

Ottimizzazione Semaforica e di Infrastruttura. Ottimizzazione del Trasporto Collettivo

Prof. Paolo Nesi, UNIFI DISIT



Decongestion



Safety



Accessibility



Cost Reduction



Decarbonization



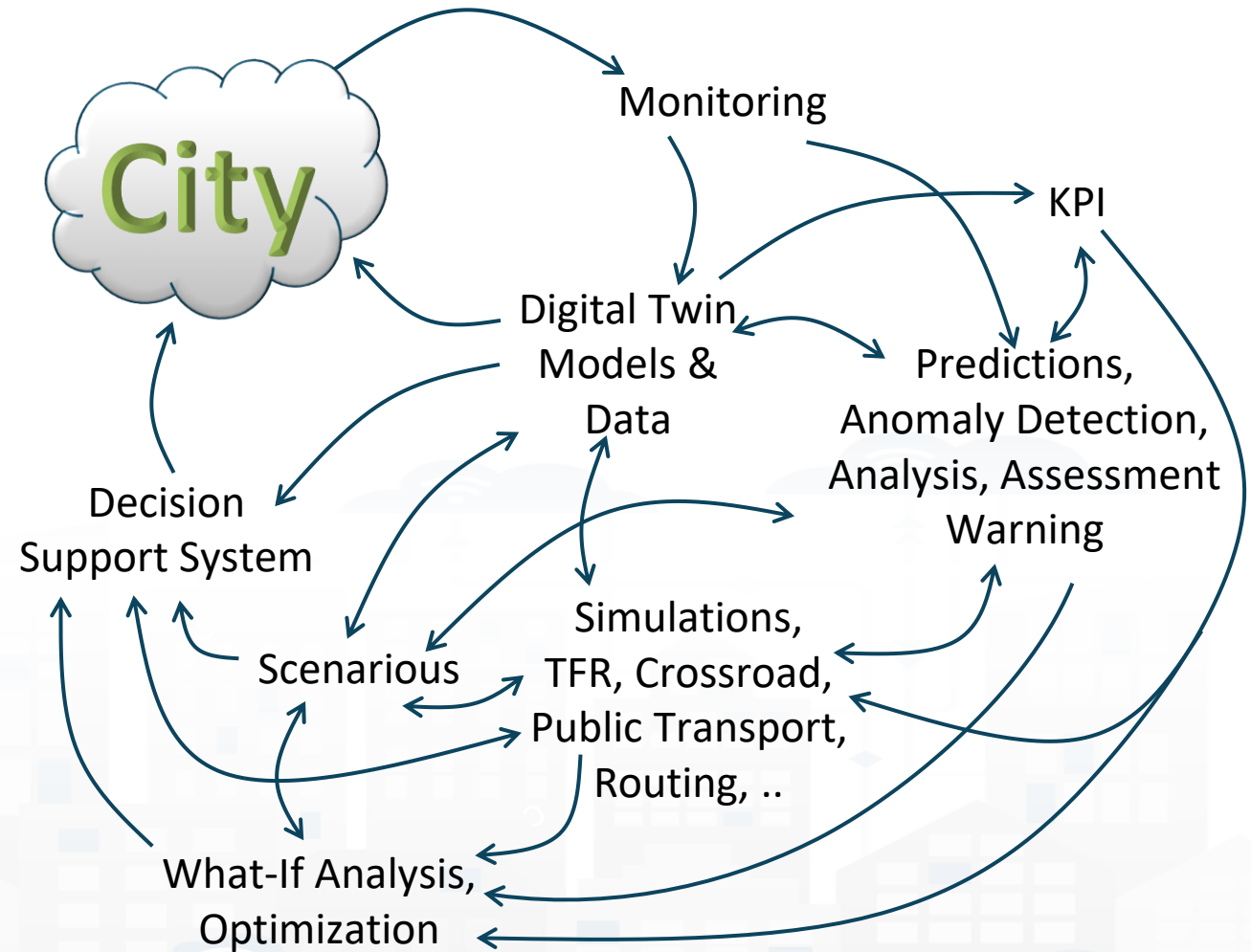
UNIVERSITÀ
DEGLI STUDI
FIRENZE

DINFO
DIPARTIMENTO DI
INGEGNERIA
DELL'INFORMAZIONE

DISIT
DISTRIBUTED SYSTEMS
AND INTERNET
TECHNOLOGIES LAB

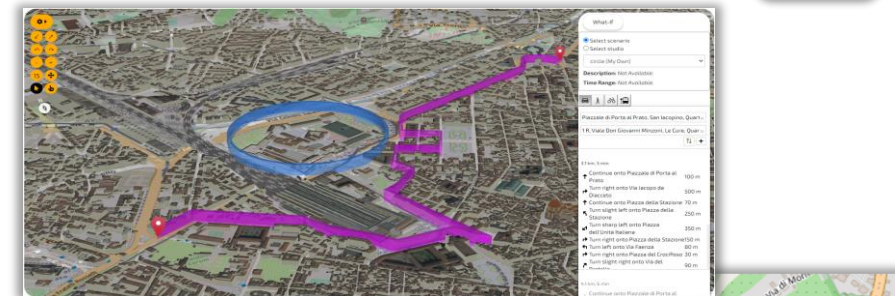


- **Controlling Status: management, and operational**
 - Monitoring via KPI
 - Predictions vs KPI
 - Anomaly detection
 - Neuro-Symbolic analysis
 - Risk assessment
 - Early warning on critical conditions
 - Fast What-if analysis
- **Making plan: tactic and strategic, medium and long range, micro/macro**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

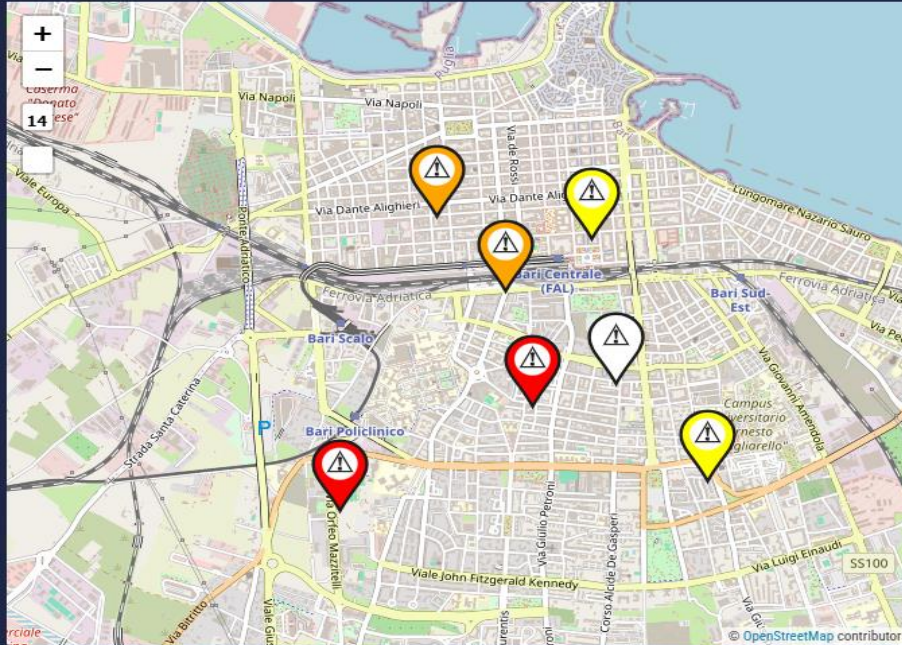


Mobility & Transport

- **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.



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



Road Monitoring

Media congestioniC	Nr. congestioniC	Picco congestioniC	Riduzione Co2 ZTLC	Emissioni medie CO2 C	Emissioni totali CO2 C
28.4	17	18:27	-5.2	282	846
%	-	-	%	ppm	ppm

Traffico in ingresso



Tot. veicoli in ingresso C	Velocità media C
12105	27
Veicoli	km/h

Traffico in uscita



Tot. veicoli in uscita C	Veicoli totali C
11703	7825
Veicoli	-

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

Trasporto Pubblico

Tempo medio di attesa C	
5.9 sec	
Ritardo autobus C	
0 %	

Attesa Media Fermate

Linea 50	12 sec
Linea 11	10 sec
Linea 33	6 sec
Linea 02/	5 sec
Linea E	5 sec
Linea 19	4 sec

Sensori

15	3
Semafori	
22	0
Videocamere	
4	1
Sensori	

☰

SNAP4CITY

Scenario Editor

Some Points of Interest

Traffic Sensors

Air Quality Sensors

Weather Sensors (OW)

Bus Stops

Tram Stops

View

Edit

Show Road graph

Show Traffic Sensors

Filter by road types

+

-

19

Piazzale Donatello

Cimitero degli inglesi

Giardino Silvano Campeggi

M. chesa P. tta Ma

Tabacchi Donatello

Piazzale Donatello

Free street

Fluid traffic

Heavy traffic

Very heavy

Sensor position

orionUNIFI_DISIT_deviceNameenrico909_2024-09-23T10-06-03

Traffic Heatmap Controls:

Max Opacity:

24H

 1

< Prev

2024-09-23 15:00:00+02:00

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	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

