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TOURISMO

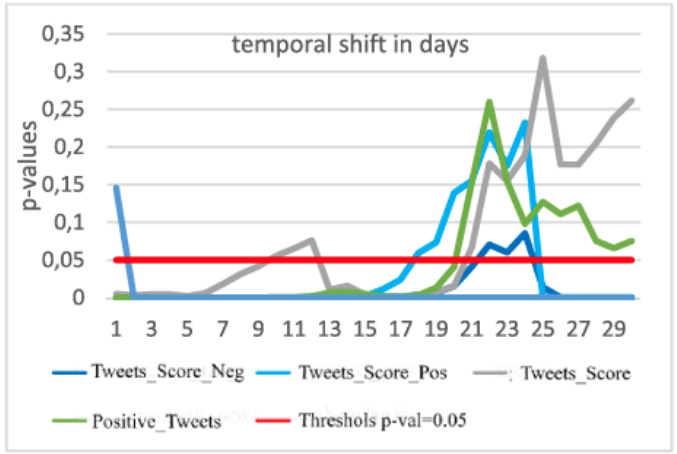
TOURism Innovative and Sustainable Management
of flOws

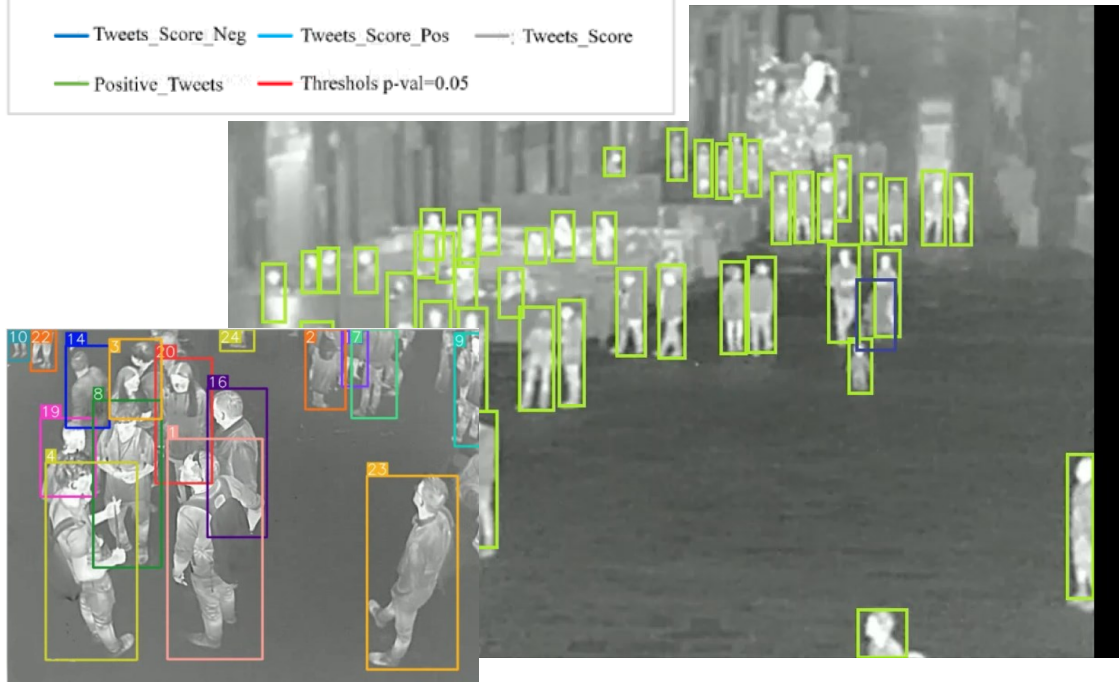
How cities are using thermal cameras and IoT sensors paired with AI to improve tourism flows efficiency and management: TOURISMO Florence pilot and beyond.

Paolo Nesi. University of Florence, DISIT Lab.

AI to Understand Users' Behavior, Tourism, DSS

- Service quality Assessment
- Engagement, … Suggestions
- Prediction of Offered Services Reputation
- Classification of Users' behaviour
- Counting and tracking user via thermal cameras
- Assessing the causality time of advertising
- From Wi-Fi/BT Sniffing to ODM





The TURISMO Perspective: A Data-Driven Framework

The TURISMO approach provides a practical five-step structure: first understand the destination, then define what should be measured, integrate the data, analyze it, and finally support decisions with AI and visual analytics.

01

Analyse

Understand tourism habits, flows, and pressure points

02

Measure

Define indicators and thresholds for continuous monitoring

03

Integrate

Combine primary and complementary datasets

04

Predict

Apply AI models and visual analytics

05

Provide Decision Support

Support planning, operational decisions, and evaluation

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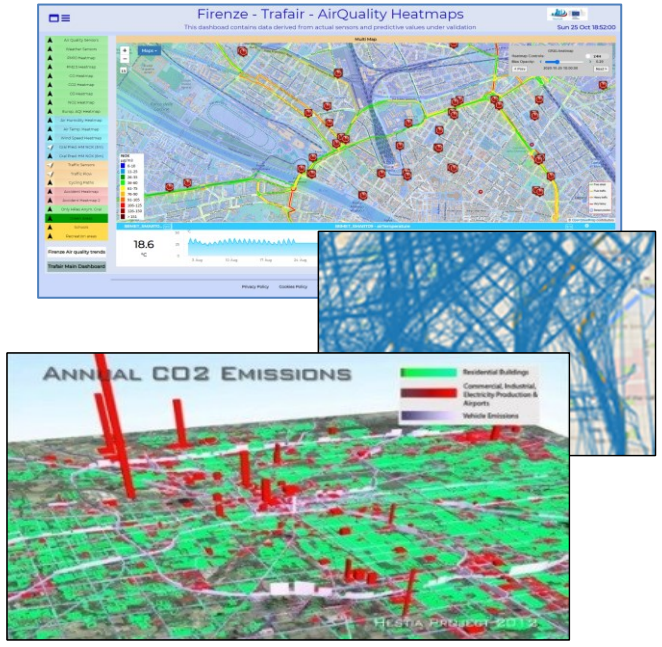
Goals

Goals	How to	technicalities
Keep under control reputation	Measuring and predicting	Multichannel collections of appreciations, AI/LLM, sentiment analysis
Predicting number of presences in advances	Measuring and predicting	Counting, tracking and computing Orig. Dest. Matrices
Controlling the overtourism	Measuring, predicting, suggesting, producing tactics and strategies	Production of suggestions, serious games, engagements, ..
Stimulating actions, stimulating the second offer	Suggesting, engaging, producing tactics and strategies	Production of suggestions, and engagements
Identification of critical conditions	Short and long terms Measuring	In deep data analysis, AI for anomaly detections
Increasing resilience	Monitoring and early warning	Strategies, dynamic routing, real time information to city users

Tourism Pressure Is Dynamic, Spatial, and Multi-Actor

Tourism pressure is not only about **total visitor numbers**. It is about *where* people are, *when* they arrive, *how* they move, and how these dynamics affect urban systems.



Data Driven Decision Support

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

Temporal Variability
Season, day, hour, weather, and events shift flows continuously

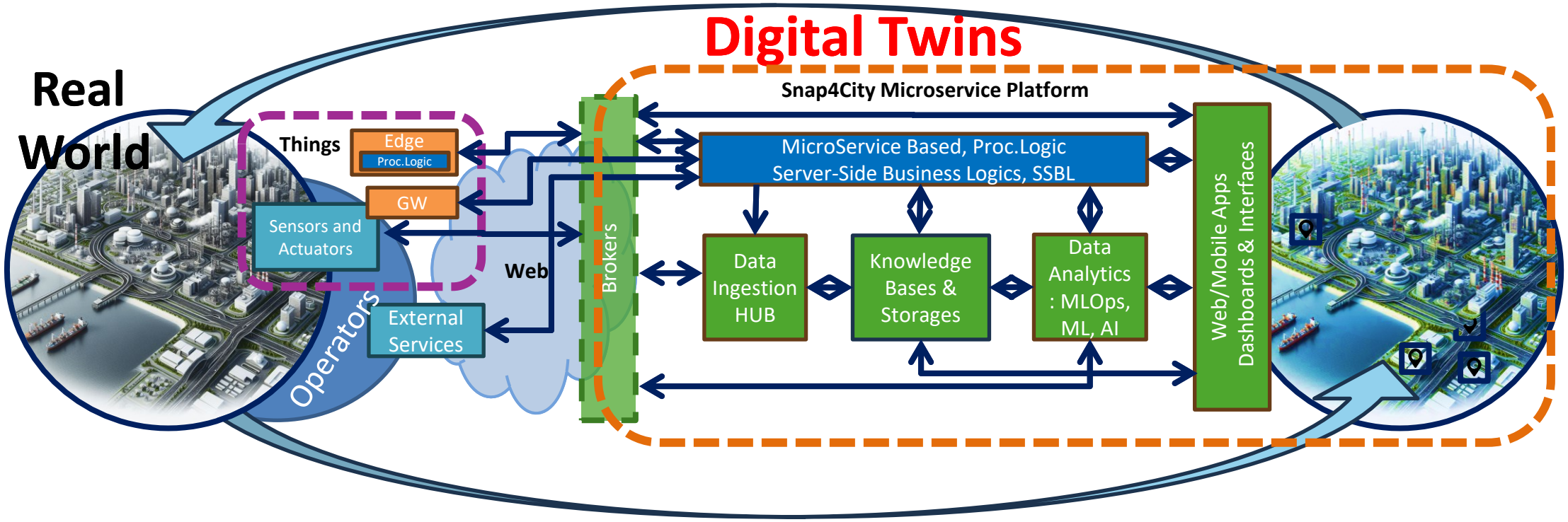
Spatial Concentration
Pressure accumulates in hotspots and along specific routes

Distributed Data
Fragmented across institutions, sensors, and platforms

Timely Decisions
Must be measurable, explainable, and actionable

What Is an Urban Digital Twin?

An Urban Digital Twin is **not just a 3D model**. It is an **operational environment** that connects the physical city with data streams, indicators, forecasting models, and decision-making processes - designed to act *before* problems become critical.



Dynamic & Real-Time
Continuously updated through live data streams

KPI-Connected
Linked to analytics, forecasting, and simulations

Decision-Oriented
Built to support timely, explainable governance actions

From Baseline to Territorial Intelligence

Before deploying AI or simulations, it is essential to establish a **baseline understanding** of the destination and then translate it into **territorial intelligence** for planning and management.

Characterizing the Destination

Build the baseline by asking: Who visits? When? Where do they arrive? Which places concentrate pressure? Which areas are underused?

Geographic Scope

Define boundaries and time frame for analysis

Visitor Profiles

Identify temporal patterns and traveler segments

Spatial Mapping

Map access points, routes, attractions, and pressure areas

Local Knowledge

Combine quantitative data with qualitative context

Territorial Intelligence

Move from visitor counts to spatial interpretation: identify access points, key attractions, movement corridors, and sensitive zones.

Access Points

Understand where people enter and concentrate

Key Attractions

Locate the places that drive visits and demand

Movement Corridors

Trace how visitors move through the territory

Sensitive Zones

Detect areas that require protection or careful management

Tourism Governance Is Multi-Institutional

A Digital Twin only works when the right stakeholders are aligned. Four actor groups must cooperate around a shared platform.

