EU Space Programme Components Status and future services for users

European Commission

EUSPA
European Union Agency for the Space Programme

UE23
PRESIDENCIA ESPAÑOLA
CONSEJO DE LA UNIÓN EUROPEA

Road and Automotive UCP

Carmen Aguilera, MDI

7th November 2023

A new EU Space Programme

EU space activities **under one umbrella**

EGNOS

EGNOS "Makes navigation signals more accurate and trustable for Safety-critical applications"

Operational in **400+ airports** & helipads in 23 countries

Galileo

Global satellite navigation and positioning system (GNSS)

More than **3 billion Galileo receivers** worldwide

Copernicus

Earth Observation (EO) and monitoring based on satellite & non-space data

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Secure satellite communications for EU governmental actors

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Space Situational Awareness (SSA)

Space Surveillance and Tracking (SST)

Space Weather Events (SWE)

Near-Earth Objects (NEO)

Others

Access to Space

Research & Innovation

Entrepreneurship

Certification & standardisation

Capacity Building

Galileo and EGNOS Services

Galileo Initial Services are provided to worldwide users **since December 2016**

Open Service (OS)	Freely accessible service for positioning and timing*
Public Regulated Service (PRS) – **Governmental Service**	Encrypted service designed for greater robustness and higher availability – secure satellite communication
Search and Rescue Service (SAR)	Locates people in distress and acknowledges that the distress signal has been received
High Accuracy Service (HAS)	Delivers high accuracy services, freely accessible
Under preparation	
Commercial Service Authentication (CS)	Delivers authentication services for commercial applications

* OS Navigation Message Authentication (OSNMA) is currently under testing

EGNOS services are provided to users since **October 2009**

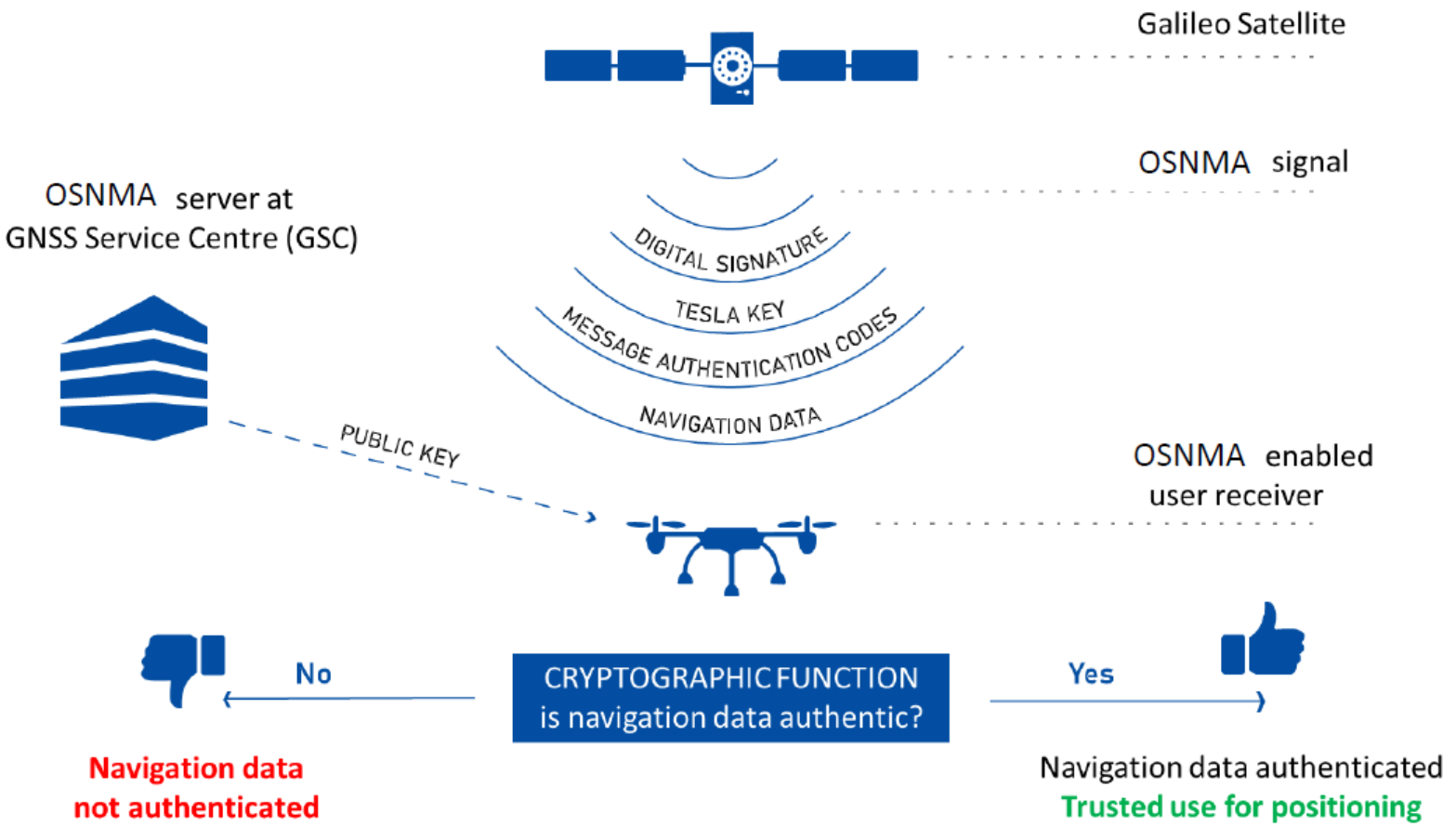
Open Service (OS)	Improving GNSS accuracy, intended mainly for high-volume satellite navigation applications for use by consumers
Safety of Life Service (SoL)	Providing a high level of integrity for users for whom safety is essential (e.g. civil aviation, in accordance with ICAO standards)
Data Access Service (EDAS)	Offering EGNOS data with greater added value through internet, intended mainly for professional or commercial use

Galileo Open Service

- Initial Operational Capability (IOC) phase in 2016, Since then, anyone with a Galileo-enabled device is able to use its signals providing free of charge outstanding seamless performance worldwide
- Improved navigation message, since mid-2023, boosting robustness and Time To First Fix (TTFF)
- An update of the Galileo Open Service (OS) Service definition Document (SDD) is planned for the end of this year.
- This fourth issue of the OS SDD will bring to the users:
  - new MPLs (e.g. Ranging rate accuracy, Ranging accuracy at high percentiles)
  - improvements of existing MPLs, such as the timeliness of certain Notice Advisory to Galileo Users (NAGU)
  - OS Extended Operation Mode, increasing the robustness of the OS.

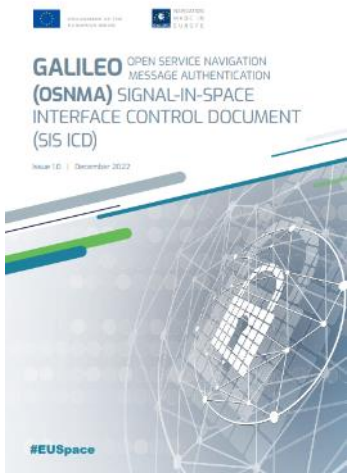
Galileo OSNMA

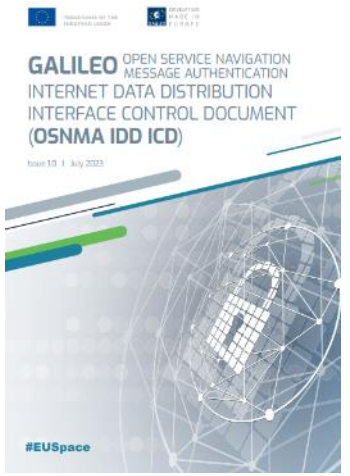
Scope

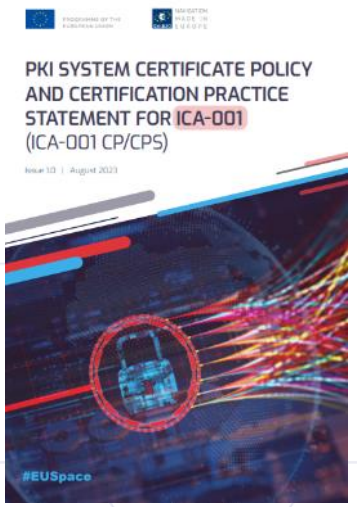


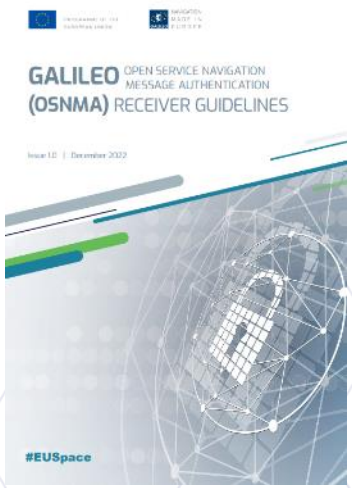
OSNMA status and roadmap

- OSNMA SiS ICD (final format) and Receiver Guidelines published in Dec'2022
- Transmission of SiS as per OSNMA SiS ICD (final format) since August 2023
- Operational cryptographic data to be published by end 2023
- Initial Service Declaration (Service Definition Document publication and signal switch to 'operational' mode) foreseen by Q1'24









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Galileo High Accuracy Service

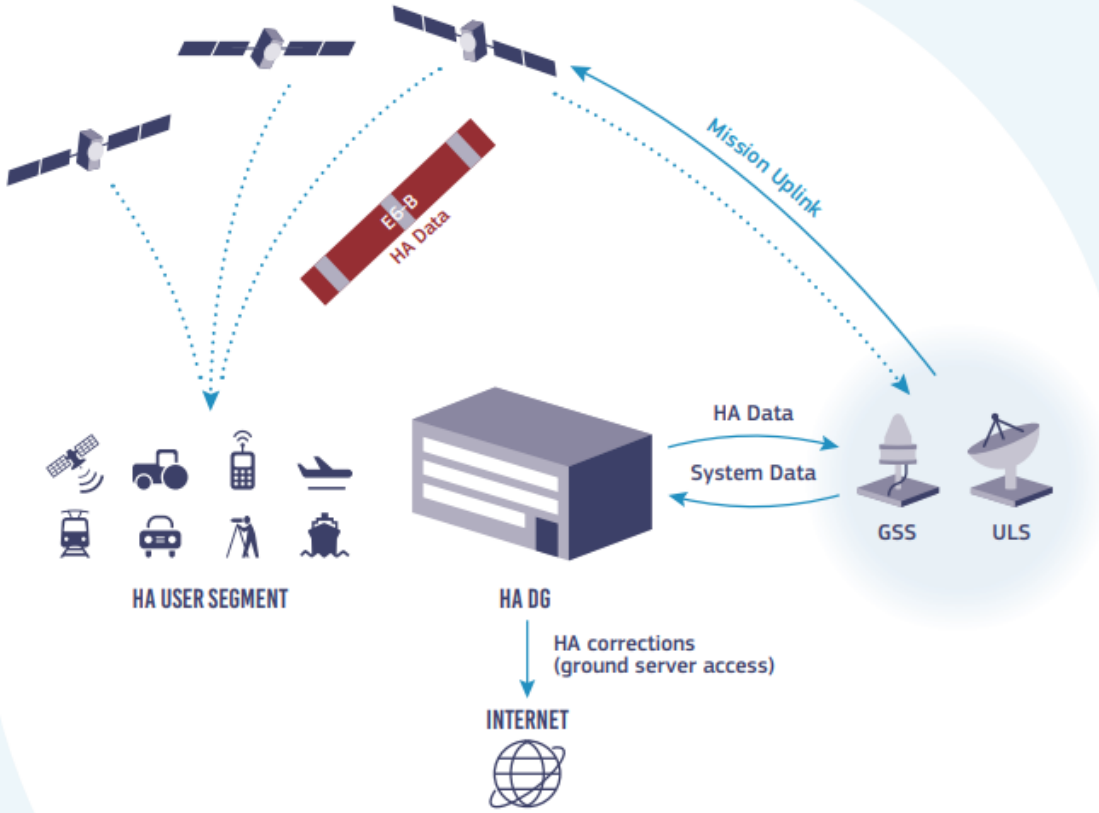
Galileo HAS provides precise corrections for satellite orbit, clock and signal biases

Galileo HAS corrections distributed via

- Galileo satellites, E6-B signal (1278.75 MHz)
- Internet

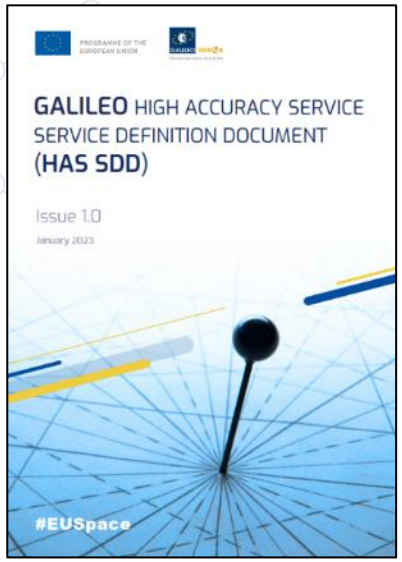
Typical accuracy in the decimetre level (after convergence), with Precise Point Positioning (PPP) receivers

(Almost*) global coverage and free



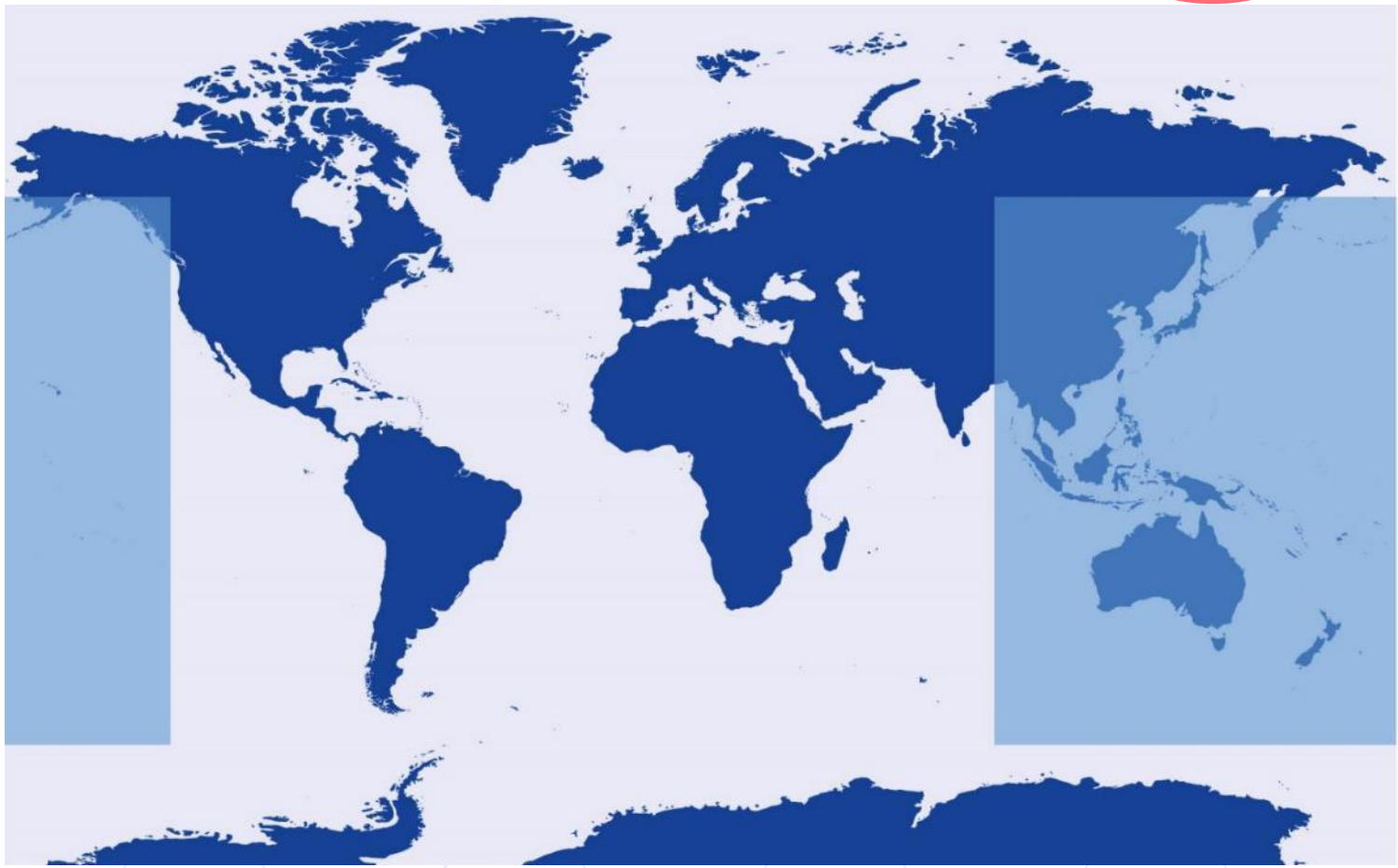
**global coverage of corrections but no global performance commitment yet*

HAS – Initial Service Area & Initial Service Performance



European Union Agency for the Space Programme (EUSPA), *HAS SDD [Online]: https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_HAS_SDD.pdf*

HAS Quarterly Performance Reports regularly published at the GSC website (https://www.gsc-europa.eu/electronic-library/performance-reports/galileo-high-accuracy-service-has)



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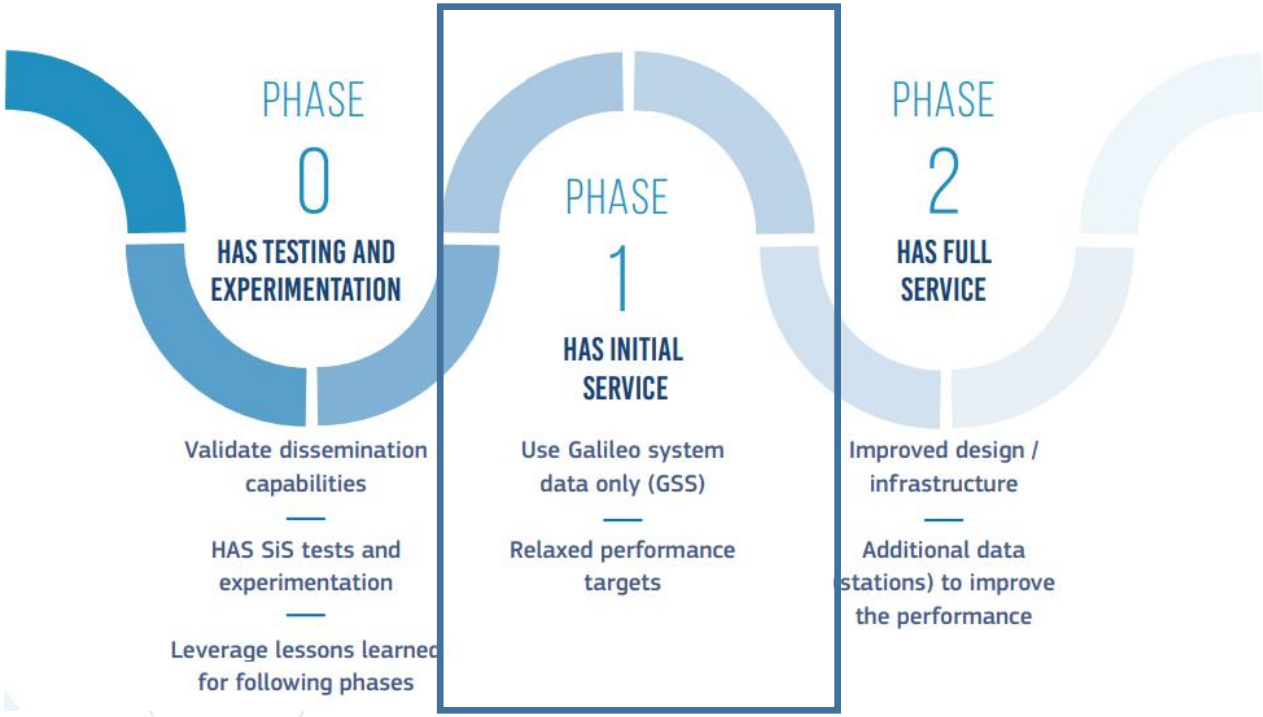
What comes next on HAS?