DISIT:OrionUNIFI:METRO1098 - VehicleFlow

8m

Time Series

3m

My Profile

Snap4City (C), Sett. 2025

6



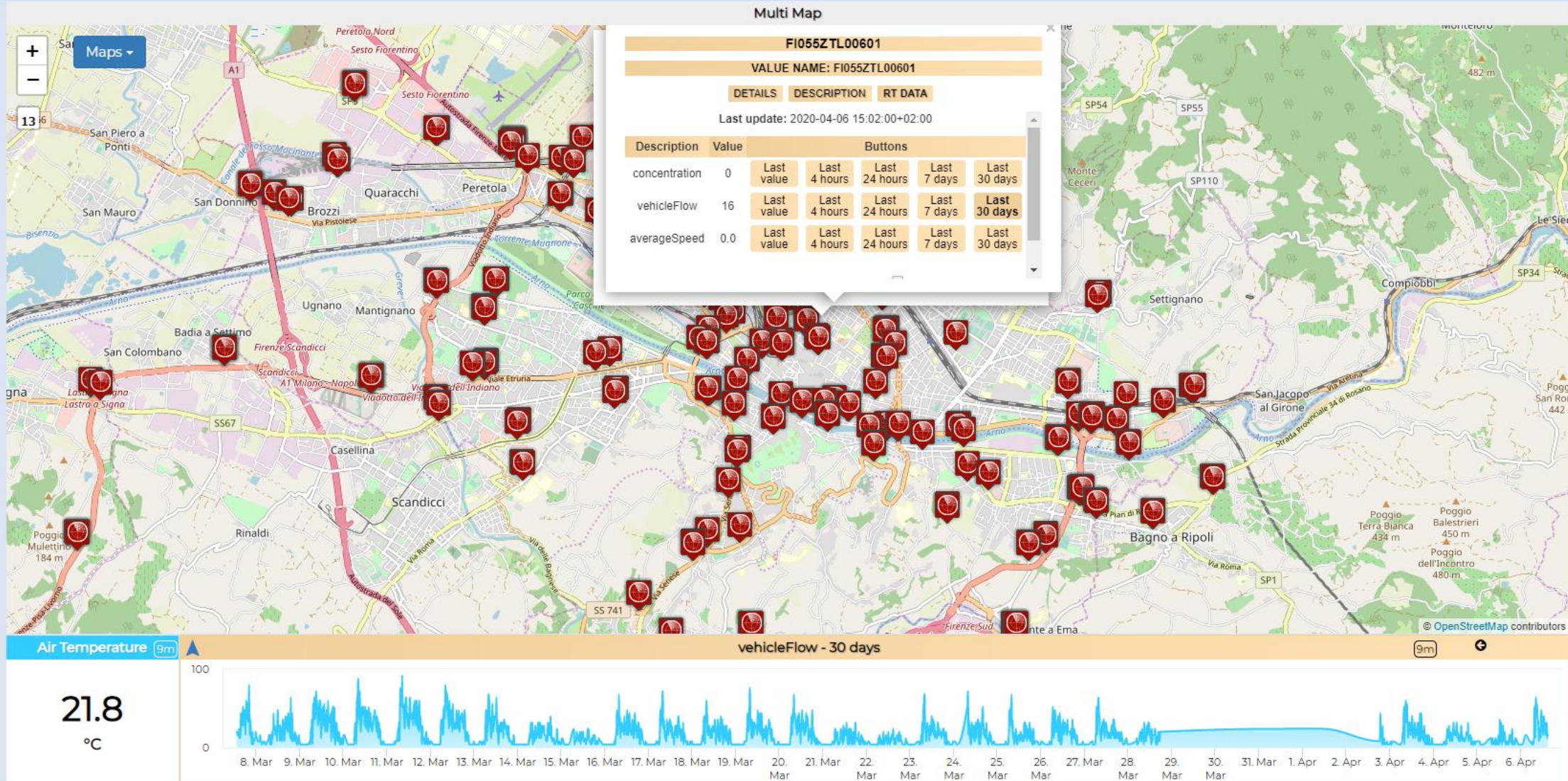
Firenze - Trafair - AirQuality Heatmaps



This dashboard 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

Privacy Policy

Cookies Policy

Terms and Conditions

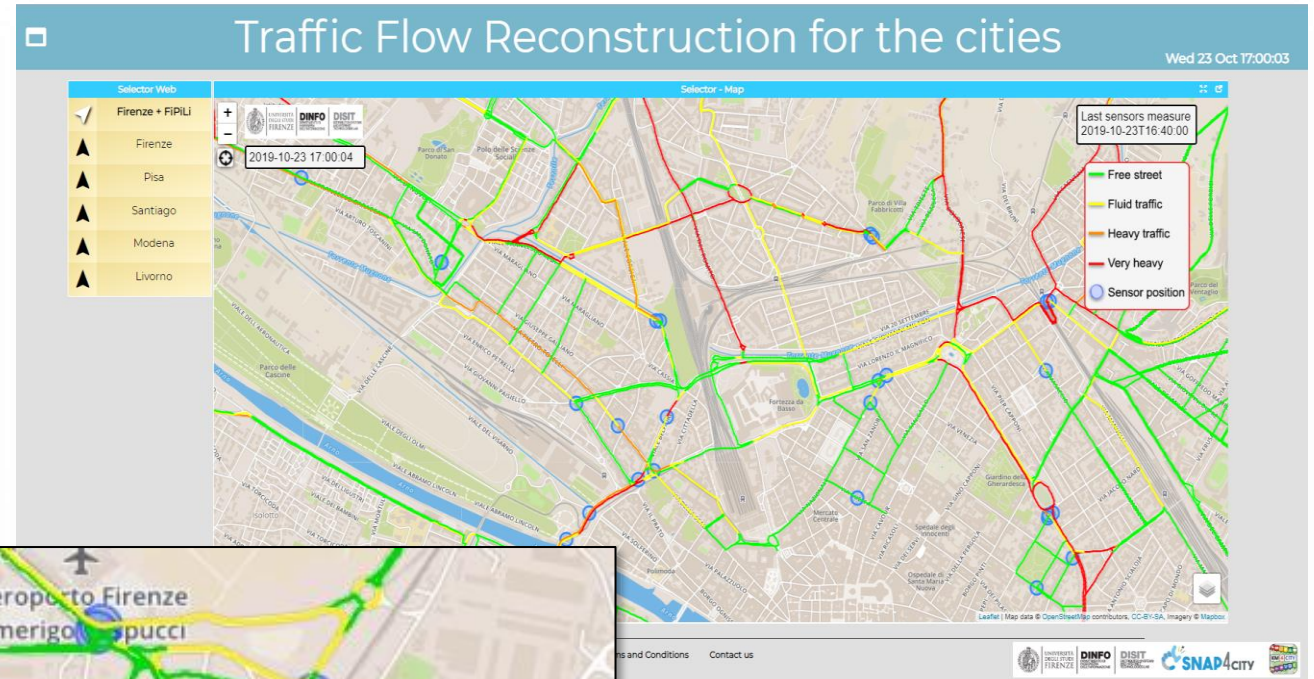
Contact us

<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MTUzMg==>



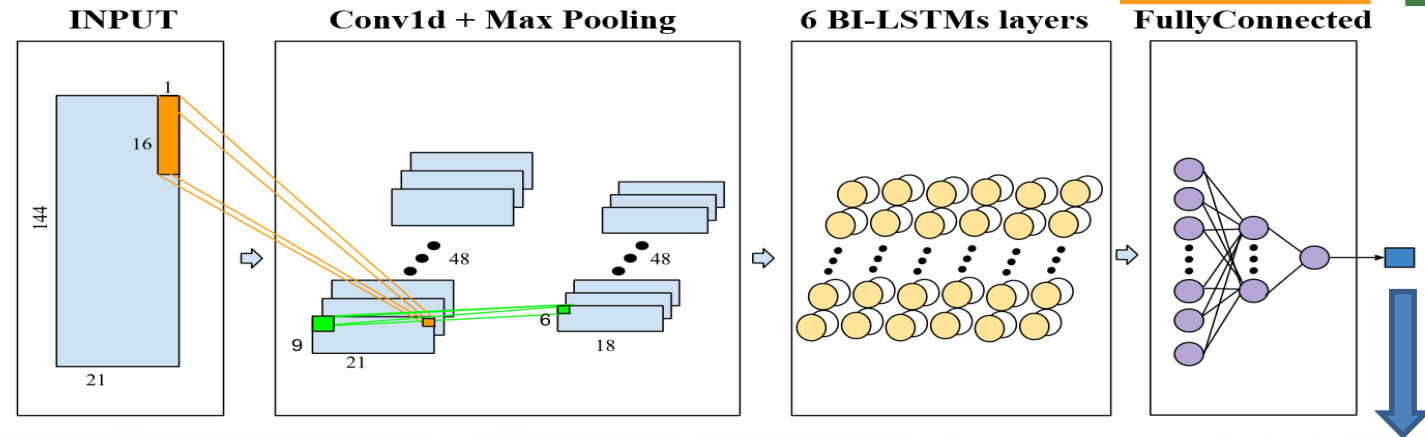
Why Dense Traffic Flow Reconstruction ?

- 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?iddashboard=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

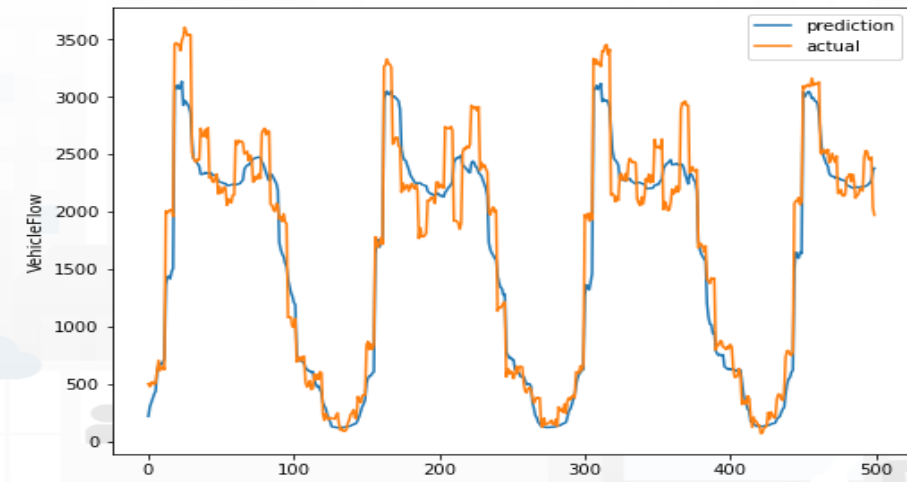
BI-LSTM

Autoencoder BI-LSTM

Attention CONV-LSTM

CONV-BI-LSTM

CONV-BI-LSTM



Routing Optimization

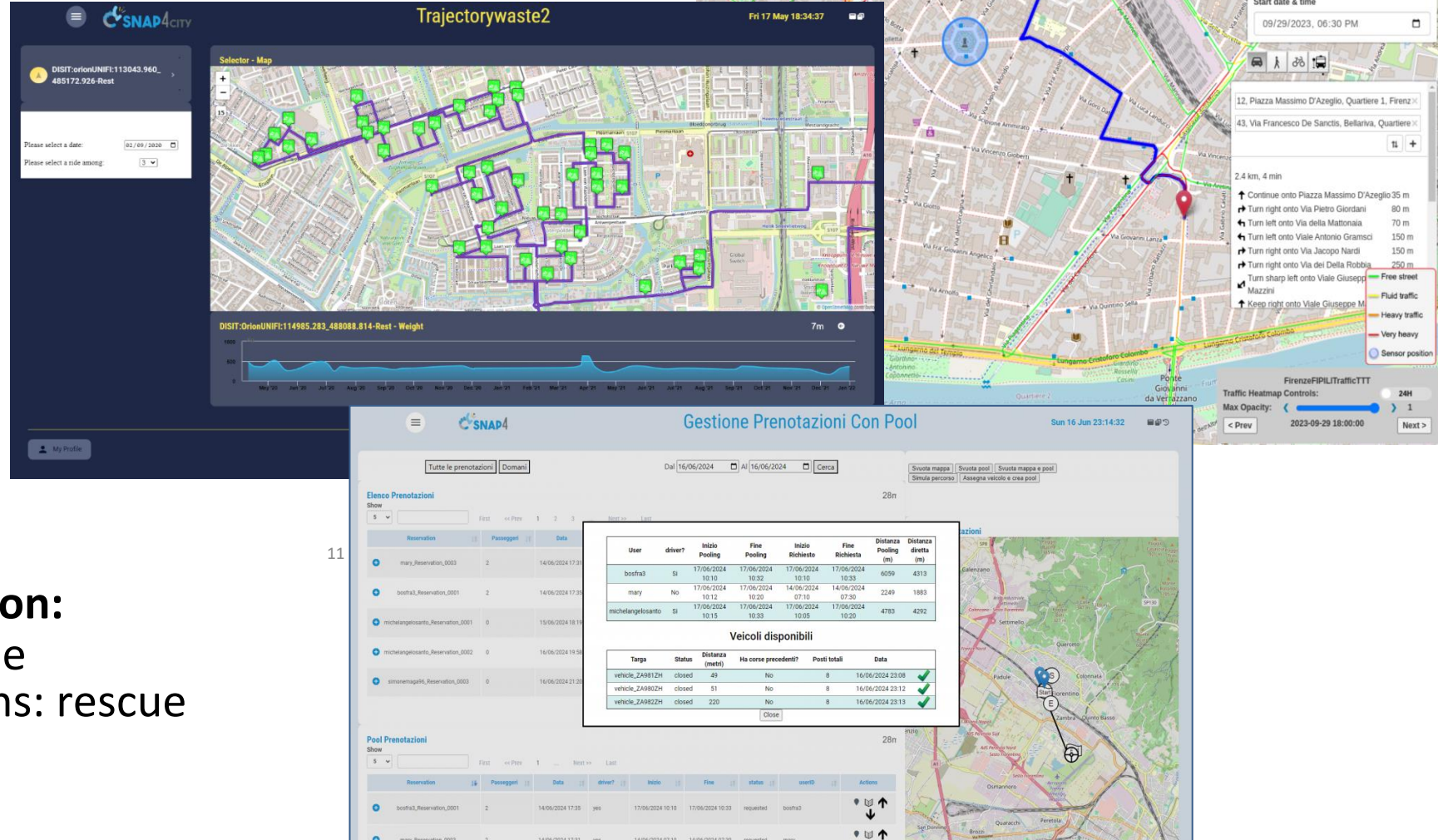
Goals on planning:

- 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

Dynamic Routing on operation:

- React in operation to define immediate routing solutions: rescue teams, ambulance, etc.
- Recovery from failure



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AND TECHNOLOGIES LAB



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

Selector

- Monuments
- Parks
- Scenario
- Scenario Editor

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?

Modal **Multimodal**

Pedestrian Bicycle

Private Transport Service Vehicles

Clear

Instructions

←

Main route
5 min (3.21 km)

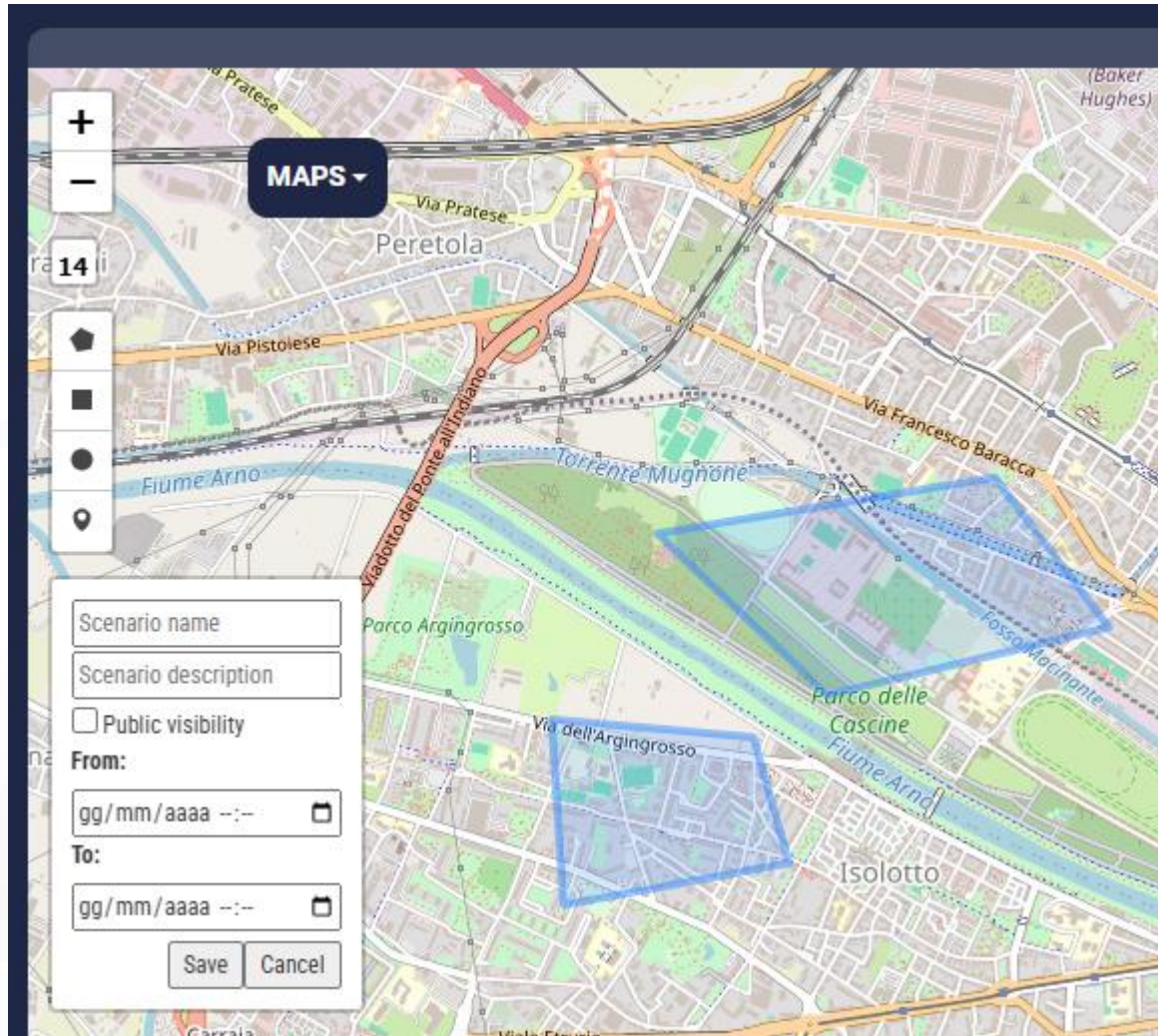
- Depart from 21, Piazza 0 sec (0 m)
- Continue onto Via Giovi 0 sec (1 m)
- Turn right onto Piazza 1 23 sec (194 m)
- Continue onto Via Silvio 11 sec (94 m)
- Turn sharp right onto Vi 5 sec (91 m)
- Make a U-turn onto Vial 2 min (1.45 km)
- Keep right onto Piazza 28 sec (348 m)
- Turn left onto Viale 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)