Public Authorities

Define policies and operational measures

Cultural Institutions

Manage heritage sites and visitor capacity

Tourism Boards & DMOs

Understand demand and visitor communication

Data & Technical Actors

Enable monitoring and analytics infrastructure

Define KPIs for Tourism Governance

STEP 2

Indicators are the language of the Digital Twin. They translate raw measurements into operational meaning — enabling decision-makers to identify pressure, saturation, and environmental conditions before they become problems.

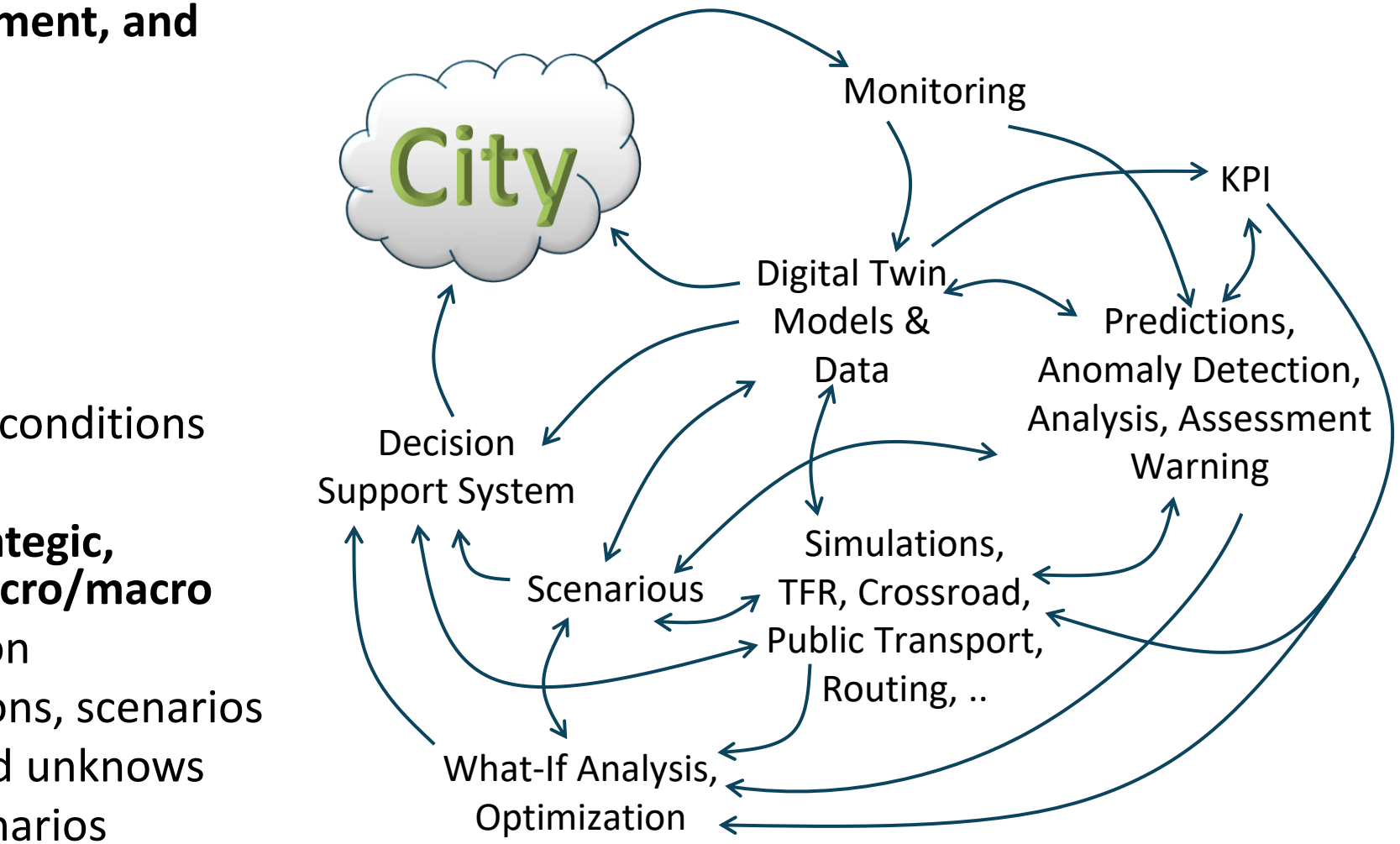
KPIs must be adapted to each destination's context and data availability, and classified as key, secondary, or complementary based on governance priorities.

City User behavior analysis multiple data sources

- **Main Data Sources on the market**
  - Mobile Cell data from telecom operators, macro areas
  - Mobile App data from their operators, micro areas
  - OBU from Insurance operators, only private vehicles
  - Social media: limited information and quality
  - Local Operators of: museum, ticket office, restaurants, etc.
  - Data integrators: a mixt of the above, not clear methods
- **Sensor Data**:
  - PAX Counters, Sniffer, Wi-Fi sniffers, Radar, laser, etc.
  - TV Camera color, Thermal Cameras, radar track
- ***Snap4City: integration and computing tools for deductions***

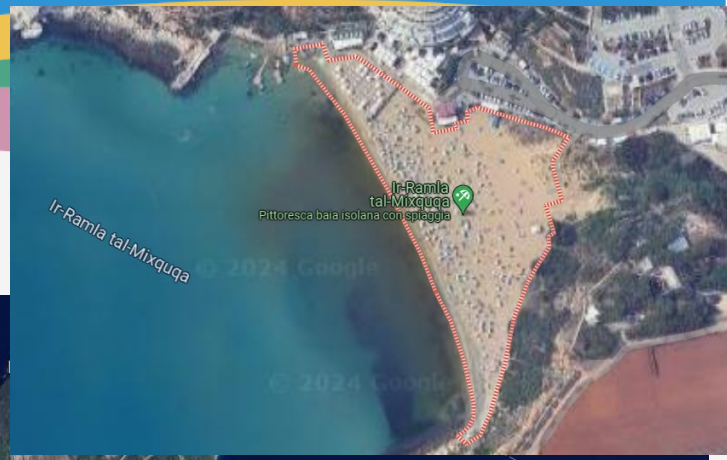
Main tasks

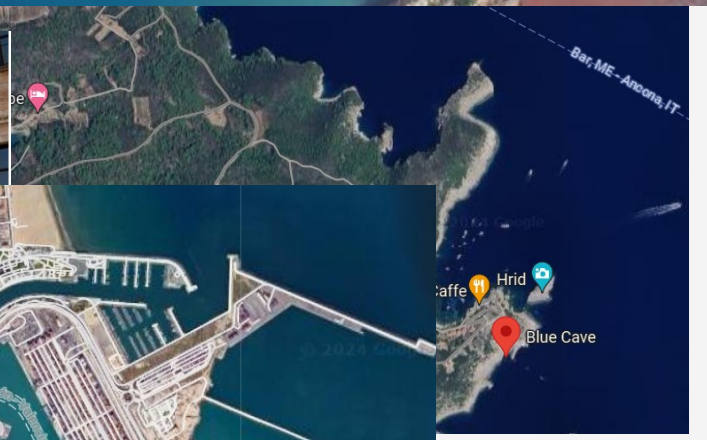
- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Predictions vs KPI
  - Anomaly detection
  - Neuro-Symbolic analysis
  - Risk assessment
  - Early warning on critical conditions
  - Fast What-if analysis
- **Making plan: tactic and strategic, medium and long range, micro/macro**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

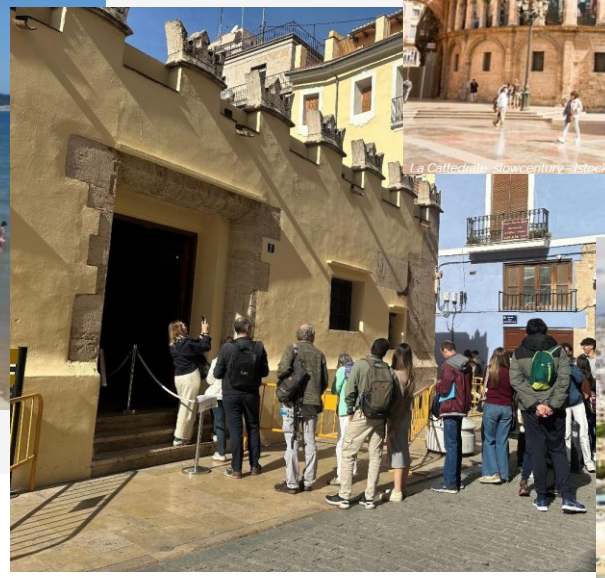


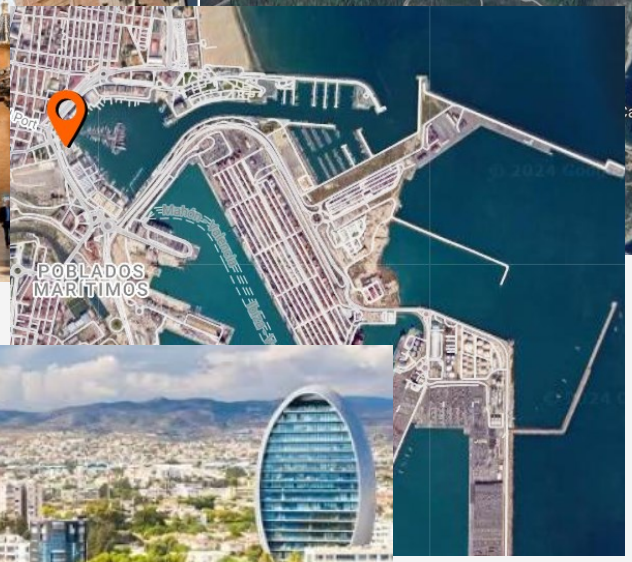
• Pilots of Snap4City on:

- Greece - READ S.A.: Rodi
- Italy – FRI, UNIFI: Firenze
- Spain – FV, FSMLR: Valencia
- Cyprus – ANELEM: Limassol
- Bulgaria – VEDA: Varna
- Croatia – RERA SD: Splitsko-dalmatinska županija
- Malta – MRDDF: La Valletta









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https://www.snap4city.org/1001

TOURISMO Main Dashboard – Public Access

Florence (Italy) – Scenario: City Centre

https://www.snap4city.org/1035

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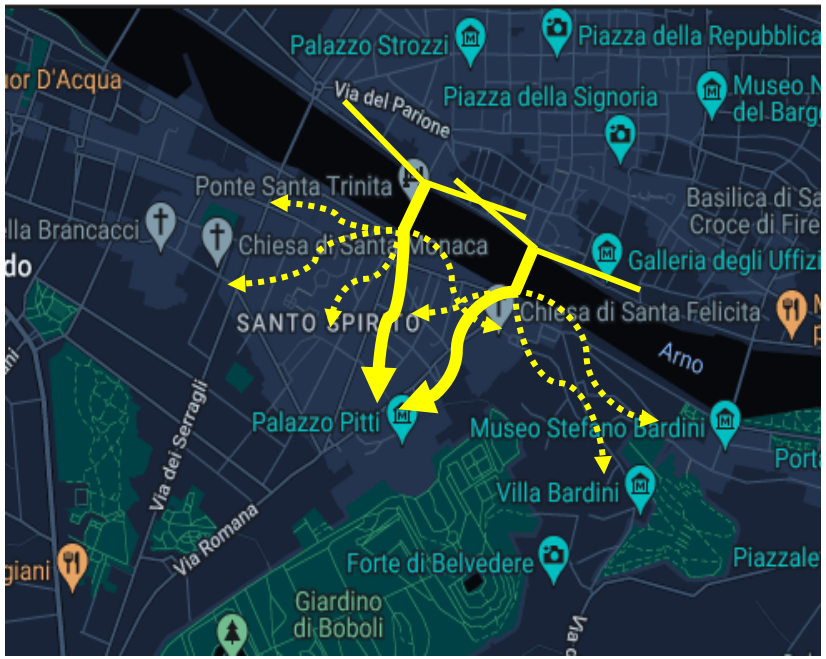
SNAP4CITY