- Short-term: use it!
  - User segment development
    - More HAS-enabled receivers
    - HAS R&D actions
    - HAS Reference Algorithm publication
  - HAS based applications development

- Mid / long-term: HAS Full Service
  - Increased global performance (e.g. better accuracy)
  - Faster positioning in EU (atmospheric corrections)
  - HAS authentication and error characterization



https://www.gsc-europa.eu/electronic-library/programme-reference-documents

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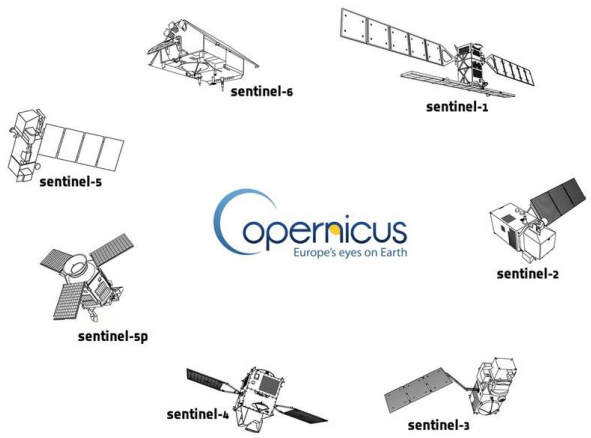
Copernicus components

SPACE



IN SITU

In Situ

SERVICES

Atmosphere Monitoring

Copernicus Marine Service

Land Monitoring

Climate Change

Security

Emergency Management

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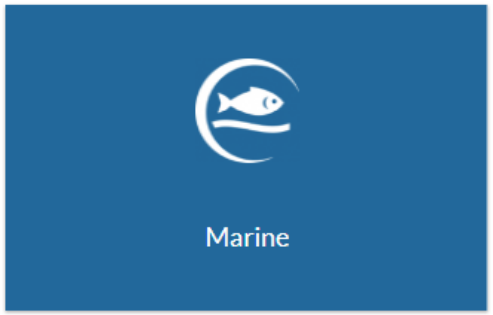
Copernicus services

https://atmosphere.copernicus.eu/

IMPLEMENTED BY ECMWF

https://marine.copernicus.eu/



MERCATOR OCEAN INTERNATIONAL

https://land.copernicus.eu/en

European Environment Agency

Joint Research Centre JRC

https://climate.copernicus.eu/

IMPLEMENTED BY ECMWF

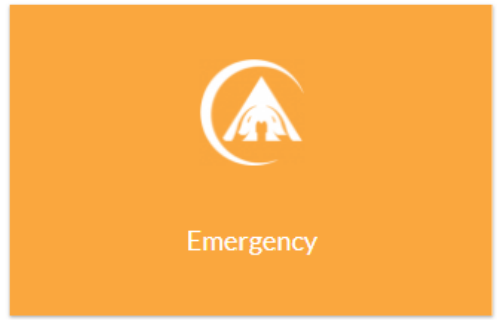
https://www.copernicus.eu/en/copernicus-services/security

SatCen European Union Satellite Centre

FRONTEX EUROPEAN BORDER AND COAST GUARD AGENCY

EMSA European Maritime Safety Agency

https://emergency.copernicus.eu/



Joint Research Centre JRC

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IRIS²

Infrastructure for Resilience, Interconnectivity and Security by Satellite

Regulation 2023/588 in force since 20 March 2023

Signature of the Regulation by EP President and Swedish Presidency

REGULATIONS

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Governmental Satellite Communications

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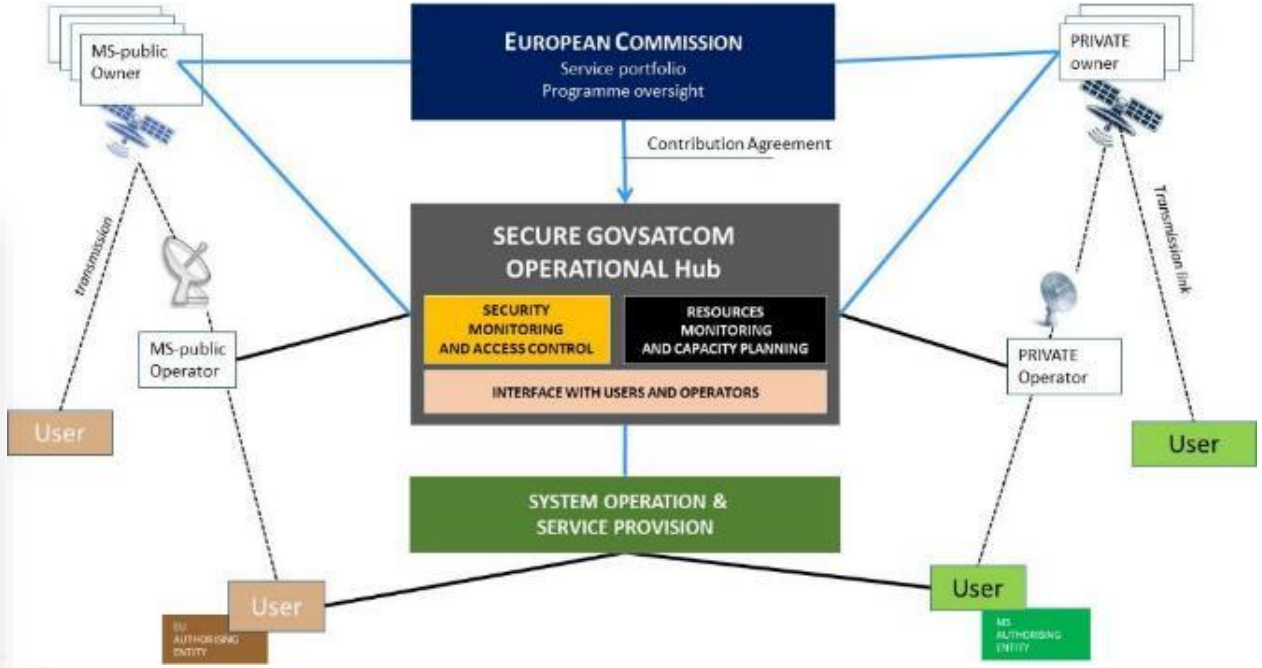
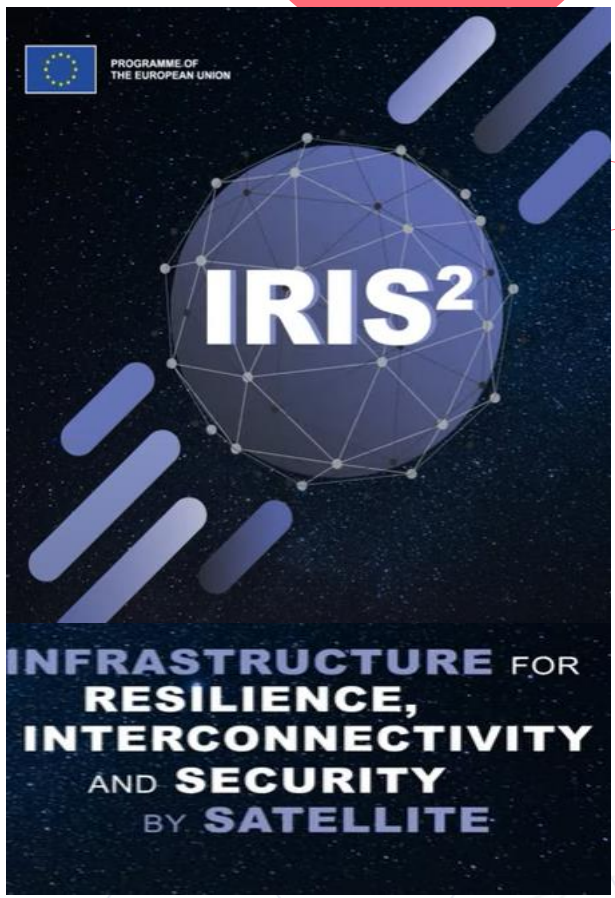
ENTRUSTED





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Horizon Europe R&D activities & Contribution to Ionospheric Prediction

Applied R&D on EGNSS Authentication → E-GIANTS

EGNSS Additional dissemination means → IDEEAS

Definition of an operational service concept for space weather impact on EGNSS (EGNOS and Galileo)

- Assess impact on user operations
- Assess how to inform users on potential EGNSS underperformance

To participate or if you have any question, please feel free to contact us:

javier.OSTOLAZA@euspa.europa.eu

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7 - 9 November - Sevilla, Spain

Downstream standardization, what for ?

or how innovations, end users and markets need it

User Consultation Platform: Road and Automotive

Miguel ORTIZ, Gustave Eiffel University

European Commission

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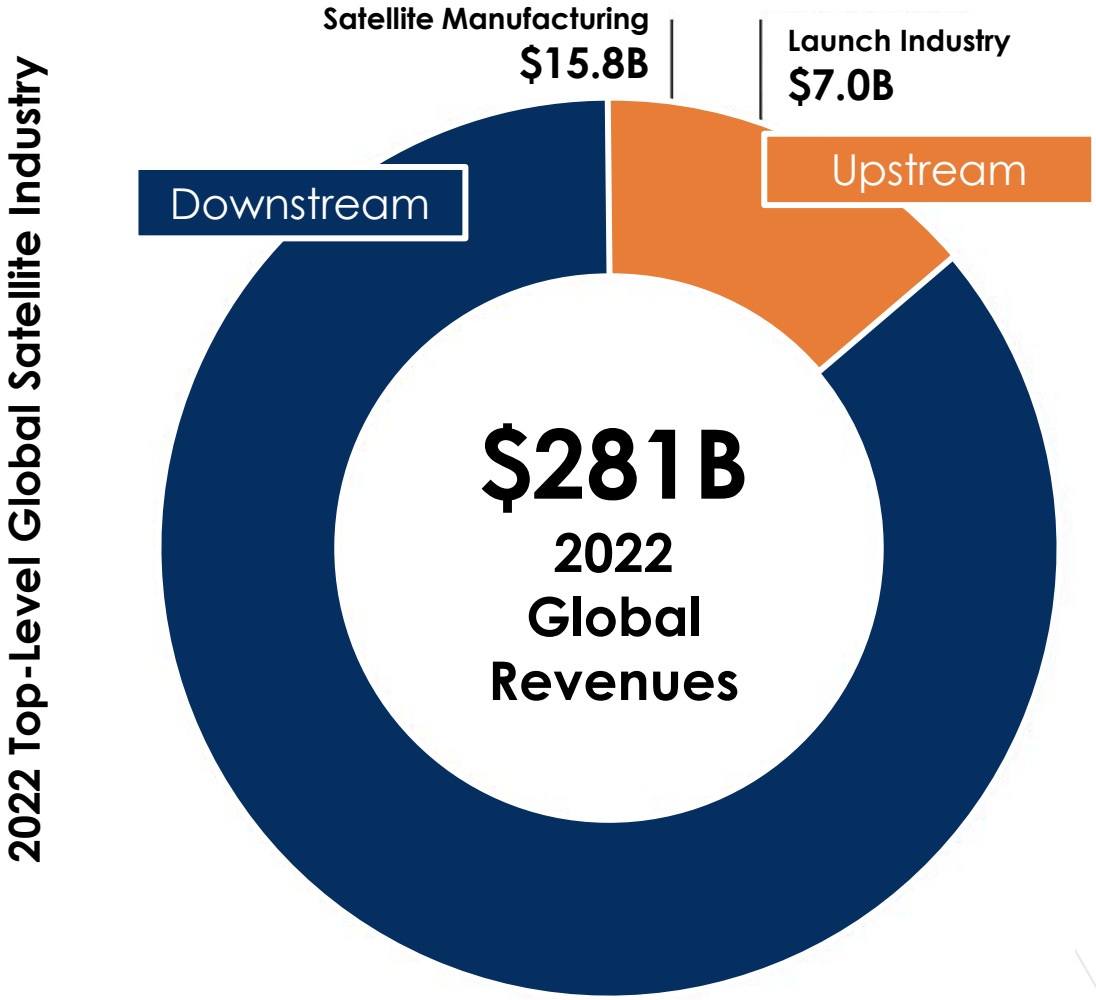
The downstream space market is huge



Source: BRYCE, SIA State of Satellite Industry Report 2023. URL here

The **global GNSS downstream market revenues**, covering both device sales and service-related revenues, is expected to grow at a CAGR of 9.2% over the next decade**, reaching a total of €492 billion by 2031**.

Source: EUSPA, EO & GNSS Market Report 2022 URL here

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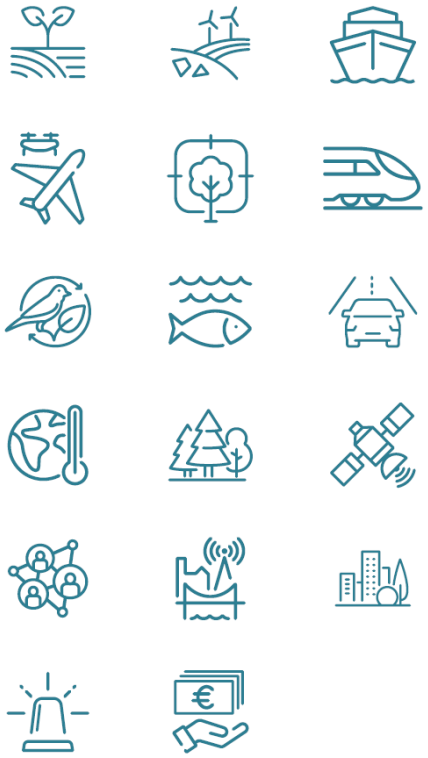
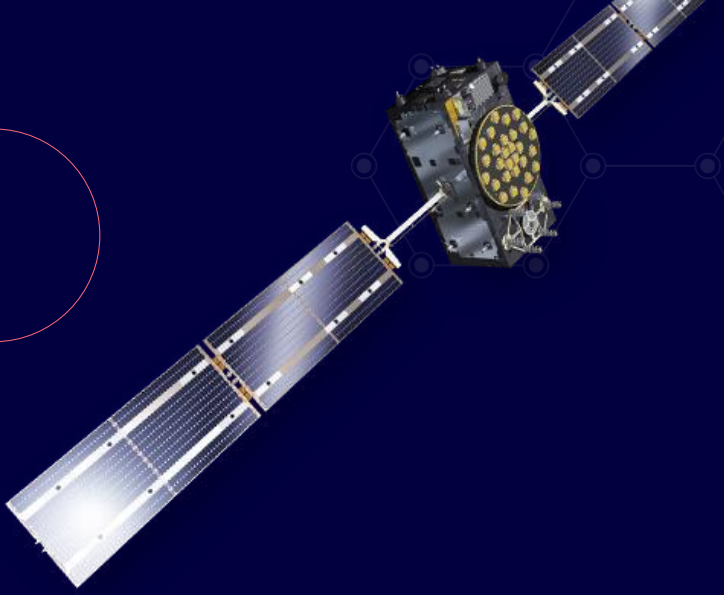
The downstream space standardization needs to:

- **Federate** experts, industries and operators in this domain
- Highlight and strengthen downstream activities
- Develop common international downstream standards to promote the
  downstream market
- Support large scale deployment of space services and applications, including safety and critical ones (eg disaster management)
- Enhance **interoperability**
- Promote **fair comparison** of performances





EN16803: a success story for PNT-GNSS

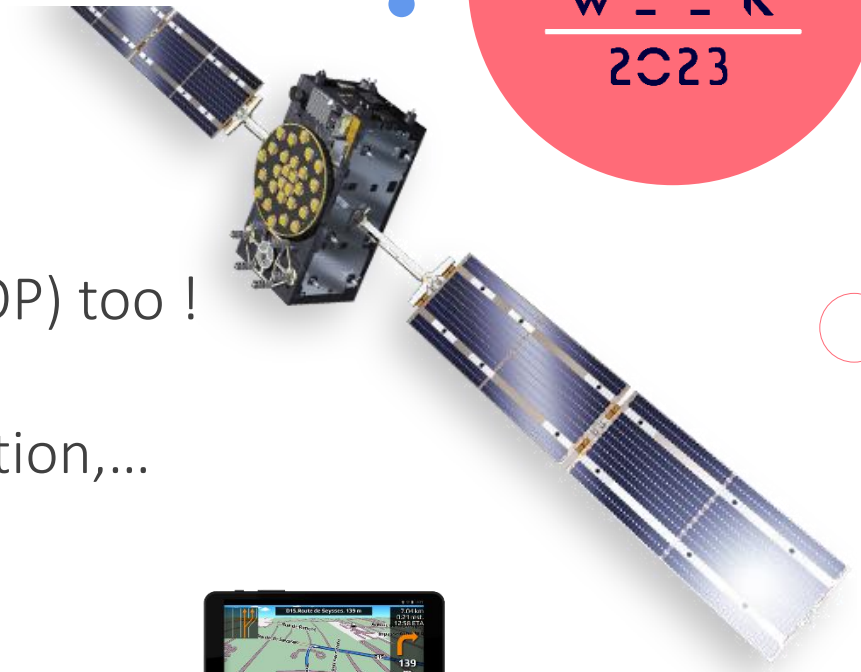
Context: GNSS based positioning systems

0.1 m ?

- **Not** for every use cases
- **Not** in all environments
- **Not** always:

  satellites are moving, Dilution Of Precision (DOP) too !
- **Not** without specific corrections:

  HAS, RTK, DGPS, PPP, iono, tropo, clock correction,…



Questions raised:
1- what is the "real" level of :

-Accuracy
-Continuity
-Availability
-Integrity

} of **my** GNSS based positioning system ?
for **its** use case ?
in **its** environment ?

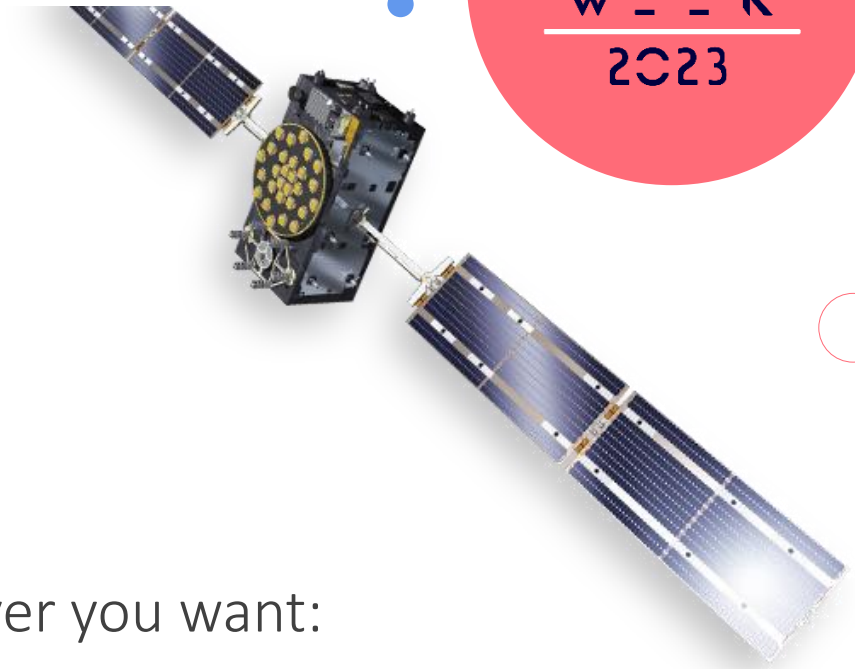
2- And how to be sure of that ?
-which standards to apply ?
-what about certification / type approval of such systems ?

Datasheets
-CEP50%
-Roof top of building
-Static mode

Context: GNSS based positioning systems

- 4 Global Navigation Satellite Systems are operational:

Europe USA China Russia



- Plus additional regional satellite systems
- From ~20,000 km altitude, they are used to locate whatever you want:

- You are here :

43°39'44.3"N 1°20'56.0"E
43.662293, 1.348878 → **0.1 m**

Really ?

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How to assess « real » GNSS performances ?

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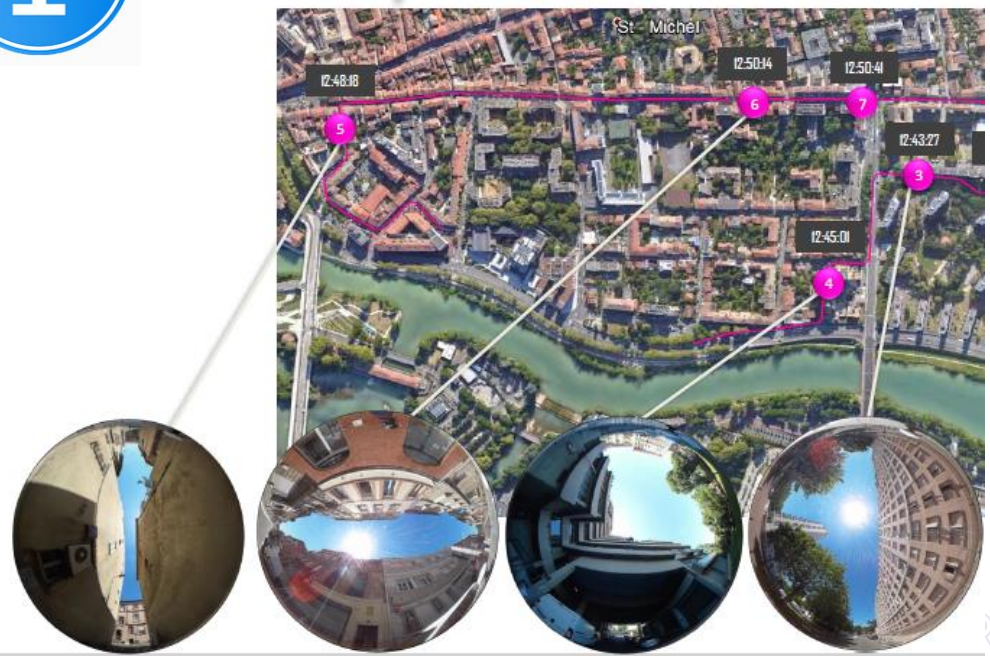
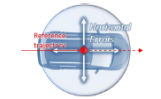
Solution proposed by EN16803:
Record & Replay YouTube

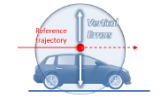
1 Record phase

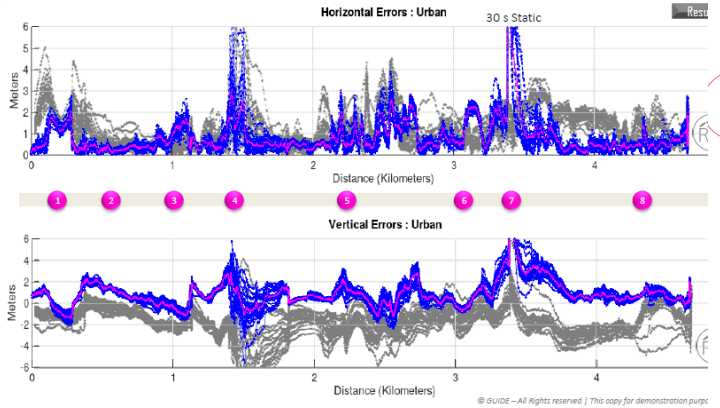


2 Replay phase



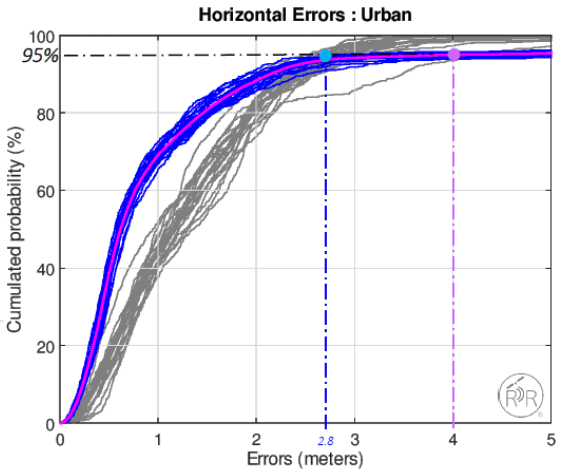
DUT Measurements
- Batch of positions SBAS
- Mean of positions SBAS
- Batch of positions Standalone





3 Analysis

EN: European Norme



Results

	50 %*		
	Err Mean	Err Max	St Dev
Horizontal	0.60 m	0.70 m	0.05 m
	75 %*		
	Err Mean	Err Max	St Dev
Horizontal	1.30 m	1.40 m	0.10 m
	95 %*		
	Err Mean	Err max	St Dev
Horizontal	4.00 m	6.10 m	0.10 m

