



Ottimizzazione Semaforica e di Infrastruttura. Ottimizzazione del Trasporto Collettivo

OPTIFaaS
IL FUTURO DELLA
MOBILITÀ
INTELLIGENTE E
SOSTENIBILE

Prof. Paolo Nesi, UNIFI DISIT



Decongestion



Safety



Accessibility



Cost Reduction

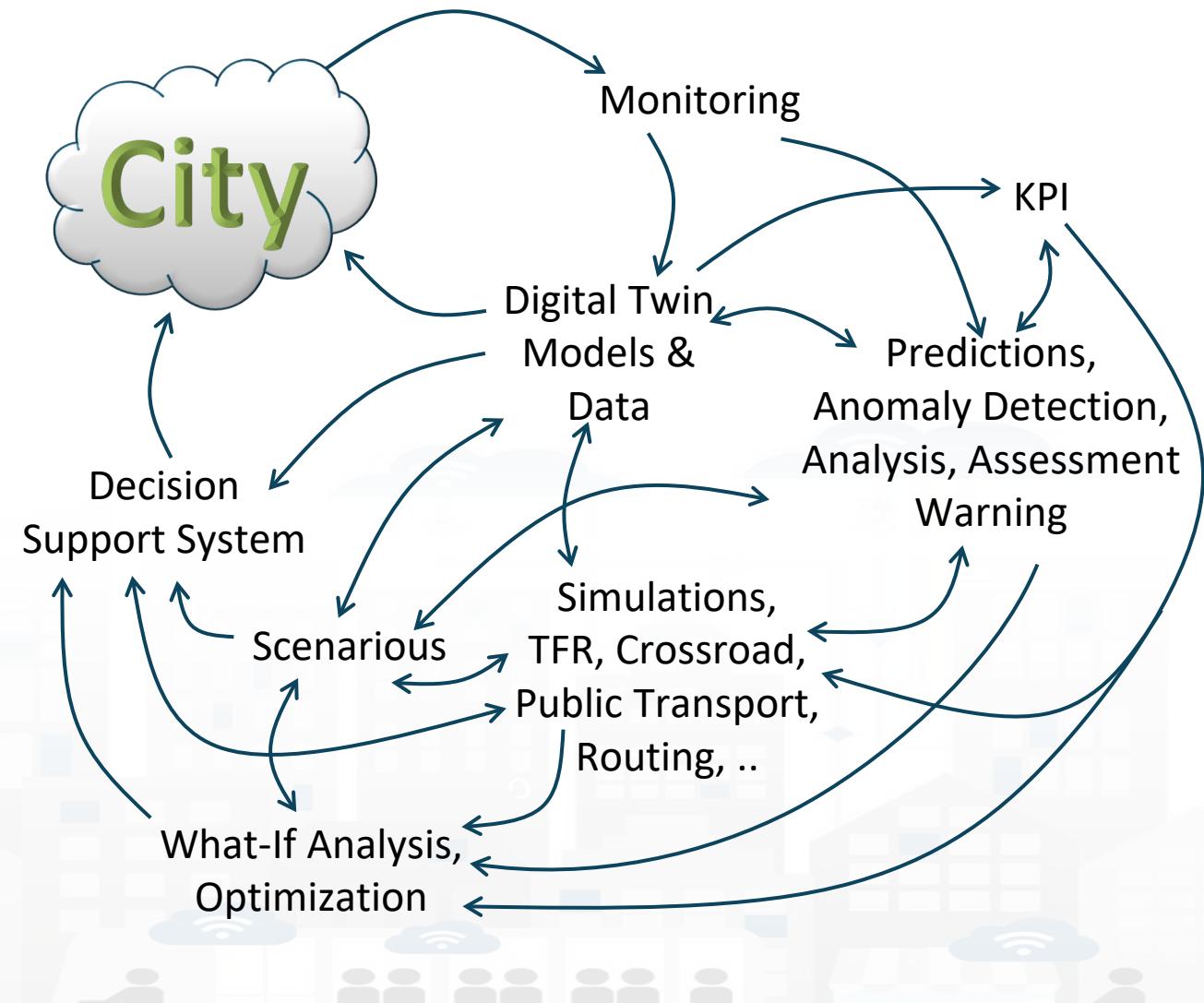


Decarbonization

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
 - Fast What-if analysis
- **Making plan:** tactic and strategic, medium and long range, micro/macro
 - Simulation & optimization
 - Generative AI Prescriptions, scenarios
 - Resilience to Unexpected unknowns
 - What-if analysis wrt scenarios
 - Collaboration with stakeholders



Mobility & Transport

- **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 plans, infrastructure**

- **Reduction:** travel time, waiting time, # stops, CO2 emissions, consume fuel, travel time for tramways and busses

- **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

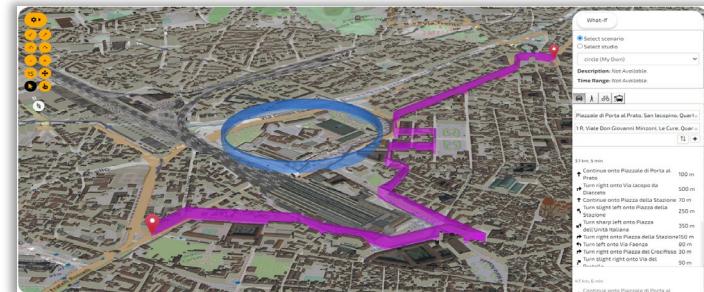
- **KPI:** SUMI/SUMP, travel time, emissions, traffic status, accessibility, ..

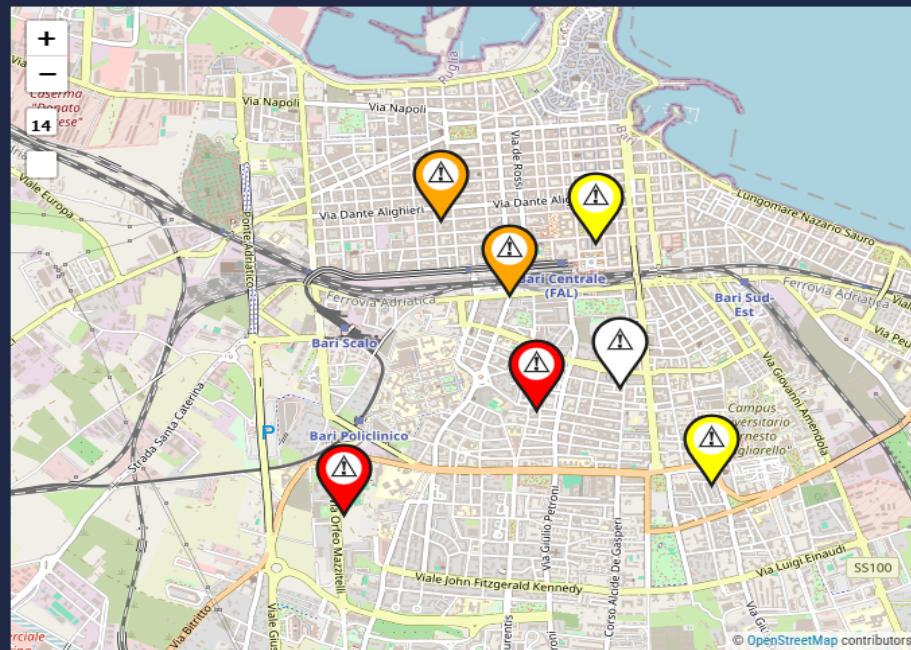
- **Mobile App:** final users and operators

- 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.





Pannello Rischi Meteo

MINIMO	BASSO	MEDIO	ALTO
Rischio Idraulico	MINIMO	Rischio Idrogeologico	MINIMO
Rischio Temporali	MINIMO	Rischio Neve	MINIMO
Rischio Ghiaccio	MINIMO	Rischio Vento	MINIMO

Viabilità

INCIDENTI	3
Chiusura Traffico	2
Chiusura Lavori	0
Limitazioni Traffico	4
Limitazioni Lavori	0
SEGNALAZIONI	7

Operation

Road Monitoring

Media congestioni C	Nr. congestioni C	Picco congestioni C	Riduzione CO2 ZTLC	Emissioni medie CO2 C	Emissioni totali CO2 C
28.4 %	17	18:27	-5.2 %	282 ppm	846 ppm

Traffico in ingresso



Tot. veicoli in ingresso C
12105 Veicoli

Velocità media C
27 km/h

Traffico in uscita



Tot. veicoli in uscita C
11703 Veicoli

Veicoli totali C
7825

Trasporto Pubblico

Tempo medio di attesa	C	Linea 50	12 sec
5.9 sec		Linea 11	10 sec
		Linea 33	6 sec
		Linea 02/	5 sec
Ritardo autobus	C	Linea E	5 sec
0 %		Linea 19	4 sec

Sensori

15 Semafori	3 Videocamere
22	0
4 Sensori	1

What-if on TFR

Mon 23 Sep 12:53:12

SNAP4CITY

Scenario Editor

Some Points of Interest

Traffic Sensors

Air Quality Sensors

Weather Sensors (OW)

Bus Stops

Tram Stops

SNAP4CITY

Traffic Flow Analysis By Scenario

Load Scenario: Scenarios waiting to be processed: enrico909 Scenario version: 2024-09-23 11:58:27

INIT to ACC Compute TFRS Compute KPI Show TFR

Data Update

enrico909 2024-09-23 12:06:03 (tfr)

2024-09-23T15:00:00+02:00

Calculate KPI

KPI

KPI	Value
Total CO2 emissions [ug/m ³]	13,979.071
Total fuel consumed [l]	0.249
Traffic state objective function [#]	3.935
number of vehicles [#]	51.394
total kilometers [km]	3.886
total travel time [s]	314.575