Florence (Italy) – Scenario: City Centre



Target:

Anticipate and mitigate negative or unexpected unknown events, predict flows and virtuously orient them

Equipment:

- 2 Thermal cameras
- 3 Pax counters: sniffer counting devices

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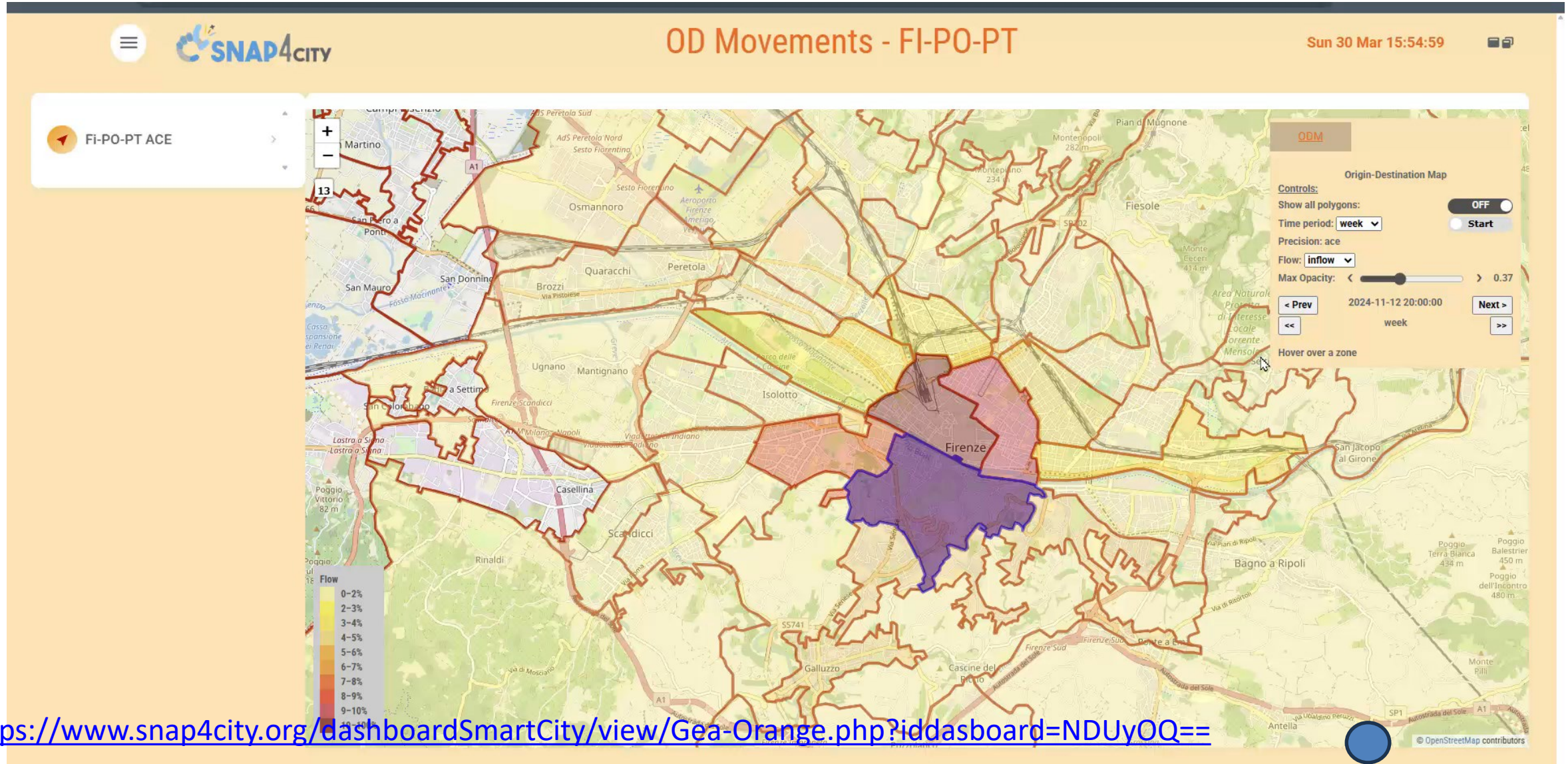
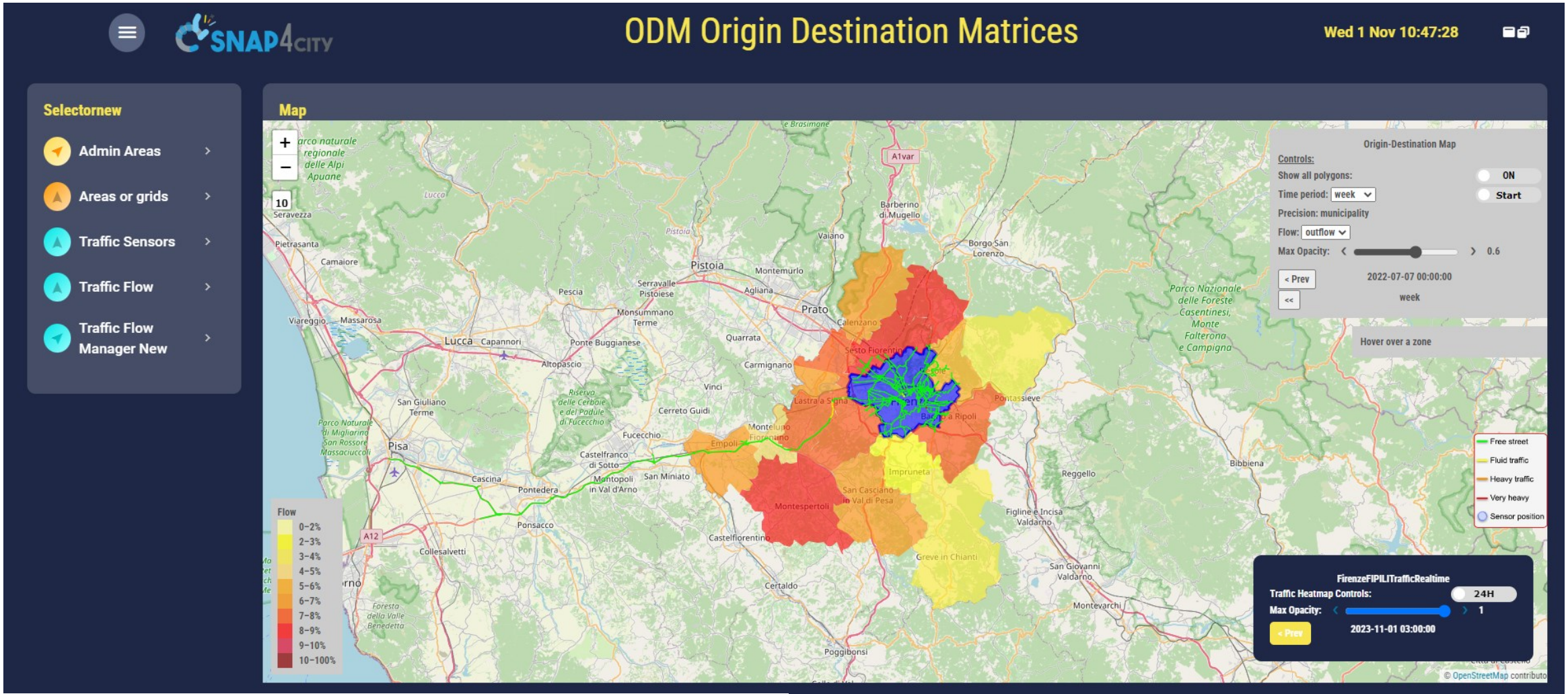
Origin Destination Matrices: Mobility Demand



https://www.snap4city.org/dashboardSmartCity/view/Gea-Orange.php?iddasboard=NDUyOQ==