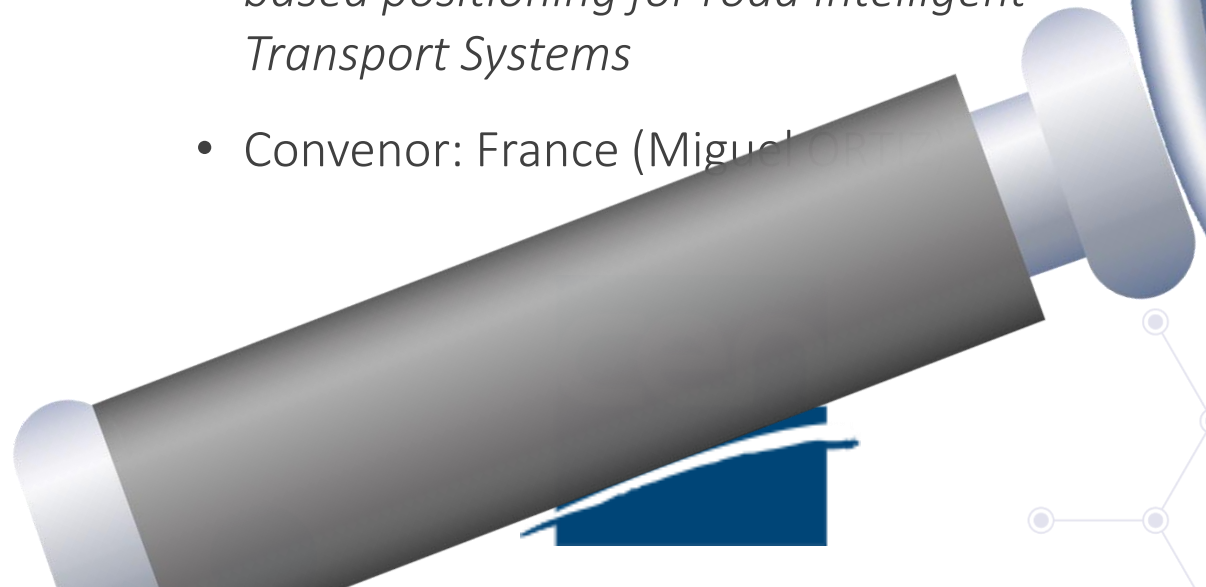
*Referred to SBAS corrections active

Illustrations are courtesy of GUIDE

Downstream space standardization

European

- CEN-TC5-WG1
- “Navigation and positioning receivers for road applications”
- 4 standards on going
- EN16803 series: *Space — Use of GNSS-based positioning for road Intelligent Transport Systems*
- Convenor: France (Miguel ORTIZ)



International

- ISO-TC20-SC14-WG8
- “Downstream space services and space-based applications”
- Officially created September 2022
- 12 standards on going on PNT/GNSS and EO
- Convenor: France (Miguel ORTIZ)
- Co-convenor: Japan (Koki ASARI)

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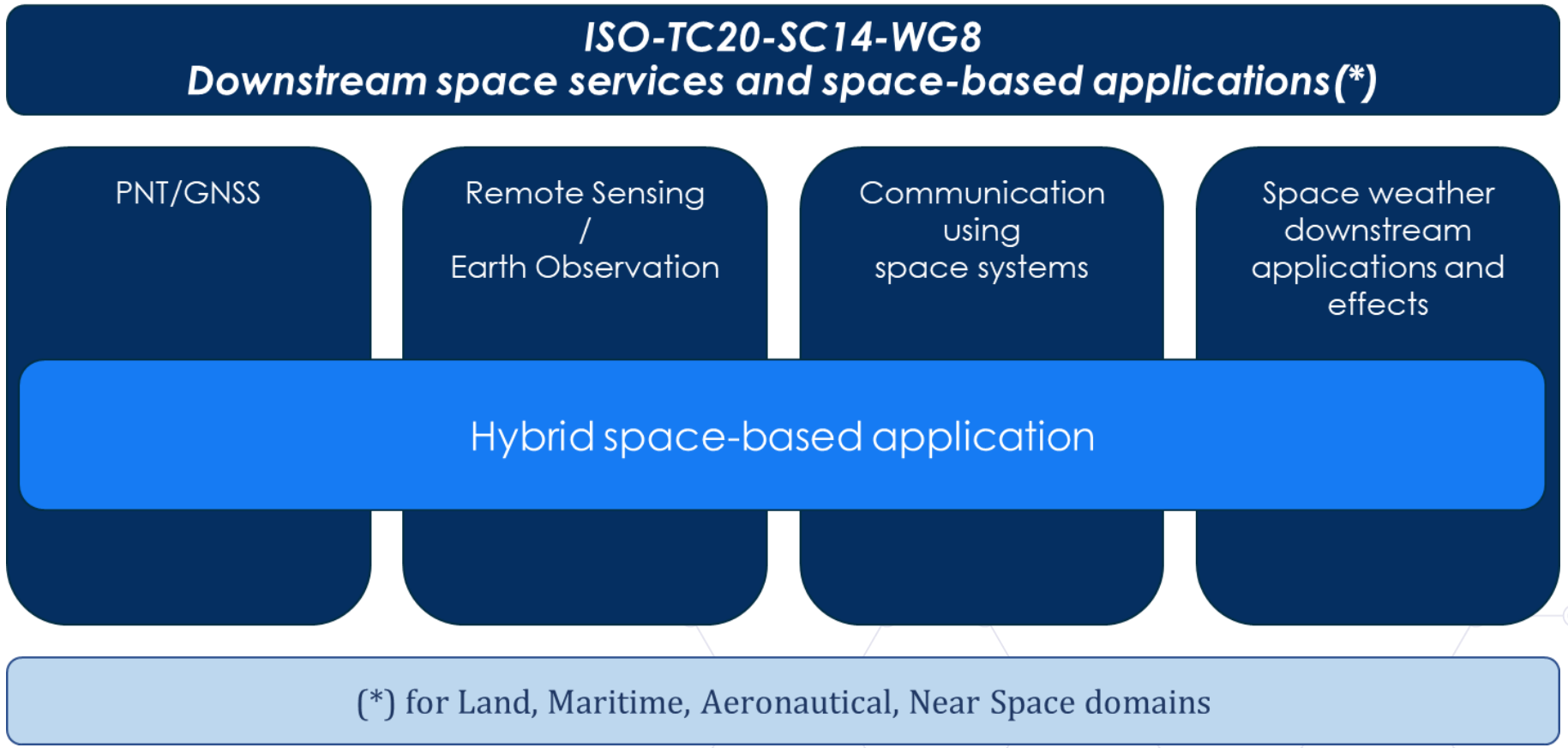
ISO-WG8: High level architecture



.PDF

TopLevel Document v1

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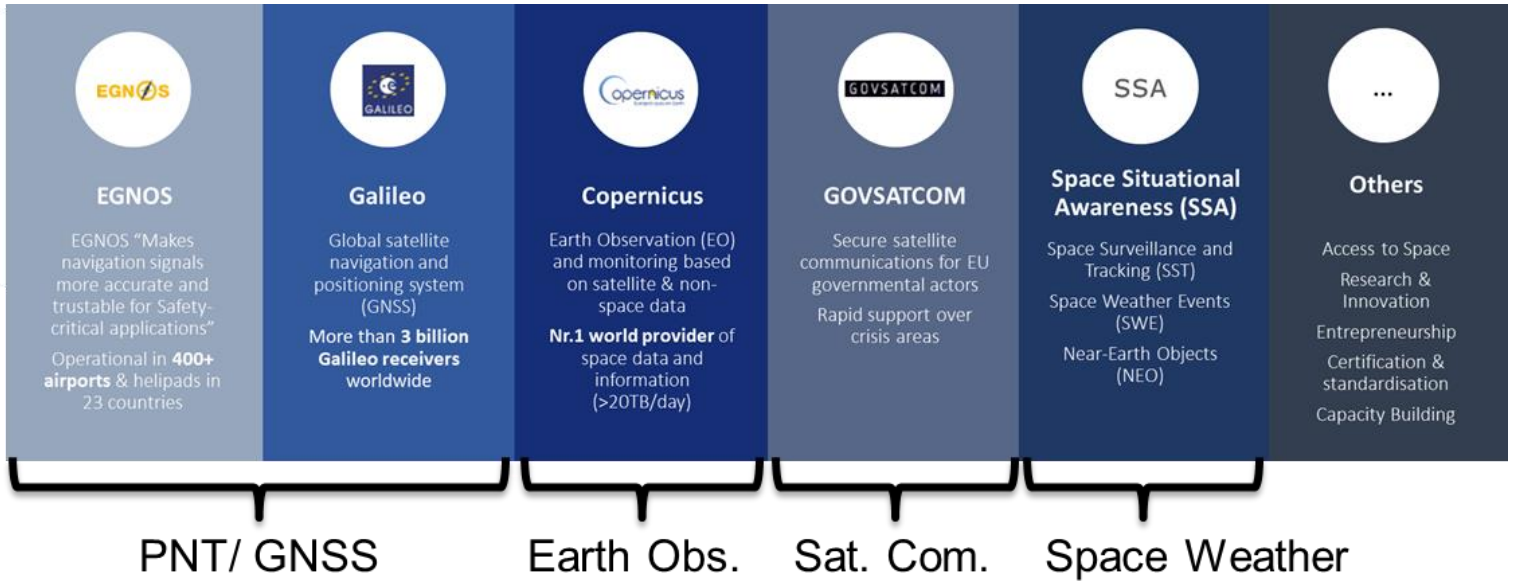
- 35 members registered on ISO platform, 9 countries, 1 liaison* :

  Brazil / France / Germany / Greece / India /
  Japan / Russia / United Kingdom / United States

- overview:

ISO-WG8 : a perfect match with EUSPA



Downstream market for space services and applications

- For Galileo, EGNOS, Copernicus, GOVSATCOM

Contribution to user standards development

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Let’s standardize together !

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Université Gustave Eiffel

Miguel Ortiz
Deputy head of GEOLOC Lab
ISO-TC20-SC14-WG8 convenor
CEN-TC5-WG1 convenor
miguel.ortiz@univ-eiffel.fr

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GNSS Tolling

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User Consultation Platform: Road and Automotive

Sergio Pérez Gámez

Kapsch see multiple schemes and use cases which fall under the ‘location-based charging’ umbrella

GNSS-based tolling

National schemes aimed at introducing distance-based tolling, typically across highways only and for HGVs

HGV

Road User Charging

Distance based road usage charges designed to replace existing fuel and/or vehicle taxes

All Vehicle

City based road pricing

Access and/or distance-based pricing within a specific city zone or urban area

All Vehicle

Pass through detection

Pass through detection at existing toll points as a replacement for existing DSRC/RFID/Video solutions

All vehicle

All are supported with the use of GNSS data within our device agnostic geo location platform

Location based charging for all vehicles represents an evolution of existing solutions and can be introduced gradually

GNSS for HGVs only + video/DSRC for LVs → LV pass through detection → Choice of video or GNSS for LVs → Mandatory use of GNSS for all vehicles

Use of EETS device data → Use of telematics device data → Use of vehicle data

Use of existing devices and/or video in urban areas → Use of smartphone data → Use of vehicle data

kapsch

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Across Europe, more and more countries, regions and cities are adopting GNSS for tolling or road user charging purposes

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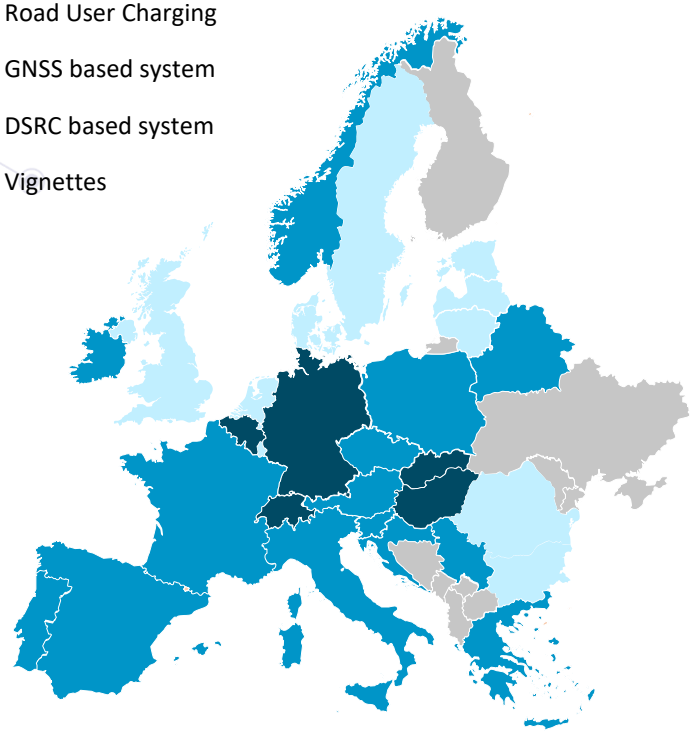
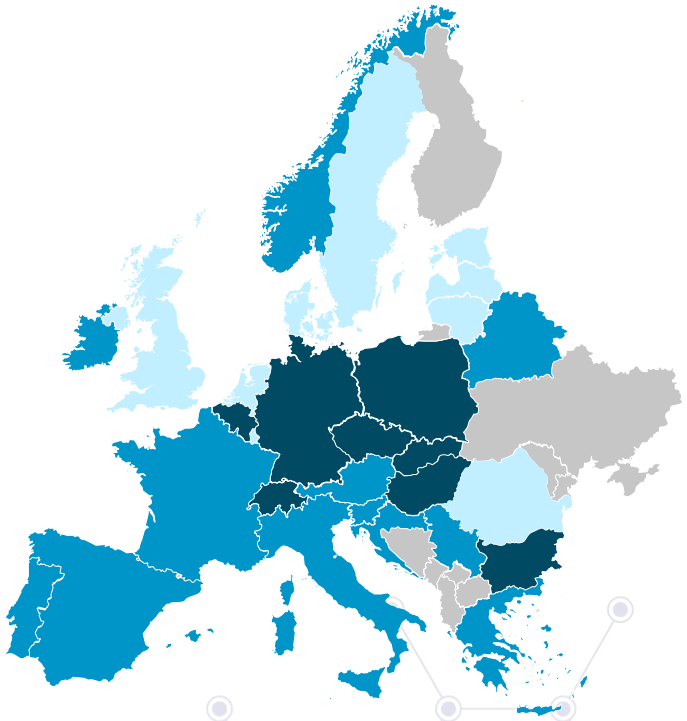
Road User Charging
GNSS based system
DSRC based system
Vignettes

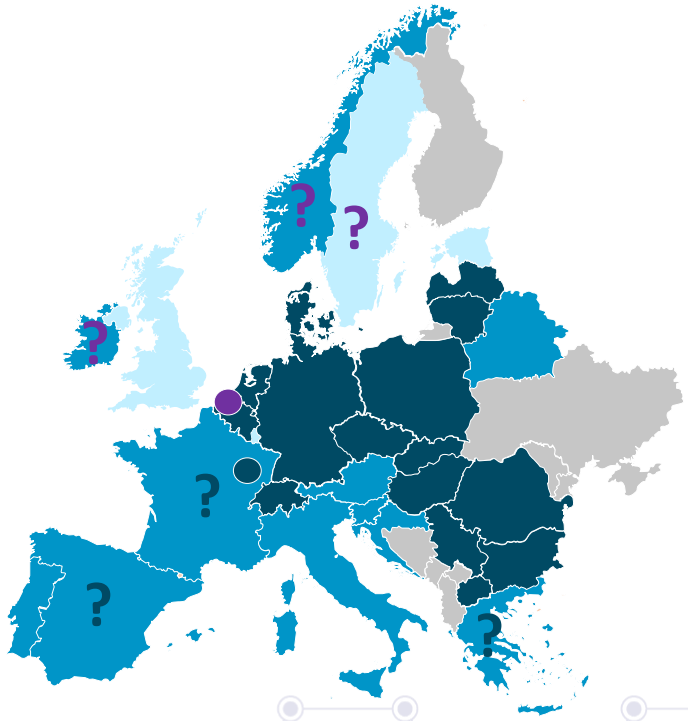
2018



2022



2026



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kapsch >>>

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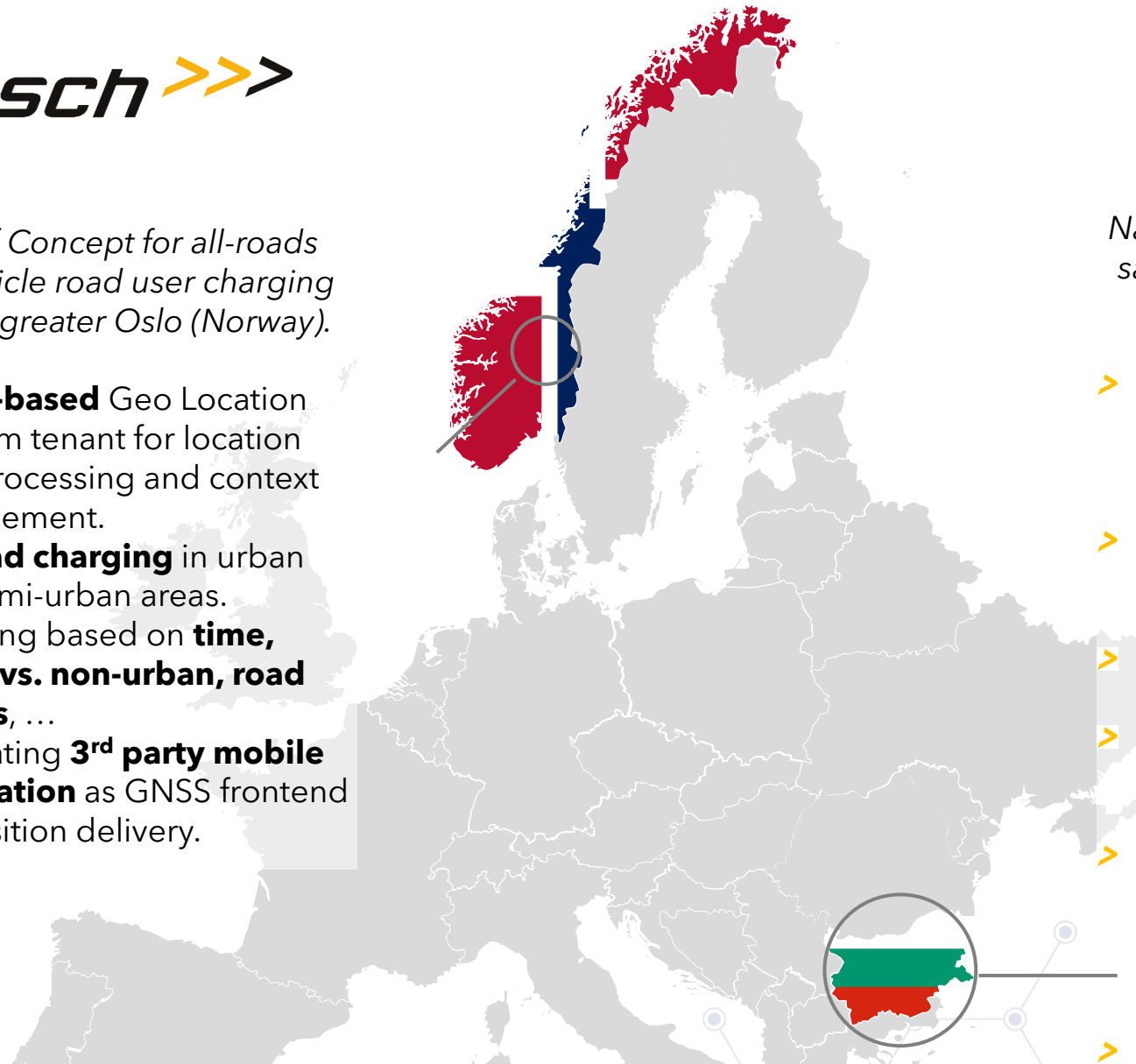
Proof of Concept for all-roads light-vehicle road user charging (RUC) in greater Oslo (Norway).

- **Cloud-based** Geo Location Platform tenant for location data processing and context management.
- **All-road charging** in urban and semi-urban areas.
- Charging based on **time, urban vs. non-urban, road classes**, …
- Integrating **3rd party mobile application** as GNSS frontend for position delivery.



Nation-wide heavy goods vehicle satellite tolling in Bulgaria – GLP on service provider side.

- **Cloud-based** Geo Location Platform tenants for location data processing and context management.
- System provided **as-a-Service**, hosted, technically operated and maintained by Kapsch.
- Processing roughly **60 million GNSS locations** per day.
- Receiving data from almost **300,000 devices,** both Kapsch OBUs and 3rd party.
- **Map Matching to roughly 20,000 kilometers** of (map matched) road network. About 6,000 kilometer of toll-liable road.
- Data processing and toll declaration generation **near real-time.**

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Requirements and future needs

GNSS user requirements

- ACCURACY
  - Horizontal - Less than 30 meters
  - Vertical - N/A
  - Timing - Less than 1 second
- COVERAGE
  - Higher than 95%
- AVAILABILITY
  - Same for all scenarios
- TTFaF
  - Less than 30 seconds

Road User Charge

Future needs

- Interference detection
- Authentication
  - OSNMA

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7 - 9 November - Sevilla, Spain

Traffic management: Dirección General de Tráfico

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ROAD & AUTOMOTIVE

Antonio Granado Pérez

INTRODUCTION
DIRECCIÓN GENERAL DE TRÁFICO

The Directorate General for Traffic is the Public Administration with competence in road safety and traffic management on interurban roads.

The Traffic Management Centers of the DGT are operational 24 hours a day, 365 days a year, and are staffed by specialized officials and technical personnel from collaborating companies

ROAD SAFETY STRATEGY 2030

OBJECTIVE DGT VISION 0

WHERE INTER-URBAN TRAFFIC IS MANAGED?

