



Multimodal Extreme Scale Data Analytics for Smart Cities Environments

Info Day on Minimum Viable Product



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[MARVEL project](https://www.linkedin.com/company/MARVEL-project)



Info Day - Why we are here?

Today we will present:

- The MARVEL framework
- Real-needs of Trento and Malta smart cities
- The Minimum Viable Product (MVP)

MOST IMPORTANTLY!

We need **your feedback** to make sure that our MVP evolves to a full-fledged solution improving the citizens' quality of life.

During the sessions **keep watching the chat** – polls will be proposed at the end of presentations

A POLL HAS BEEN STARTED RIGHT NOW

January 28, 2028. MVP Info Day - AGENDA

09:00	Welcome	Elisabetta Farella, Marco Pistore - FBK
09:15	Why is MARVEL relevant to the city of Trento?	Giacomo Fioroni - MT
09:45	MARVEL Overview	Sotiris Ioannidis - FORTH
10:05	MARVEL Scientific & Technical View	Dragana Bajovic - UNS
10:30	The MARVEL Smart City test cases - Municipality of Trento	Thomas Festi - MT Yiming Wang - FBK
10:50	The MARVEL Smart City test cases - Municipality of Malta	Adrian Muscat - GRN
11:10	Break	
11:30	The MARVEL Minimum Viable Product	Christos Dimou – ITML Stella Markopoulou - ZELUS
12:00	Round table: Discussions, Feedback & Conclusions	Elisabetta Farella - FBK

End of the meeting



Info Day - Session chairs



Elisabetta Farella

Head of E3DA unit,
FBK – Digital Society
center



Despina Kopanaki

Project Manager,
FORTH-ICS

Info Day - Speakers

9:00 – 9:45

Welcome from the hosts



Marco Pistore

Director of the Digital Society
Center at Fondazione Bruno
Kessler

Welcome



Giacomo Fioroni

Head of the "Smart
City" project of the
Municipality of Trento

Why is MARVEL relevant to the city of Trento?

Info Day - Speakers

9:45 - 10:30

MARVEL project



Sotiris Ioannidis

MARVEL Project
Coordinator, FORTH
Professor at Technical
University of Crete

MARVEL Overview



Dragana Bajovic

MARVEL Scientific and
Technical Coordinator,
Professor at University
of Novi Sad

MARVEL Scientific & Technical View

Info Day - Speakers

10:30 - 11:10

Pilots



Thomas Festi

Project manager of
"Smart City" project -
Municipality of Trento



Yiming Wang

Researcher at FBK in
the Deep Visual
Learning (DVL) unit

**The MARVEL Smart
City test cases -
Municipality of Trento**



Adrian Muscat

Malta pilot Lead
Researcher, Greenroads
Professor at University
of Malta

**The MARVEL Smart City test cases -
Municipality of Malta**

Info Day - Speakers

11:30 - 12:00

MARVEL MVP



Christos Dimou

MARVEL Integration Manager,
Information Technology for
Market Leadership IKE (ITML)



Stella Markopoulou

Software Engineer at
ZELUS

The MARVEL Minimum Viable Product



Multimodal Extreme Scale Data Analytics for Smart Cities Environments

MVP Info Day

Why is MARVEL relevant for the city of Trento?

Giacomo Fioroni - Head of the Smart City Project - Municipality of Trento

January 28th, 2021



Municipality of Trento - Introduction

- Located in the north of **ITALY**
- The **3rd** largest city in the Alps (**120.000 inhabitants**)
- About **1.500 employees**
- Very high **Quality of life**
- **Selected by IEEE** in 2014 as one of the 10 “**Smart City excellence**” in the world
- For 10+ years one of the smartest cities in Italy (*FPA Icity Rank – EY Smart City Index*)
- With a strong, long-standing, successful collaboration with **FBK** and **our University**



COMUNE DI TRENTO







- Let's have a look....*

Freely

- Online petitions **change.org**
- Reports, suggestions and complaints

Requested

- Call for ideas - Pools
- Open Innovation
- Participatory discussion of documents



1 Listening *(an example)*



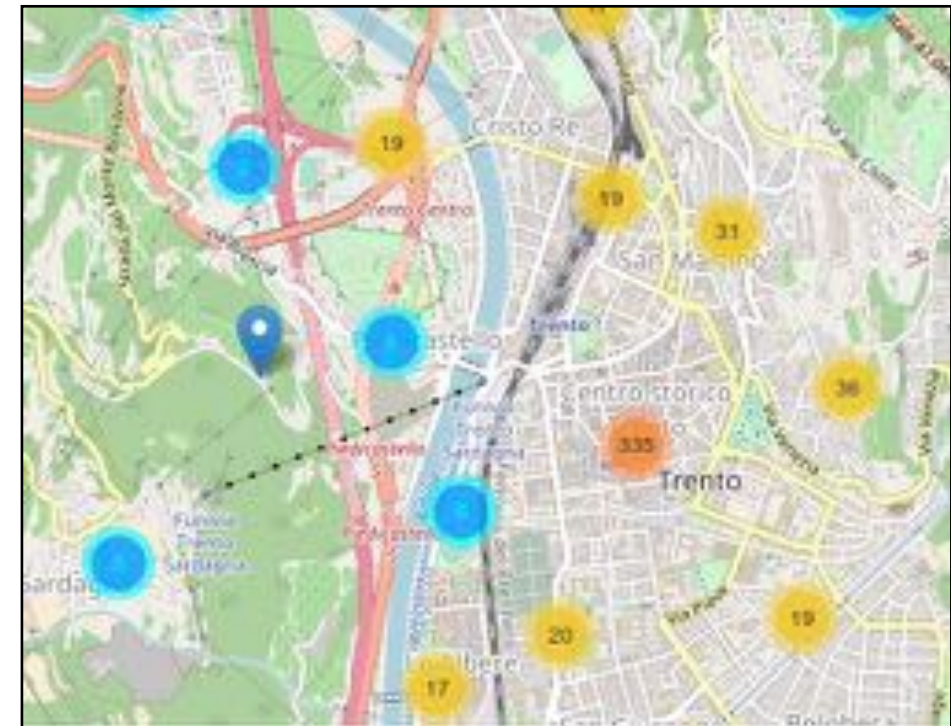
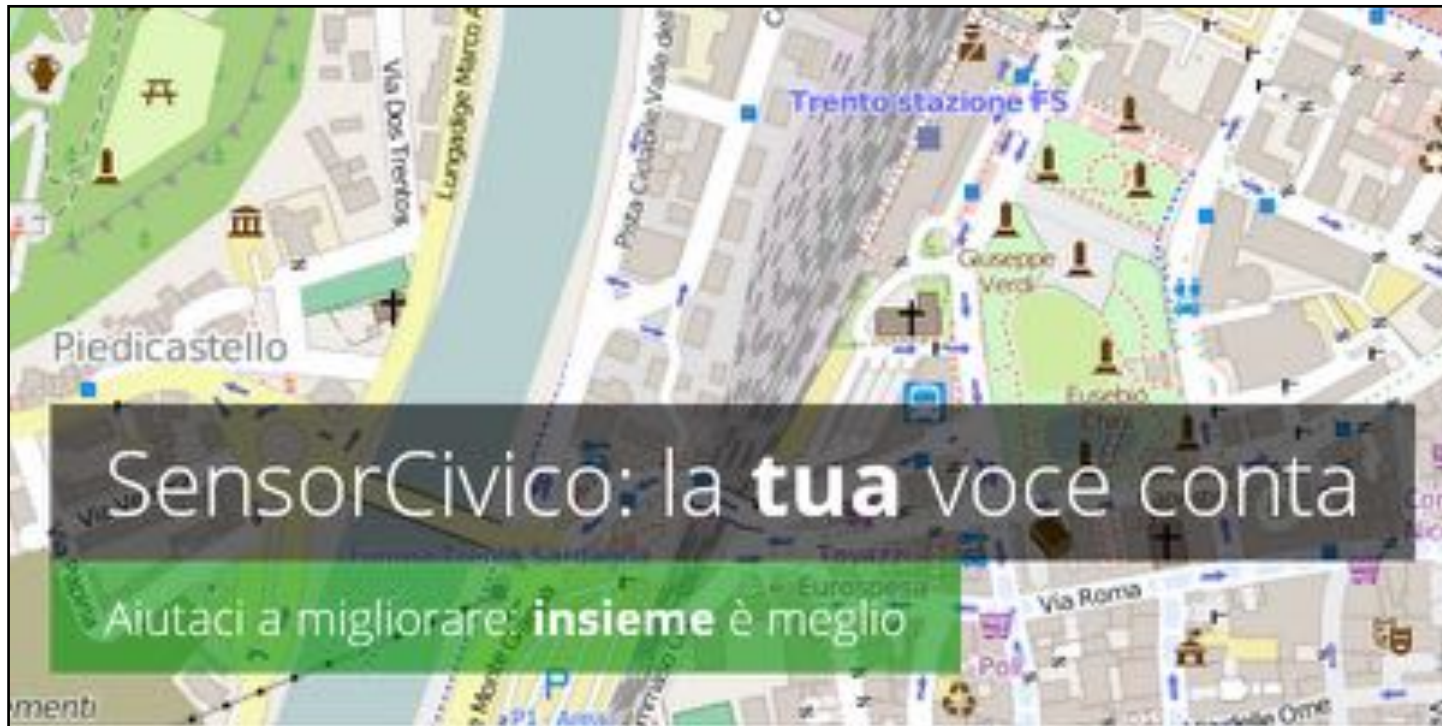
Freely

Report issues to Municipality and see all the answers



SensorTrento

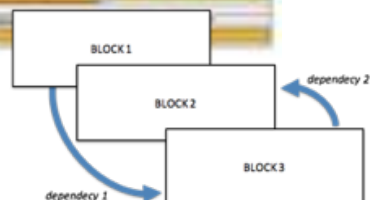
Confronto tra cittadini ed il Comune



WORKFLOW ADAPTATION



User Capabilities



Workflow
Interaction Model





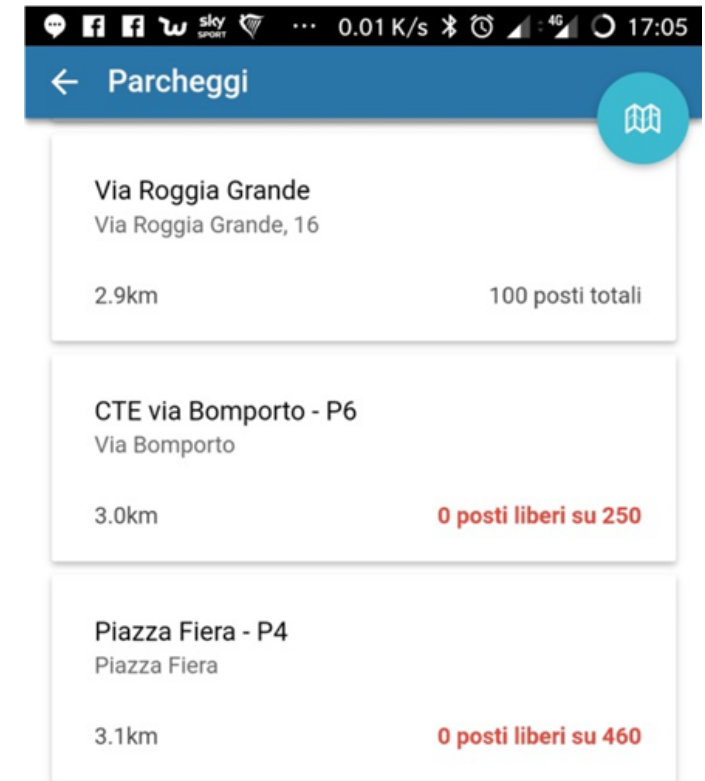


Car parking slots availability in underground parking

Innovative services

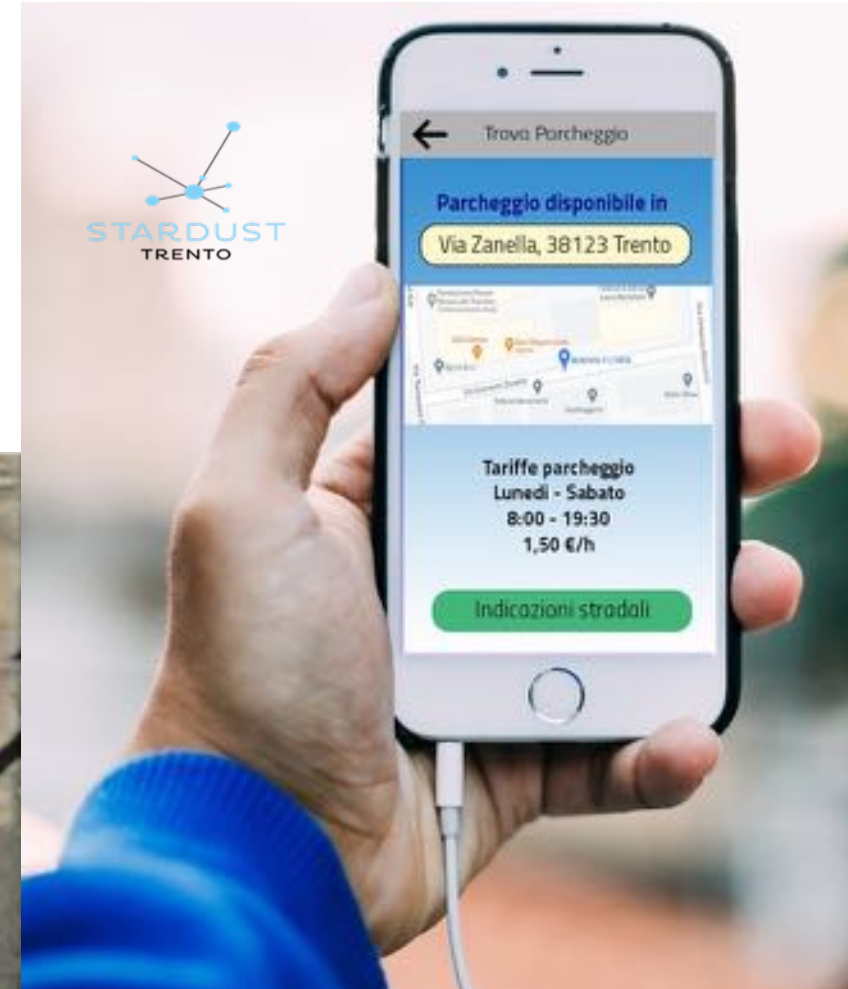


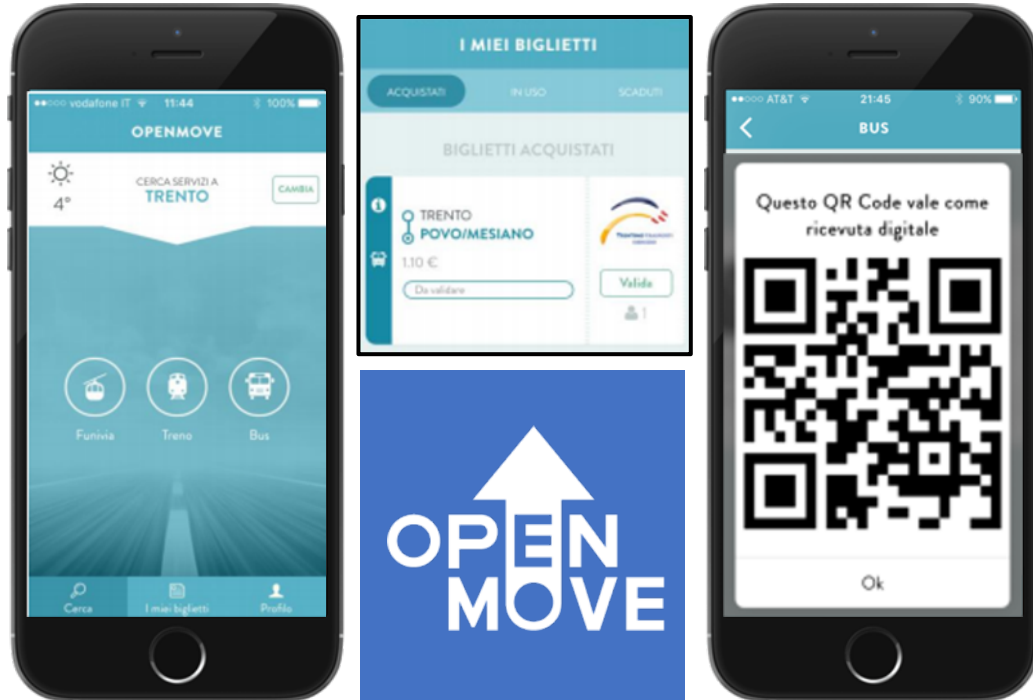
on the road



on your smartphone

Knowing nearby location of parkings for disabled and freight load/unload





Public transportation
(Bus – Trains - Cable)



Parking
By App or SMS

View streets affected by the street cleaning service and receive notifications about the streets of interest

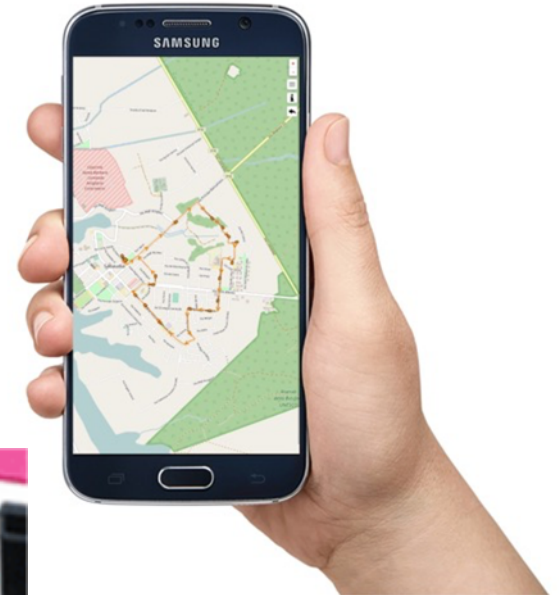
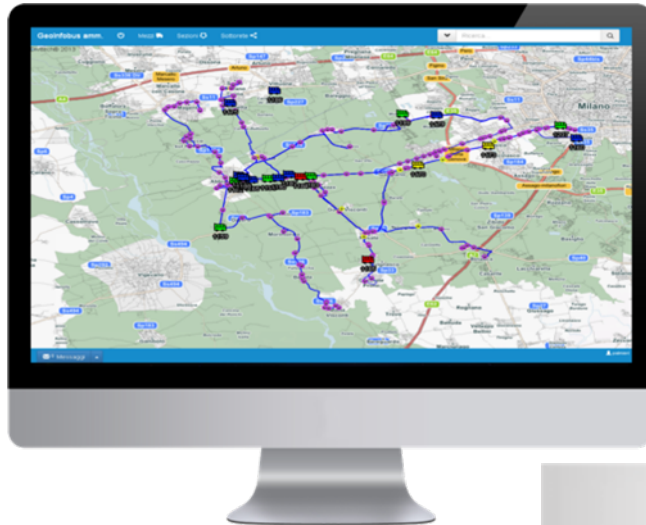


Dashbaord for each day



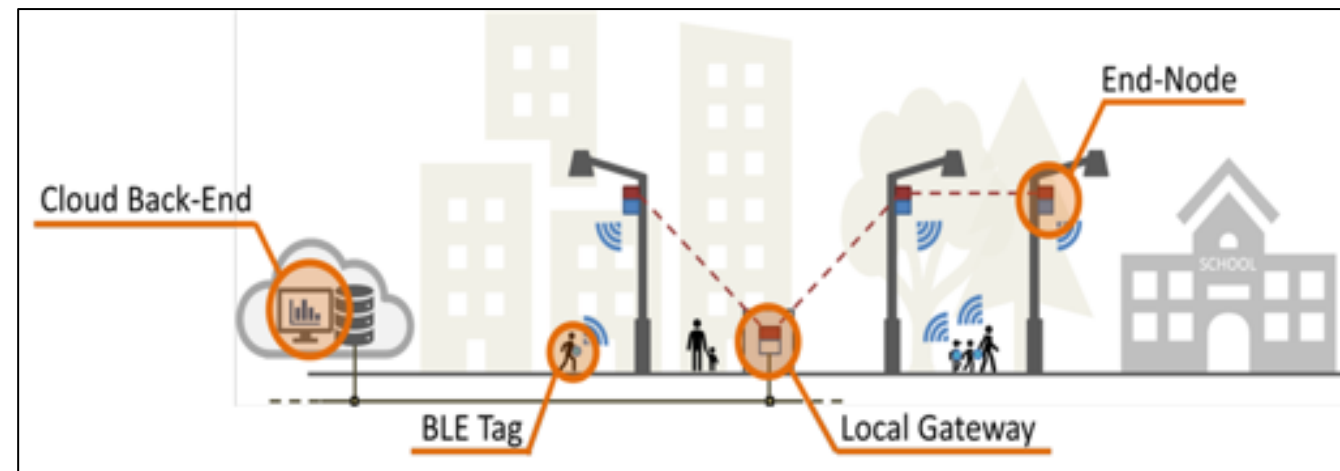
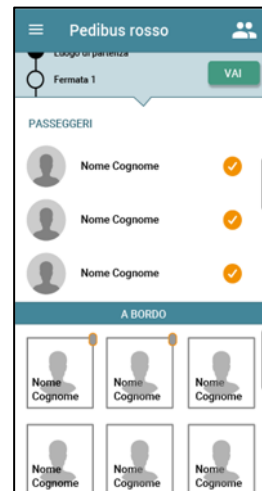
Notification on smartphones

Real-time notifications pushed about delays of public transport network

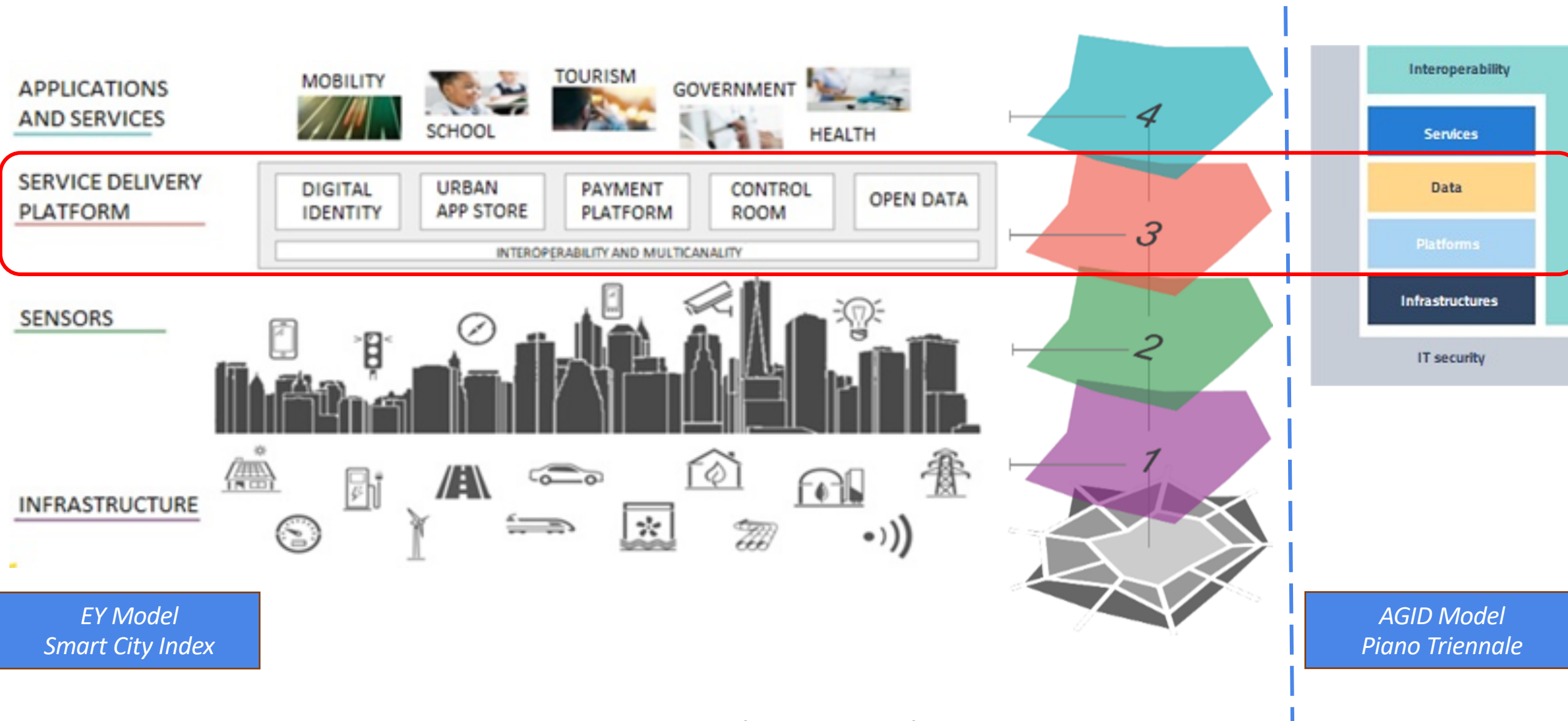


Modulated lighting from evening to morning based on the actual presence on two cycle paths and a city park





How to be so smart to deliver these innovative services?



