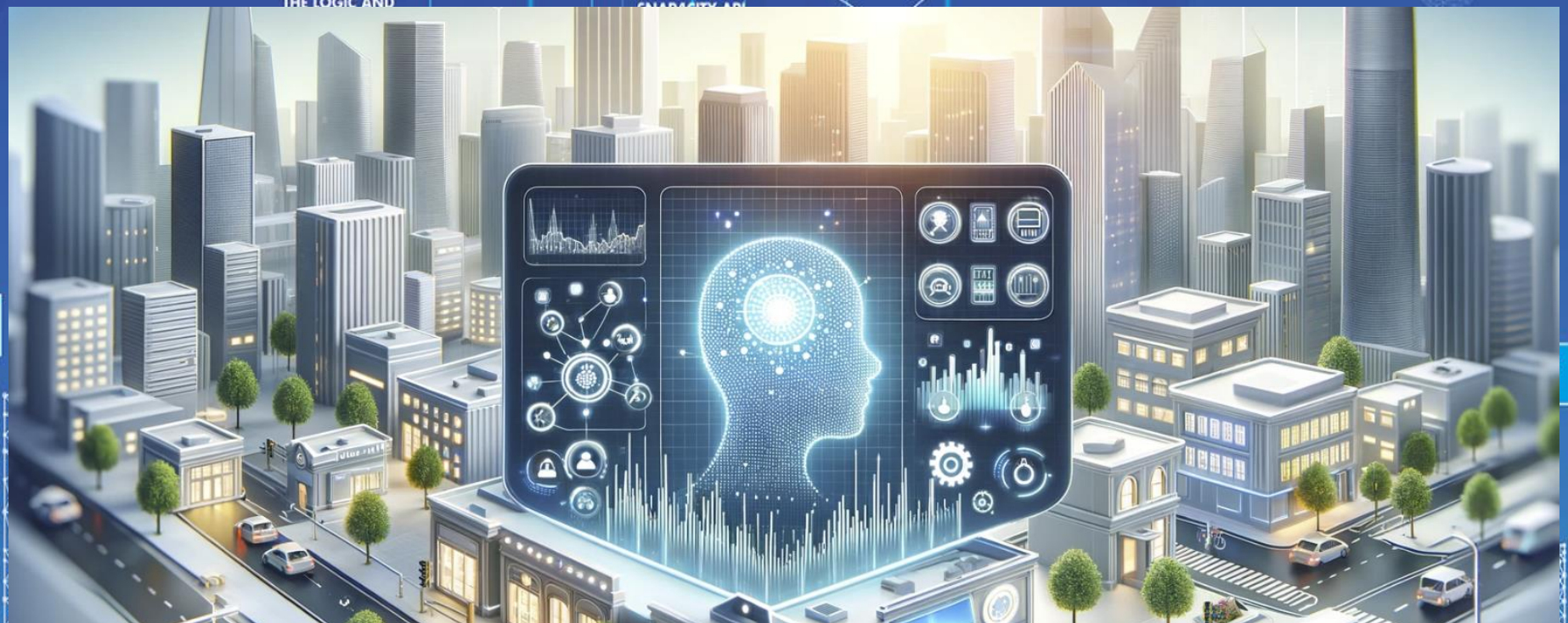
2.4km
4min

Dyamic Routing in 3D space





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/

Mobility and Transport Domain (2024/8)

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

Tools for Mobility and Transport (2024/8)

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

Mobility and Transport Traffic Flow Analysis

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

reference

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

UNIVERSITÀ DEGLI STUDI FIRENZE

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DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB

SNAP4CITY

KM4CITY

Traffic Light Plan Optimization

11 SUSTAINABLE CITIES AND COMMUNITIES

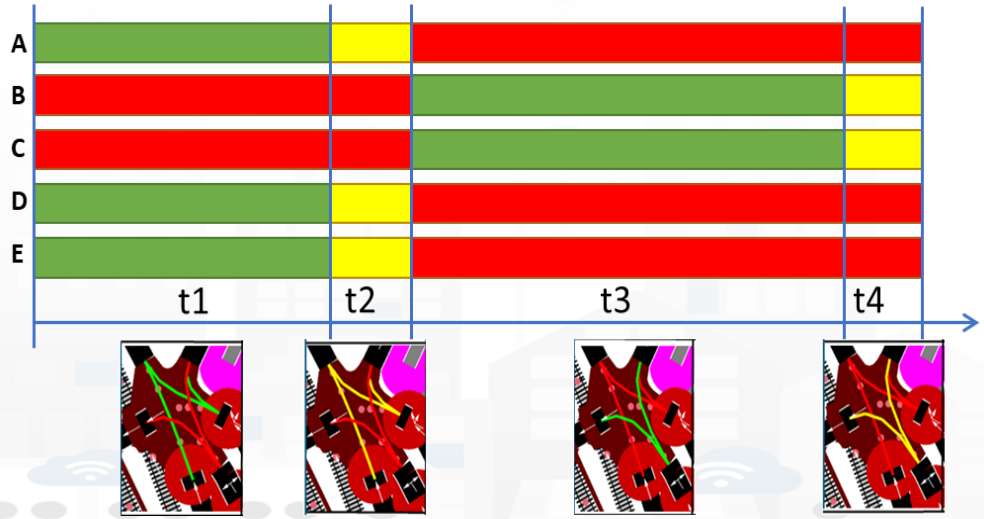
MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

https://www.snap4city.org/1015

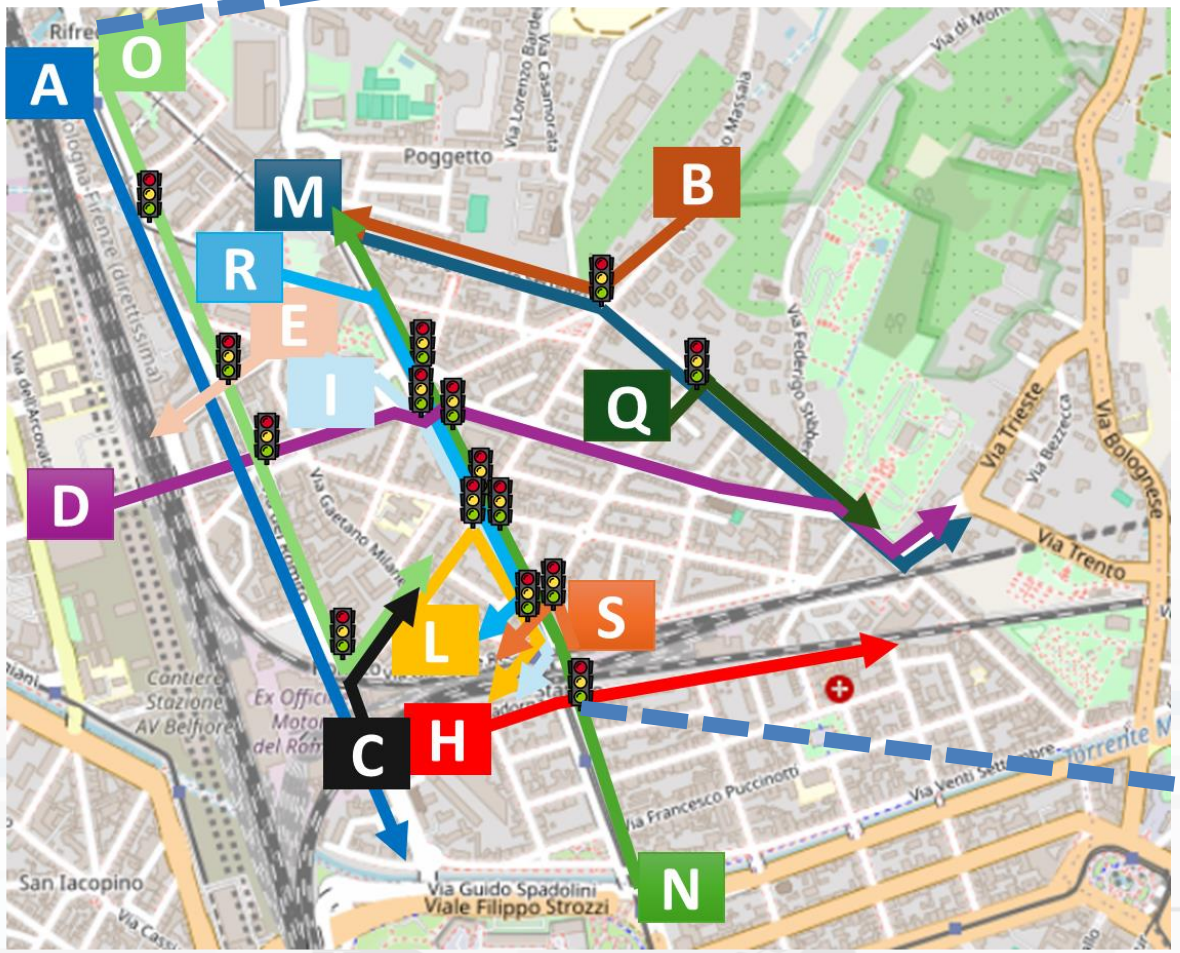
Traffic Light Plan Optimisation, Digital Twin

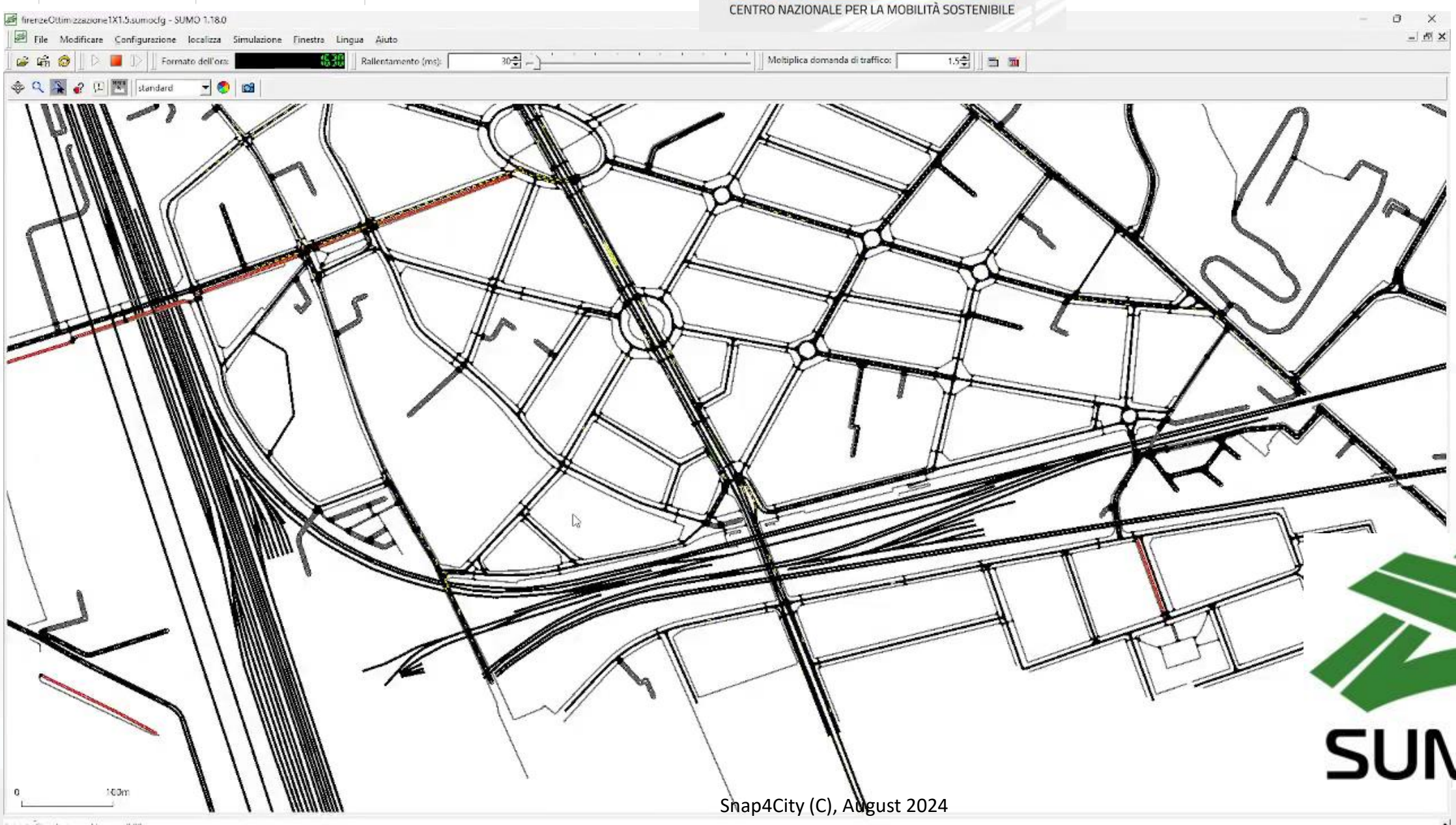
- **Match Multiple Objectives and Synchronization:**
  - public and private traffic, tramway priority
  - Micro and Macro Scales
  - **AI: Genetic Algorithms, Reinforced Learning**
    - Fixed and Actuated Cycles
    - Adjusted on Demand
- **Validation/integ.** with ***SUMO*** simulation
  - Travel Time,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

MOST CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE



Example, main paths




firenzeOttimizzazione1X1.5.sumocfg - SUMO 1.18.0
File Modificare Configurazione localizza Simulazione Finestra Lingua Aiuto
Formato dell'ora:
Rallentamento (ms):
Moltiplica domanda di traffico:
standard
0
100m

SUMO

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DISTRIBUTED DATA INTELLIGENCE AND TECHNOLOGIES LAB

SNAP4CITY

KM 4 CITY

Traffic Infrastructure Optimization

MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

FROM CITY DASHBOARD TO APPLICATIONS

MEDIA ANALYSIS

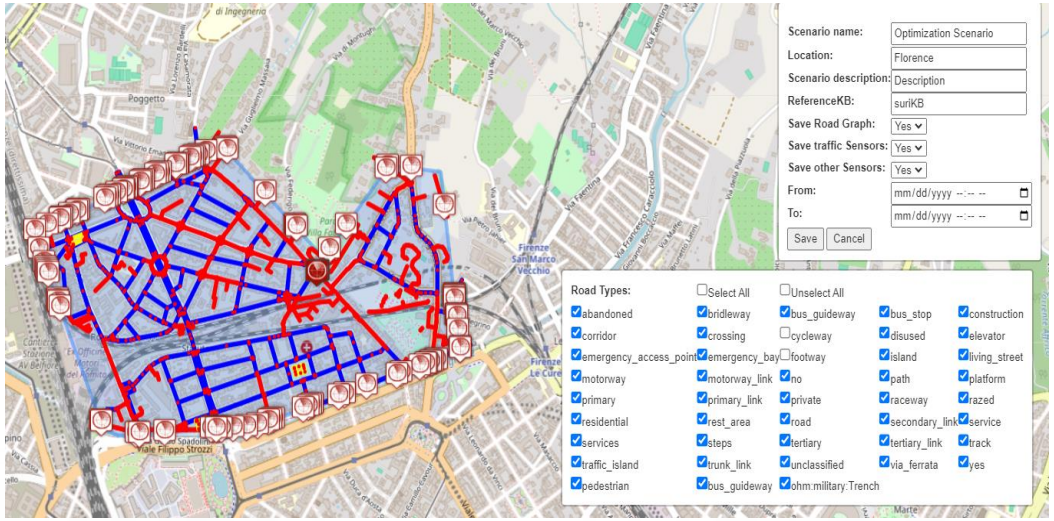
SNAP4CITY THE VIEW OF THE ADMINISTRATORS

11 SUSTAINABLE CITIES AND COMMUNITIES

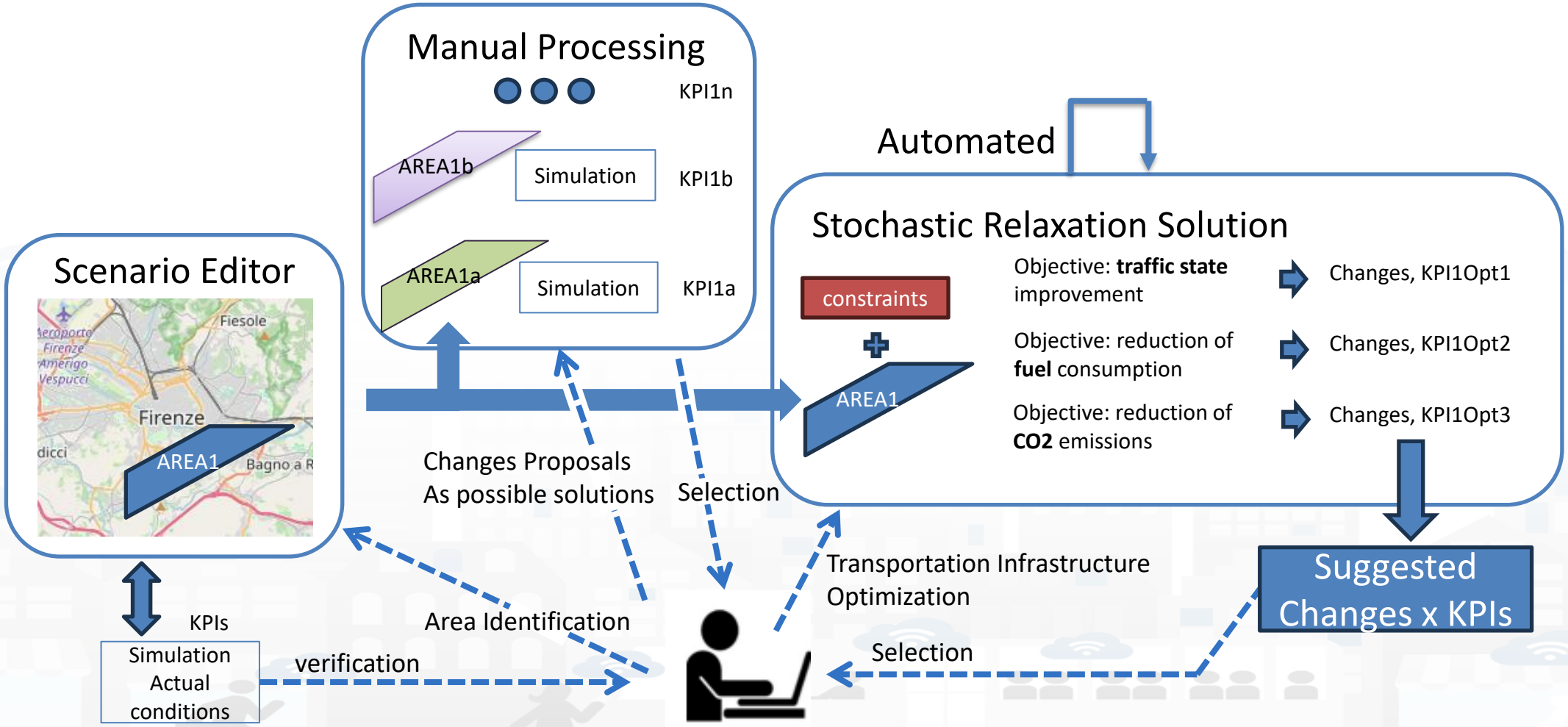
https://www.snap4city.org/1014

Traffic Infrastructure Optimisation, Digital Twin

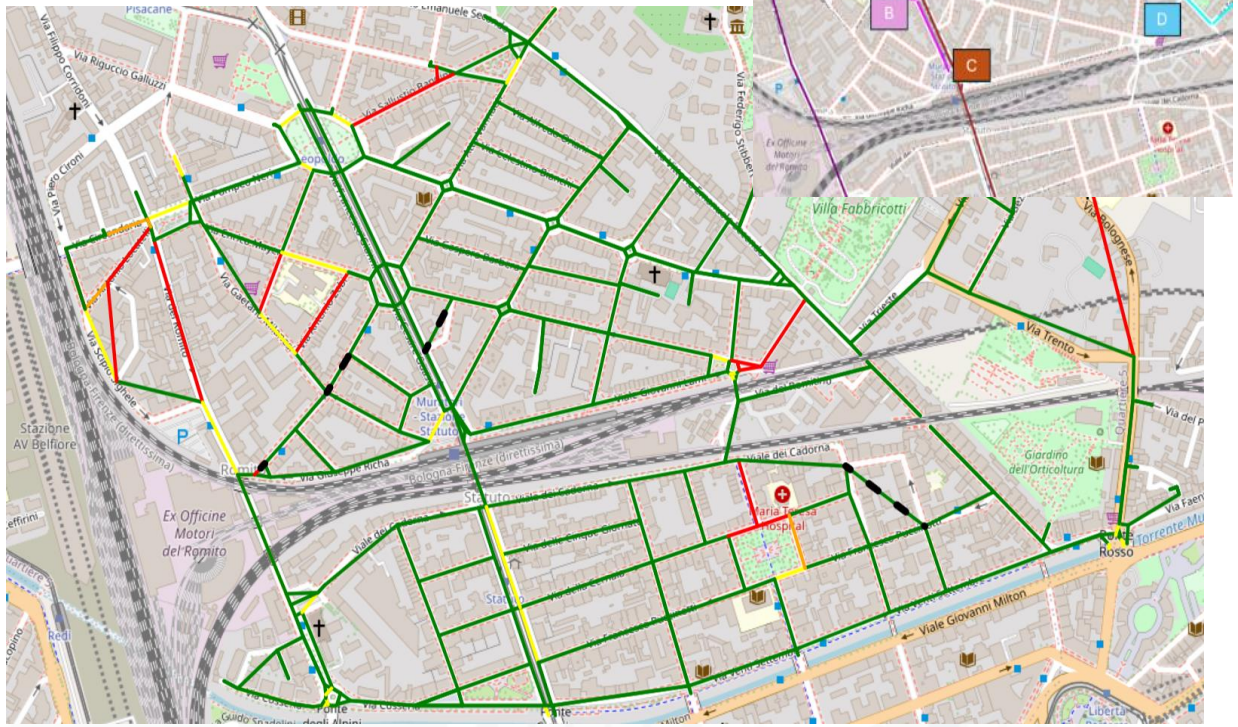
- **Identification of Scenario** (Scenario Editor), any changes
  - Definition of traffic loads by flows
- What-if or Automated Optimisation
- **Automated Optimisation:**
  - Stochastic Relaxation, Simulated Annealing, Traffic Flow Reconstruction
  - Multiple objectives targeting
    - Travel time, emissions,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



Traffic Infrastructure Optimisation



Optimization Results



Case max 4 changes	*KPI estimation on the best solution*		
Optimization Target	***Traffic State***	***Fuel***	***CO2***
Optim 4 Traffic State	**91.341**	17.964	128536
Optim 5 Fuel	91.514	**16.633**	128227
Optim 6 CO2	92.859	19.192	**127876**
Original	115.475	25.680	165822

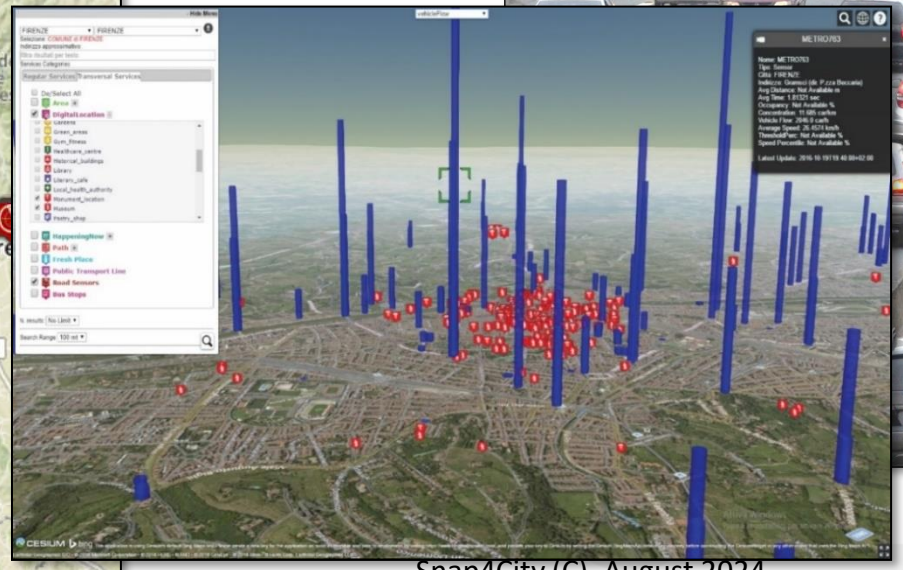
Travel Time [s]	***Path A***	***Path B***	***Path C***	***Path D***	***Total Time***
Original Scenario	183.2	59.6	80.9	132.5	456.4
Optim 4 Traffic State	93.2	60.0	63.7	**96.0**	313.1
Optim 5 Fuel	89.6	**51.2**	59.7	96.4	**296.9**
Optim 6 CO2	**89.5**	53.2	**58.4**	100.1	301.3