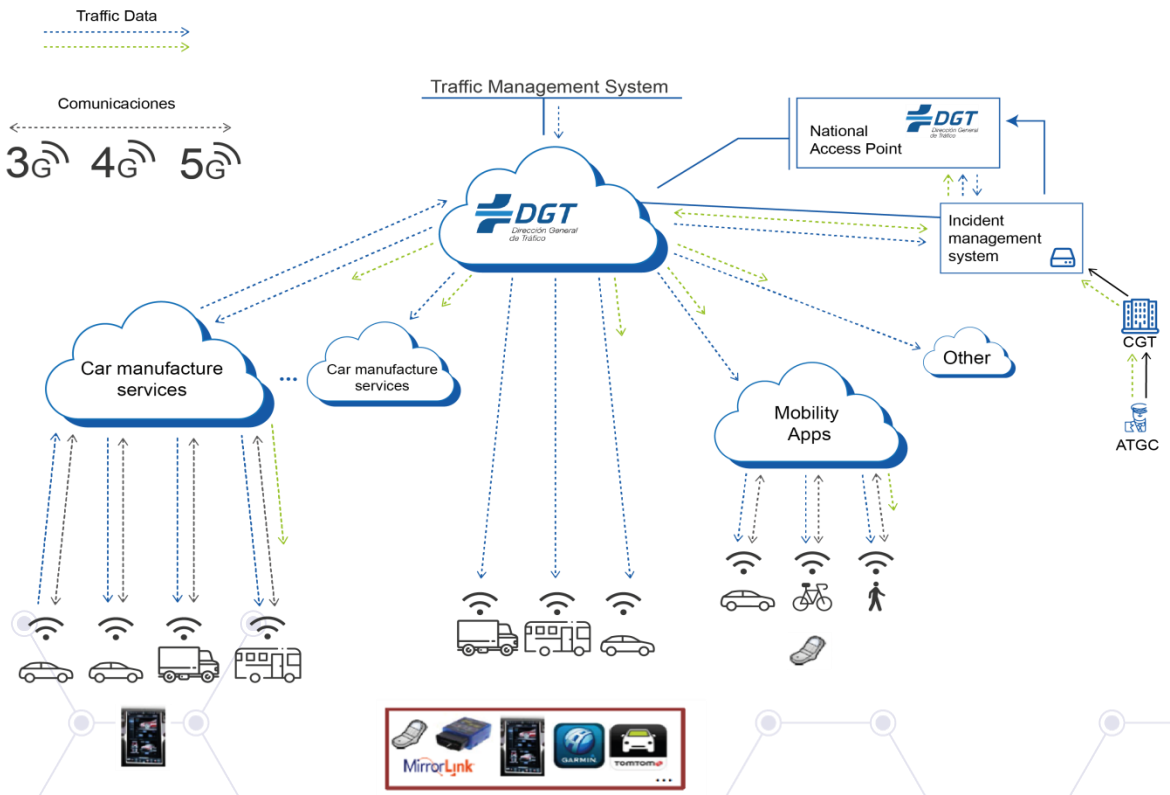
IMPORTANCE of deriving new functionalities from ITS systems through INNOVATION

- Data Collection and Integration
  - Data from ITS
  - Data from other entities/agencies
  - Geospatial Data.
  - NAP: National Access Point (NAP) for Transport and Mobility

https://nap.dgt.es/

INNOVATION – DGT 3.0 - Connected Vehicle Platform

- It is the IoT Platform developed by Dirección General de Tráfico (DGT).
- Public cloud, with scalability, availability, security and portability capabilities.
- Allows interconnection between all the actors that are part of the traffic and mobility ecosystem, such as: manufacturers of vehicles and signaling devices, public transport platforms, city councils, insurance companies, and application providers; related to safe and smart mobility and different road users.



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INNOVATION - IOT DEVICES INFORMATION

USE CASE 1	USE CASE 2	USE CASE 3
V16	REAL-TIME TOW TRUCK LOCATION INFORMATION	LOCATION OF INTELLIGENT ROAD CONES
		

DESCRIPTION	It collects information on all those breakdowns or accidents that occur on the road	The roadside assistance requires communicating by telematic means to the competent authority for traffic regulation, for publication in the NATIONAL ACCESS POINT	The works service provides centralized access to information on the impact on the roadway caused by works that have been registered with the General Directorate of Traffic
INFORMATION	Emits a warning light. It connects to DGT 3.0 to transmit its location in real time.	The DGT provides the DGT 3.0 platform so that, once the real-time geolocation of the roadside assistance vehicle is received, it is published through the platform	The information published refers to the time frame and how affected the section is

INNOVATION

USE CASE 4

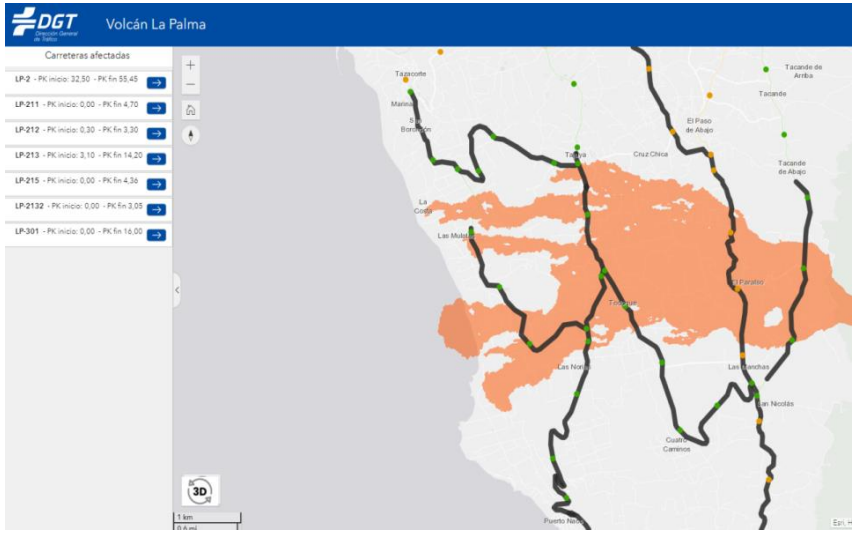
ROAD MANAGEMENT IN NATURAL DISASTERS

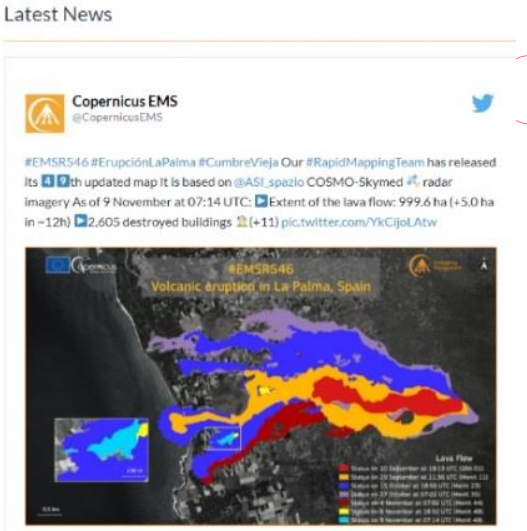
Cumbre Vieja Volcano
La Palma (Canary Islands)

September 2021

INFORMATION

Integration of images from the European Copernicus satellite with the National Access Point for real-time dissemination of road closures and possible alternative routes.





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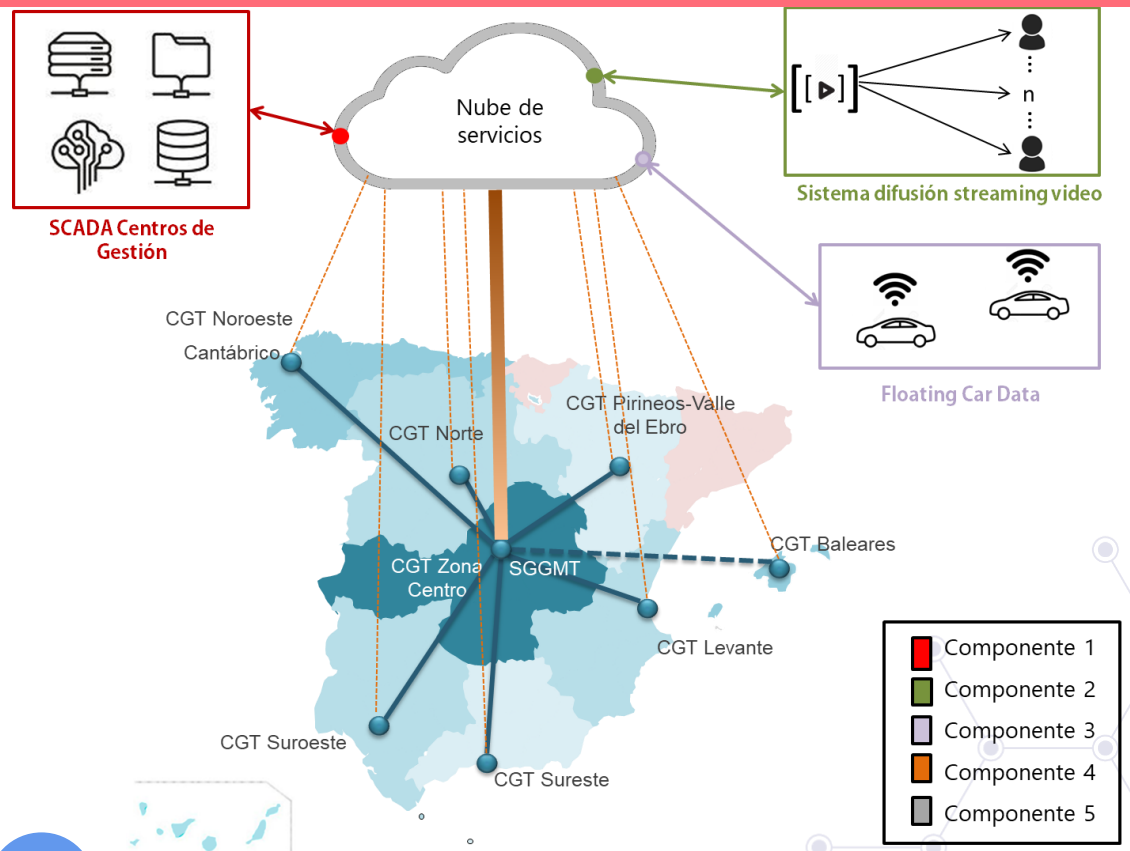
INNOVATION

USE CASE 5

PROJECT FOR IMPLEMENTATION OF A CORPORATE SCADA IN DGT WITH FLOATING CAR DATA INTEGRATION



Corporate SCADA in the 8 Traffic Management Centres in Spain.
Floating Car Data Integration - Real Time / Historical

Objectives:

- Improved identification of road problems.
- Improved decision making.
- Improved response times.

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CONCLUSIONS

The integration of geospatial/geolocated/satellite data represents a major improvement opportunity for DGT.

They are part of aspects related to innovation and improvement of the services provided to users within the scope of our competences.

ASPECTS THAT COULD BE SUBJECT TO IMPROVEMENT IN THE USE OF DATA

- Improvement of integration procedures.
- Greater knowledge of existing data sources and their applications.
- Data quality in the cross-referencing with DGT information systems.
- Possibility of developing joint actions / innovation projects.

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COPERNICUS FOR ROAD INFRASTRUCTURES, END-USER PERSPECTIVE - ANAS EXPERIENCE

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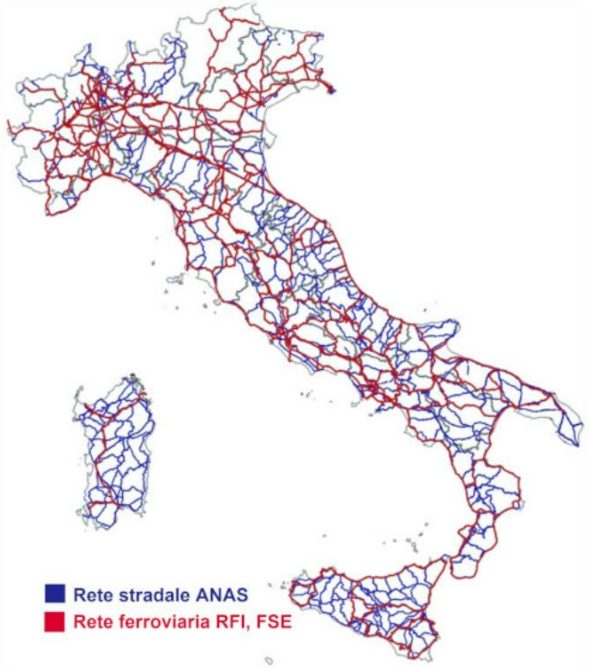
Road & Automotive session

Roberto Giuliani – Technology Innovation & Digital Spoke Dpt
Anas S.p.A.

ABOUT ANAS S.p.A.

Managing national roads and motorways since 1928

Anas is an innovative, efficient and transparent **joint-stock company** that operates at national and international level with **Ferrovie dello Stato Italiane** as sole shareholder



FS Italiane Infrastructure Pole (RFI, Anas, Italferr and Ferrovie del Sud-Est) can play a **key role** by working synergistically to build **accessible, integrated, resilient, interconnected road and rail works**

Anas deals with **roads** from **design,** starting with feasibility study and environmental impact assessment, to **construction** and subsequent **routine and extraordinary maintenance**

Anas roads infrastructure

32.000 km roads

2.034 tunnels

20.151 bridges and viaducts

21 local control rooms

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THE CHALLENGE

Road networks management with high hydrogeological instability

Italy

Geologically young country with significant **instability of the ground** (structural terrain movements, floods, earthquakes)

- **94%** of municipalities considered at risk of landslides, floods or coastal erosion
- More than **620.000** landslides recorded from 2016 to 2021
- Average increase of **1.000** events per year

(ISPRA - Italian Institute for Environmental Protection and Research Report 2021)

It makes sense **to adapt the specifics of road infrastructures** making them **more performing** and **less exposed to climate change** and natural hazards

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ANAS POSITIONING IN EO VALUE CHAIN*

Space technology added value in roads management

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Drivers	Upstream	Midstream	Downstream	End users
Data needs	Data capture	Data handling	Data exploitation	Data use

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The **integration of space technology** into the design, construction and operation of infrastructure represents an **opportunity** for the development of **safer, resilient and eco-friendly roads and motorways**

TARGET BENEFITS

- **More accurate preliminary study** for a new road in a territory
- Detection and **understanding ground motion**
- **Reduction survey cost** by prioritizing field analysis
- **Reduction** of **cost for road condition maintenance** and remedial works
- **Reduction** of **works delay and related cost**

** source: Geoawesomeness*

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EO TECHNOLOGY AND HYDROGEOLOGICAL RISK

Development Cycle of Roads by phase

PLANNING PHASE

Priorities definition
Surveying of the area limited and addressed to **understand the geological characteristics**
Evaluation of **environmental and economic trade-offs**

DESIGN PHASE

To focus **design criteria to establish a set of road standards** and **traffic service levels**
Route confirmation
Construction techniques and **costs**

OPERATION AND MAINTENANCE PHASE

Dealing with **monitoring and maintenance** of **critical infrastructures**
To carry out a **risk assessment** for existing infrastructures
To strengthen the **resilience** and the **safety** of **roads**

CONSTRUCTION PHASE

To limit the risk that **ground movements previously undetected will occur during construction**, even that movements are caused by construction works

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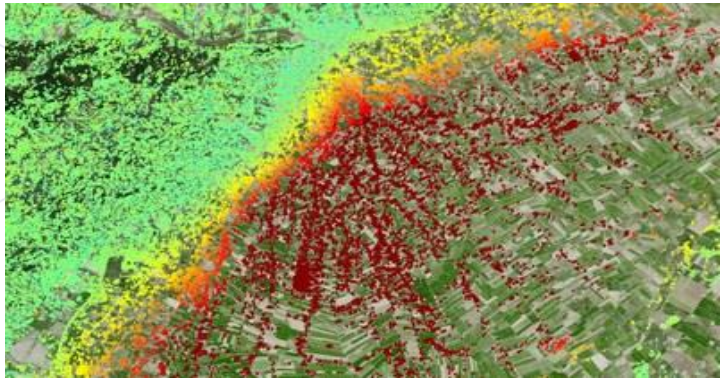
EO DATA WITHIN ANAS BUSINESS

Use cases domains



GROUND DISPLACEMENT IN ROADS DESIGN AND CONSTRUCTION

To assess risks and **adapt road projects** with the aim of **reducing the danger of subsequent problems** for roads

Anas is approaching **SAR Interferometry (In**data derived from Sentinel-1 based on EGMS**SAR)**, thanks to past and updated maps showing millimetric movements on the ground

- **Sentinel 1 Copernicus mission**

MONITORING BRIDGES AND VIADUCTS

Co-design R&D project* financed by **Italian Space Agency (ASI)**

- **EO DATA:** DInSAR, imaging geodesy
- **GNSS receivers**: timely and continuous information of the infrastructure
- **UAV**: surface image acquisition
- **Machine learning**: automatic recognition of structural defects
- Compliance with **Guidelines for Risk Classification and Management, Safety Assessment and Monitoring of Existing Bridges (Italy, 2020)**
  - **Cosmo – SkyMed**
  - **Cosmo – Second Generation**

IRIDE
NEW ITALIAN EO SATELLITE PROGRAMME

Anas is participating in **user requirements definition phase** of the services for the following lots:

- **landslide monitoring**
- **critical infrastructures monitoring**

Features

- **LEO** constellation
- **Microwave imaging** (SAR),
- **Optical imaging** (from high to medium resolution)
- **Different frequency ranges**, (panchromatic, to multispectral, hyperspectral, infrared bands)

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Images credits: EGMS, Anas, Iride

EUSPA USER CONSULTATION PLATFORM (1/2)

Use cases vs user requirements

Use Case	Limit	Need for applications
To identify **critical ground motion phenomena** for the design and construction of **new road sections**	The deformation phenomenon cannot be measured only on the basis of the measured speeds based on interferometric techniques; they always require **to be supported by geological and geomorphological data**	To complent the PS chromatic scale with **indicators that characterize the soil factors contributing to the phenomenon** (site specific geo-morphological and geological features)
To identify and quantify the **rates and displacement trends of active landslides** along road sections	Good results while observing slowly evolving movements; due to the inherent characteristics of the methodology and the physics of the signal **fast displacements cannot be measured** (i.e. collapses and debris flows)	**To monitoring of landslide with moderate velocities** (according to the landslide velocity scale proposed by Cruden and Varnes, 1996)
Evaluation of the **trends of deformations**	Revisit time: limit of the use of the interferometric data for the **static mapping of the deformations updated to the latest available acquisition**	**Provide predictive analysis** by utilizing historical time series/statistical data and machine learning algorithms

EUSPA USER CONSULTATION PLATFORM (2/2)

Use cases vs user requirements

Use Case	Limit	Need for applications
Monitoring bridges and viaducts	The deformation measurement A-DInSAR interferometry addresses a reference point, **it is not an absolute value**. GNSS sensors can be integrated, continually updating the 3D position of target points	**Integration of satellite technology domains** and services to be addressed **through a multi-scale and multi-frequency approach**, in support to in situ verification and improving their efficiency at national scale (static and dynamic monitoring)
	To point out the possible **interaction of potential ground displacements with a target infrastructure**	Capability **to identify landslide/ground motion phenomena that occur around the infrastructure**, within a buffer zone determined by the user
	Reporting of differential settlements and relative displacements between different parts of the infrastructure	To detect and measure **potential differential settlements and relative displacements between distinct parts of the same structure** (e.g., relative displacements between the spans of a bridge)
	To merge synergistically the expertise of **satellite interferometry and structural engineering** into co-design GM services	**Small scale (up to €150K-€200k EUR) R&D funding open calls** for innovative applications developments (PoCs, demo pilot projects**), to design new generation of user driven EGMS**

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ADAPTARE

For improving climate resilience of road infrastructures

User Consultation Platform. Road and Automotive session

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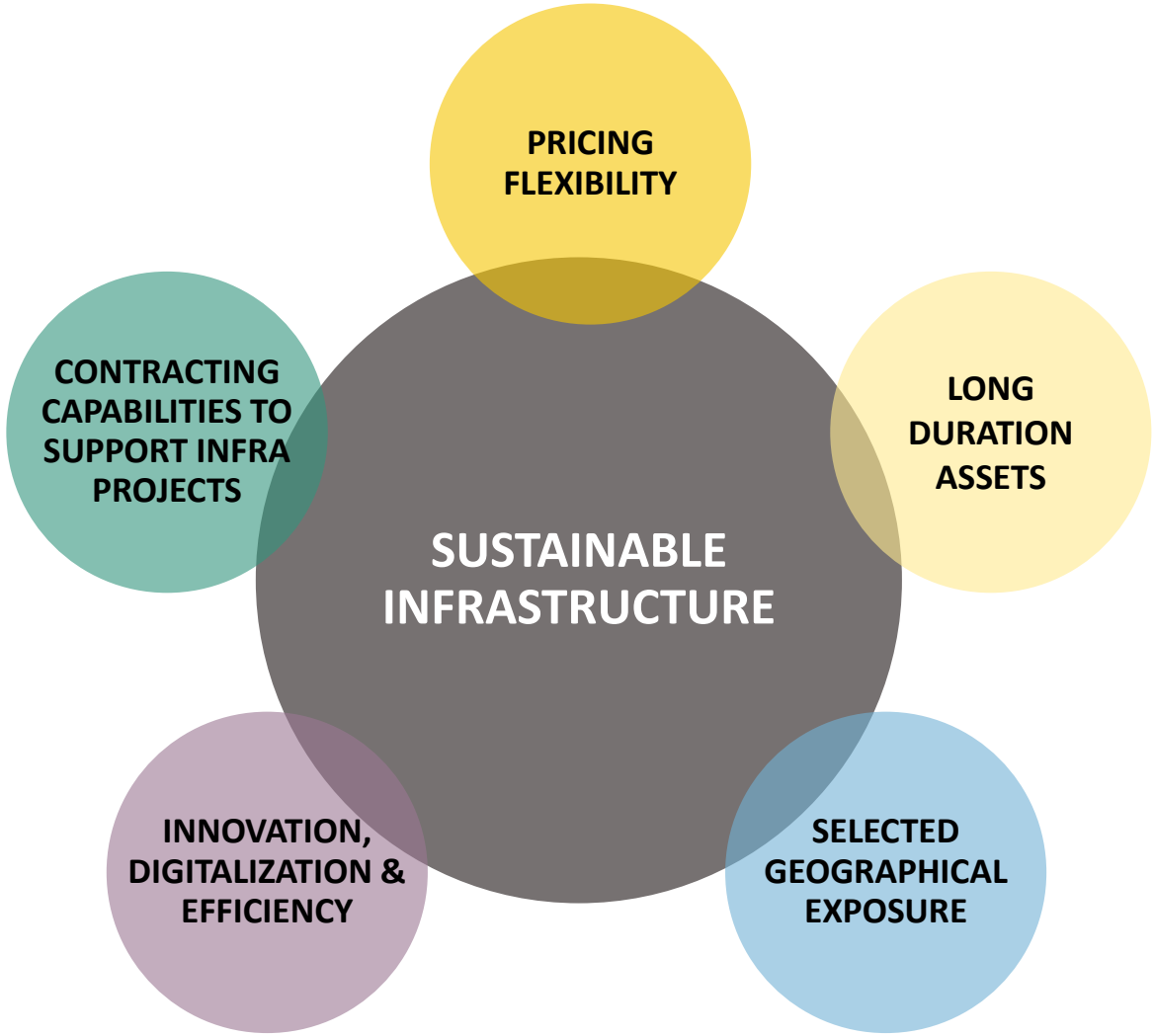
Dr. Valentin Alfaya
ferrovial

BUSINESS MODEL

DEVELOPING & OPERATING INNOVATIVE, EFFICIENT AND SUSTAINABLE INFRASTRUCTURES WHILE CREATING VALUE FOR OUR STAKEHOLDERS



TOLL ROADS

- Maintain & develop competitive advantages with traffic risk & availability projects and grow in greenfield projects of high concessional value.
- Focus on Managed Lanes.
- Main assets:
  - 407 ETR (Toronto, Canada)
  - Managed Lanes in USA: DFW in Texas (NTE, LBJ & NTE35W), I-77 in Charlotte & I-66 in Virginia (full configuration Nov.22)
  - IRB a leading Indian road developer (24.86%)

AIRPORTS

- Yellow-field projects & operational capabilities
- Remain conservative and asset specific
- Main assets:
  - Heathrow (25% stake) – regulated asset
  - UK Regional Airports, AGS (50% stake)
  - Dalaman International Airport (60% stake)
  - JFK – New Terminal One (49% stake)

CONSTRUCTION

- Key to the development of greenfield projects
- Focus on markets with a commitment to infrastructure
- Ferrovial Construction, Webber (TX, US) & Budimex (Poland)

ENERGY INFRASTRUCTURE & MOBILITY

- Exploring new sustainable infra related opportunities
- Power infrastructure, Energy efficiency, Water & Mobility

Adaptare: an assessment tool for **identifying climate risks** associated with different emission scenarios/climate projections for most relevant concessions and assets.