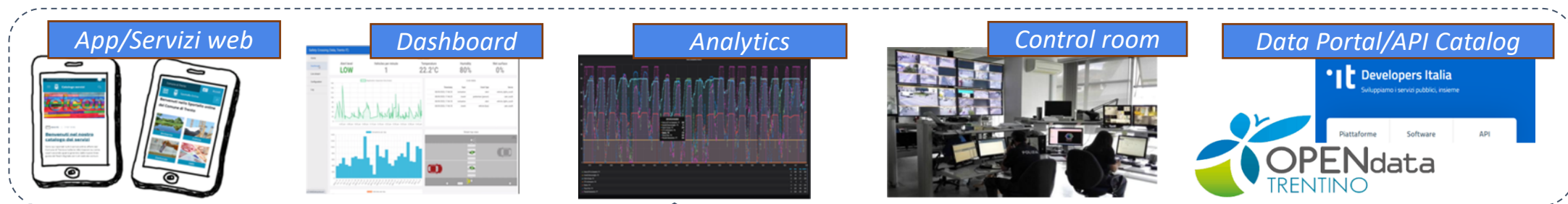
EY Model
Smart City Index

AGID Model
Piano Triennale

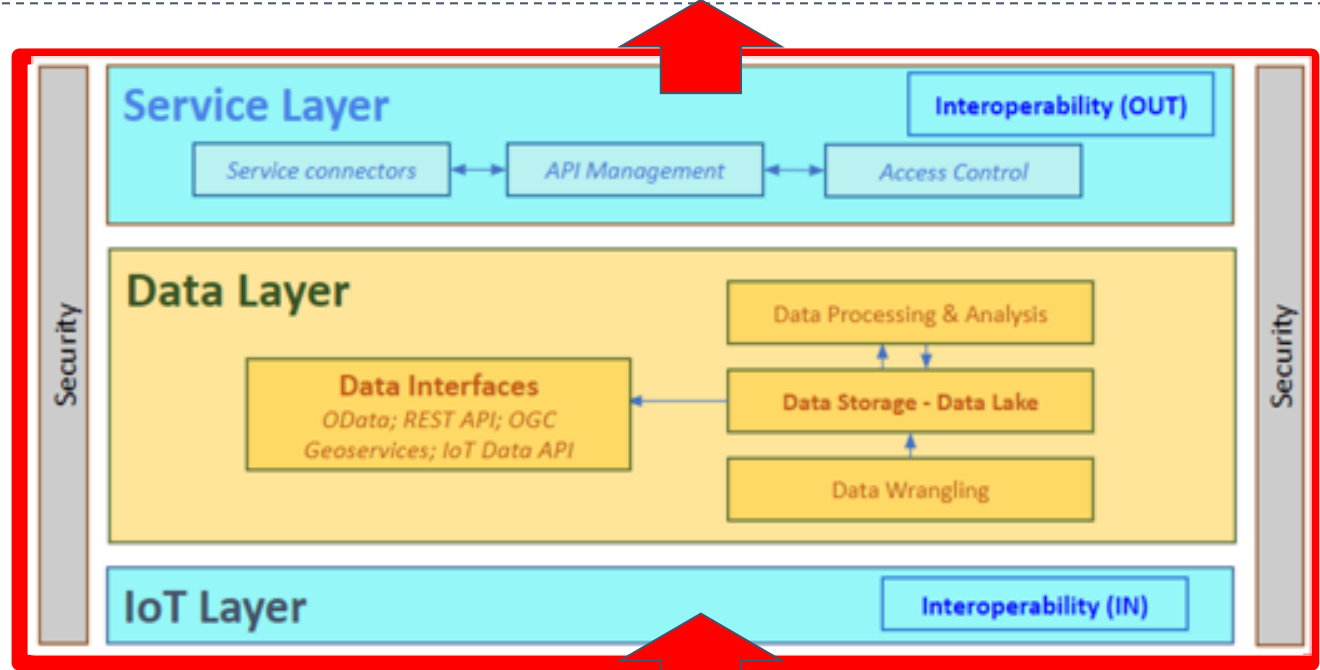


Focus on Data (at the center of the system)

APPLICATIONS
& SERVICES

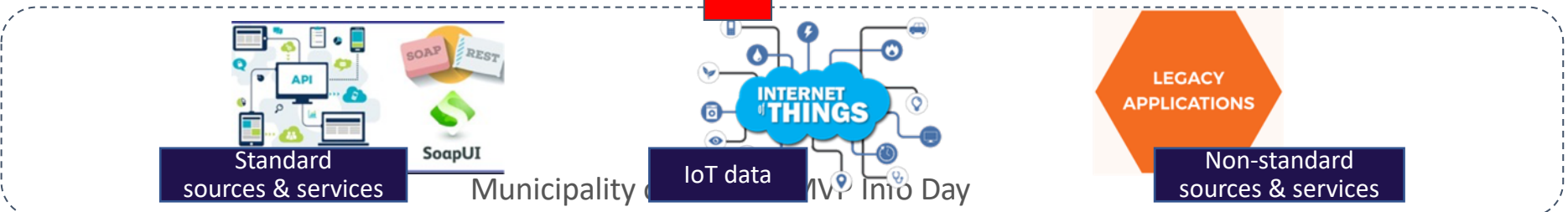


SERVICE DELIVERY
PLATFORM



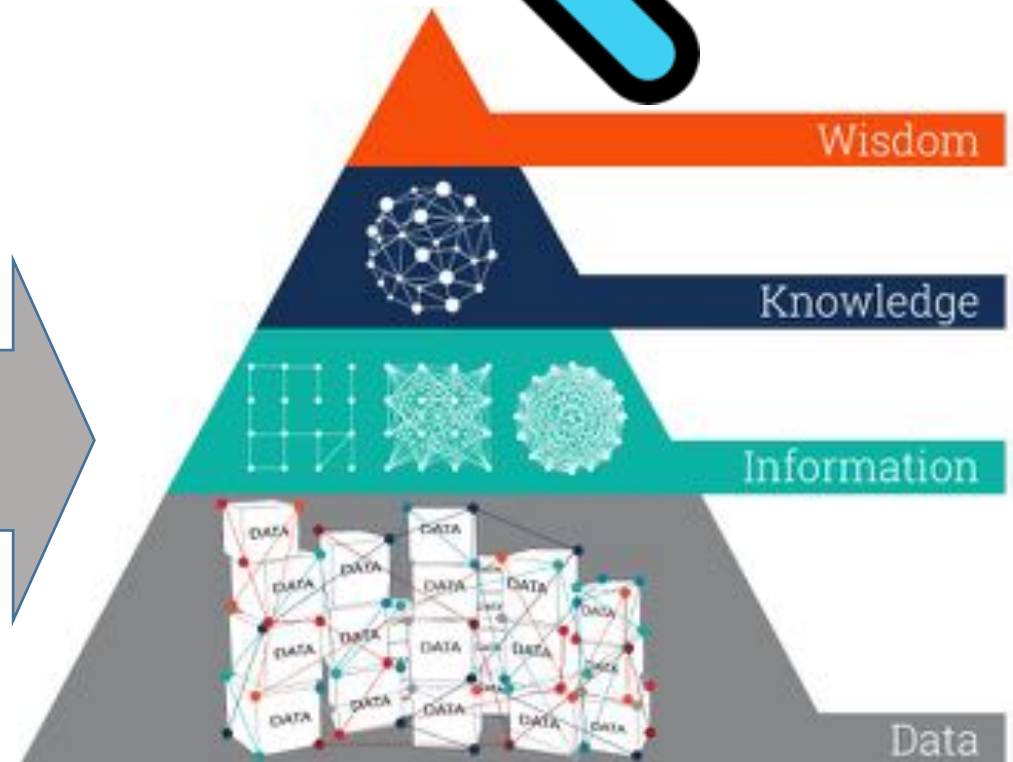
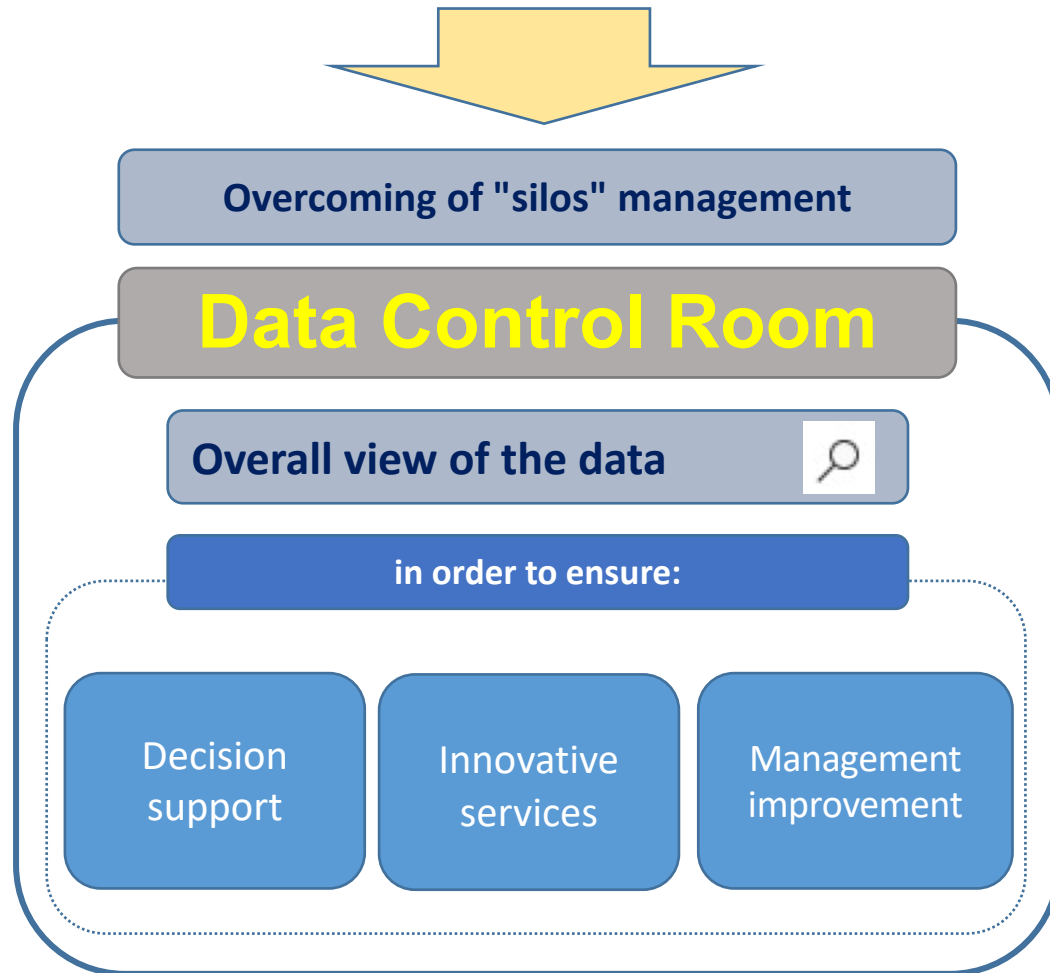
Digital Hub
Data
Control room

SOURCES
and
INFRASTRUCTURE



Our data-driven strategy

Organic data management



The objective : To understand ...

Immediately



Descriptive
(What happens?)



Diagnostic
(Why is it happening?)

- What happens now
- What happened in the past
- Why it happens (now and in the past)

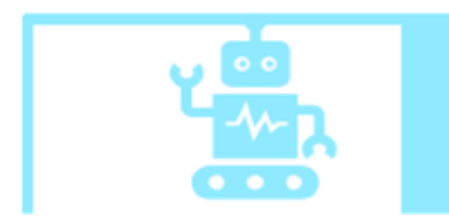
To Strive



Predictive
(What will happen?)



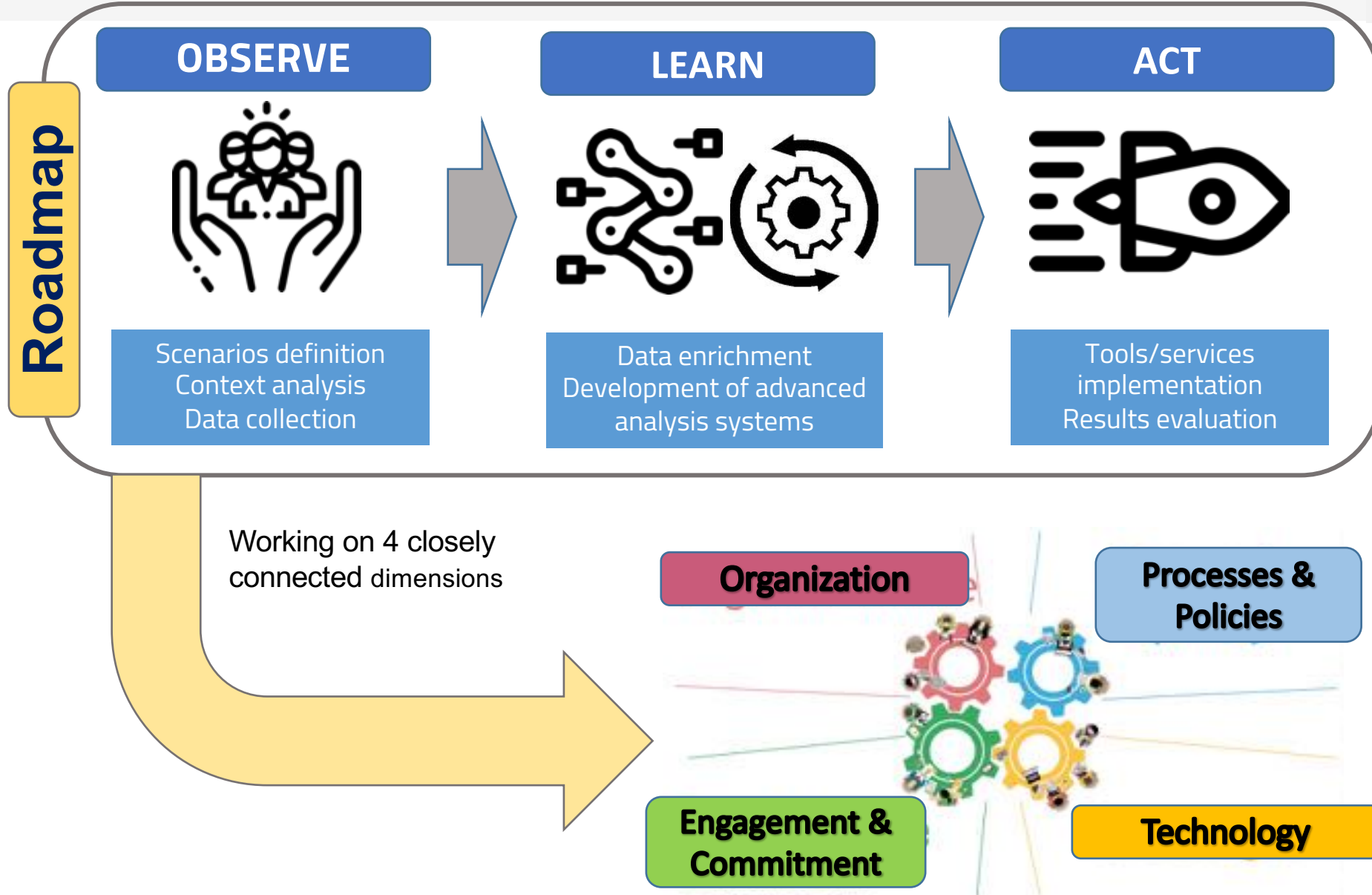
Prescriptive
(How can we do better?)



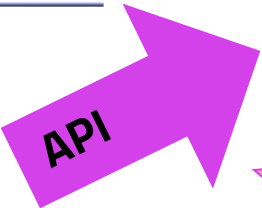
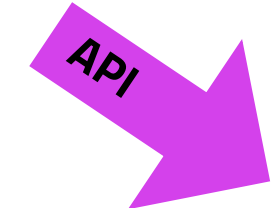
Adaptive
(How in real time?)

- What will happen (in case ...)
- How can you do better
- How to intervene in real time

Our Roadmap



A concrete example: Sharing mobility monitoring



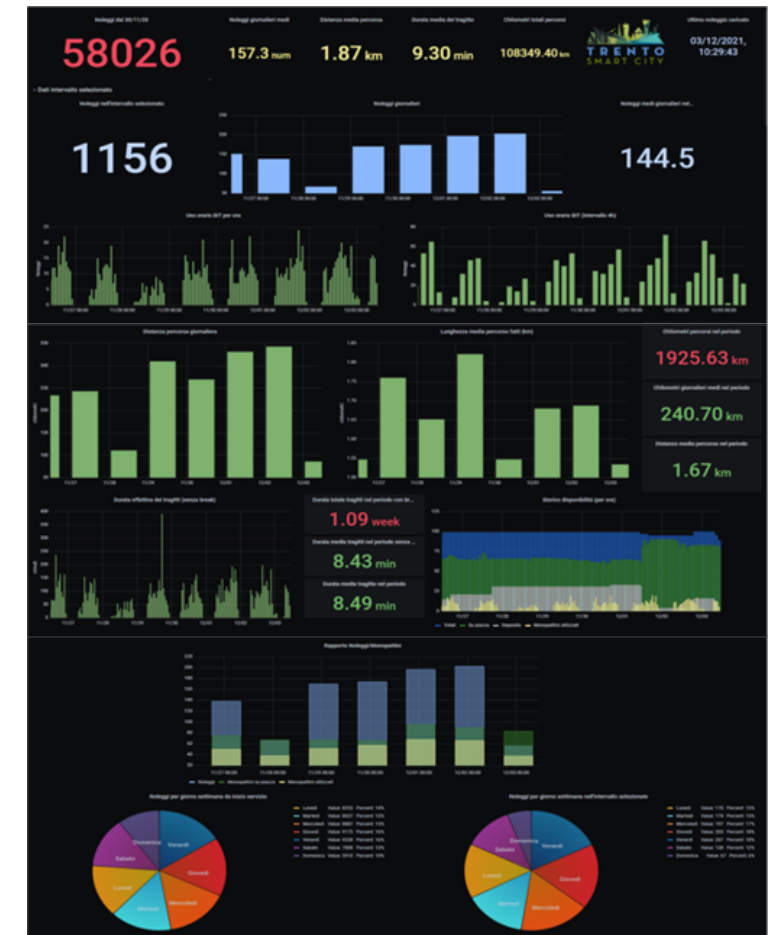
An example: Sharing mobility monitoring ⁽²⁾