Traffic Flow

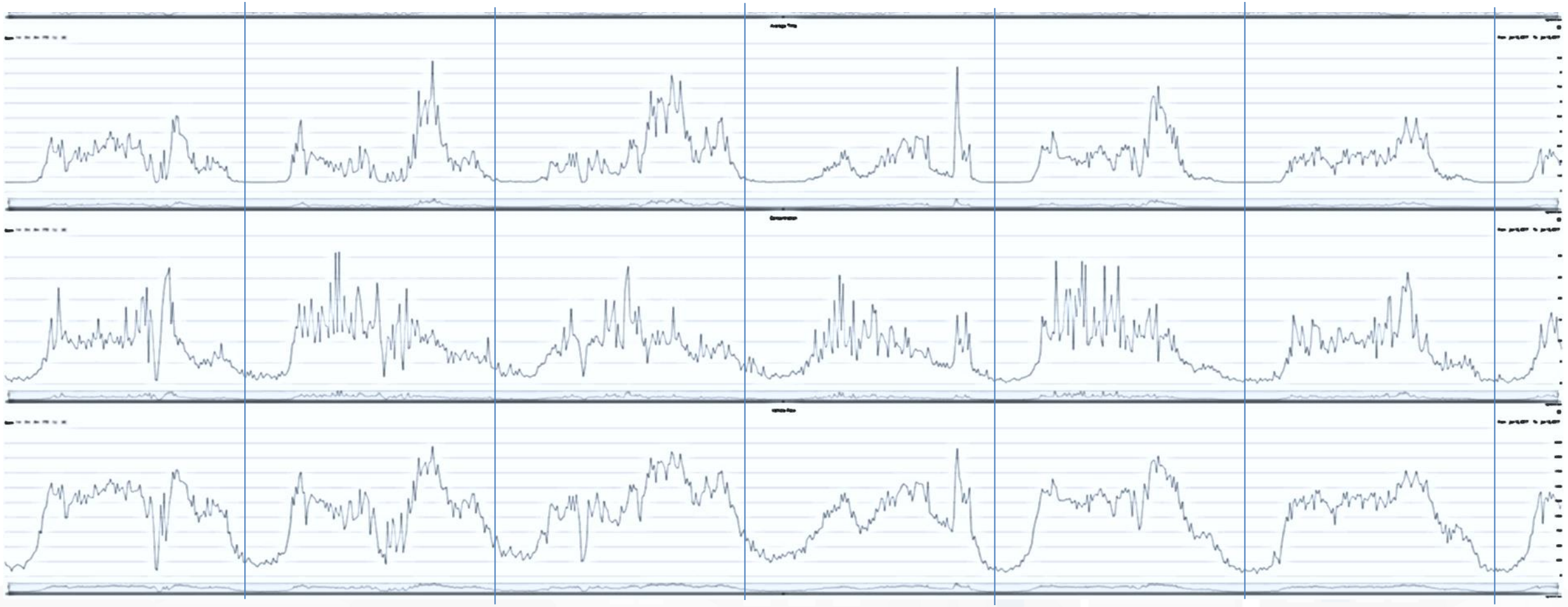
Traffic Flow Tools

Spire and Virtual Spires (cameras), Bluetooth, …

Specifically located: along, around, on gates, on x…



Traffic Flow data



- Day by day traffic flow, on the week data from 3 sensors

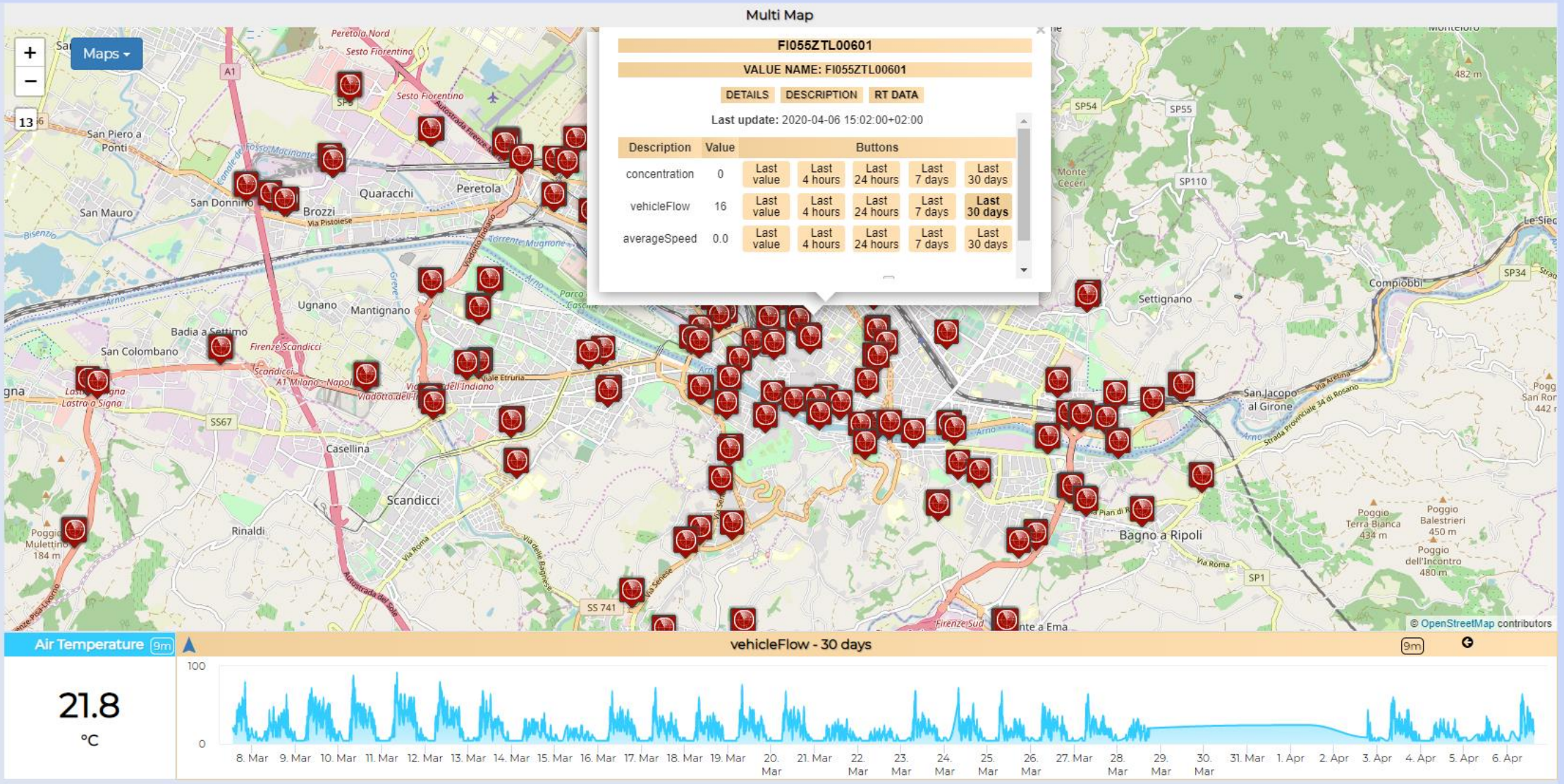
Firenze - Trafair - AirQuality Heatmaps

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

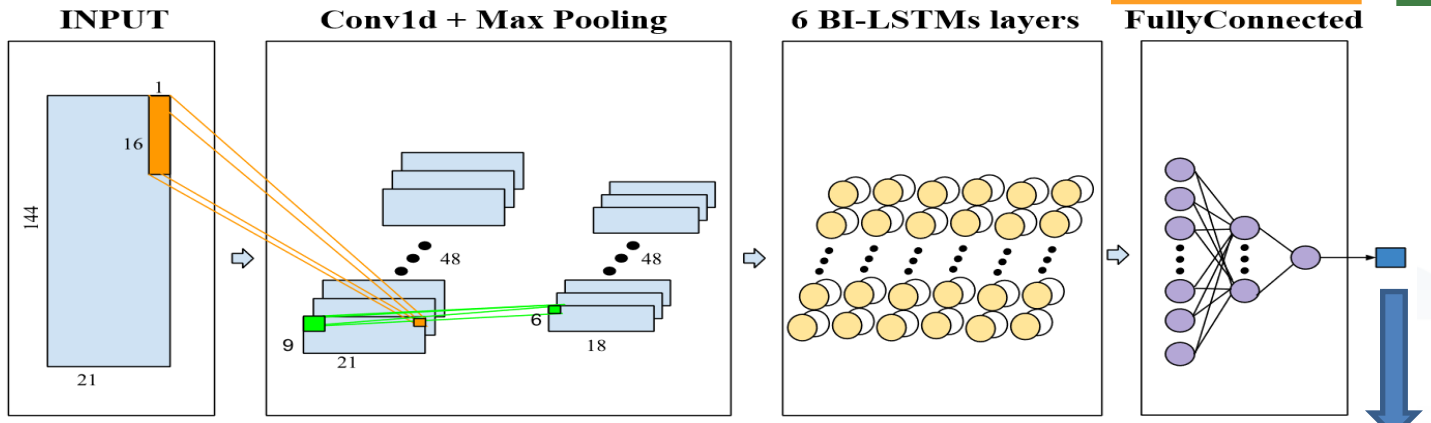
Mon 6 Apr 15:12:27

- Air Quality Sensors
- Weather Sensors
- PM10 Heatmap
- PM2.5 Heatmap
- CO Heatmap
- CO2 Heatmap
- O3 Heatmap
- NO2 Heatmap
- Europ. AQI Heatmap
- Air Humidity Heatmap
- Air Temp. Heatmap
- Wind Speed Heatmap
- Gral Pred. HM NOX (3m)
- Gral Pred. HM NOX (6m)
- Traffic Sensors
- Traffic Flow
- Cycling Paths
- Accident Heatmap
- Accident Heatmap 2
- Only HRes Anym. Gral
- Green Areas
- Schools

Air quality trends



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

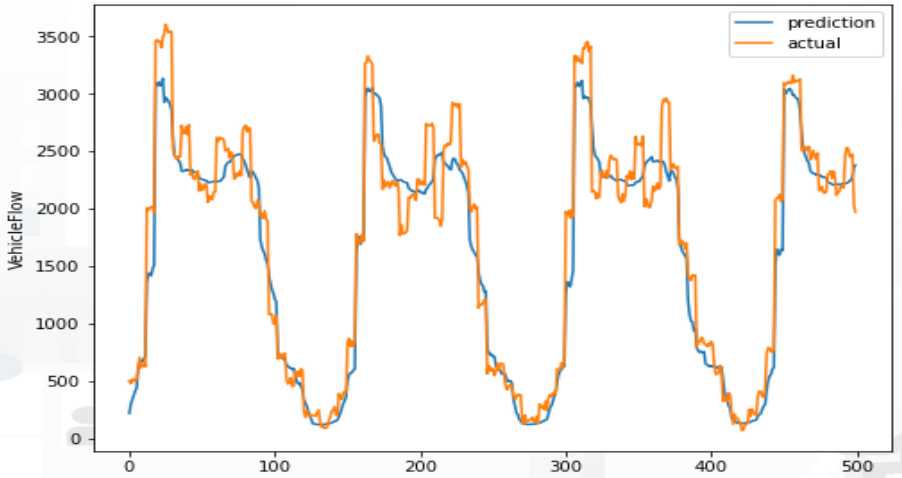


Urban data:

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

RF
XGBOOST
DNN
LSTM
BI-LSTM
Autoencoder BI-LSTM
Attention CONV-LSTM
CONV-BI-LSTM

CONV-BI-LSTM



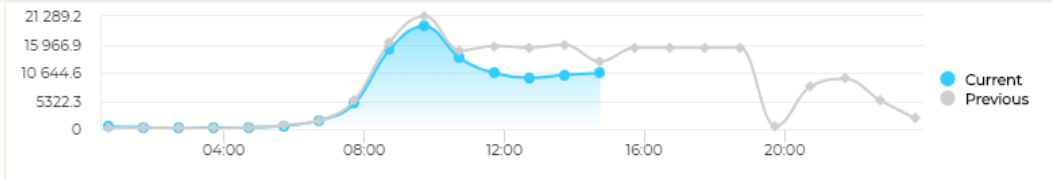
Traffic Flow Monitoring - Firenze - Cloned2

Wed 11 Nov 15:01:32

 # IN FLOW 9m

10549 #ofvehicles

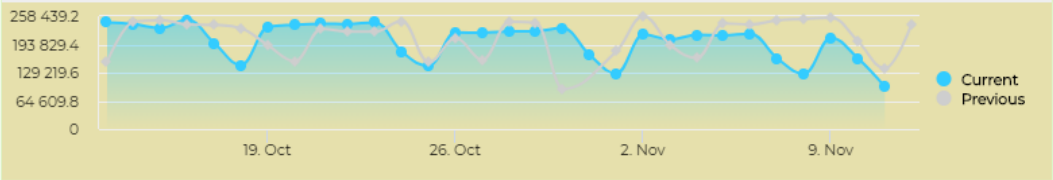
Firenze IN Traffic Flow (number of vehicles) 9m



Inc Daily Inp... 9m

97137 #ofvehicles

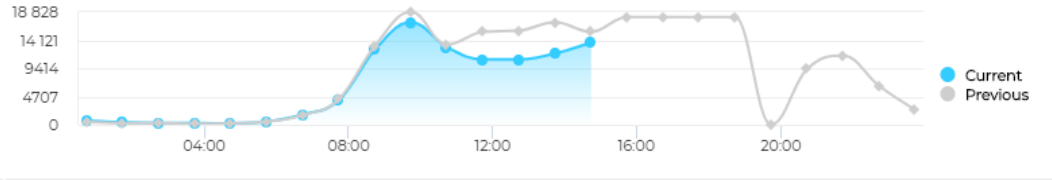
Daily Inputs (monthly) (last value is incremental, real time) 9m



 # OUT FLOW 9m

13720 #ofvehicles

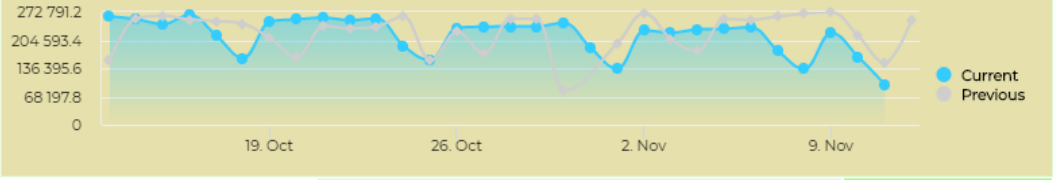
Firenze OUT Traffic Flow (number of vehicles) 9m



Inc Daily Out... 9m

97457 #ofvehicles

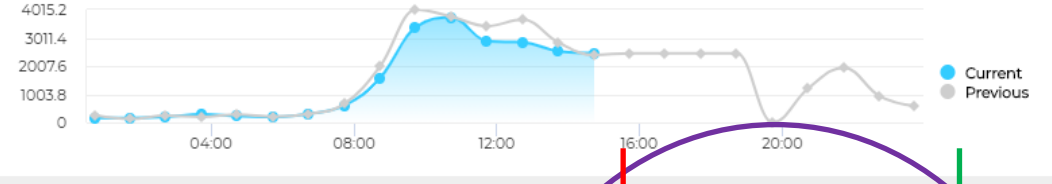
Daily Outputs (monthly) (last value is incremental real time) 9m



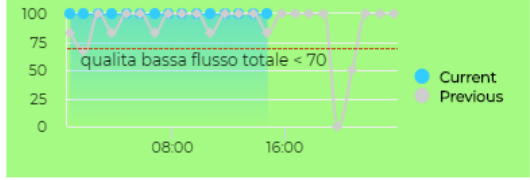
ZTL in 9m

2468 #ofvehicles

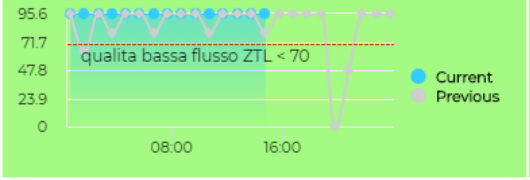
ZTL in Traffic Flow daily trend, entering in ZTL 9m



QoS as perc. of measures taken 9m



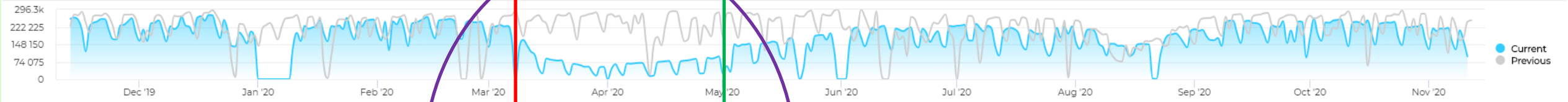
QoS as perc. of measures in ZTL 9m



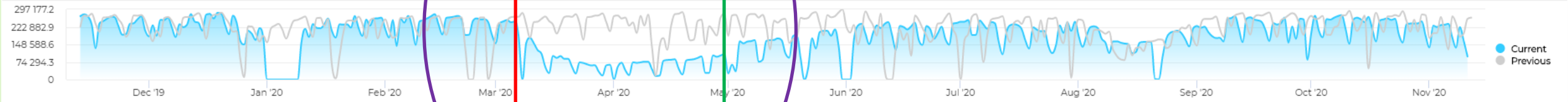
11/11/2020

15:01:33

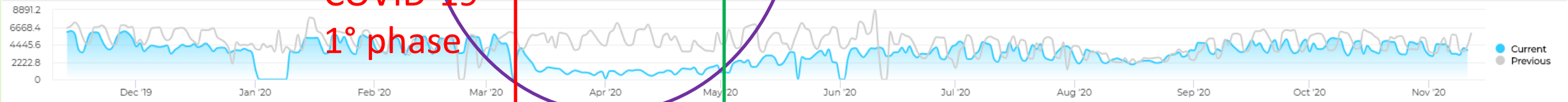
inflow total of the day, yearly 9m



outflow total over the day Yearly 9m



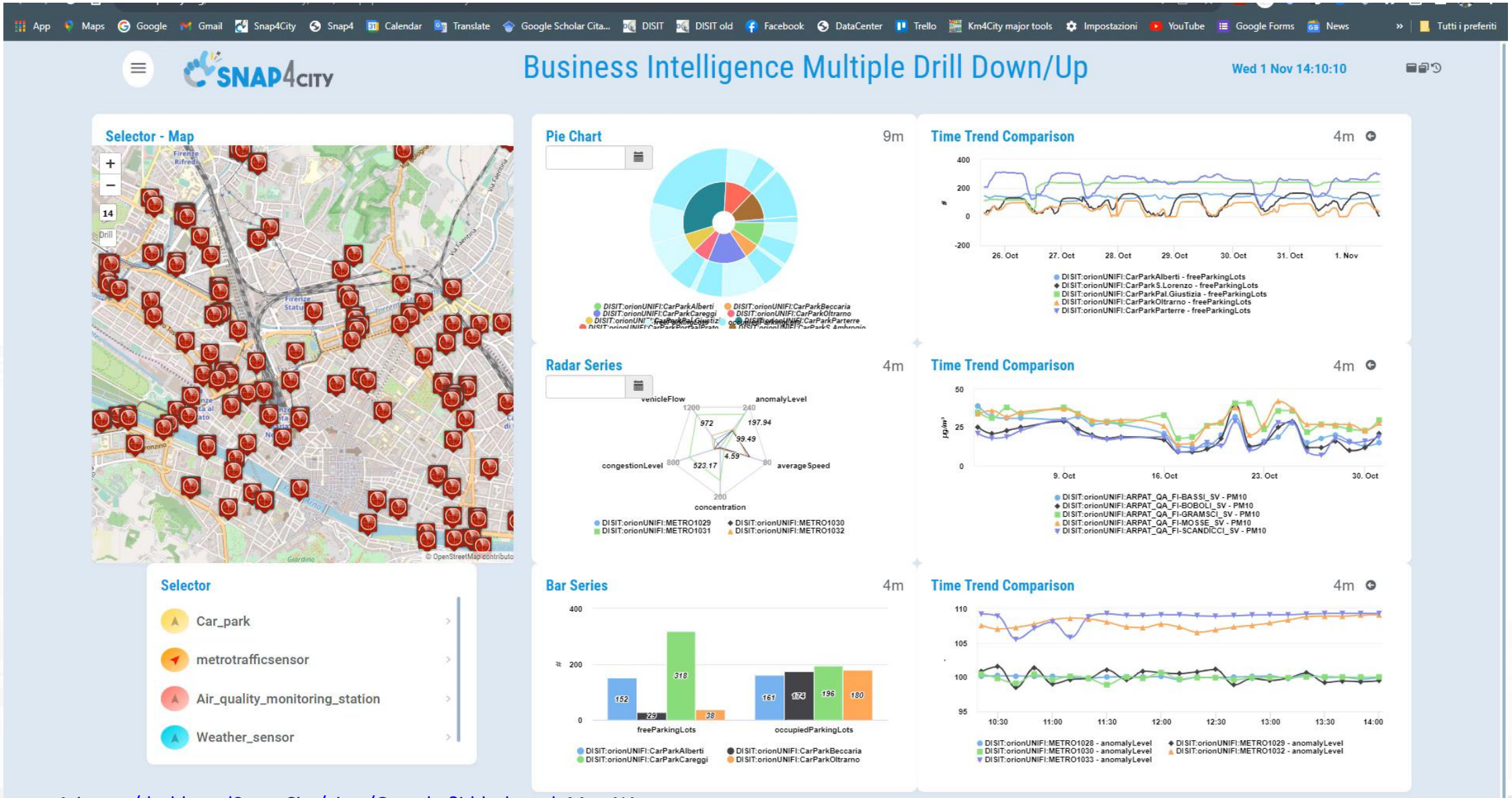
in ZTL yearly compare 9m



COVID-19

1° phase

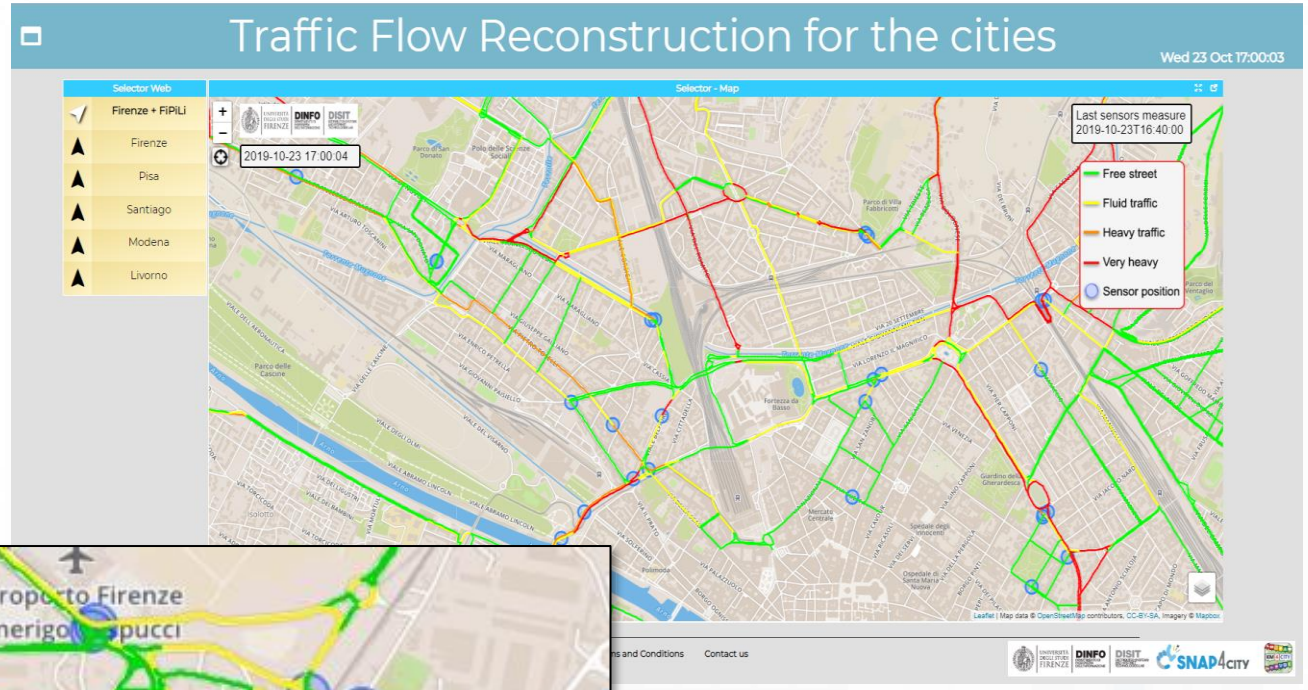
BI on data



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

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



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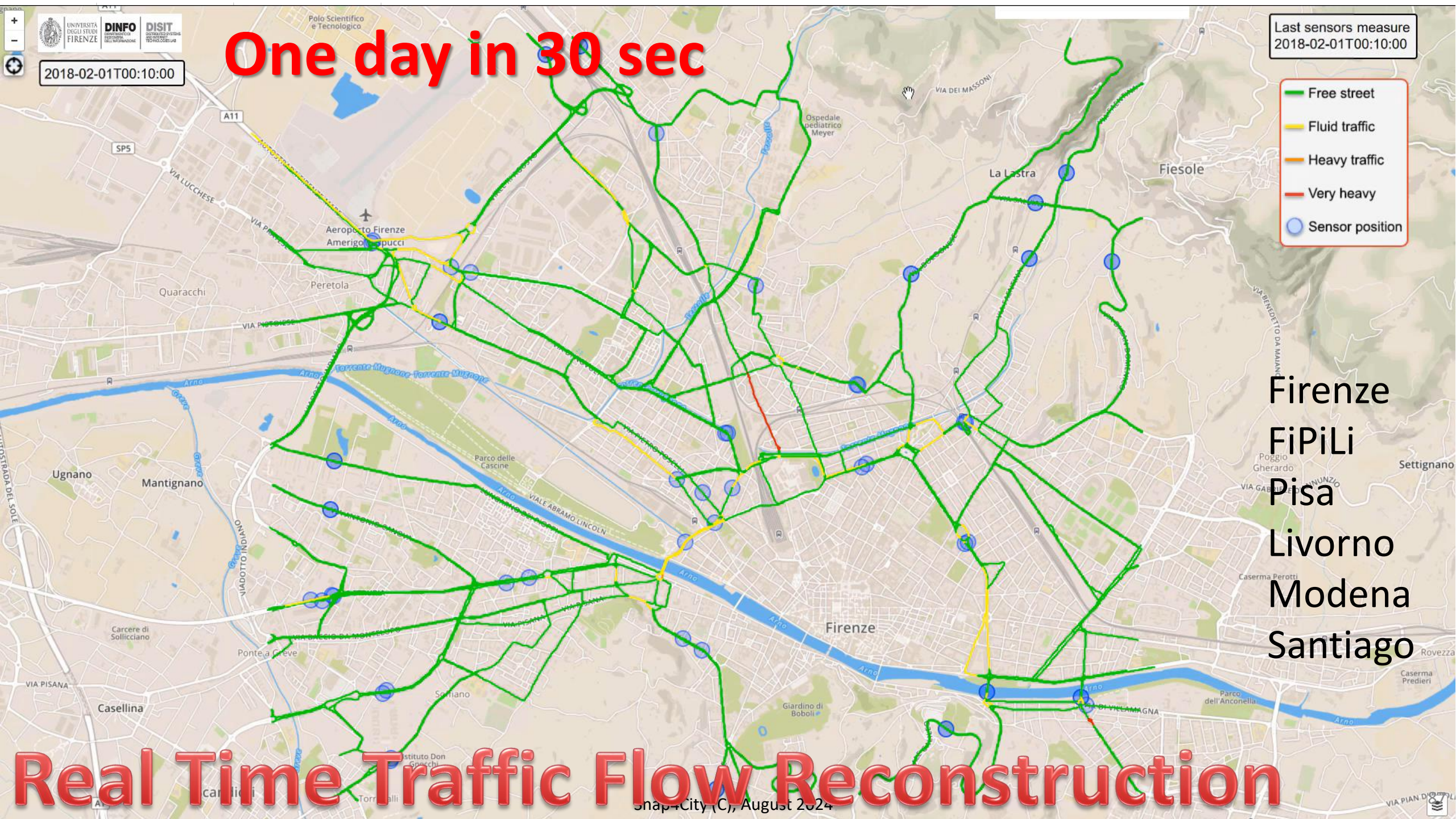
One day in 30 sec
2018-02-01T00:10:00
Last sensors measure
2018-02-01T00:10:00
Free street
Fluid traffic
Heavy traffic
Very heavy
Sensor position
Firenze
FiPiLi
Pisa
Livorno
Modena
Santiago
Real Time Traffic Flow Reconstruction
Snap4City (C), August 2024