The main **objective** of the platform is to reduce the impact of physical risks and take advantage of the opportunities arising from climate change.

ferrovial

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA
R+D+i FOR SUSTAINABLE DEVELOPMENT

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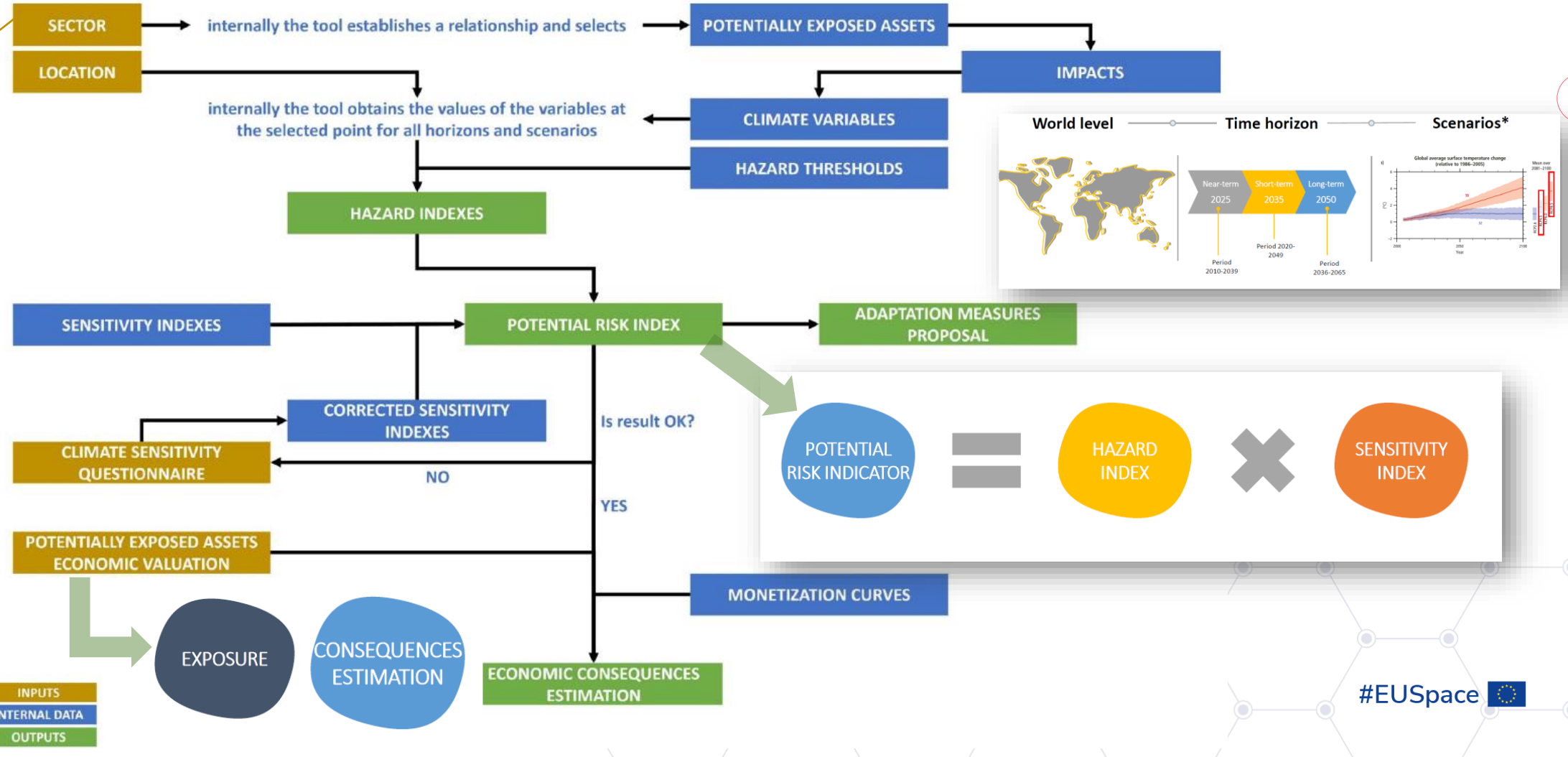
- Roads
- Airports
- Ports
- Building
- Railways
- Grids
- Renewable assets
- Water treatment facilities
- Etc.



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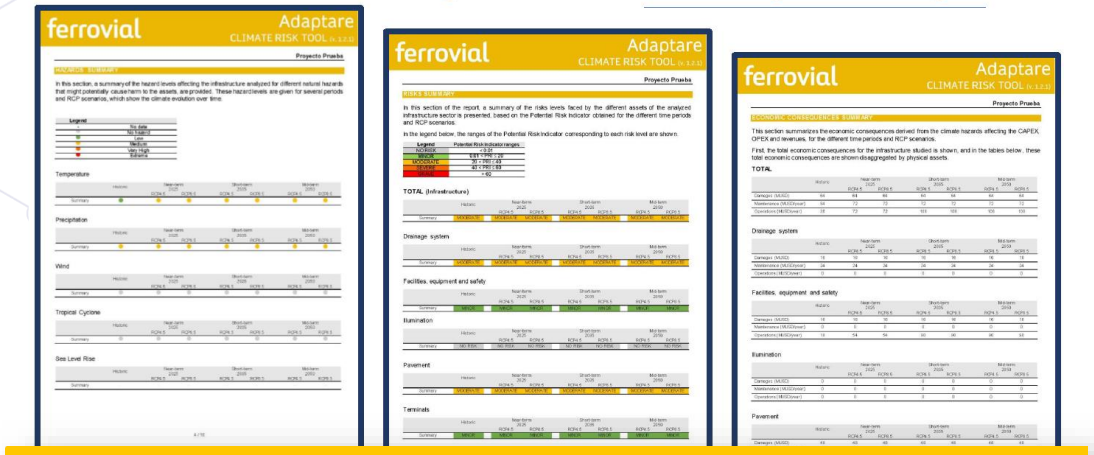
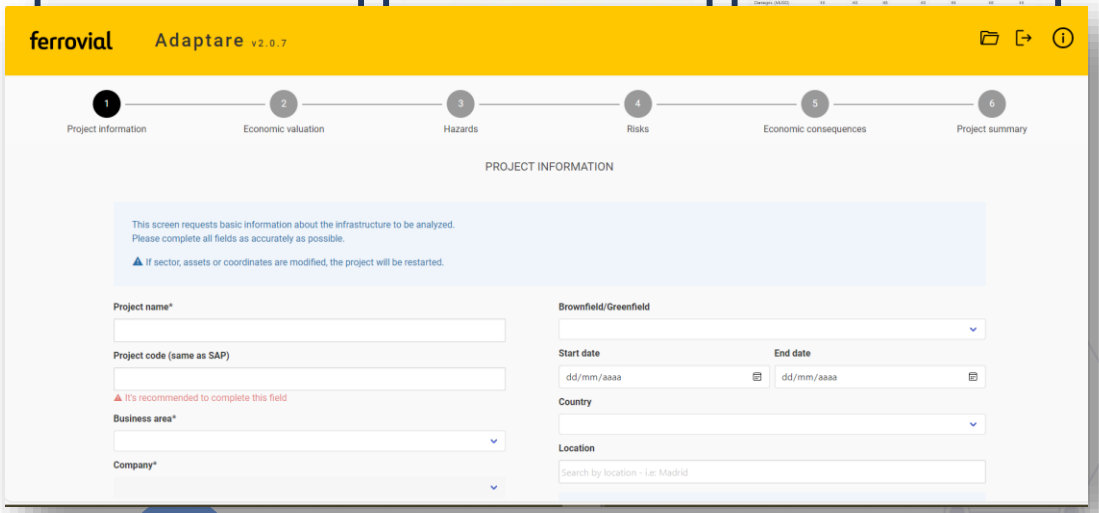
Adaptare also provides a set of **adaptation measures** appropriate for addressing adaptation and improving resilience.

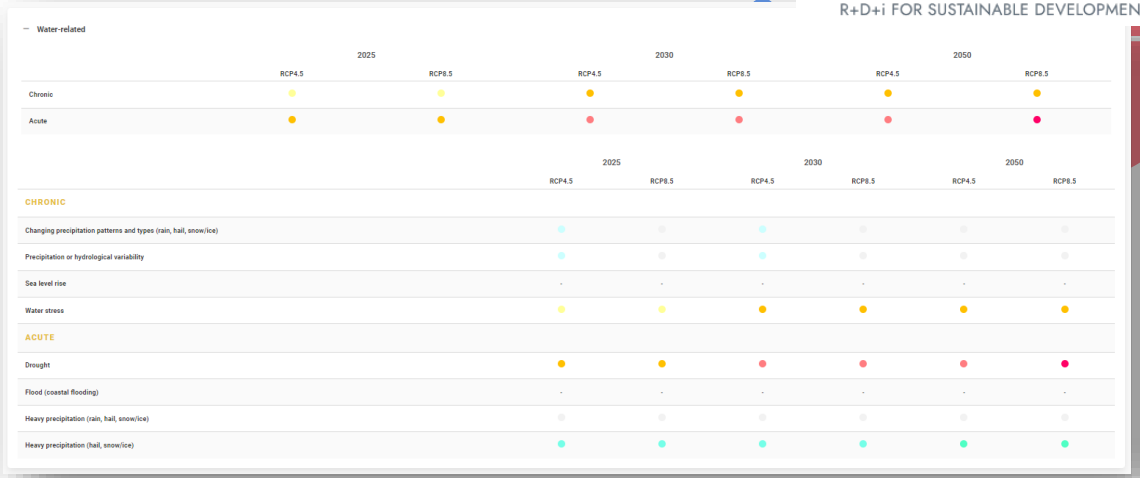
The platform allows us to perform both **technical and economic assessments** in order to make more informed decisions.

Compliance: ADAPTARE provides inputs for **EU Taxonomy** (summary of physical risks evaluation) for more than 1,000 contracts and assets worldwide.

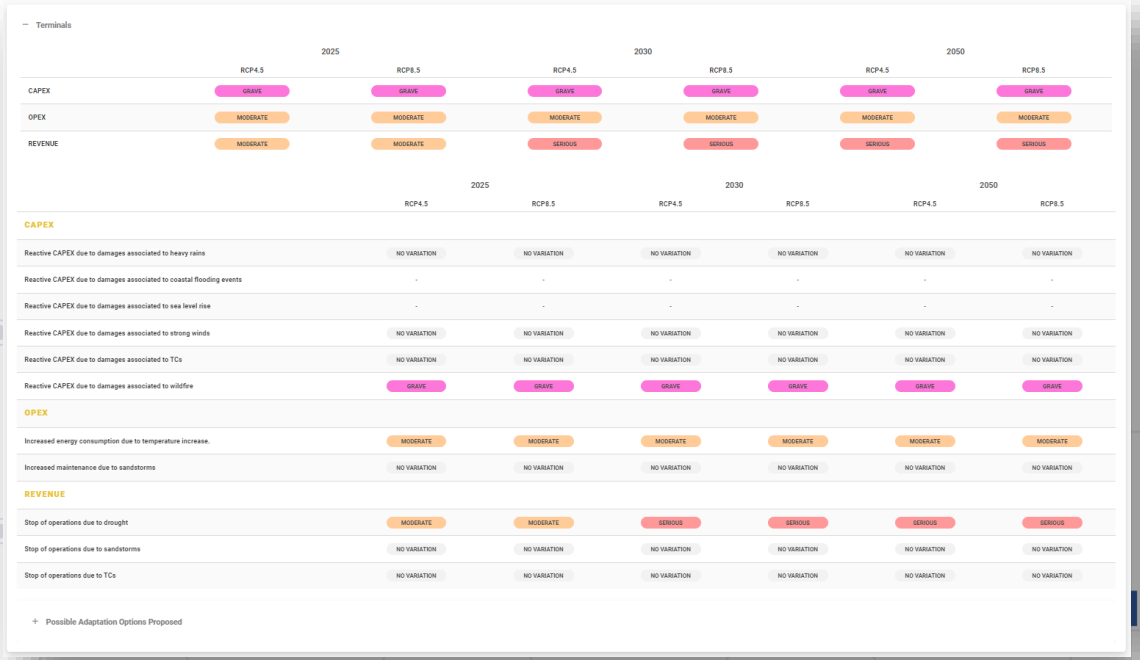




Hazard change levels: e.g. temperature-related climatic indicators



Risk assessment: CAPEX, OPEX, Revenues



Conclusions & suggestions

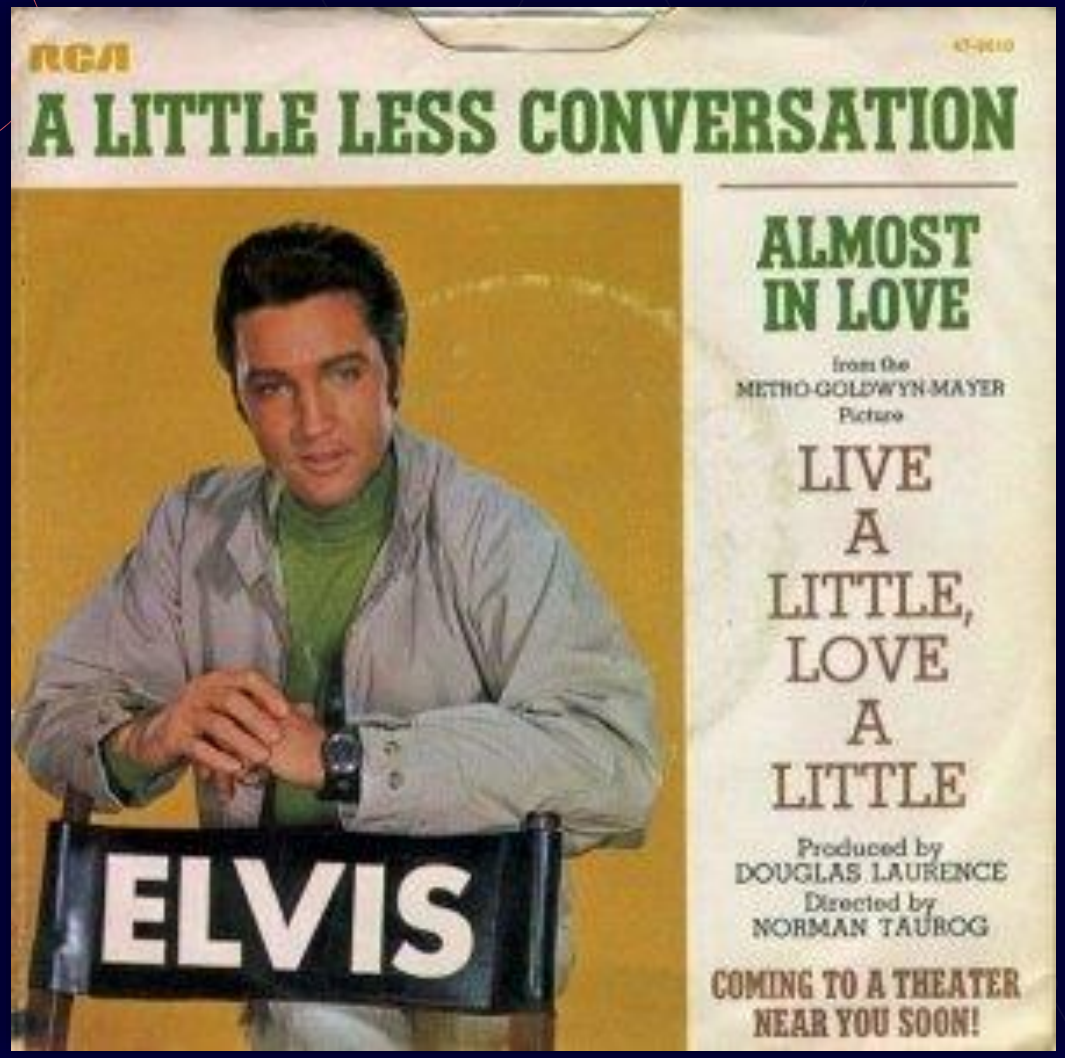
- **Climate resilience** as one of the most relevant topics across industry sectors, BUT…
  - … not many tools appropriate and available for making decisions into the daily business
- **Interactions** with space data / Copernicus products on climate, land use…
  - To assess **present exposure** (baseline, based on local info) and track-record of **exposure evolution**
  - To assess present exposed assets **vulnerability**
  - Climate modelling (i.e. **hazards validation**, after extreme weather events)
- Others… (e.g. satellite flexible tolling, short-term predictions in construction works…)

Some points that could (maybe) be considered

✓ More friendly for not (extremely) advanced users

✓ More/better disaggregation (filtering) of services/products by industry sectors

✓ Short-term and local uses: latency, trajectories considerations



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Copernicus for road infrastructure - products

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UCP: Road and Automotive

Joanna Balasis-Levinsen, European Environment Agency

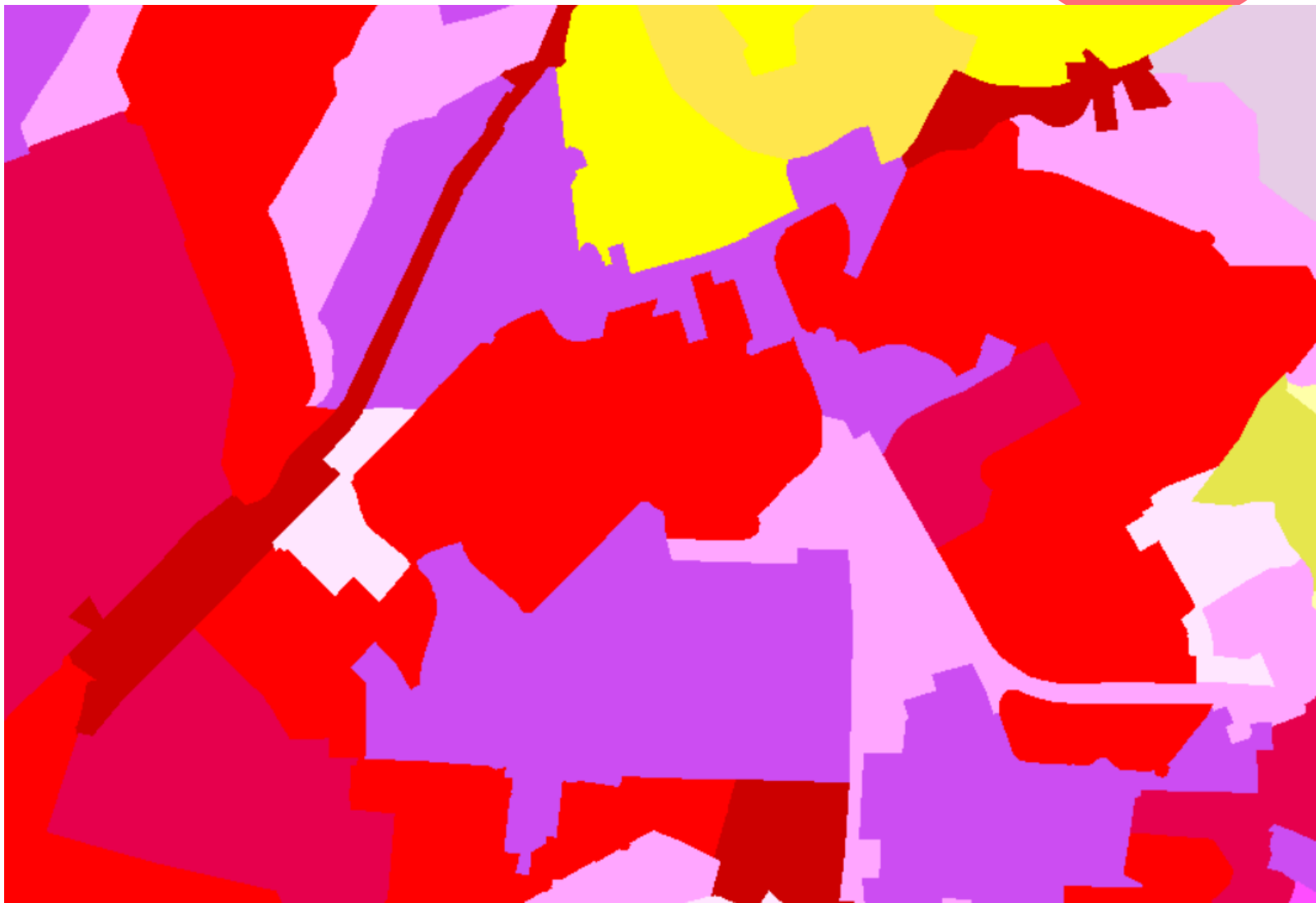
Copernicus Land Monitoring Service

- **Geographical** information on **land cover and its changes, land use, vegetation** state, **water cycle** and Earth's **surface energy variables** on European and global levels for environmental applications
- **Harmonized** and **consistent** in time and space
- Products and manuals are free and open
- Implemented by JRC and EEA
- Website: https://land.copernicus.eu/