orionUNIFI_DISIT_deviceNameenrico909_2024-09-23T10-06-03

Traffic Heatmap Controls: 24H Max Opacity: 1 2024-09-23 15:00:00+02:00

DISIT:OrionUNIFI:METRO1098 - VehicleFlow

2k car/h 8m

29. Jul 5. Aug 12. Aug 19. Aug 26. Aug 2. Sep 9. Sep 16. Sep 23. Sep

Time Series

20 car/m² 3m

29. Jul 5. Aug 12. Aug 19. Aug 26. Aug 2. Sep 9. Sep 16. Sep 23. Sep

DISIT:orionUNIFI:METRO1098 - concentration

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RISCHIA E RESILIENZA

MOST CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

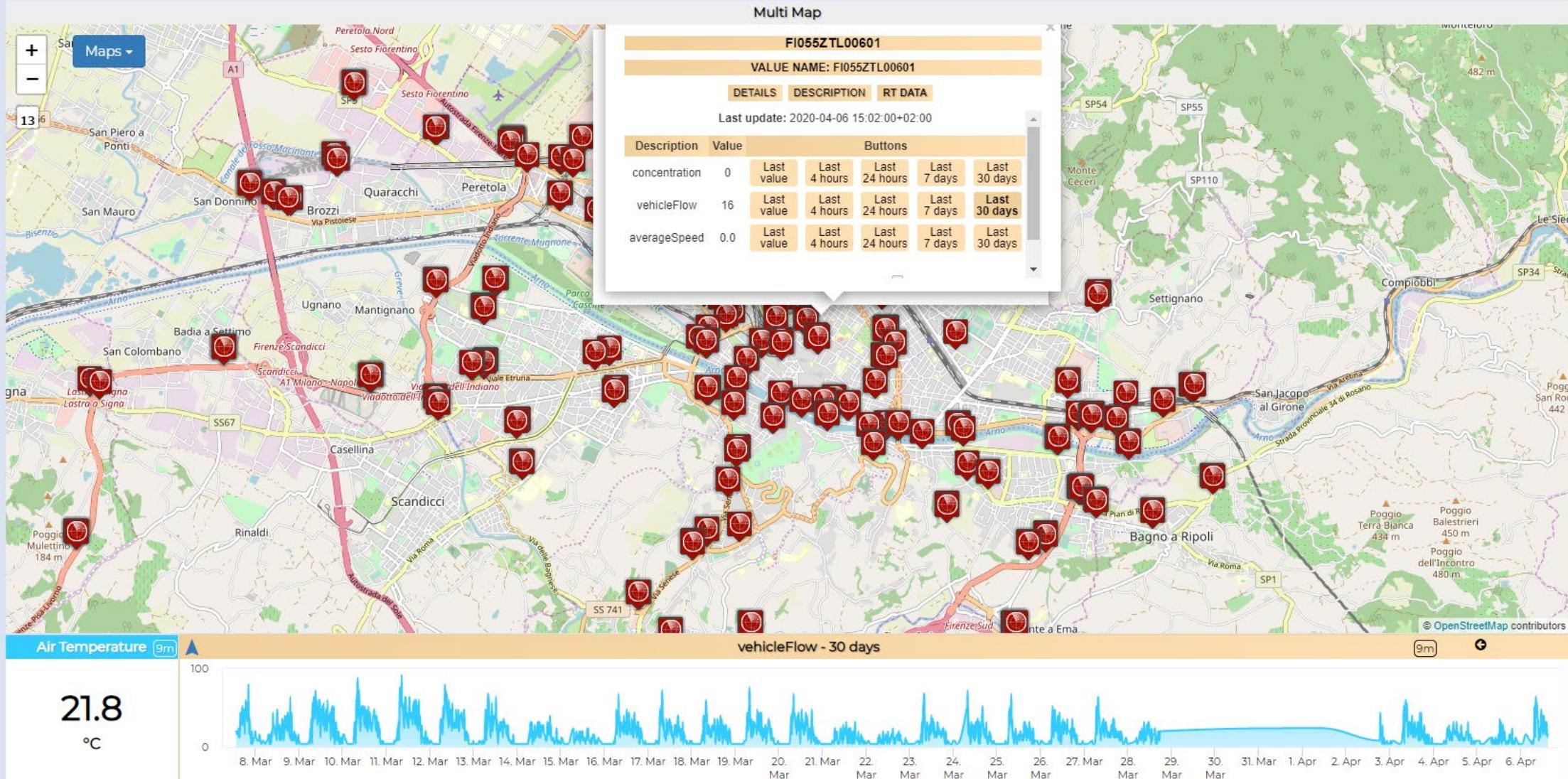
UNIVERSITÀ DEGLI STUDI DI FIRENZE DINFO DISIT MOST SNAP4CITY KM4CITY

Firenze - Trafair - AirQuality Heatmaps

Mon 6 Apr 15:12:27

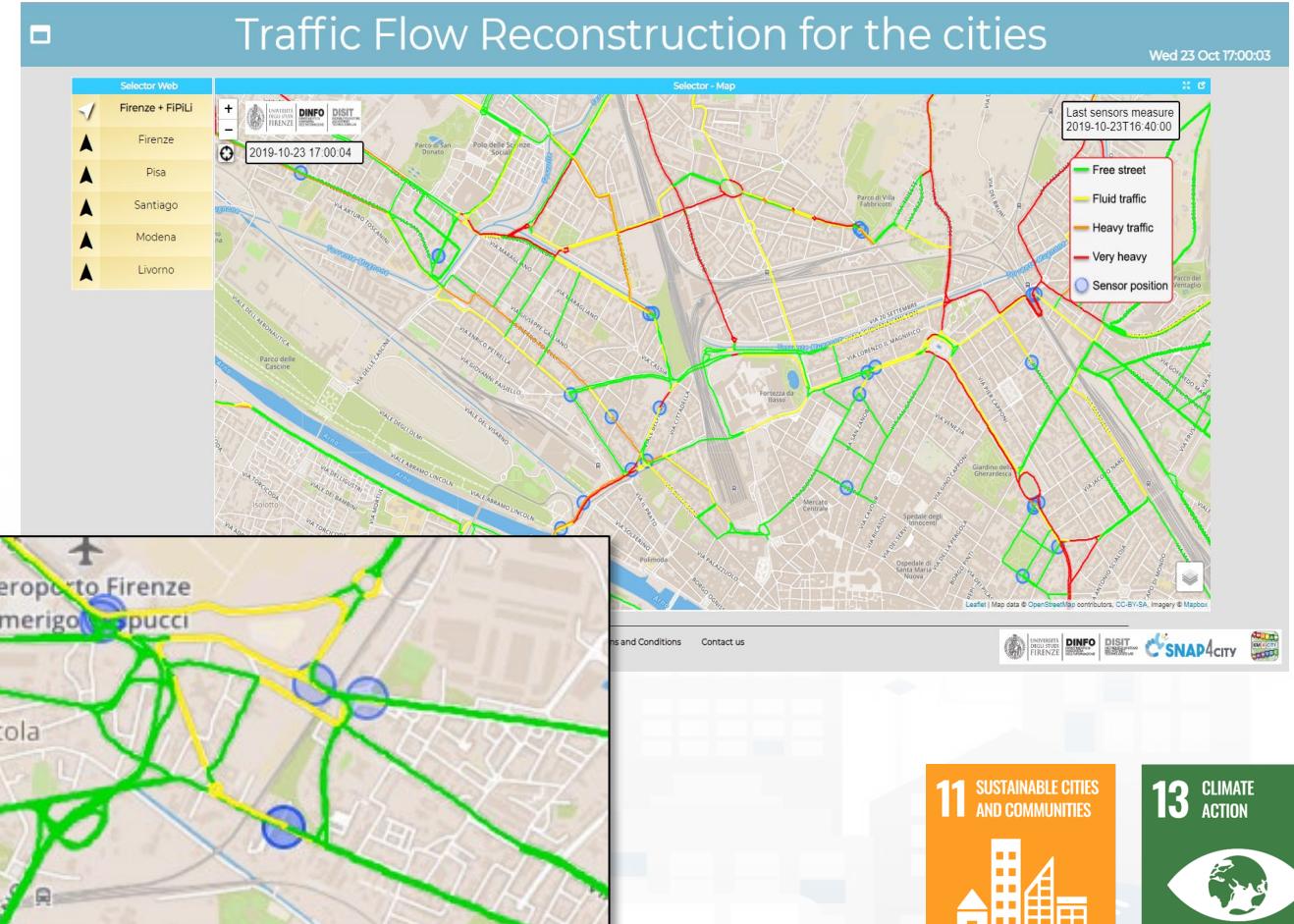
This dashboard contains data derived from actual sensors and predictive values under validation

- ▲ 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 Anonym. Gral
- ▲ Green Areas
- ▲ Schools

Air quality trends


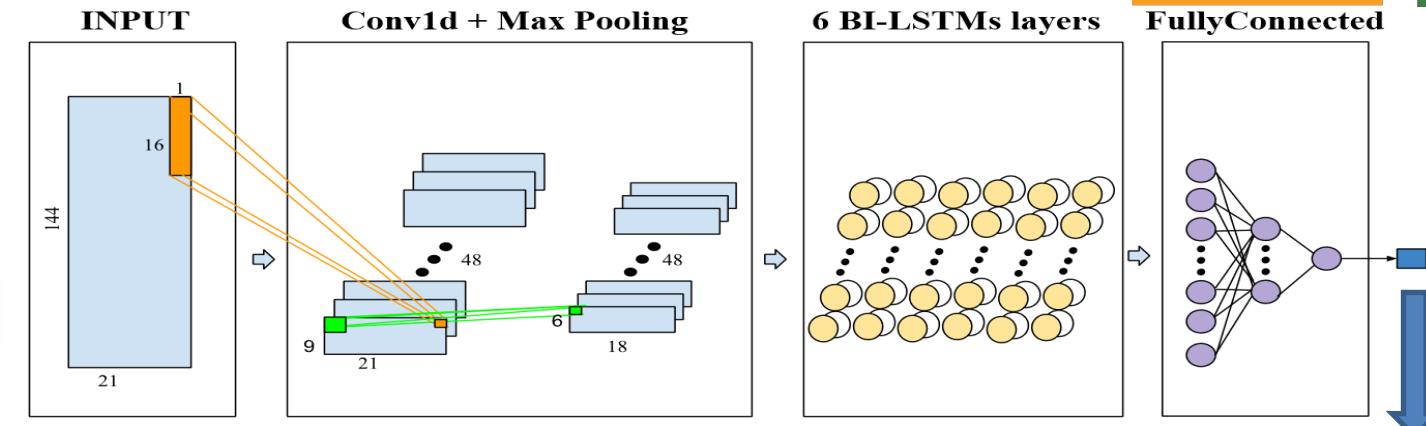
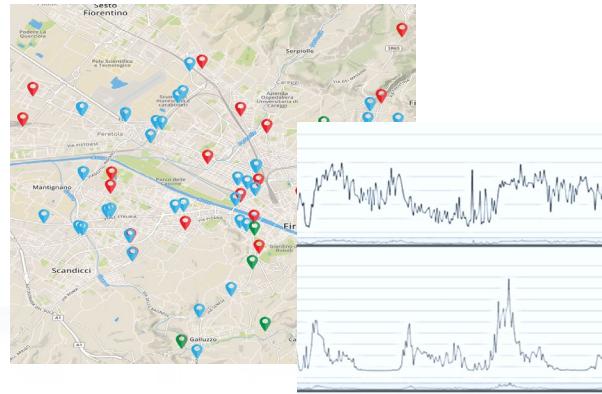
Why Dense Traffic Flow Reconstruction ?

- 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?idashboard=MTc5NQ==>

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

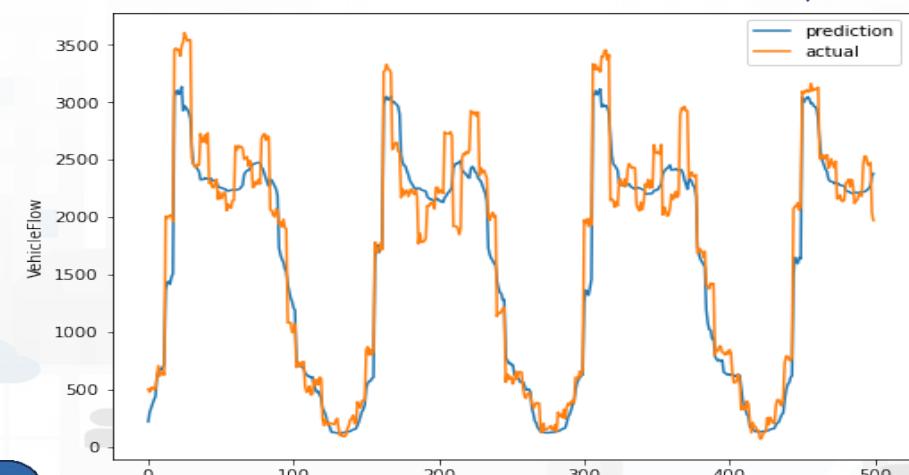


Urban data:

- 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

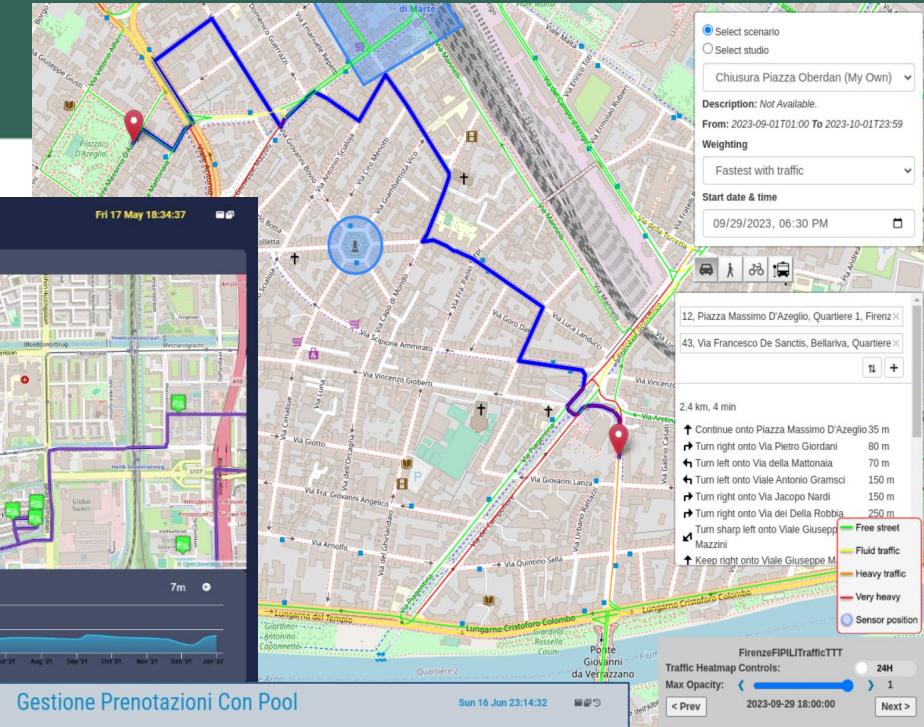
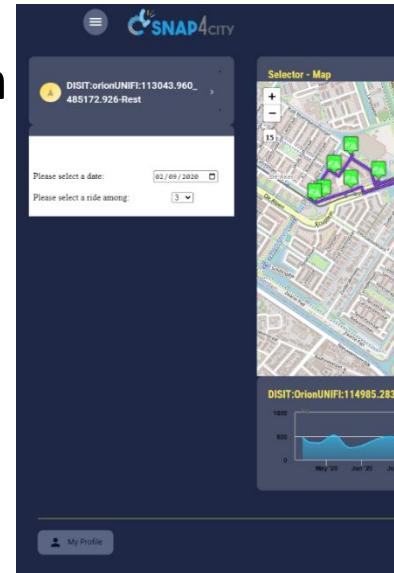


Routing Optimization

Goals on planning:

- Reduction of costs on plan
- **waste collection** optimization, Reduction of Km
- **car pooling trajectories** optimization for maximize the pool usage
- **delivering optimization**, reduction of travel time, reduction of Km
- etc.

Snap4City (C), Sett. 2025



UNIVERSITÀ
DEGLI STUDI
FIRENZE

DINFO
DIPARTIMENTO DI
INGEGNERIA
DELL'INFORMAZIONE

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

SNAP4CITY

Routing Facilities

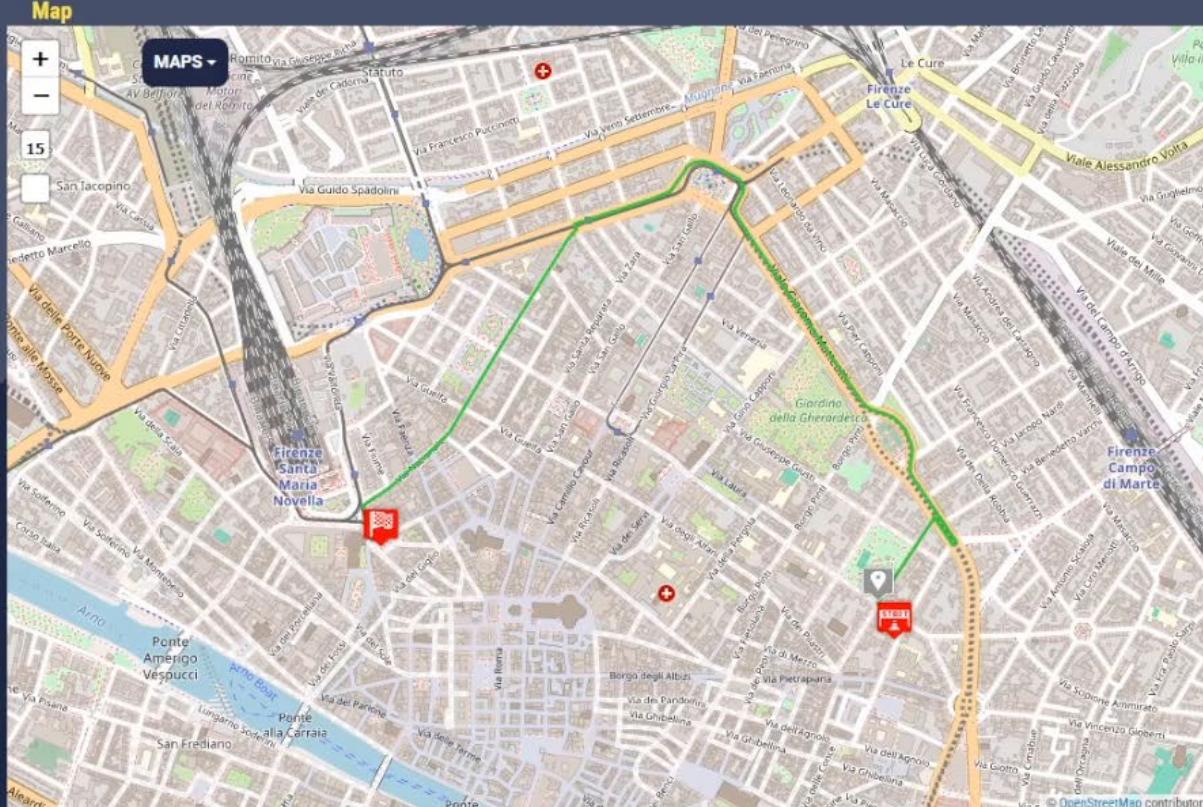
- **modal routing: private vehicles, bikes, pedestrian**
 - with start, end and multiple intermediate points
 - selecting: shorter, faster, quitter, etc..
 - dynamic conditional routing taking into account the effective traffic flow status, or typical traffic flow status
 - dynamic conditional routing taking into account eventual blocked areas (by scenario) for example for street working, restoring, etc. (what-if cases and analysis)
- **multimodal routing** for the city users to walk and take the public collective transport
- **modal routing for public administrations** (ambulance, fire brigade, police, busses, etc.) exploiting the reserved lanes, etc.
- **a combination of cases.**
- **Full API for exploitation from your applications**

Some Routing Service Capabilities

Routing Modal And Multimodal With What-If

Tue 10 Jun 10:30:28

Map



What If - Routing

Scenario: Studio

Select scenario: Choose a scenario

Save as studio

Weighting: Fastest

Start date and time: 10/06/2025 10:29

Show alternatives?