ODM and Traffic Flow



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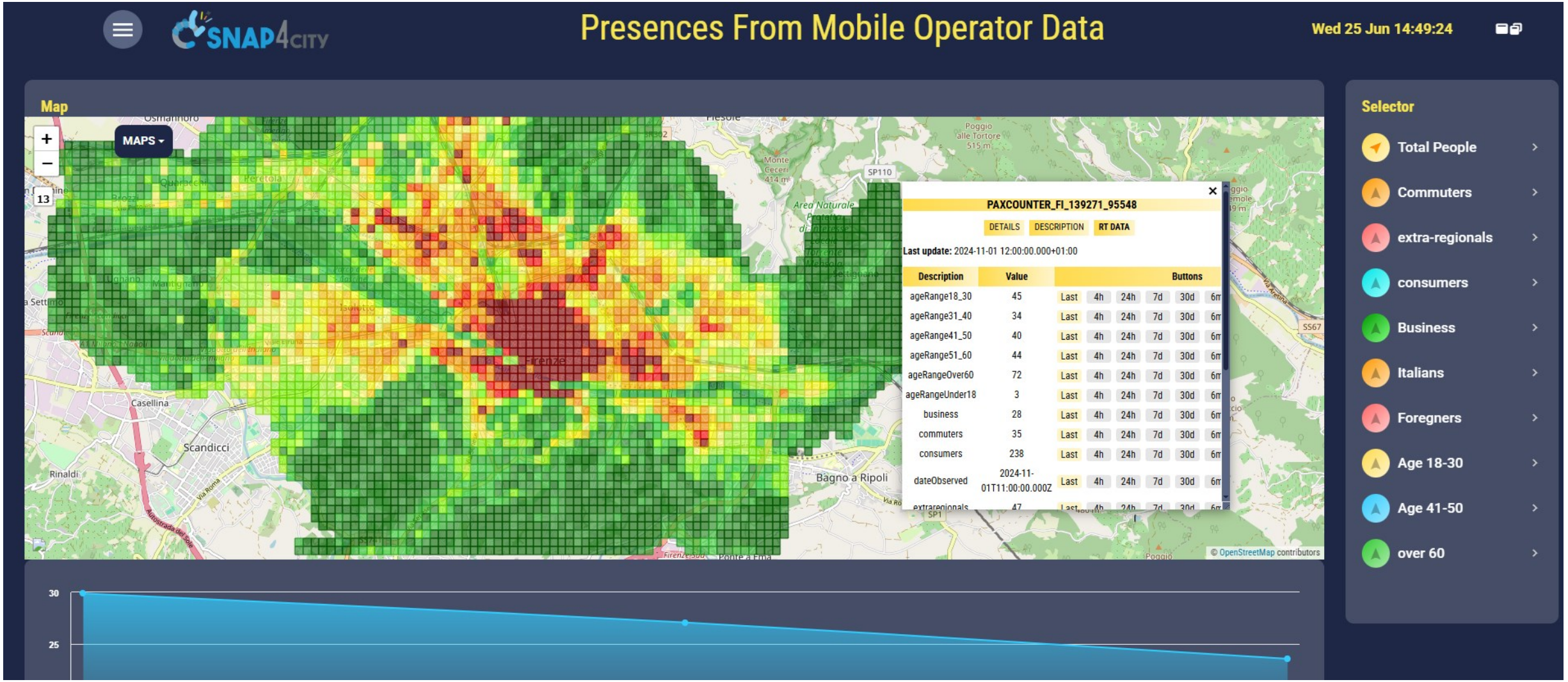
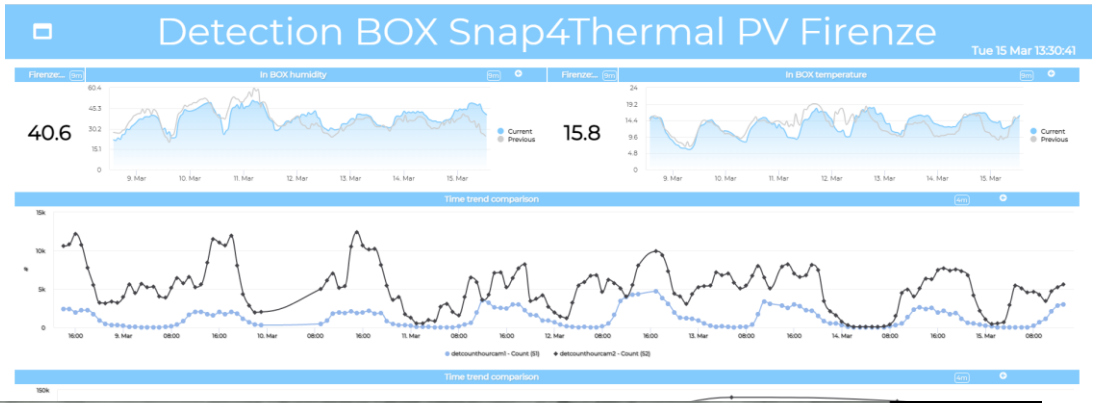
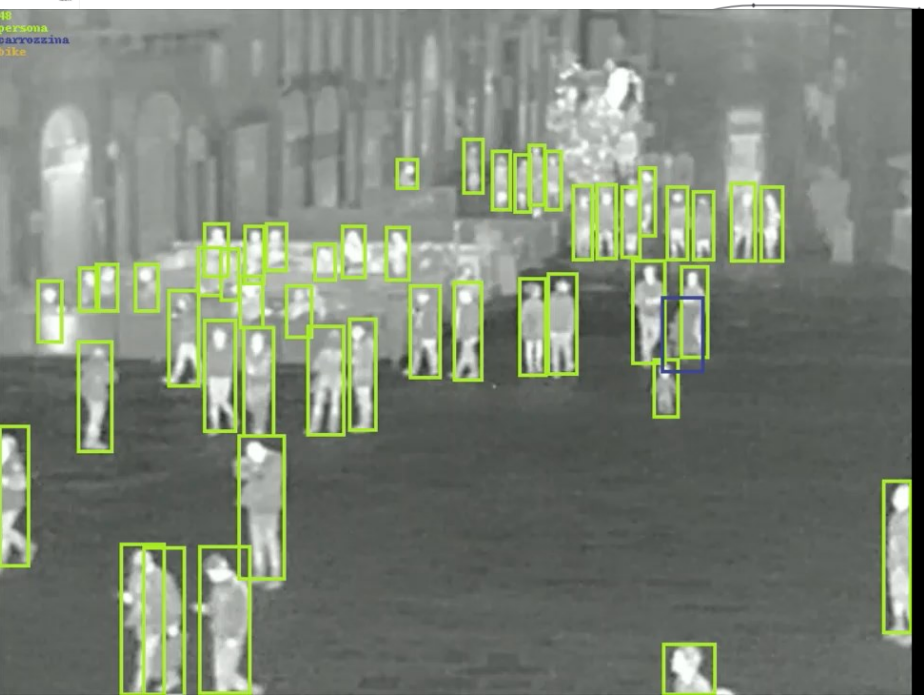
Presences from Mobile Operator



A view and data from the Thermal Camera





11 SUSTAINABLE CITIES AND COMMUNITIES

TOURISMO Pilots: Florence

Data **Ingestion Processes** and **data flows** from devices in Florence pilot.

- 6 Sniffers Wi-Fi (real-time via MQTT)

(Wi-Fi detections; Bluetooth detections, ALL detections)
Starting on 1 July 2025 – Frequency: every 15 min

- 2 AXIS cameras (real-time)

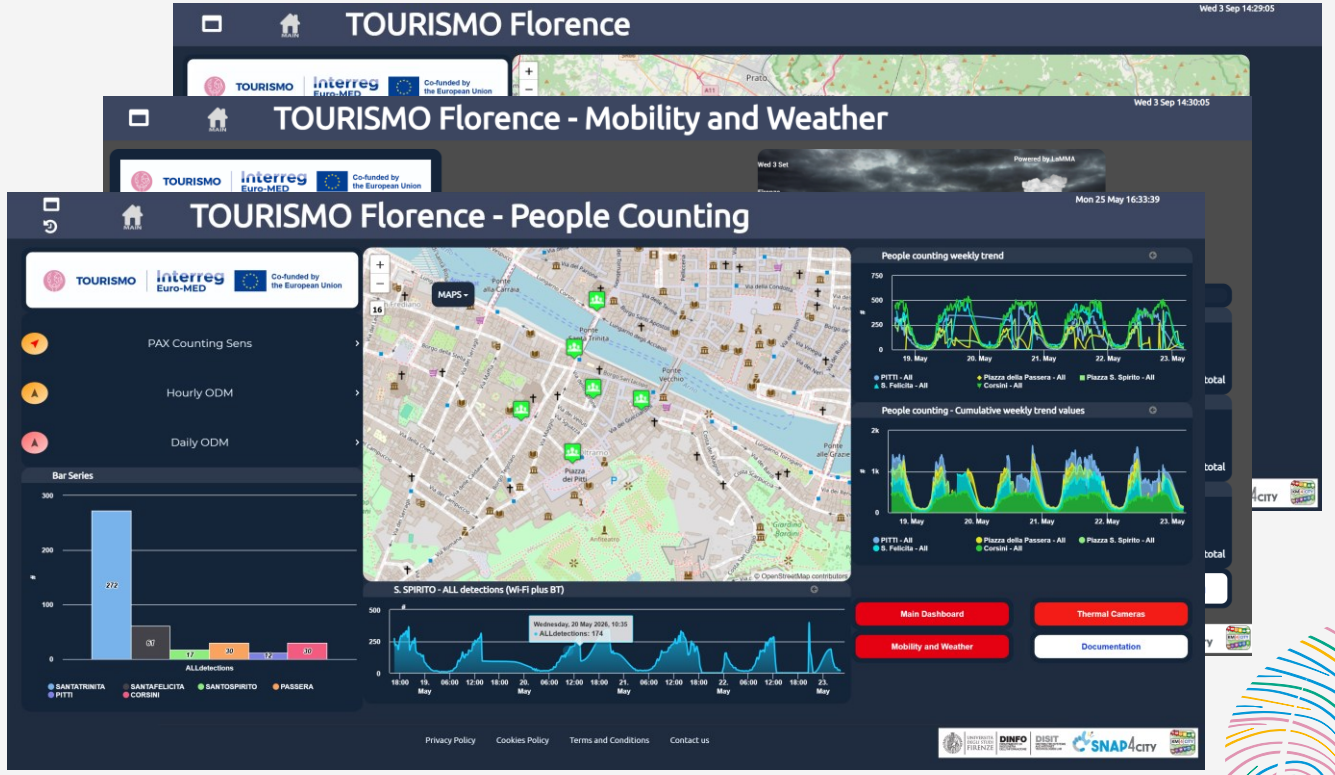
(people, bikes, strollers)
Starting on Oct 2025 – Frequency: every 5 min

- Vehicle Traffic Data (real-time via API)

(inflow, outflow, etc.)
Starting on Jan 2017 – Frequency: 10 min

- Env. sensors (real-time via API)

(humidity, temperature, CO, NO2 etc.)
Starting on Jan 2021 – Frequency: 15 min



TOURISMO Pilots: Florence

Data **Ingestion Processes** and **data flows** from devices in Florence pilot.

- Open weather (real-time open source)

Starting on 16 Dec 2024 – Frequency: every 30 min

- Air pollution (real-time open source)

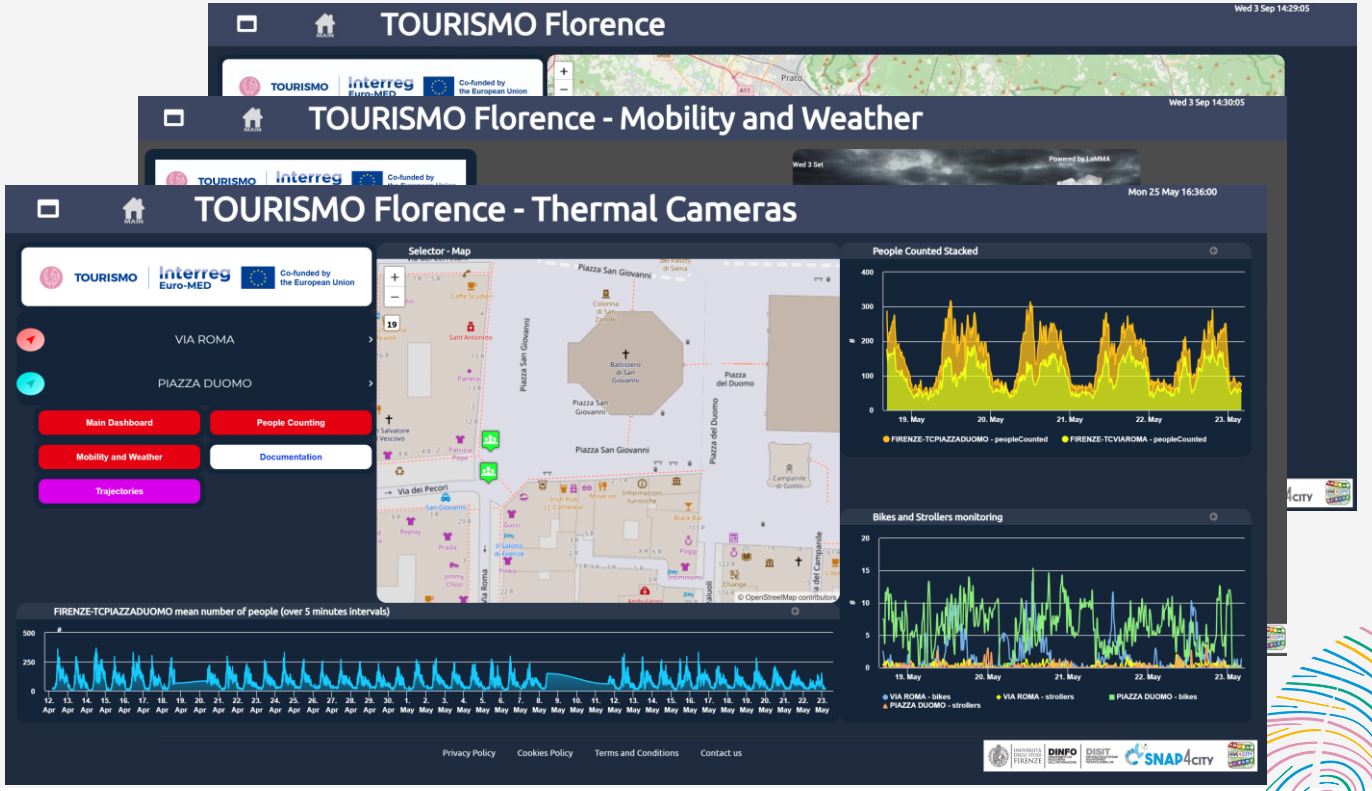
Starting 21 Jan 2025 – Frequency: every 30 min

- Car Parking (real-time open source)

(freeParkingLots, Capacity, etc.)
Starting on May 2022 – Frequency: 15 min

- Forecasting Approach

automated approach for configuring and visualizing forecasts related to different measures from installed devices.