- Land cover and land use mapping
- Priority area monitoring
- Bio-geophysical parameters
- Ground motion monitoring
- Satellite data
- Reference and validation data

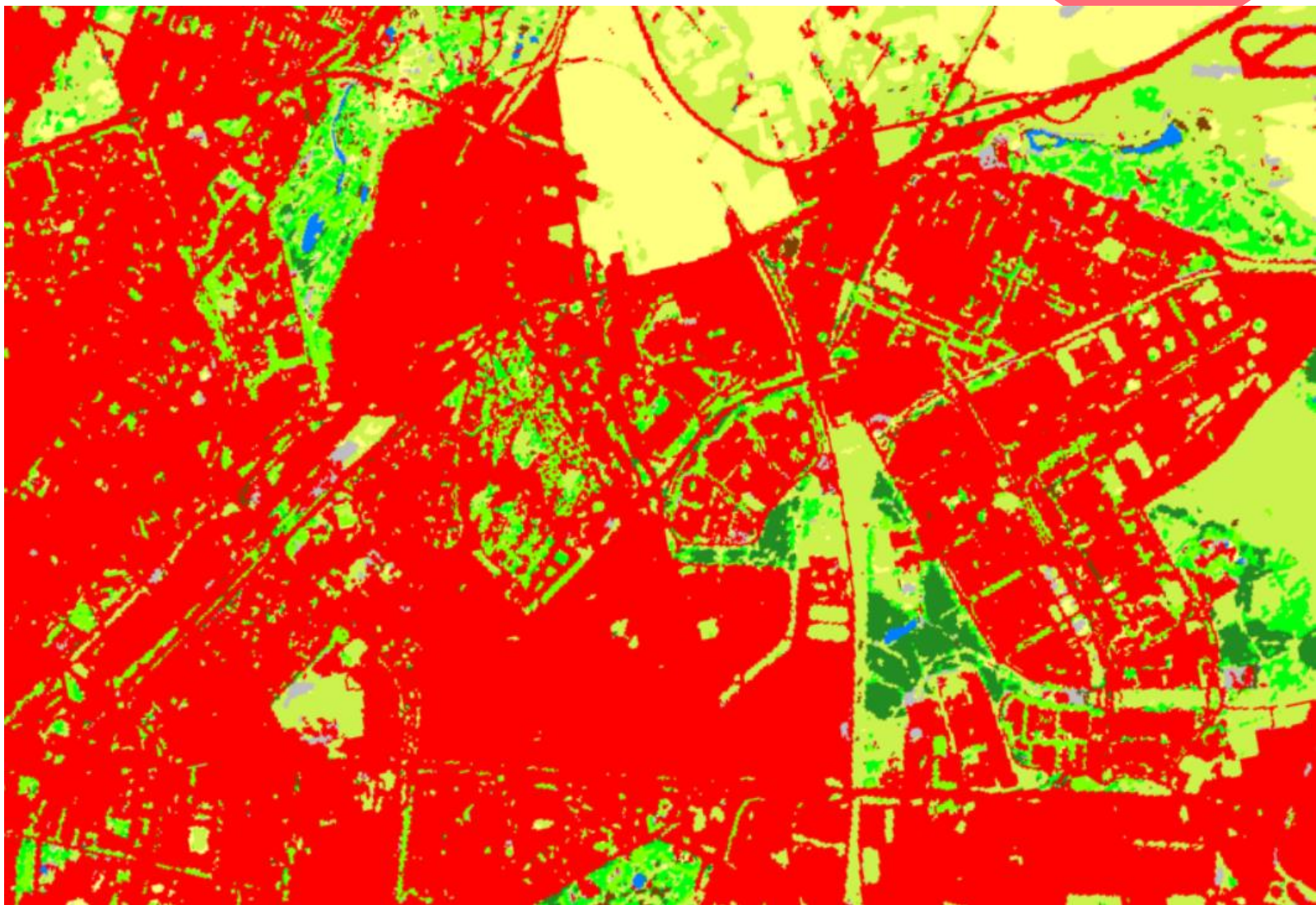
Corine Land Cover

- Spatial resolution: 25/5 ha MMU
- Update frequency: 6 years
- Most recent reference layer: 2018
- Example of application:
  - Planning location of new infrastructure: What kind of land cover, land use?



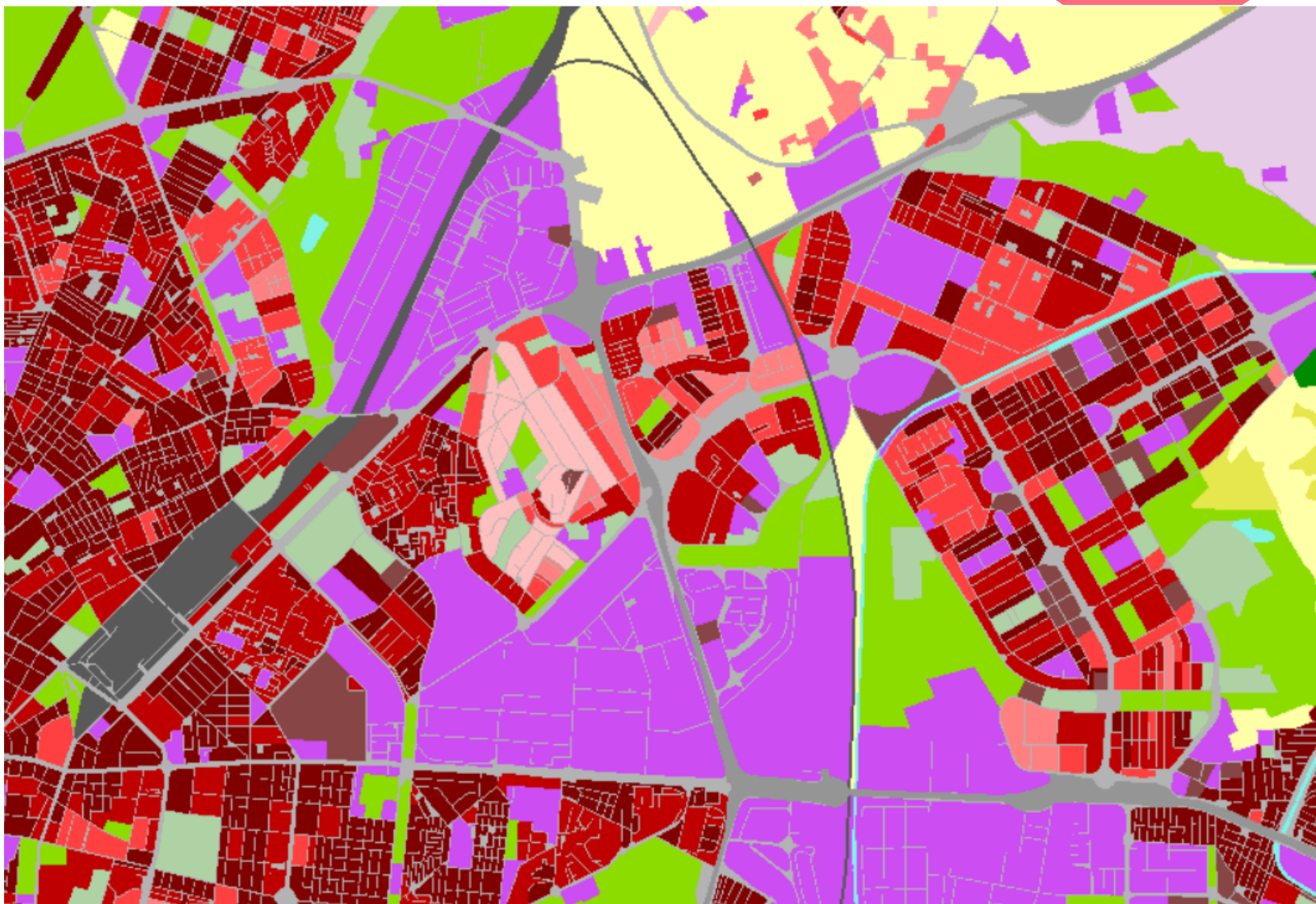
Corine Land Cover+ Backbone

- Spatial resolution: 10 m
- Update frequency: 3 (soon 2) years
- Most recent reference layer: 2018
- Examples of applications:
  - Planning location of new infrastructure: What kind of land cover, land use?
  - Monitoring evolution → asset management and impact assessment



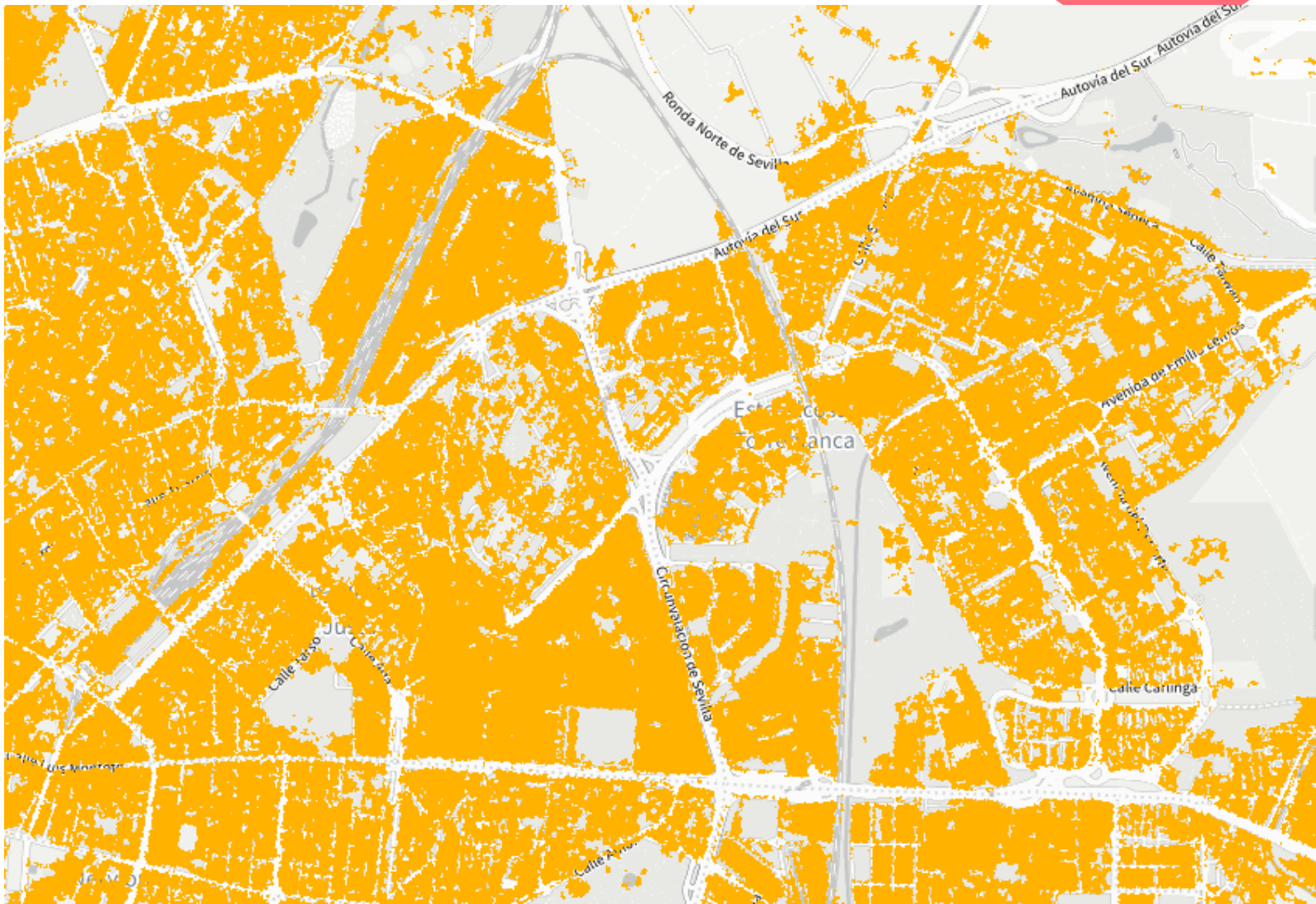
Urban Atlas

- Spatial resolution: 0,25/1 ha MMU
- Update frequency: 6 years
- Most recent reference layer: 2018
- Examples of applications:
  - Planning location of new infrastructure: What kind of land cover?
  - Monitoring evolution → asset management and impact assessment



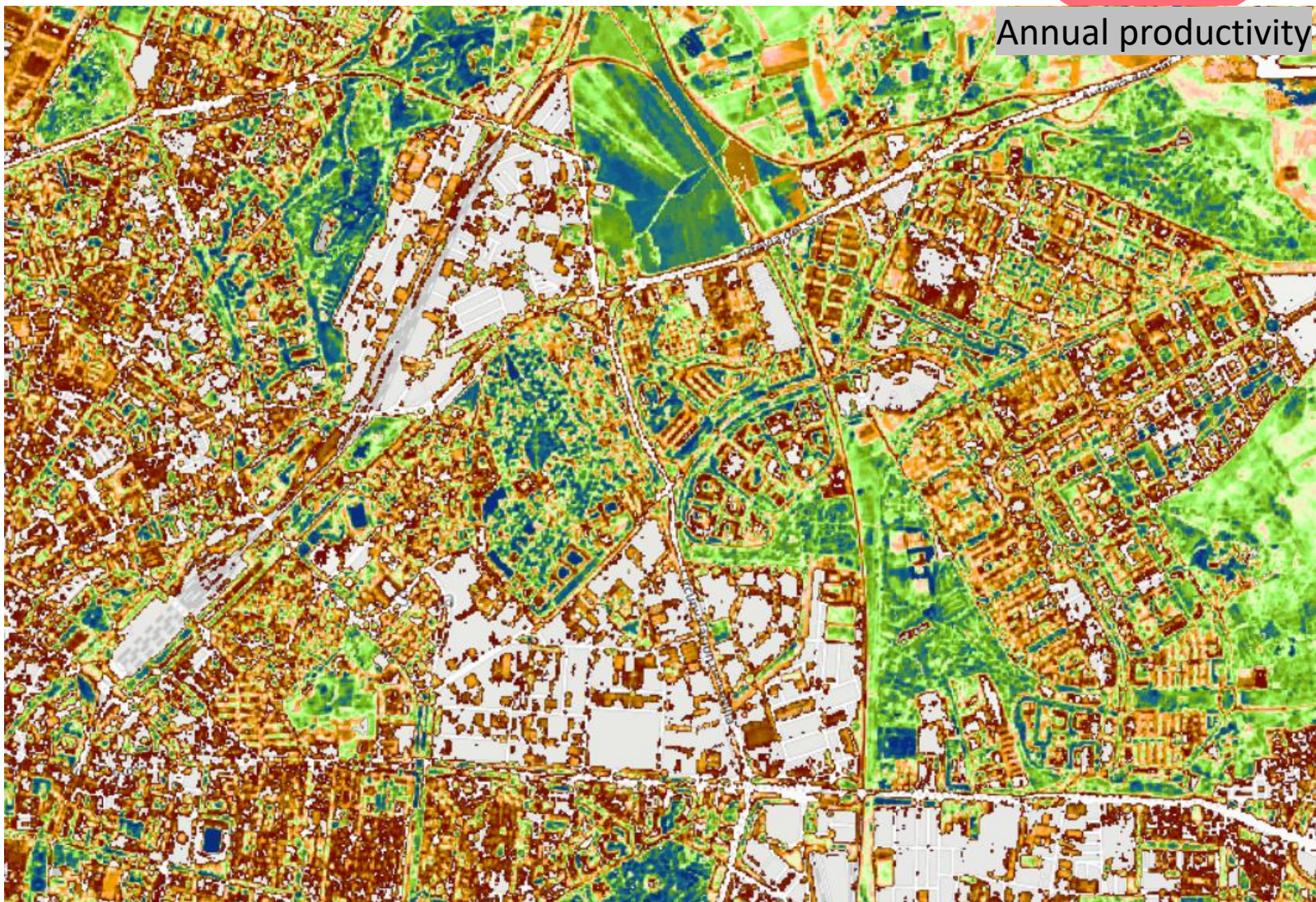
HR Impervious Built-up

- Spatial resolution: 10/100 m
- Update frequency: 3 years
- Most recent reference layer: 2018
- Examples of applications:
  - Models of run-off/ flood scenarios



HR Vegetation Parameters

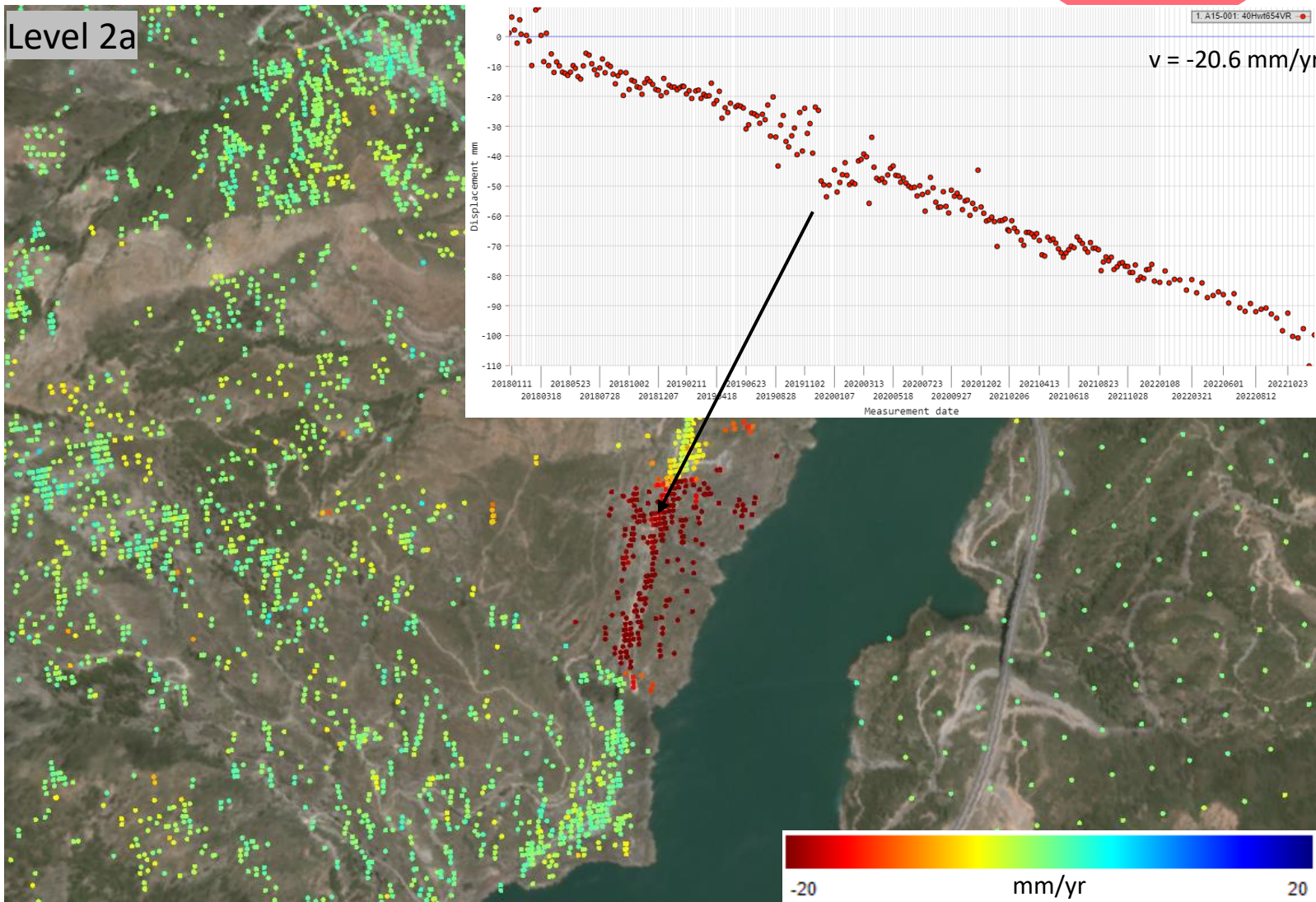
- Spatial resolution: 10 m
- Update frequency: Daily/10-daily/Yearly
- Most recent reference layer: 2022/2023
- Example of applications:
  - Assessing evolution in vegetation → asset management



European Ground Motion Service

- Spatial resolution: 5x20/ 100x100 m
- Update frequency: Yearly, with time series
- Most recent reference layer: 2018 – 2022
- Example of applications:
  - Monitoring infrastructure and slope instabilities → asset management and impact assessment

Webinar: https://land.copernicus.eu/en/products/european-ground-motion-service?tab=user_outreach



Thank you!

Joanna.Balasis@eea.europa.eu
https://land.copernicus.eu/

Demo sessions Nov. 8th:
10:30 – 11:00: EGMS
11:15 – 11:45: CLC and CLC+

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Copernicus for Road Infrastructures, Intermediate User perspective

ITS & Infrastructures

Nuno Duro dos Santos (Spotlite)

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Agenda

- Spotlite Platform and Services
- Our Services with Copernicus
  - Ground Motion Detection
  - Landslide Susceptibility Mapping
  - Vegetation Monitoring
- Sum-up

About Spotlite

Spotlite

Online Platform

Online platform for multi-hazard analysis and risk management, where we combine ground data with our satellite-based analytics.

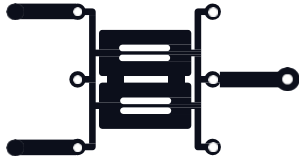
ACQUISITION

SATELLITE DATA

SENSOR DATA

ANALYTICS

DATA PROCESSING



MANAGEMENT

ALERTS & RECOMMENDATIONS

Spotlite is able to integrate remote sensing data from Earth Observation satellites and in situ IoT sensor data. By processing all this information, Spotlite delivers actionable insights in a robust monitoring and management platform.