Traffic Flow Reconstruction for the cities

Sun 3 Nov 20:37:43

Santiago di Compostela

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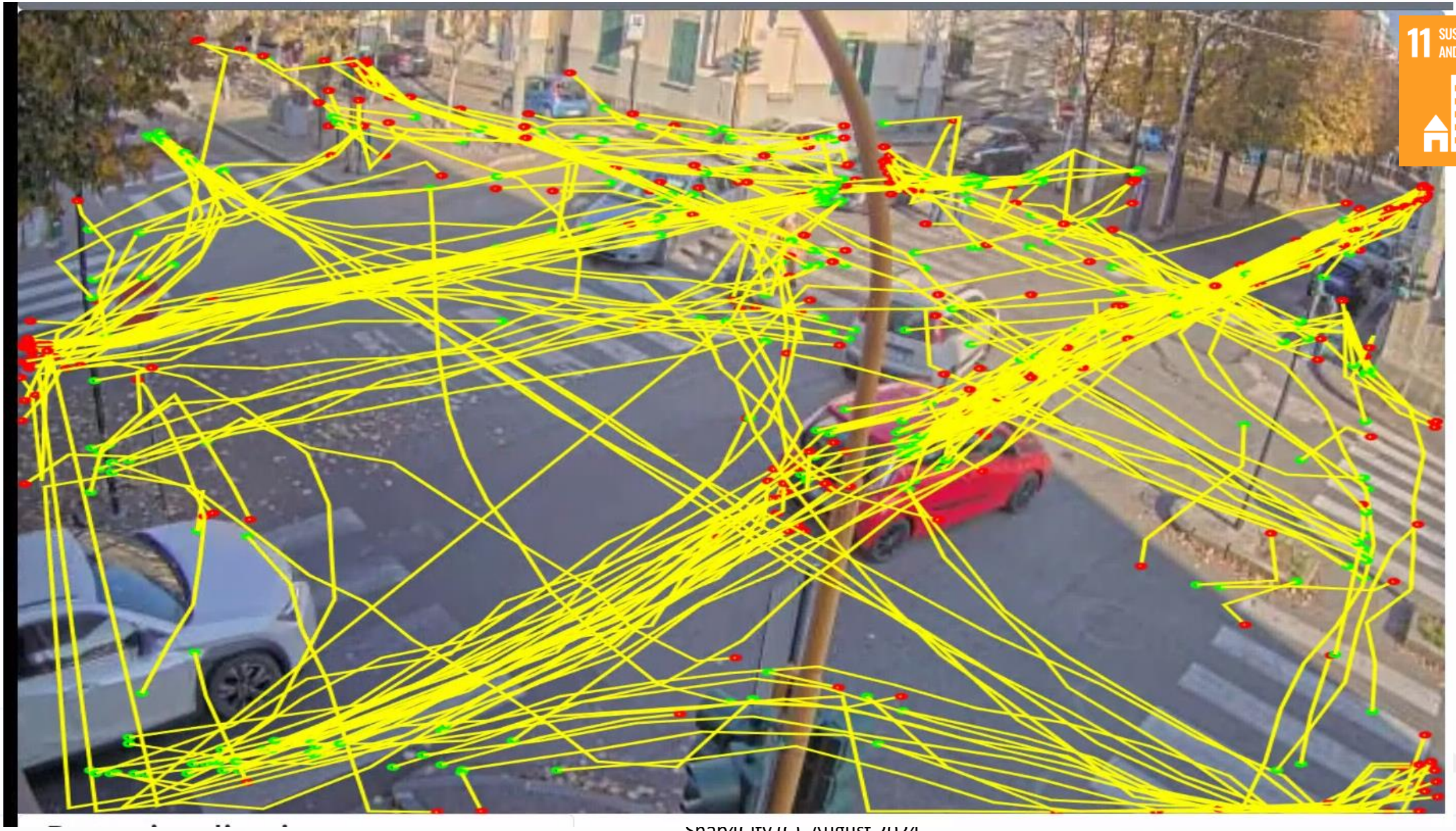
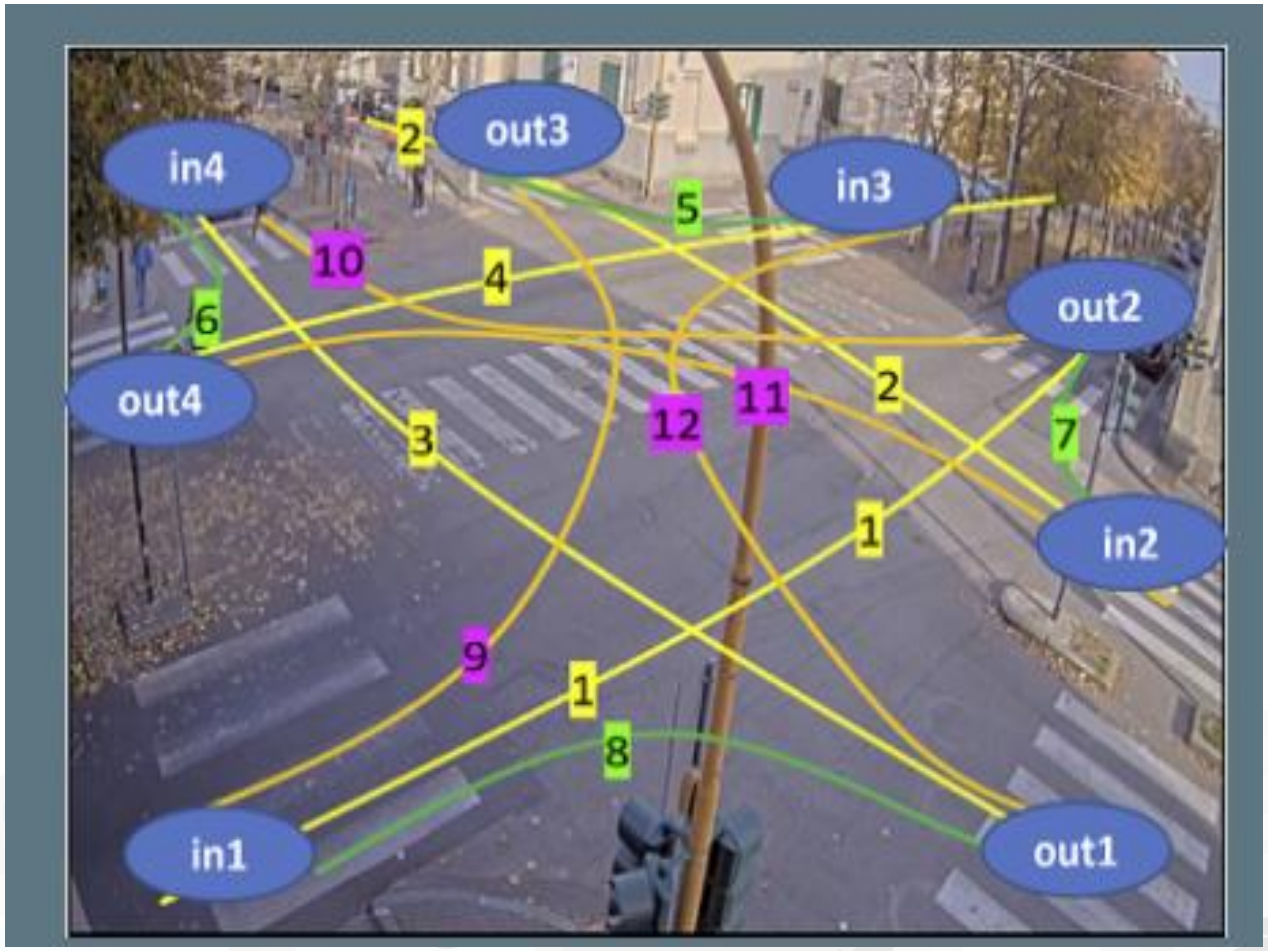
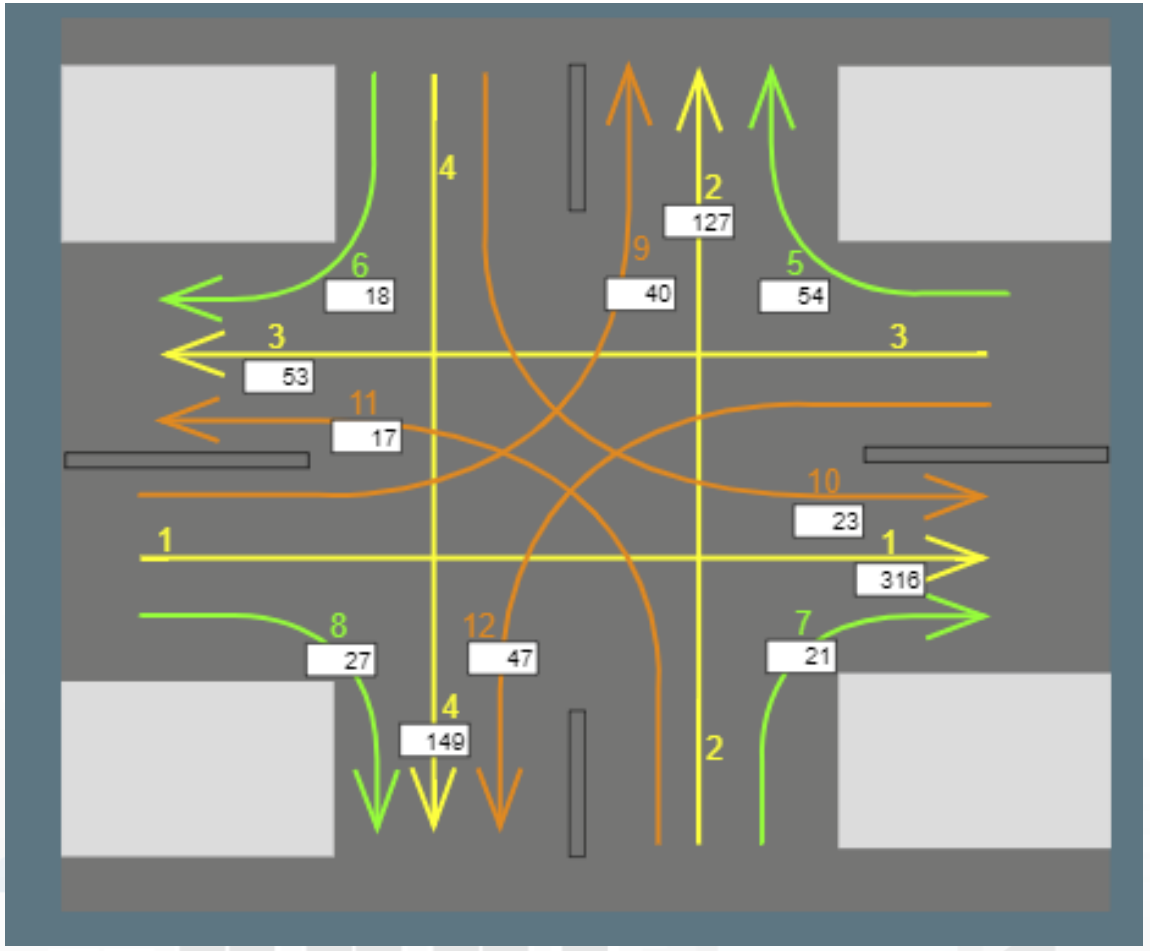
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTc5NQ==



Real time Clustering: legenda and synoptic



Legenda

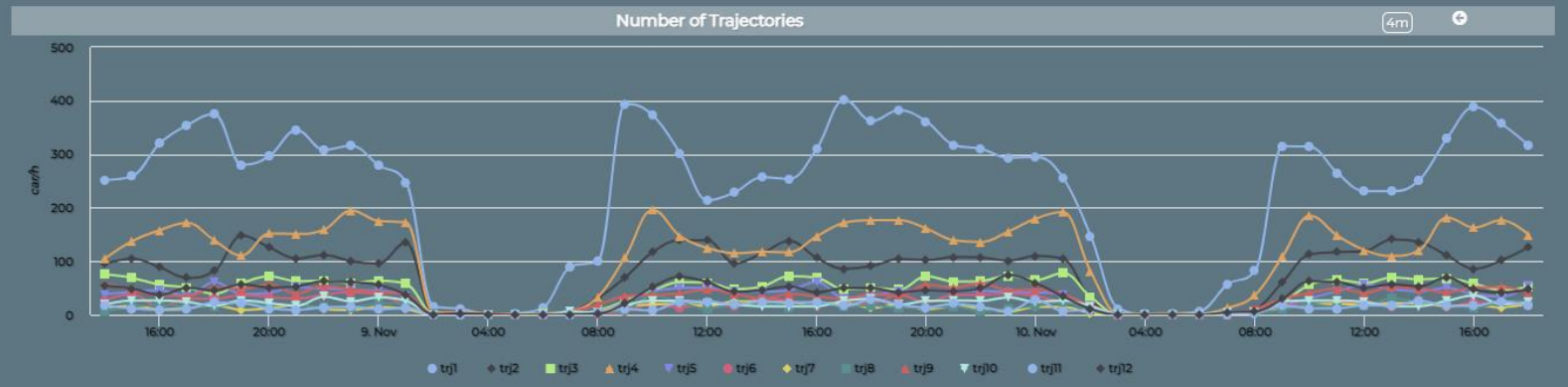


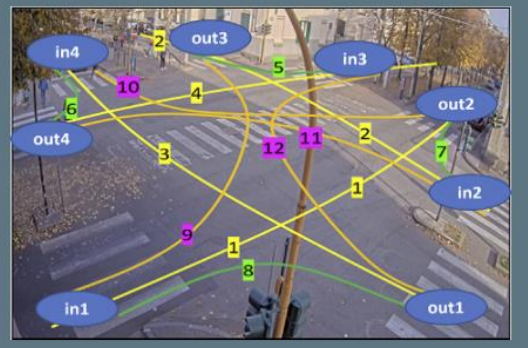
Synoptic with real time data

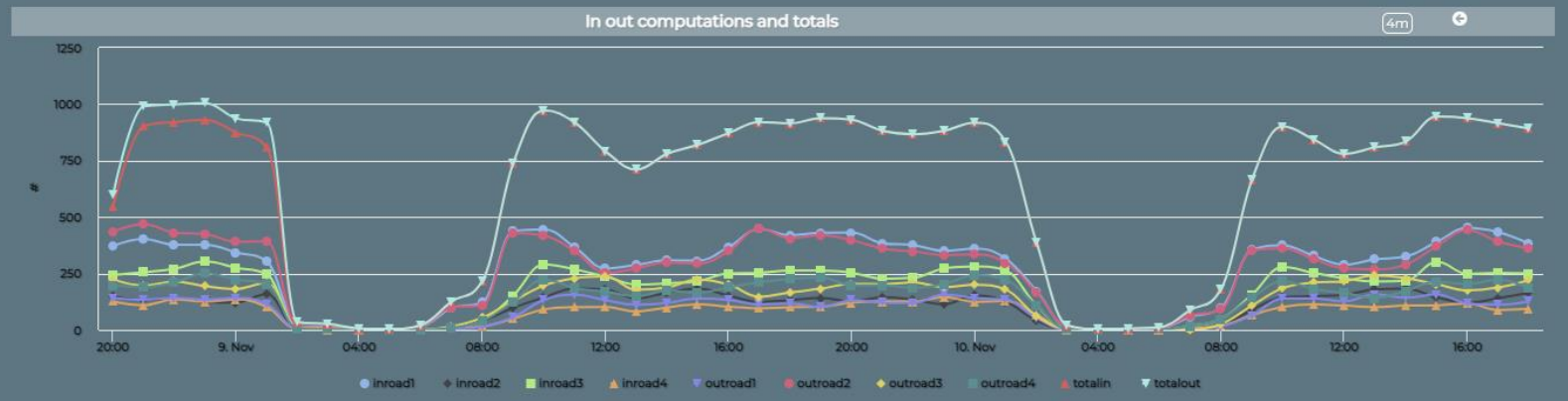
Venaria Reale

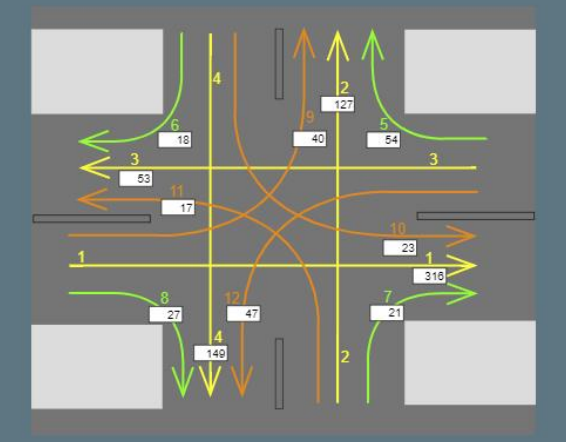
Monitoring Cross Road Venaria - (AXIS Camera)

Wed 10 Nov 18:50:53









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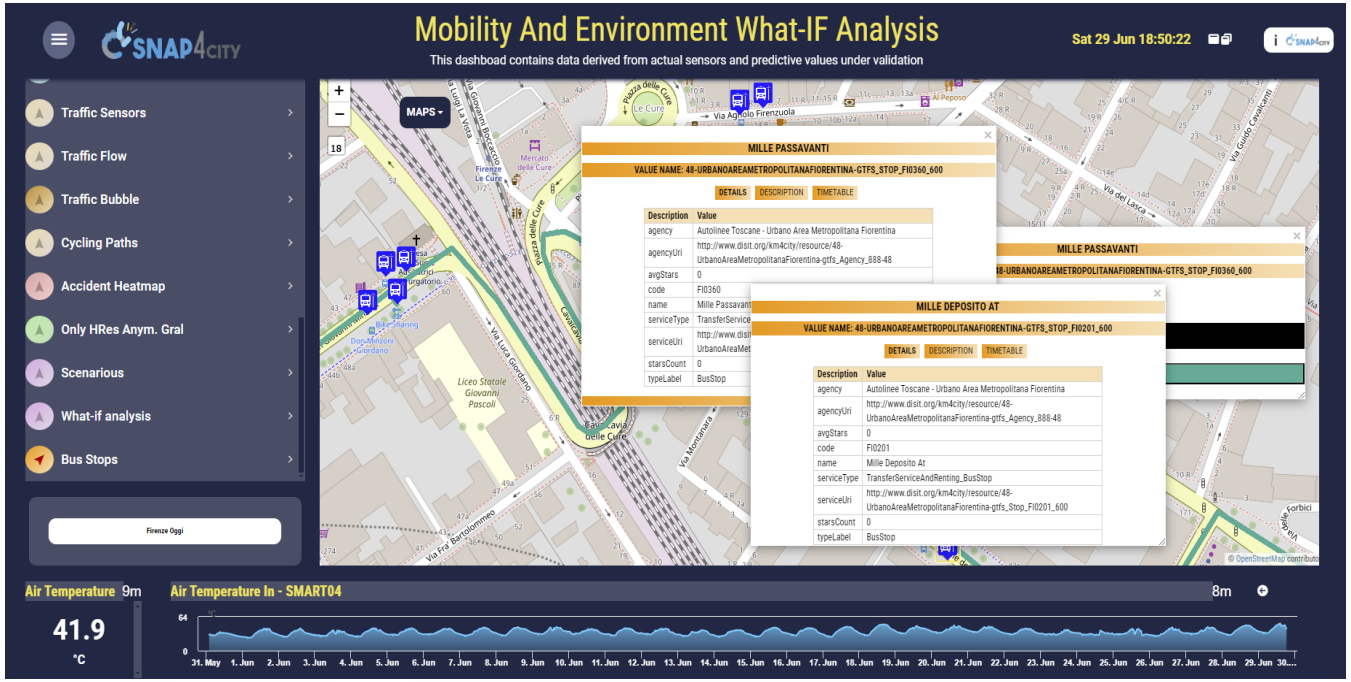
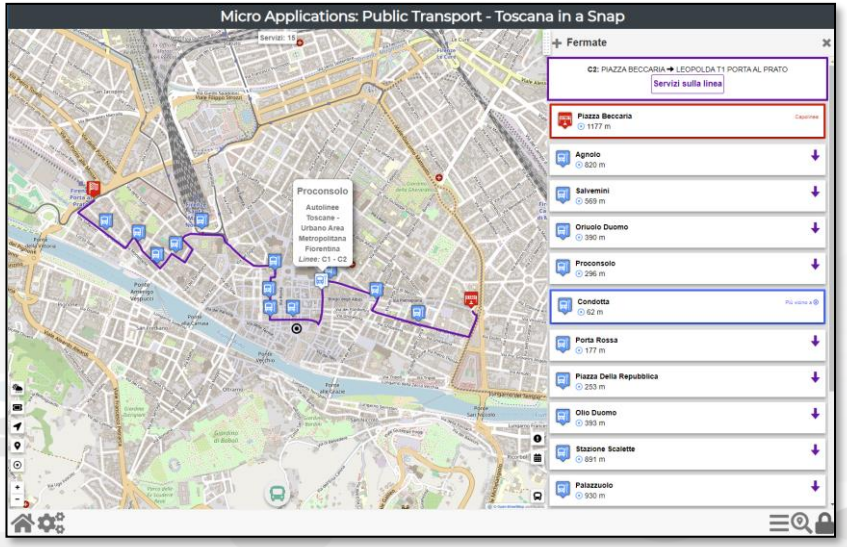
https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzI5Ng==

Transport Offer

Public Transport Offer

- Via
  - Dashboards
  - MicroApplications
  - Mobile Apps
  - ServiceMap



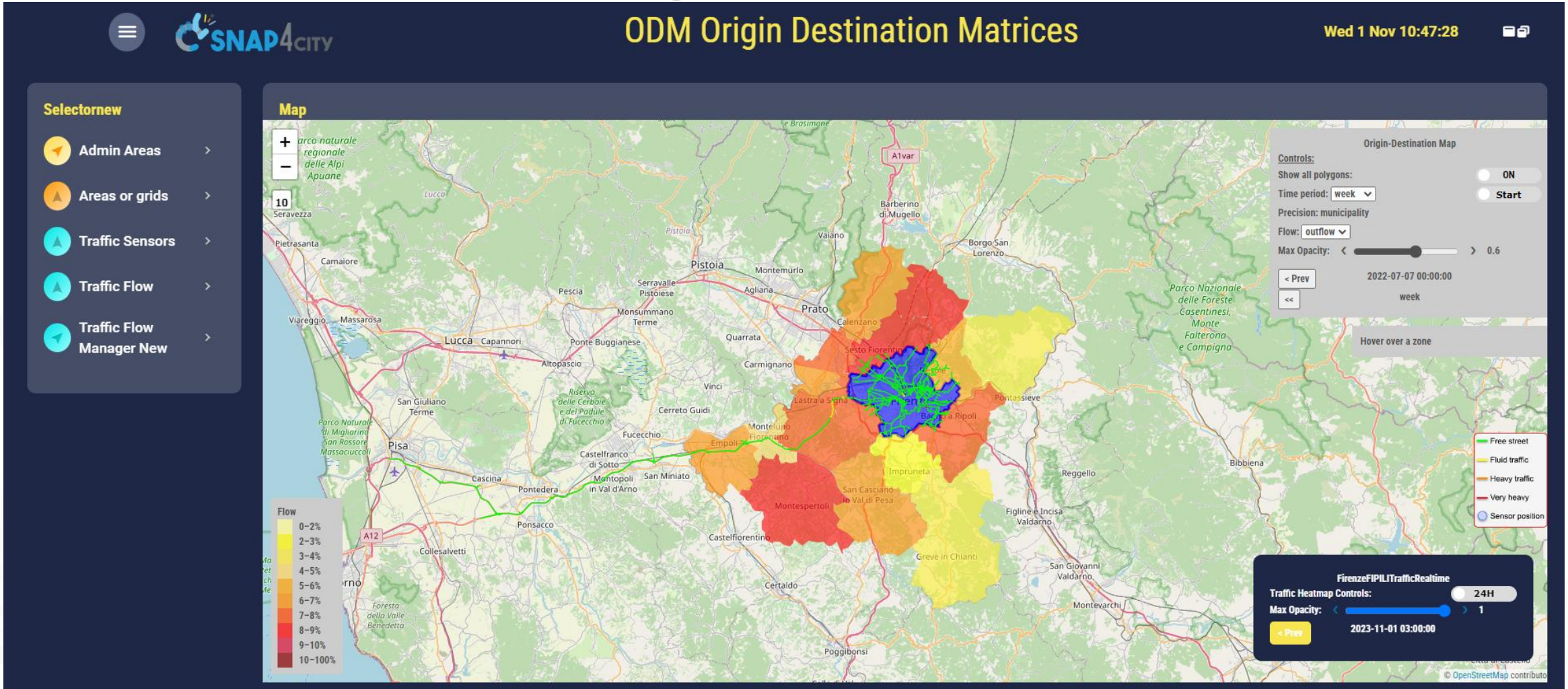


Public Transport Information/file/streams

- **Other sources as ODM and POI: parking, sharing, etc.**
- **Models used for**: busses, train, ferry, metro, tramways, etc.
- **Include**:
  - Public Transport Lines, Rides with paths and timeline, stops, polylines for paths, etc.
  - real time data about the position of the vehicles: train, busses, etc.
  - Multi operator data
- **Information is modelled as**
  - **GTSF** format: multiple files in XML
  - **Transmodel** format
  - **Netex** format
- **GTSF files can be ingested on Snap4City via**
  - **Python** which takes GTFS files and convert them in triples «.n3» file for the Knowledge Base
    - https://github.com/disit/smart-city-etl/tree/master/TrasformazioneTPLBus_new_model/Triplification/Models
    - Former version: https://www.snap4city.org/download/snap4cityETL/TPL_bus_gtfs/
  - **GTFS RT can be ingested via IoT App and sent to the Broker**
  - **Chouette** and then
    - using a Python developed by **Snap4City to converter** to produce Triples for the Knowledge Base, service map
    - https://github.com/disit/snap4city/blob/master/Snap4CityGTFS/chouette-gtfs-n3.py
- **Transmodel (EN12896) or Neptune files can be ingested in Snap4City via**
  - **Chouette** and then, with a certain level of adaptation,
    - using a Python developed by **Snap4City to converter** to produce Triples for the Knowledge Base, service map
    - https://github.com/disit/snap4city/blob/master/Snap4CityGTFS/chouette-gtfs-n3.py