Main route
5 min (3.21 km)

Depart from 21, Piazza 0 sec (0 m)
Continue onto Via Giov: 0 sec (1 m)
Turn right onto Piazza 1 23 sec (191 m)
Continue onto Via Silvio 11 sec (94 m)
Turn sharp right onto Vial 5 sec (91 m)
Make a U-turn onto Vial 2 min (1.45 km)
Keep right onto Piazza 1 28 sec (348 m)
Turn left onto Viale Spa 2 sec (16 m)
Turn right onto Via Sant 2 min (993 m)
Turn left onto Piazza de 2 sec (20 m)
Arrive at destination 0 sec (0 m)

Instructions

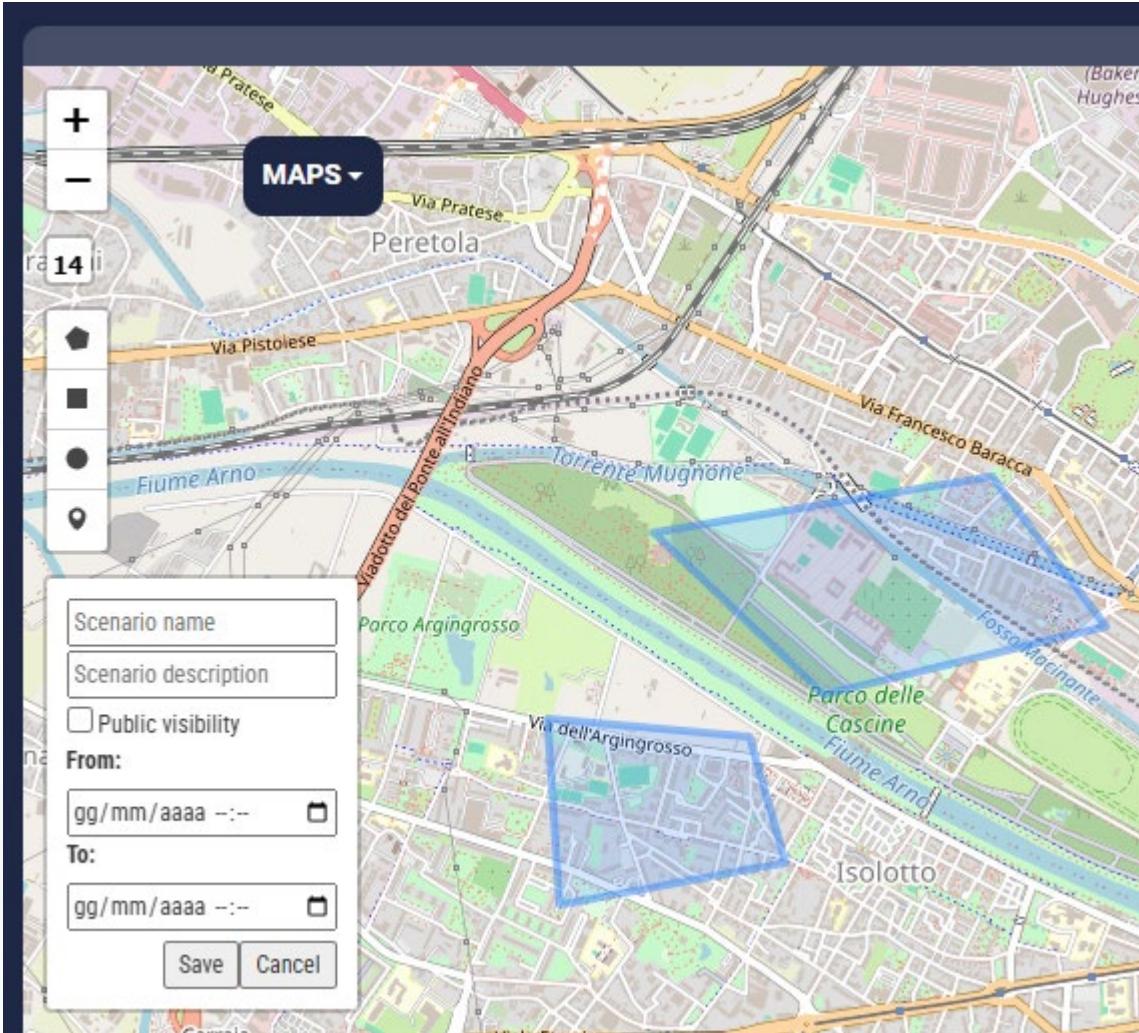
Modal

- Pedestrian
- Bicycle
- Private Transport
- Service Vehicles

Multimodal

Clear

What you can do with advanced tools



- **Basic Scenario editor**
 - Single and multiple blocked areas, which can be shared among users
- **What-if analysis tool**
 - Ready to use tools for exploiting Basic Scenarios as blocked areas and simulating/
 - computing in real time routing, in different traffic conditions

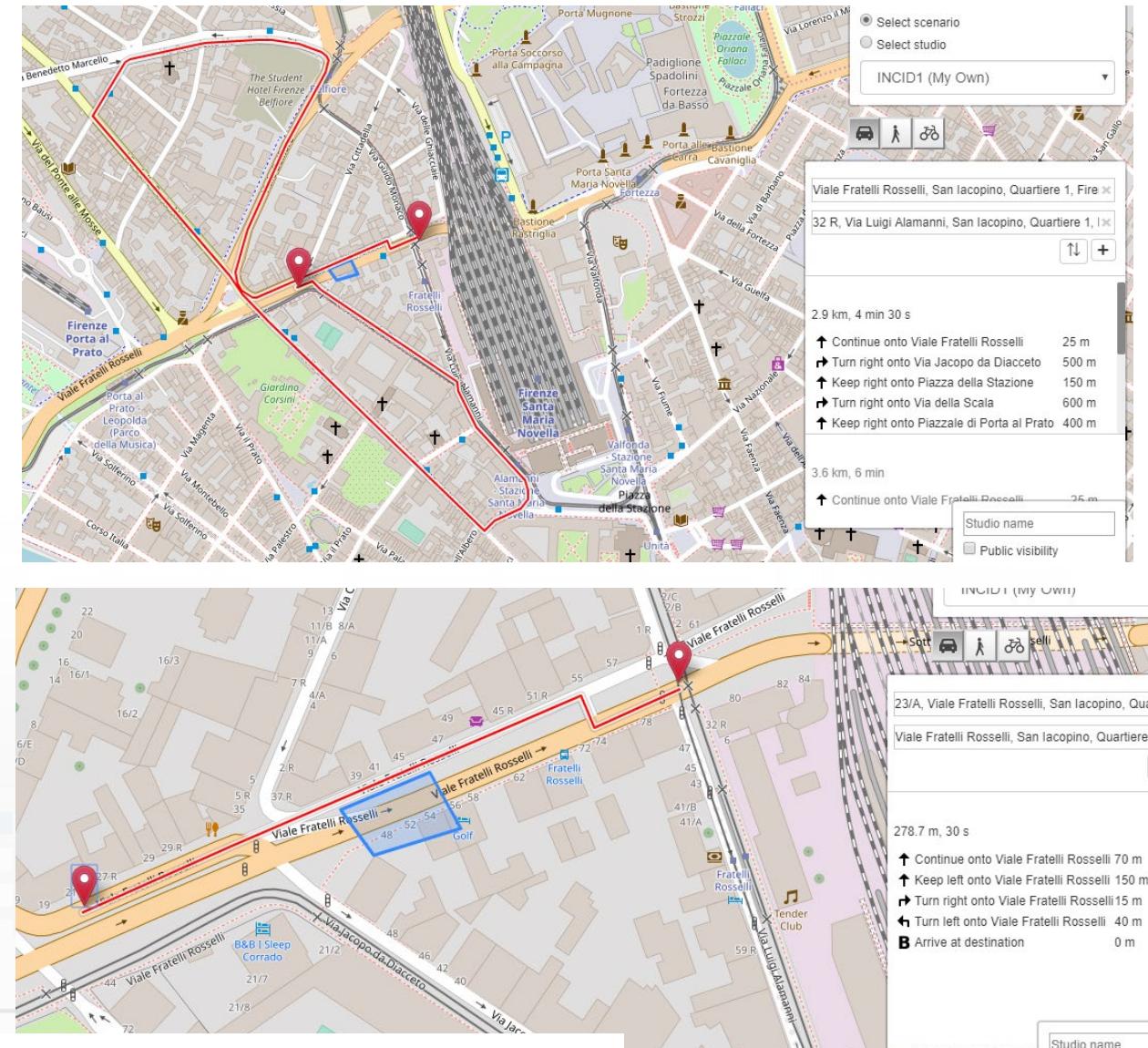
Route Description	Distance	Time
34, Via Francesco De Sanctis, Bellariva, Quartiere 14	3.4 km	4 min
Continue onto Piazza Massimo D'Azeglio	70 m	
Continue onto Via Silvio Pellico	90 m	
Turn sharp right onto Viale Antonio Gramsci	500 m	
Continue onto Piazza Cesare Beccaria	700 m	
Continue onto Lungarno Guglielmo Pecori Giraldi	1.5 km	
Make a U-turn onto Lungarno Cristoforo Colombo	150 m	
Turn right onto Via della Bellariva	200 m	
Turn sharp left onto Via Giovanni Laanza	150 m	

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



Road Parking

Parking Conditions Monitoring

Wed 23 Oct 16:24:41



Parking Slots

Parking Status

- Free
- Busy
- Busy bluetooth
- Busy authorized
- Busy paid user
- Busy paidanon
- Busy paidanon over
- To be fined
- Fined
- Forbidden
- Do not care

DISIT:OrionUNIFI:METRO1095 - VehicleFlow

400 car/h

8m

Management

Parking KPIs

Select Group: Alberti 11

Group capacity : 26

Grouped by slot type

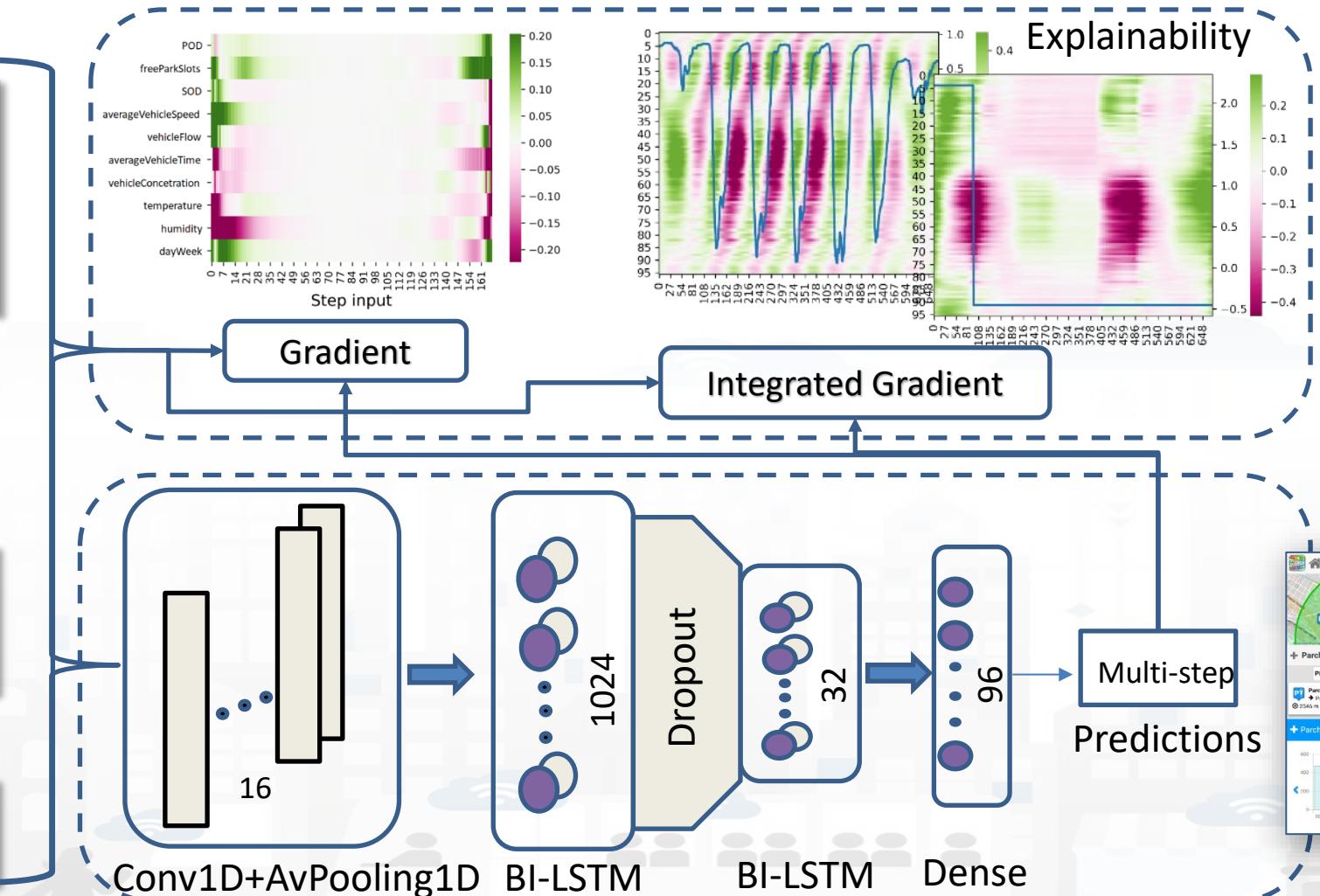
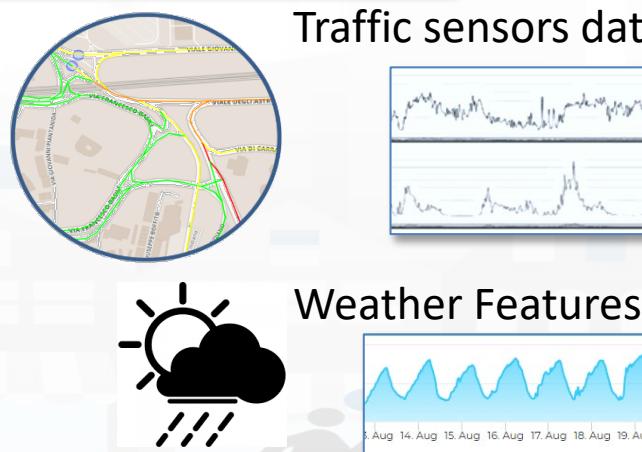
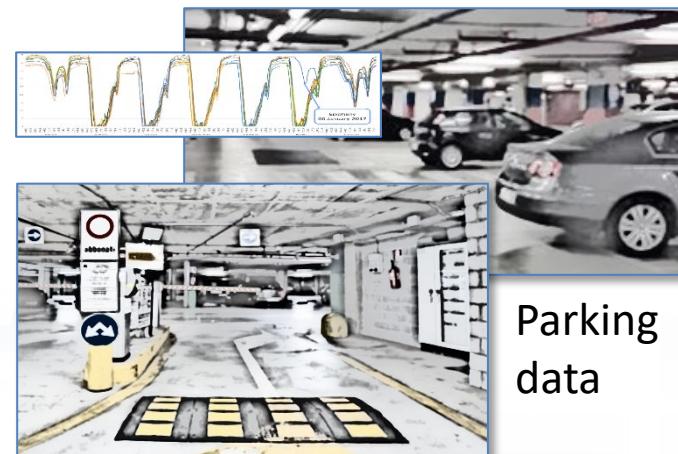
Event Car

- Free Slots: 4/22
- Busy Slots: 2/22
- Busy Bluetooth Slots: 3/22
- Busy Authorized Slots: 5/22
- To Be Fined Slots: 5/22
- Fined Slots: 1/22
- Do Not Care Slots: 2/22

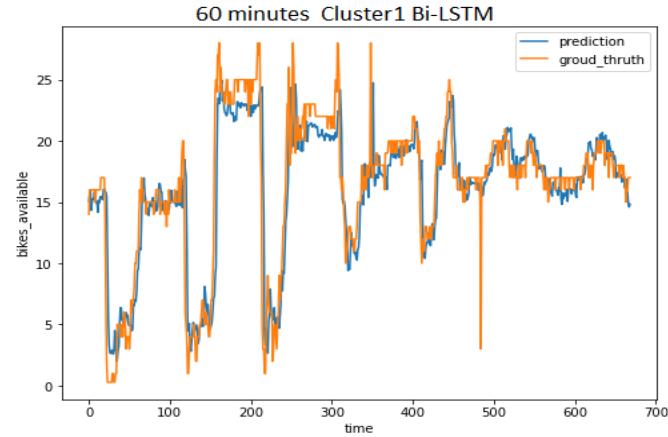
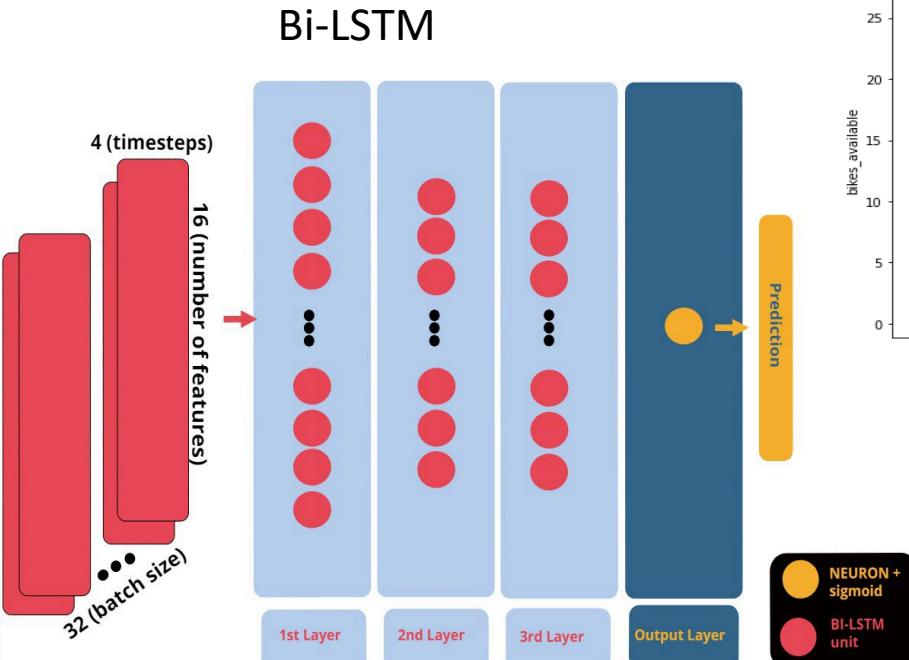
Event Moto

- Free Slots: 0/4
- Busy Slots: 1/4
- Busy Authorized Slots: 0/4
- To Be Fined Slots: 1/4
- Fined Slots: 1/4

Deep Learning AI to surely Park!