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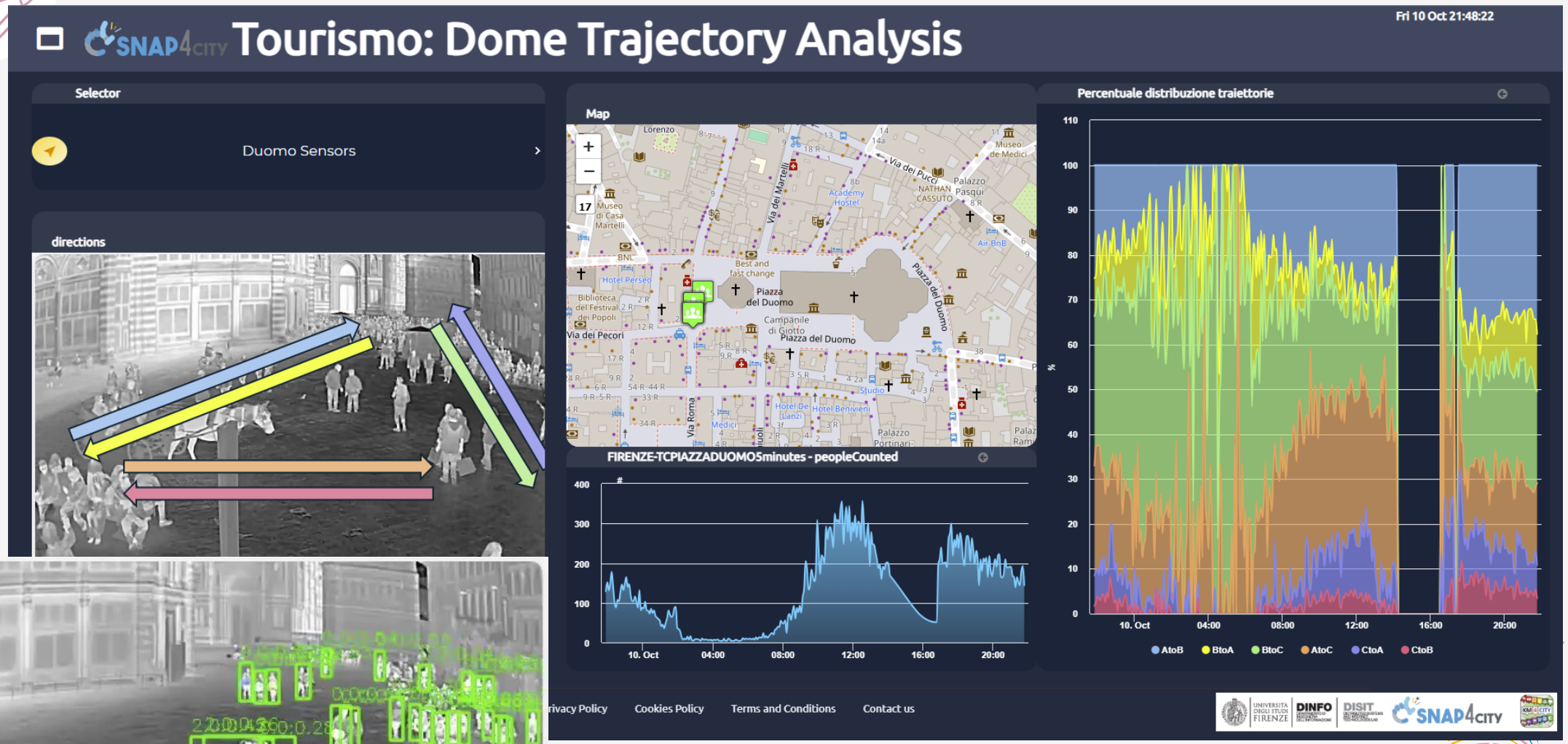
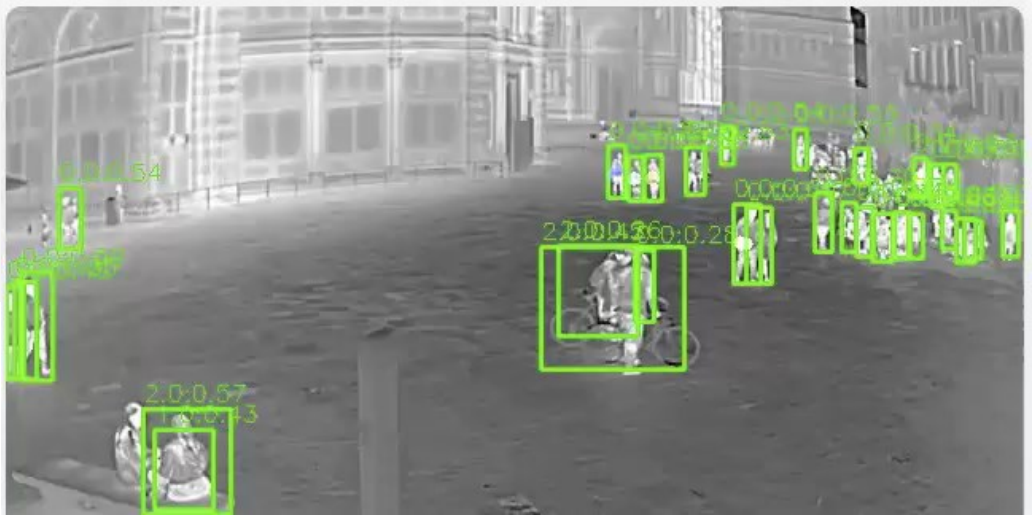




https://www.snap4city.org/dashboardSmartCity/view/newTheme.php?iddasboard=NDcyMQ==