My Profile

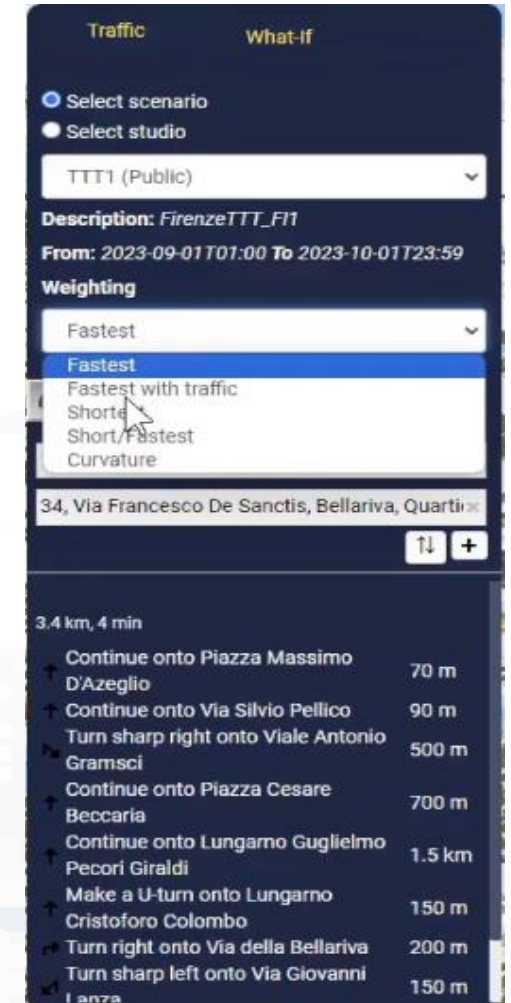
Snap4City (C), Sett. 2025

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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

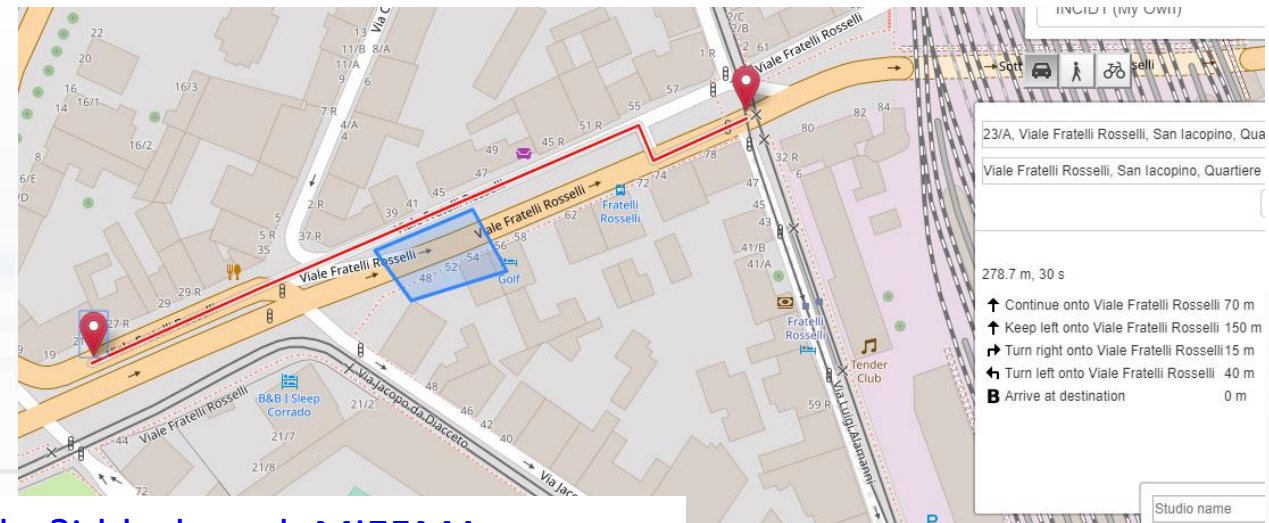
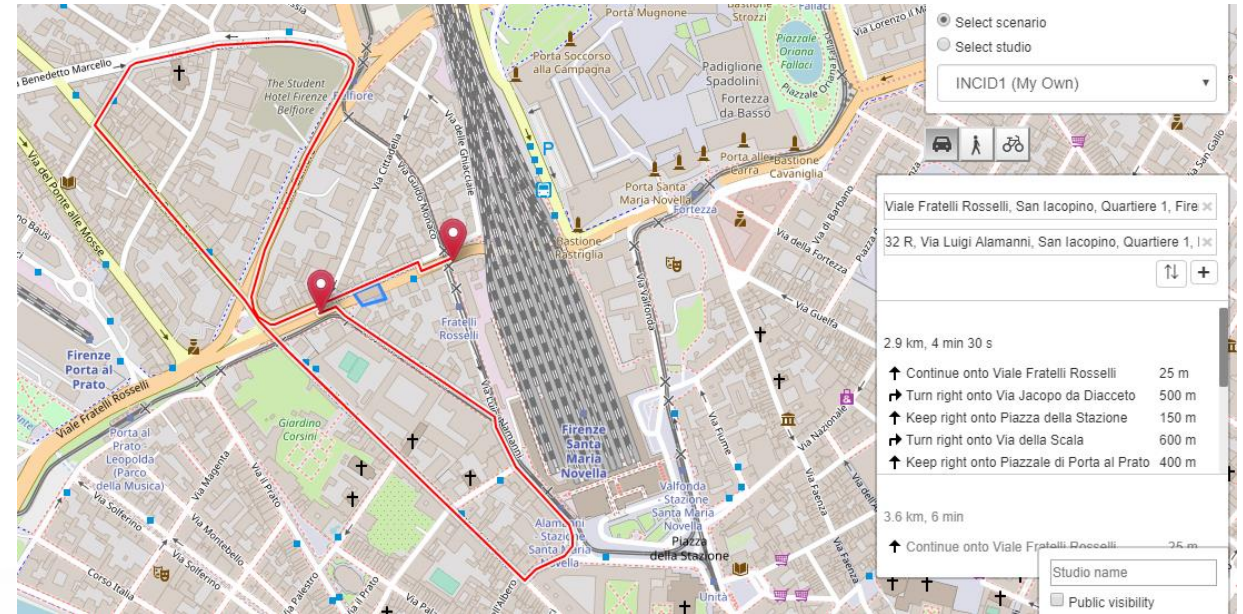


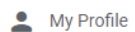
Accidents and elements blocking Points and Shapes taken into account for:

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

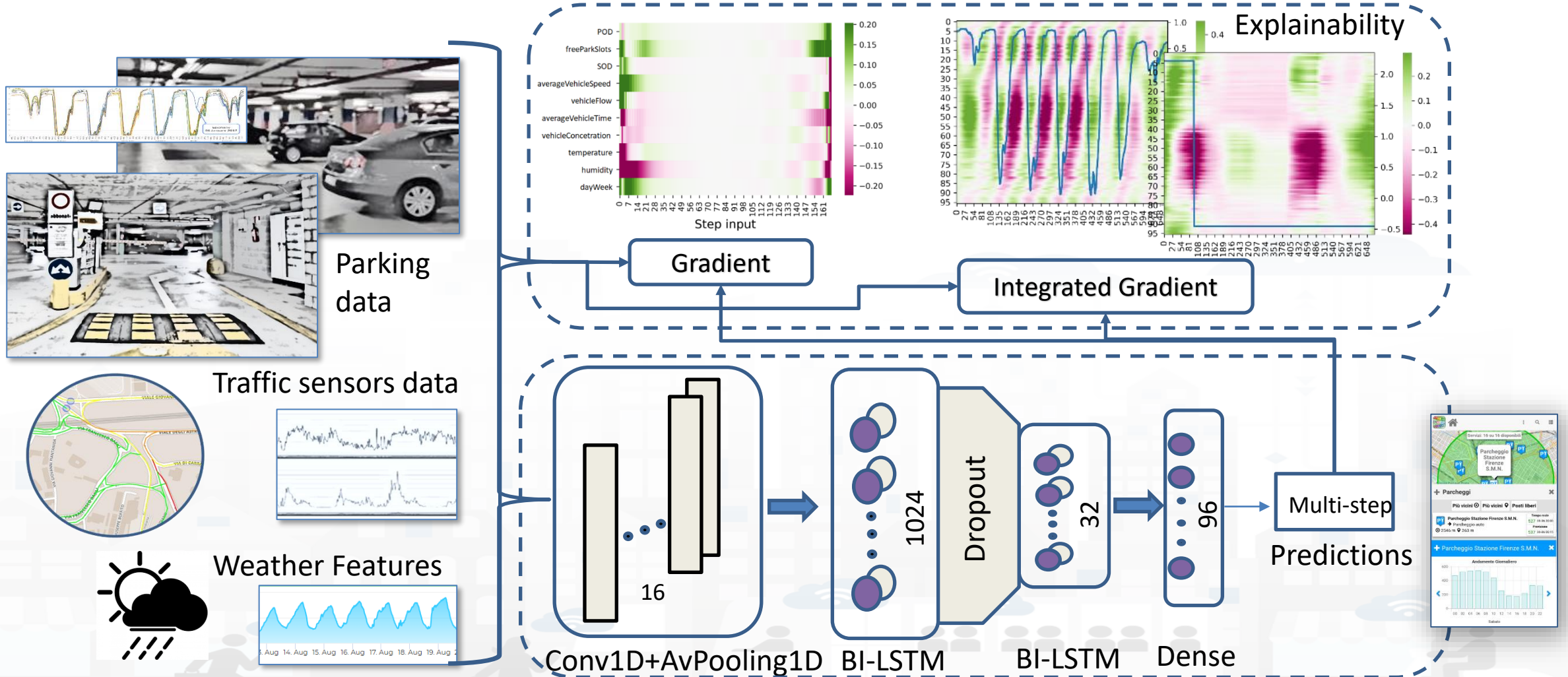
Assessment on the basis of changes:

- Mobility demand assessment
- Mobility Offer assessment

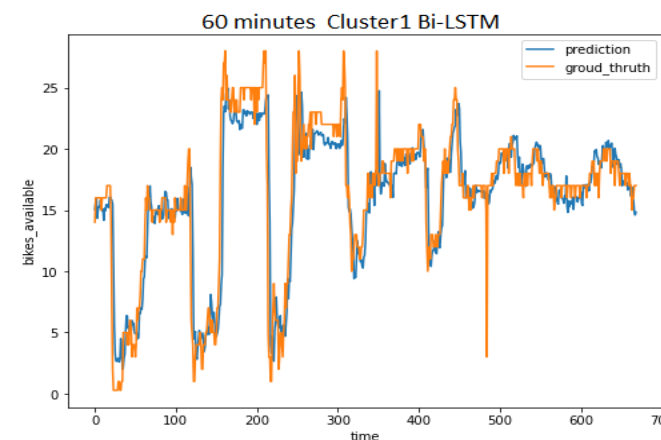
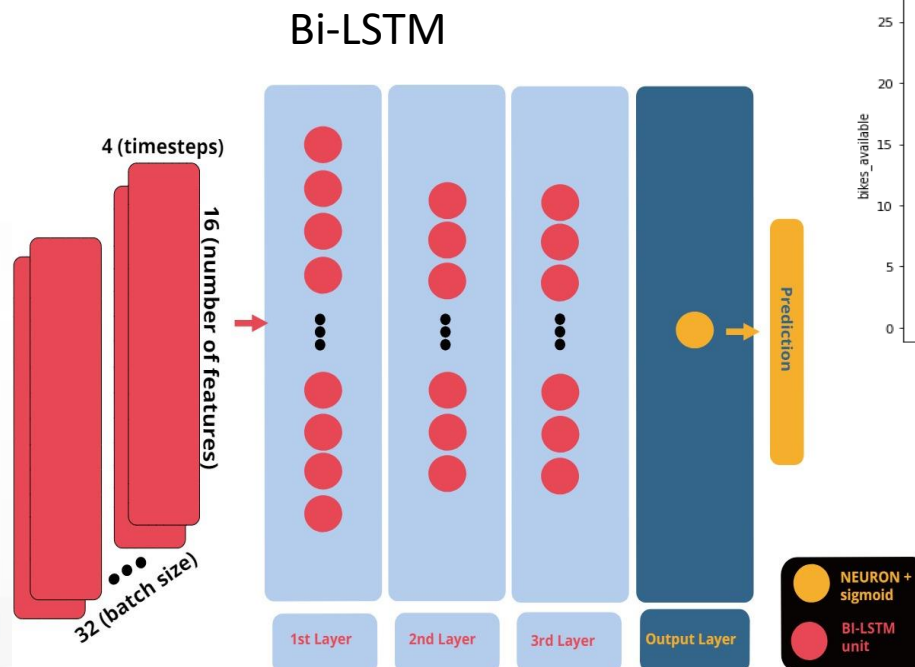
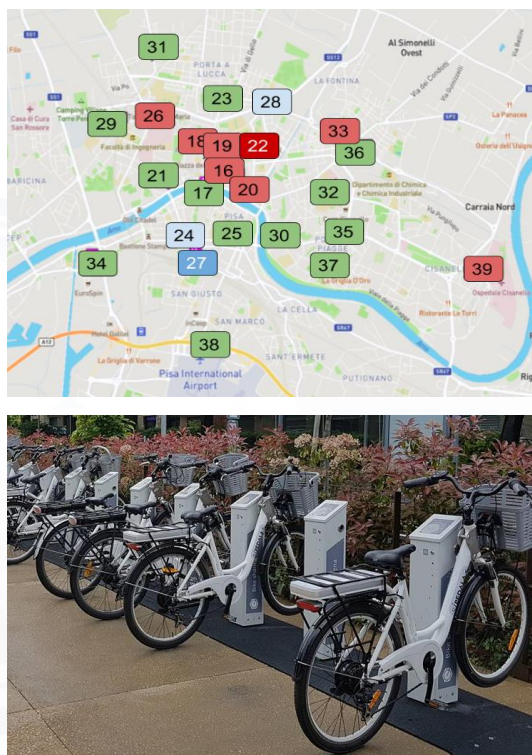




Deep Learning AI to surely Park!