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>

Snap4ISPRA Parking: ISPRA JRC

Parking 58C Fri 6 Oct 18:33:41

Capacity	9m	Free Slots	9m	Occupanc...	9m
85#		74#		12.9%	

OverparkingSlots 9m **Unknown State Slots** 9m

0# 3#

Free Slots Weekly Time Trend Compare 9m

Percentage Of Occupancy Daily Time Trend Compare 9m

Overparking Weekly Time Trend Compare 9m

Time Trend Comparison 4m

30. Sep 12:00 1. Oct 12:00 2. Oct 12:00 3. Oct 12:00 4. Oct 12:00 5. Oct 12:00 6. Oct 12:00

Free Slots Overparking Unknown

Smart parking

OPTIFaa S

- Home
- Traffic Monitoring
- Smart Parking
- 15 minuti index
- Urban Security

- Posto auto
- Posto auto per tipologia parcheggio
- Posto auto per tipologia veicolo



Disponibilità parcheggi	
Liberi	20
stalli	stalli

Tipologia parcheggio	
Gratuiti	3
stalli	stalli
A pagamento	35
stalli	stalli
Residenti	0
stalli	stalli

Tipologia veicolo		
Auto	46	stalli
Moto	0	stalli
Bici	0	stalli

Non disponibili
0
stalli

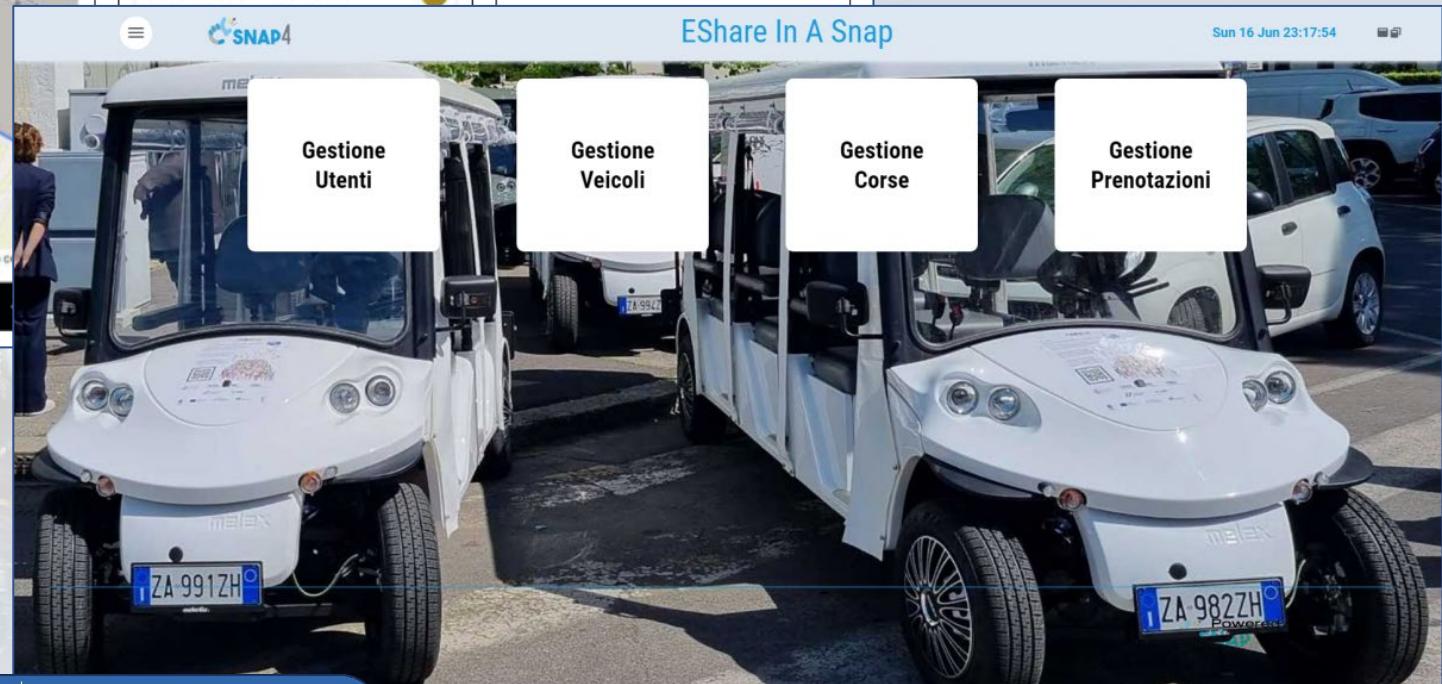
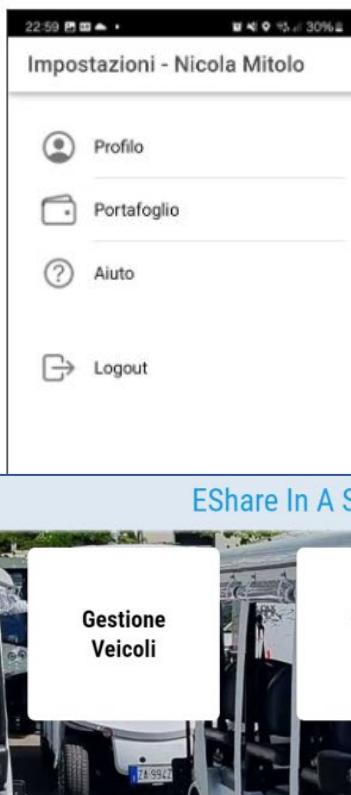
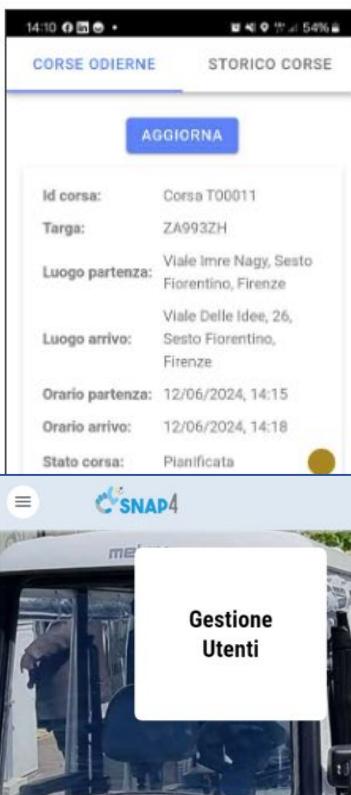
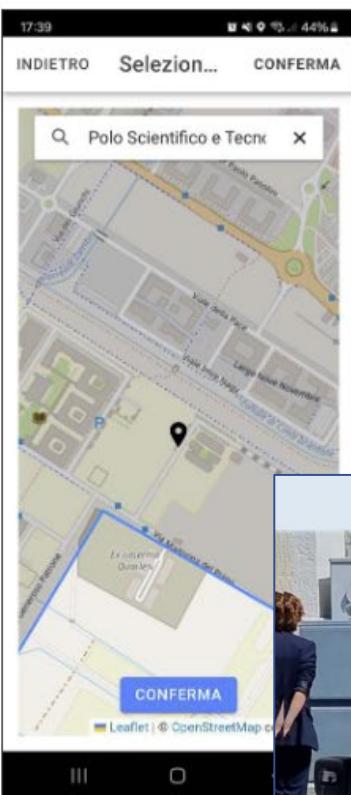
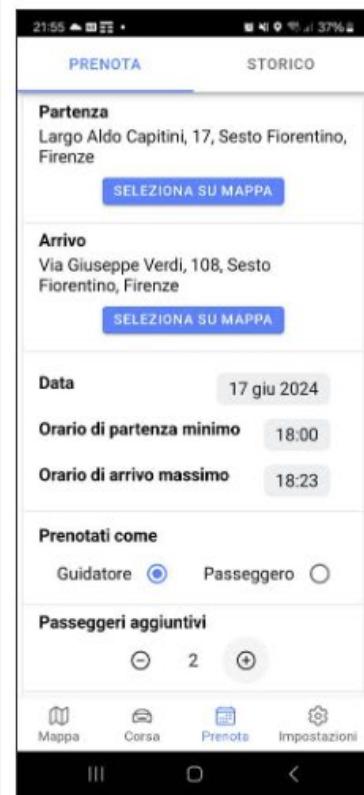
Prioritari	Disabili	Carico/Scarico
4	4	0
stalli	stalli	stalli

Camion	Camper
0	0
stalli	stalli

eSharing and Pooling



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



Gestione Veicoli

Vehicle list (5 items):

Vehicle	Batteria	condition	Data	Blocco	Targa	status	Km/h	Actions
vehicle_ZA994ZH	97.75	Ok	16/06/2024 04:36	On	ZA994ZH	closed	0	
vehicle_ZA993ZH	98.67	Ok	16/06/2024 21:44	On	ZA993ZH	closed	0	
vehicle_ZA991ZH	92.64	Ok	16/06/2024 21:13	On	ZA991ZH	closed	0	
vehicle_ZA992ZH	88.76	Ok	16/06/2024 22:09	On	ZA992ZH	closed	0	
vehicle_ZA983ZH	87.33	Ok	16/06/2024 23:06	On	ZA983ZH	closed	0	

Map view showing vehicle locations in Sesto Fiorentino, Italy.

Time Trend Batteria (11 Jun - 16 Jun):

Time Trend Velocità (11 Jun):

Gestione Prenotazioni Con Pool

Reservation list (5 items):

Reservation	Passeggeri	Data
mary_Reservation_0003	2	14/06/2024 17:31
bosfra3_Reservation_0001	2	14/06/2024 17:39
michelangelosanto_Reservation_0001	0	15/06/2024 18:19
michelangelosanto_Reservation_0002	0	16/06/2024 19:58
simonemaga96_Reservation_0003	0	16/06/2024 21:20

Available Vehicles (3 items):

Targa	Status	Distanza (metri)	Ha corse precedenti?	Posti totali	Data
vehicle_ZA981ZH	closed	49	No	8	16/06/2024 23:08
vehicle_ZA980ZH	closed	51	No	8	16/06/2024 23:12
vehicle_ZA982ZH	closed	220	No	8	16/06/2024 23:13

Map view showing vehicle locations in Sesto Fiorentino, Italy.

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

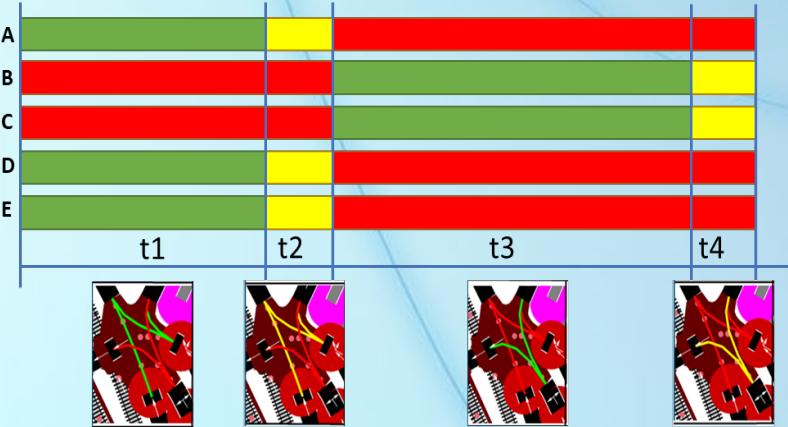
Trucks' Plates and Container ID Recognition



- **Managing Gates to Salerno Port**
- Gates: in/out
- **Recognition and decoding**
 - BIC code: TSSU 204006
 - ISO code: 22G1
 - Seal status: on/off
 - Multi-national Plates: 74-0771

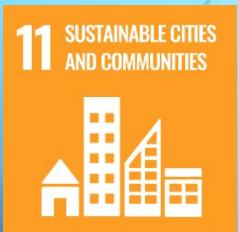


The screenshot shows the SNAP4CITY software interface for managing truck and container recognition at a port gate. The main display shows a camera feed of a truck and a brown shipping container. The truck's license plate is EX-398AE and the container's code is FCIU 964484 8, 45G1. To the right, a detailed view of the container's code is shown with its breakdown: FCIU, 964484, 8, 45G1. The interface includes a header with the date Fri 5 Sep 15:36:52 and a list of previous detections for the gate. The detections include HHAH123, BFC456, and EX398AE, each with its date and time. The bottom right corner of the interface features the SNAP4Tech logo.



Ottimizzazione Semaforica

Prof. Paolo Nesi, UNIFI DISIT



<https://www.snap4city.org/1015>

Traffic Light Optimisation

- **Traffic Light Plan:**

- General construction of Traffic Light Plans for the area
- TLP are loaded on the basis of the expected conditions: football game, ferial and festive, school period, morning and afternoon, etc.
- Single Junction TLP can be:
 - adjusted exploiting local data, on demand signals, etc.
 - Actuated on the basis of the measures of traffic

- **Issues:**

- Making multijunction synchronization to keep under control of quality of Service for TRAMWAYS and/or Busses Rapid Transit, BRT/HRB



Select map

Zoom

New Scenario

Editing

Drag & drop

Split & Join

Delete

Do and Undo

The screenshot shows the SNAP4CITY Scenario Editor interface. The main area displays a map of a road intersection with various traffic sensors (red circles with arrows) and a road graph (blue lines with arrows). A context menu is open for a road segment, showing options like 'Edit', 'View', 'Show Road graph', 'Show Traffic Sensors', and 'Filter by road types'. A properties dialog is open for the selected road segment, with fields for 'Scenario name', 'Location', 'Scenario description', 'Reference KB', 'Save Road Graph' (Yes), 'Save traffic Sensors' (Yes), 'Save other Sensors' (Yes), 'From' (gg/mm/aaaa--::--), and 'To' (gg/mm/aaaa--::--). Below this is another properties dialog for 'Category Street: primary', 'Nr.Lanes: 3', 'Speed Limit (km/h):', 'Direction: Positive direction', and 'Restrictions: Select or create restriction'. A 'Road Types' list is also visible, showing checkboxes for various road types: abandoned, bridleway, corridor, crossing, emergency_access_point, emergency_bay, footway, motorway, primary, residential, services, traffic_island, secondary, bus_guideway, bus_stop, disused, footpath, motorway_link, no, primary_link, private, rest_area, road, steps, tram, yes, construction, elevator, island, living_street, path, platform, raceway, razed, secondary_link, service, tertiary, tertiary_link, track, unclassified, via_ferrata, and bus_guideway. A legend on the right lists properties: identifier, composition, elemLocation, elementClass, elementType, length, operatingStatus, speedLimit, trafficDir, width, highwayType, and route. The bottom of the interface shows the URL <https://www.snap4city.org/976> and the text 'Properties of Road Elements'.