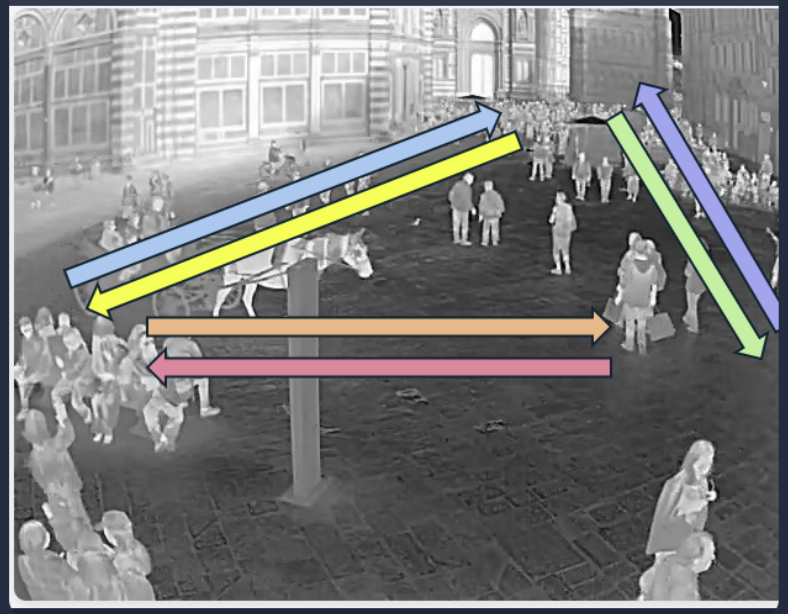
Tourismo: Dome Trajectory Analysis

Mon 13 Oct 23:11:10

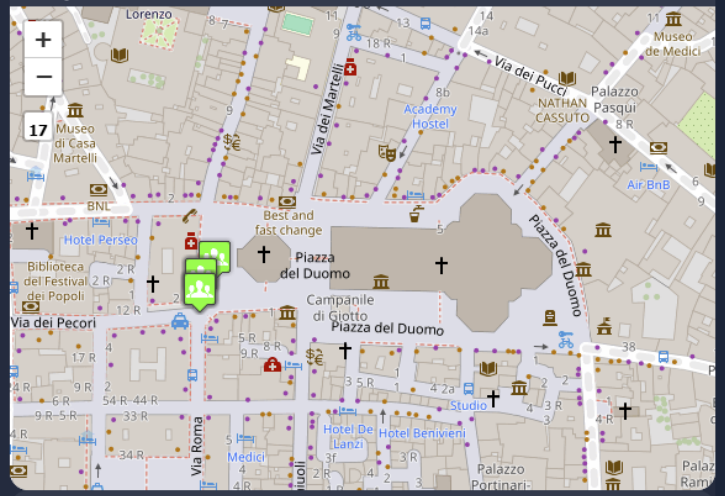
Selector

Duomo Sensors

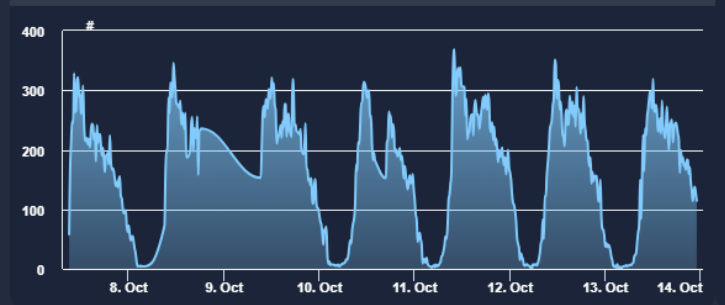
directions



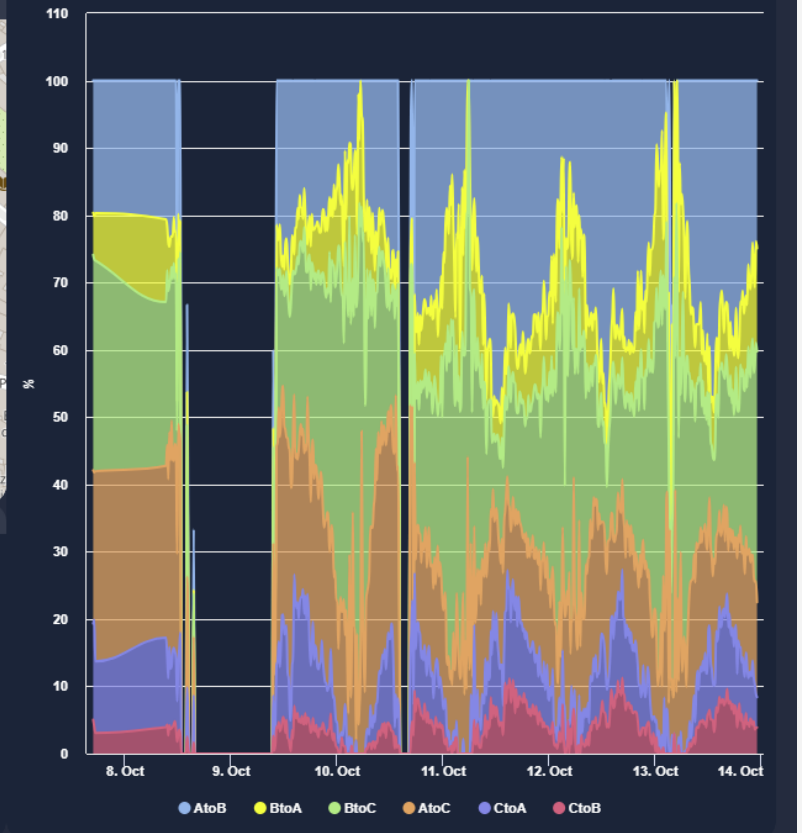
Map



FIRENZE-TCPIAZZADUOMO5minutes - peopleCounted



Percentuale distribuzione traiettorie



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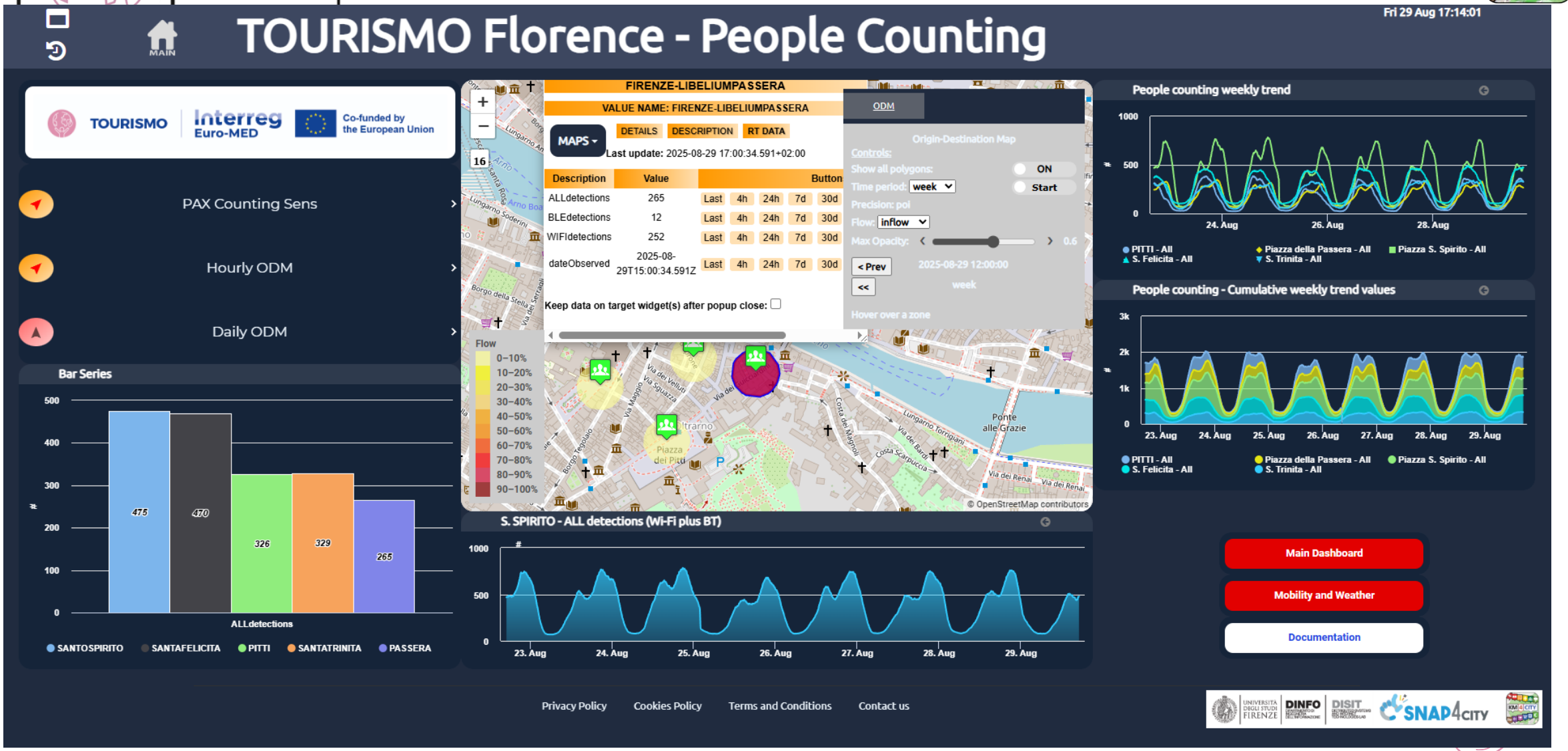
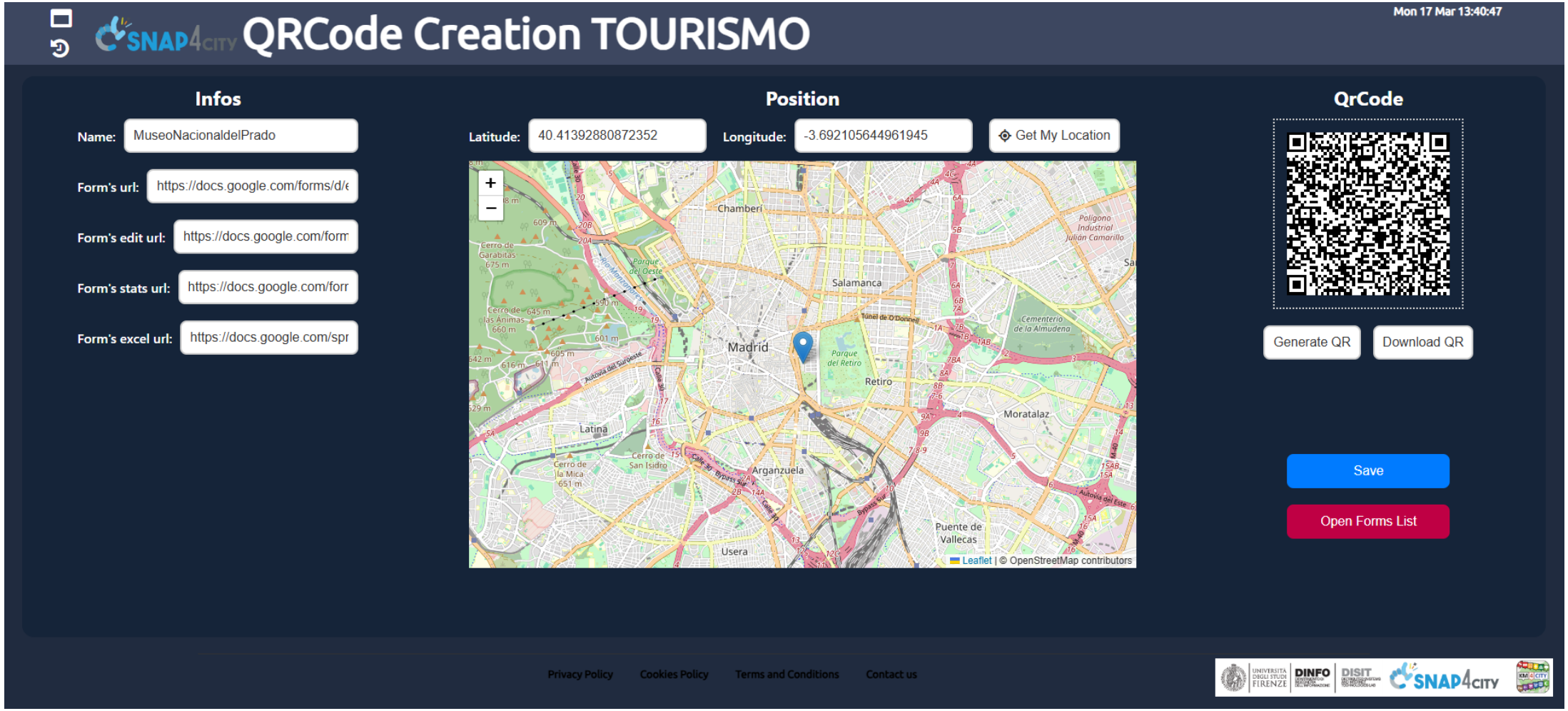


Complains Analysis to Support Decision Making Processes



Complains Analysis to Support Decision Making Processes

Standard data/form creation
for reputation analysis:

- Initial Sentiment Analysis/NLP by analysing questionnaires collected from QR code distribution.

Summary of Findings (June–August 2025, 36 responses received - Golden Bay, Malta) produced by a Large Language Model (LLM) based on the responses obtained from questionnaire

Average Ratings (scale -2 to +2)

Overall experience: +0.67 → slightly positive but inconsistent (range -2 to +2)
Toilets: -0.83 → strongly negative, among the worst-rated aspects.
Showers: -0.31 → generally negative.
Bins distribution: -0.33 → slightly negative, with complaints about lack of bins.
Safety & lifeguard services: +0.55 → moderately positive.
Cleanliness: -0.52 → overall negative, many complaints about cigarette butts and plastics.
Natural conditions (dunes, seawater, etc.): -0.40 → negative, issues with seagrass, water quality.

SNAP4CITY

Logged in as:
edoardo_tester

Your Profile

Logout

SnapAssistant model:

Llama3.3

New Chat

- EdoChat1
- EdoChat2
- EdoChat3
- EdoChat4
- prova
- chatNuova
- chatTest1LLAMA
- chatTest2LLAMA
- testGianniLLAMA
- testTastoInvioPreChanges
- ChatTestPostPSWINVIO

https://www.snap4city.org/1116

SnapAdvisor

Current chat: debug0

Visualize references

Personal Advisor LLM

Come creo una dashboard?

Per creare una dashboard, puoi utilizzare la piattaforma Snap4City. La dashboard si compone di un insieme di widget grafici che possono essere impostati separatamente assegnando una serie di parametri, come origine dati, dimensioni, colori, forma, font, allarmi, relazioni con altri, ecc. (SOURCE: Snap4 City per la creazione di Smart City Control Room, SCCR). Inoltre, la piattaforma offre la possibilità di creare vere e proprie applicazioni interattive, multipagina/multidashboard, e non semplici storie monopagina da scrollare. Puoi anche condividere la dashboard con altri utenti anche fuori dalla Smart City Control Room tramite canali autenticati e protetti in HTTPS, in accordo al GDPR (SOURCE: Snap4 City per la creazione di Smart City Control Room, SCCR). Per vedere alcuni esempi di dashboard, puoi visitare il sito https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjU0Mg== (SOURCE: Snap4 City 1st Overview v4 8 annot). Tuttavia, non ho trovato informazioni dettagliate sulla procedura di creazione di una dashboard. Se hai bisogno di ulteriore assistenza, ti consiglio di contattare direttamente il team di supporto di Snap4City. Non so dirti altro in merito.

Write a message...

SnapAdvisor: AI based Assistants, DSS

- **Snap4CityAdvisor:**
  - for developers and promoters knowing all Snap4City and DISIT Lab literature, articles, manuals, slides, codes, etc. The SnapAdvisor with this skill is accessible only for selected Snap4City users. It allows users of saving a lot of time by providing answers to facilitate the development of smart solutions, to the exploitation of Snap4City tools, and recently on data and services accessible on the platform, producing offers, etc.
- **Legal Advisor**
  - expert on specific disputes at service of the Legal department of Careggi Hospital of Florence. It allows to save time in recovering precise information from complex legal documents, ordering of events, understanding causes and effects, producing reports, etc.
- **Expert of industrial machines, user manuals, technical manuals, rules,**
  - Answering on technical manuals
- **Complains and Questionnaire analysis**
  - Answering on trends, via questionnaires collected via QR, blobs, emails, etc.
- **Commercial Advisor:**
  - processing orders understanding them and preparing the offer, thus reducing the time to process them.
- **Generative Designs**:
  - Multimodal Generative AI supporting designers in producing innovations
- etc.