Origin Destination Matrices

ODM, Traffic Flow



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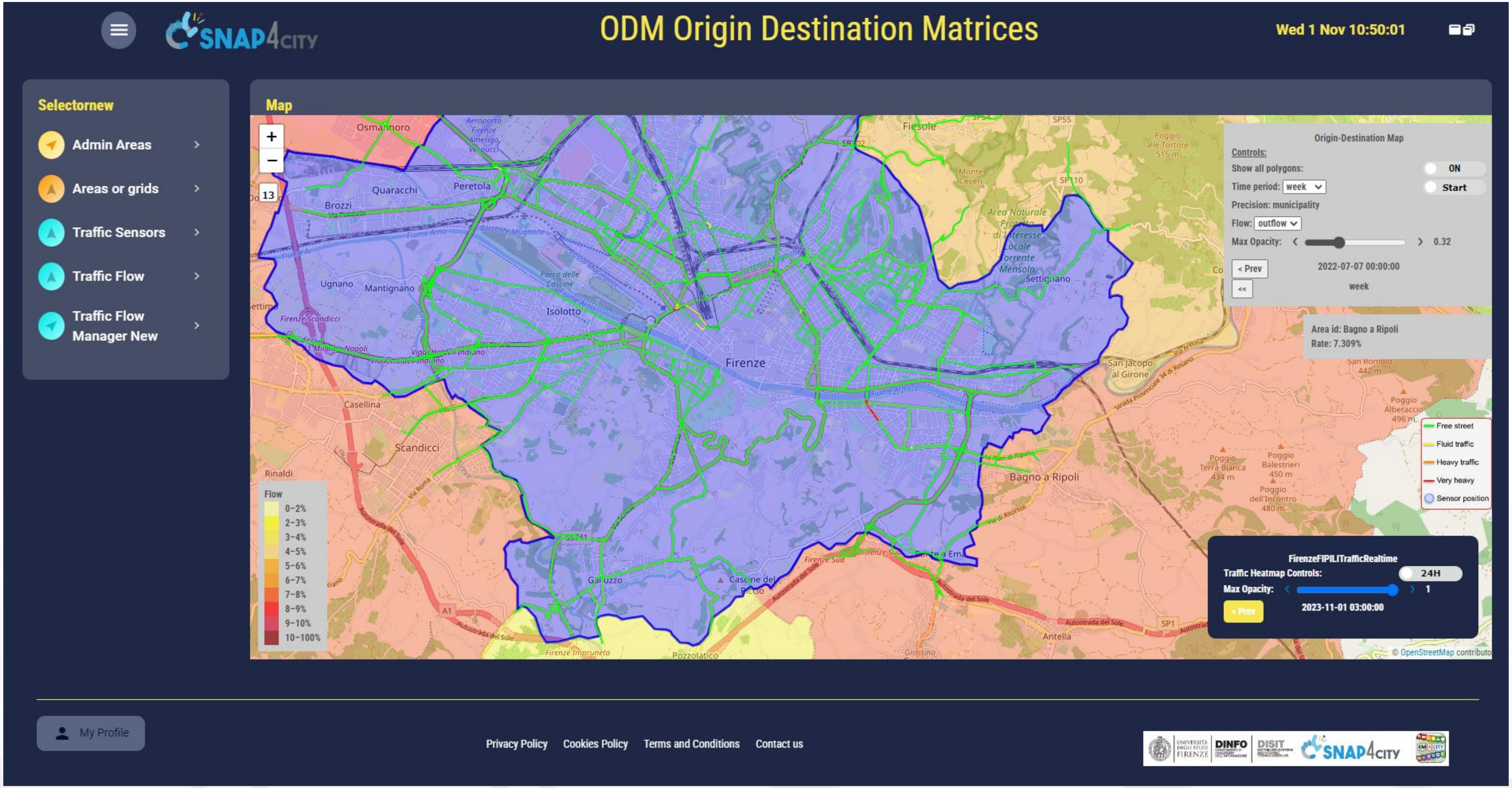
ODM Origin Destination Matrices
Wed 1 Nov 10:50:01
Selectornew
Admin Areas
Areas or grids
Traffic Sensors
Traffic Flow
Traffic Flow Manager New
Map
Origin-Destination Map
Controls:
Show all polygons:
ON
Time period:
week
Start
Precision: municipality
Flow:
outflow
Max Opacity:
0.32
< Prev
<<
2022-07-07 00:00:00
week
Area id: Bagno a Ripoli
Rate: 7.309%
Flow
0-2%
2-3%
3-4%
4-5%
5-6%
6-7%
7-8%
8-9%
9-10%
10-100%
Free street
Fluid traffic
Heavy traffic
Very heavy
Sensor position
FirenzeFIPILITrafficRealtime
Traffic Heatmap Controls:
24H
Max Opacity:
1
2023-11-01 03:00:00
Firenze
Bagno a Ripoli
Scandicci
Fiesole
Settignano
Galluzzo
Isolotto
Peretola
Quaracchi
Brozzi
Ugnano
Mantignano
Casellina
Antella
My Profile
Privacy Policy
Cookies Policy
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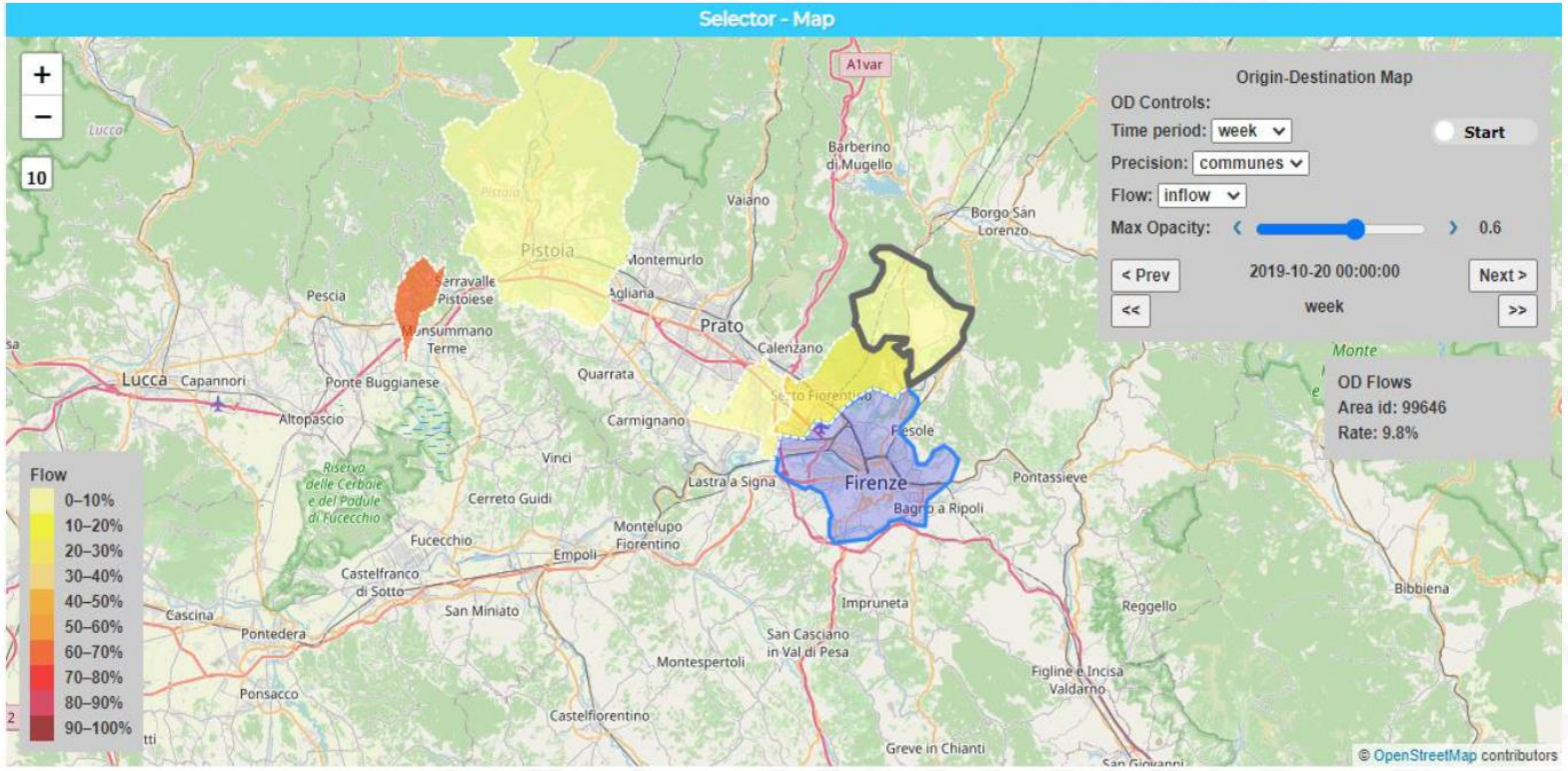
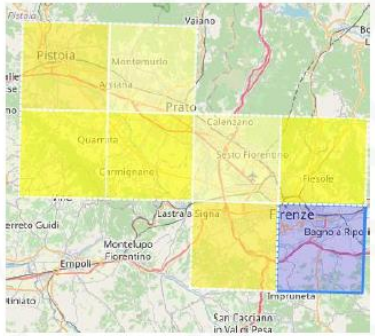
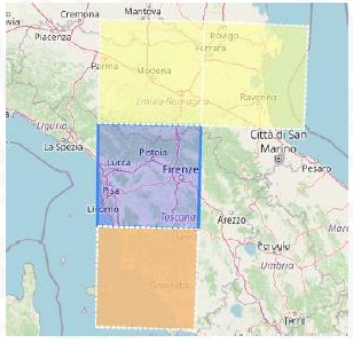
Different Origin Destination Matrices





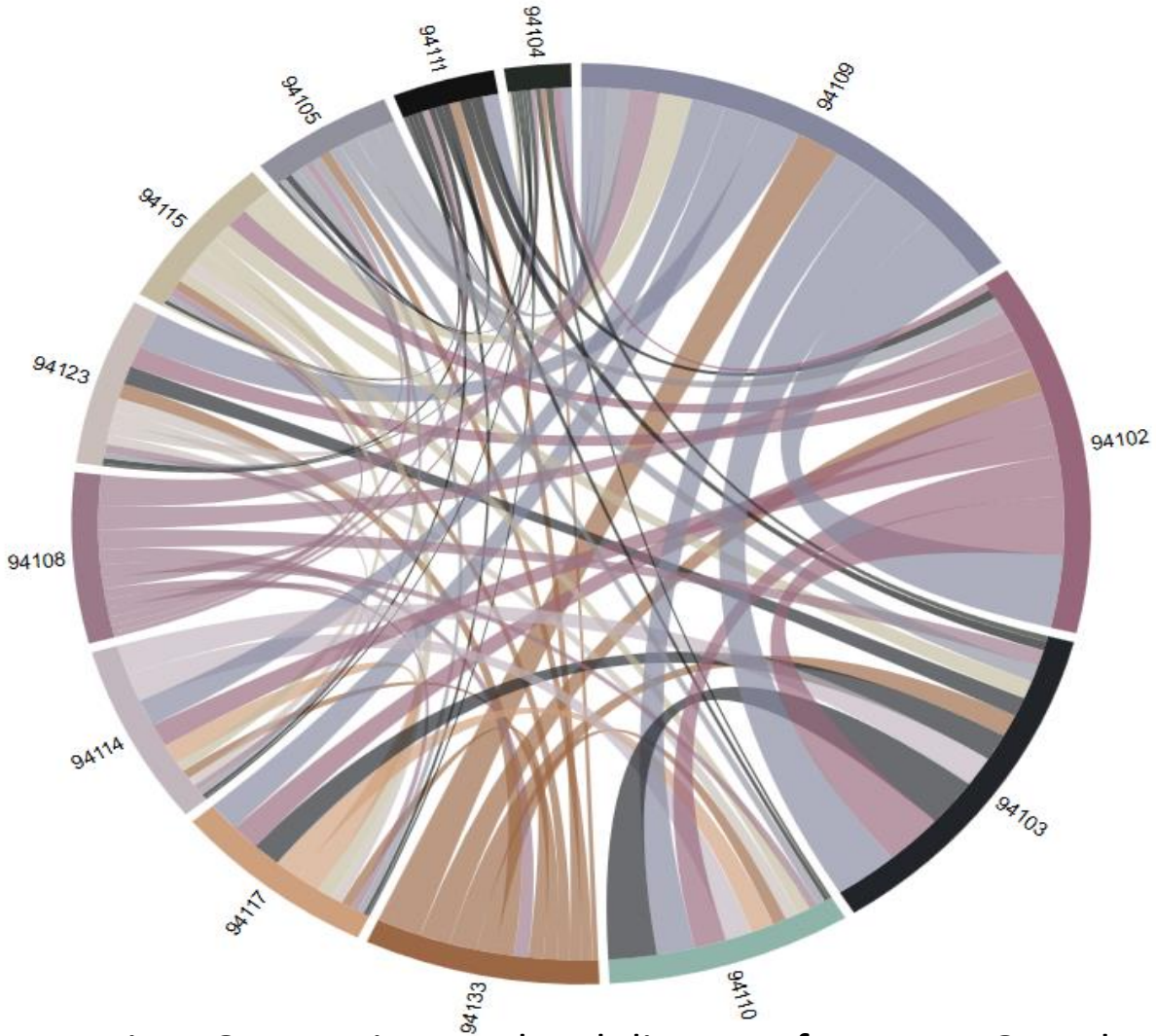


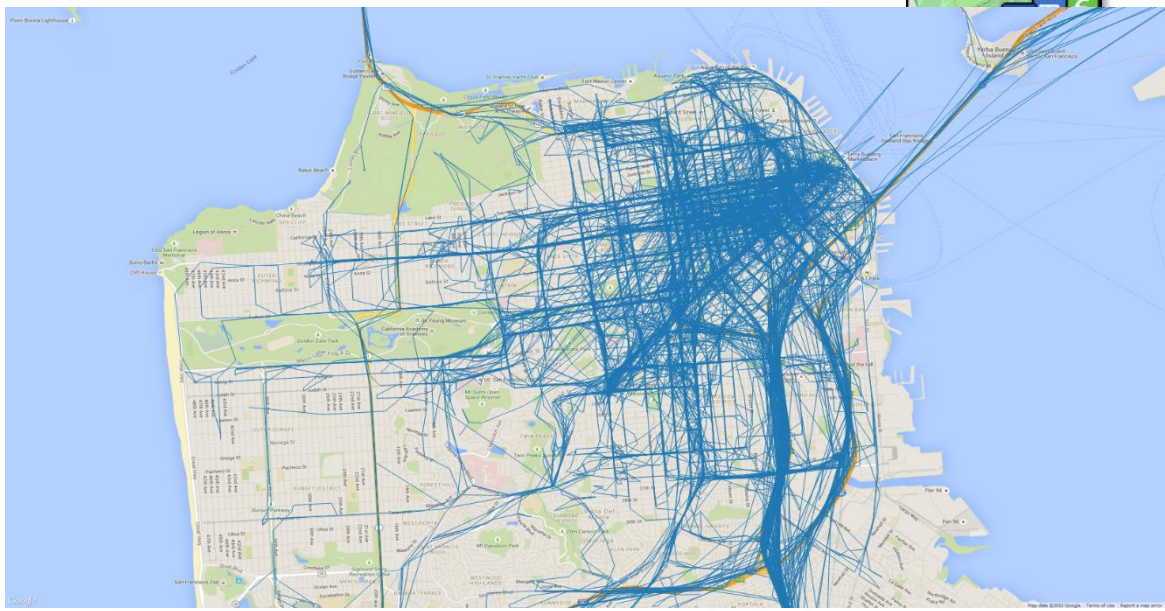
- **Get specific value**
- **Time window**
- **Opacity**
- **Animation**
- **Inflow/outflow**
- **Sequence of OD matrices: next/prev**

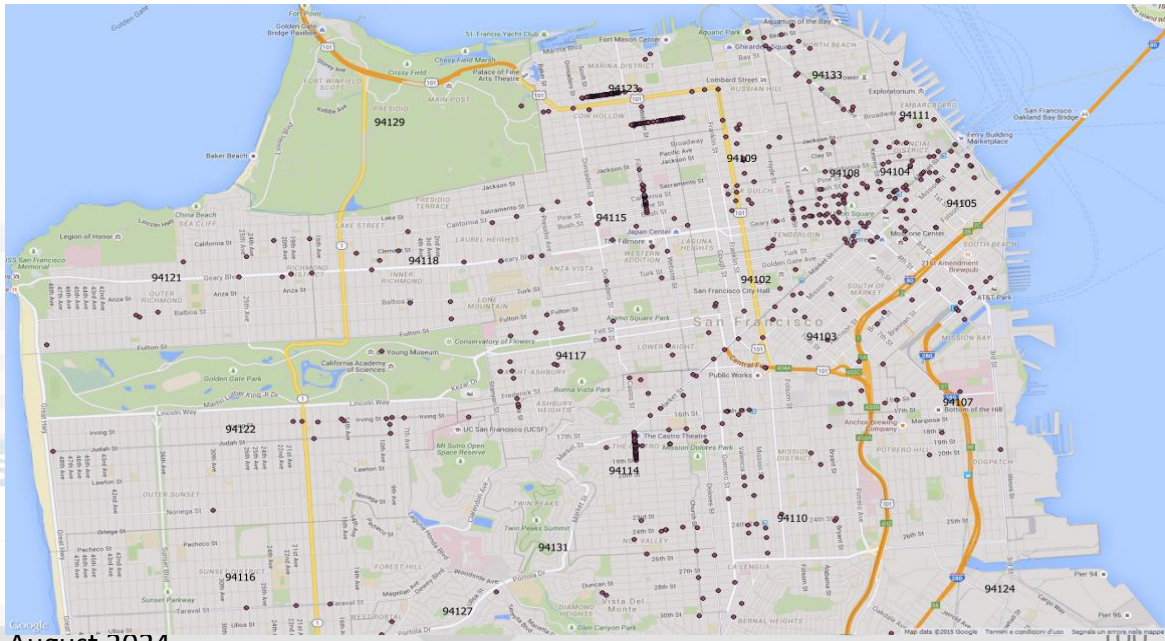
shapes

- **Shapes**: city, region, territories, etc.
  - GADM https://gadm.org/ , and ACE
- **Squared** MGRS:
  - 1m, 10m, 100m, **1Km, 10Km, 100Km**

San Francisco



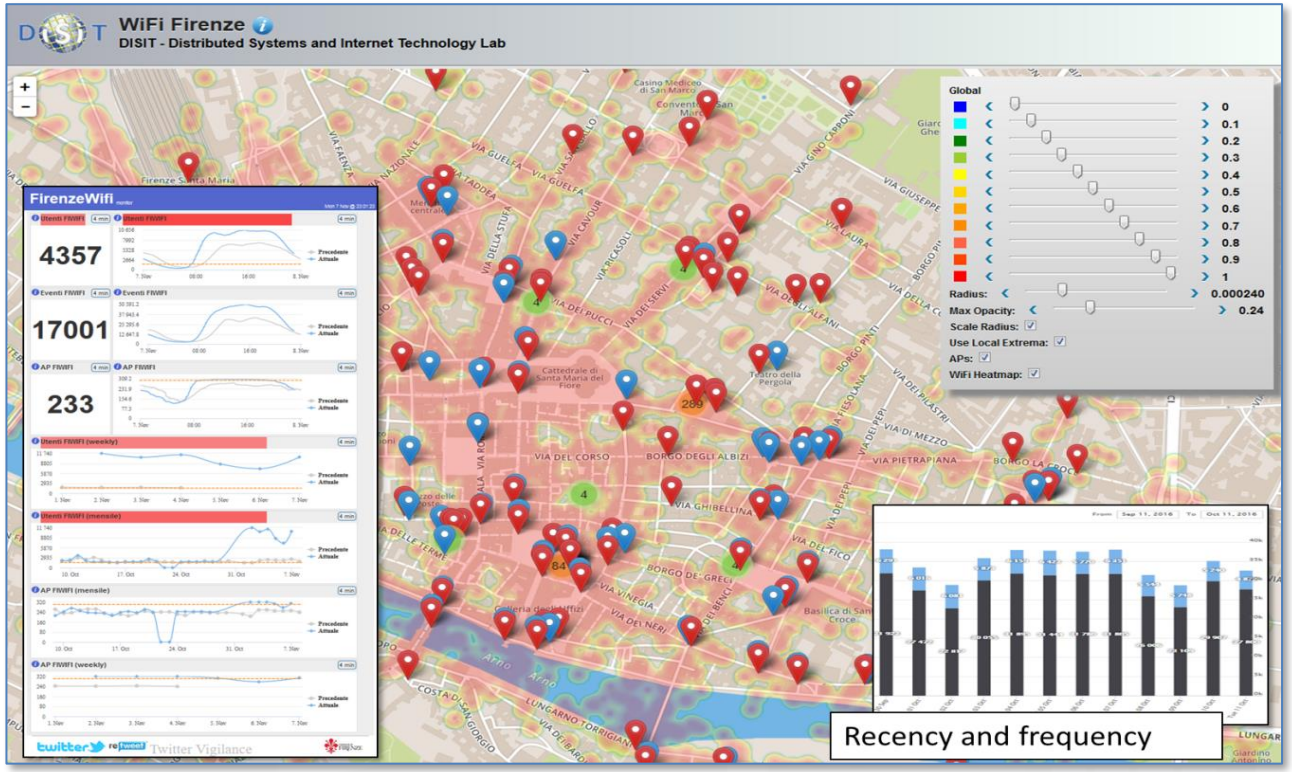


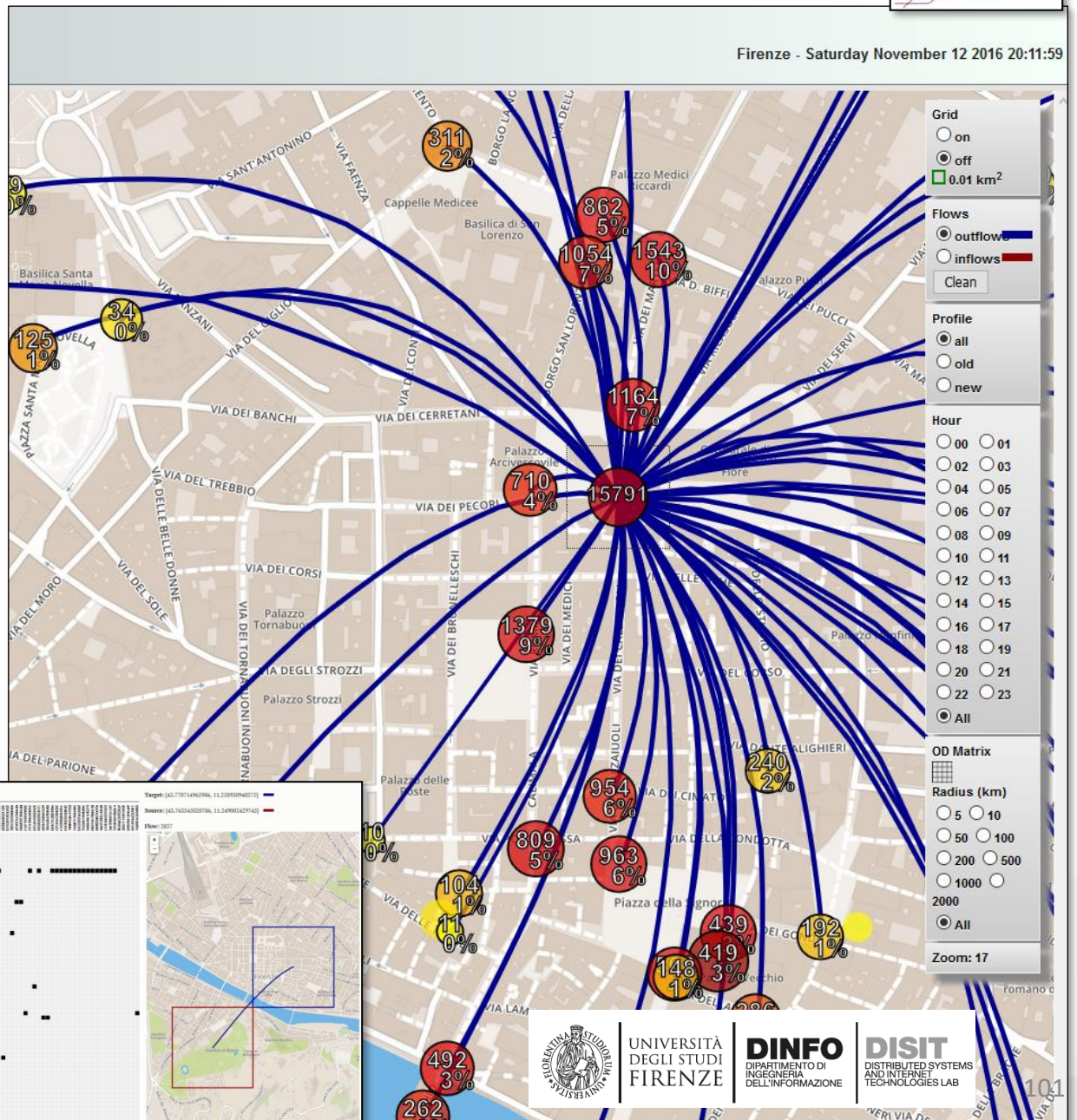


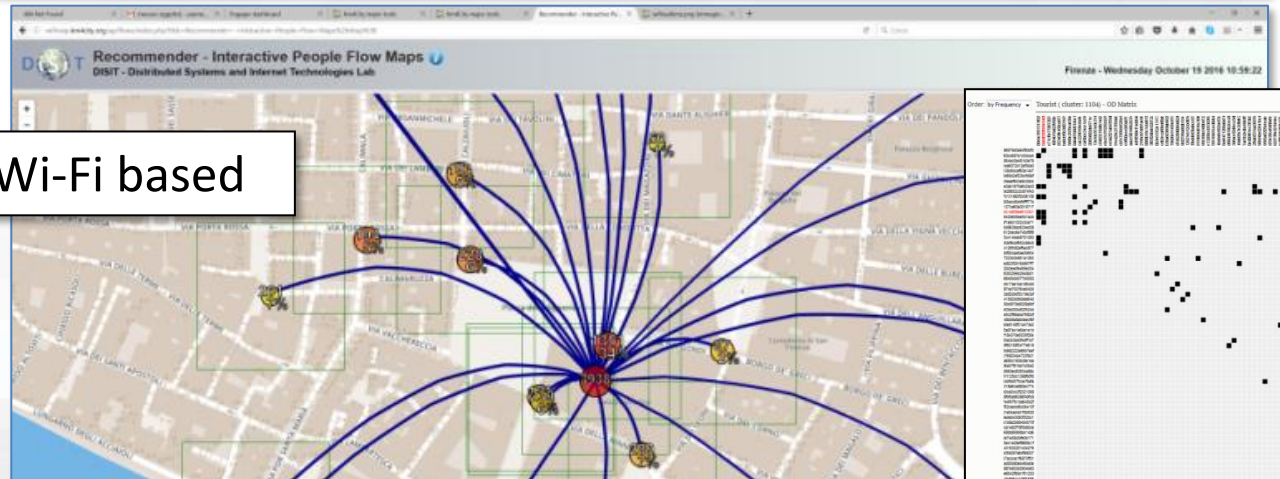
San Francisco OD matrix as a chord diagram, from TAXI OBU data

- 13 central ZIP areas of the city (real cab flows),
- ONLY on FLOW: from to

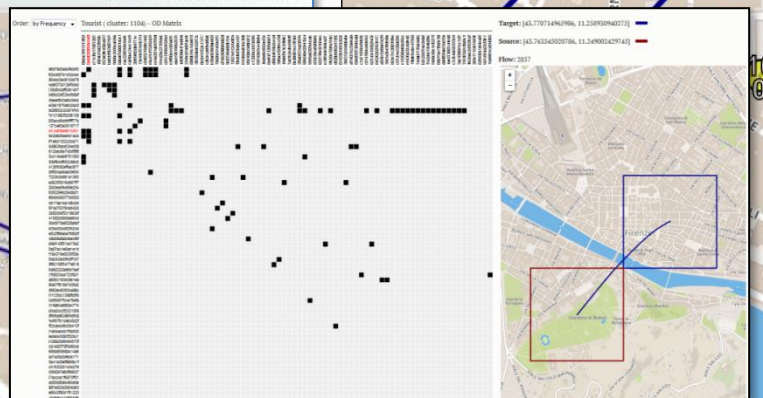
Origin Destination Matrix Estimation



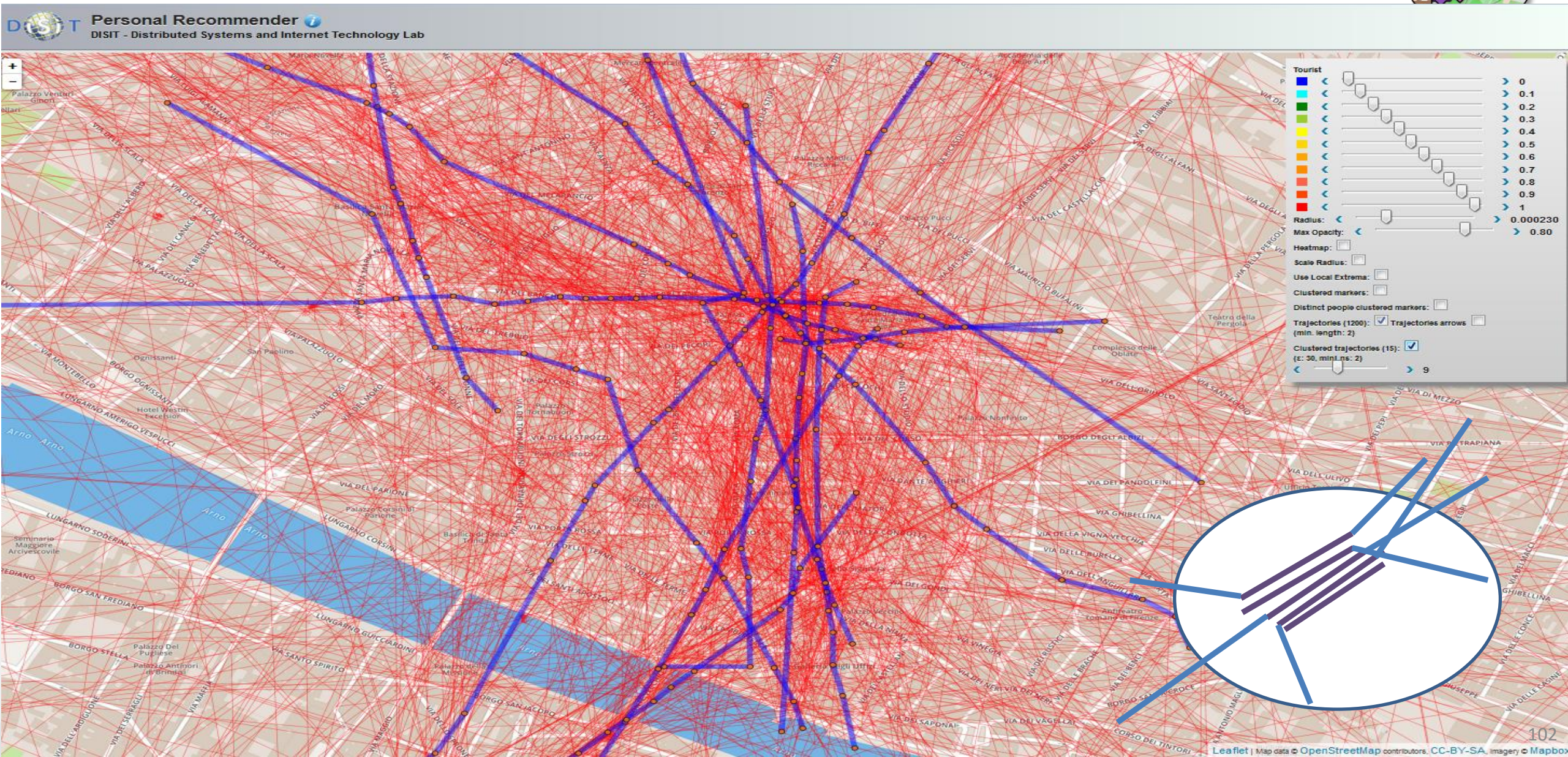




Wi-Fi based



Cluster di Trajectories



Smart Parking

11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

Data Analytic

Smart Parking

- **Main features**
  - On-road and off-road, multiple sensors kinds
  - Profiled parking slots: regular, residential, disable, charging, forbidden, etc.
  - Multiple: areas, cities, and business models/profiles
  - Multiple payment modalities and wallets
  - User profiling and models
  - Fine detection and management, overparking, etc.
- **Mobile App** for City Users and on road Operators
- **Smart Parking Manager**: operator controller and notifications to on-road operators