What-if on TFR

Mon 23 Sep 12:53:12

SNAP4CITY

Scenario Editor

Some Points of Interest

Traffic Sensors

Air Quality Sensors

Weather Sensors (OW)

Bus Stops

Tram Stops

+

-

19

Piazzale Donatello

Cimitero degli Inglesi

Agip

Giardino Silvano Campeggi

La Spiga

Mesticheria Donatello

2 R Lavandaia

Bar Donatello

Tabacchi Donatello

3

3a

4

5

6

7

37

34

35

36

66

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2a

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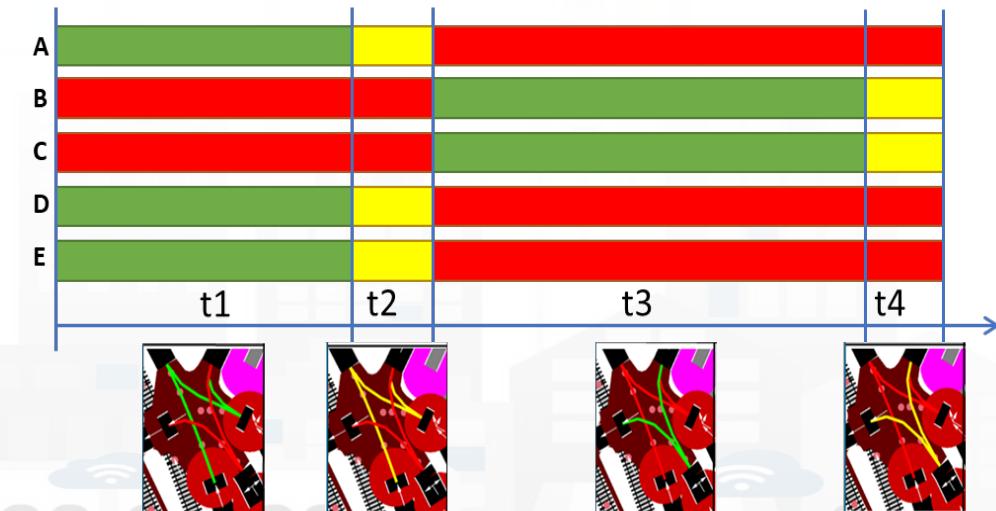
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Traffic Light Plan Optimisation, Digital Twin

- **Match Multiple Objectives and Synchronization:**
 - public and private traffic, tramway priority
 - Micro and Macro Scales
 - **AI: Genetic Algorithms, Deep 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%**



Traffic Light Plan Editor

Traffic Light Plan Editor

Query radius: 30
Semaphore name: crispi-settembre
Directions: 5
Time cycle: 100

Save Traffic Light **debug** **Clear** **View Mode** **Edit Mode**

	Via Ve...	Via Fr...	Via Ve...
Via Ve...	1	0	0
Via Fr...	2	0	3
Via Le...	0	4	5

1 : Via Venti Settembre - Via Venti Settembre
2 : Via Francesco Crispi - Via Venti Settembre
3 : Via Francesco Crispi - Via Venti Settembre
4 : Via Leone Decimo - Via Francesco Crispi
5 : Via Leone Decimo - Via Venti Settembre

Traffic Light Plan Generator Wed 23 Oct 18:50:03

Selector - Map

Load Scenario: Init Acc
Scenarios waiting to be processed: dbologna_scenary2
Scenario version: 2024-02-21 17:20:42
Load Scenario Clean

View Edit
Show Road graph
Show Traffic Sensors
Filter by road types

Optimization of Traffic Light Plan

Traffic Flow Analysis By Scenario

Fri 25 Oct 17:56:16

INIT to ACC Compute TFRs Compute KPI Show TFR

Load Scenario: Scenarios waiting to be processed: StututoCase1 Init Acc Load Scenario Clear

Scenario version: 2024-10-25 16:36:59

Scenario Editor Some Points of Interest Traffic Sensors Air Quality Sensors Weather Sensors (OW) Bus Stops Tram Stops

Map View Edit Show Road graph Show Traffic Sensors Filter by road types

DISIT:OrionUNIFI:METRO1098 - VehicleFlow 8m

Time Series 3m

2k cars/m 0 5. Aug 19. Aug 2. Sep 16. Sep 30. Sep 14. Oct

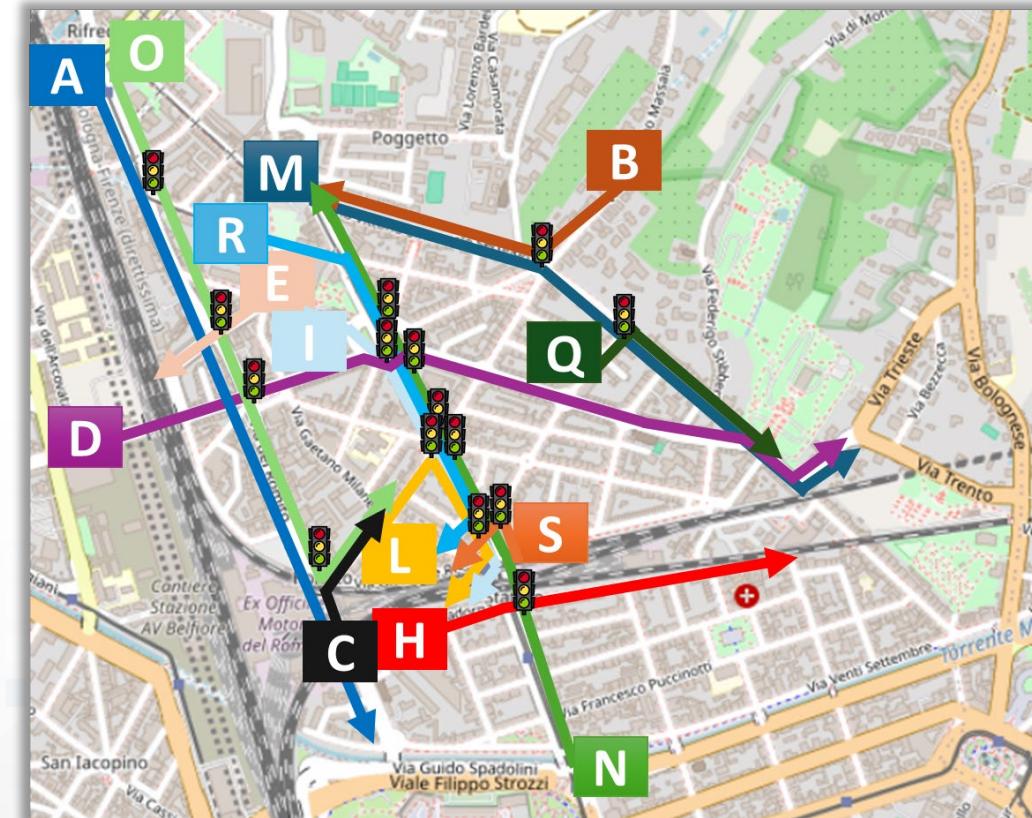
0 20 cars/m 0 5. Aug 19. Aug 2. Sep 16. Sep 30. Sep 14. Oct

© DISIT:orionUNIFI-METRO1098 - concentration

This screenshot displays the SNAP4CITY platform interface for traffic flow analysis. The main map shows a dense urban area with a network of traffic lights and sensors. A legend on the left identifies various data types: Scenario Editor, Some Points of Interest, Traffic Sensors, Air Quality Sensors, Weather Sensors (OW), Bus Stops, and Tram Stops. The map includes a zoom control, a 'View/Edit' button, and checkboxes for 'Show Road graph' and 'Show Traffic Sensors'. Below the map are two time-series charts. The left chart, titled 'DISIT:OrionUNIFI:METRO1098 - VehicleFlow', shows vehicle count over an 8m distance from 18:00 to 15:00. The right chart, titled 'Time Series', shows concentration levels over a 3m distance from 5. Aug to 14. Oct. Both charts have a y-axis scale from 0 to 2k or 20.

Optimization Drivers

- **MTT**, Mean Travel Time on
 - Multiple Directions or globally
 - For specific service
- **MWT**, Mean Waiting Time on
 - specific direction or globally
 - For specific service
- **MNS**, Mean Number of Stops on
 - specific direction or globally
 - For specific service



GA based: Mean Travel Time

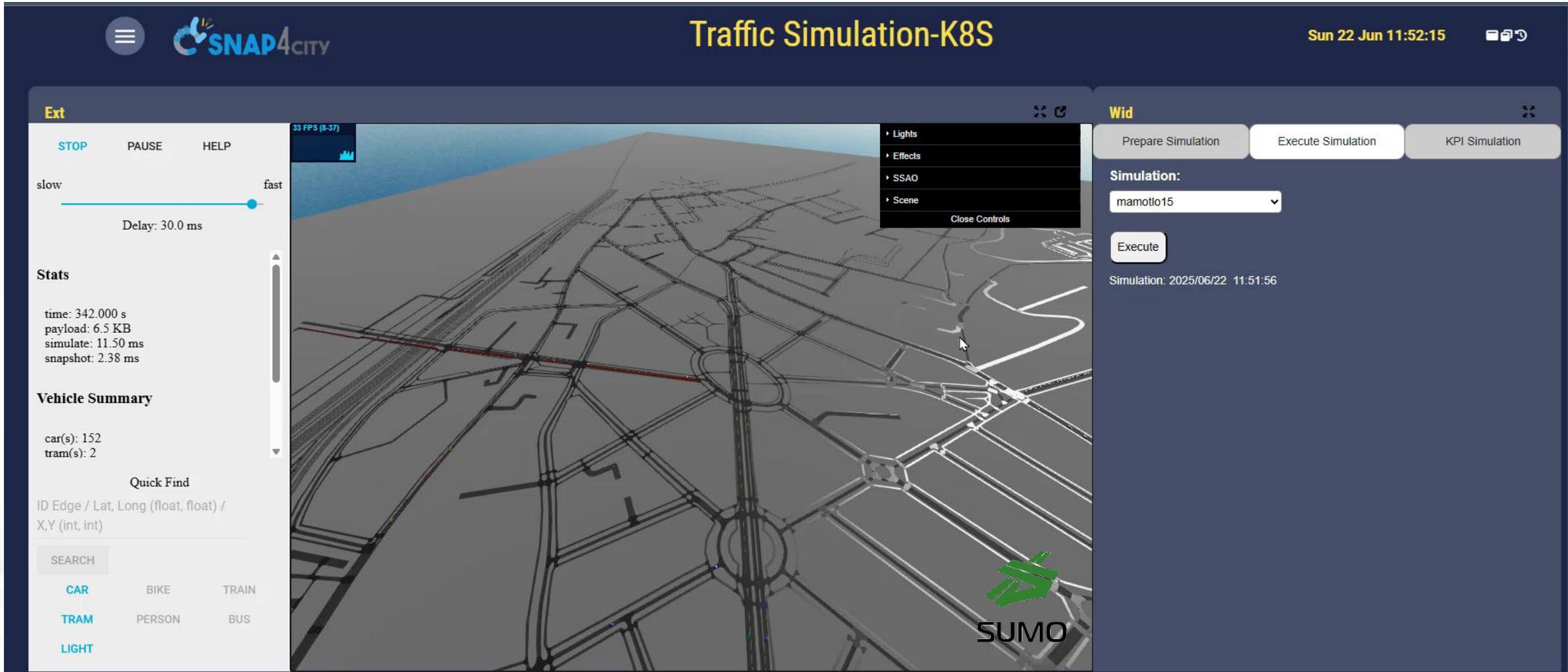
	Traffic Load	MTTall	MTT dir_N	MTT dir_M	MTT dir_A	MTT TW Careggi	MTT TW Costanza
4TW-NTNS-MWD-P	1.5	3542.50	198.90	242.14	197.64	436.00	427.00
4TW-NTNS-MWD-A	1.5	3242.71	178.33	243.28	195.79	436.00	427.00
4TW-NTNS-MWD-P-A	1.5	3242.71	178.33	243.28	195.79	436.00	427.00
2TW-NTNS-MWD-P	1.5	4538.02	207.40	456.14	615.00	436.00	427.00
2TW-NTNS-MWD-A	1.5	3940.07	179.30	428.67	481.53	436.00	429.75
2TW-NTNS-MWD-P-A	1.5	4380.63	182.05	456.59	654.21	436.00	427.00
SUMO Actuated	1.5	3409.13	280.09	515.34	200.66	497.54	499.81
Webster	1.5	6474.95	465.45	441.93	210.50	1379.25	493.87
WebsterAdjusted	1.5	4035.08	195.82	441.09	205.66	463.87	447.06

-5% **-8%** **-45%** **-3%** **-6%** **-4.5%**

**Reductions of Travel time of
3-45% and elimination of the
#stops for the tramways**

4TWD-NTNS-MWD-P-A: optimization by prioritizing traffic directions, the normalized number of **vehicles stops**, **NTNS**, the **mean waiting delay MWD**, for all traffic lights, and post synchronization, with Penalty and Adjust dynamically performed

S. Bilotta, Z. Fereidooni, L.A. Ipsaro Palesi, P. Nesi, "Macroscopic GA-based Multi-Objective Traffic Light Optimization Prioritizing Tramways", Applied Soft Comp. Journal, Elsevier, 2025.