Real time & Historical data Analysis

Real Time data aggregated
& Service provider benchmarking



Historical deep Analysis
for each operator

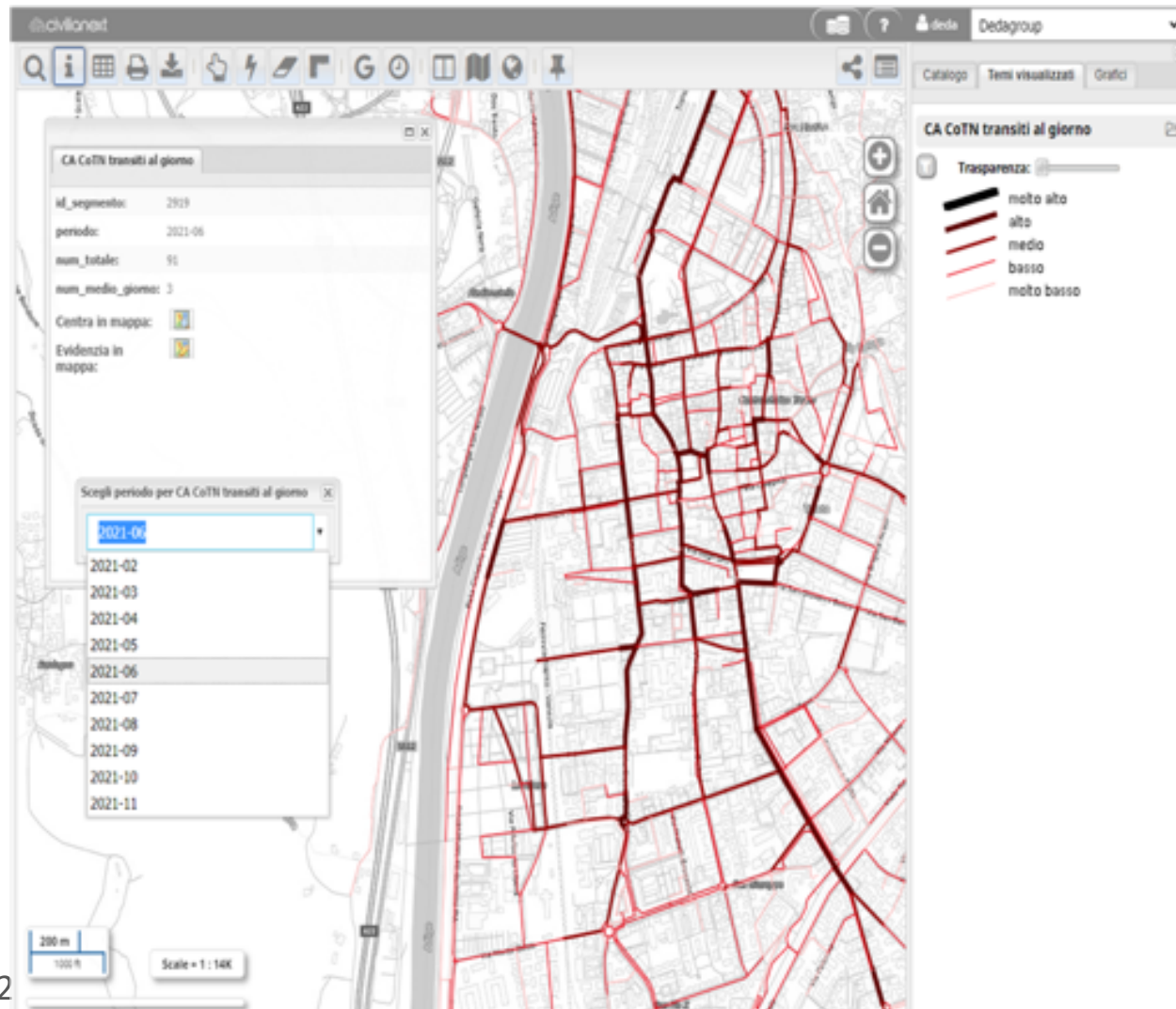


An example: Sharing mobility monitoring ⁽²⁾

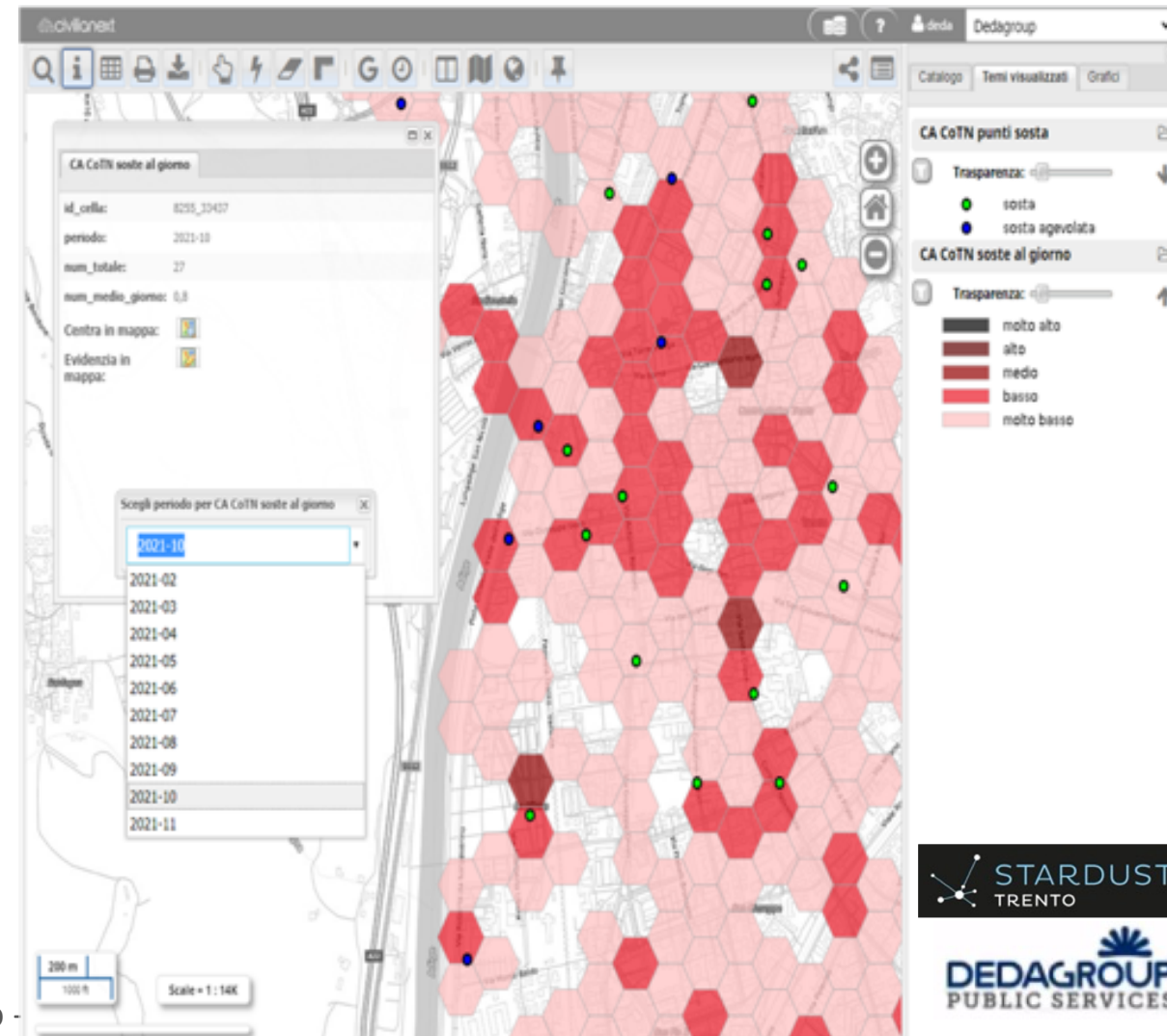
Geographic Analysis









1. The most used routes

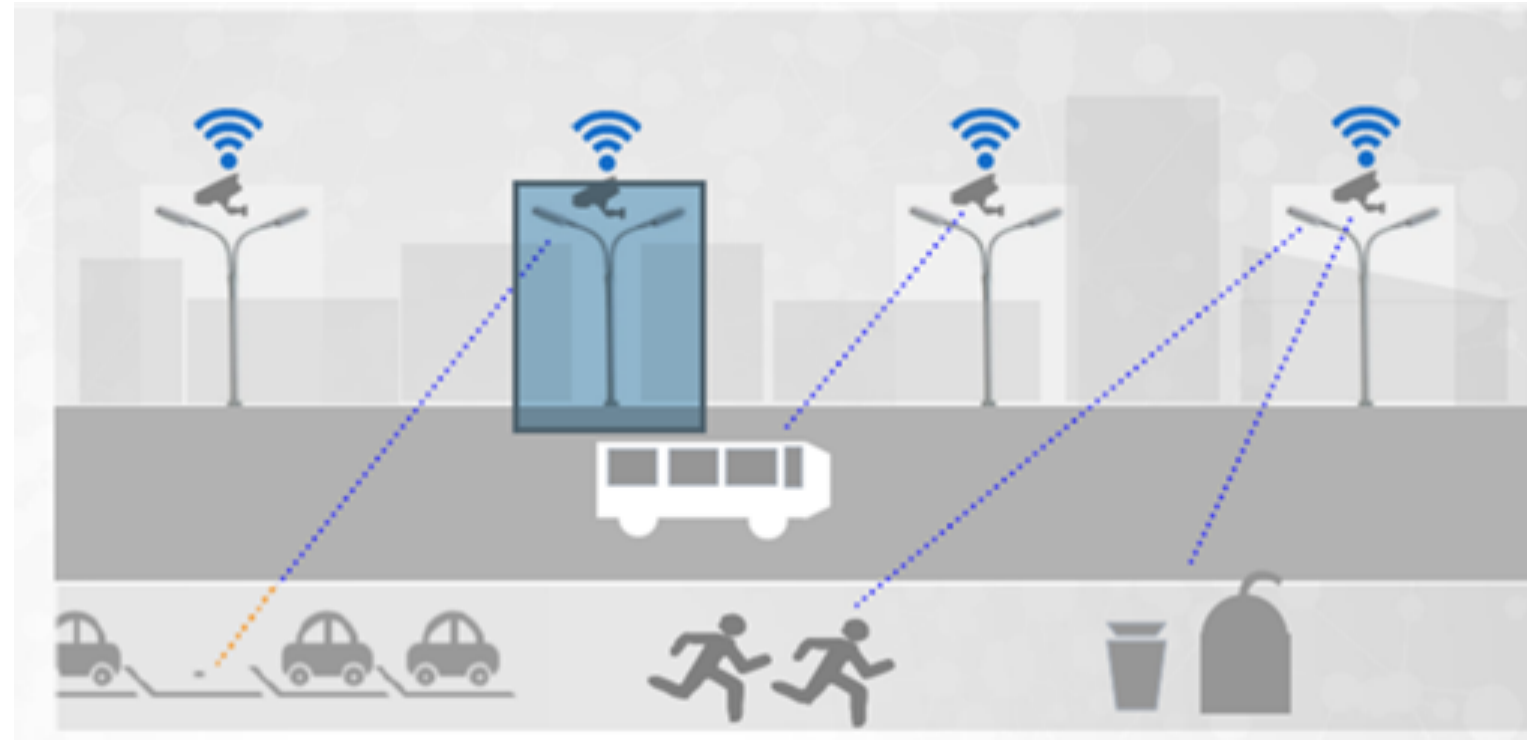


2. Mostly used parking areas



Where are we applying this strategy?

- Intelligent public lighting 
- Digitized traffic light network 
- Management of parking and rest areas 

- Limited traffic area access management
- Sustainable mobility monitoring & management
- Air control units
- Smart grid water & electrical network
- Video surveillance systems 
- Georeferenced management of local police activities
- Monitoring buildings, roads, etc. 
- Still others



 Parking stalls

 Garbage collection

 Vehicles and bicycles

 Remote reading gas and water meters

 Position of TPL vehicles

 Air pollution monitoring

 Anomalous events

 Temperature, humidity and other parameters

Why is MARVEL relevant for the city of Trento?



MARVEL



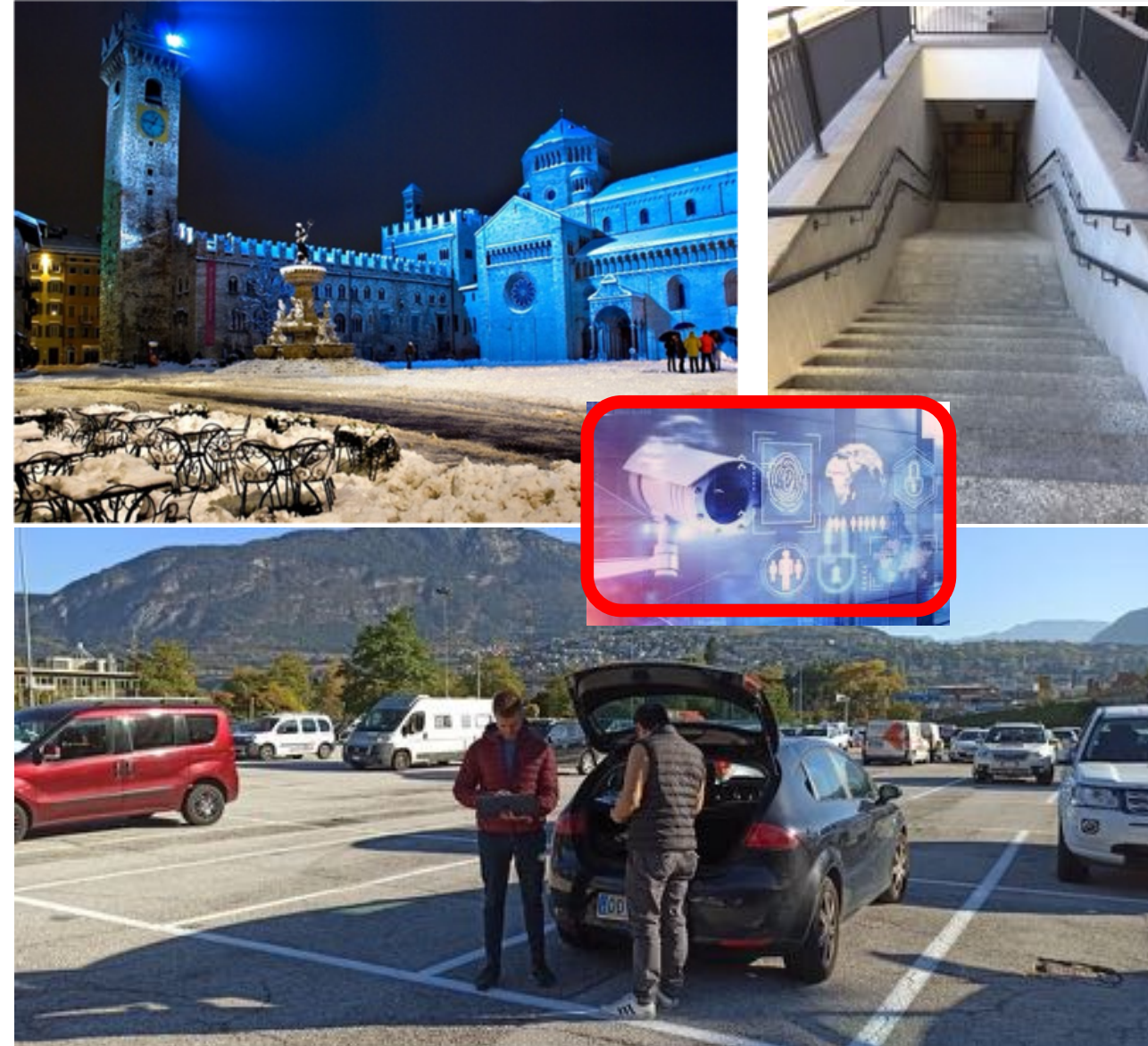
is an absolutely **useful**
implementation of our
*“Smart city data-driven
strategy”* in the
Urban Safety field



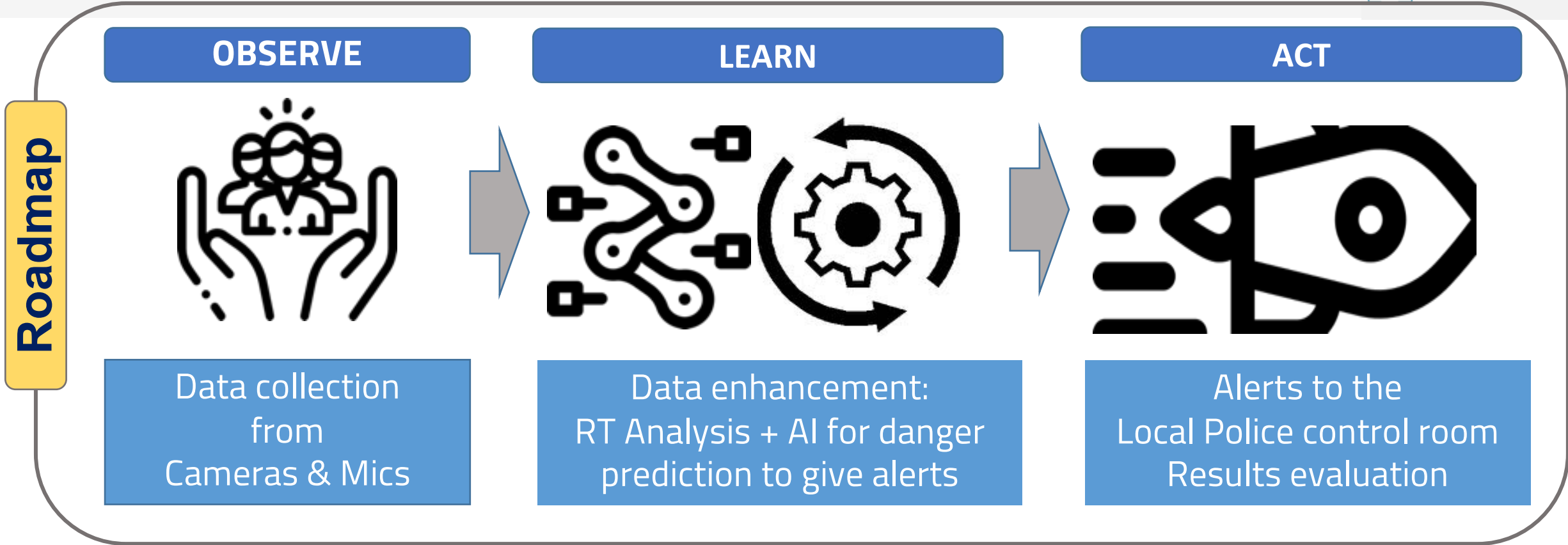
The current scenario relating to urban safety



- We want to **understand what is happening in various outdoors areas** of the city (*squares, underpasses, parking areas, ...*)
- We currently own **600+ camera** BUT we are **unable to exploit their value**
- We don't handle the amount of data, its velocity, and its heterogeneity
- The local Police can manage only **6 cameras in RT** and uses data only «**a posteriori**»



The MARVEL project implementaion



Processes & Policies

Engagement & Commitment

Technology

Municipality of Trento's people involved in MARVEL



Department of Innovation, Research and Digital Transition



Giacomo Fioroni
Head of the Smart City Project



Thomas Festi
Project Manager Smart City Project



Alex Tomasi
Project Manager Smart City Project



Andrea Fronza
Project Manager Smart City Project

Local Police of Trento



Thank you!

Giacomo Fioroni
giacomo.fioroni@comune.trento.it



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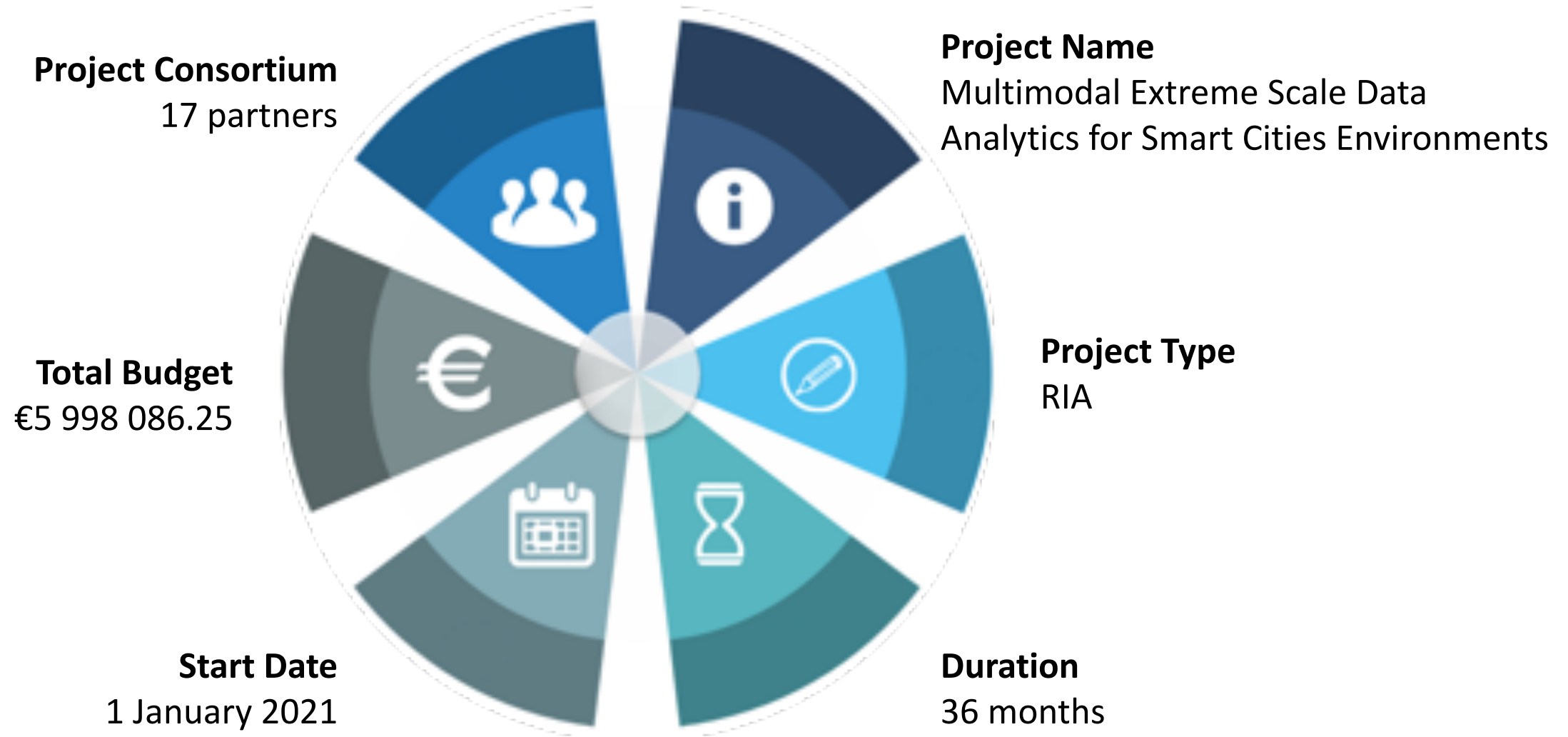
Multimodal Extreme Scale Data Analytics for Smart Cities Environments

MARVEL MVP Info Day

Prof. Sotiris Ioannidis (TUC, FORTH)

January 28, 2022

Project Identity Card



MARVEL Consortium



1. FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS (**FORTH**)
2. INFINEON TECHNOLOGIES AG (**IFAG**)
3. AARHUS UNIVERSITET (**AU**)
4. ATOS SPAIN SA (**ATOS**)
5. CONSIGLIO NAZIONALE DELLE RICERCHE (**CNR**)
6. INTRASOFT INTERNATIONAL SA (**INTRA**)
7. FONDAZIONE BRUNO KESSLER (**FBK**)
8. AUDEERING GMBH (**AUD**)
9. TAMPEREEN KORKEAKOULUSAATIO SR (**TAU**)
10. PRIVANOVA SAS (**PN**)
11. SPHYNX TECHNOLOGY SOLUTIONS AG (**STS**)
12. COMUNE DI TRENTO (**MT**)
13. UNIVERZITET U NOVOM SADU FAKULTET TEHNICKIH NAUKA (**UNS**)
14. INFORMATION TECHNOLOGY FOR MARKET LEADERSHIP (**ITML**)
15. GREENROADS LIMITED (**GRN**)
16. ZELUS IKE (**ZELUS**)
17. INSTYTUT CHEMII BIOORGANICZNEJ POLSKIEJ AKADEMII NAUK (**PSNC**)



A blue-toned graphic featuring a city skyline with several icons overlaid: a shopping cart, a globe, a dollar sign, a house, and a cloud. The text "Smart Cities" is centered in white.

Smart Cities

- **Highly sophisticated systems** that attract the interest of
 - governments, policy makers and municipalities
 - Industries
 - Scientists
- **Definition:** *“Smart city is an innovative city that **uses ICT** and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects”*

Motivation

Cities have become actual **“data engines”**

*huge variety of IoT urban sensors and devices
recording multiple everyday activities
producing large scale heterogeneous datasets*

Need for accurate **predictions**
and better **analytics**

Challenges

1. Valuable **knowledge extraction**
2. **Commercial value** from data

Need to **shift** traditional
methodologies, techniques and
tools of information extraction
into **new dimensions**.

How?