See: "Context-Aware Retrieval Augmented Generation using Similarity Validation to handle Context Inconsistencies in Large Language Models", IEEE Access, 2025. https://doi.org/10.1109/ACCESS.2025.3614553

SnapAdvisor

- **working on your private content** and thus producing answers.
  - Select a subset of documents
- **domain control**: you can decide the knowledge base (internal wikis, PDFs, APIs),
- **explainability** capability, provide references to your documents
- **multilingual via content**
- **modularity**: it is possible to pass from one collection of documents to another, and multiple users can work on the advisor asking for different topic on different collections/domains at the same time, independently as needs change, without any interferences among them.
- **lower hallucinations**

https://www.snap4city.org/1116

Business Intelligence for shopping areas/retails

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- Dati Locali
- Dati vendita
- Dati Contesto
- Global behavior
- Eventi, meteo
- Parcheggi, etc.
- Cross marketing
- Social media
- Feedbacks
- ...

SADI-MIAC

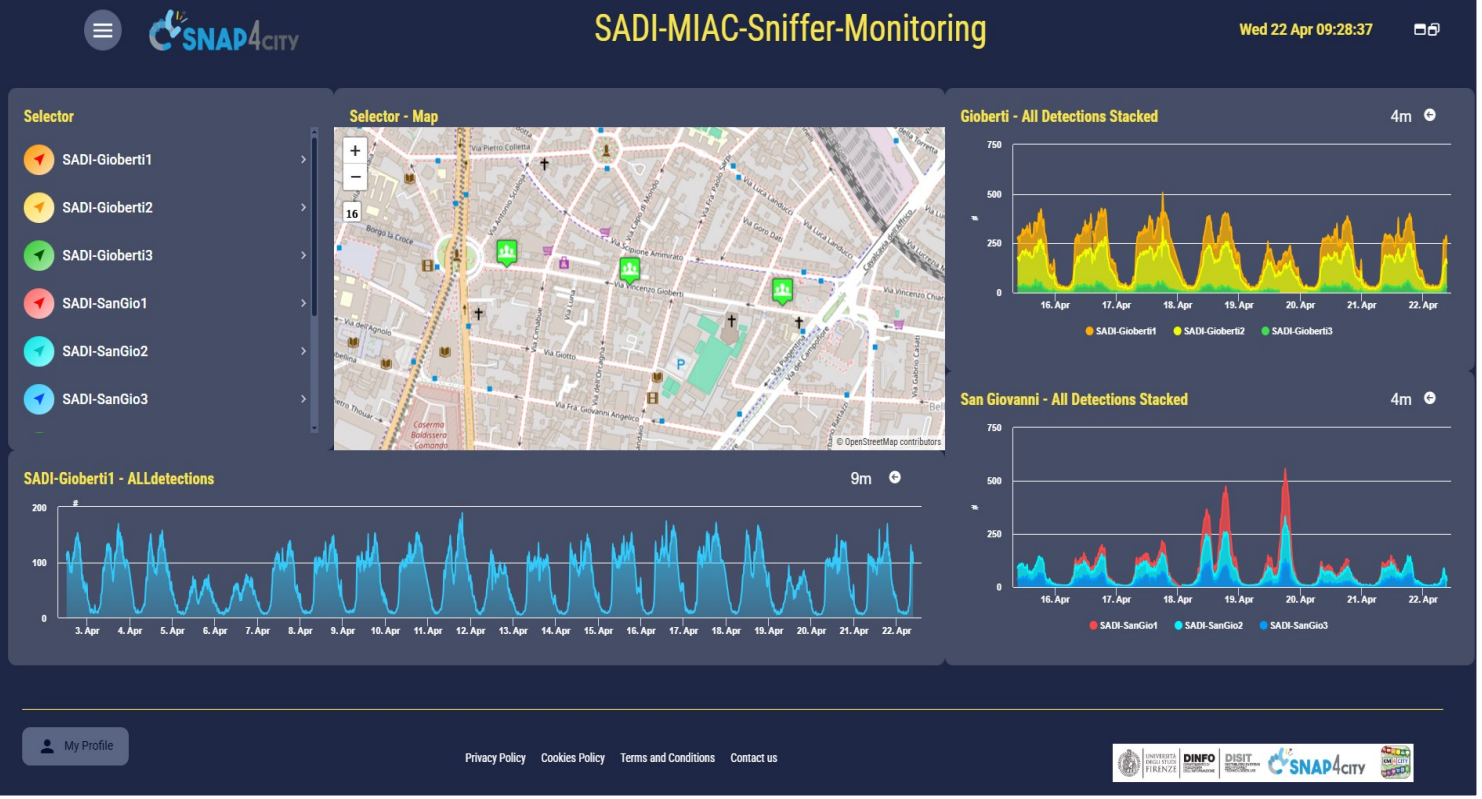
- DSS
- Digital Twin
- AI/XAI
- Generative AI

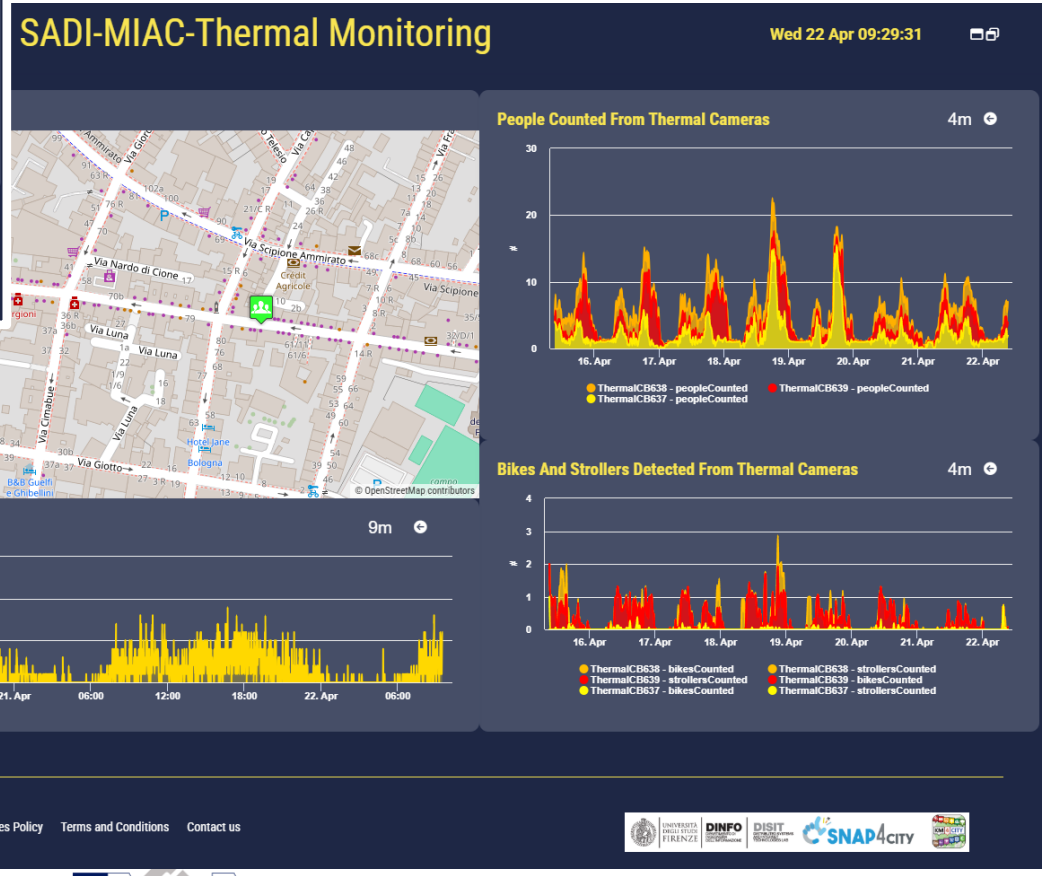
- Dashboard
- Predizioni
- Anomalie
- Scenari
- Strategie
- Suggerimenti
- ...