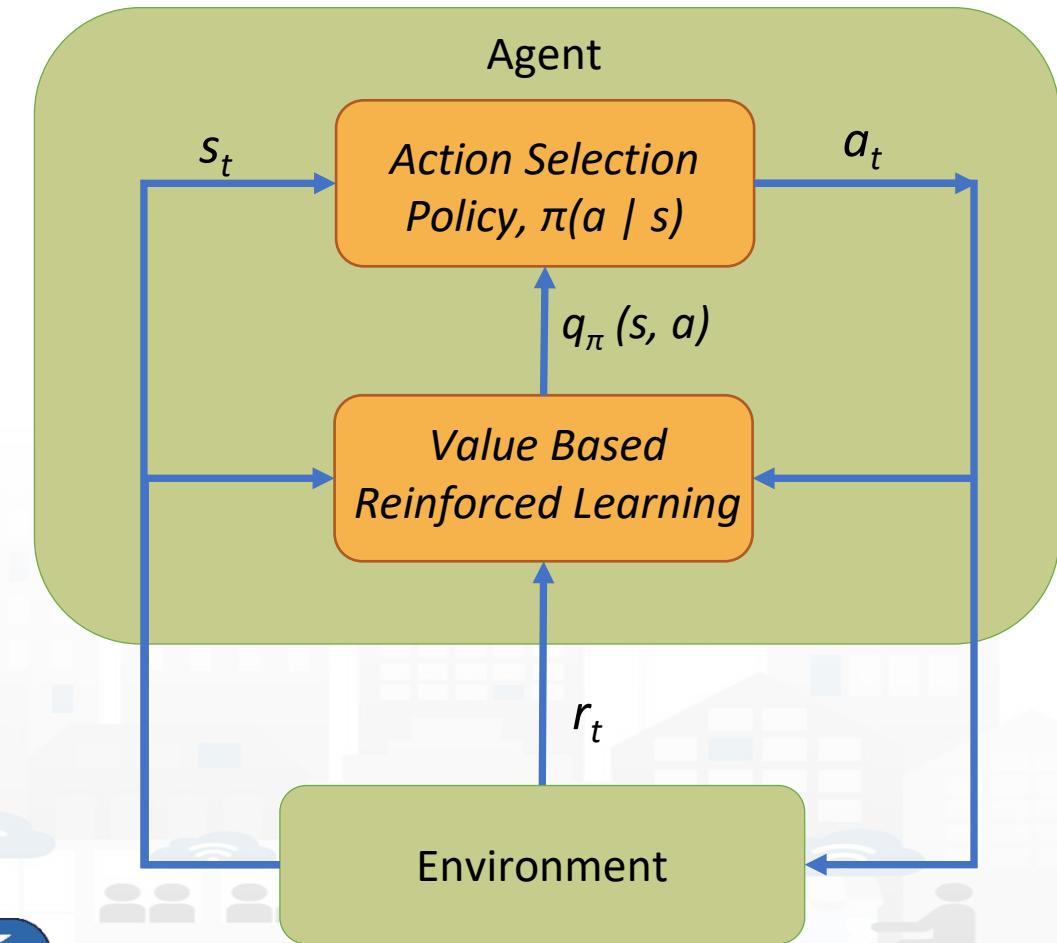
Multi Agent Reinforced Learning

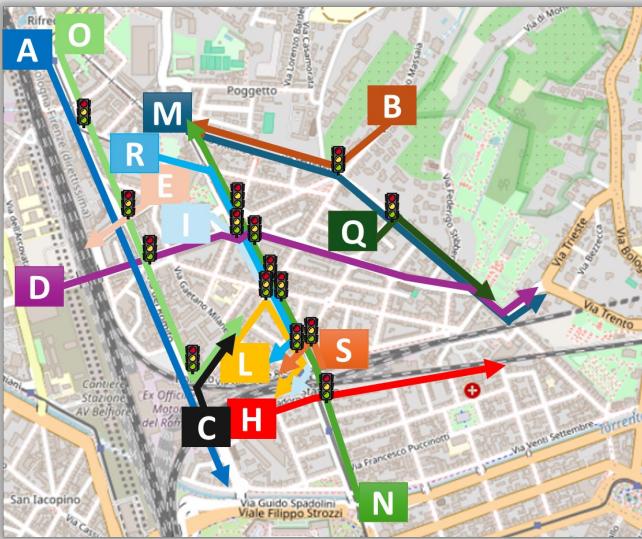
- **Single Actuated**

- Taking into account the status of each traffic source of each Juction
- Computing the best compromise of G/R ratio
- Act on the next cycle

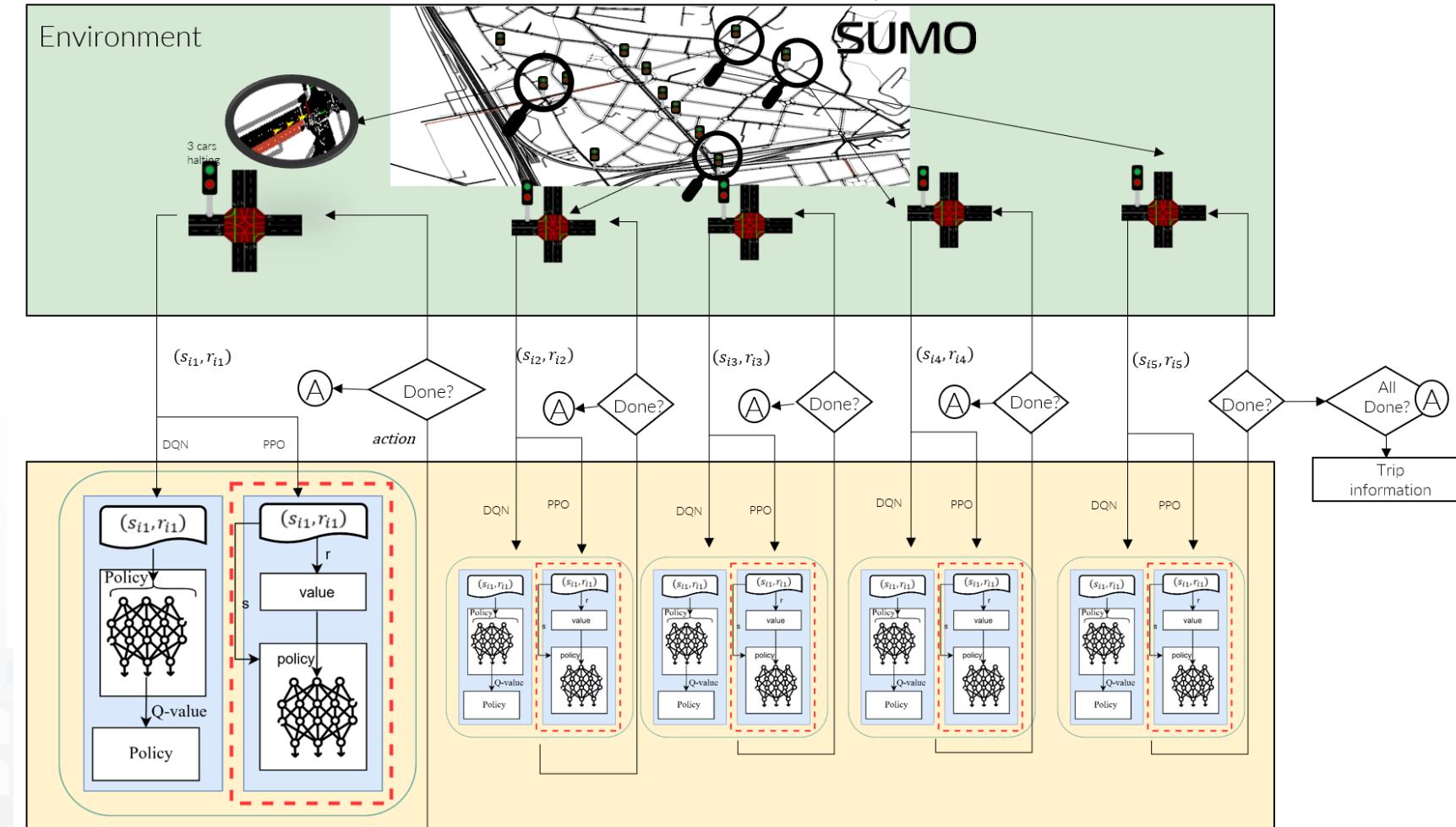
- **Multi Agent**

- As Single Actuated
- Taking into account synchronization, as condition and travel time of main specific travel means





Multi Agent DRL



MTT for Multi Agent DRL for TLP

Model	TL	all	dir_N	dir_M	dir_A	dir_D	Careggi	Costanza
4TWD-NTNS-MWD-A	1	3013.85	176.93	233.75	194.46	237.65	436.00	427.00
4TWD-NTNS-MWD-P-A	1	3013.85	176.93	233.75	194.46	237.65	436.00	427.00
SUMO Actuated	1	2935.41	249.60	209.77	202.42	270.86	486.73	478.36
Webster	1	5188.87	211.66	242.32	205.46	562.31	984.00	427.00
Webster A	1	2968.90	183.50	242.67	201.27	251.76	482.27	427.00
SARL-FC DQN	1	2834.93	206.68	244.78	199.21	243.26	486.72	485.00
SARL-FC DQN A	1	2760.12	206.35	244.63	198.00	244.76	436.00	427.00
MADRL-FC DQN	1	3089.20	188.29	220.91	205.07	248.06	485.00	445.00
MADRL-FC DQN A	1	2983.69	189.11	220.70	187.00	248.79	436.00	427.00
MARL-FC PPO	1	2910.76	200.38	235.41	198.14	237.78	547.00	445.00
MARL-FC PPO A	1	2855.12	200.93	235.53	196.39	237.97	436.00	427.00
SMART A	1	2599.13	182.14	200	188.28	235.11	436.00	427.00

Ottimizzazione Trasporto Collettivo

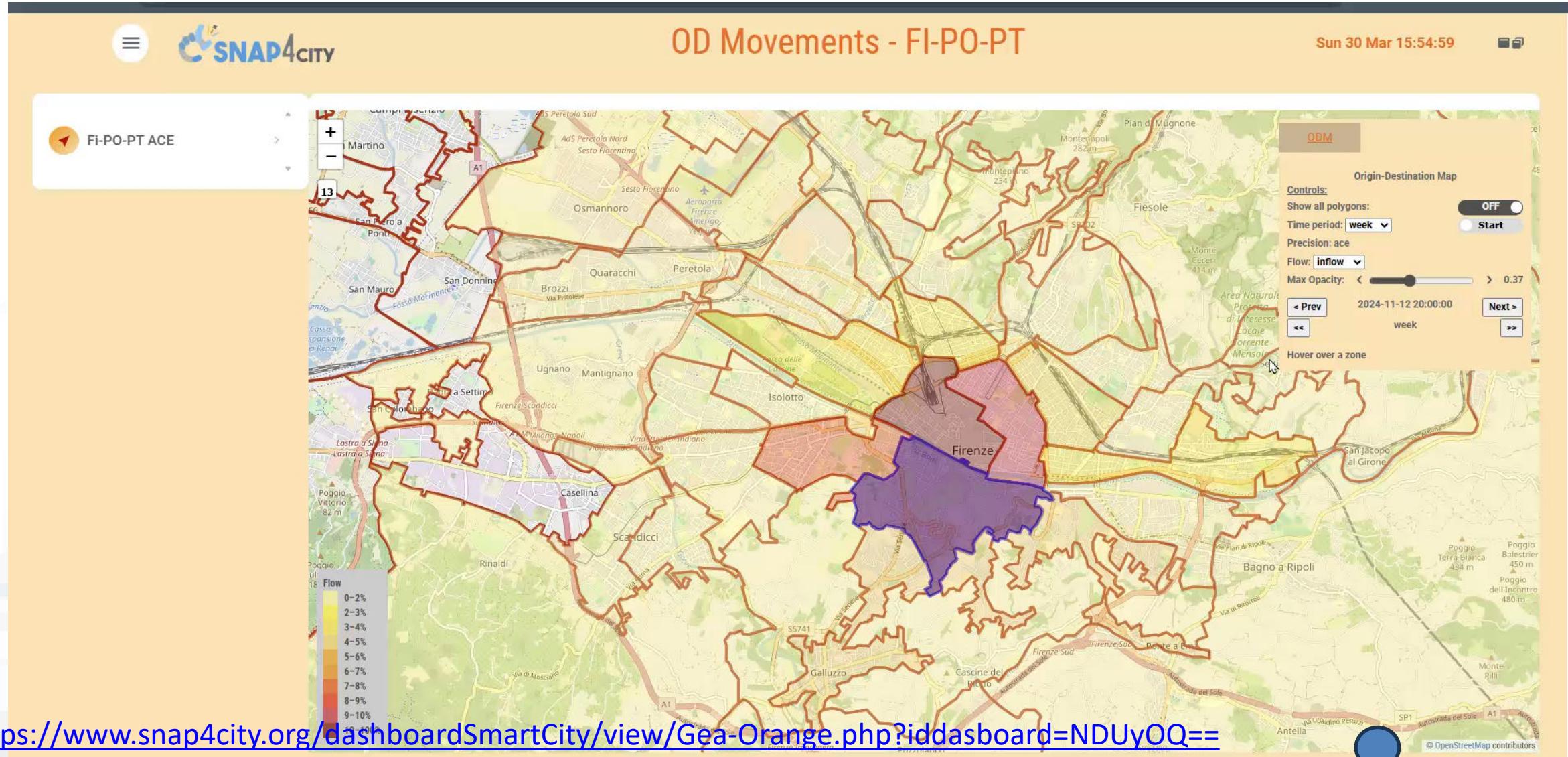
Prof. Paolo Nesi, UNIFI DISIT



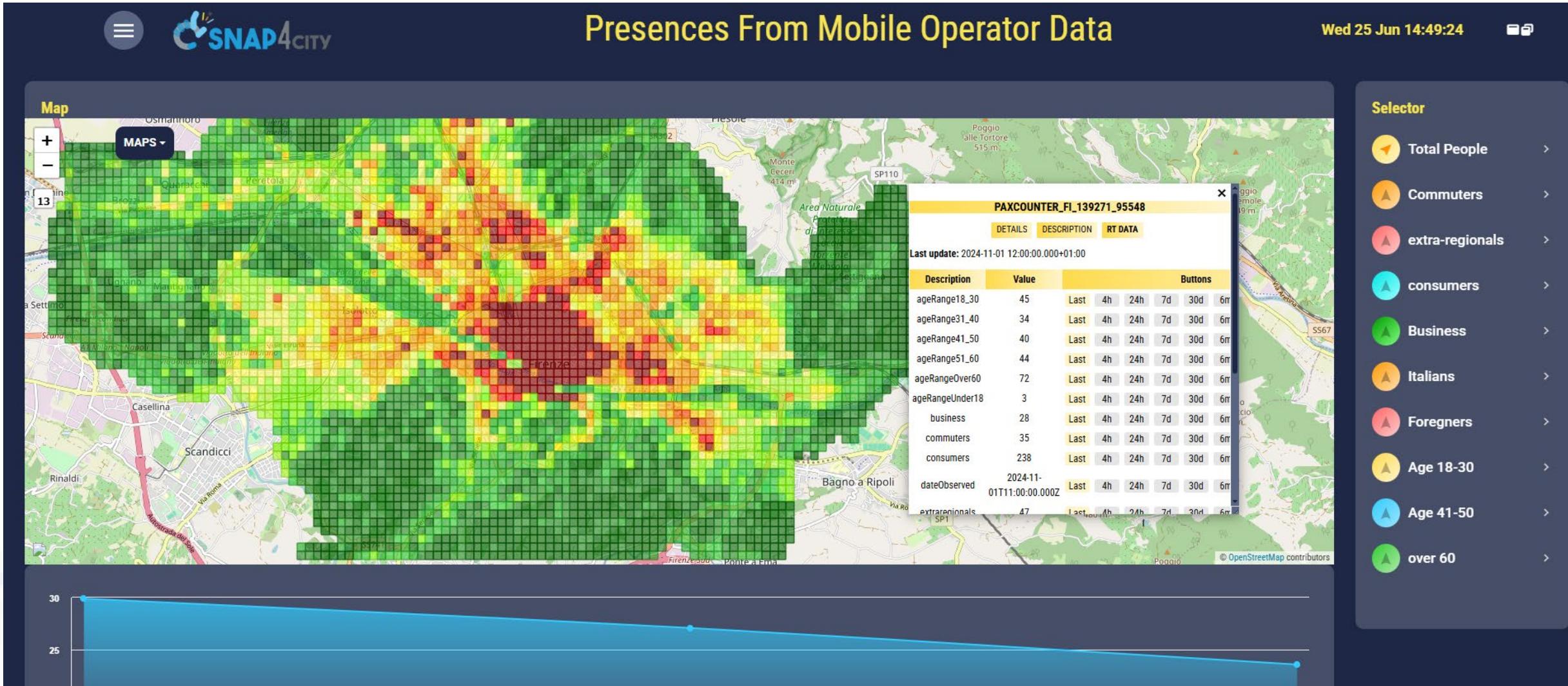
In the large

- **Mobility Demand → ODM:**
 - Telecom Operator ODM, all movements on ACE Area
 - Reduction on local actual percentage and behaviour distributions
 - Matching on MGRS 200 mt, exploiting presence data of Telecom Operators
- **Transportation offer**
 - Road graph
 - GTFS/NeTex, transmodel
 - Bike sharing, carsharing, scooters, etc.