By cracking the problem of **extreme scale data analytics**

MARVEL aims to foster the vision of EU Data Economy by:

1

addressing and solving **challenges** in the **Big Data Value chain**

2

prioritising strengthening of **open science** and **open data** through enriching and sharing a **Data Corpus** to drive R&I

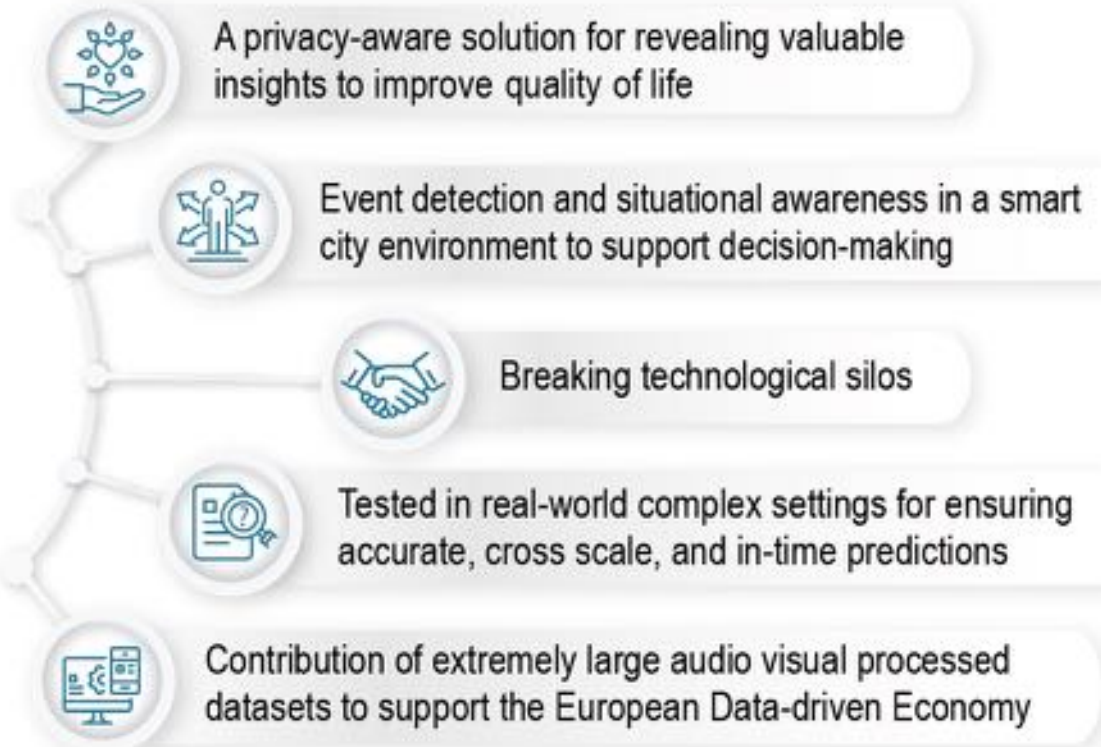
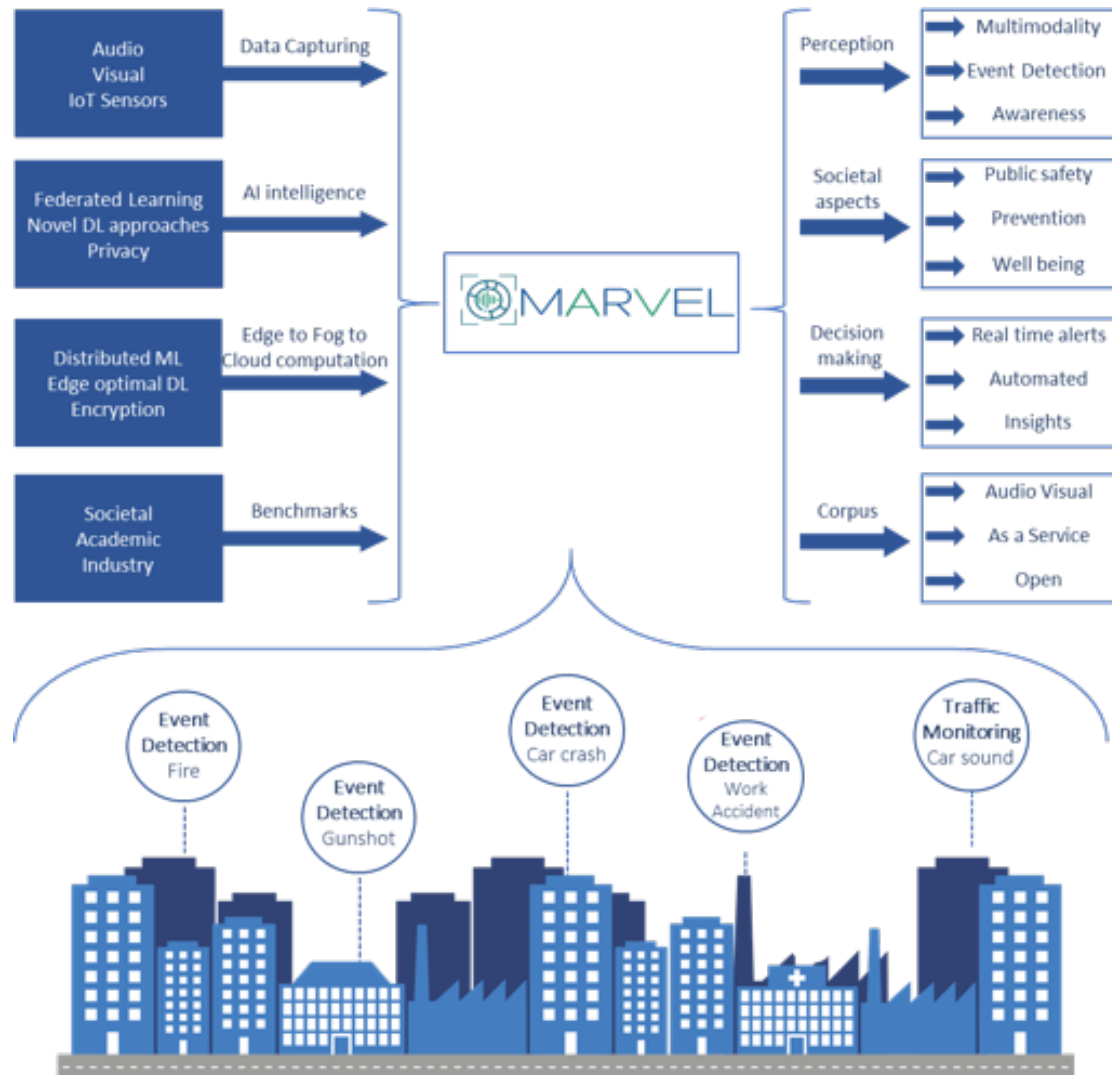
3

heavily **investing** in **R&I** to derive **new knowledge** and advance existing one, ensuring a **sustainable growth** for the technological advancements

4

engaging **citizens** to promote breakthrough **innovation**.

MARVEL in a nutshell



Our mission

Collect, analyse and data mine
multi-modal **audio-visual data** streams of a Smart City
and **help decision-makers** to improve the quality of life of their citizens and
the services they offer to them **without violating ethical and privacy limits**
in an AI-responsible manner.

MARVEL Framework - Pillars

1

Real **heterogeneous distributed** Big Data in **smart cities** environments

3

AI-based intelligence for multi-modal perception and situational awareness.

2

Edge-to-fog-to-cloud (E2F2C) distributed ubiquitous computing **architecture.**

4

Quantitative assessment of E2F2C and Multi-modal AI tools and methods via societal, academic and industry validated **benchmarks.**



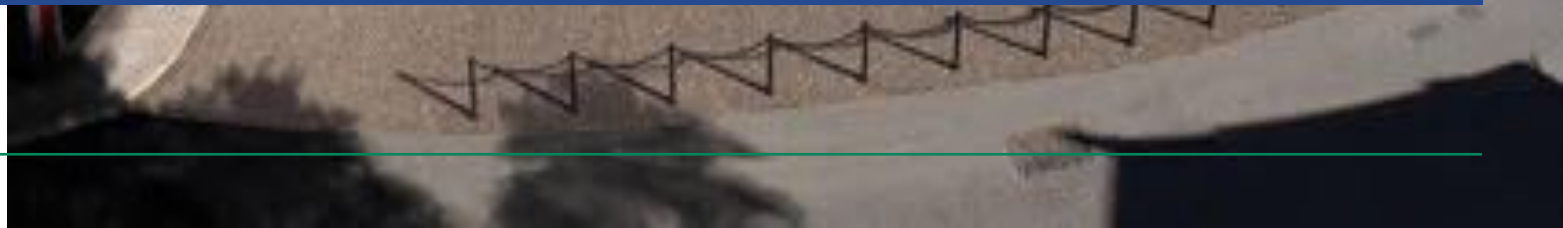
Real Life Experiments in Smart Cities

Inform local authorities and emergency services of potential anomalous events that may lead to dangerous situations:

- Monitoring of crowded areas
- Detecting criminal/anti-social behaviors
- Monitoring of parking places
- Analysis of a specific area for better urban planning



City monitoring in Trento, Italy

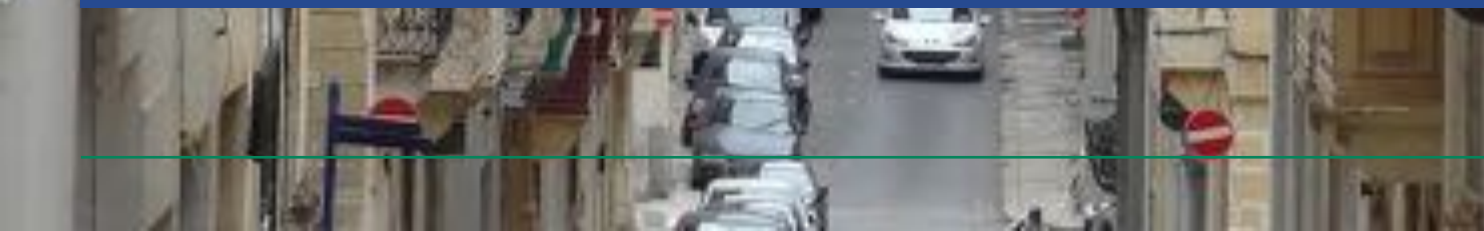




Data monitoring and analysis for planning infrastructure upgrades and implementing mobility management measures:

- balancing the needs of mixed traffic, planning, and use of shared road space
- understanding behavior by mode of transport
- improving perceived safety for active mobility modes; and creating anonymisation tools for road-monitoring cameras.

Road Traffic Management in Malta



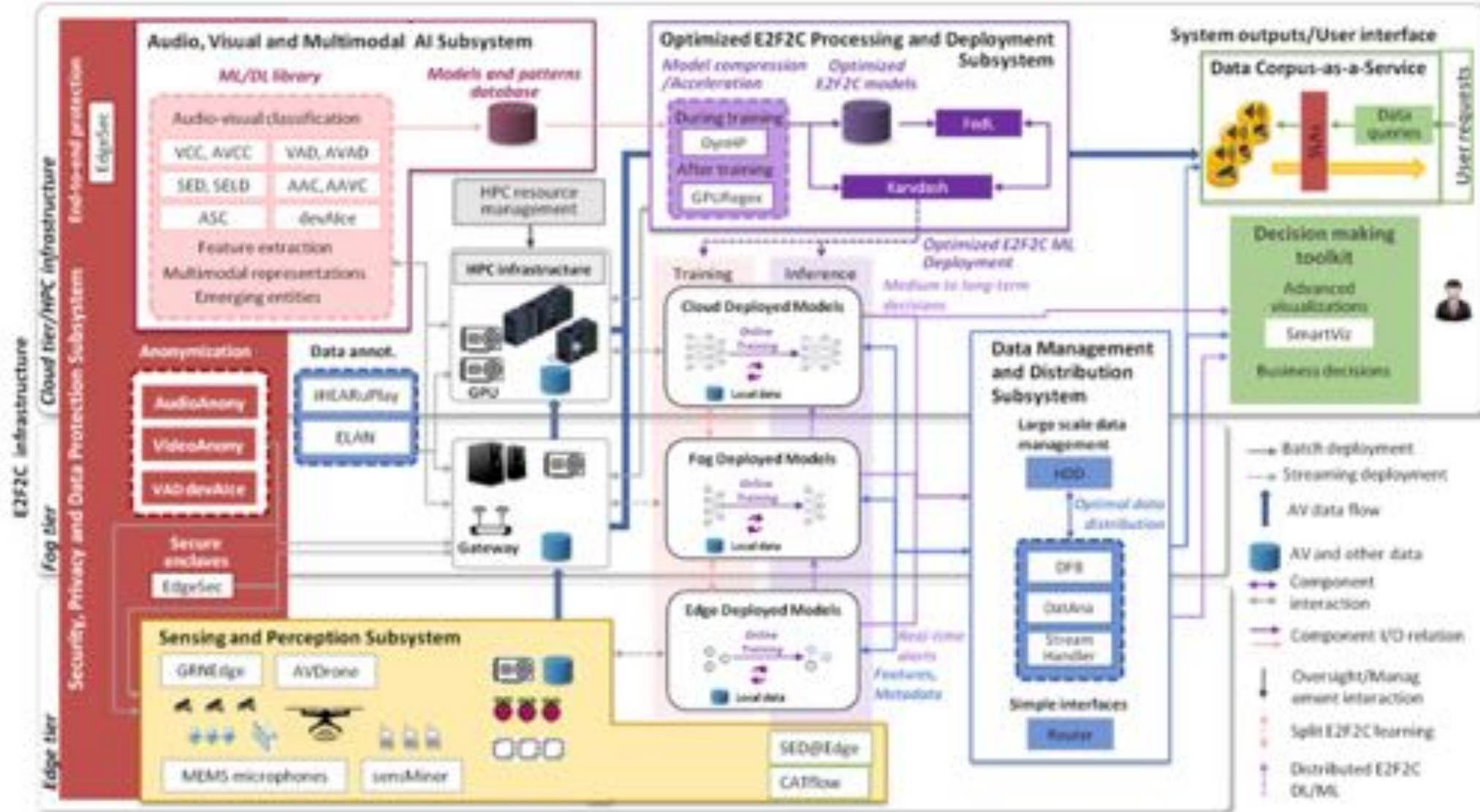
Data collection using drones and experimental evaluation in controlled environments to support the Trento and Malta use cases

- Monitoring of large public events
- Evaluate MARVEL technologies using drones
- Audio-Visual emotion recognition



Crowd behaviour monitoring in Novi Sad, Serbia

MARVEL Architecture





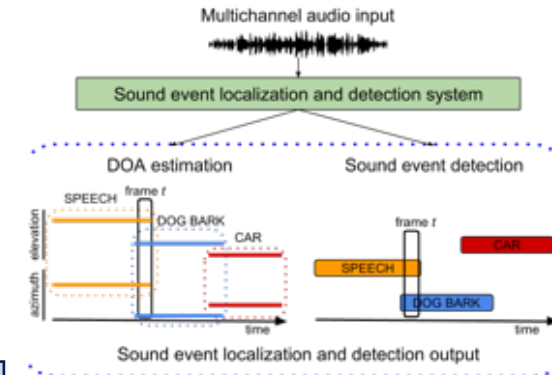
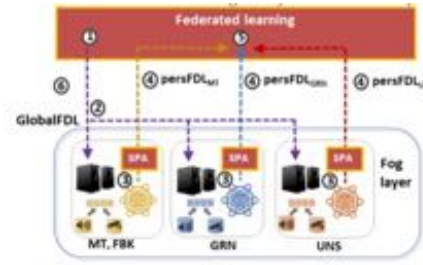
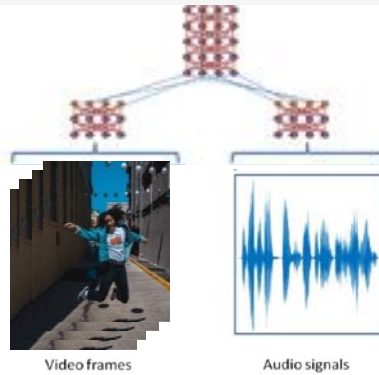
Multimodal Extreme Scale Data Analytics for Smart Cities Environments

MARVEL MVP Info Day S&T view

Prof. Dragana Bajovic (UNS)

January 28, 2022

MARVEL Framework - Pillars



1

Real **heterogeneous distributed** Big Data in **smart cities** environments

2

Edge-to-fog-to-cloud (E2F2C) distributed ubiquitous computing **architecture**.

3

AI-based intelligence for **multi-modal perception** and **situational awareness**.

4

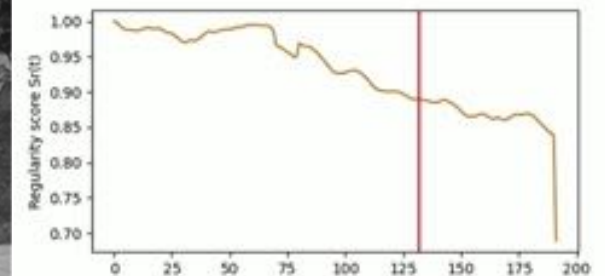
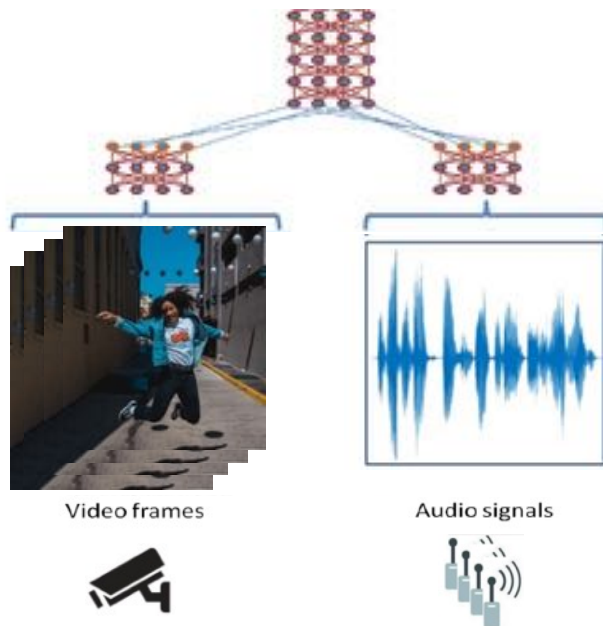
Quantitative assessment of **E2F2C** and **Multi-modal AI tools and methods** via societal, academic and industry validated **benchmarks**.

Multimodal perception and intelligence

Project's rationale: explore hidden correlations in synchronous streams of audio, visual and other data to increase classification accuracy of audio-visual/environmental events.

Audio-visual analytics and perception

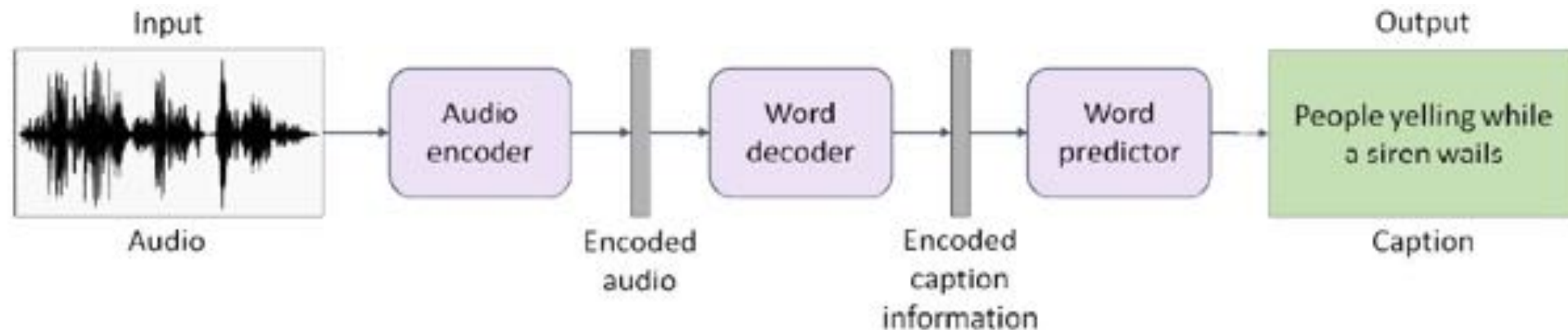
- Early fusion: human – like perception, e.g., for emotion detection
- Audio-visual anomaly detection/ classific. e.g., in low visibility conditions, presence of occlusions, etc.



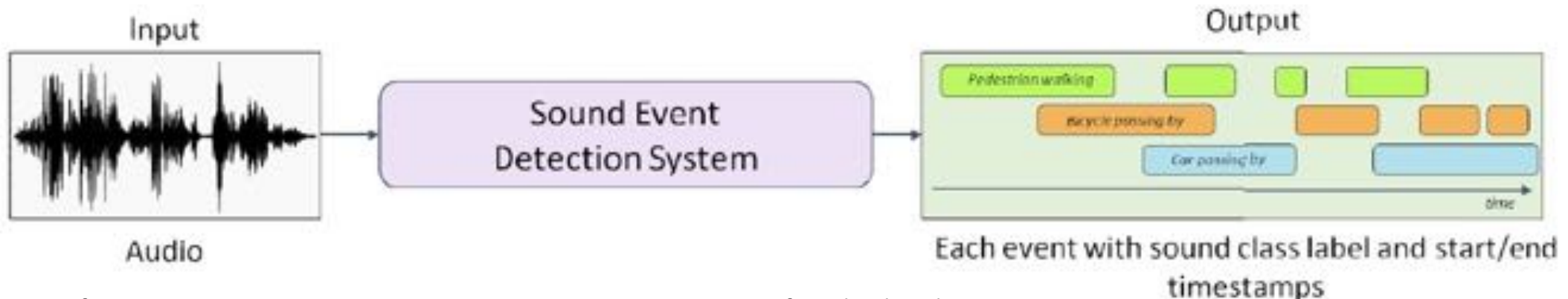
Multimodal perception and intelligence

Audio analytics and perception

- Automated audio captioning, e.g., for situational awareness



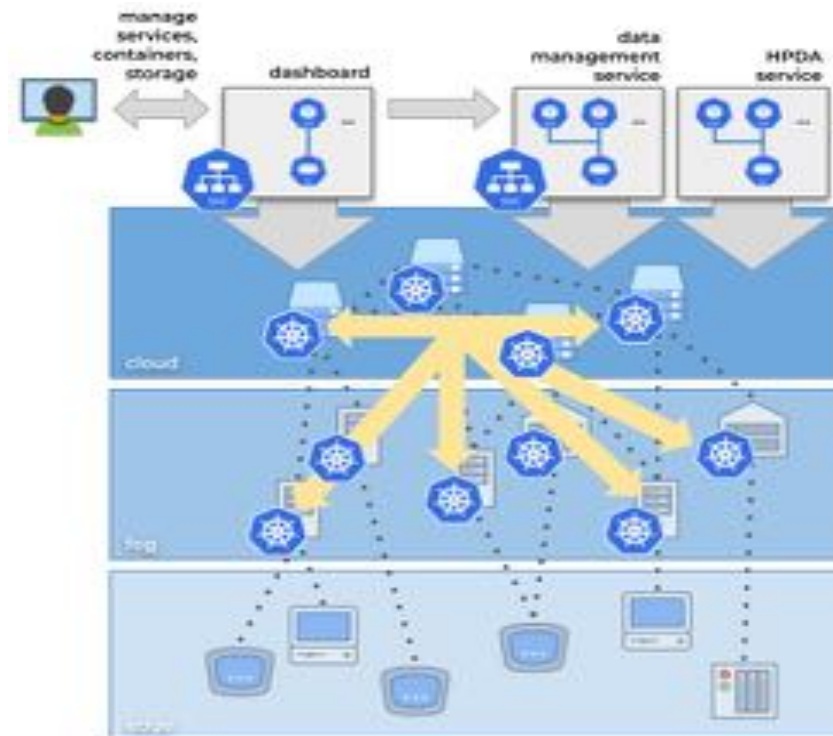
- Sound event localization and detection



E2F2C continuum computing

Project's rationale: capitalize on the vast amount of distributed computing resources in a Smart City infrastructure to achieve faster, better and deployment optimized analytics (bandwidth preservation, higher accuracy, faster insights, privacy protection, ...).