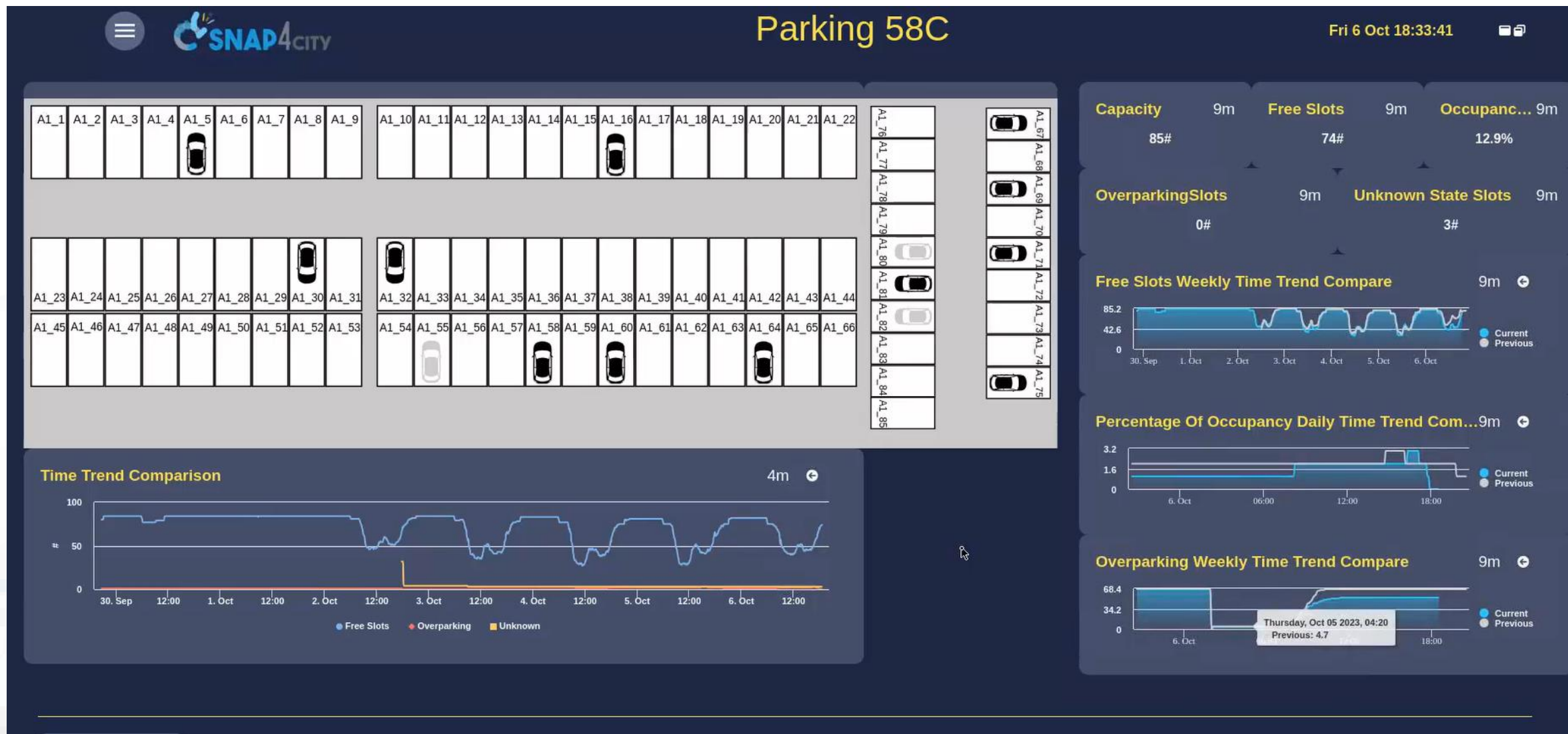


Deep Learning for Short-Term Prediction of Available Bikes on Bike-Sharing Stations



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



- 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

Occupati

26

stalli

Non disponibili

0

stalli

Tipologia parcheggio

Gratuiti

3

stalli

A pagamento

35

stalli

Residenti

0

stalli

Prioritari

4

stalli

Disabili

4

stalli

Carico/Scarico

0

stalli

Tipologia veicolo

Auto

46

stalli

Moto

0

stalli

Bici

0

stalli

Camion

0

stalli

Camper

0

stalli

eSharing and Pooling

FROM CITY
DASHBOARD TO
APPLICATIONS

DATA
AND C
KNOW
MANA

TWITTER
VIGILANCE
SOCIAL
MEDIA ANALYSIS

SNAP4CITY
AND KM4CITY
PROJECTS

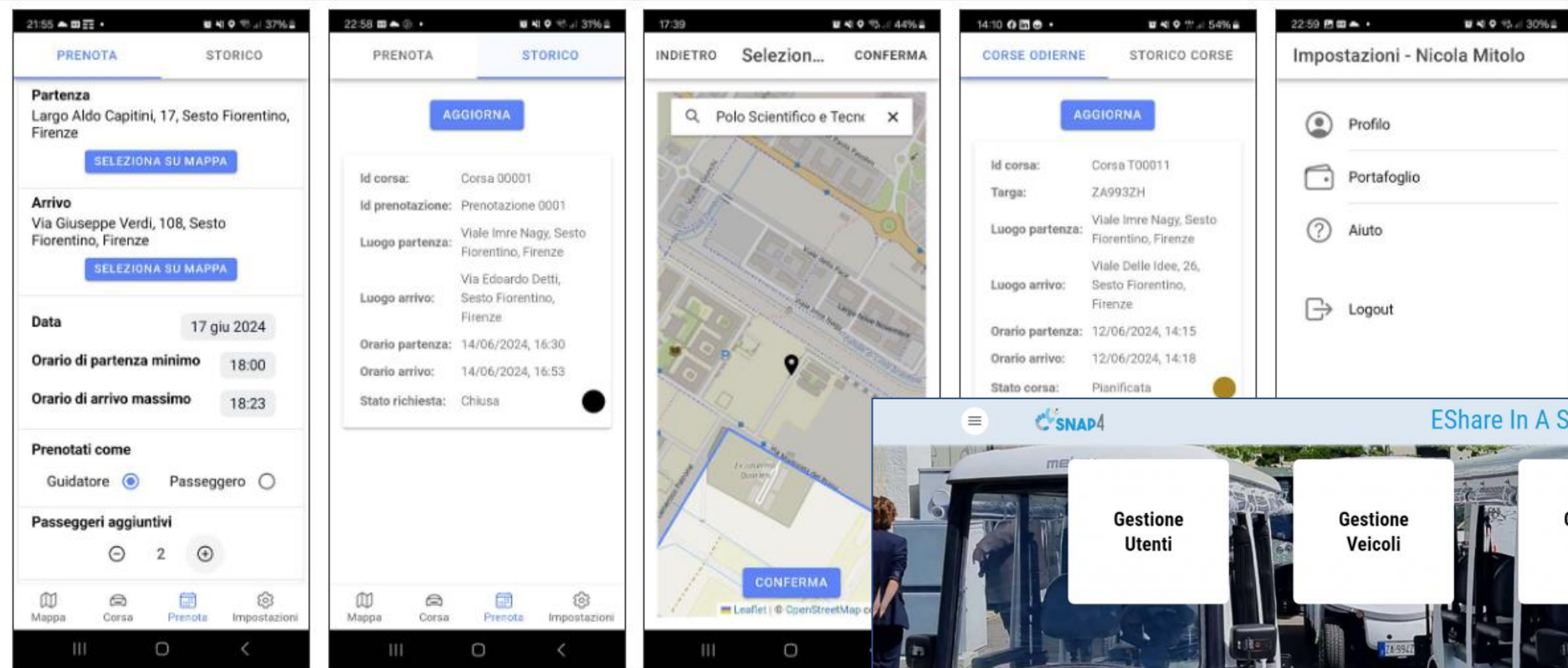
HOW TO ADOPT
SNAP4CITY, AND
ROADMAP

SNAP4CITY THE
VIEW OF THE
ADMINISTRATORS



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



SNAP4

Gestione Veicoli

Sun 16 Jun 23:09:13

VehiclesDeviceTable

Show

5

First

<< Prev

1

2

Next >>

Last

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	

Time Trend Batteria

3m

11 Jun 12 Jun 13 Jun 14 Jun 15 Jun 16 Jun

vehicle_ZA993ZH - batteryLevel

Time Trend Velocità

11 Jun

Results

Ricerca tutti i veicoli

show area

Selector - Map



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

SNAP4

Gestione Prenotazioni Con Pool

Sun 16 Jun 23:14:32

Tutte le prenotazioni

Domani

Dal 16/06/2024

Al 16/06/2024

Cerca

Svuota mappa

Svuota pool

Svuota mappa e pool

Simula percorso

Assegna veicolo e crea pool

Elenco Prenotazioni

Show

5

First

<< Prev

1

2

3

Next >>

Last

Reservation	Passeggeri	Data
mary_Reservatio_0003	2	14/06/2024 17:31
bosfra3_Reservatio_0001	2	14/06/2024 17:35
michelangelosanto_Reservatio_0001	0	15/06/2024 18:19
michelangelosanto_Reservatio_0002	0	16/06/2024 19:58
simonemaga96_Reservatio_0003	0	16/06/2024 21:20

Pool Prenotazioni

Show

5

First

<< Prev

1

Next >>

Last

Reservation	Passeggeri	Data	driver?	Inizio	Fine	status	userID	Actions
bosfra3_Reservatio_0001	2	14/06/2024 17:35	yes	17/06/2024 10:10	17/06/2024 10:33	requested	bosfra3	
mary_Reservatio_0003	2	14/06/2024 17:31	yes	14/06/2024 07:10	14/06/2024 07:30	requested	mary	

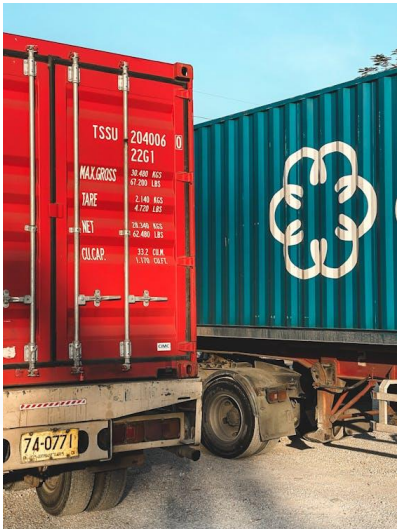
Veicoli disponibili

Close

User	driver?	Inizio Pooling	Fine Pooling	Inizio Richiesto	Fine Richiesta	Distanza Pooling (m)	Distanza diretta (m)
bosfra3	Si	17/06/2024 10:10	17/06/2024 10:32	17/06/2024 10:10	17/06/2024 10:33	6059	4313
mary	No	17/06/2024 10:12	17/06/2024 10:20	14/06/2024 07:10	14/06/2024 07:30	2249	1883
michelangelosanto	Si	17/06/2024 10:15	17/06/2024 10:33	17/06/2024 10:05	17/06/2024 10:20	4783	4292

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

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

SNAP4CITY GATE07 - Out Fri 5 Sep 15:36:52

Qcr

Immagine originale container

Targa truck

Codice Container

Container gate

HH4B123	05/09/2025, 10:22:17
BF C456	05/09/2025, 11:45:22
EX398AE	05/09/2025, 13:16:43

EX398AE
05/09/2025, 13:18:43
Orario: 05/09/2025, 13:18:43
Durata OCR (s): 2.3
Truck - Accuratezza: 97.9

Targa: EX398AE
Nazione: IT

Container - Accuratezza: 98.2

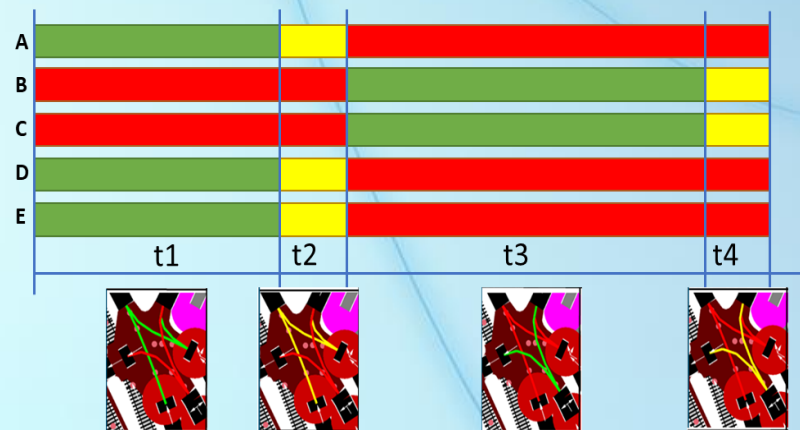
Codice: FCIU9644848
Codice ISO: 45G1
Nazione: Hong Kong

Rimorchio

Modifica Annulla Invia Scarica

My Profile

Powered by SNAP4Tech



IL FUTURO DELLA MOBILITA'
INTELLIGENTE E SOSTENIBILE



Ottimizzazione Semaforica

Prof. Paolo Nesi, UNIFI DISIT

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



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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



Scenario Editor

Select map

Zoom

New Scenario

Editing

Drag & drop

Split & Join

Delete

Do and Undo

The main interface displays a map with road segments represented by colored lines and arrows. A left toolbar contains icons for map selection, zooming, and editing. A top-right panel allows for scenario configuration, and a bottom-right panel lists properties for selected road elements. A central panel shows a list of road types with checkboxes for selection.