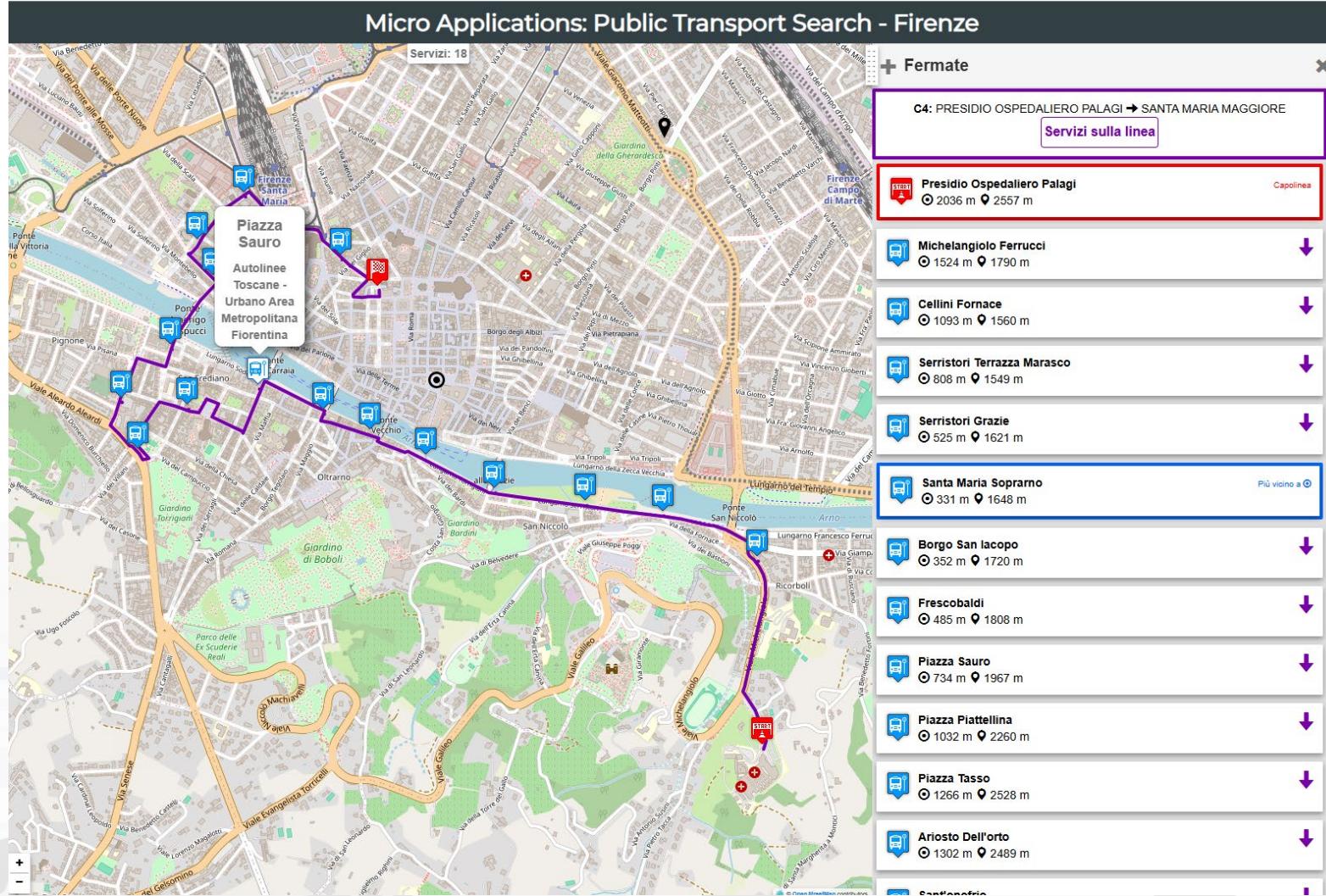
Origin Destination Matrices: Mobility Demand



Presences from Mobile Operator



Offer of Transportation, GTFS, for example



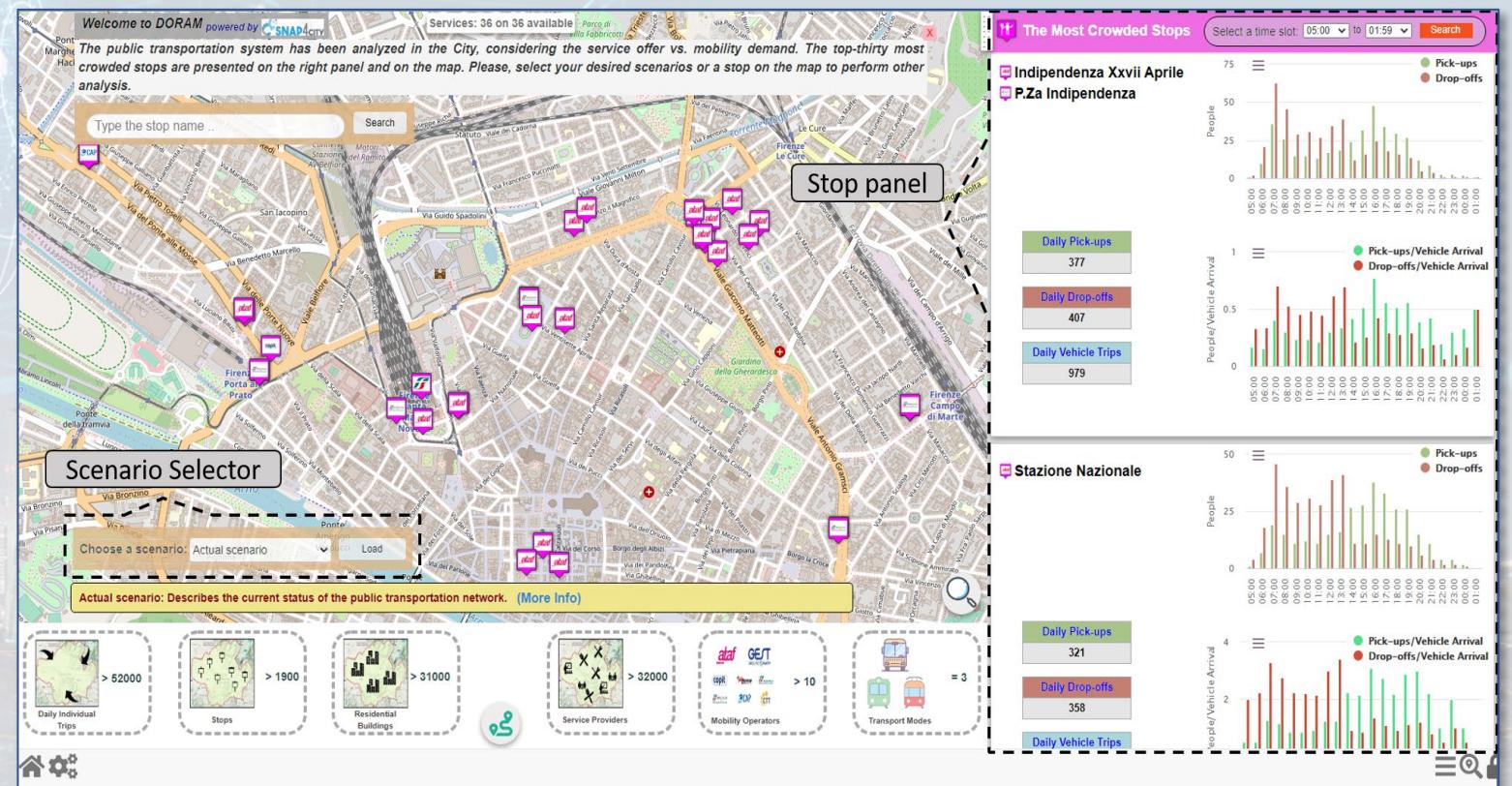
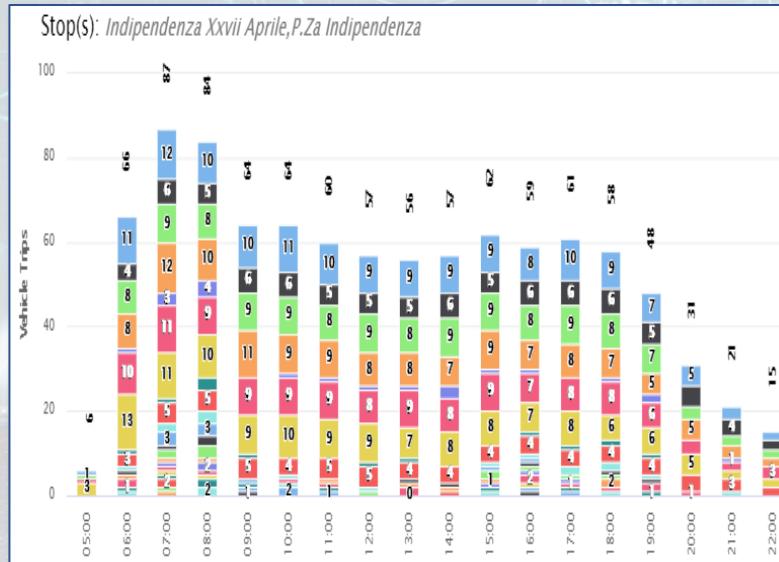
What-if Analysis on Collective Transport: DORAM

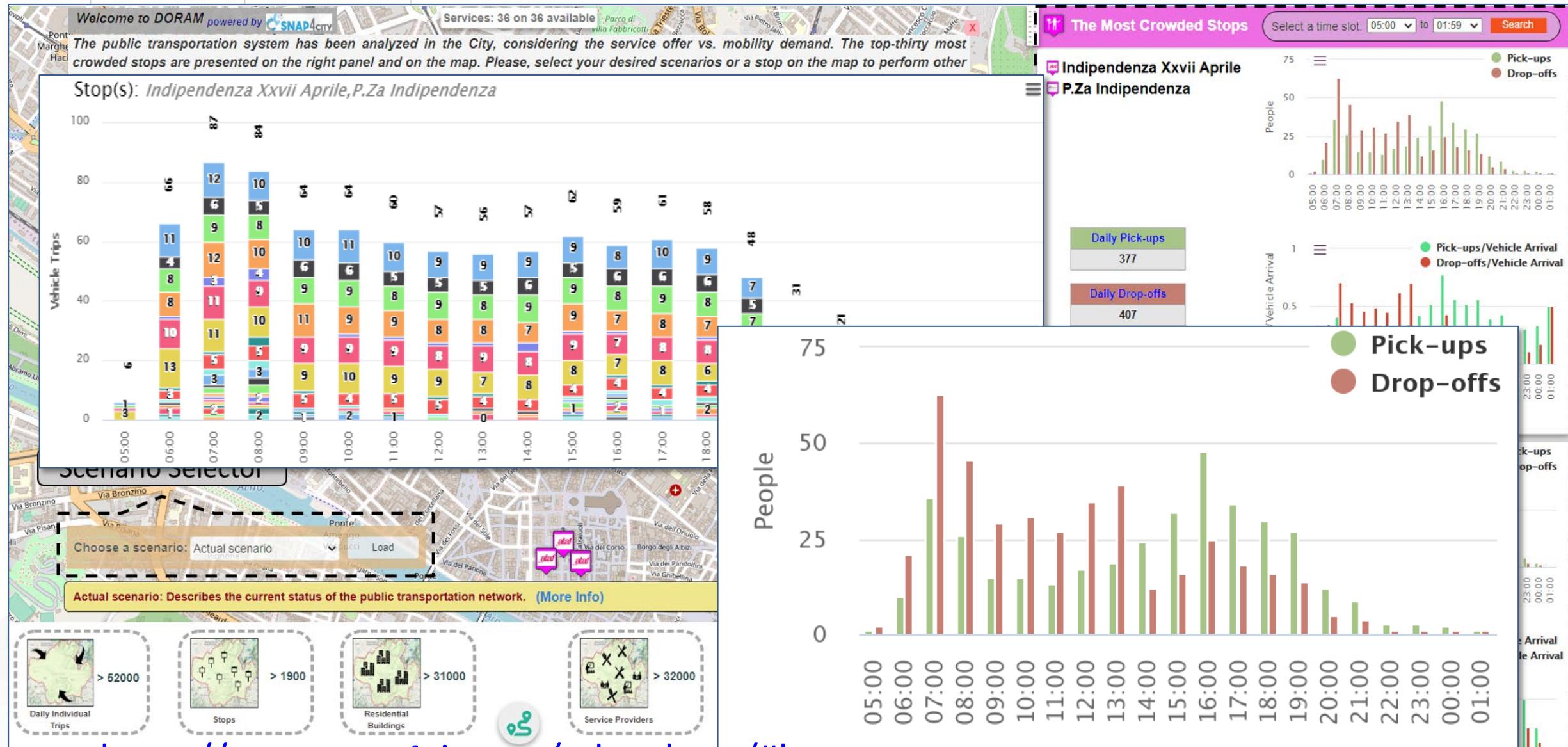


- Simulation / analysis of Mobility Demand wrt Transportation Offer
 - **GTFS/TranSmodel vs ODM**, taking into account road graph and services
- Definition of scenarios impact on
 - Traffic, Pollutant, parking, public transport, private flows, etc.
 - KPI analysis



Public Services





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

Traffic Simulation-K8S

Sun 22 Jun 11:53:30

Ext

STOP PAUSE HELP

slow fast

Delay: 30.0 ms

Stats

time: 0.000 s
payload: 0.0 KB
simulate: 0.00 ms
snapshot: 0.00 ms

Vehicle Summary

Quick Find
ID Edge / Lat, Long (float, float) /
X,Y (int, int)