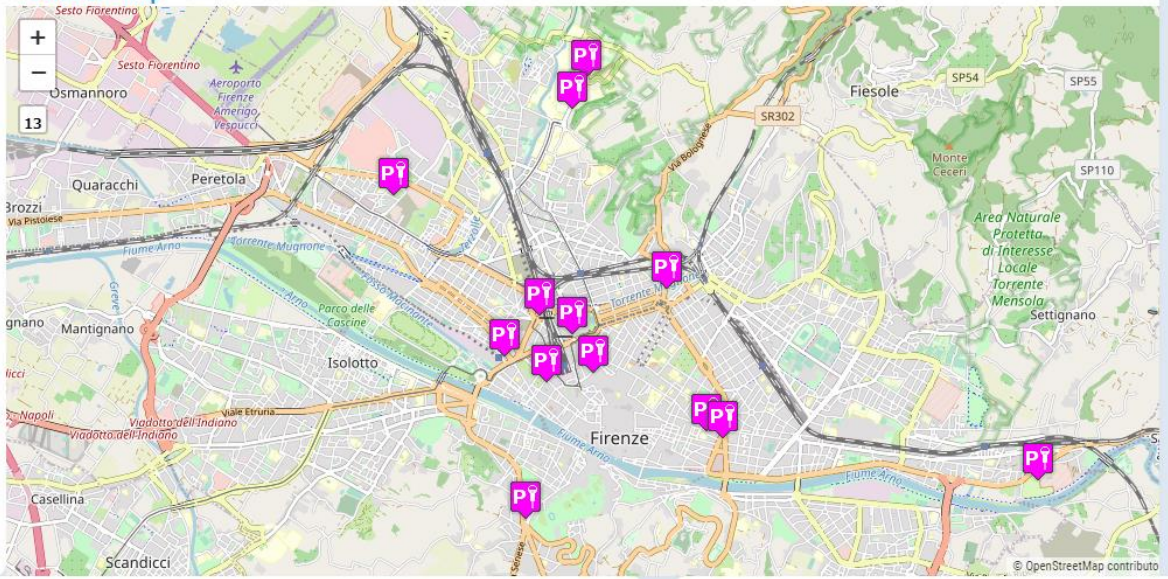
Monitoraggio Parcheggi

Sat 13 May 23:26:20

Selector

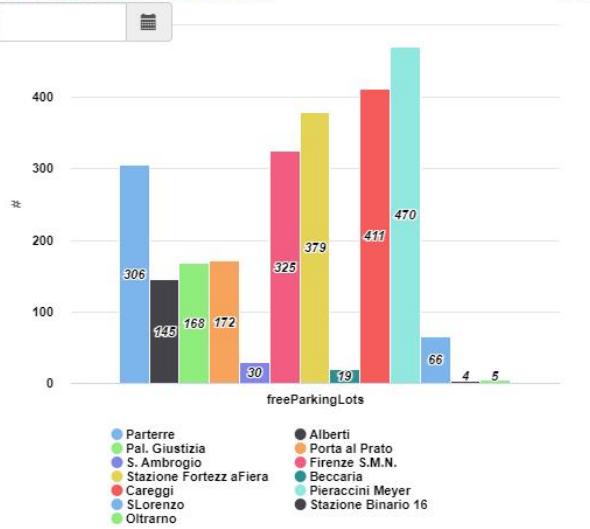
- Parterre
- Piazza Alberti
- Palazzo di.Giustizia
- Porta al Prato
- S. Ambrogio
- Stazione Firenze S.M.N.
- Stazione Fortezza Fiera
- Piazza Beccaria

Selector - Map



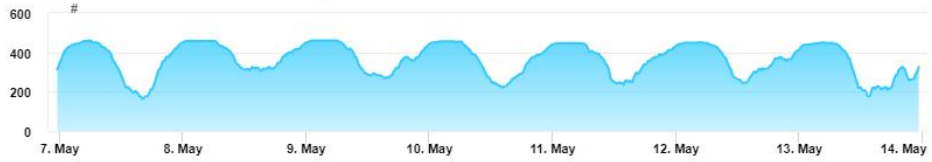
Parcheggi: Numero Posti Liberi

4m



StazioneFirenzeS.M.N. - FreeParkingLots

9m



Andamento Posti Occupati

4m

My Profile

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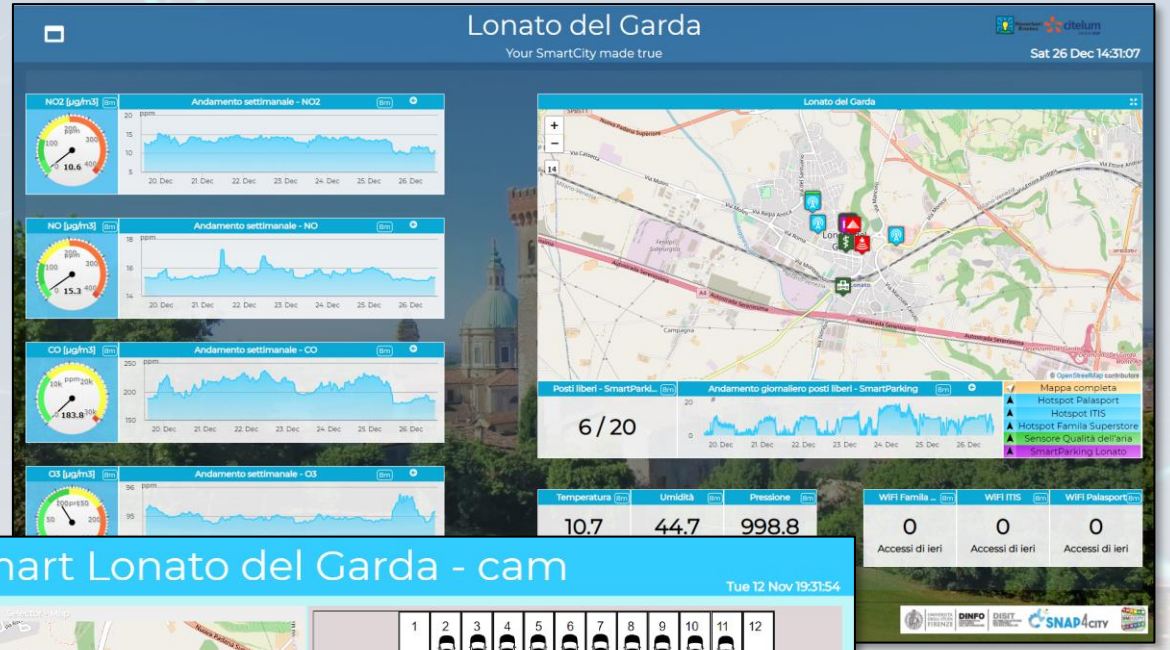
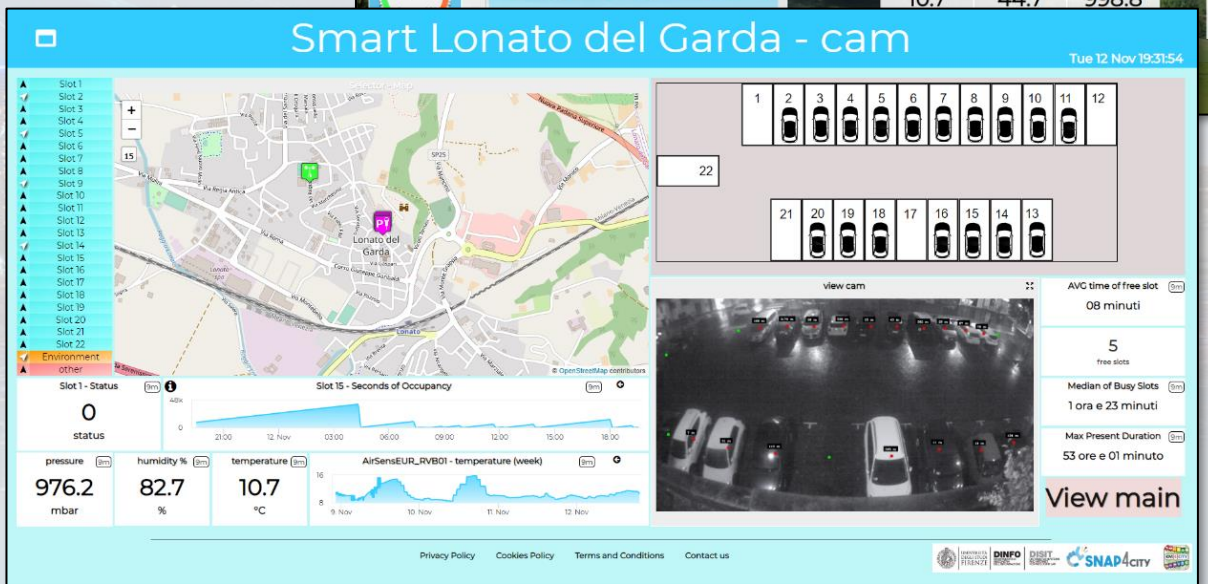
Smart City / Smart Parking + Environment Reverberi, Lonato del Garda

reference

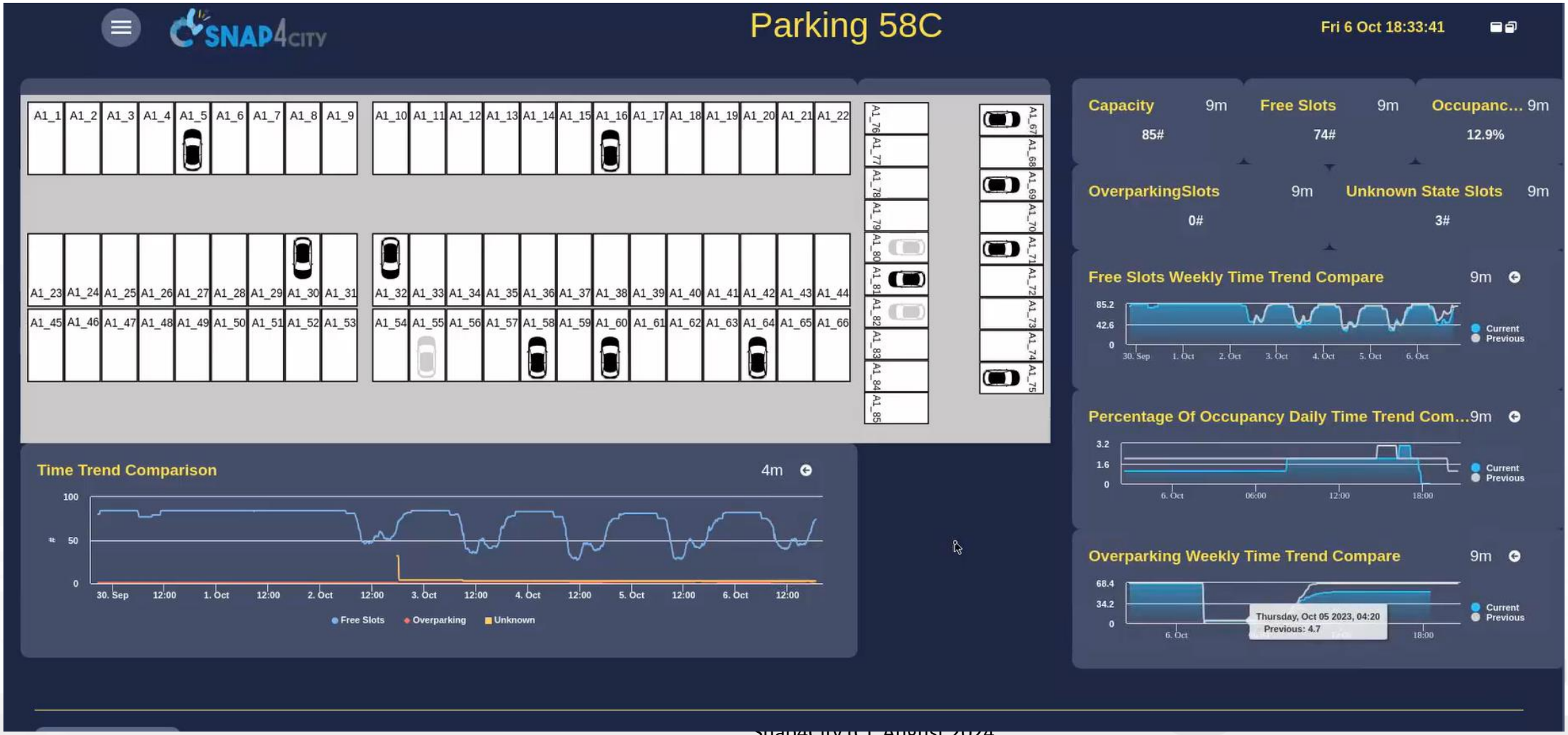
- **Multiple Domain Data**
  - Smart Parking, Environment, Wi-Fi
- **Multiple Decision Makers**
  - City Officer, operators
  - Data monitoring, alerting
  - analytics
- **Historical and Real Time data**
  - Dashboards
- **Services Exploited on:**
  - Dashboards, API
- **Since 2019**



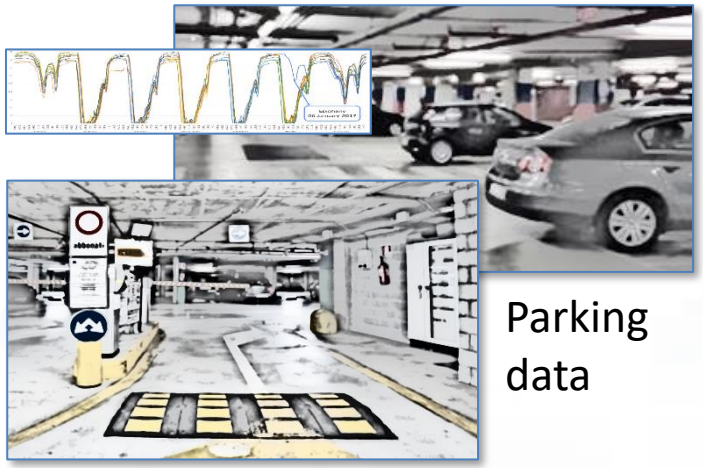


11 SUSTAINABLE CITIES AND COMMUNITIES

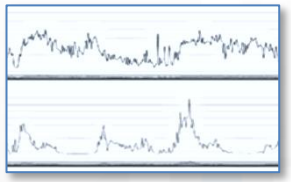
Snap4ISPRA Parking



Deep Learning AI to surely Park!

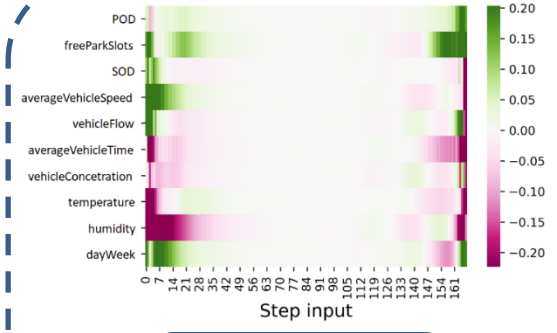


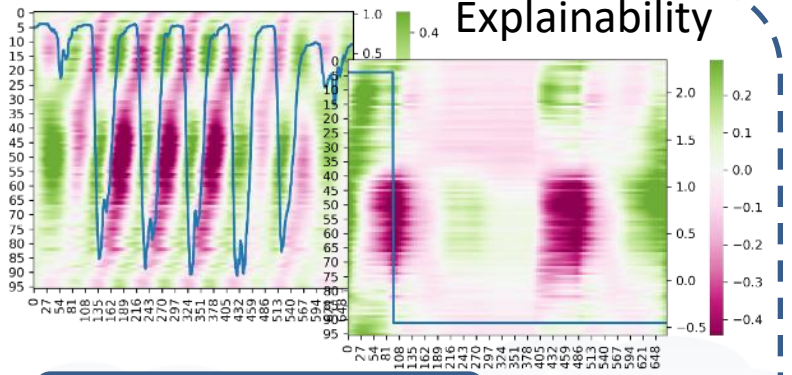
Parking data



Traffic sensors data

Weather Features

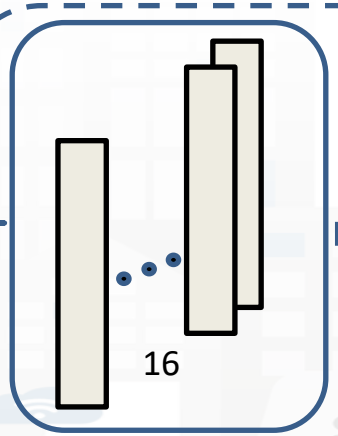


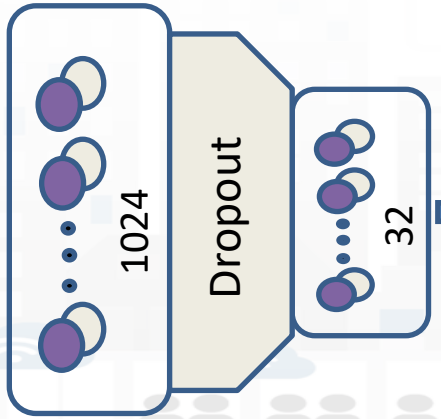


Explainability

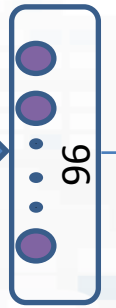
Gradient

Integrated Gradient

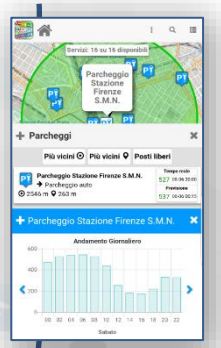




Dropout



Multi-step Predictions



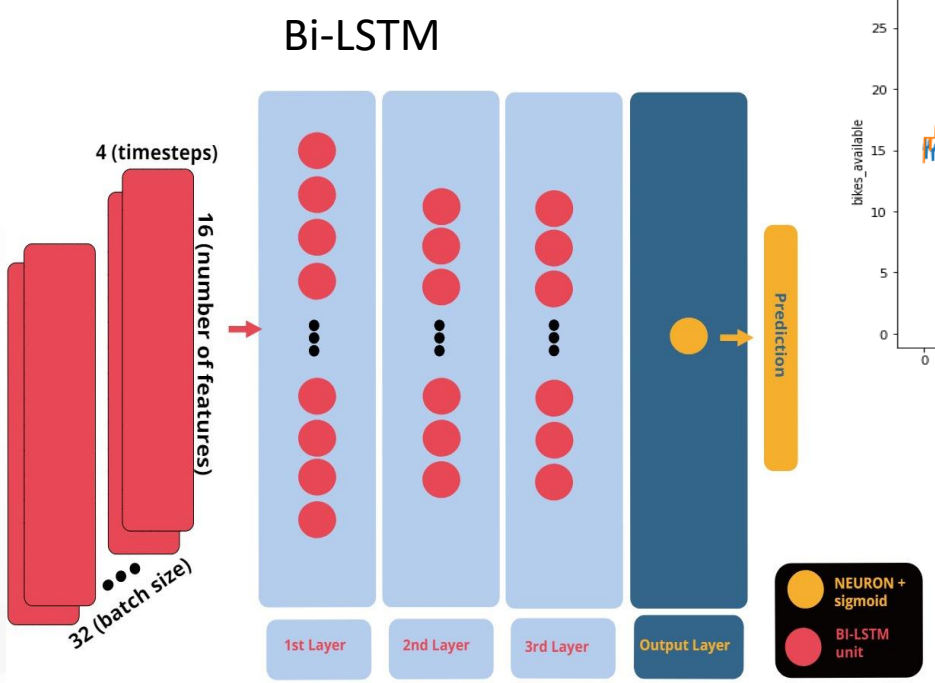
Conv1D+AvPooling1D BI-LSTM BI-LSTM Dense

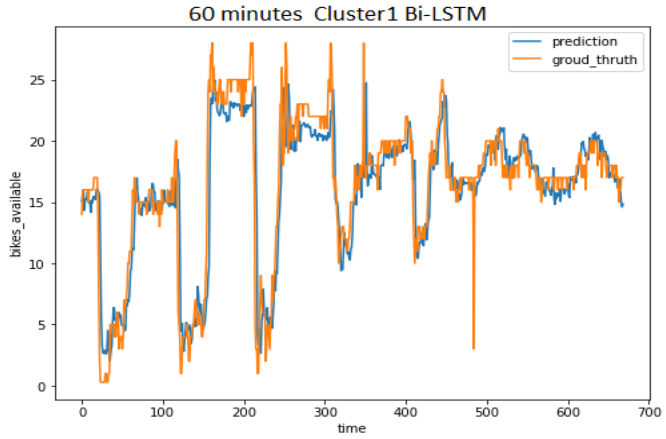
Smart Bike

Free Bike predictions

Data Analytic

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





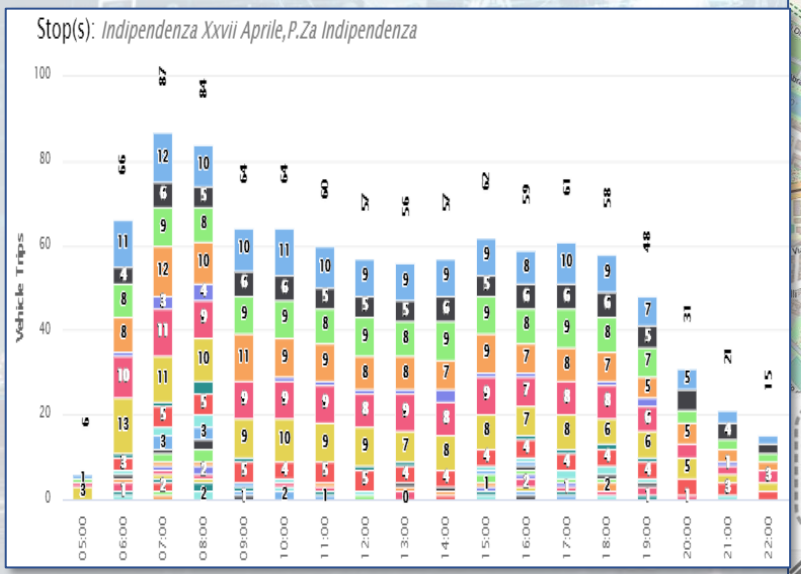
E. Collini, P. Nesi and G. Pantaleo, "Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations," in *IEEE Access*, vol. 9, pp. 124337-124347, 2021, doi: 10.1109/ACCESS.2021.3110794.
https://ieeexplore.ieee.org/abstract/document/9530580