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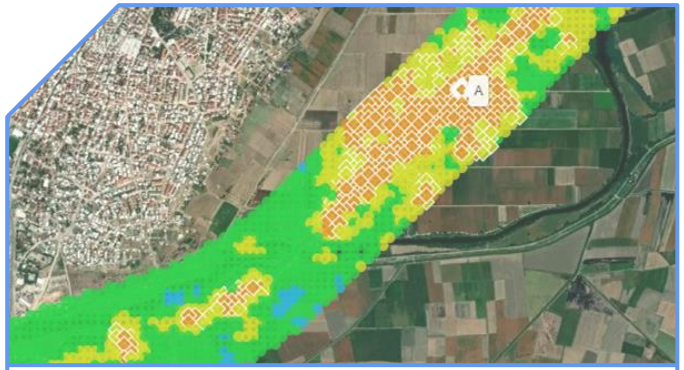
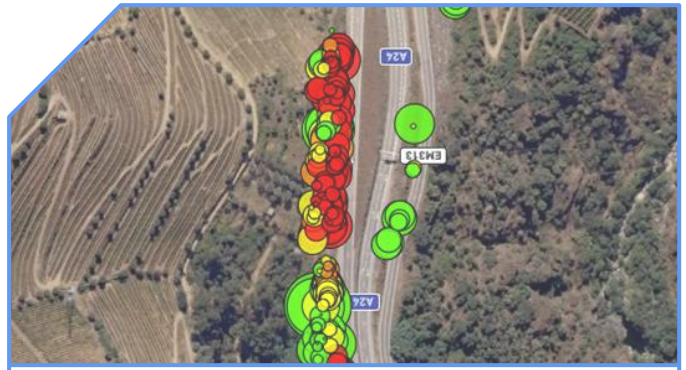
Spotlite Services

Spotlite
Modules



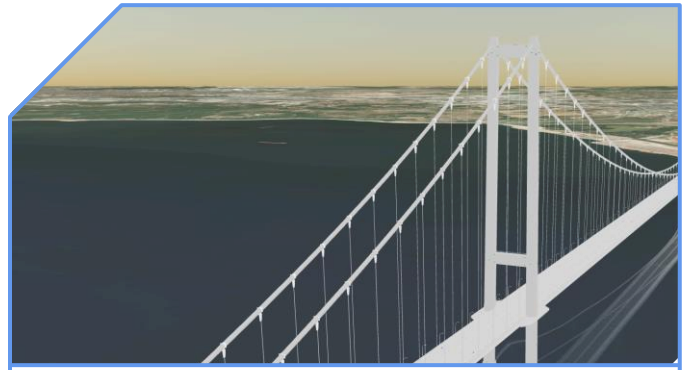
GROUND & STRUCTURAL MOTION MONITORING

- Surface displacements Detection with inSAR;
- Landslide Susceptibility Mapping with Copernicus services.



VEGETATION MONITORING

- Tree height (fall radius) vitality based on VHR;
- Other services with HR & VHR.



ASSET MANAGEMENT

- Sensors & operational data used to complement & validate remote sensing.

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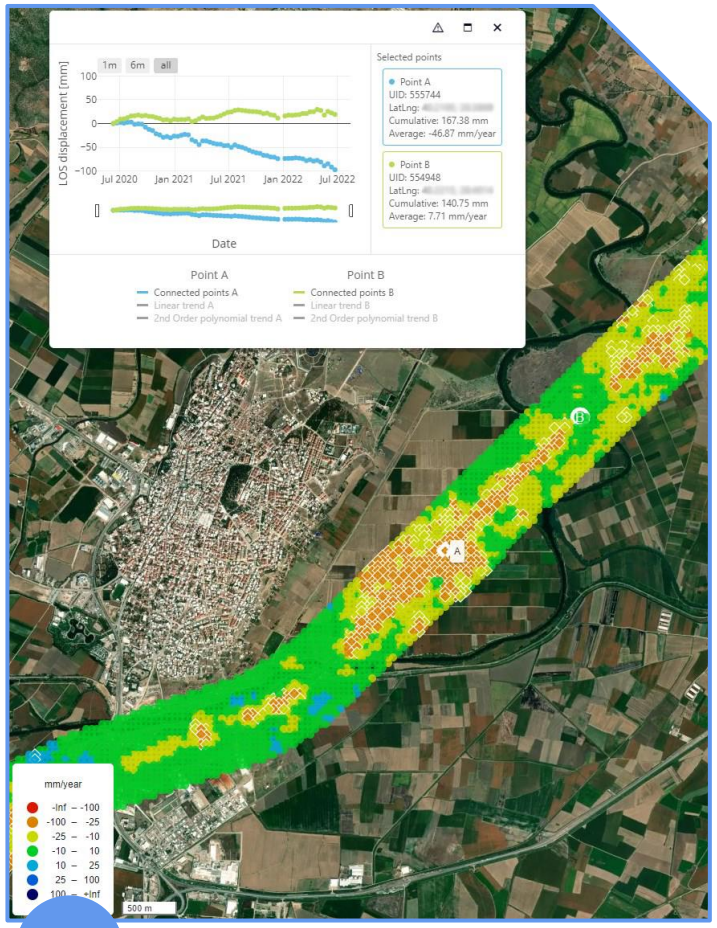
Ground & Structural Motion Monitoring

Surface Displacements

Ground and structural motion monitoring for stability assessment using Interferometric Synthetic Aperture Radar (InSAR). With sub-millimetric precision on a network-wide scale (including remote or inaccessible locations), we are able to detect unstable areas and manage risks.



Historical analysis of ground and structural motion using archive data

Date prediction for exceeded safety thresholds

Regular monitoring (bi-annual, quarterly or monthly)

Automated alerts once safety thresholds are crossed

Visualization tools (time-series and cross sections)

Recommendation engine for maintenance activities

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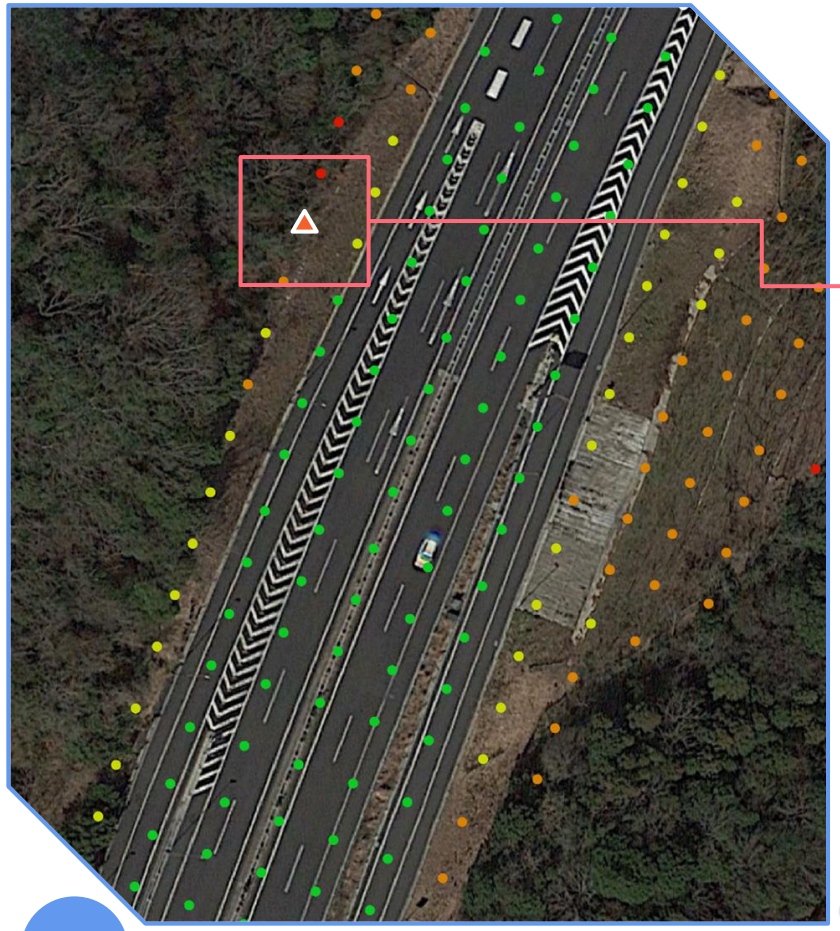
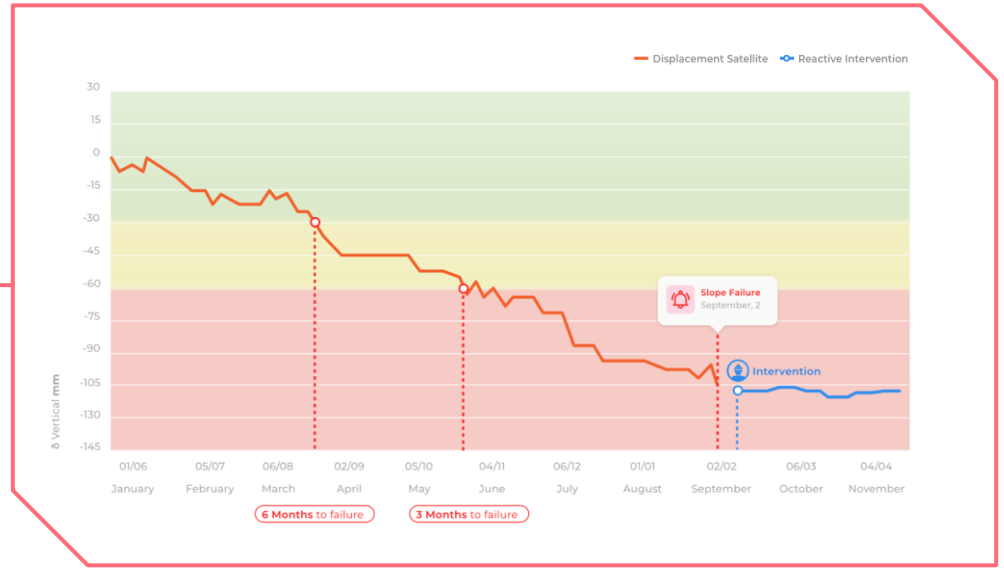
Case of study - Excavation slope

Displacements with Automated Alerts

Displacement trend display combined with alert and alarm thresholds highlighting significant events.





CLIENT Motorway maintenance operator

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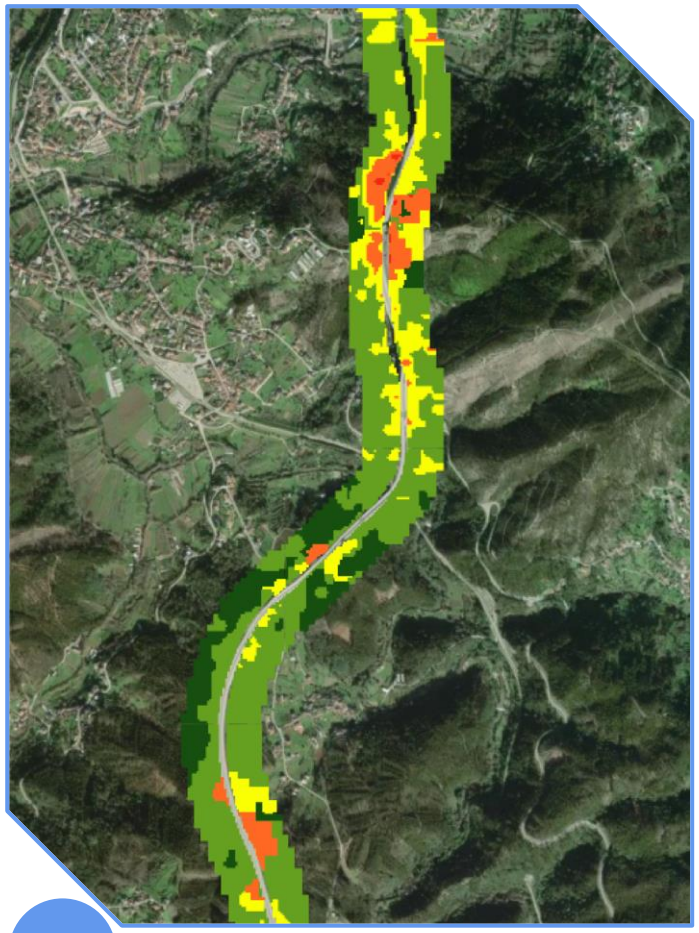
Ground & Structural Motion Monitoring

Landslide Susceptibility

Use static knowledge-base or event driven methodologies from multiple sources, including geomorphology (LULC, NDVI, DEM, Lithology), weather and slope operations (maintenance data).

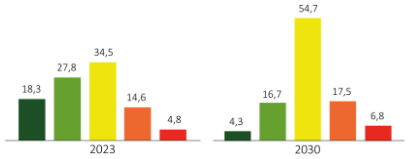


Mapping of slopes and environment landslide susceptibility

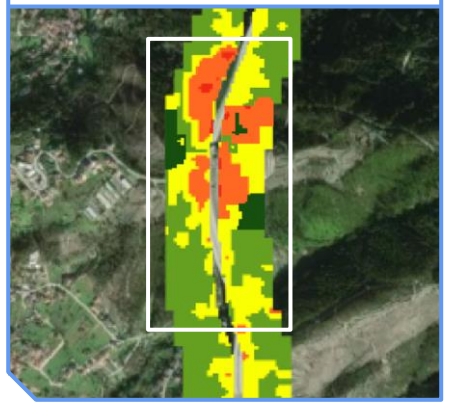
Classification of slopes

Preview of the slope classification on coming years

LSM Slopes Classification (%)



LSM Slope & Environment Raster Classification



LSM Slope & Vectorial Classification

Susceptibility Classes

- Very High
- High
- Moderate
- Low
- Very Low

* LULC - Land Use Land Cover, NDVI - Vegetation Index & DEM - Digital Elevation Model

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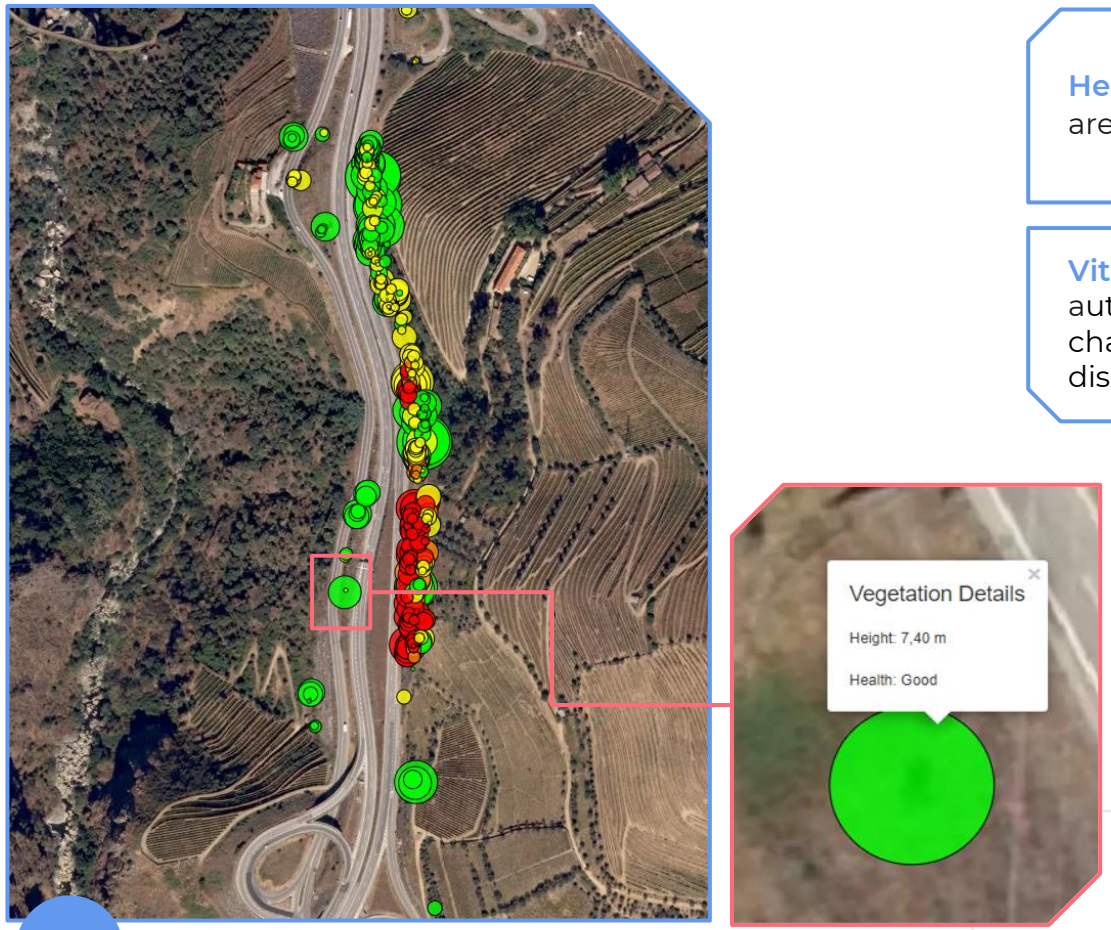
Spotlite Module

Vegetation Monitoring

Using Very High Resolution (VHR) optical satellite data in the visible spectrum (RGB) and Near Infrared (NIR), Spotlite is able to monitor vegetation encroachment in the vicinity of critical infrastructures and along infrastructure networks.



Height and estimated area of impact

Species identification

Vitality index, issuing automated alerts for changes caused by diseases or droughts

Vegetation encroachment monitoring for green corridors management

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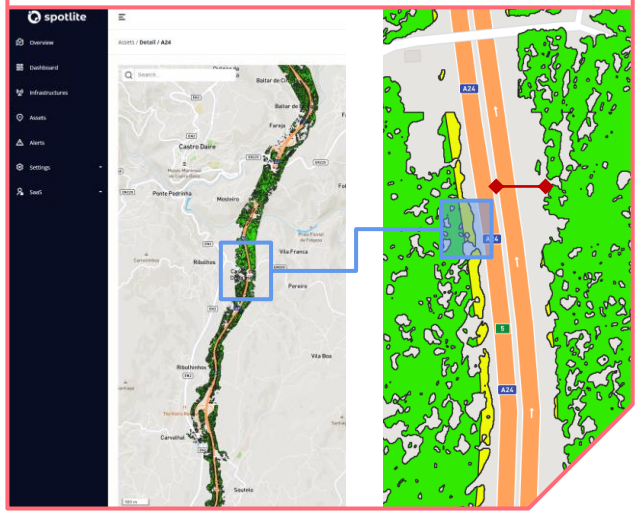
Vegetation Monitoring

Vegetation

Clearing Services

REMOVAL NEED DETECTION



Tree - Road distance

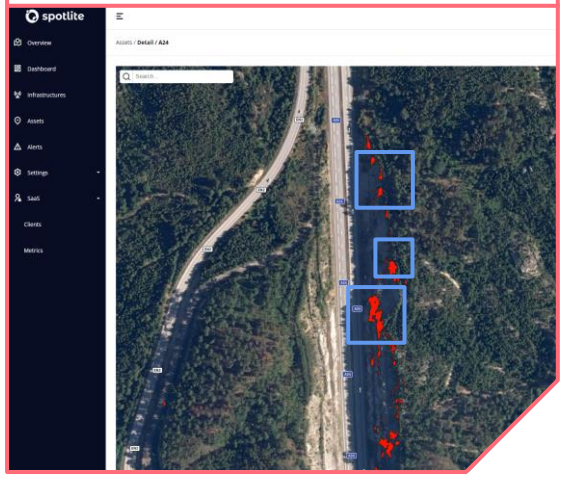
Trees

Trees on 10M limit of the road (need to be cleaned)

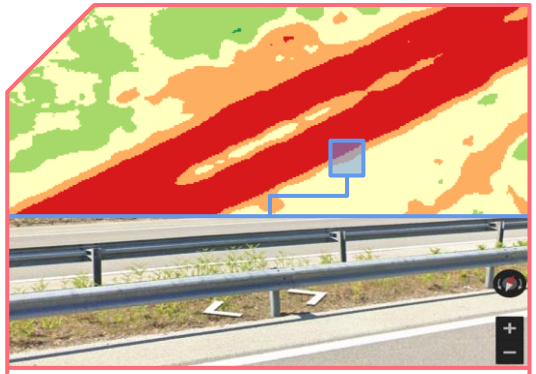
CLEARING MONITORING

1. 07/02/2023, 2. 28/05/2023

DEAD TREES DETECTION



Dead Trees



GROWING VEGETATION DETECTION ON CENTER MEDIAN

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SUM-*UP*

Spotlite uses extensively SAR and multispectral Copernicus Satellites but also third-party missions.

- Sentinel 1 is acceptable in many of our business cases;
- Multispectral very high resolution (VHR) are required from third-party missions: Pleiades, geosat, PlanetScope.
- Sentinel 2 is used to complement multispectral VHR data

Spotlite uses Copernicus Services, in particular Land services, to complement or validate our services.

- LULC, Ground Motion.

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7 - 9 November - Sevilla, Spain

Road & Automotive

European Commission

EUSPA
European Union Agency for the Space Programme

ROAD INFRASTRUCUTRE MONITORING

Marco Bolchi – Executive Director – EY Belgium

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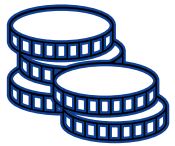
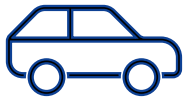
GNSS FOR ROAD USER CHARGING

GNSS ROAD USER CHARGING



Road User Charging is the practice of issuing levies or charges to road users, such as car or truck drivers, for their distance travelled on a defined section of road



GNSS-based solutions for Road User Charging (RUC) are designed to charge motorists for the actual distance travelled, without barriers or gantries, and provide interoperability between national cross border schemes

Role of GNSS

- GNSS-based tolling
- City based road pricing
- Road User Charging – Distance recording
- Pass through detection

- *Can you think about any further use case?*

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GNSS user requirements for RUC

- *How can the necessary **level of trust** in the position of the vehicle be achieved, so to correctly determine the fee to be charged?*
- *How important is the **authentication of the position of the vehicles** covered by the charging scheme? Can you elaborate on the need to authenticate the GNSS positioning?*
- *Do you see **R&I gaps for the uptake that funding programmes** could address?*

EARTH OBSERVATION FOR INFRASTRUCTURE MONITORING

Introduction

The road infrastructure sector has been employing EO to carry out tasks such as surveying, mapping, monitoring, and disaster response. Recent developments in satellite technologies, data analytics and machine learning have been expanding EO role.