Optimal allocation and deployment of data and services



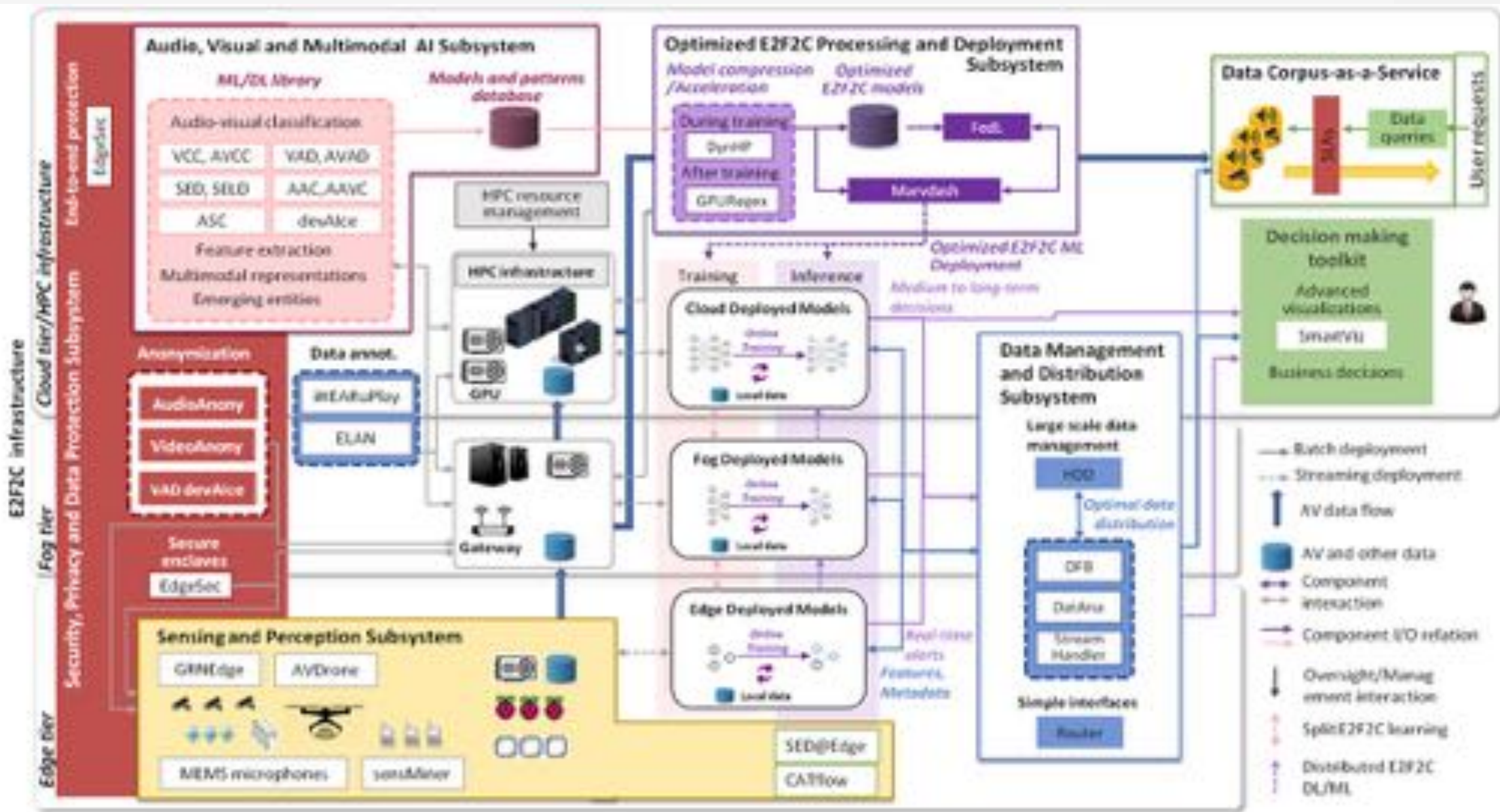
- Optimally deploy AI and other services across E2F2C
- Bring the data where best utilized by the AI tasks
- Edge processing: embedded anonymization/AI

MARVEL conceptual architecture



- The MARVEL framework consists of **29 technological components** of a wide range of functionalities and the associated framework roles.
- The components have been grouped into **seven subsystems**:
 1. Sensing and perception subsystem
 2. Security, privacy, and data protection subsystem
 3. Data management and distribution subsystem
 4. Audio, visual, and multimodal AI subsystem
 5. Optimised E2F2C processing and deployment subsystem
 6. E2F2C infrastructure
 7. System outputs: Data corpus-as-a-Service and the decision-making toolkit.

MARVEL conceptual architecture

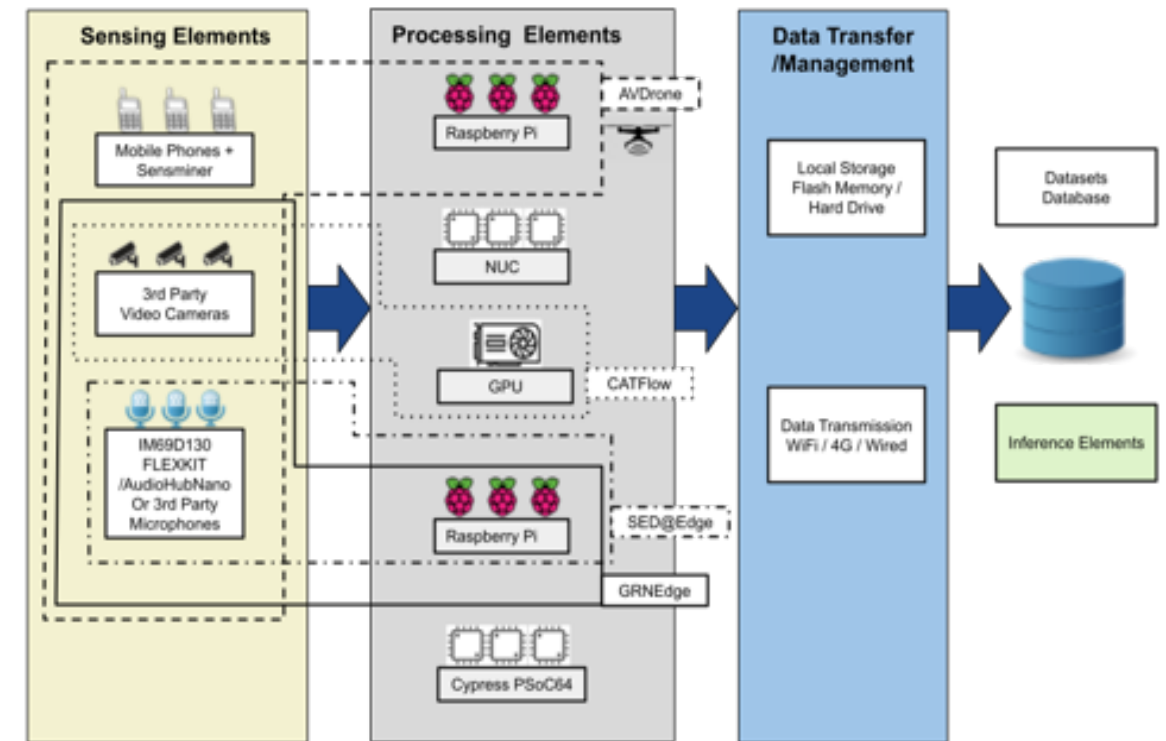


1. Sensing and perception subsystem

- **The role:** *sensing elements and devices* in the edge tier, including *embedded AI*

Components:

- MEMS microphones (**MEMS**- IFAG)
- Sound event detection at the edge (**SED@Edge** – FBK)
- Audio-Visual sensing at the edge (**GRNEdge** – GRN)
- Audio-Visual sensing on board drones (**AVDrone** – UNS)
- Audio recording and annotation (**sensMiner** – AUD)
- Traffic objects detection (**CATFlow** – GRN)

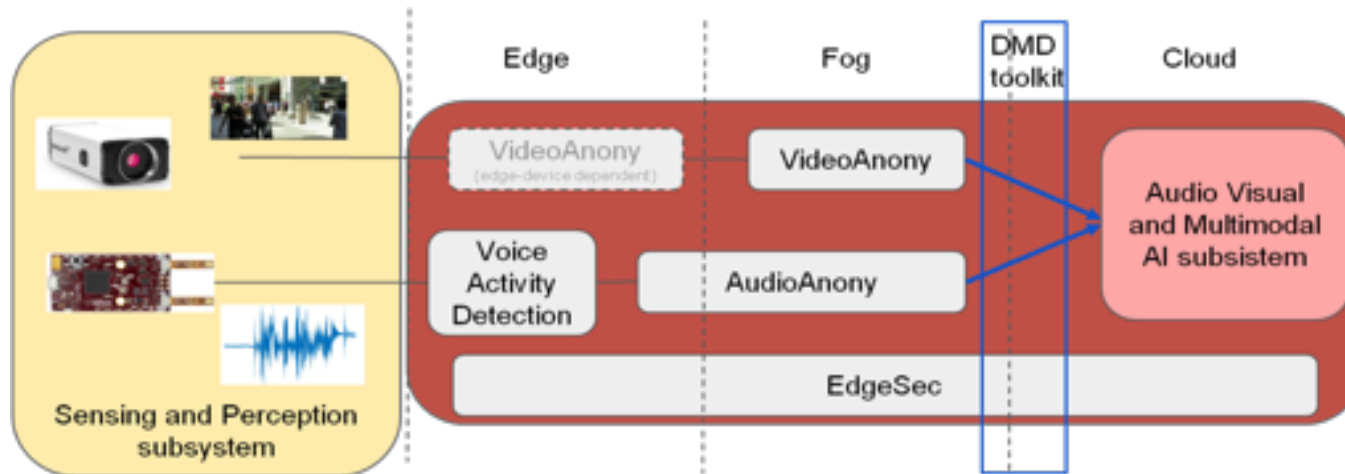


2. Security, privacy, and data protection subsystem



MARVEL

- **The role:** (i) *security* of the data and devices, against malicious attacks on data and code;
(ii) *anonymisation to ensure privacy and protection of personal data*



Components

- Security framework (**EdgeSec** - FORTH)
- Video anonymization software (**VideoAnony** – FBK)
- Voice anonymization software (**AudioAnony** – FBK)
- Intelligent audio analytics including voice activity detection (**devAlce** - AUD)

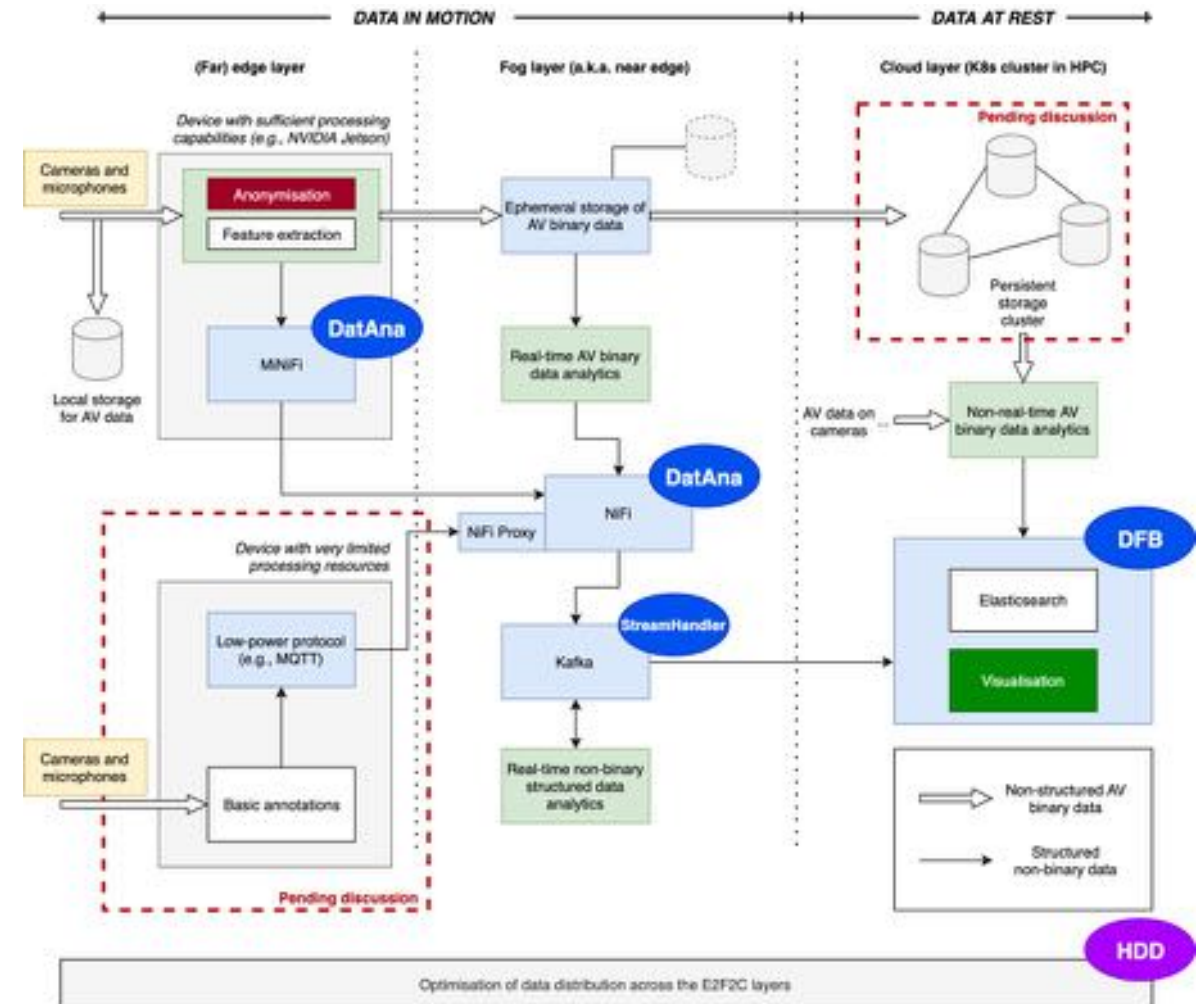
3. Data management and distribution subsystem



- **The role:** handle massive amounts of data coming from various sources and deal with their *management and proper, optimized distribution* at all architectural levels.

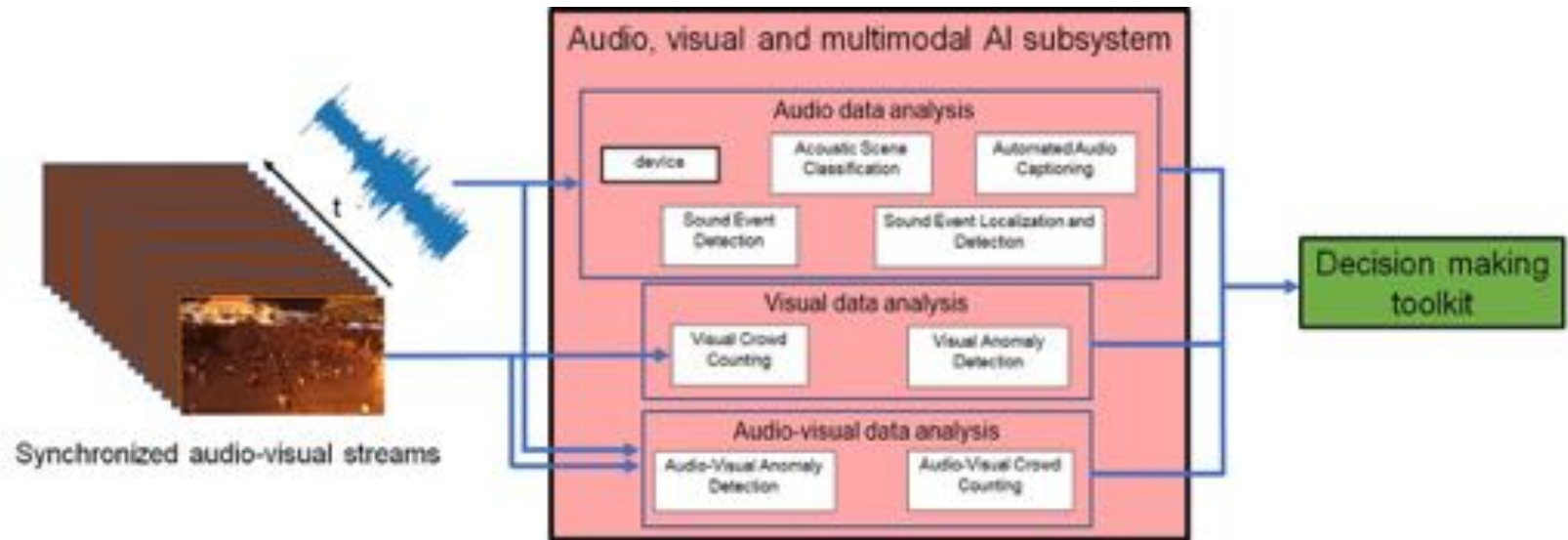
Components:

- Platform for fusing data from different components, Data Fusion Bus (**DFB** – ITML)
- Platform for data streams (**StreamHandler** – INTRA)
- Framework based on the usage of the Apache NiFi ecosystem to allow the processing of data flows between the edge/fog and the cloud (**DatAna** – ATOS)
- Data distribution in wireless environments with heterogeneous nodes, Hierarchical data distribution (**HDD** – CNR)



4. Audio, visual and multimodal AI subsystem

- **The role:** components building ML/DL models from available AV and other data



Components

- Intelligent audio analytics including voice activity detection (**devAIce** - AUD)
- Visual anomaly detection (**VAD** - AU); Audio-Visual anomaly detection (**AVAD** - AU)
- Visual crowd counting (**VCC** - AU); Audio-Visual crowd counting (**AVCC** - AU)
- Automated audio captioning (**AAC** - TAU)
- Sound event detection (**SED** - TAU); Sound event localisation and detection (**SELD** - TAU)
- Acoustic scene classification (**ASC** - TAU)

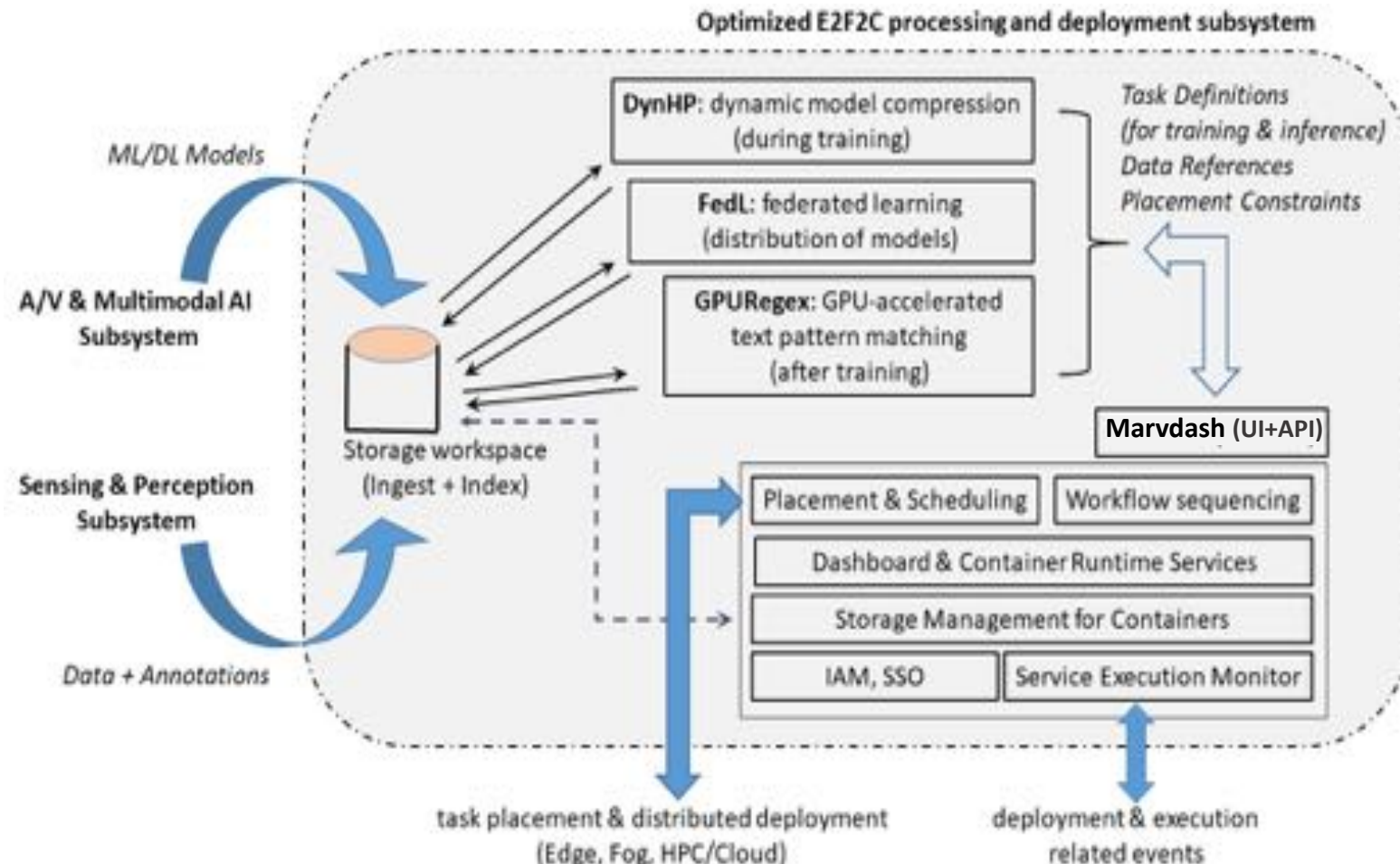
5. Optimised E2F2C processing and deployment subsystem



- **The role:** (i) *optimised deployment* of various tasks and services; (ii) optimised ML/DL models.