Scenario Configuration Panel:

- Scenario name:
- Location:
- Scenario description:
- ReferenceKB:
- Save Road Graph: ☐
- Save traffic Sensors: ☐
- Save other Sensors: ☐
- From:
- To:
- Buttons: Save, Show Summary, Cancel

Road Properties Panel:

- Category Street:
- Nr.Lanes:
- Speed Limit (km/h):
- Direction:
- Restrictions:
- Update button

Road Types List:

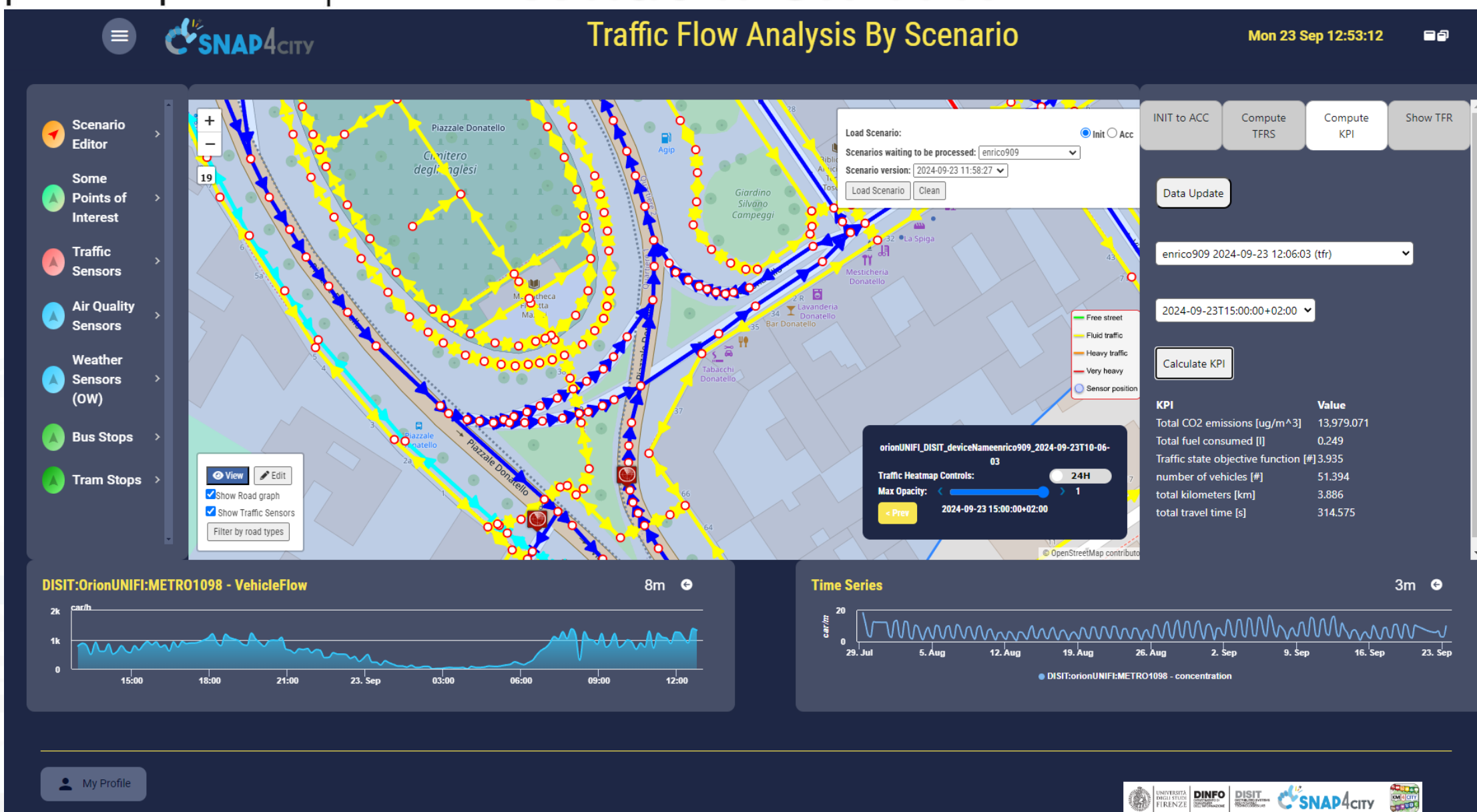
- ☐ Select All
- ☐ Unselect All
- ☒ abandoned
- ☒ corridor
- ☒ emergency_access_point
- ☒ motorway
- ☒ primary
- ☒ residential
- ☒ services
- ☒ traffic_island
- ☒ secondary
- ☒ brideway
- ☒ crossing
- ☒ emergency_bay
- ☒ motorway_link
- ☒ primary_link
- ☒ rest_area
- ☒ steps
- ☒ tram
- ☒ yes
- ☒ bus_guideway
- ☒ cycleway
- ☒ footway
- ☒ no
- ☒ private
- ☒ road
- ☒ tertiary
- ☒ trunk_link
- ☒ pedestrian
- ☒ bus_stop
- ☒ disused
- ☒ island
- ☒ path
- ☒ raceway
- ☒ secondary_link
- ☒ tertiary_link
- ☒ unclassified
- ☒ bus_guideway
- ☒ construction
- ☒ elevator
- ☒ living_street
- ☒ platform
- ☒ razed
- ☒ service
- ☒ track
- ☒ via_ferrata
- ☒ ohm.military.Trench

View/Filter Panel:

- ☒ Show Road graph
- ☒ Show Traffic Sensors
- Filter by road types

Edit Road
Segment

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



Traffic Light Plan Optimisation, Digital Twin

- **Match Multiple Objectives and Synchronization:**

- public and private traffic, tramway priority
- Micro and Macro Scales

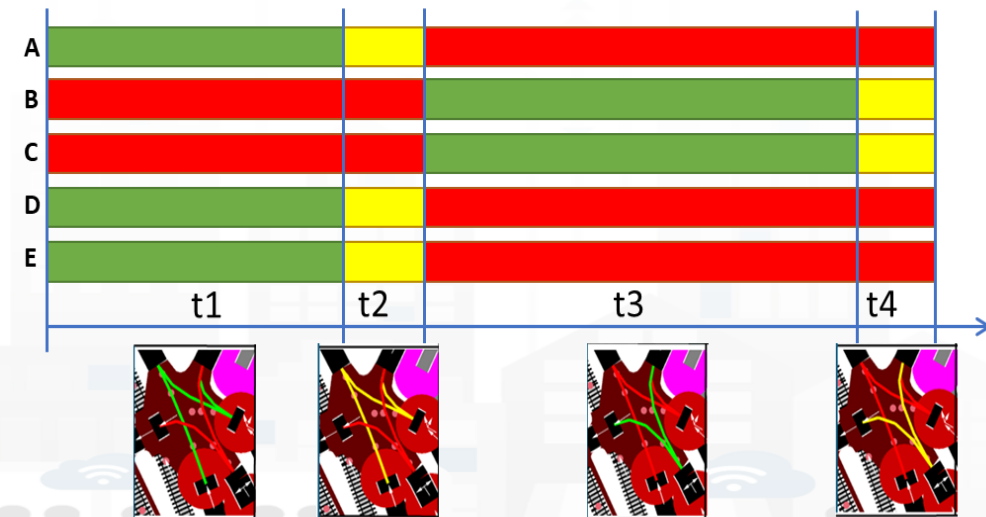
- **AI: Genetic Algorithms, Deep Reinforced Learning**

- 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 Generator

Wed 23 Oct 18:50:03

Traffic Light Plan Editor

Query radius:

Semaphore name:

Directions:

Time cycle:

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

Selector - Map

Load Scenario: ☐ Init ☐ Acc

Scenarios waiting to be processed: dbologna_scenario2

Scenario version: 2024-02-21 17:20:42

Load Scenario Clean

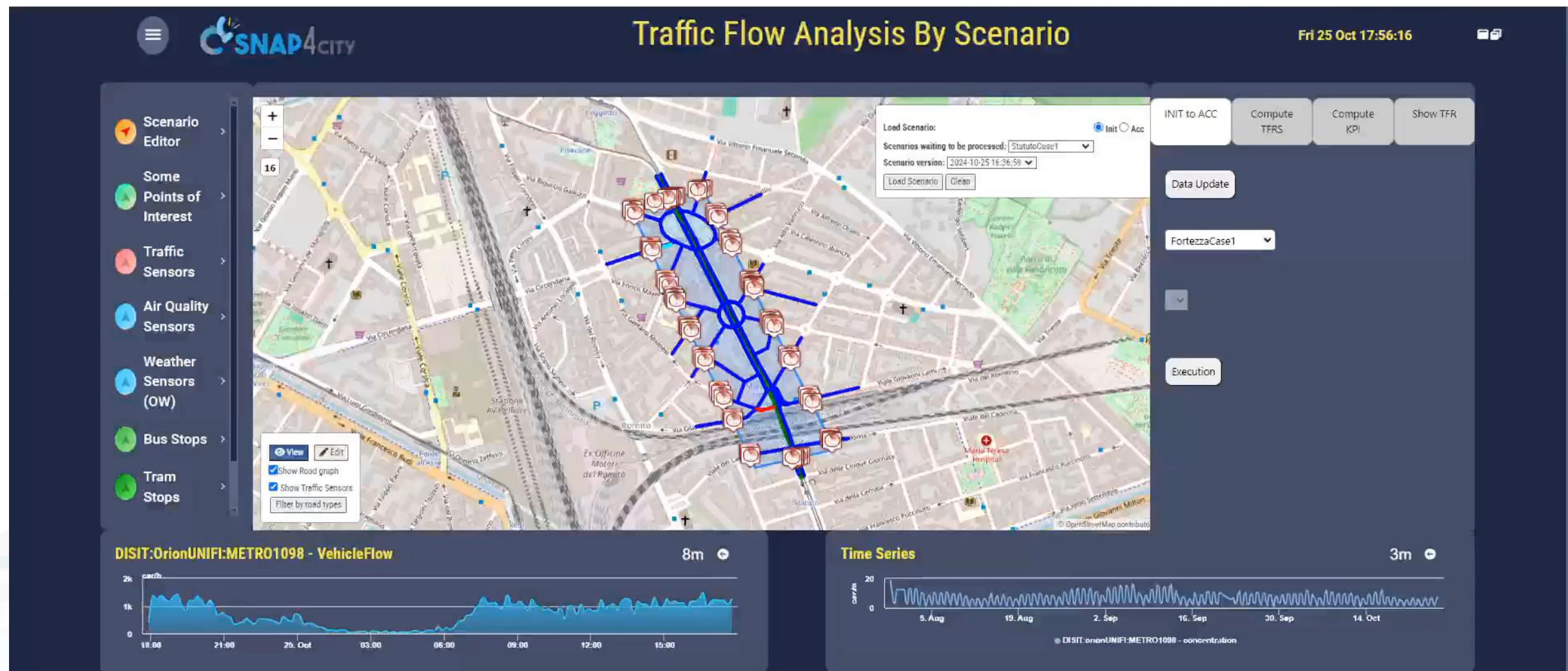
View Edit

Show Road graph

Show Traffic Sensors

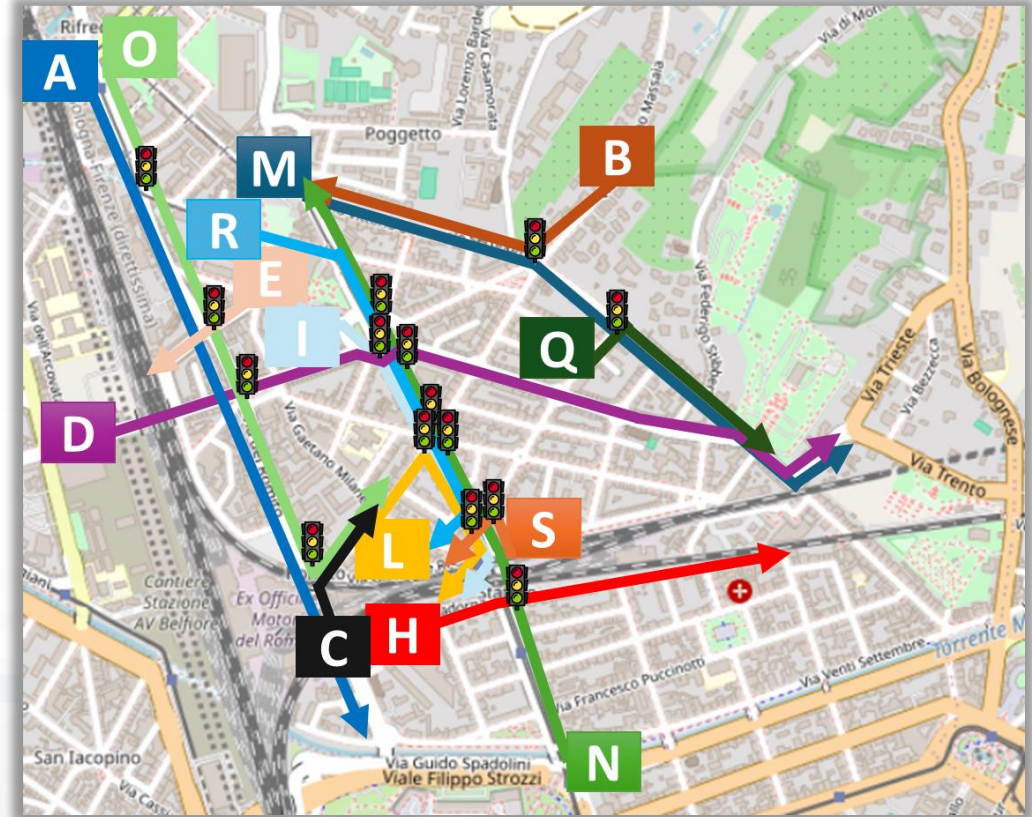
Filter by road types

Optimization of Traffic Light Plan



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%

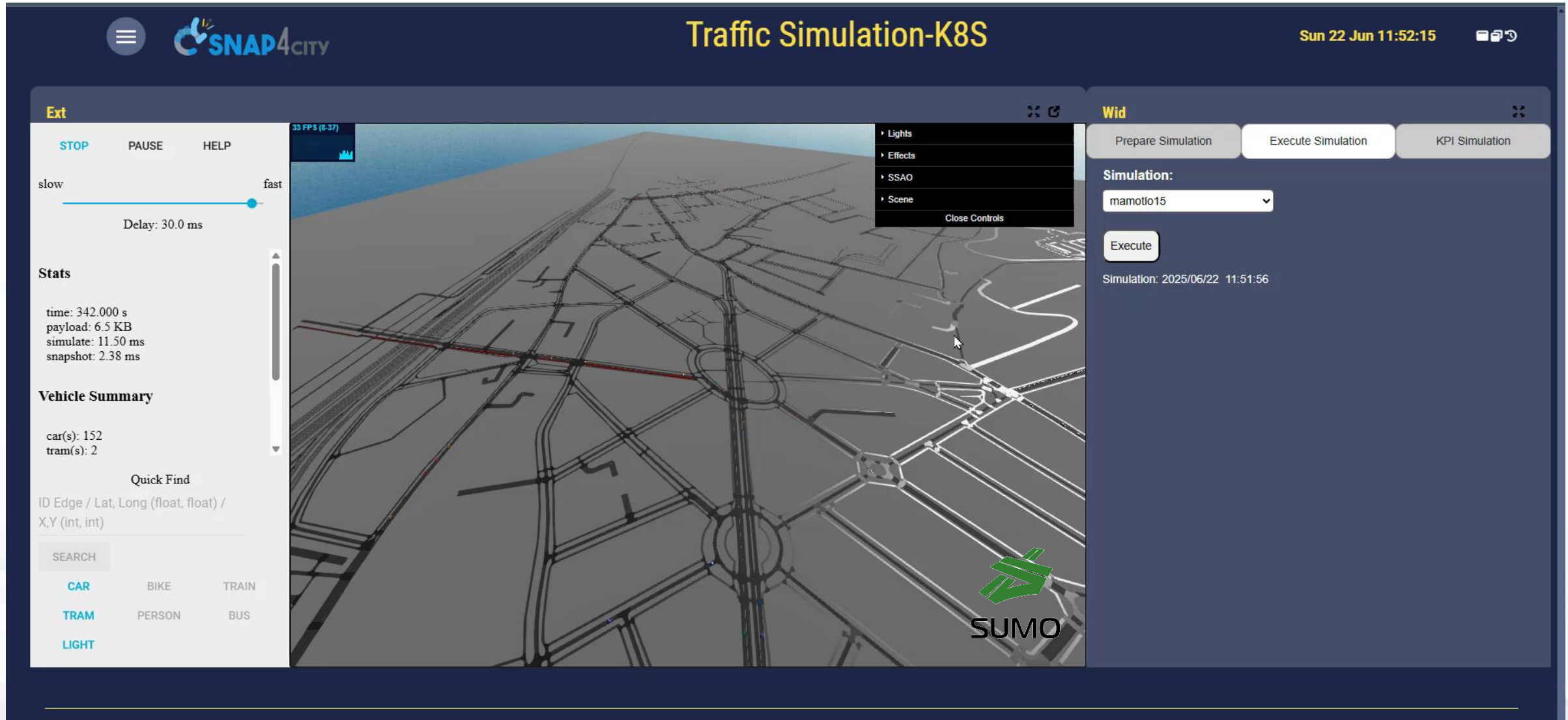
-6%

-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.