SEARCH

CAR BIKE TRAIN
TRAM PERSON BUS
LIGHT

Wid

26 FPS (17-26)

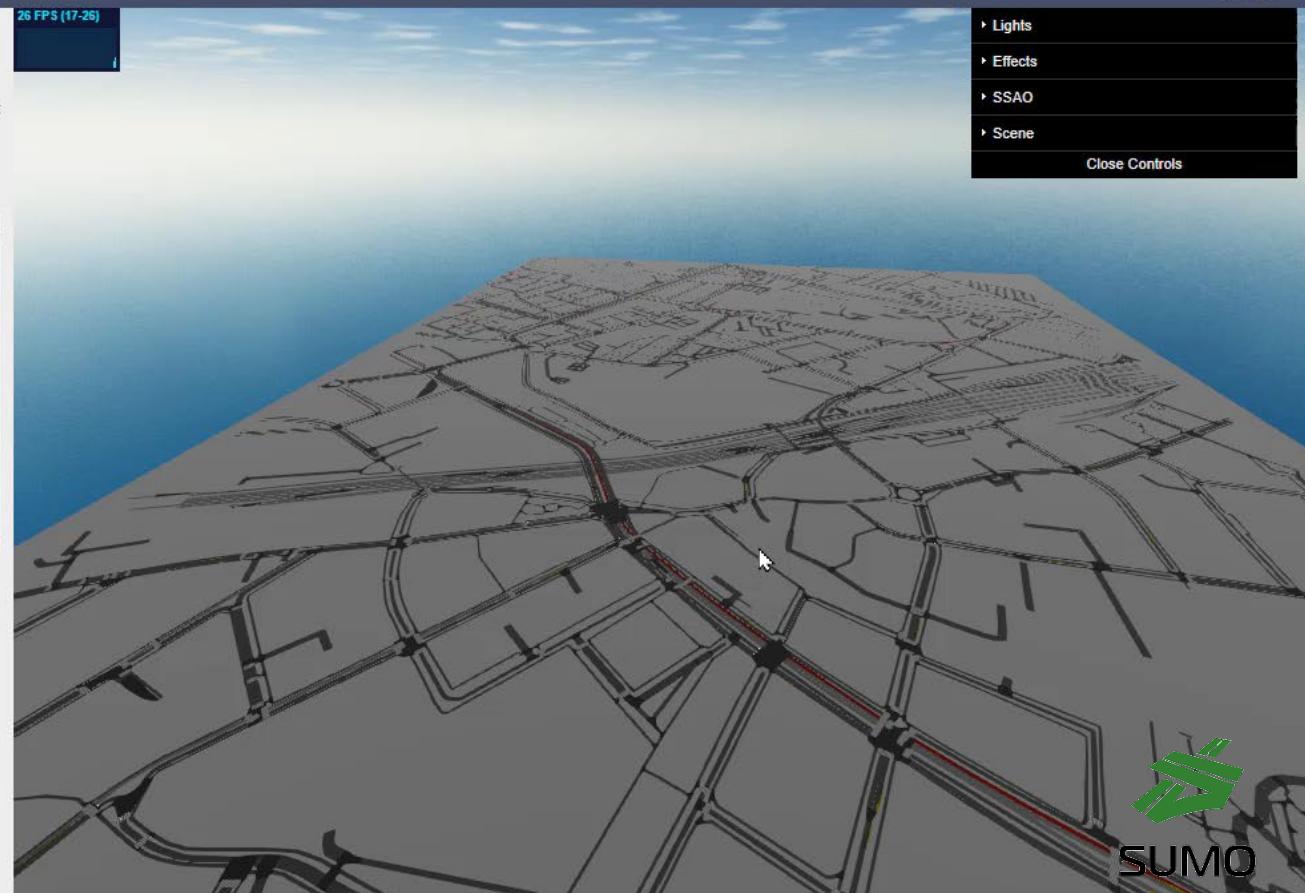
Lights
Effects
SSAO
Scene
Close Controls

Prepare Simulation Execute Simulation KPI Simulation

Simulation:
firenzeodbus

Execute

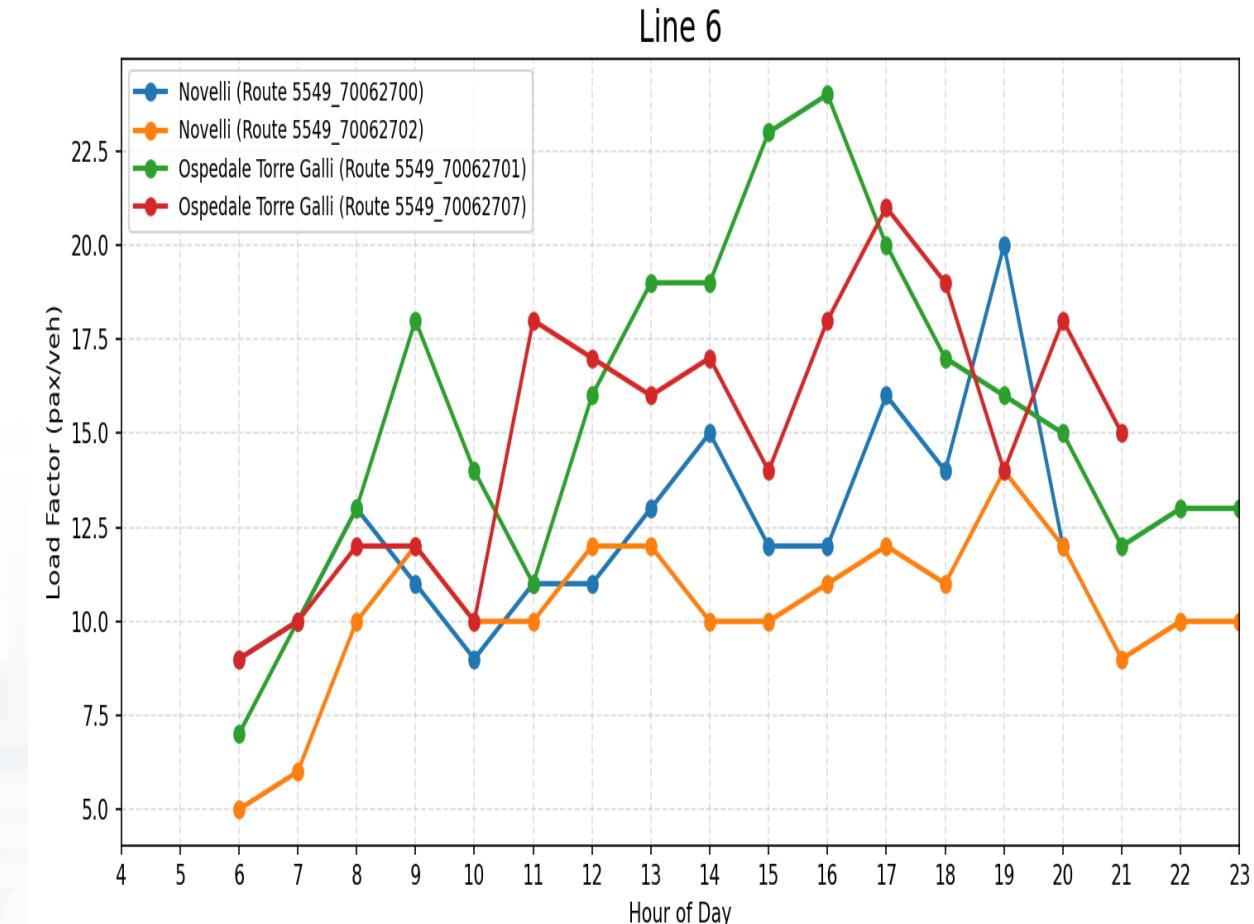
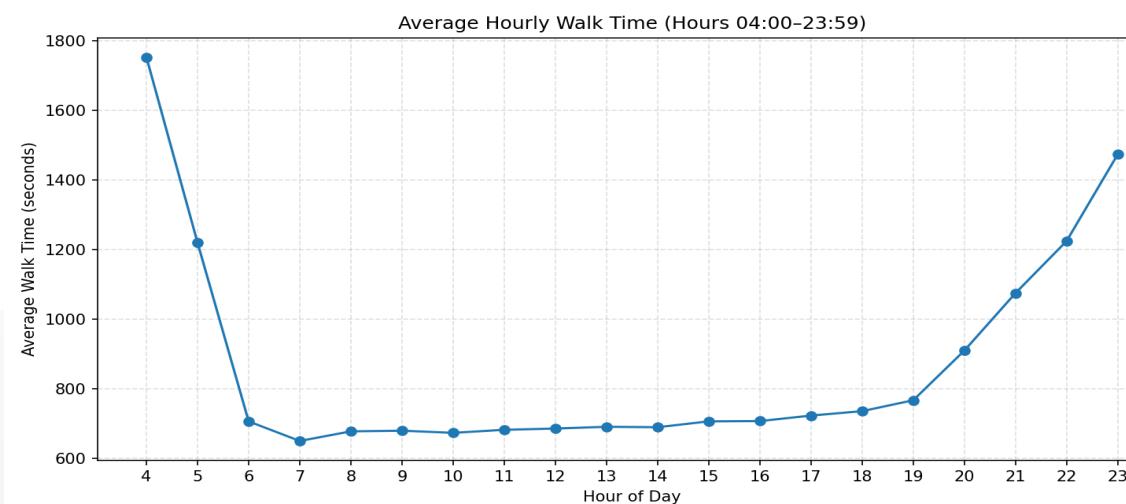
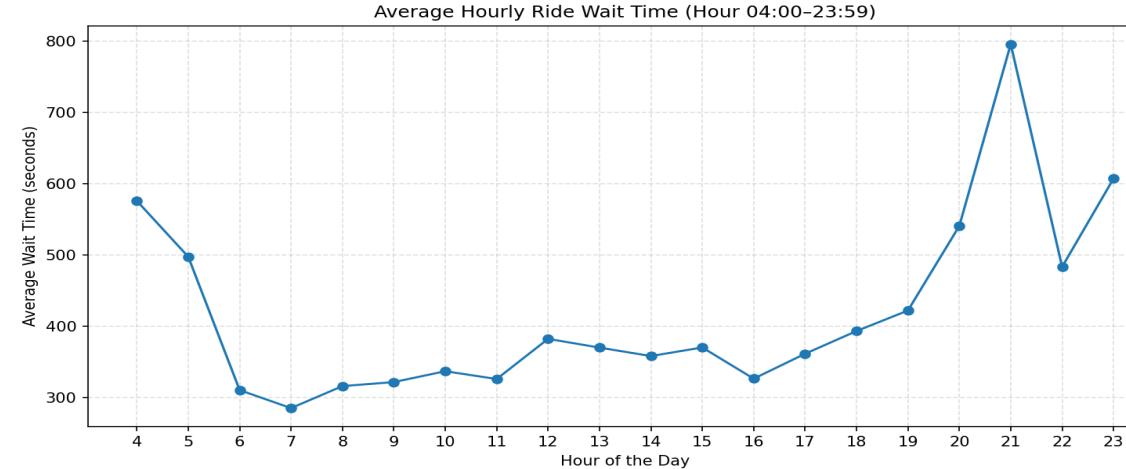
Simulation: 2025/06/22 11:53:27



KPI on Match D-O of Collective Transport

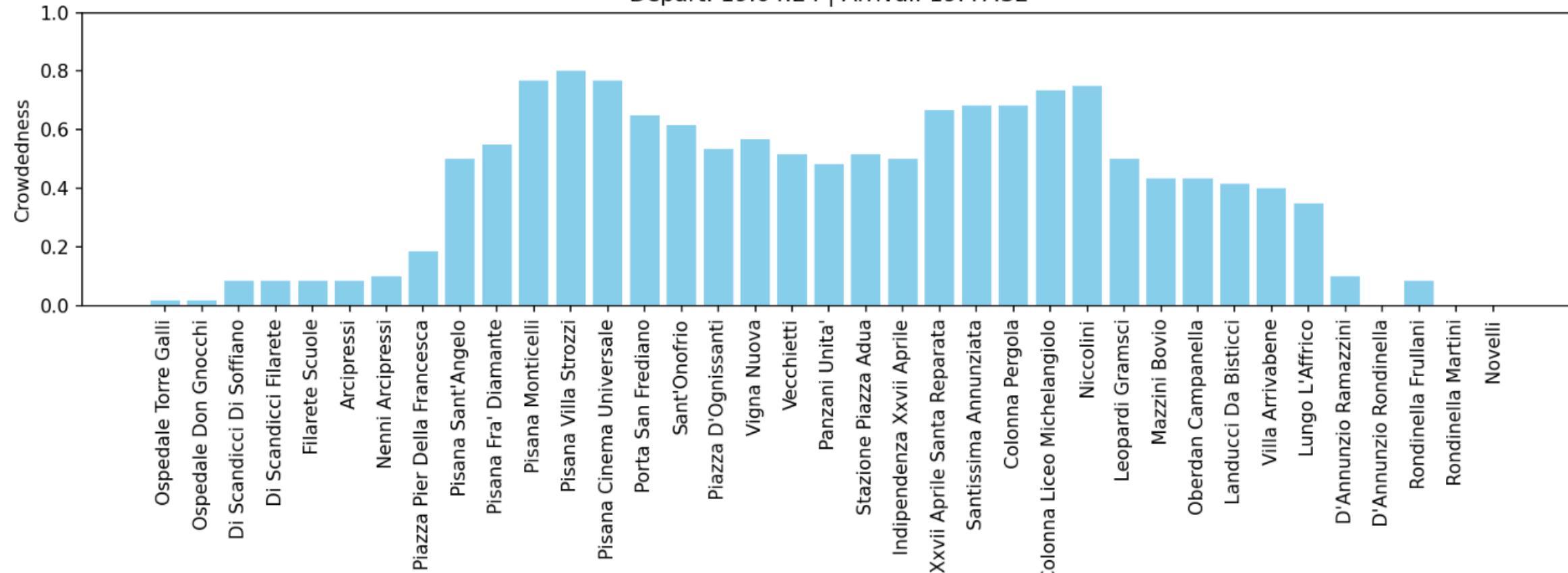
- **On users**
 - **Unmet Demand**
 - Number of passengers who could not board their planned bus
 - **Average Walk Time**
 - The average time spent by passengers during walking before and after taking a ride from source to destination of their trip.
 - Etc.
- **On Service performance**
 - **Average Ride Wait Time**
 - The average amount of time spent by passengers at bus stops while waiting for their desired vehicle.
 - **Average Ride Duration**
 - The average time spent by passengers in a vehicle taking a ride from source to destination of their trip.
 - **Average Vehicle Occupancy**
 - The average number of people boarded in vehicles of different bus lines at different timestamps of a day.
 - **Critical Bus Lines**
 - Bus lines for which the load factor of a bus line exceeds the threshold value of 15 in the service hours.
 - **Critical Bus Stops**
 - Bus stops where the crowding ratio is highest at top 20 bus stops served by different bus lines.
 - **Average Vehicle Depart Delay**
 - Vehicles which depart later than their expected time from the bus stops.
 - **Etc.**

The typical working day



Crowdedness

Trip 5549_70062700 | Line 6 - Novelli
Depart: 19:04:24 | Arrival: 19:47:32



Agenda



IL FUTURO DELLA MOBILITÀ
INTELLIGENTE E SOSTENIBILE

Registrazione	10:00 - 10:30	Registrazione e Welcome Coffee Saluti
Avvio Lavori	10:30 - 10:40	- Prof. Paolo Nesi , UNIFI DISIT Lab/Snap4City - Franco Prampolini , Head of R&D and Innovative Industry Solutions Lutech Group
CN MOST SPOKE 8	10:40 - 11:00	Mobility-as-a-Service: tra integrazione e sostenibilità - Prof. Mario Marinelli , Politecnico di Bari
Overview OPTIFaaS	11:00 - 11:20	Presentazione generale e obiettivi di OPTIFaaS - Mauro Starinieri , Head of Smart City & Mobility Solutions CoE Lutech Group
Strumenti OPTIFaaS	11:20 - 11:50	Presentazione dell'infrastruttura - Prof. Paolo Nesi , UNIFI DISIT Lab/Snap4City
Scenario OPTIFaaS	11:50 - 12:10	Ottimizzazione del Traffico - Ing. Alessio Tesone , Università degli Studi di Napoli
Scenario OPTIFaaS	12:10 - 12:40	Ottimizzazione Semaforica e di Infrastruttura. Ottimizzazione del Trasporto Collettivo - Prof. Paolo Nesi , UNIFI DISIT Lab/Snap4City
Q&A	12:40 - 13:00	Sessione aperta
Light Lunch (offered)	13:00 - 14:00	
Incontri 1:1	14:00 -	Incontri 1:1 con i referenti di Snap4City/OPTIFaaS (in presenza)



IL FUTURO DELLA MOBILITÀ INTELLIGENTE E SOSTENIBILE

Digital Twin & Intelligenza Artificiale.
Innovazione tecnologica “As a Service”
per la gestione operativa
e la pianificazione tattico-strategica
della mobilità urbana sostenibile e interconnessa

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