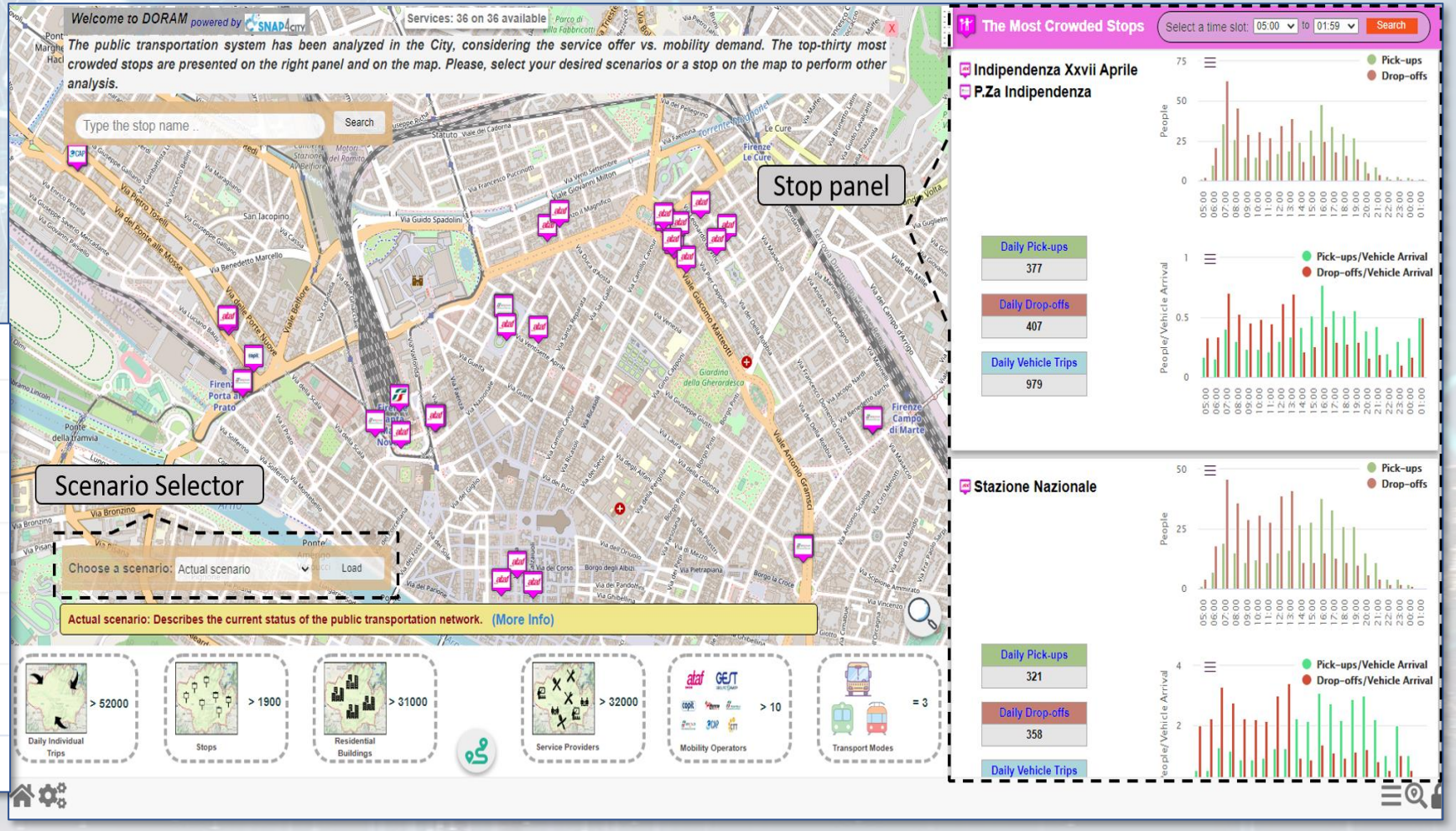
Public Transport Analysis

What-if Analysis on Pub Transport

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

Public Services





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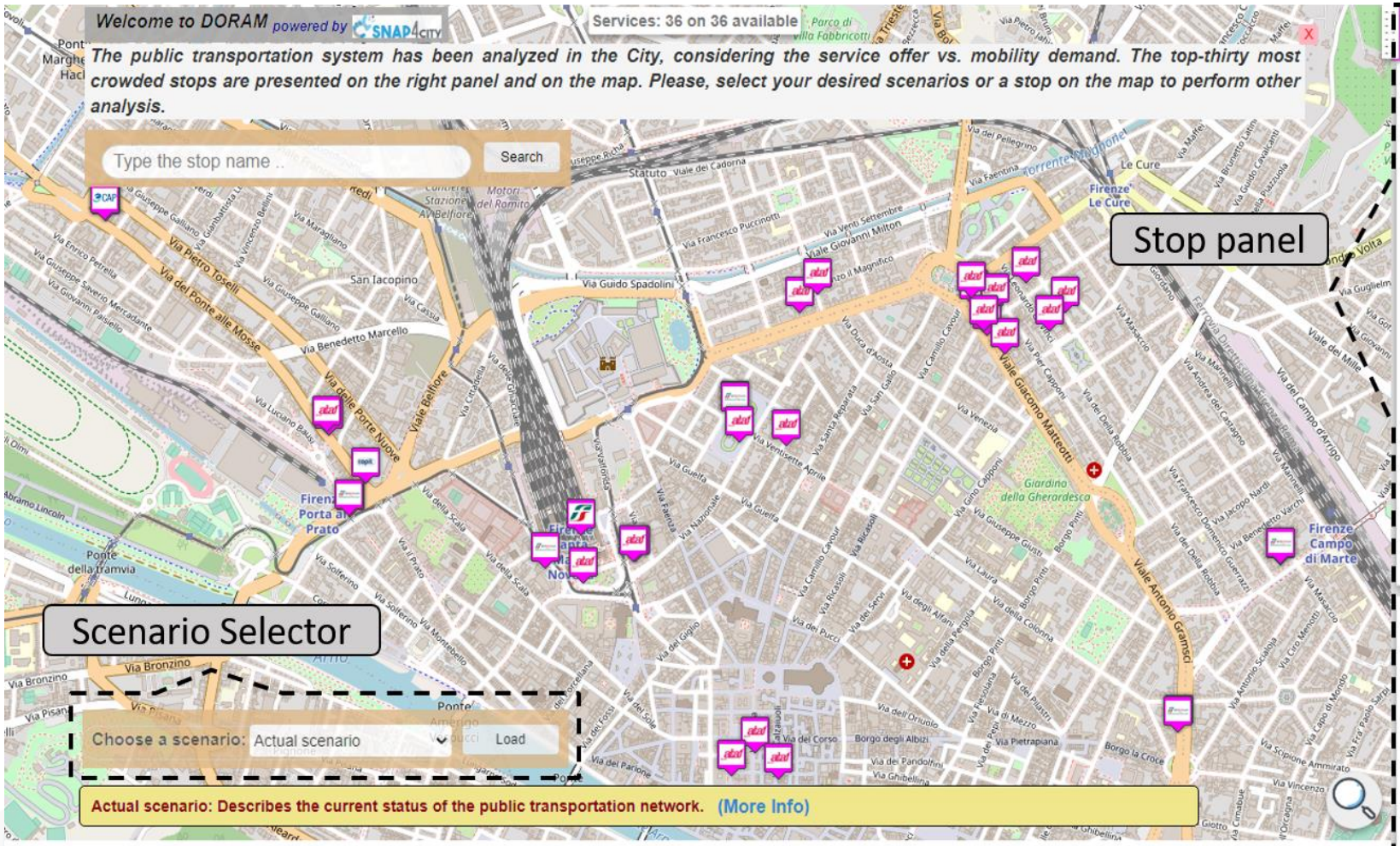
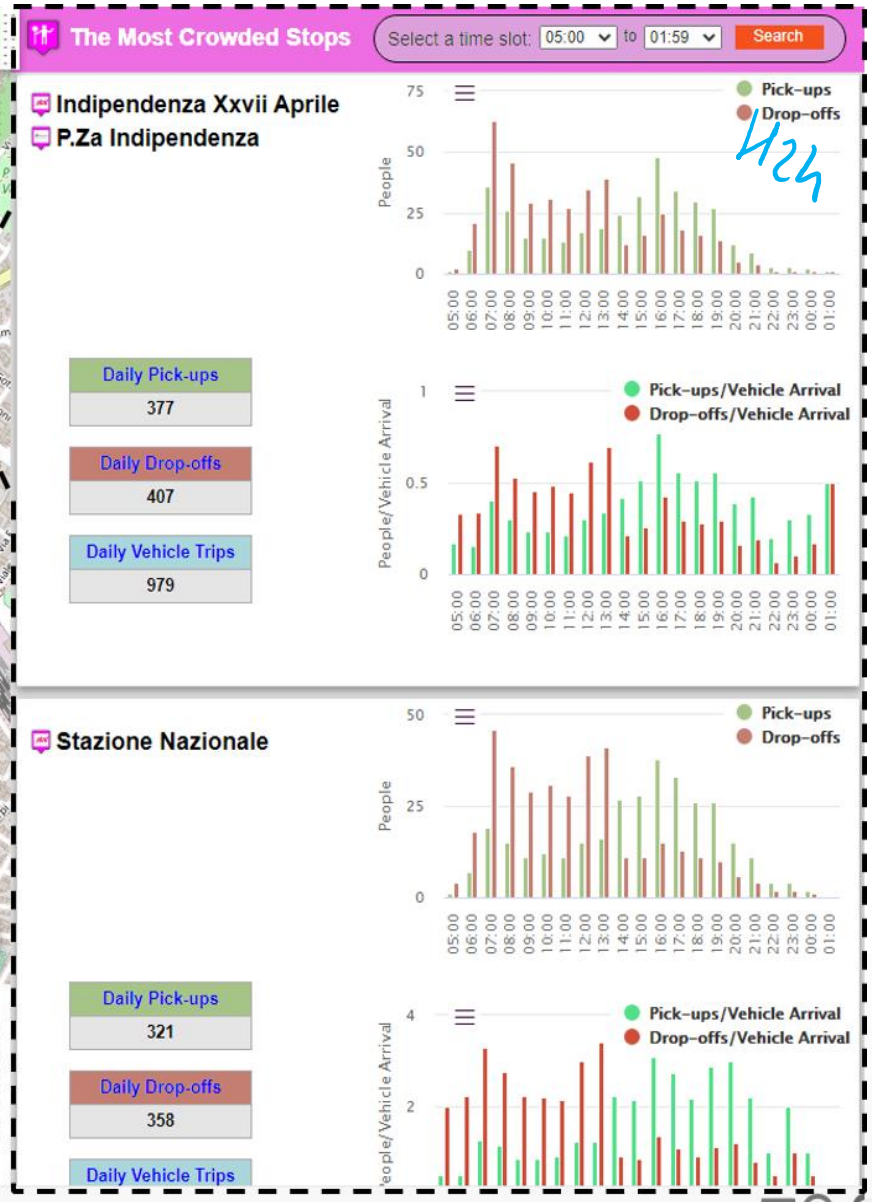
DORAM

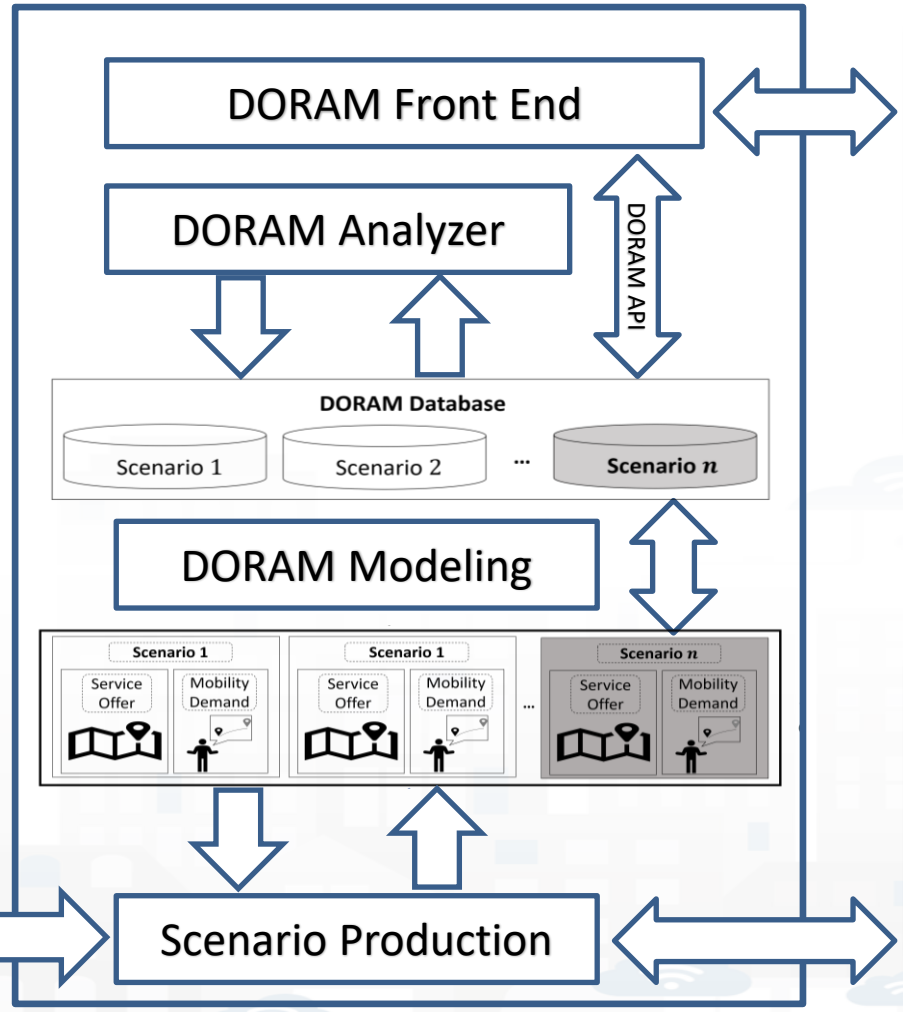
SNAP4CITY | KM 4 CITY

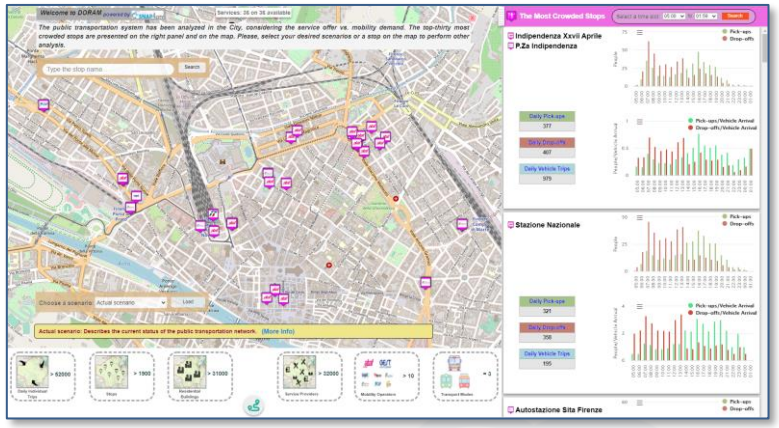




https://www.snap4city.org/odanalyzer/#b

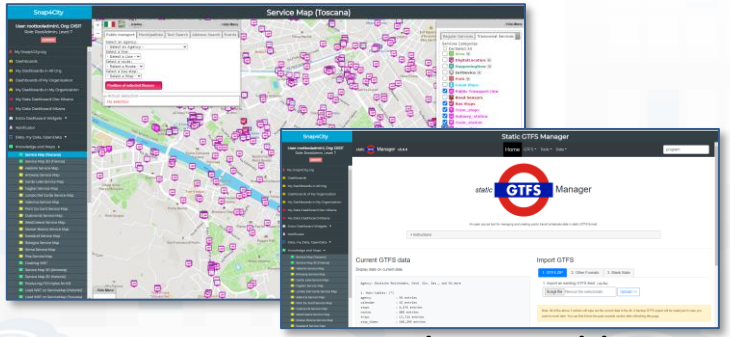
DORAM





DORAM tool

Snap4City tools for City data



GTFS Editor and browser

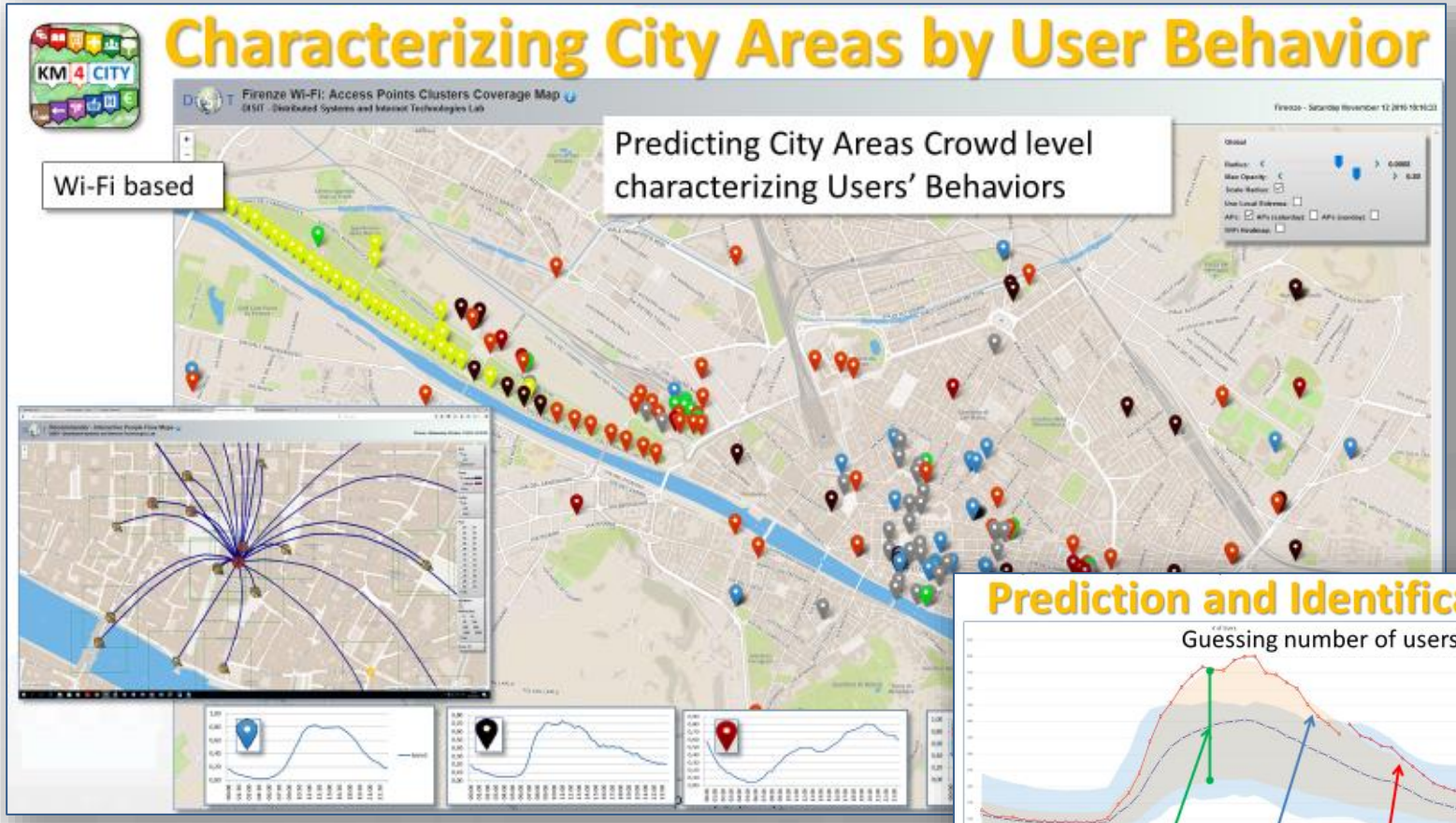
https://www.snap4city.org/odanalyzer/#b

User Behavior Analysis

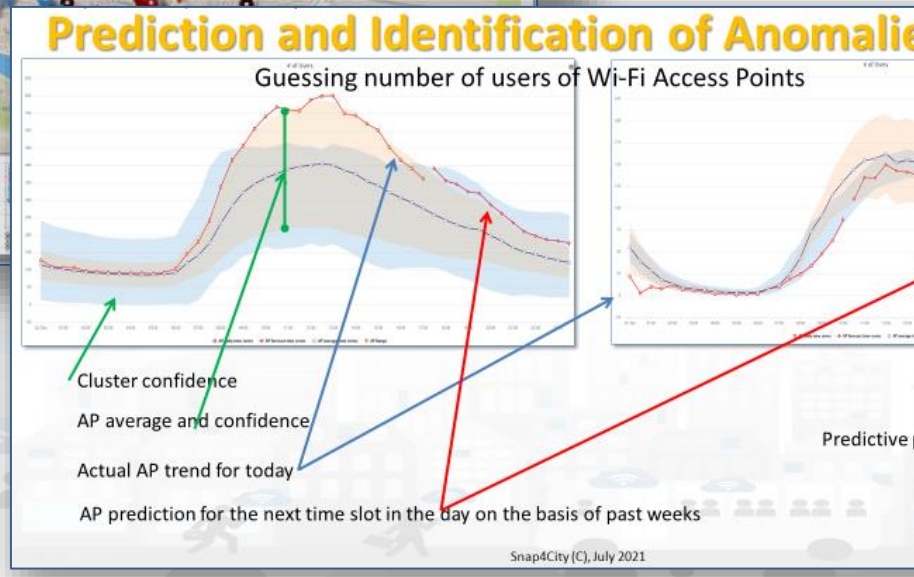
People Flows

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

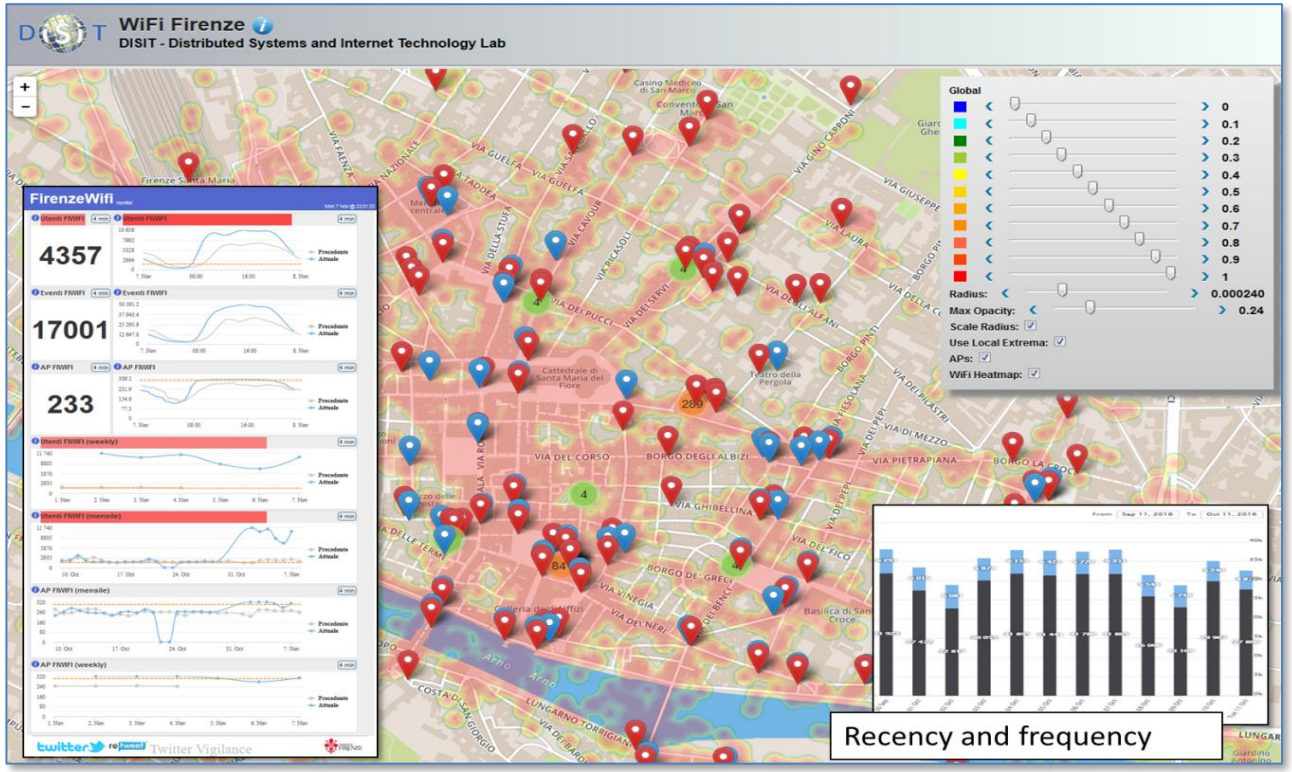
Characterizing City Areas by User Behavior