The screenshot displays the SNAP4CITY Traffic Simulation-K8S interface. The main window shows a 3D perspective view of a city street network with a tram line highlighted in red. The interface is divided into several panels:

- Ext Panel (Left):**
 - Buttons: STOP, PAUSE, HELP
 - Speed control: A slider from 'slow' to 'fast' with a 'Delay: 30.0 ms' indicator.
 - Stats:**
 - time: 342.000 s
 - payload: 6.5 KB
 - simulate: 11.50 ms
 - snapshot: 2.38 ms
 - Vehicle Summary:**
 - car(s): 152
 - tram(s): 2
 - Quick Find:**
 - Input: ID Edge / Lat, Long (float, float) / X,Y (int, int)
 - SEARCH button
 - Filters: CAR, BIKE, TRAIN, TRAM, PERSON, BUS, LIGHT
- Wid Panel (Right):**
 - Buttons: Prepare Simulation, Execute Simulation, KPI Simulation
 - Simulation:**
 - Dropdown menu: mamotio15
 - Execute button
 - Simulation: 2025/06/22 11:51:56
- Top Bar:**
 - Menu icon, SNAP4CITY logo
 - Title: Traffic Simulation-K8S
 - Date/Time: Sun 22 Jun 11:52:15
 - Icons for window management
- Bottom Right:**
 - SUMO logo

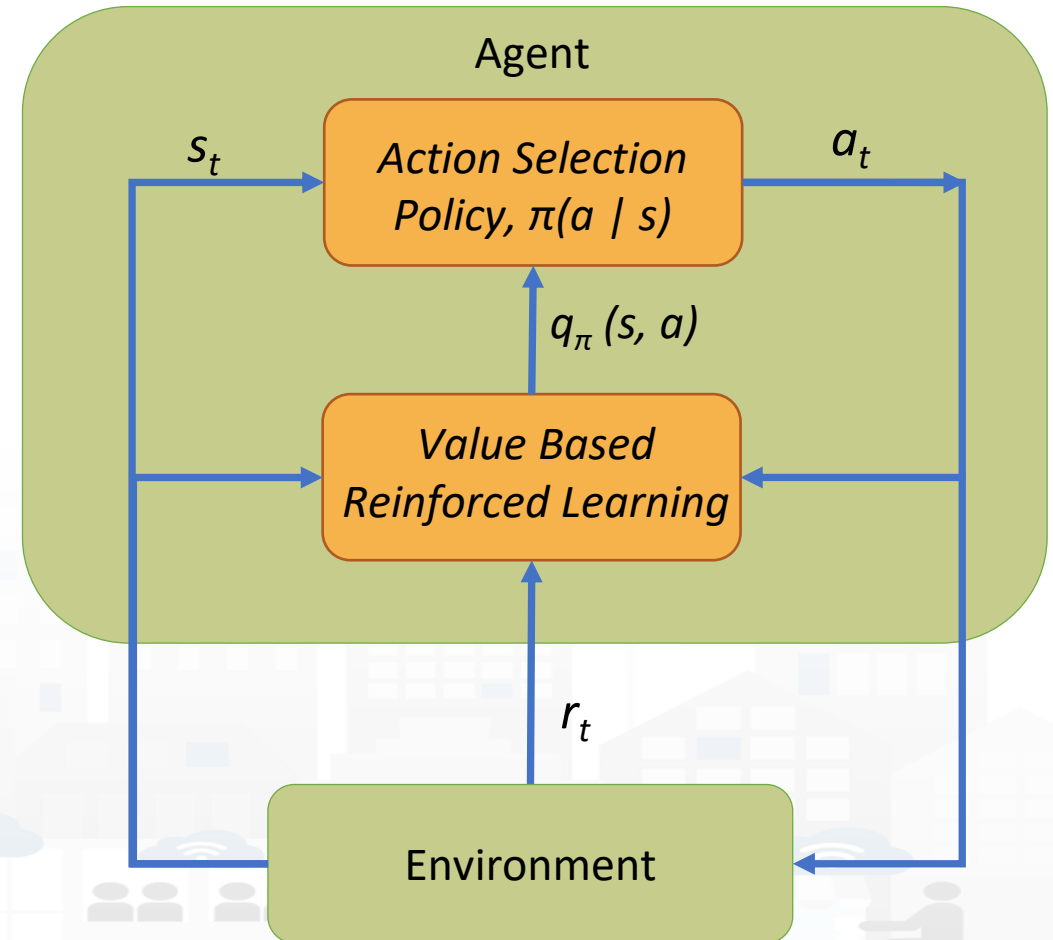
Multi Agent Reinforced Learning

- **Single Actuated**

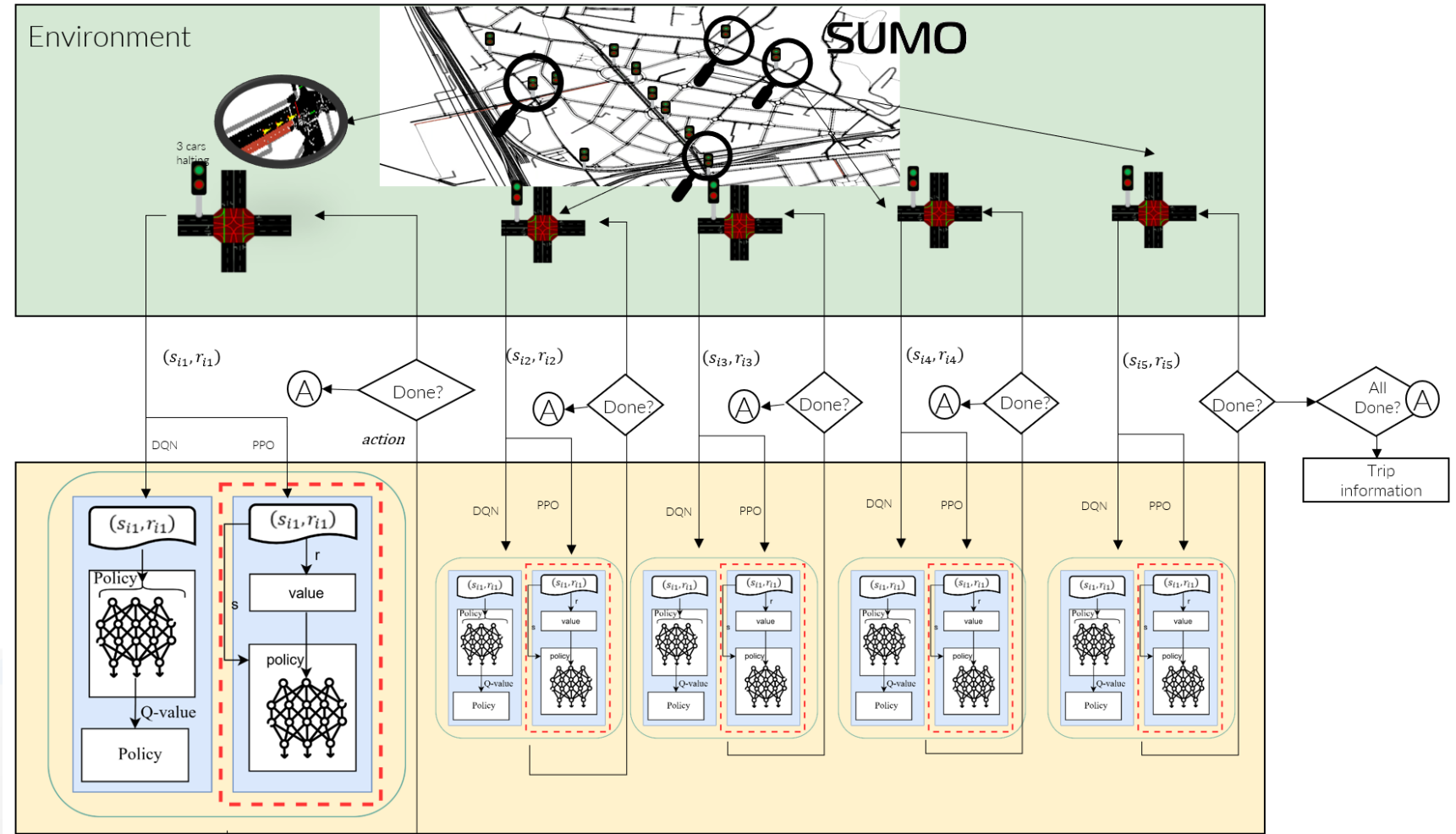
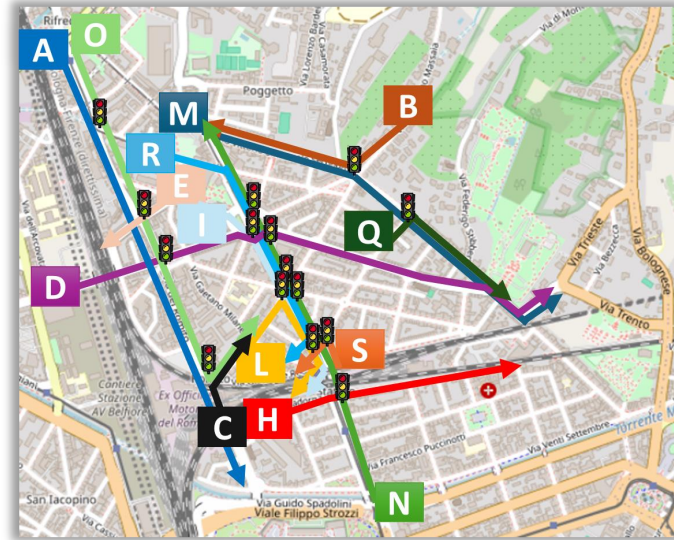
- Taking into account the status of each traffic source of each Junction
- Computing the best compromise of G/R ratio
- Act on the next cycle

- **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



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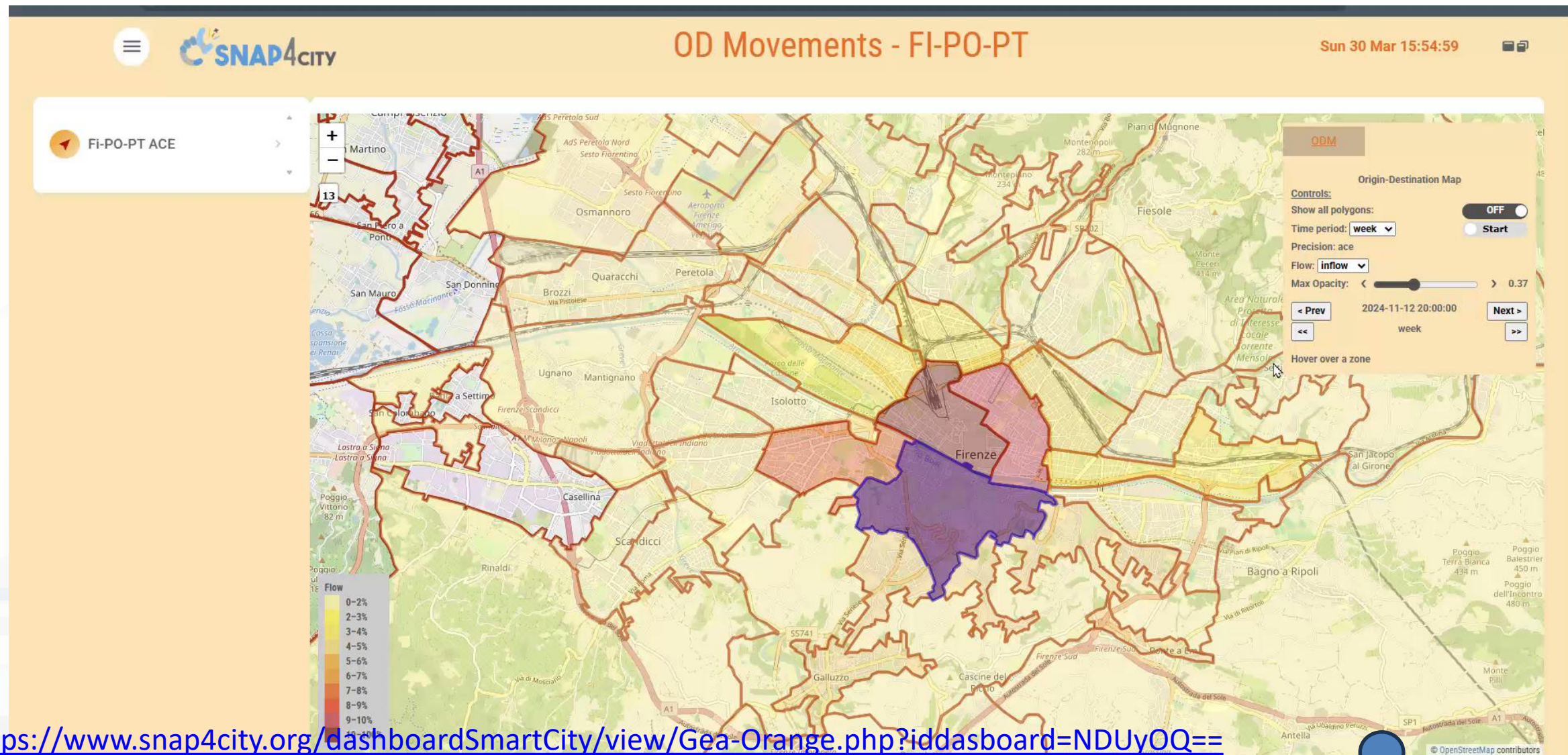
Italiadomani
PIANTA NAZIONALE
DI INTELLIGENZA

MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

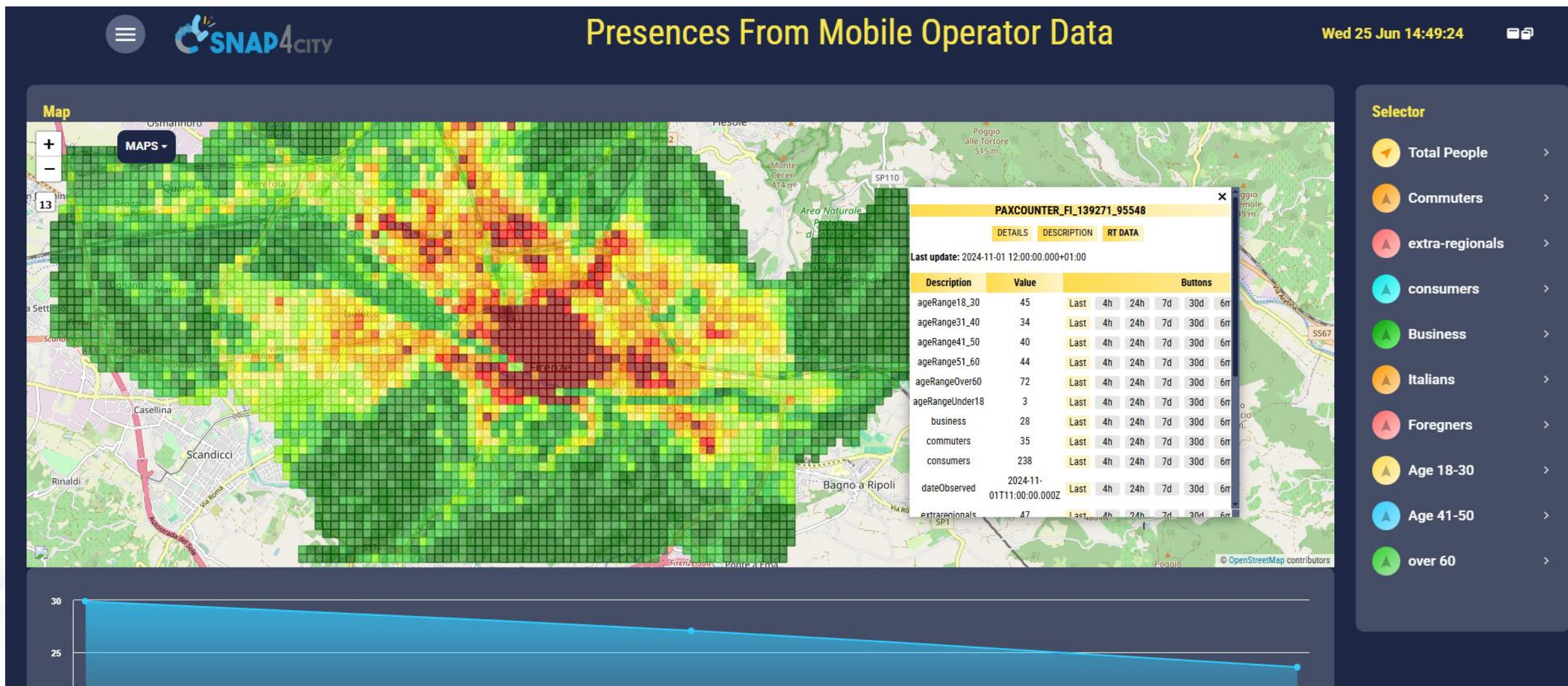
In the large

- **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.

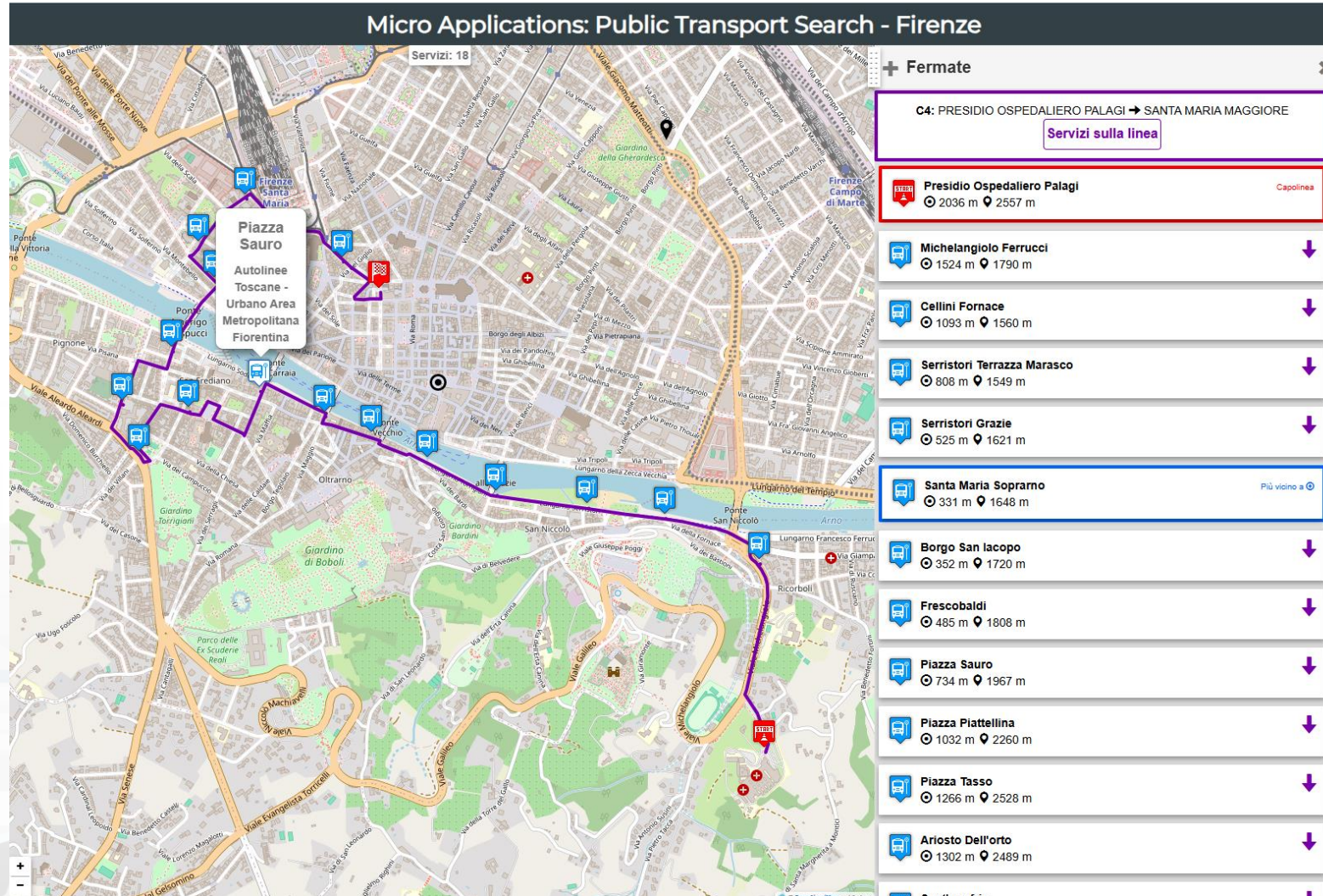
Origin Destination Matrices: Mobility Demand



Presences from Mobile Operator



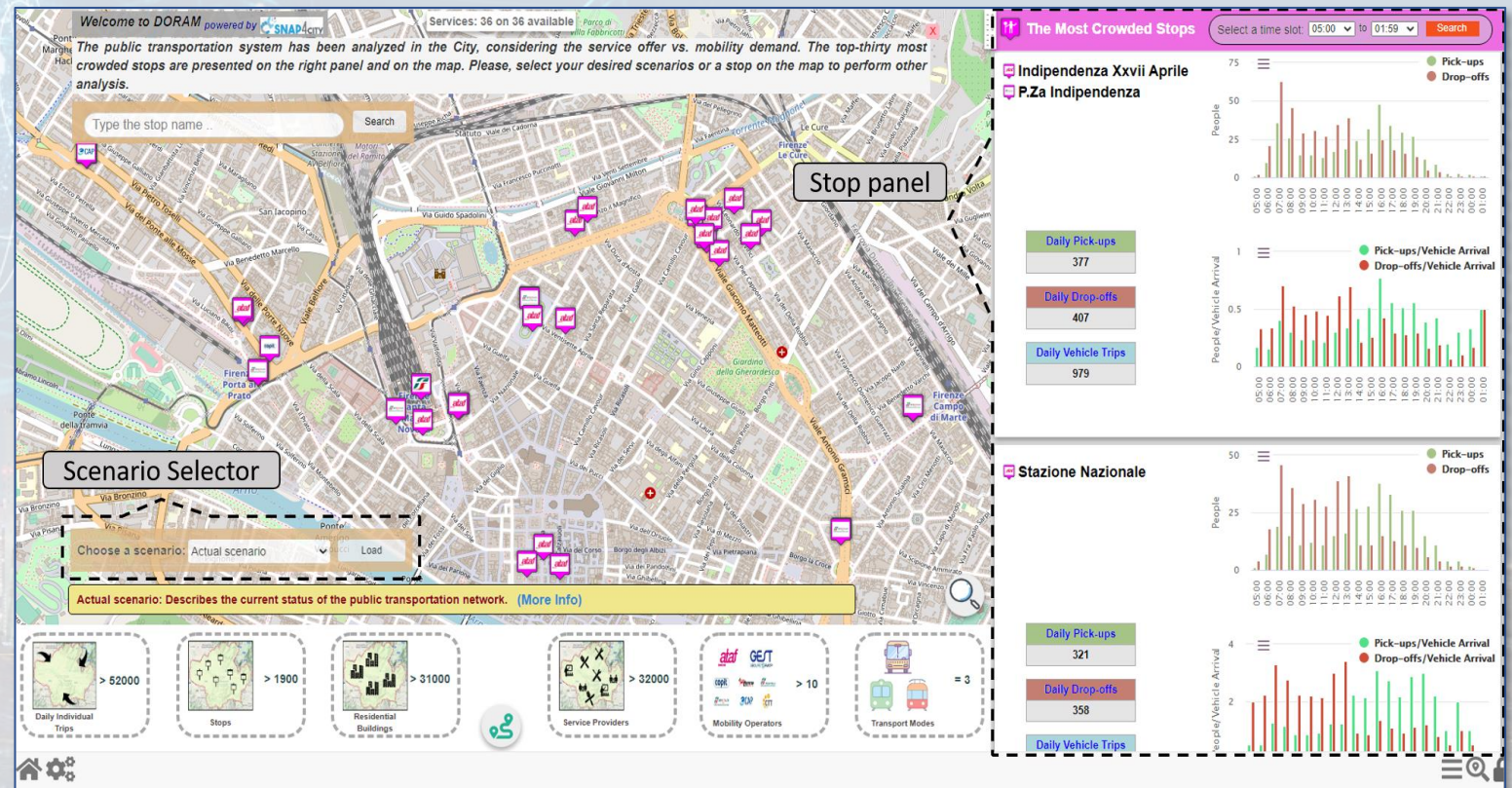
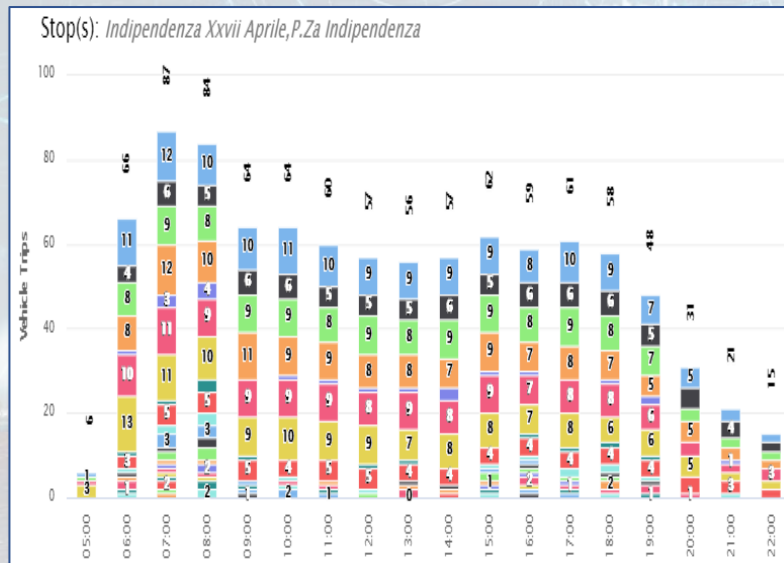
Offer of Transportation, GTFS, for example