https://www.snap4city.org/1156

SADI-MIAC

Shopping area monitoring





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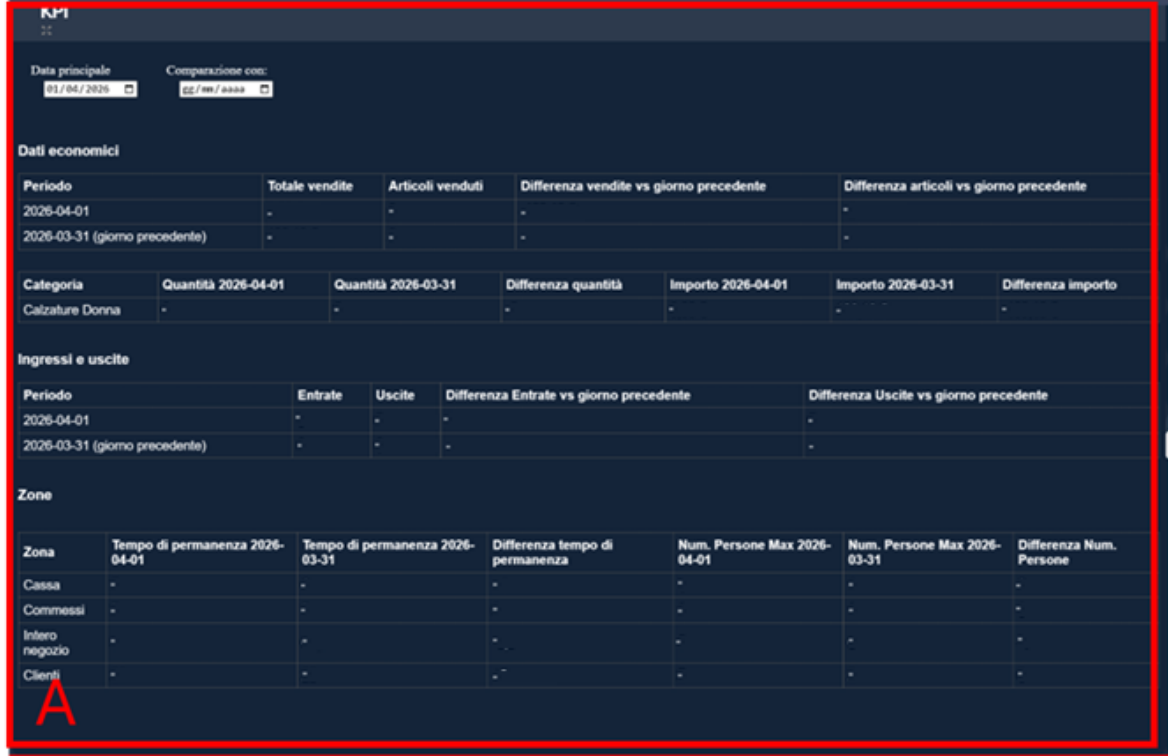
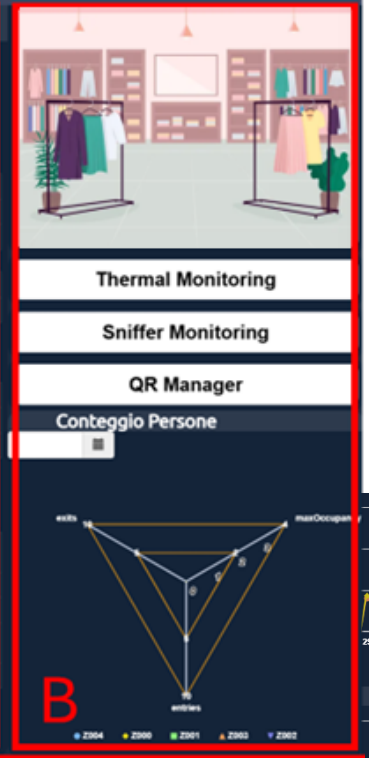
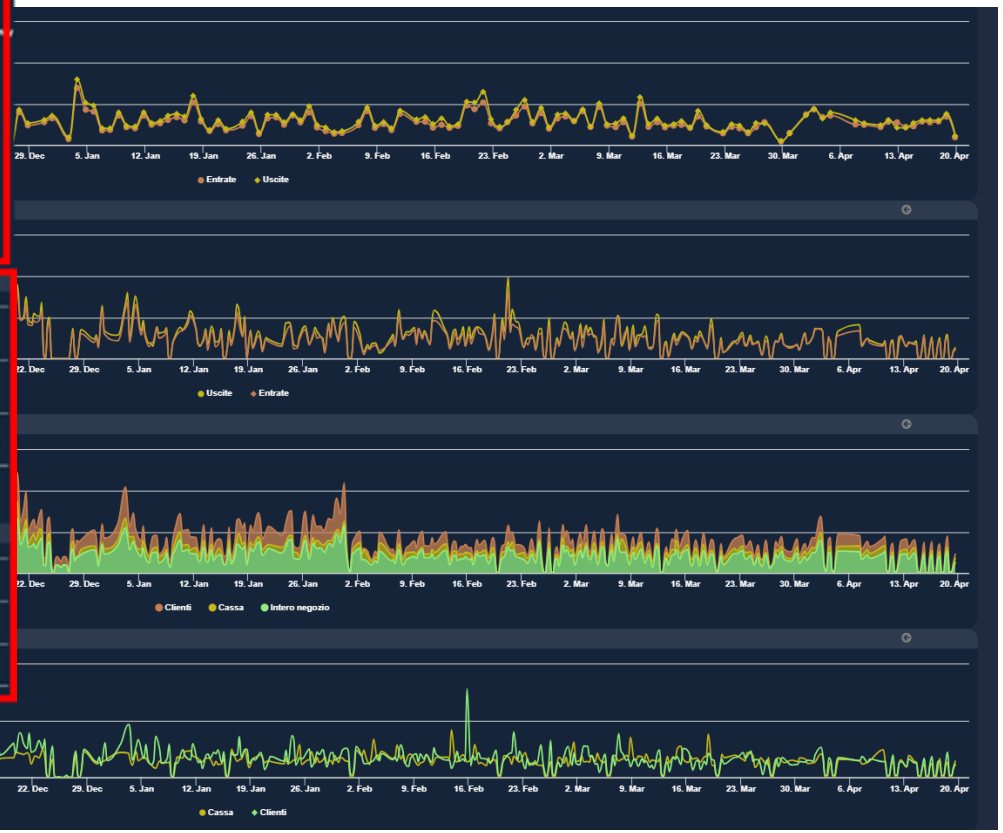
Smart Retail







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Thank you for your attention.

Questions?

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Making the Mediterranean Green Transition happen

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TOURISMO

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...

TOURISMO Pilots: Malta

Data **Ingestion Processes** and **data flows** from devices in Malta pilot.

- 2 Sniffers Wi-Fi (real-time via MQTT)

(Wi-Fi detections; Bluetooth detections, ALL detections)
Starting on 17 March 2025 – Frequency: every 15 min

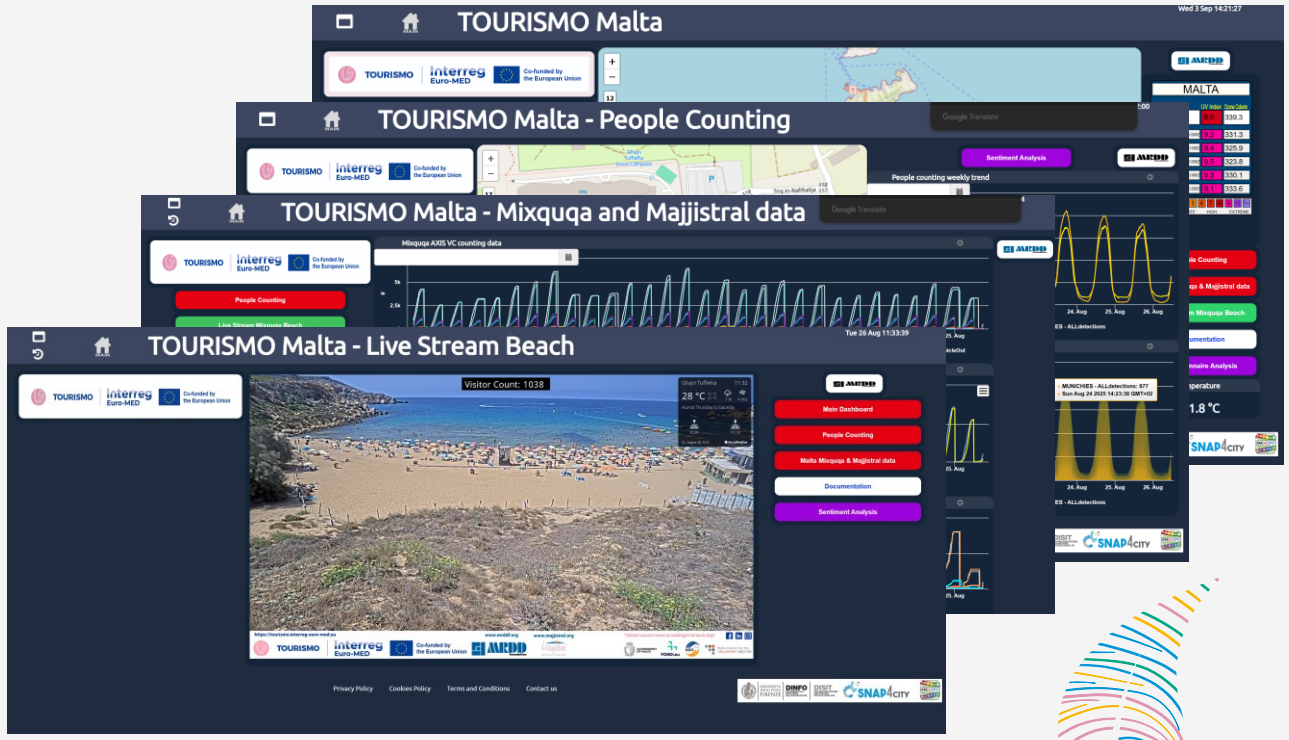
- 3 AXIS cameras (real-time)

(inHuman, outHuman, inCar, outCar, inBus, outBus, etc.)
Starting on 22 April 2025 – Frequency: every 5 min

- Analysis derived from data cameras

(occupancy, density, humanSpace, etc.)
Starting on 4 Jul 2025 – Frequency: every 5 min

- Live Video Stream



TOURISMO Pilots: Malta

Data **Ingestion Processes** and **data flows** from devices in Malta pilot:

- Open weather (real-time open source)

Starting on 16 Dec 2024 – Frequency: every 30 min

- Sea conditions (real-time open source)

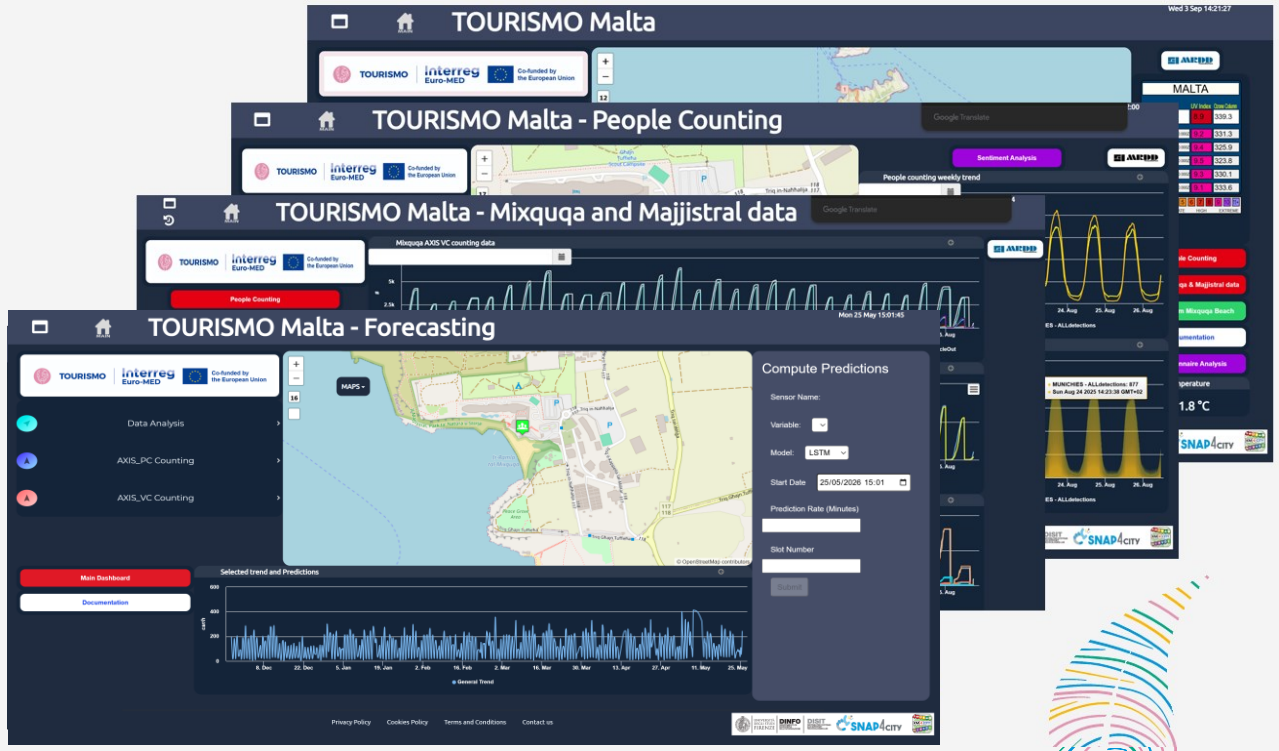
Starting on 14 Jan 2025 – Frequency: every 60 min

- Air pollution (real-time open source)

Starting on 21 Jan 2025 – Frequency: every 30 min

- UV index (real-time open source)

Starting on 31 Mar 2025 - Frequency: every 24 hour



TOURISMO Pilots: Malta

Data **Ingestion Processes** and **data flows** from devices in Malta pilot:

- Mixquqa Monthly Trends (Key Indicators)

key indicators related to beach attendance,
including total visitor counts, vehicles counts,
and peak day during the mouth
Starting on May 2025 – Frequency: monthly

- Forecasting Approach

automated approach for configuring and
visualizing forecasts related to different measures
from installed devices.