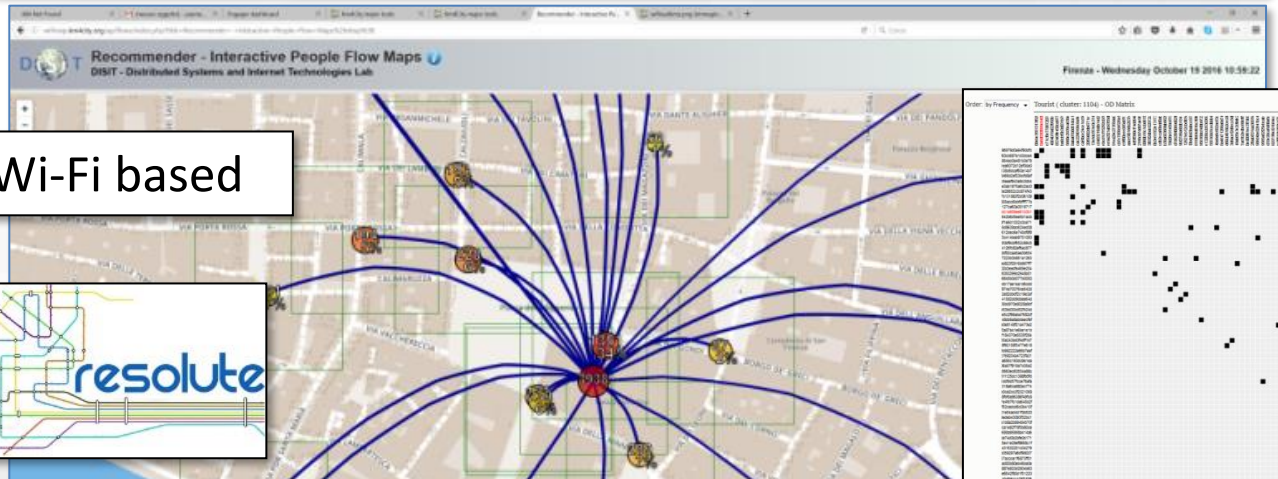


11 SUSTAINABLE CITIES AND COMMUNITIES

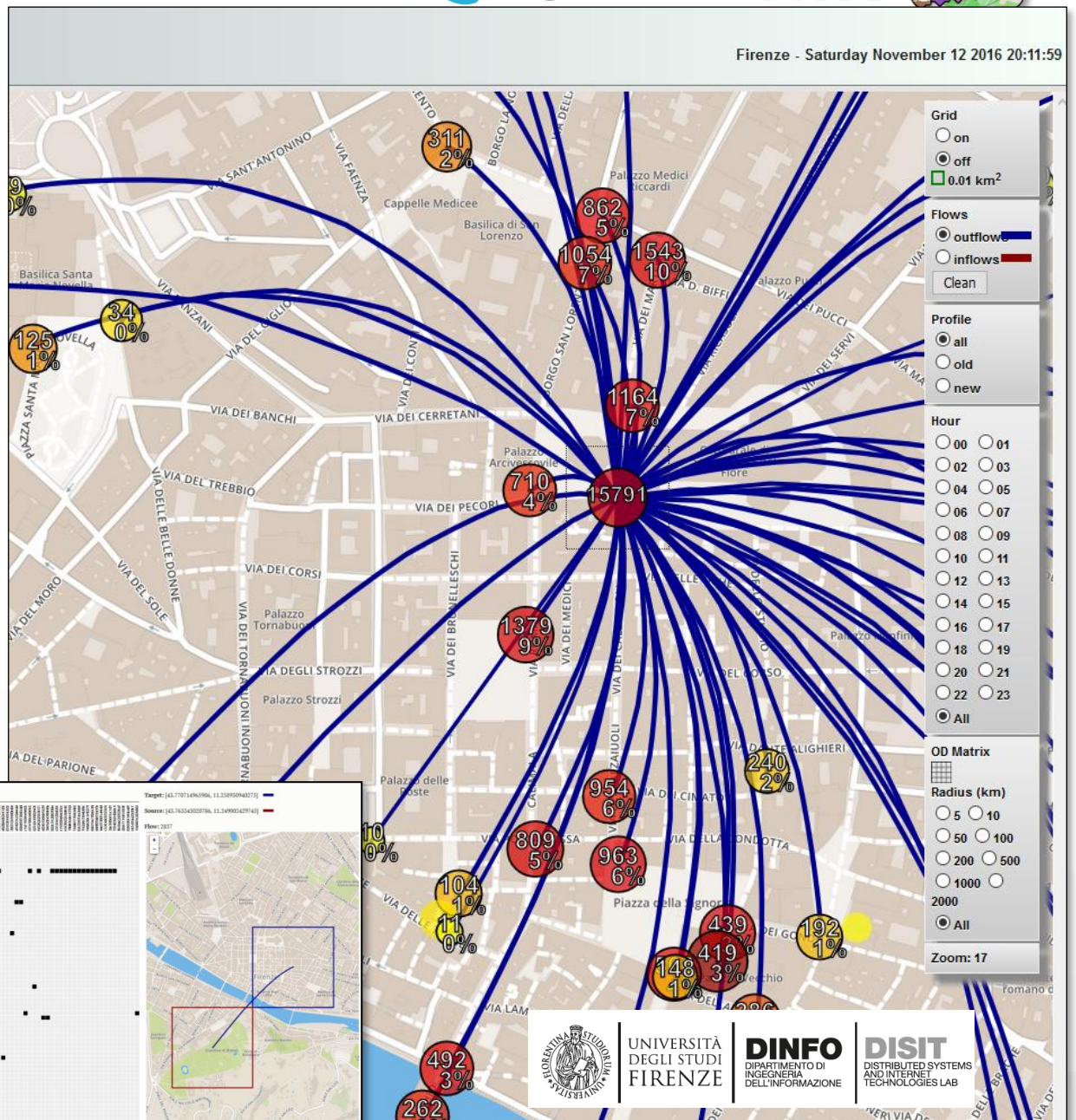


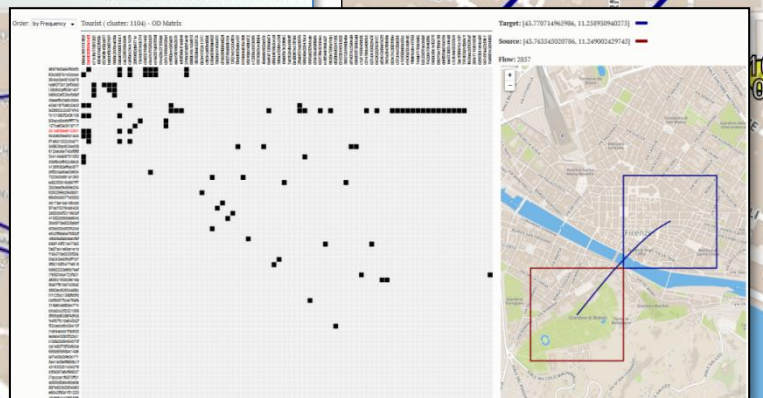
Origin Destination Matrix Estimation





Wi-Fi based





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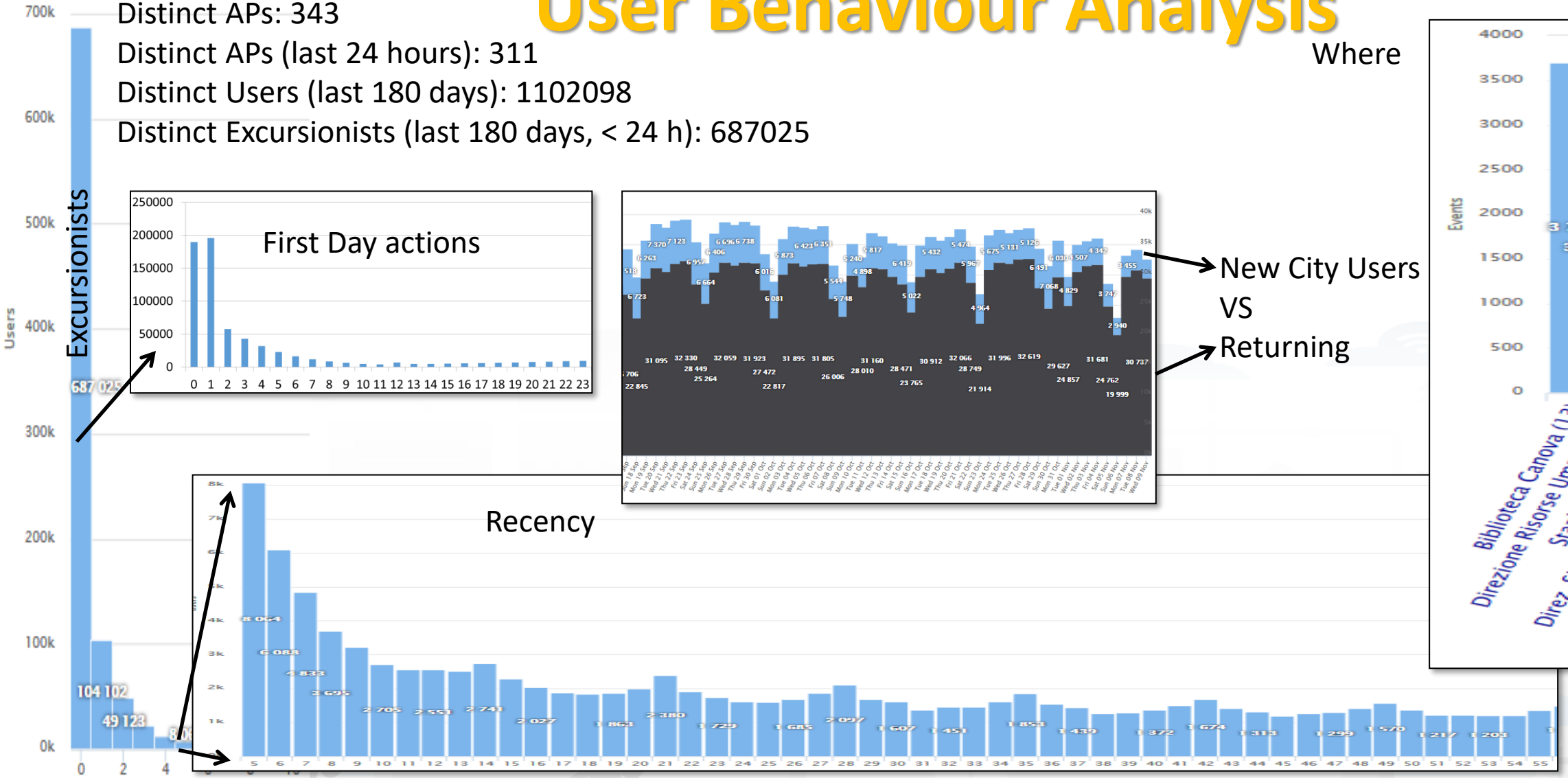
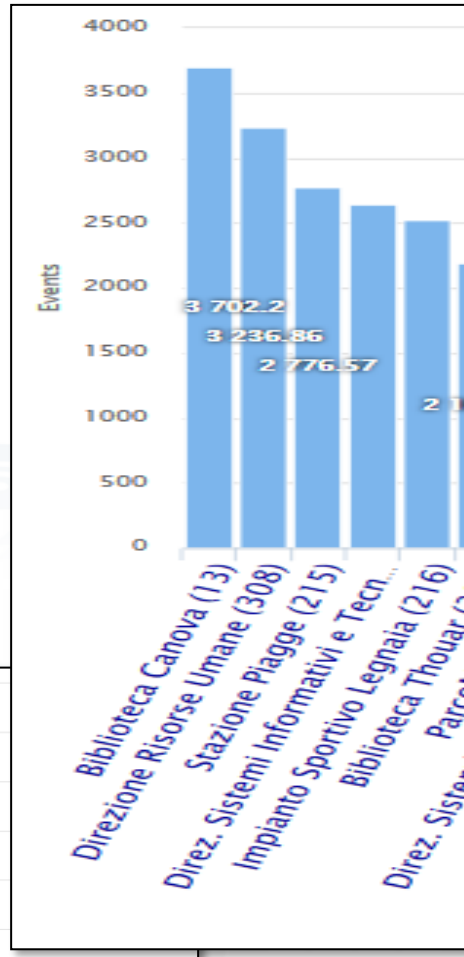
User Behaviour Analysis

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



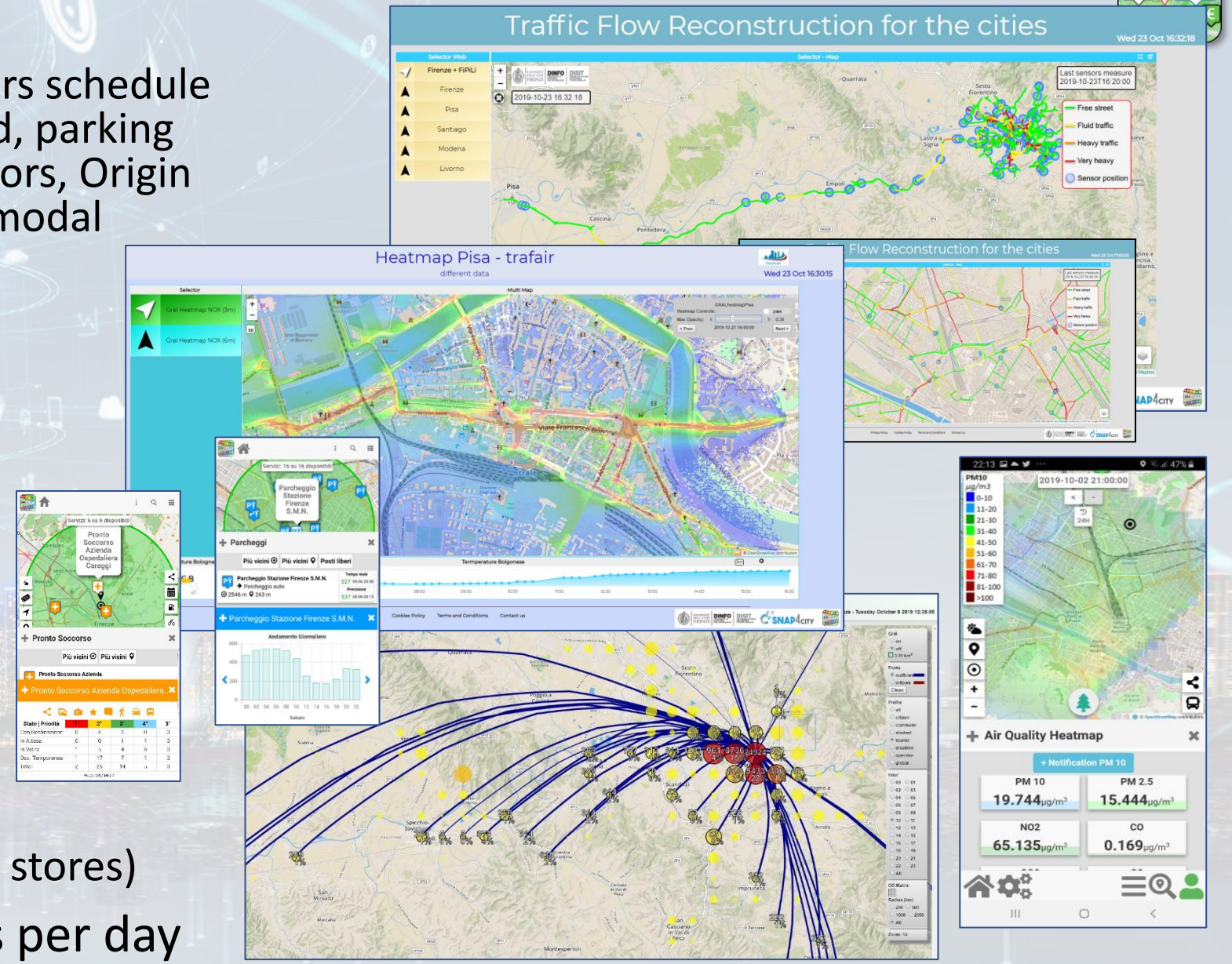
New City Users
VS
Returning

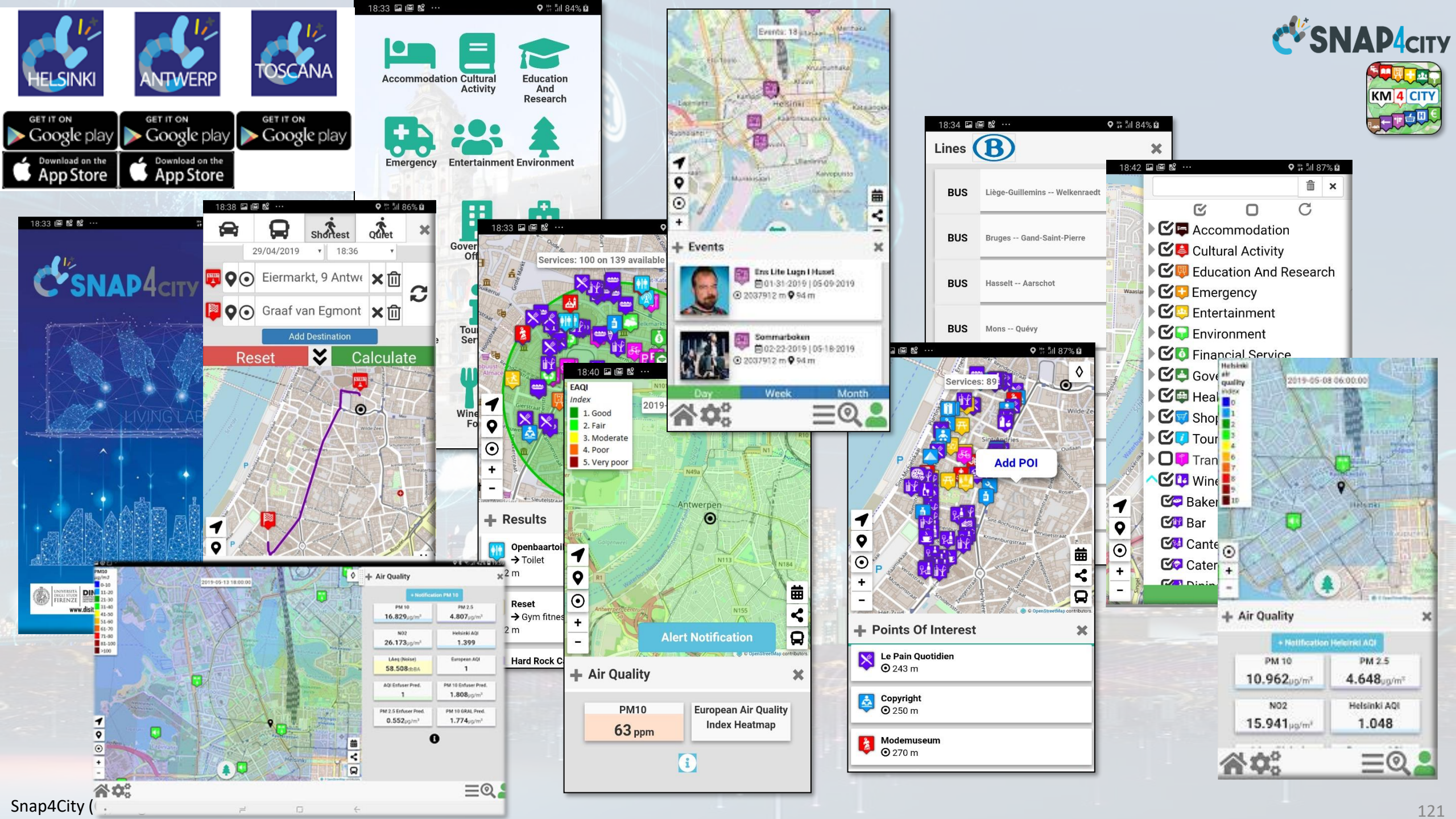
Where



Tuscany Region

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

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ANTWERP
TOSCANA
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KM 4 CITY
Accommodation
Cultural Activity
Education And Research
Emergency
Entertainment
Environment
Shortest
Quiet
Add Destination
Reset
Calculate
Events
Day
Week
Month
Lines
BUS
Liège-Guillemins -- Welkenraedt
Bruges -- Gand-Saint-Pierre
Hasselt -- Aarschot
Mons -- Quévy
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
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

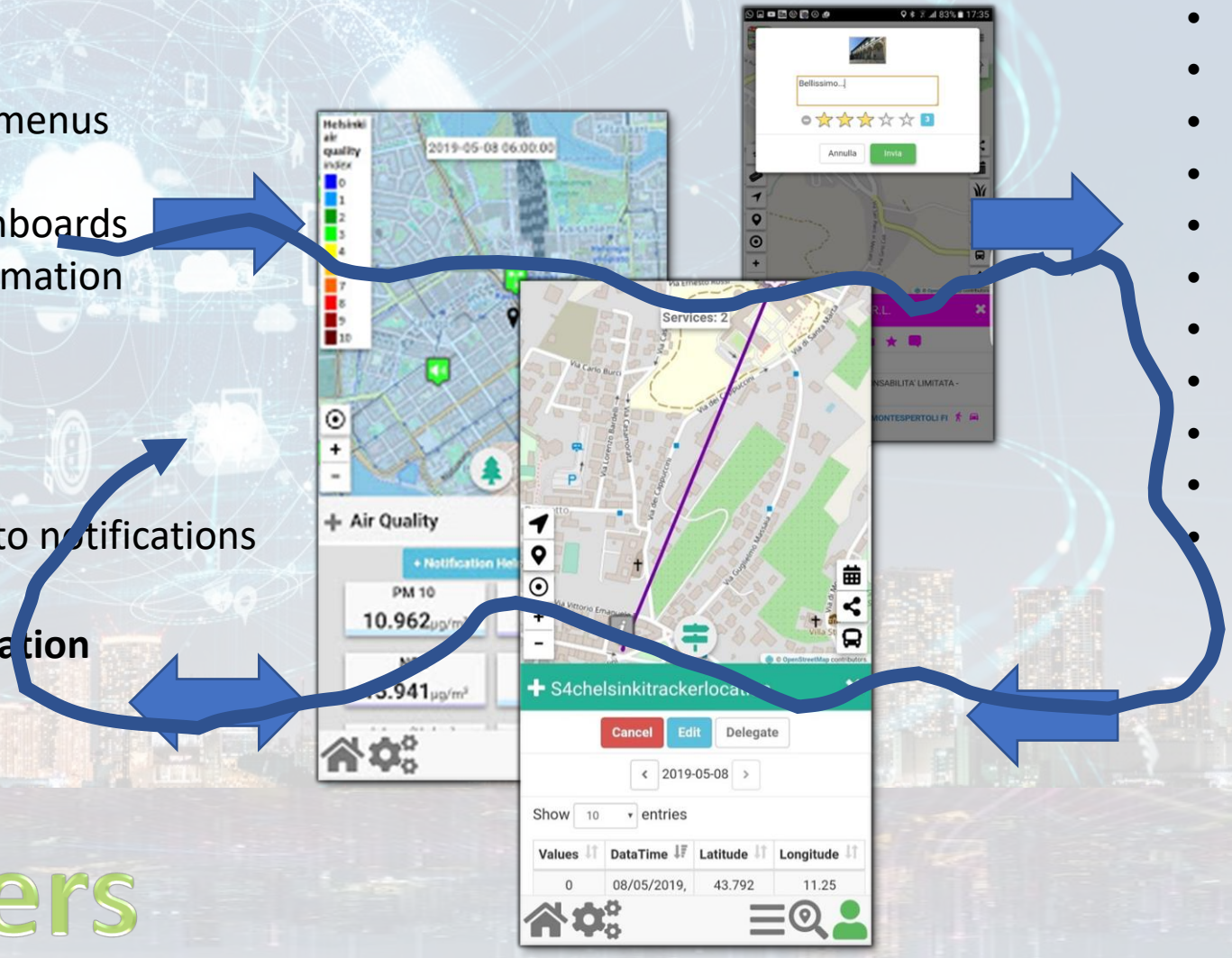
Citizen Engagement via Mobile Apps

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

Produced information

- Viewed ?
- Accepted ?
- Performed ?
- …

Users



Derived information

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

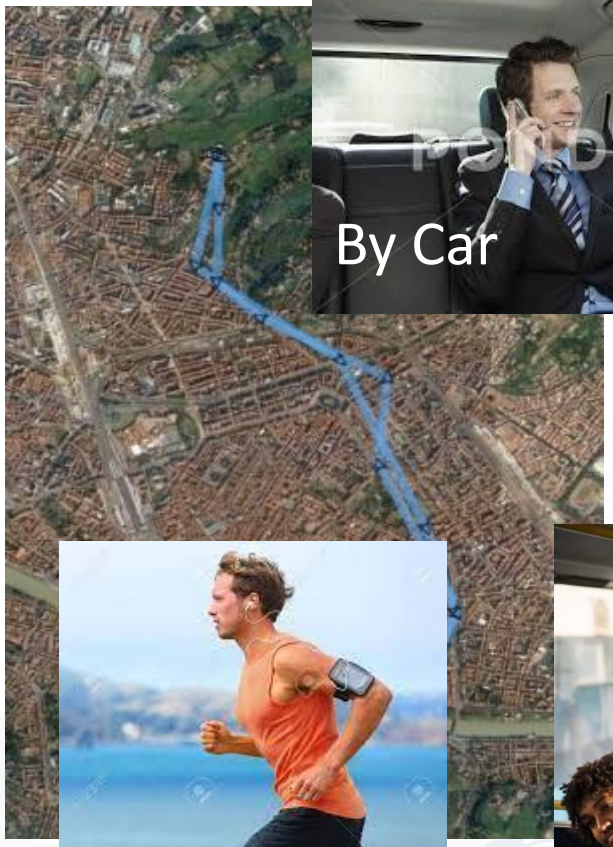
Produced information

- Suggestions
- Engagements
- Notifications
- …

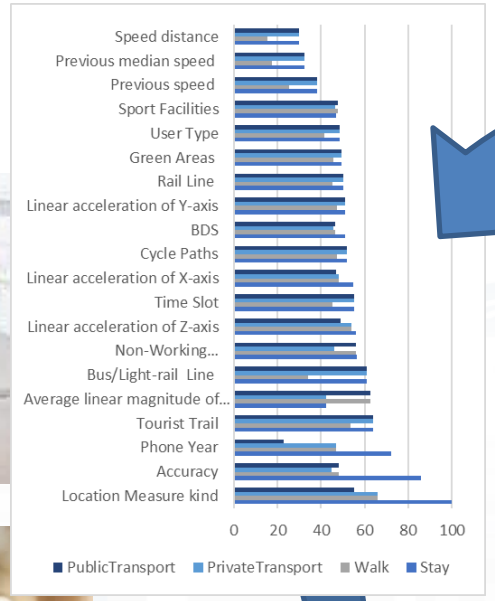
System

To propose suggestions and Engage city user

we need to know how they are moving

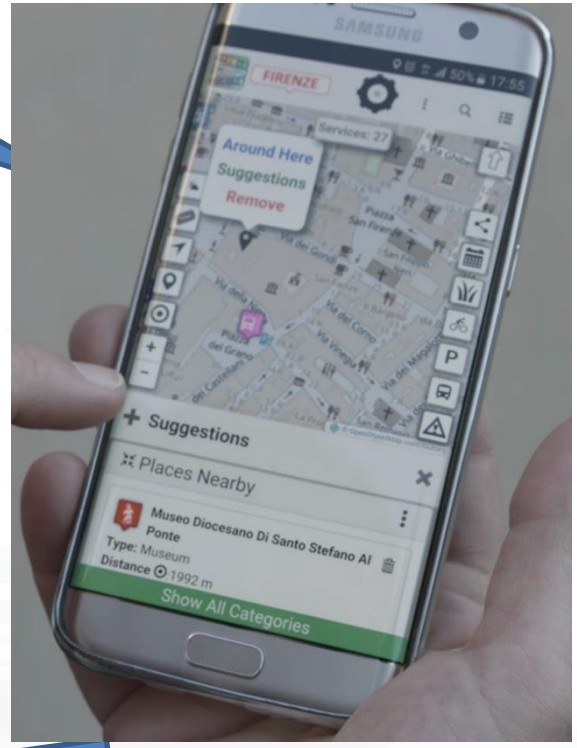


Walk

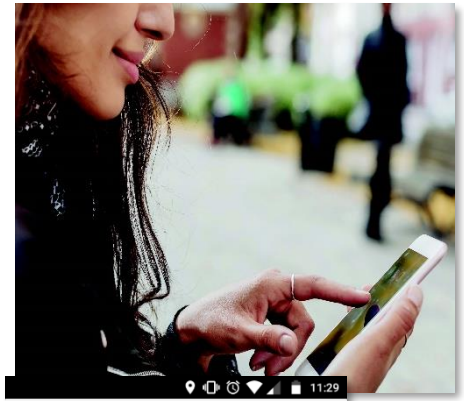


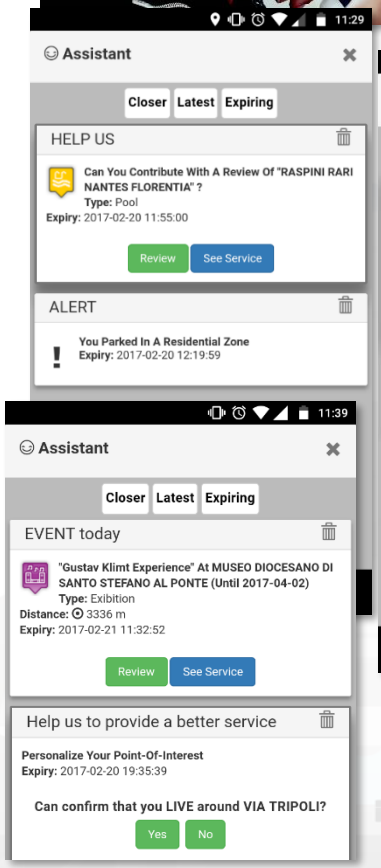
Artificial Intelligence Classification

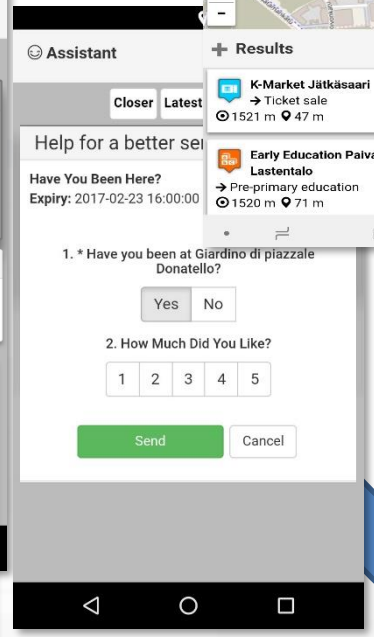
Suggestions

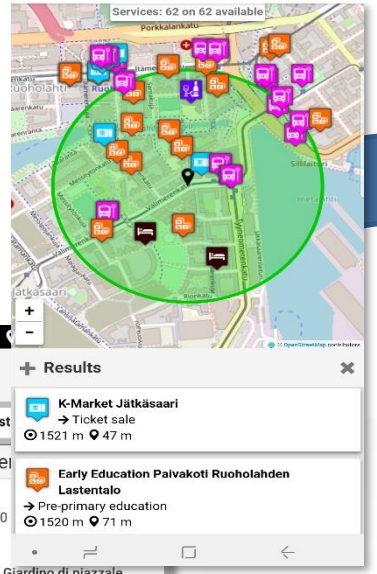


Users' Engagement

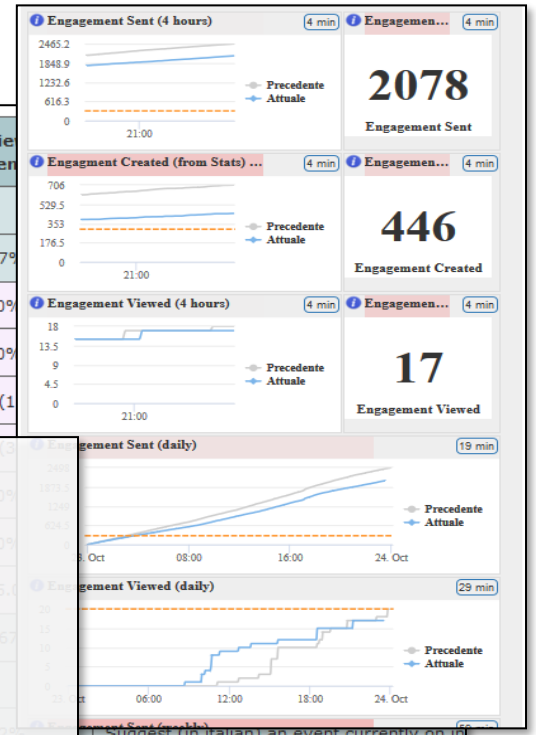


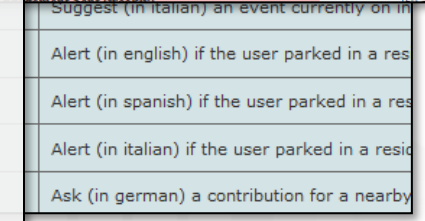






Rule name	Type	#sent	#viewed	#vie #sen
daily_event_de	ENGAGEMENT	1 (0%)	0 (0%)	0%
daily_event_en	ENGAGEMENT	1720 (2.12%)	70 (7.1%)	4.07%
	- commuter	5 (0.29%)	0 (0%)	0 (0%
	- student	14 (0.81%)	0 (0%)	0 (0%
	- tourist	1462 (85%)	25 (35.71%)	25 (1





Inform
- Air Quality forecast is not very nice
- You have parked out of your residential parking zone
- The Road cleaning is this night
- The waste in S.Andreas Road is full

Engage
- Provide a comment, a score, etc.

Stimulate / recommend
- Events in the city, services you may be interested, etc..