Components

- Methodology to train and compress at the same time a DNN model (**DynHP** – CNR)
- Personalised federated learning framework (**FedL** – UNS)
- Real-time pattern matching engine that leverages the parallelism properties of general-purpose GPUs to accelerate string and/or regular expression matching (**GPURegex** - FORTH)
- Managed execution platform (**Marvdash** – FORTH)

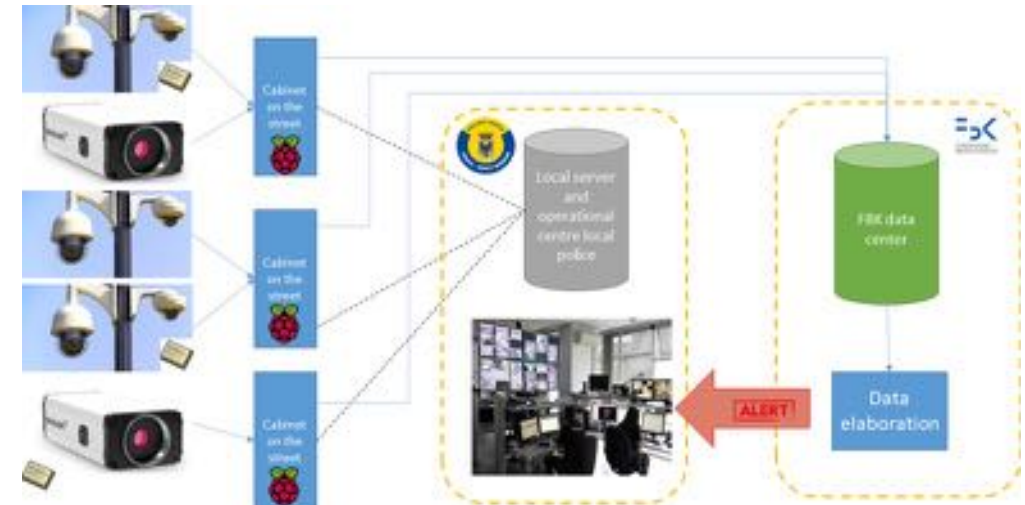
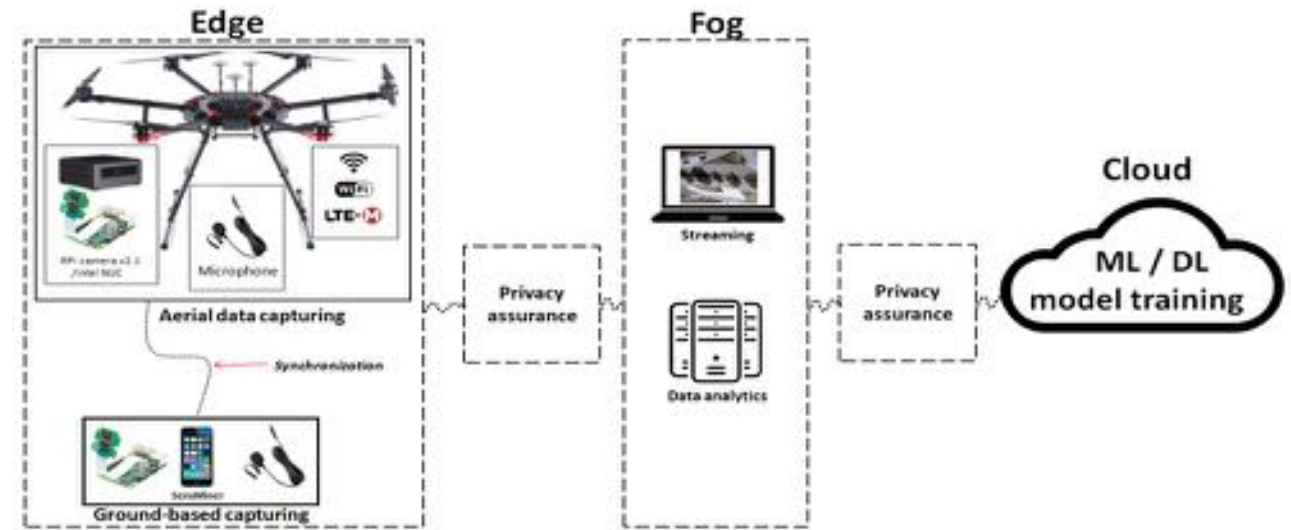


6. E2F2C infrastructure

- **The role:** execution infrastructure featuring all the three infrastructural tiers

Components

- HPC cluster (**Eagle Cluster** – PSNC)
- HPC resource management and orchestration (PSNC)
- Three underlying infrastructural tiers – **cloud**, **fog**, and **edge** (GRN, MT, and UNS).

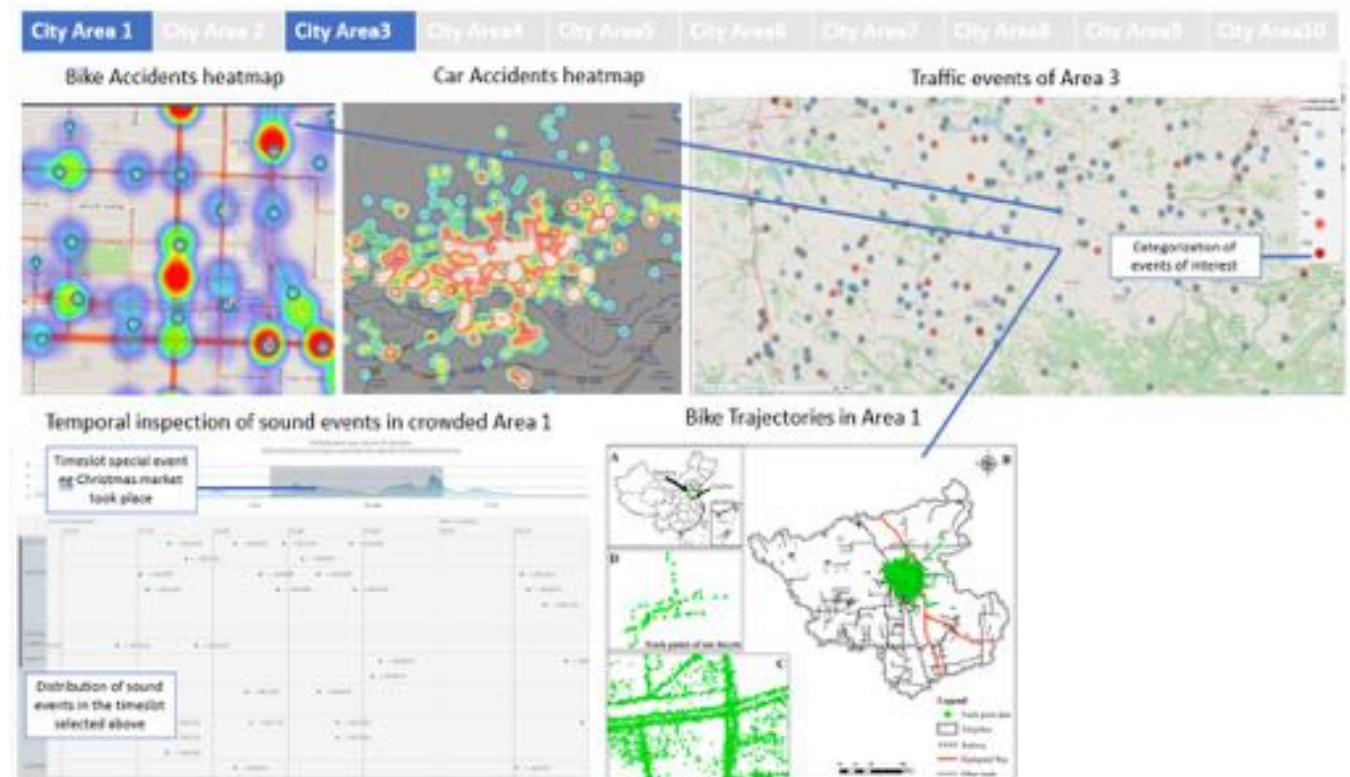


7. System outputs: Decision-making toolkit and MARVEL Data Corpus-as-a-Service

- **The role:** Visualizations and decision making, and data queries for MARVEL Data Corpus

Components

- Decision-making toolkit consists of the **SmartViz** component (ZELUS) for advanced visualisations, and short and long-term decision-making
- **MARVEL Data Corpus-as-a-Service** (STS), a large-scale corpus of processed multimodal AV public data.





Multimodal Extreme Scale Data Analytics for Smart Cities Environments

MVP Info Day

MARVEL smart cities test cases: The Municipality of Trento Pilot

Thomas Festi, Project Manager, Municipality of Trento

January 28th, 2021

Inform local authorities and emergency services of potential anomalous events that may lead to dangerous situations:

- Monitoring of crowded areas
- Detecting criminal/anti-social behaviors
- Monitoring of parking places
- Analysis of a specific area for better urban planning



City monitoring in Trento, Italy



UC#1: Monitoring of crowded areas

Goals:

- exceptional crowd
- suspect or unusual crowd movements

The situations analysed will refer to:

- robberies
- aggressions
- people who are unwell or faint
- gatherings

Piazza Fiera



28-01-2022

Piazza Duomo



Equipment:

- 3 fixed digital cameras (Local Police surveillance network)

Municipality of Trento - MVP Info Day

UC#2: Detecting criminal/anti-social behaviours

Goals:

- detect criminal or anti-social behaviours

The situations analysed will refer to:

- bothersome gangs (to detect groups, noises, actions)
- aggressions or robberies
- gang fights
- drug dealing

Piazza Santa Maria Maggiore



Equipment:

- 2 fixed digital cameras (Local Police surveillance network)
- 2 microphone

UC#3: Monitoring of parking places

Goals:

- prevent robberies or damages to the cars parked
- detect anomalous behaviors

Piazzale ex Zuffo



The situations analysed will refer to:

- robberies
- aggressions
- correct use of parking spaces reserved for taxis
- occupation of spaces reserved for the vehicles of disabled people
- number of parked campers and time of stay
- average parking time of vehicles
- use of the cycle boxes installed in the area
- detection of possible damage and other occurrences that will emerge during the execution of the experimentation.

Equipment:

- 2 fixed digital cameras
(Local Police surveillance network)
- 2 microphone

UC#4: Analysis of a specific area

Goals:

- monitor city's main places to support the Administration's decision-making

Piazza Dante (Via Dogana – Via Pozzo)



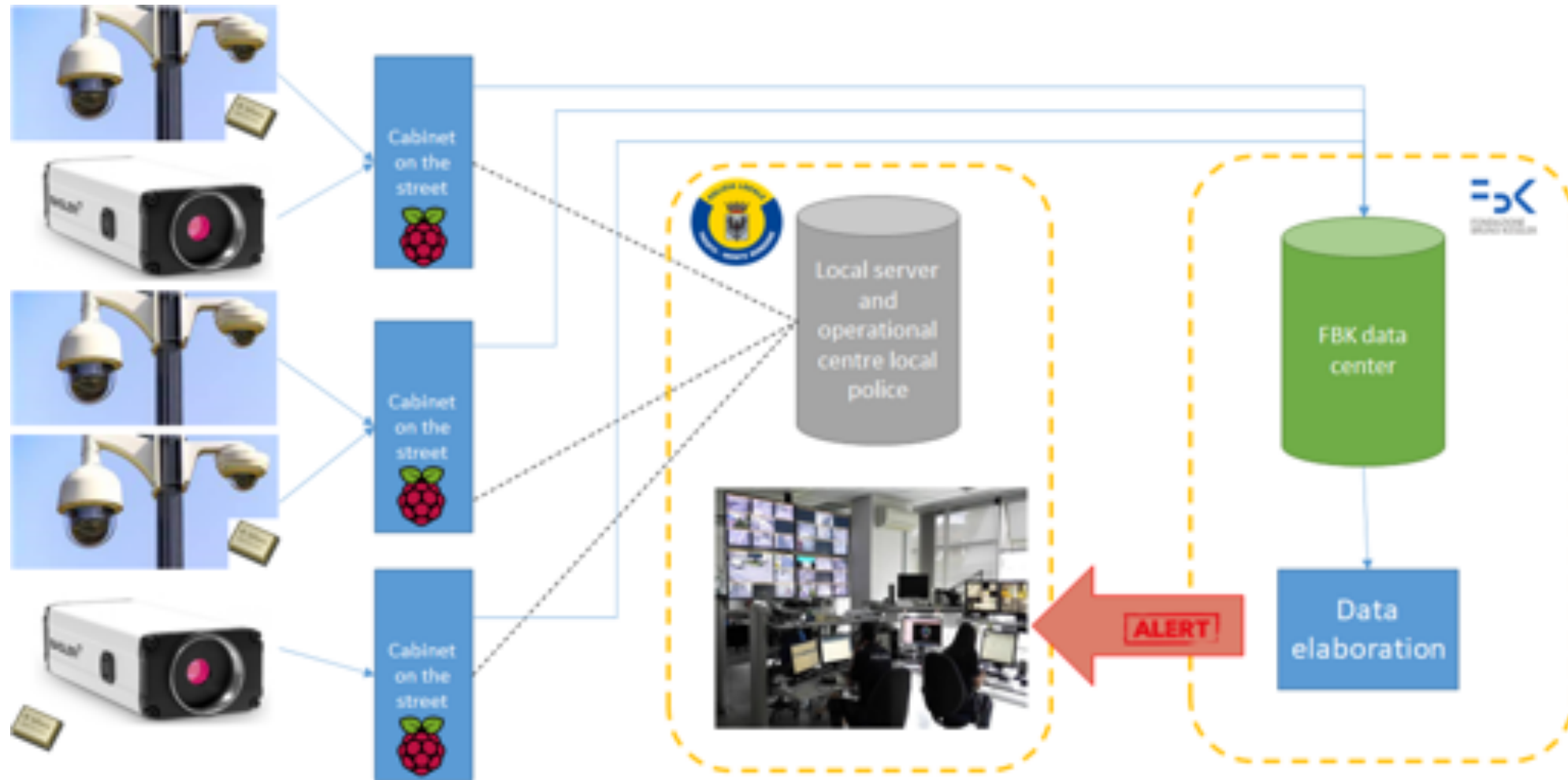
The situations analysed will refer to:

- counting of persons, cars, buses, taxis, bikes, calculate their trajectories and calculate any notable event during a specific timeframe
- integration into the project for the creation of the "Smart City Control Room"

Equipment:

- 4 fixed digital cameras (Local Police surveillance network)
- 2 microphone

MT infrastructure, hardware and sensors



- **Real-life recordings** data acquired by the **surveillance cameras** currently mounted in four sites of the use cases.
- **Microphones** (IFAG-MEMS) will also be mounted nearby some cameras.
- Recordings will be **pre-processed** to meet the requirements of the MT DPO:
 - anonymising person faces and
 - removing or anonymising speech content

- MT and FBK will record target events staged by enrolled participants for the two institutions to:
 - **complement real data**, in particular for what concerns rare events
 - **tackle the limitations due to privacy.**
- Staged recording will simulate the target events and scenario of:
 - UC#2: “Detecting Criminal and Anti-Social Behaviours” and
 - UC#3: “Monitoring of Parking Places”

- **TrentoOutdoor - Real data**

- for each use case we provided **direct access to our surveillance network** to FBK
- FBK provided the **anonymised videos** to the consortium through MARVEL platform

- **TrentoOutdoor - Stage Recording**

- Necessary to simulate rare events that are otherwise difficult to pick-up in real-life
- **Suitable for all the trial cases** planned (UC#2, UC#3)

- **Re-use of public datasets** to improve the algorithms

- Existing crowd datasets for pre-training models, which can then be fine-tuned with the acquired dataset under MARVEL.

- **Annotations** will be registered through **metadata** in the recordings (i.e. date, time and location weather conditions, scenario, in video stream, real or stage, day/night, etc.)



Multimodal Extreme Scale Data Analytics for Smart Cities Environments

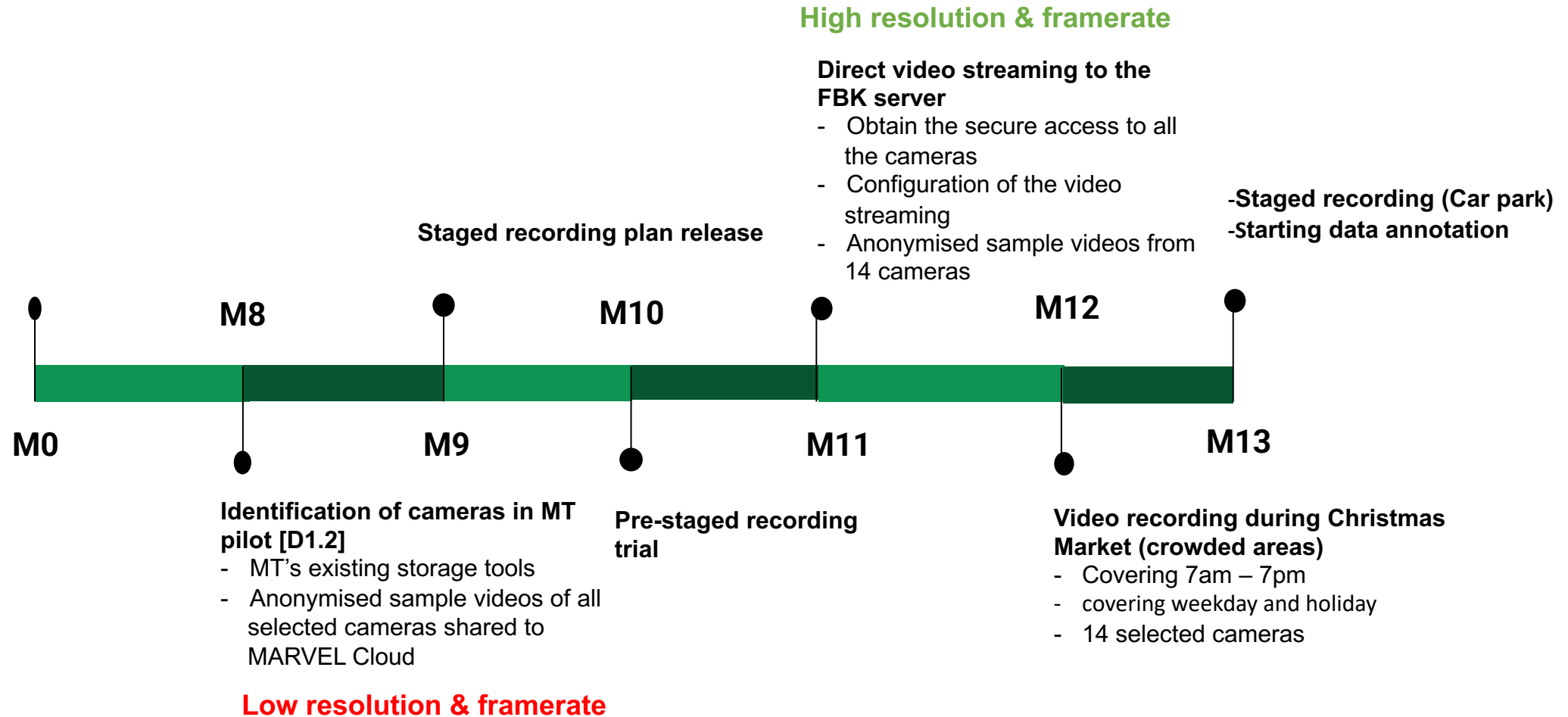
MVP Info Day

MARVEL smart cities test cases
Pilot 2: Municipality of Trento

FBK

January 28th, 2022

MT roadmap up to now (FBK & MT)



Pilot site and cameras/mikes plan - 1

Monitoring of crowded areas

- Piazza Fiera (row 1) + Piazza Duomo (row 2)
- 6 cameras (BIP2), ~12 fps, 1600 x 1200
- No mikes



Pilot site and cameras/mikes plan - 2

Detecting Criminal and anti-social behaviours

- Santa Maria Maggiore
- 2 cameras (BIP2), ~12 fps, 1600 x 1200
- With Mikes



Pilot site and cameras/mikes plan - 3

Monitoring of parking places

- Carpark Zuffo
- 2 cameras (BIP), ~2 fps, 1600 x 1200
- With Mikes



Pilot site and cameras/mikes plan - 4

Analysis of a specific area

- Piazza Dante
- 4 cameras, 3BIP2+BIP
- With mikes



Staged recording

- The recording will **complement anomalous events that rarely occur in real-world recordings**, to support model training and testing.
- We are planning to perform recordings in **carpark Zuffo** and **S.M. Maggiore**
- Each site will have 4 main events categories, where each event will occur 10 times
- Each video clip is for one event that will be less than 1 min.
- The participants are:
 - the MT and FBK personnel involved in the MARVEL projects
 - Other volunteers with signed consent forms
 - we will introduce **as much variability as possible in the subjects involved**, in terms of clothes, items they carry, skin colors.
- We have **consulted the local police** for criminal events, e.g. drug dealing
- Scheduled time: Jan 2022 in carpark Zuffo; March 2022 in S.M. Maggiore

Pre-staged recording @ carpark Zuffo



Car stealing



Fight



Loud noise (gunshot)



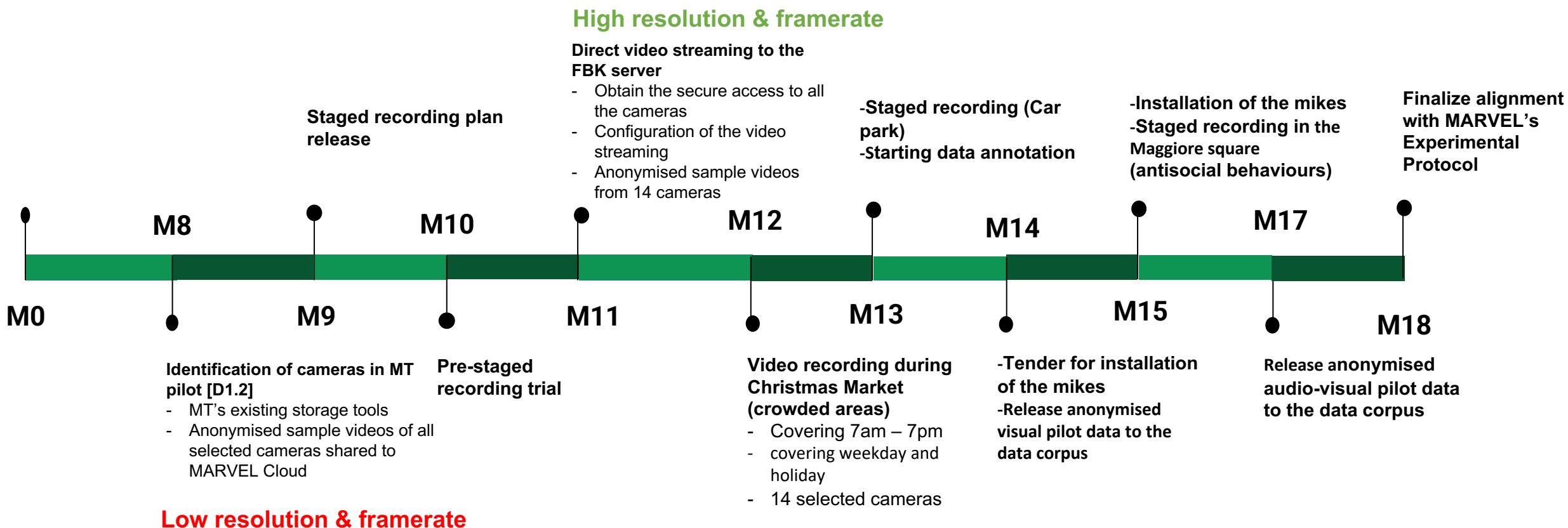
Inappropriate parking



Anonymised Videos of Trento Christmas market



Future work up to M18





Multimodal Extreme Scale Data Analytics for Smart Cities Environments

MVP Info Day

The MARVEL Smart City test cases - Malta

January 28, 2022

Mobility contributes significantly to

- **land use** (public space taken up by roads)
- **premature deaths and injuries, pollution and congestion**
 - increased health problems, lowering of quality of life & climate change

It is therefore desired to have

- efficient land use
- increased safety
- less air pollution

Pilot aims at showcasing technology that can help in the management and planning of urban mobility

Encouraging sustainable mobility, especially commuting by bicycle, which is at its infancy

- Increase safety for vulnerable road users
- Data-driven insights for efficient and safer infrastructure
- Identify areas for enforcement and/or education campaigns

Monitoring the use and allocation of physical transport resources,

- Minimising additional land use
- Reduction of vehicle emissions in urban and non-urban areas
- Timely maintenance of physical infrastructure

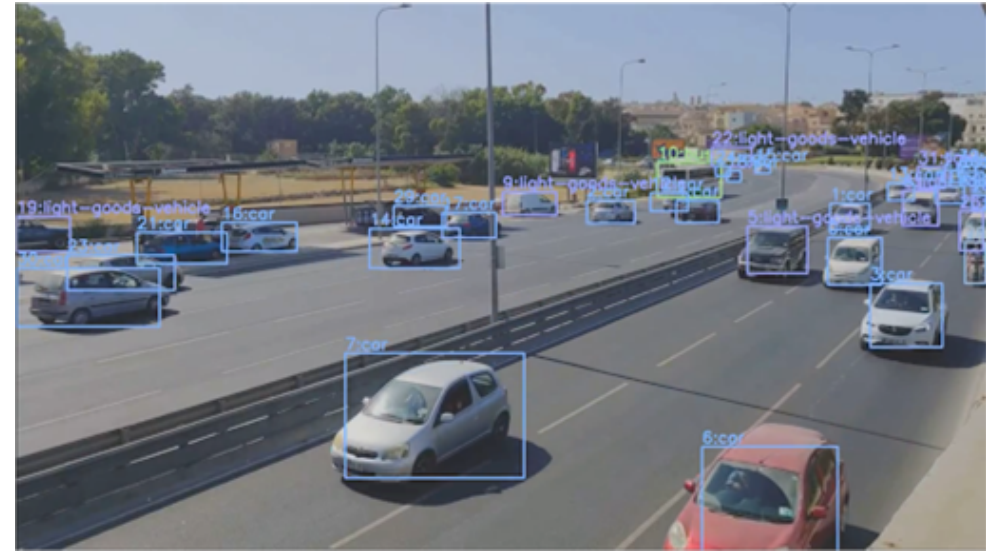
The use-cases will showcase data analytics technology to address some of the above items.