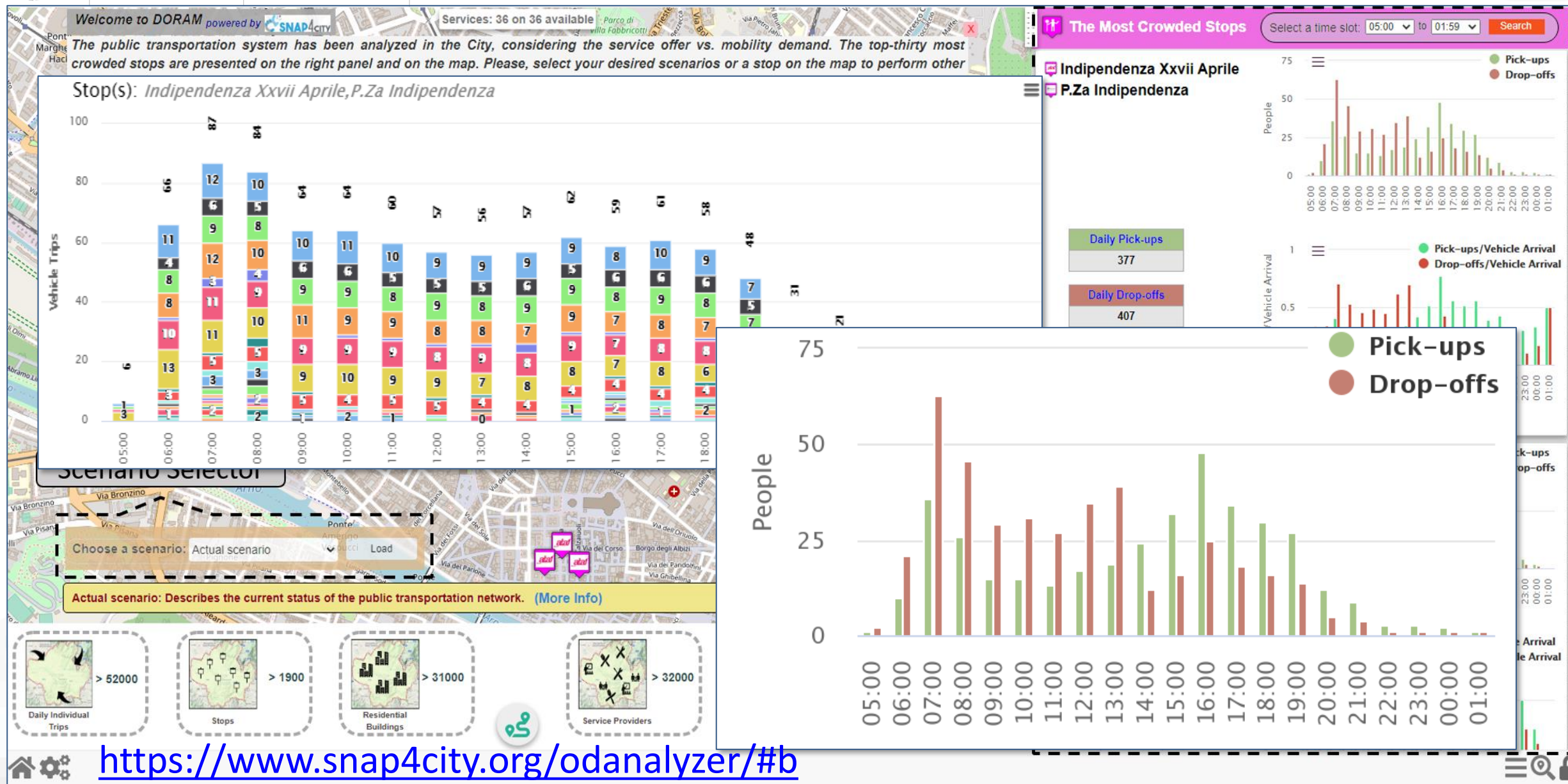


What-if Analysis on Collective Transport: DORAM

- 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







Traffic Simulation-K8S

Sun 22 Jun 11:53:30



Ext

STOP

PAUSE

HELP

26 FPS (17-26)

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

▸ Lights

▸ Effects

▸ SSAO

▸ Scene

Close Controls

Wid

Prepare Simulation

Execute Simulation

KPI Simulation

Simulation:

firenzeodbus

Execute

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

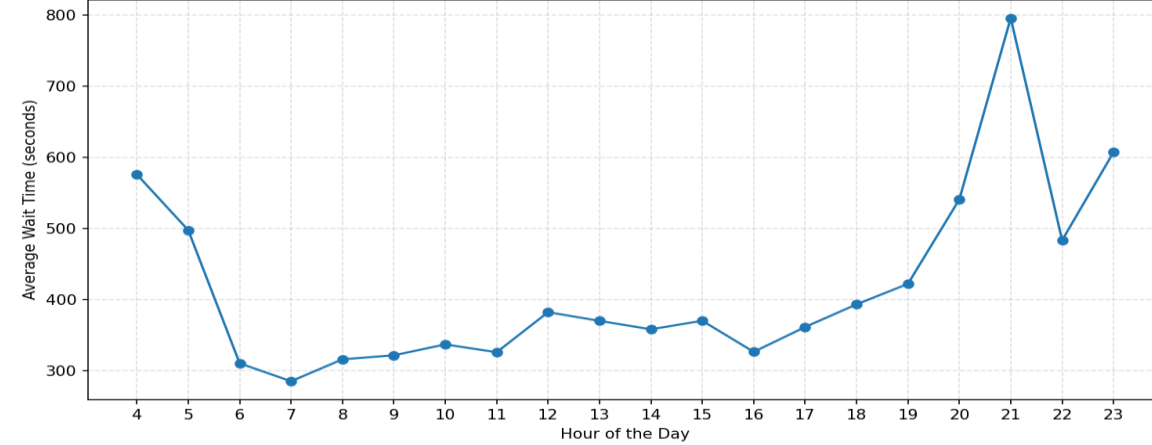


KPI on Match D-O of Collective Transport

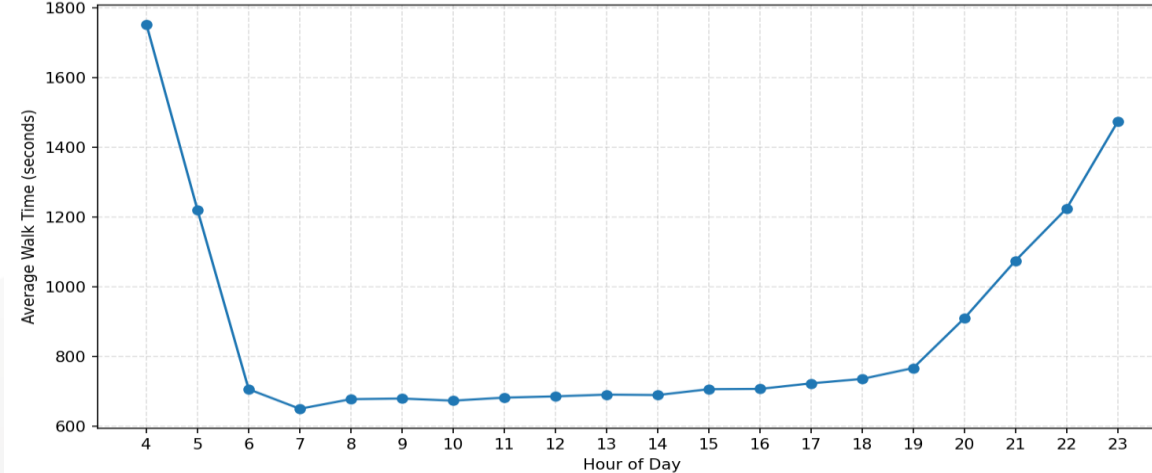
- **On users**
 - **Unmet Demand**
 - Number of passengers who could not board their planned bus
 - **Average Walk Time**
 - The average time spent by passengers during walking before and after taking a ride from source to destination of their trip.
 - Etc.
- **On Service performance**
 - **Average Ride 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

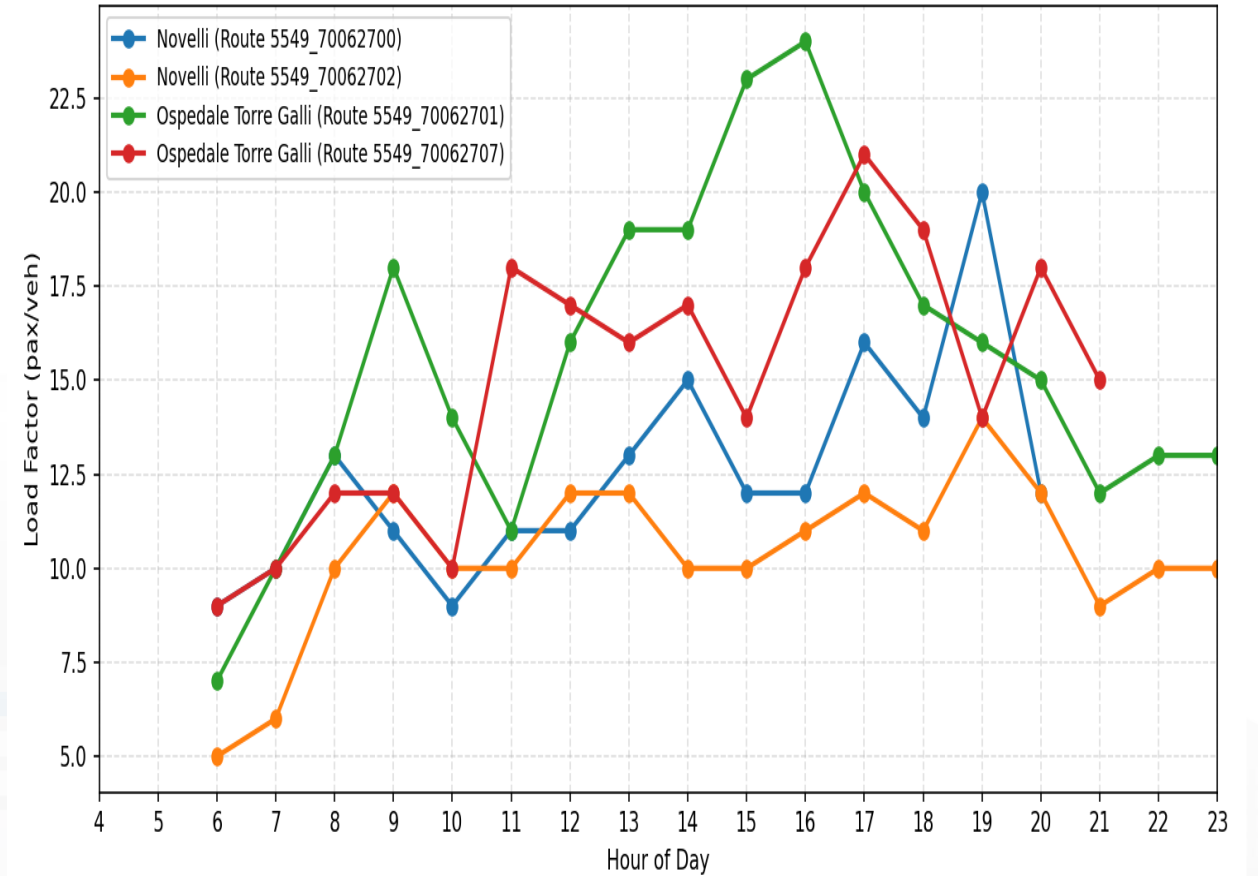
Average Hourly Ride Wait Time (Hour 04:00–23:59)



Average Hourly Walk Time (Hours 04:00–23:59)

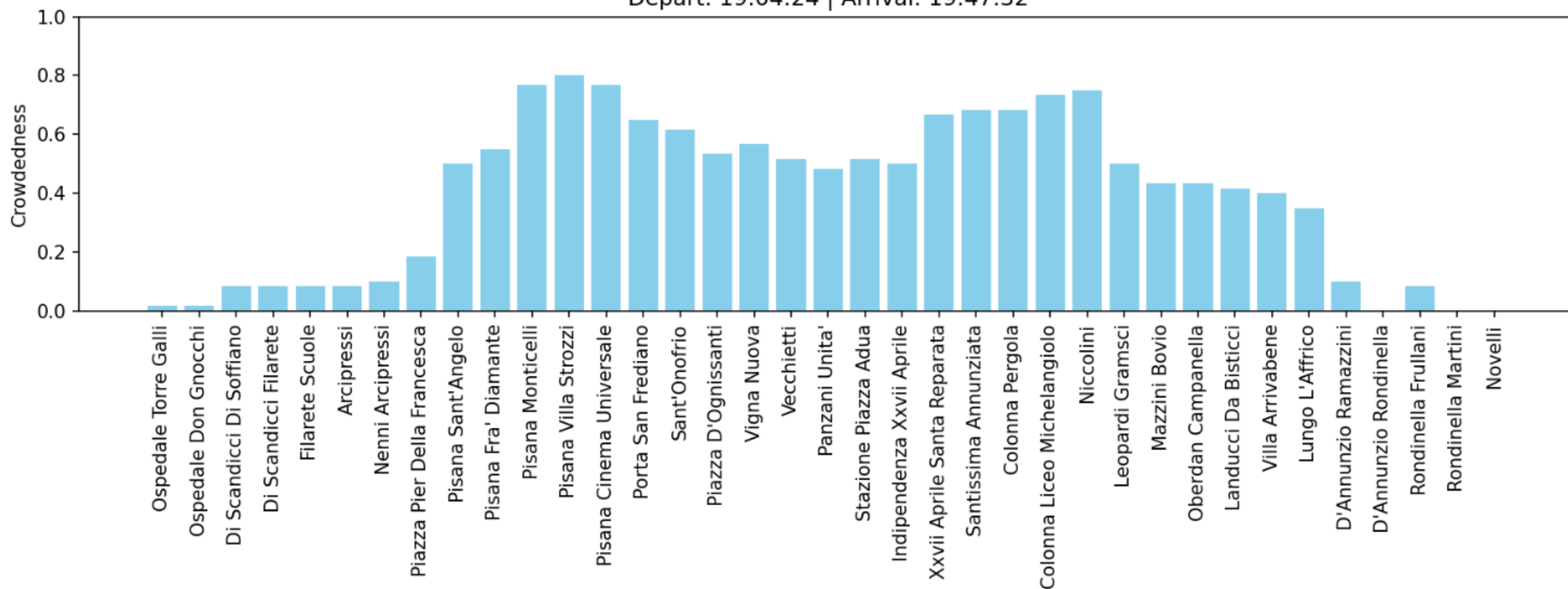


Line 6



Crowdedness

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



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 - Prof. Luigi Pariota , 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 MOBILITA' INTELLIGENTE E SOSTENIBILE

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e la pianificazione tattico-strategica
della mobilità urbana sostenibile e interconnessa

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