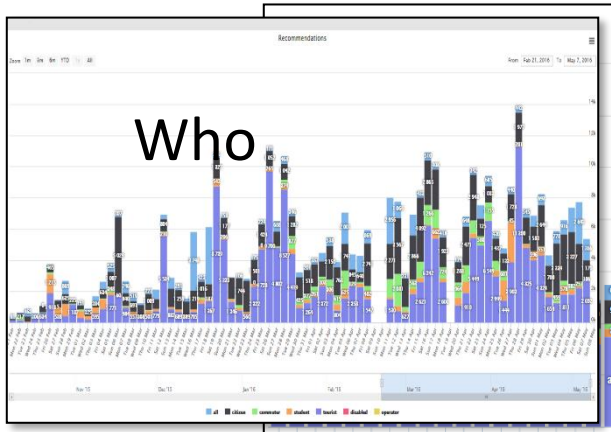
Provide Bonus, rewards if needed
- you get a bonus since you parked here
- We suggest: leave the car out of the city, this bonus can be used to buy a bus ticket

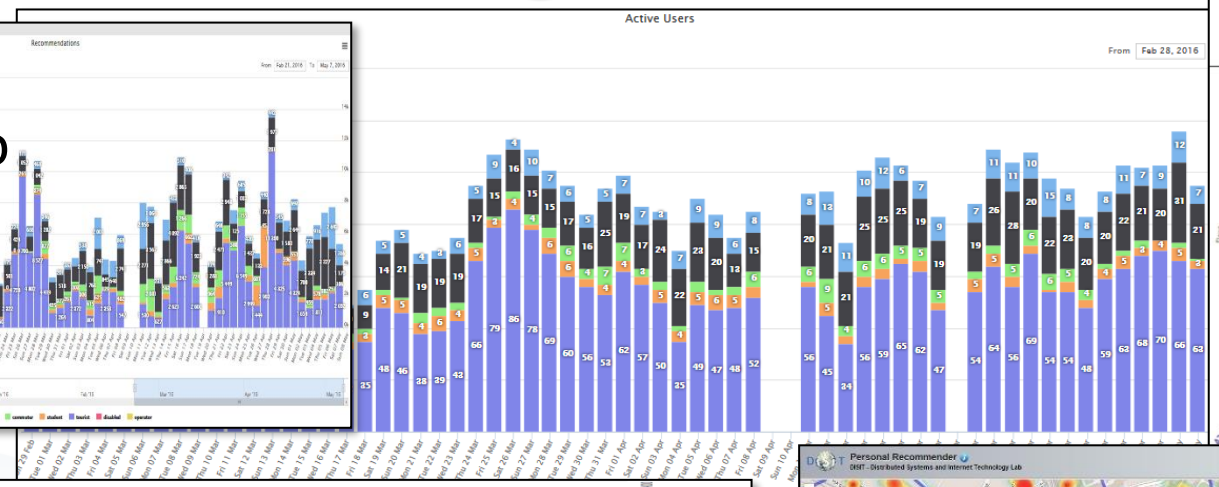
User context

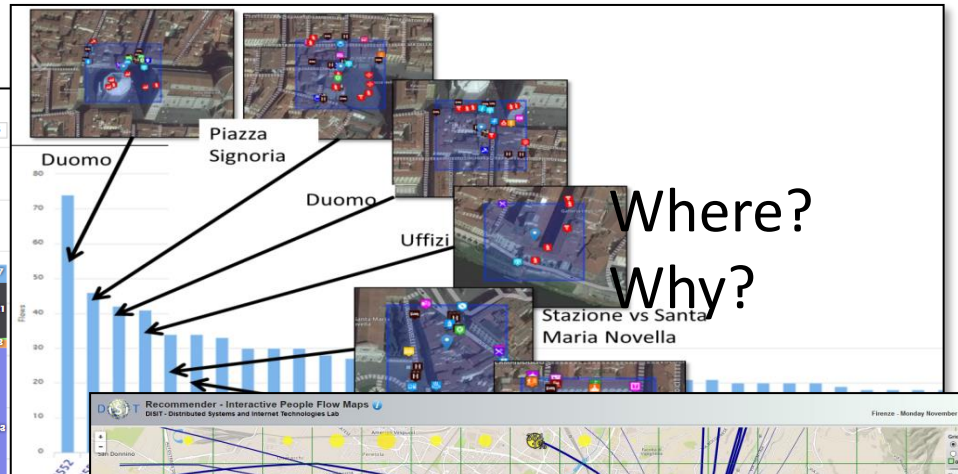
Rules

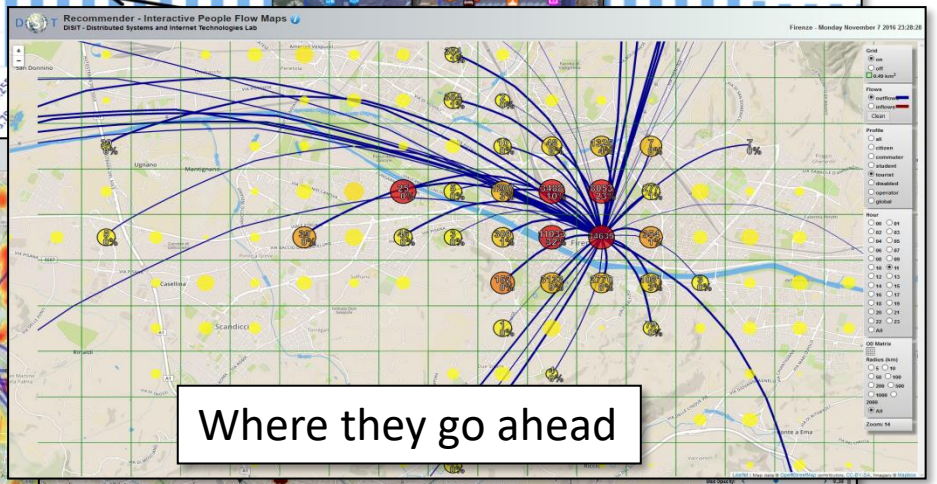
City context

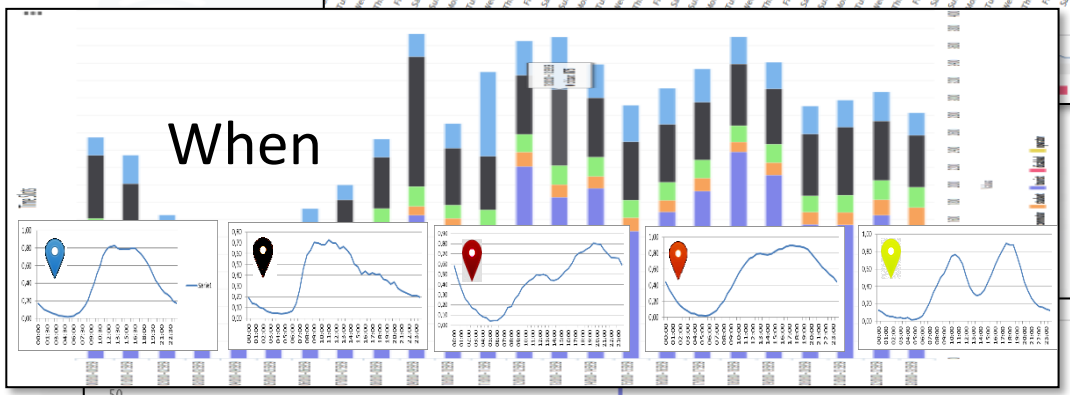
User Behavior Analyser for Collective Profiling

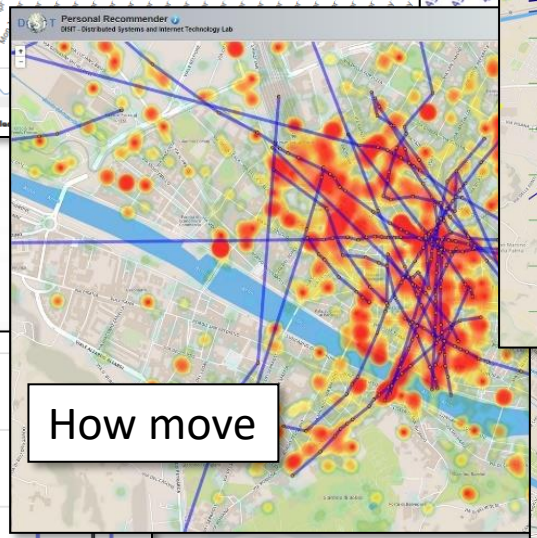


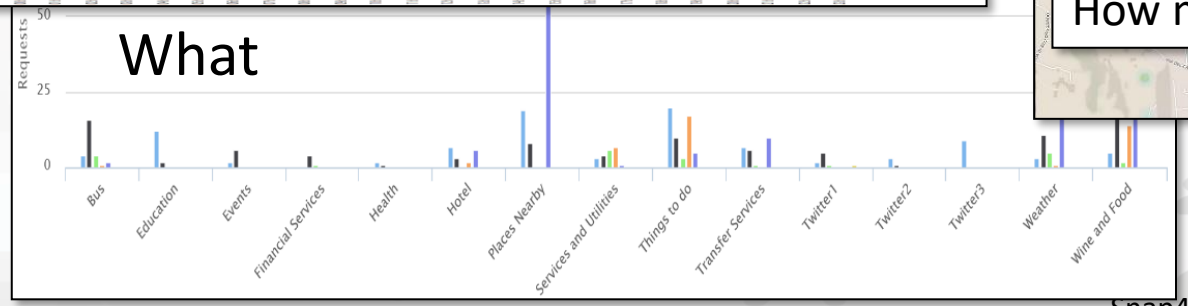


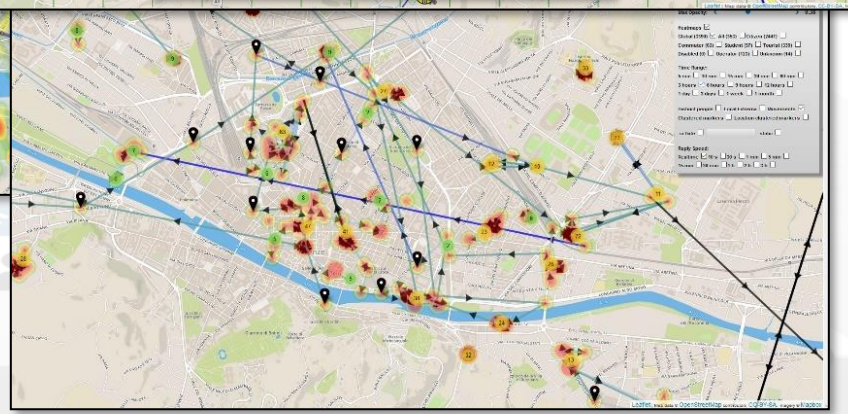




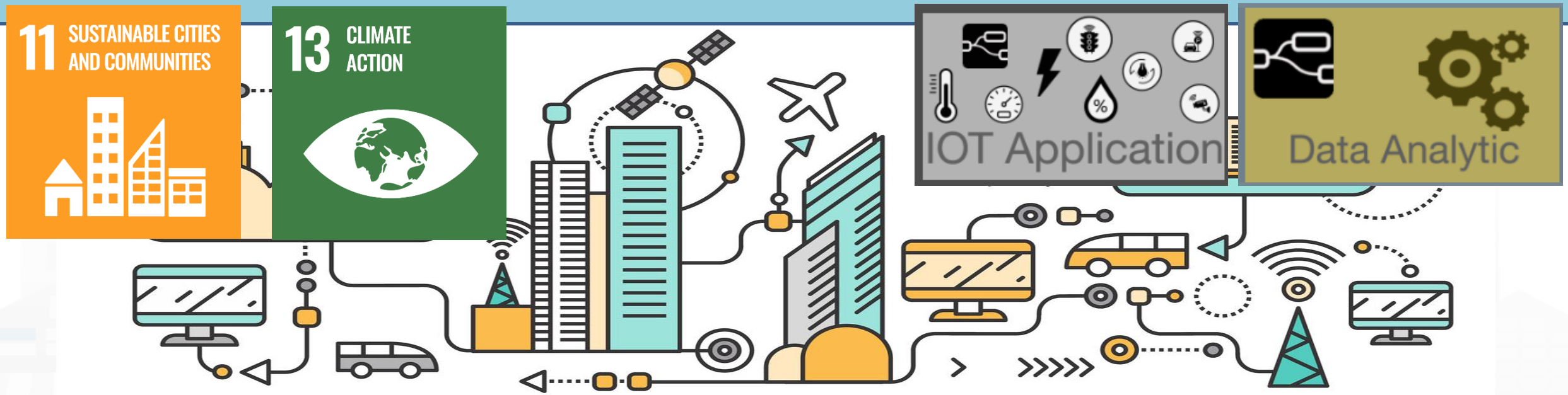




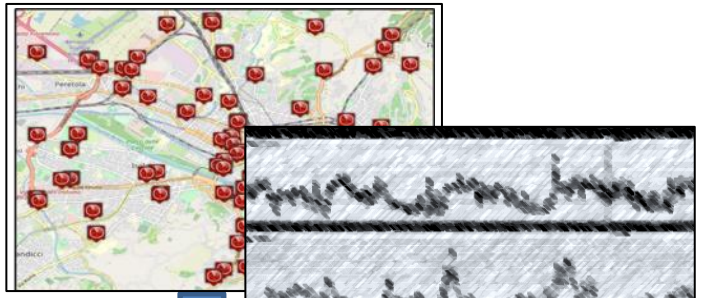




Computing / predicting CO2/NO2 from traffic Data



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

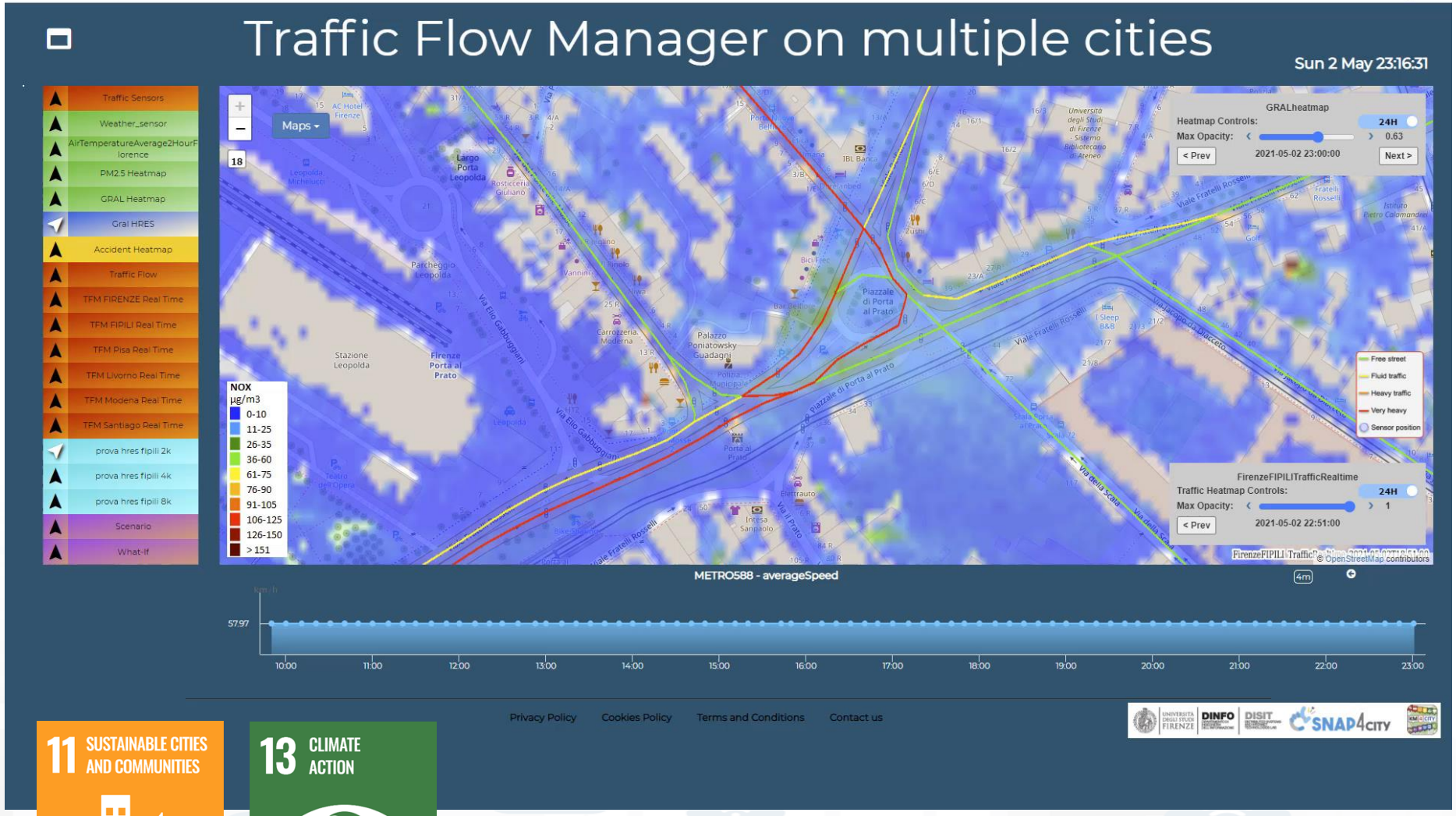
Computing CO2 on the basis of traffic flow data

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/

Environment

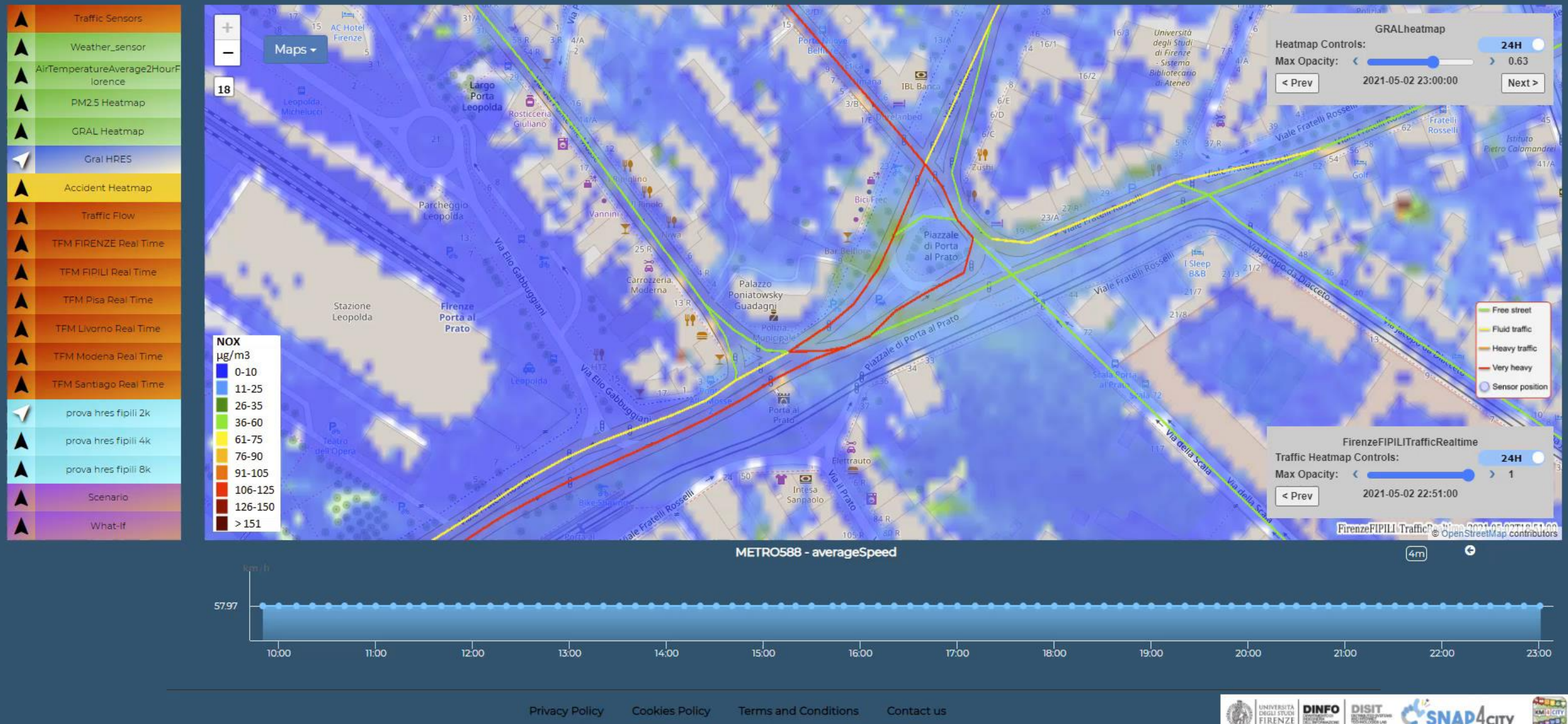
- **Prediction**
  - **NOX Pollutant** diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
  - **NO2 progressive average** (Long term)
- **Project:**
  - **Trafair** CEF EC
  - Mixed solutions of Fluidinamics modeling and AI



11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

Traffic Flow Manager on multiple cities



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

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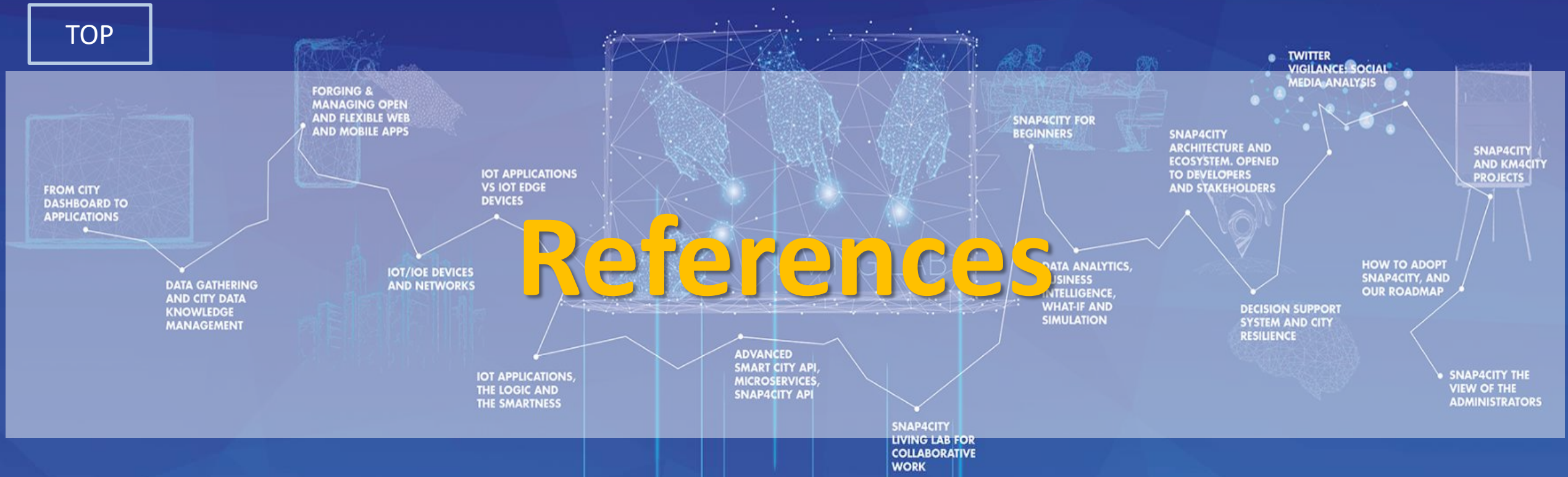
References



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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

2017
Sii-Mobility
- Origin-Destination and trajectories
- Traffic Reconstruction
- Offer Analysis
- OBU, smart devices

E015 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

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

IOT/IOE
Km4City 1.6.6
Node-RED

SNAP4CITY SELECT for Cities H2020 (2017-19)

2019
5G (2018-21)
- 5G tech
- Energy
- Industry 4.0
- Synoptics

TRAFAIR
CEF (2018-21)
- Traffic and Mobility Impact on Pollution
- NOX predictions

EUROPEAN OPEN SCIENCE CLOUD

SIRIUS

LAID Smart Bed
- Smart Health

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

bee smart city
- Smart Lonato

Reverberi Enetec Gruppo MPES

SNAP4CITY

SODA

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)

Enterprise (2021-22) Industry 4.0

Contract

Contract

PC4City (2020-21) Monitoring Terrain

Winner of Open Data Challenge of

- Smart Light
- Sweden

2022

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

Asymmetrica Smart City, 2022-23

Contract, 2022-23

2023

Contract, 2022-23

2022-2023

Contract, 15min

Security and Risk

Italferr, Smart City

CN MOST, 2022-26

EI THE, 2022-26

2023-26

G. Agile, 2021-23

Merano, smart light

OceanRace, Genova, AWS

Cuneo, smart city

2024

TOURISMO

ELLIE IA 2025-2027

Contract, 2024-25

CAI4DSA

OPTIFaaS

SASUAM

Rhodes, smart city

eShare UNIFI TUSS

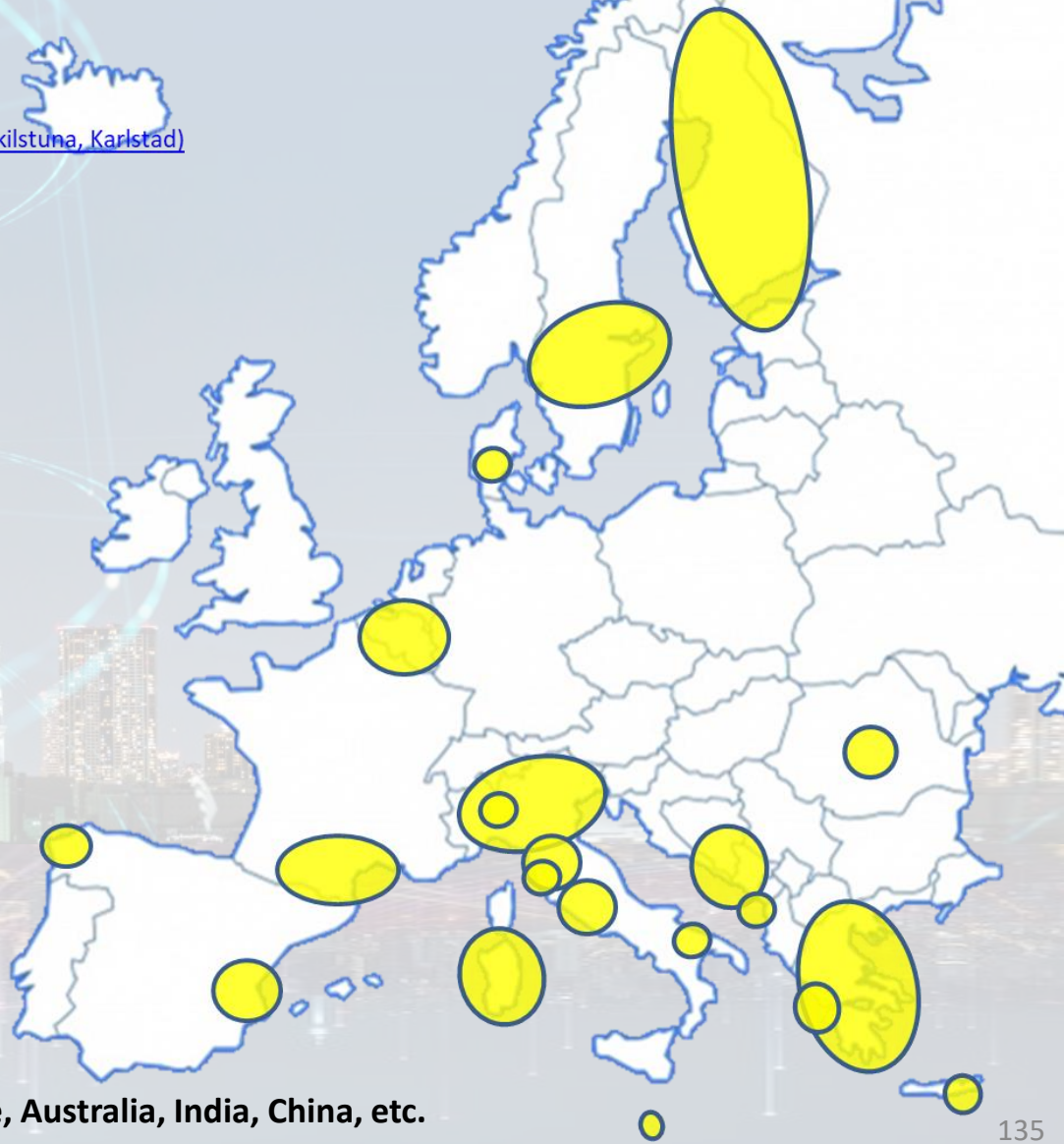
AMMIRARE

https://www.Snap4City.org

- 11 running installations in Europe
  - Snap4.city.org, Greece, Merano, Cuneo, …
  - Toscana, Pisa, Sweden, ISPRA, Snap4.eu,
  - Altair, Italmatic, Romania, ….
- 16 projects, 12 pilots on 10 Countries
  - >40 cities/area
- **Widest MULTI-tenant deploy has**
  - 24 Organizations / tenant
  - > 8850 users on
  - > 1800 Dashboards
  - > 17 mobile Apps
  - **> 2.2 Million of structured data per day**
  - > 580 IoT Applications/node-RED
  - > 750 web pages with training
  - > 75 videos, training videos

Main Organizations/areas

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



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

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KM4CITY

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SMARTCITY EXPO WORLD CONGRESS

7-9 November 2023, Barcelona, Spain

Visit Snap4City in Hall 1

SNAP4 Appliances and Dockers **Installations**

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