Greenroads is focused on developing technology that can be used to tackle problems wrt urban mobility.

Core product: Set of AI models to analyze video traffic data, and deliver information on how the various road users use the infrastructure via a cloud based dashboard.

Potential uses

- Data driven long term decision making
- Manage demand for road space
- Plan and manage safety of roads and open spaces before, during and after road works



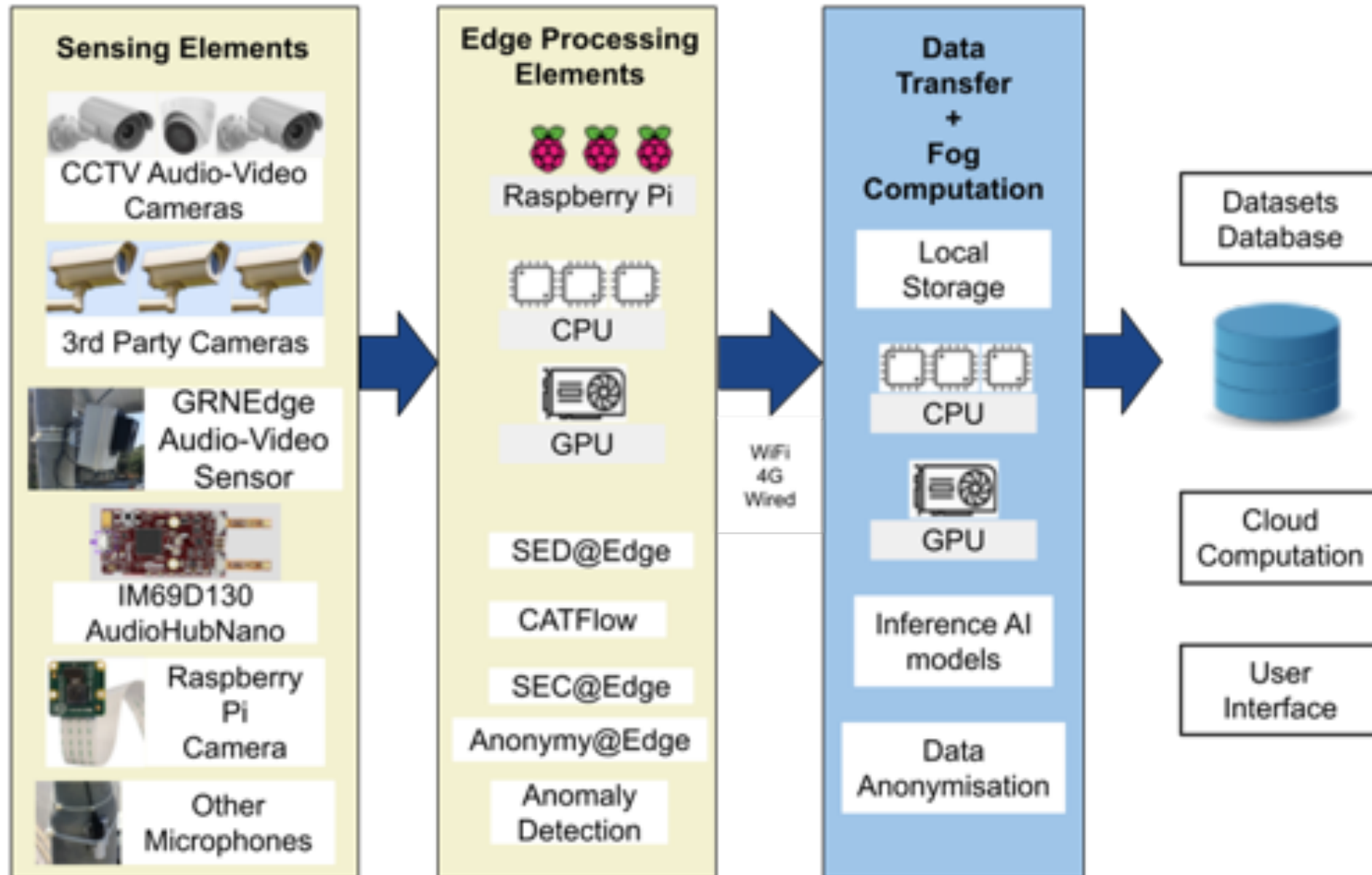
Shared goals and benefits

Affords exposure, building connections and sharing best practices.

MARVEL is important for Greenroads due to the shared goals, added knowhow and the opportunity to experiment with novel products :

- **EFFICIENT** Transforms existing smart city passive sensors, typically manually monitored in control rooms (recorded or live), to useful data insights
- **GDPR Compliant** anonymous outputs to process as needed and preserves privacy
- **Multi-modal data** processed over heterogeneous infrastructure
- **Exportable data** and easier integration and management

Sensors and Equipment



I. Safer roads for bicycle commuting

Motivation

Encourage and facilitate cycling, thereby reducing car dependency and its negative effects (Malta National Transport Strategy, 2050)

How?

Local research studies strongly indicate two main obstacles to cycling:

- The perceived lack of safety on the road, and
- the lack of dedicated cycling infrastructure

[Maas & Attard, 2021]

I. Safer roads for bicycle commuting

Background

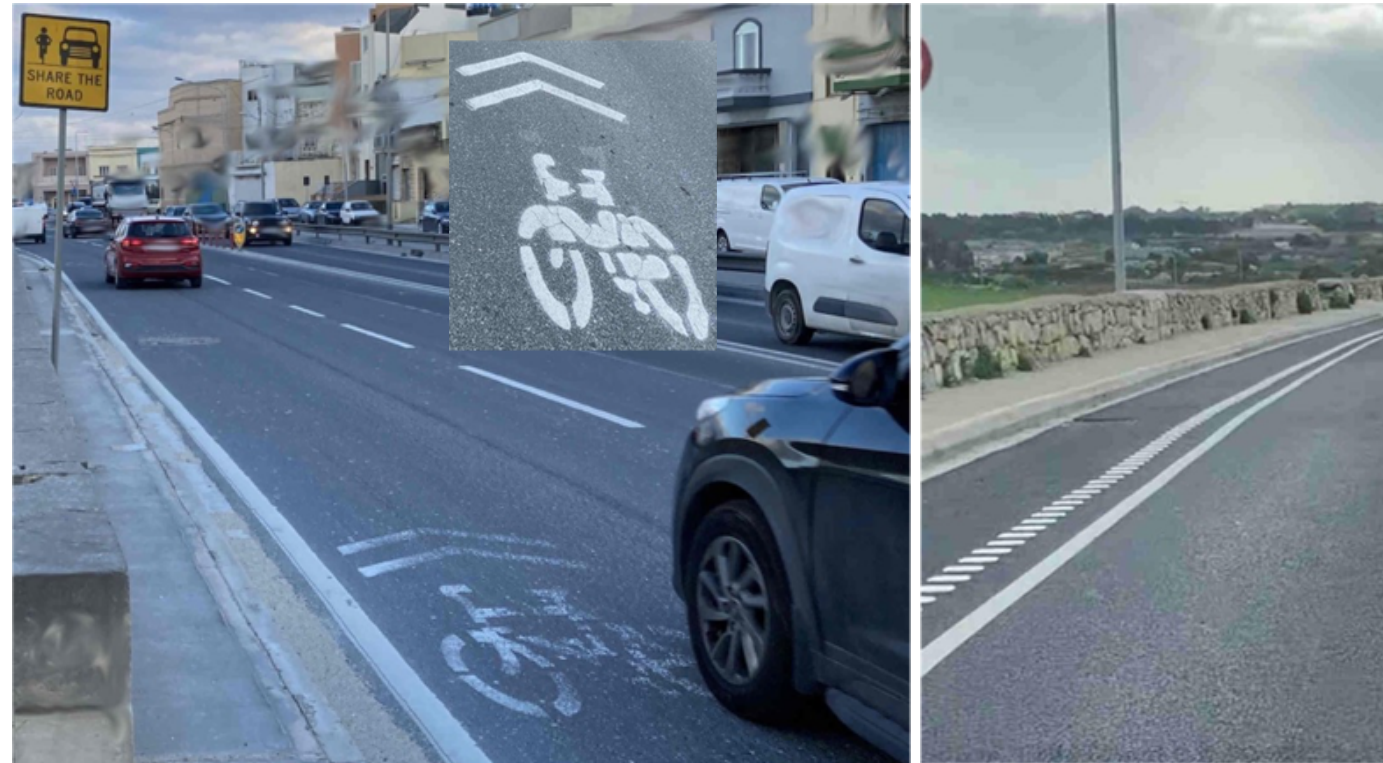
Efforts, from both the authorities and cycling commuting lobby, in encouraging cycling, mainly through infrastructural changes.

- Shared infrastructure
- Segregated cycle paths

Use-case

Actively **assist** vehicle drivers when cyclists are present.

i.e., making shared infrastructure safer for cyclists



I. Safer roads for bicycle commuting...

Rationale: Detect cyclists, exiting a junction and inform car drivers of the presence of cyclists via variable message signs or equivalent



Challenges:

- Real-time and low-latency
- AI models at the edge
- Detection in low-visibility conditions
- Confused with motor-cycles



II. Road User behaviour

Motivation and problem:

Malta has experienced fast changes in the transport landscape

- Human response often lags behind infrastructural and technical progress

Educational campaigns* for responsible driving and cycling are thought to be the most effective method in closing the gap (Malta National Transport Strategy, 2050)

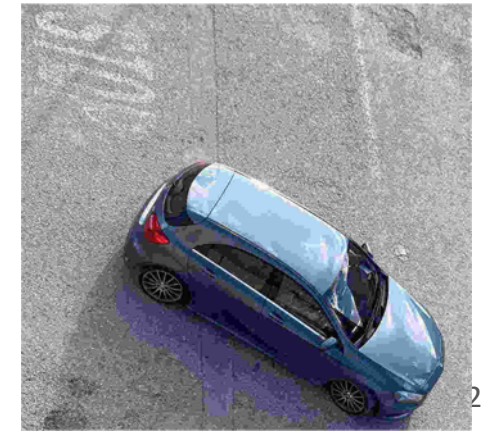
*This use case will not be implementing the educational campaigns; instead technology is demonstrated with some examples.

II. Road User behaviour

Examples of actions include*

1. Cars on green cycling infrastructure
2. Car drivers not giving way or not stopping
3. Cyclists not using available green infrastructure
4. The way pedestrians cross over the intended crossings,
5. Car drivers and cyclists not indicating when turning
6. Vehicles not on the right side at junctions
7. Pedestrians not stopping at crossings

*The AI models will be trained on a subset of these examples

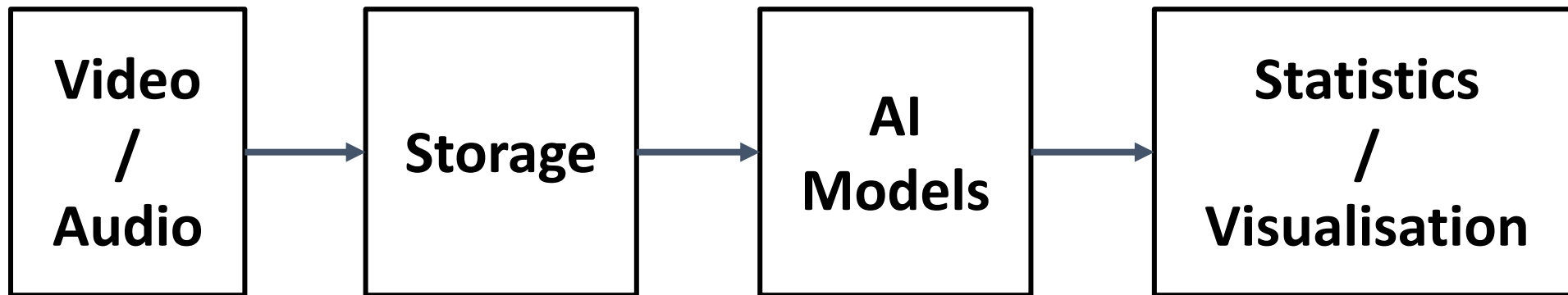


II. Road User behaviour

Use case develops and demonstrates technology to classify actions into **exemplary** and **objectionable** behaviour.

The technology can be used in for example

- The study of objectionable behaviour on the road
- The design and evaluation of educational campaigns



III. Traffic Conditions and Anomalous events

Monitor traffic conditions

- Flow rate and volume of traffic

Automatically Detect anomalous events,

- Abnormal traffic jams (may indicate other anomalies downstream)
- Stationary vehicles obstructing a junction or carriageway,
- Service vehicles parked on the side



III. Traffic Conditions and Anomalous events

- Execution in **Quasi-Real-Time**,
- Includes low-cost AI models that are computed at the edge.

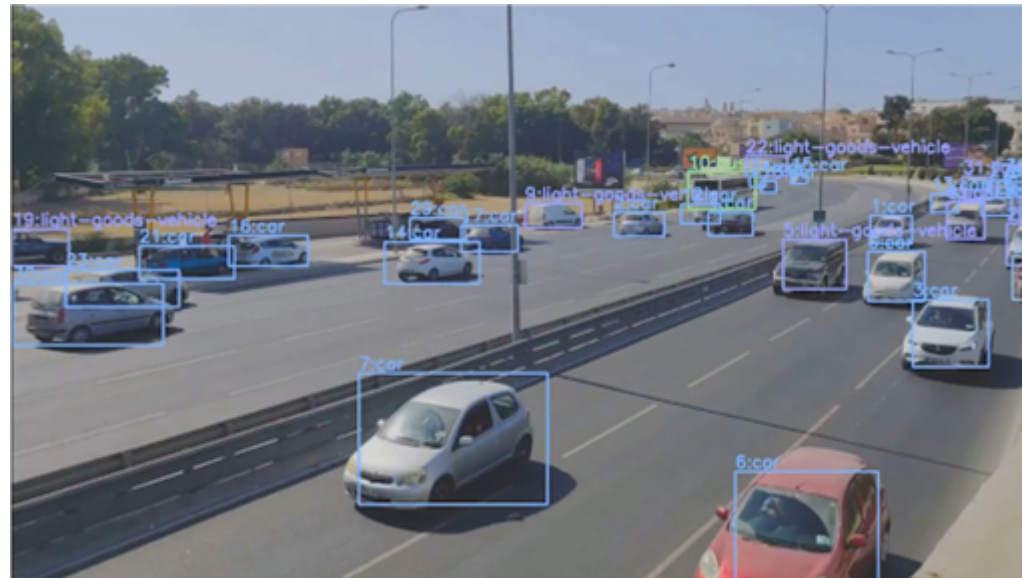
Potential applications for this technology include;

- Real-time automatic traffic monitoring
- Systems intended to inform drivers of traffic state or anomaly
- Raise anomaly at traffic management control rooms, where traffic managers can manually review the data and take any necessary action.

IV. Junction Traffic Trajectory Collection

Focused on the requirement of long-term data analytics for **long-term transport planning and evaluation**

- Sheds light on how and when traffic entities (car drivers, motorcyclists, cyclists, pedestrians, etc.) use the infrastructure.
- The gathering of traffic statistics from the road network.



IV. Junction Traffic Trajectory Collection

Some examples

- Counting the number of heavy vehicles passing through residential streets
- Optimising the position of pedestrian crossings
- Studying whether provisions for cyclists at complex junctions are adequate
- Studying whether installed provisions for cyclists are being used as intended.



IV. Junction Traffic Trajectory Collection

Off-line processing of video and audio data

User interface allows the end user to select the data and task

Potential end users:

- Traffic engineers, consultants and planners
- Transport researchers engaged in academia and transport authorities

Technology:

- Detection of entities and their trajectory across a junction or road segment
- Anomaly detection
- Output converted to descriptive statistics and visualisation



Multimodal Extreme Scale Data Analytics for Smart Cities Environments

The MARVEL MVP

January 28, 2022

Christos Dimou - cdimou@itml.gr

Contents



- Overview of the MARVEL MVP
- Development activities
- MVP scope, use case scenarios and technologies
- Demonstration

- **MARVEL framework releases**

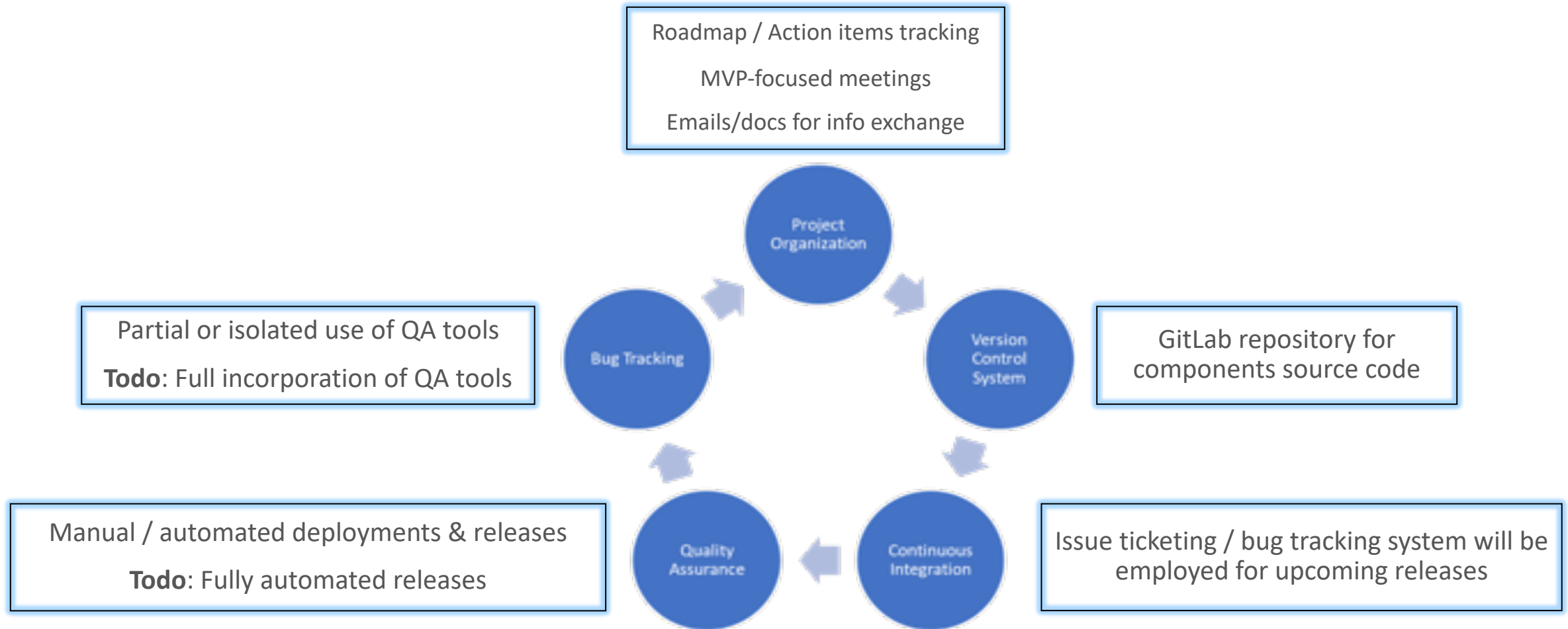
- December 2021 - MVP
- June 2022 - 1st complete prototype
- June 2023 - Final prototype



- **The MARVEL Minimum Viable Product**

- Minimum, end-to-end demonstration that shows the fundamental function of the framework
- Receive feedback at a very early stage
- Detect shortcomings and obstacles early on and have time to act

MVP development activities



Use case selection

- **GRN Use case 4: Junction Traffic Trajectory**
- Long-term data analytics to
 - analyse behaviour of road users
 - gather traffic statistics at road network junctions
- Technical elements
 - Street-level cameras that monitor a junction
 - Detection of traffic objects
 - Tracking of detected objects
 - Detect events



Components & Use case scenarios

Map all relevant technology components to the selected use case

For this Use case, 3 scenarios are implemented

- **Scenario 1**

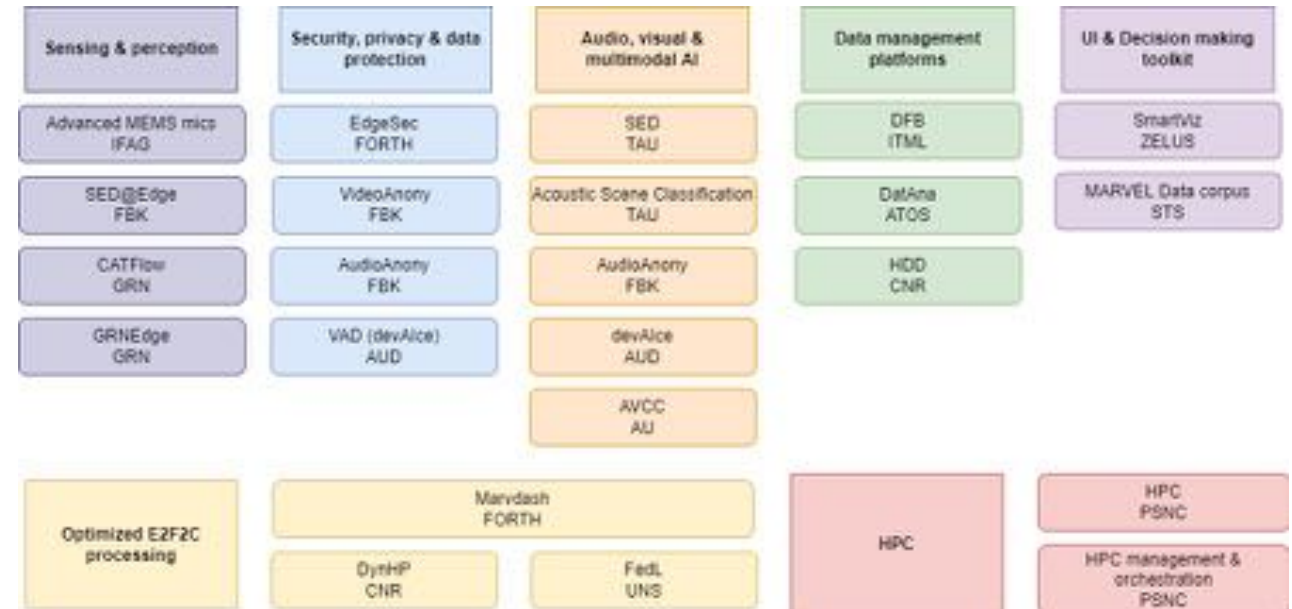
Identify vehicle type and trajectory

- **Scenario 2**

Sound events and crowd counting

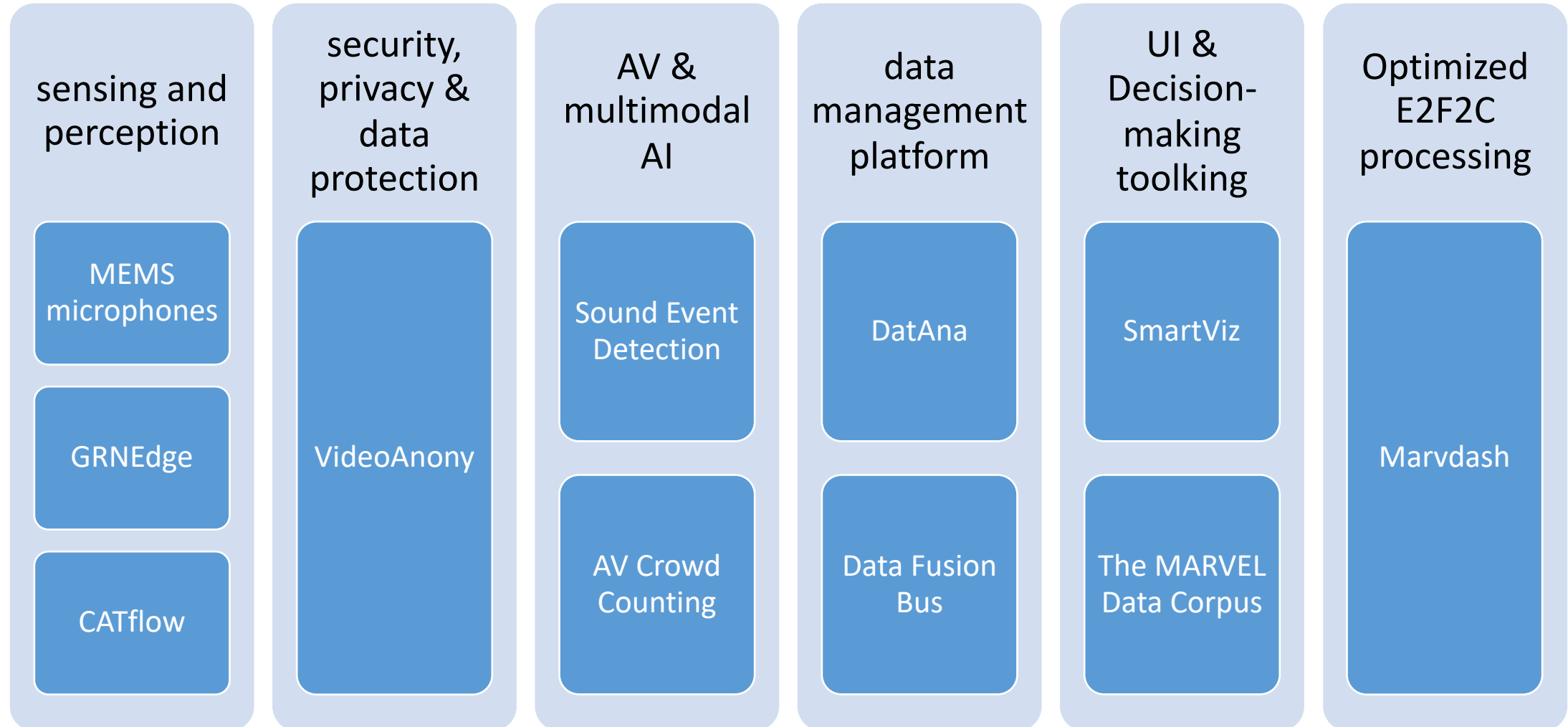
- **Scenario 3**

Populate the MARVEL Data Corpus with AV data



For detailed description of the technologies, please visit <http://www.marvel-project.eu/solution-assets/>

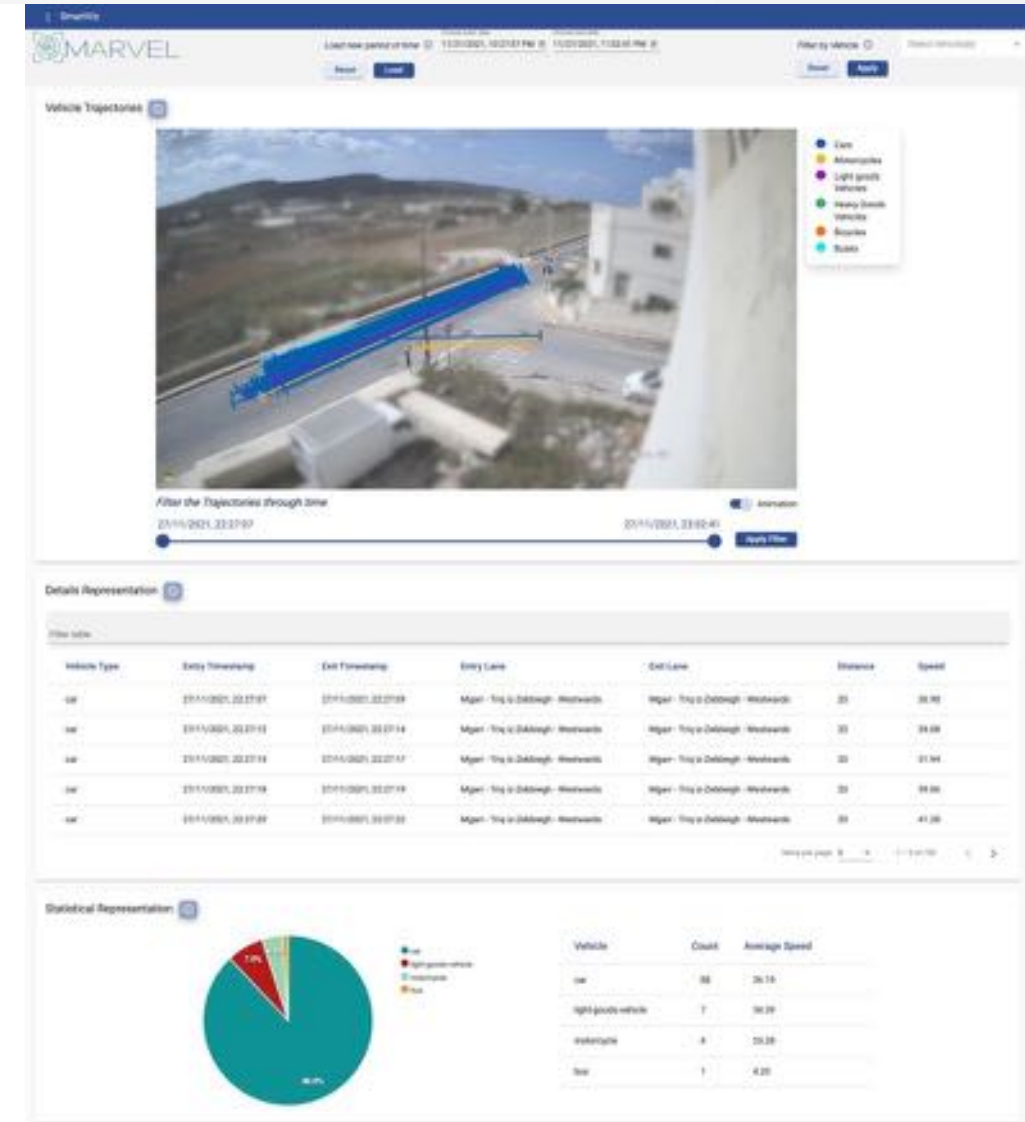
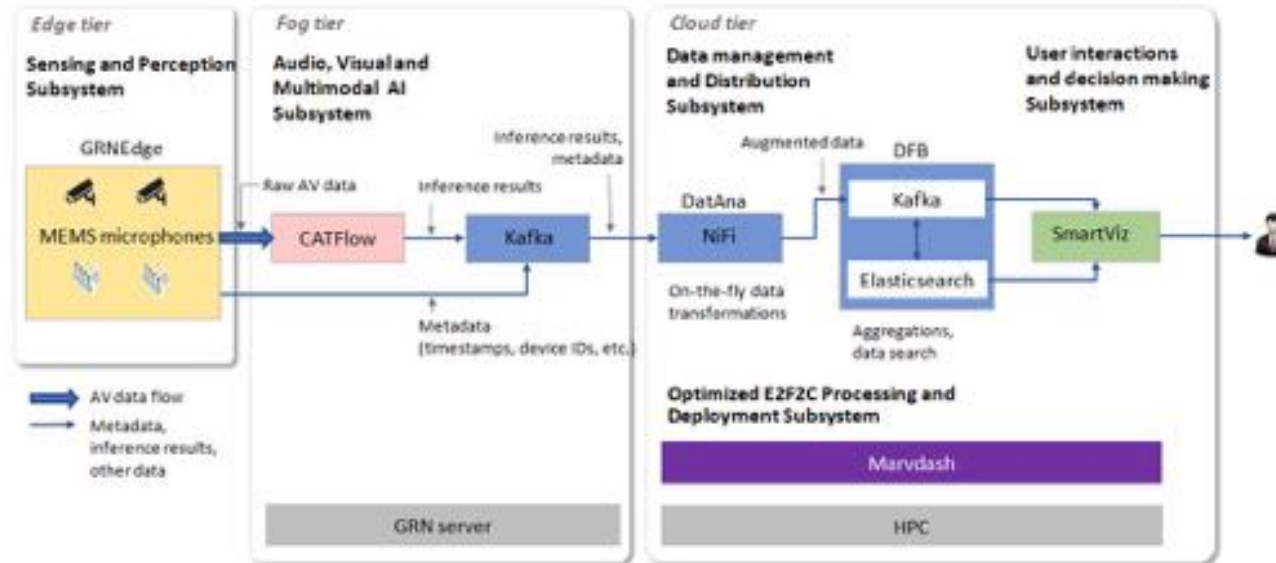
Selected MARVEL components



Use case scenarios



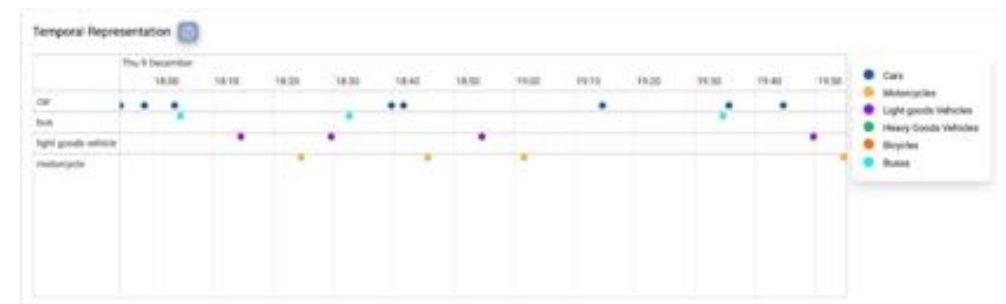
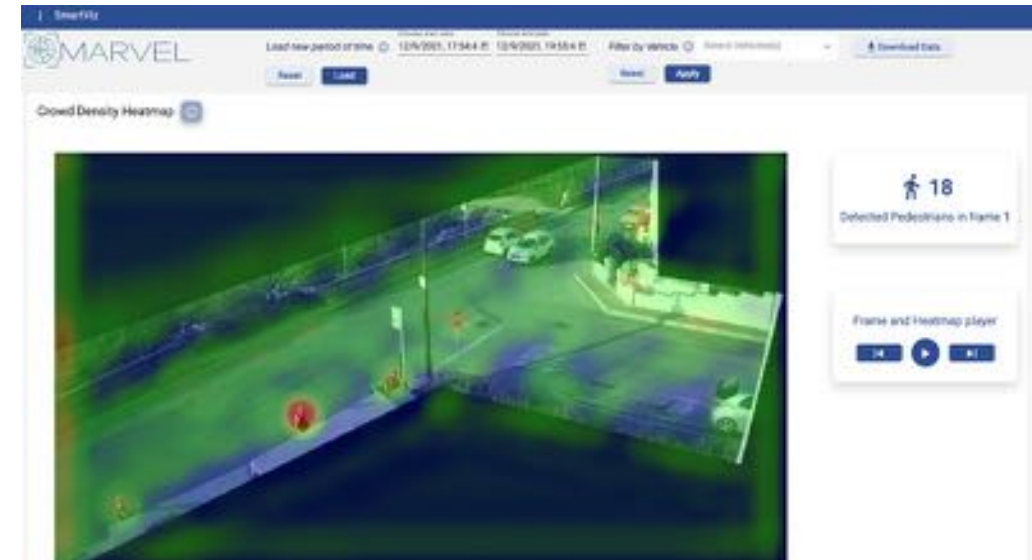
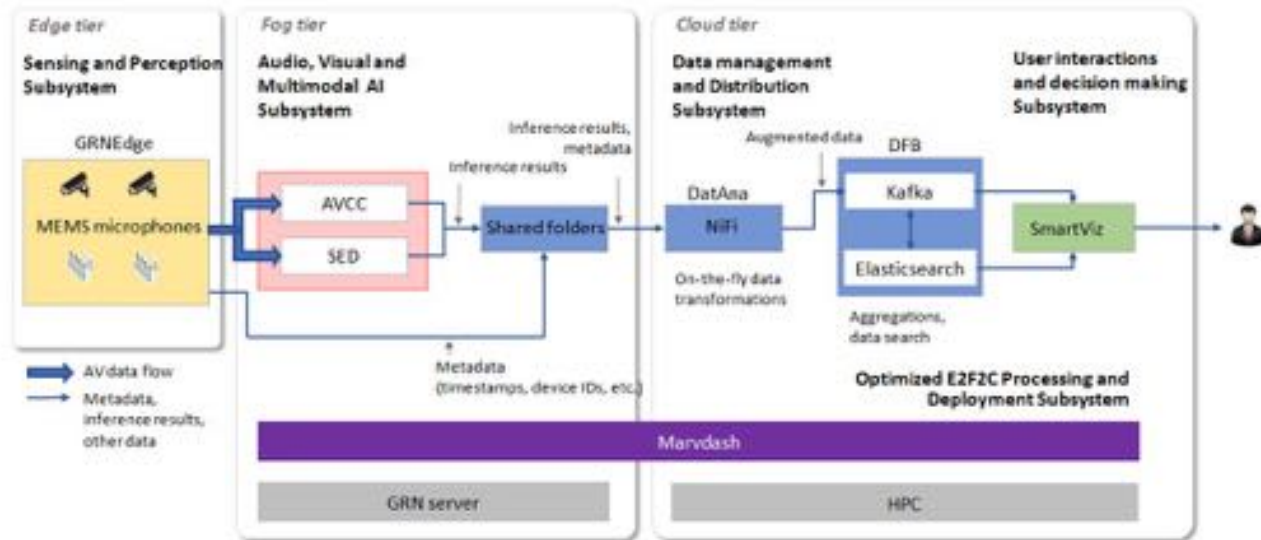
Scenario 1: Identify vehicle type and trajectory



Use case scenarios

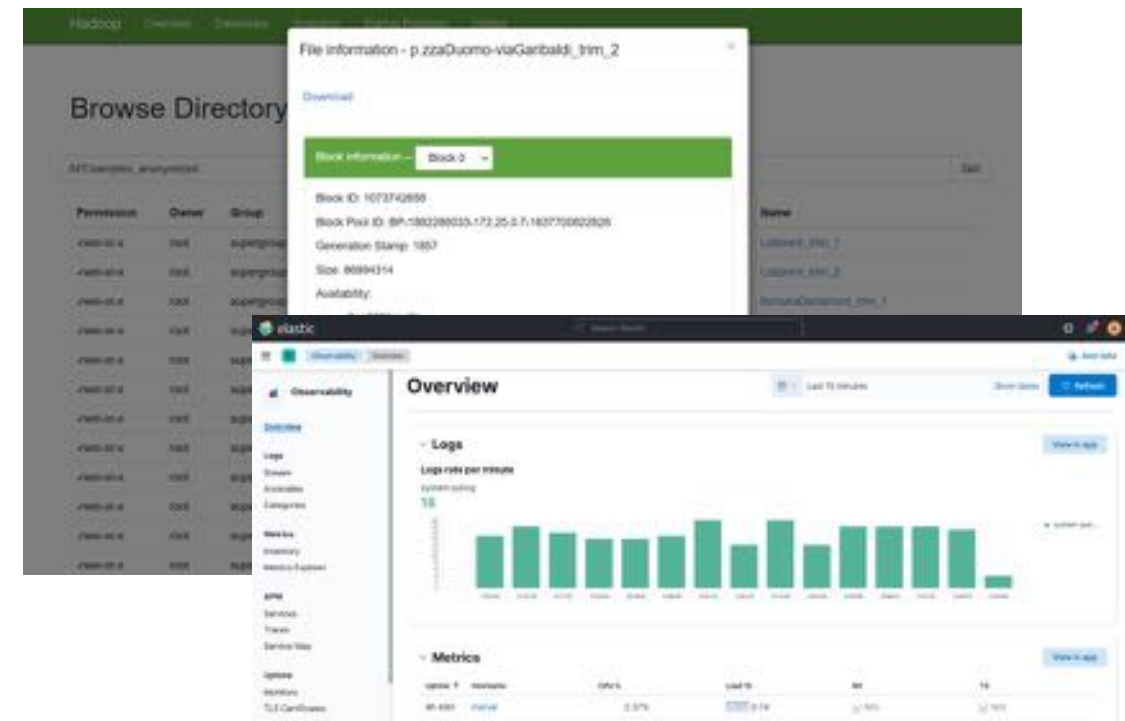
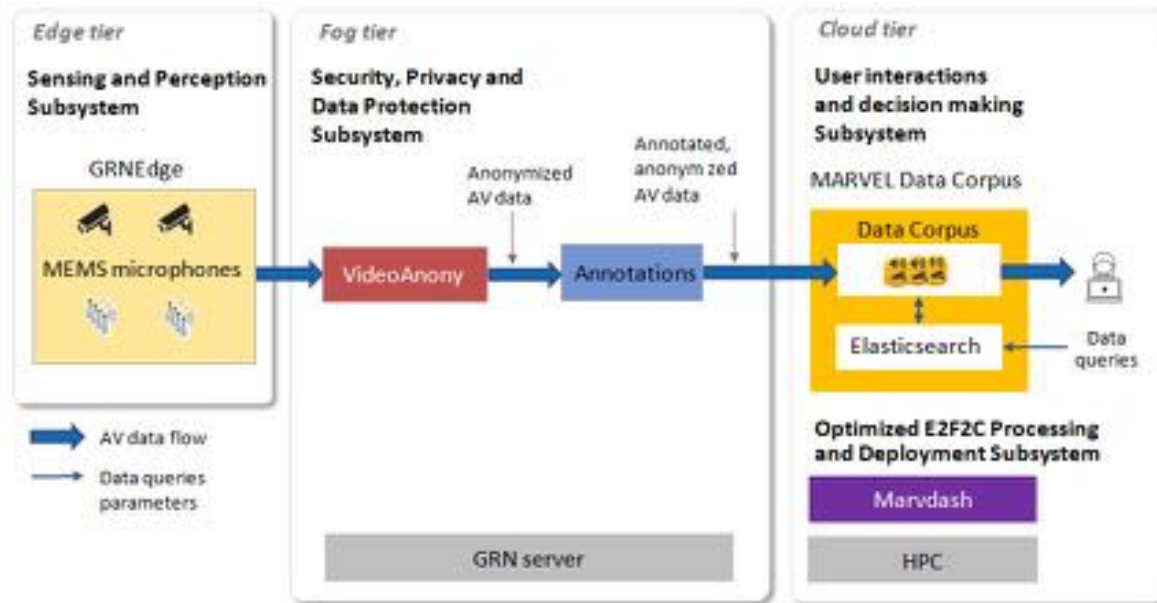


Scenario 2: Sound events and crowd counting



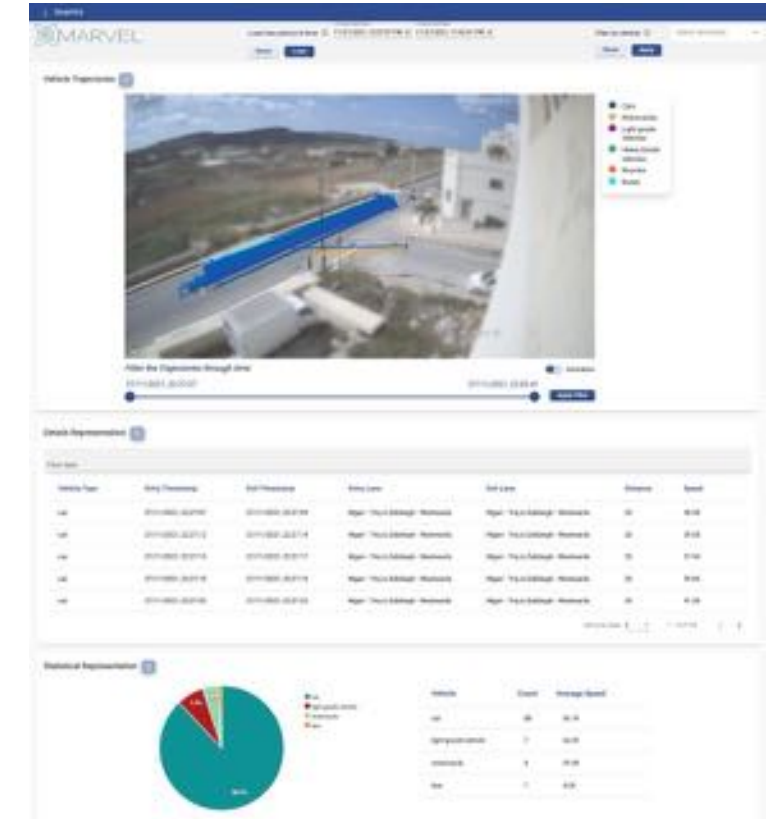
Use case scenarios

Scenario 3: Populate the MARVEL Data Corpus with AV data



Demonstration

The Decision-Making Toolkit



Next steps

- MARVEL framework **future releases**
 - June 2022 - 1st complete prototype
 - June 2023 - Final prototype



- Implement Use cases for the **Trento** and **Novi Sad** pilots
- Incorporate **all MARVEL components**
- Perform analytics and deliver services **in real-time**

Thank you!

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 <https://zenodo.org/marvelproject>

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