The objective of this session is to help consolidate our understanding of the role of EO to ultimately connect end user needs with specific EO requirement, useful to help understand the associated service inputs

Analytical framework for User Needs and Requirements related to EO

Final users

Service providers

EO service providers

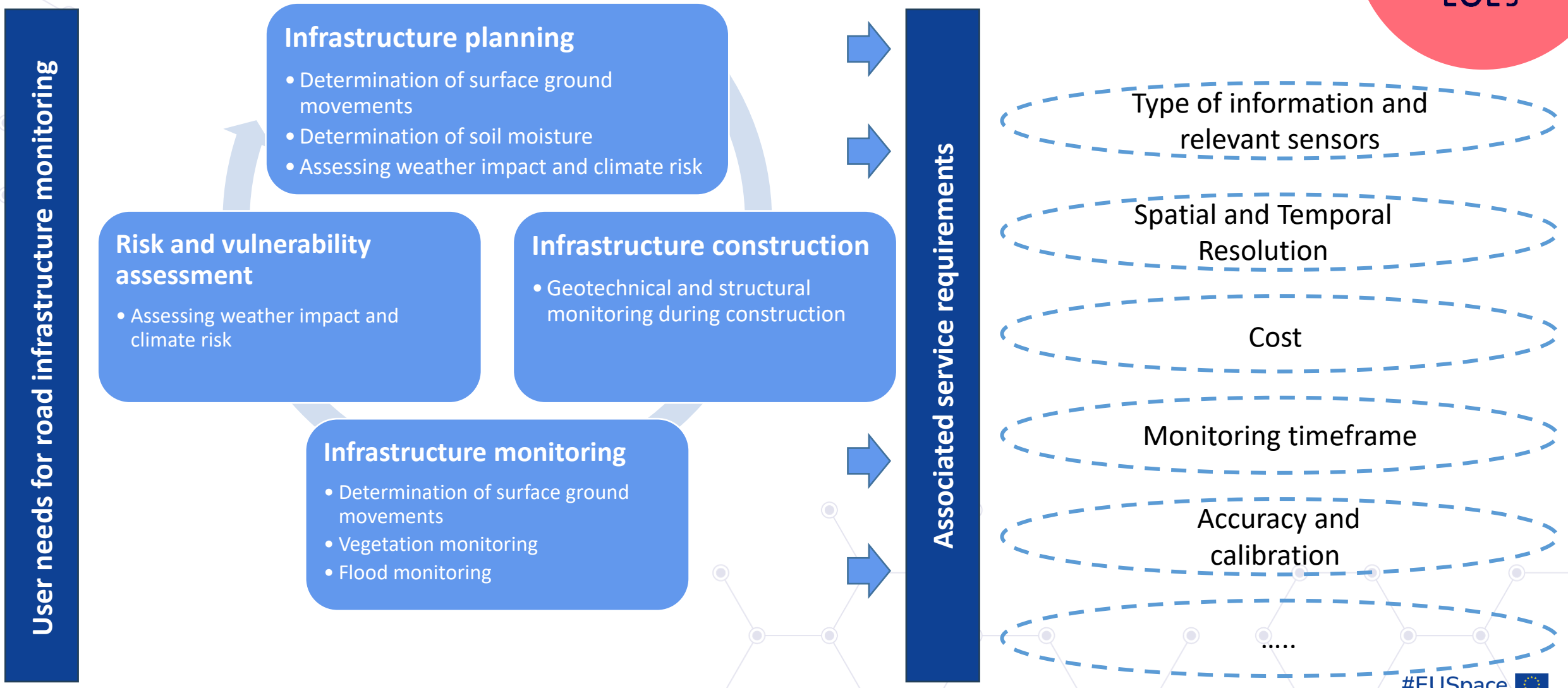
EO satellites and data

User Needs
What is the need on the side of the road authorities, construction companies, etc. to improve their planning, construction, monitoring and maintenance operations? What are the relevant operational scenarios?
Service Provider Offer
What kind of service is offered by service providers to satisfy user needs? How does the service work?
Service Provider Satellite EO Requirements
What kind of parameters does the service provider offer in its EO products to meet the needs of the users in terms of the capacities of the satellite system?
Service Inputs
Which EO data and other data sources are able/needed to meet the service requirements?

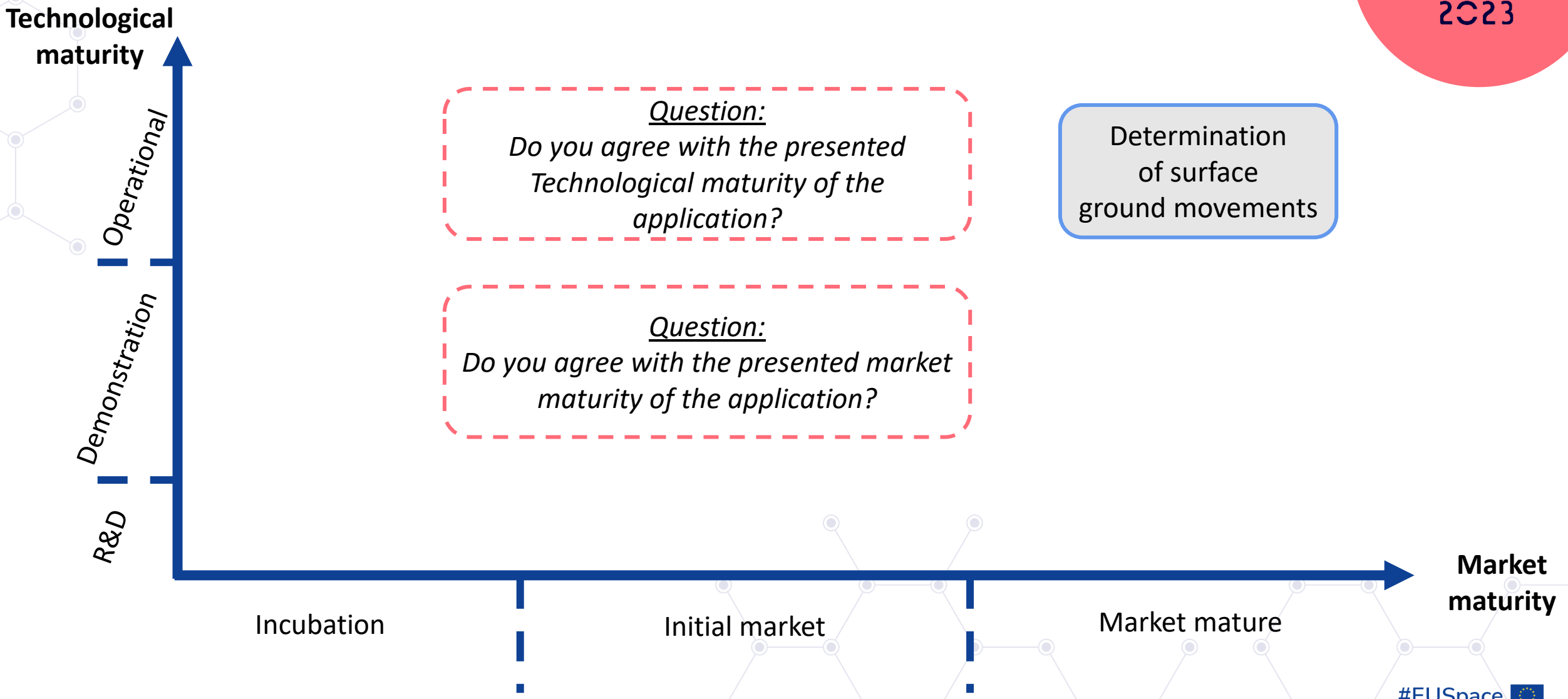
UCP

FOLL OW UP

Earth observation techniques are relevant along all phases of the asset life cycle



Technological & Market maturity level



Question:
Do you agree with the presented Technological maturity of the application?

Question:
Do you agree with the presented market maturity of the application?

Determination of surface ground movements

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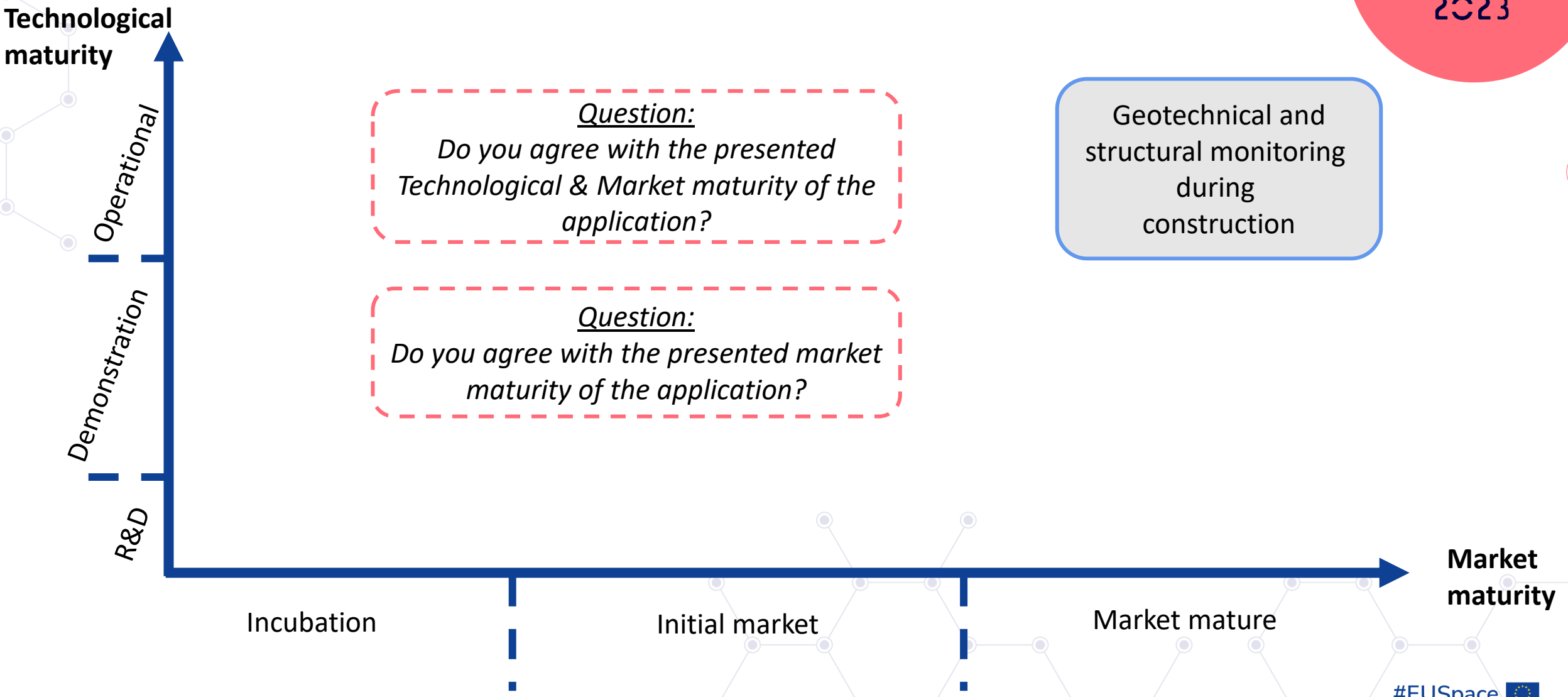
Technological & Market maturity level



Question:
Do you agree with the presented Technological & Market maturity of the application?

Question:
Do you agree with the presented market maturity of the application?

Geotechnical and structural monitoring during construction

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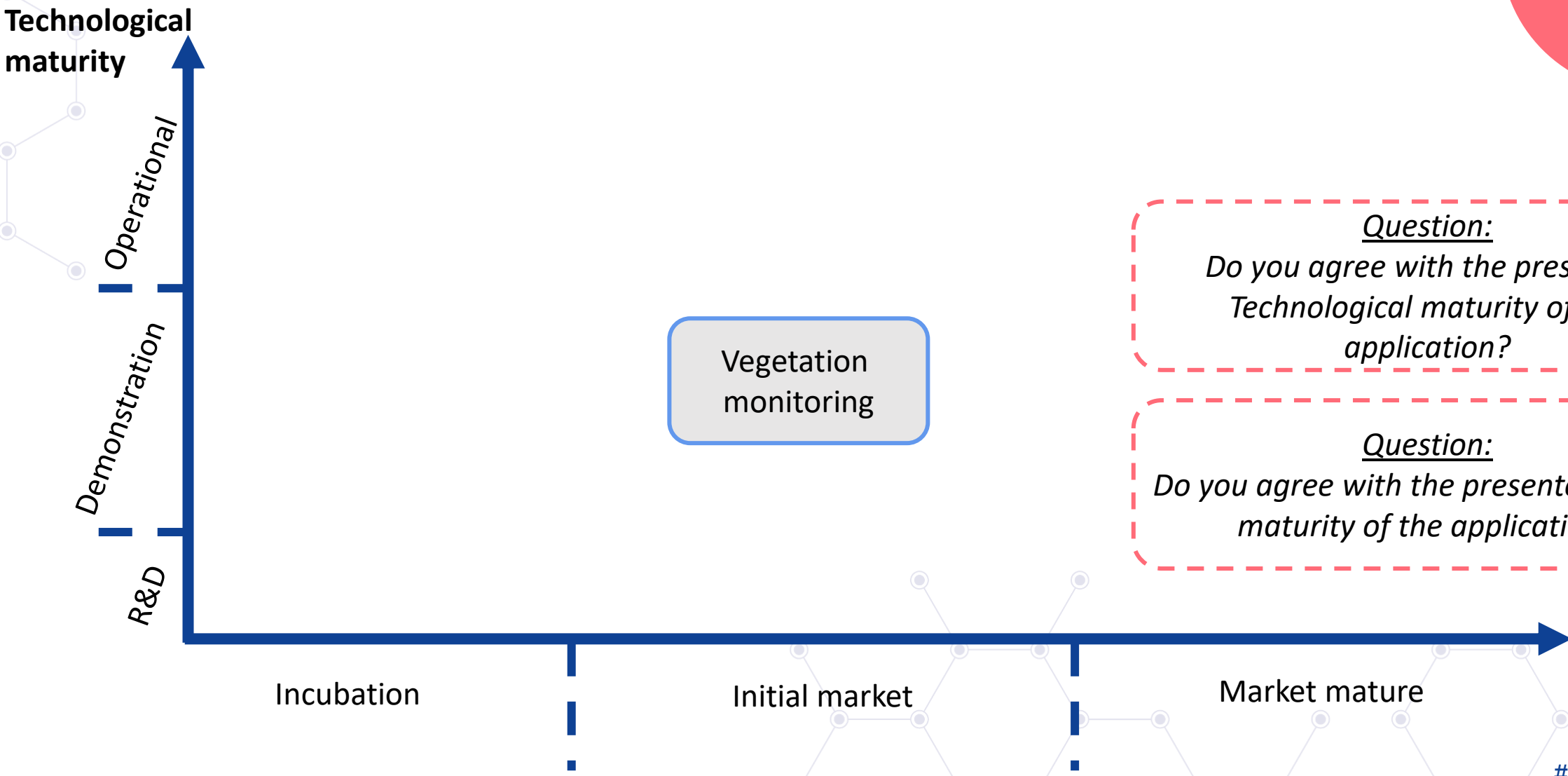
Technological & Market maturity level



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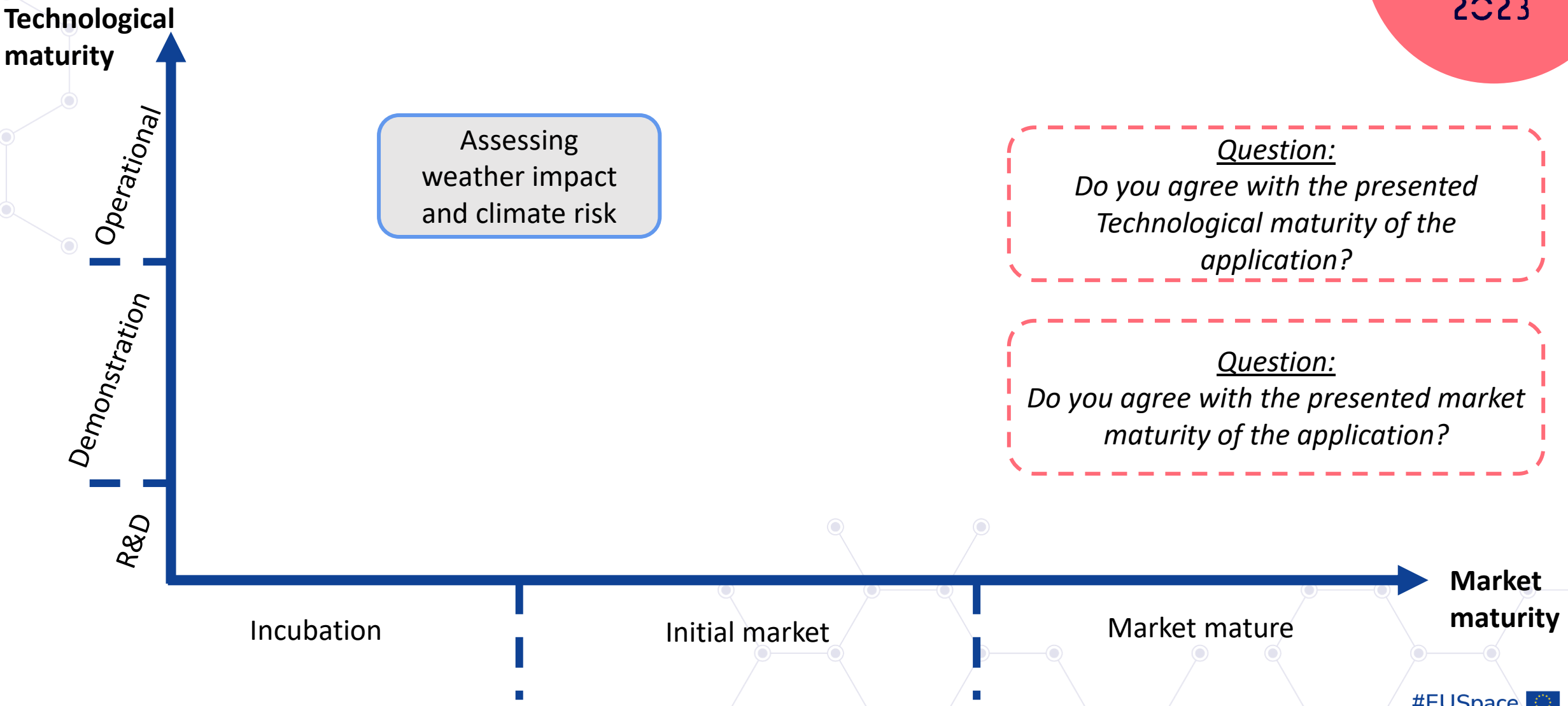
Technological & Market maturity level



Assessing weather impact and climate risk

Question:
Do you agree with the presented Technological maturity of the application?

Question:
Do you agree with the presented market maturity of the application?

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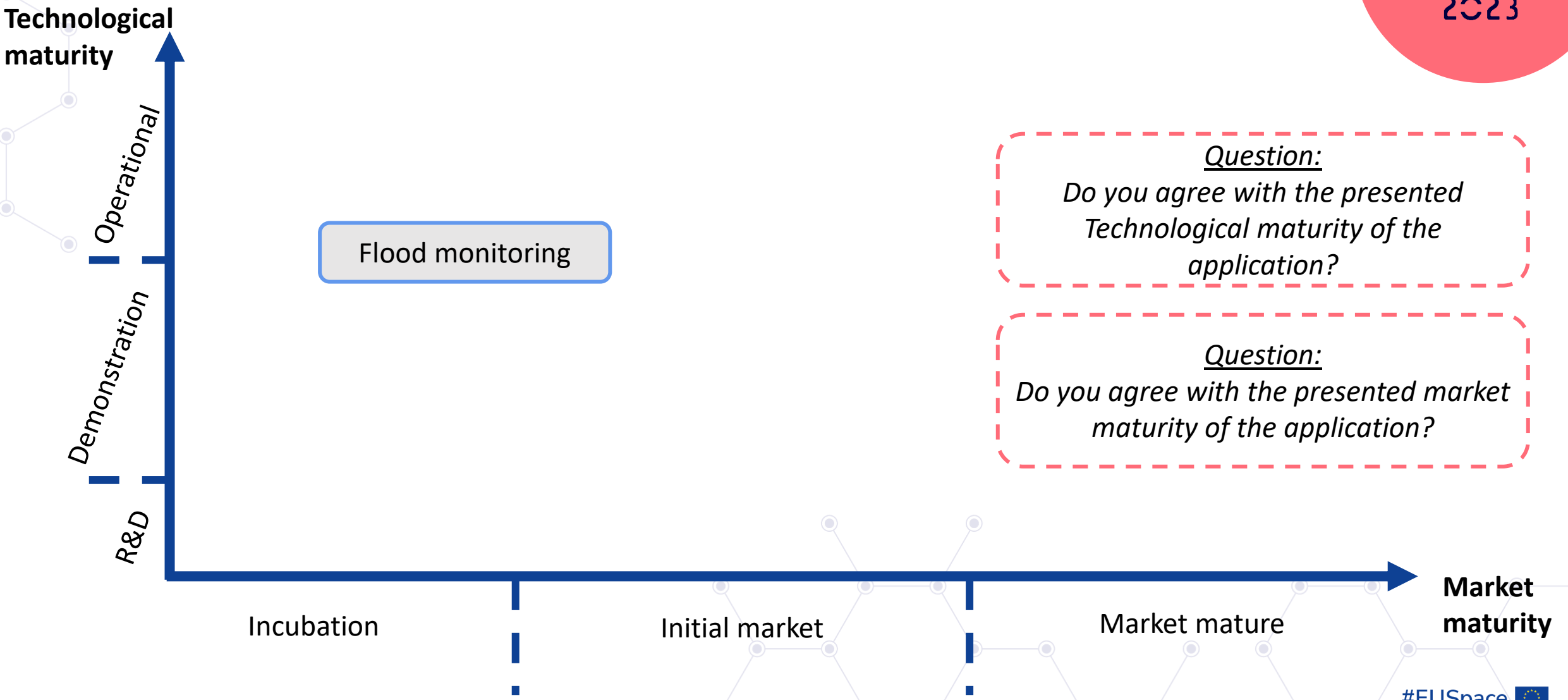
Technological & Market maturity level



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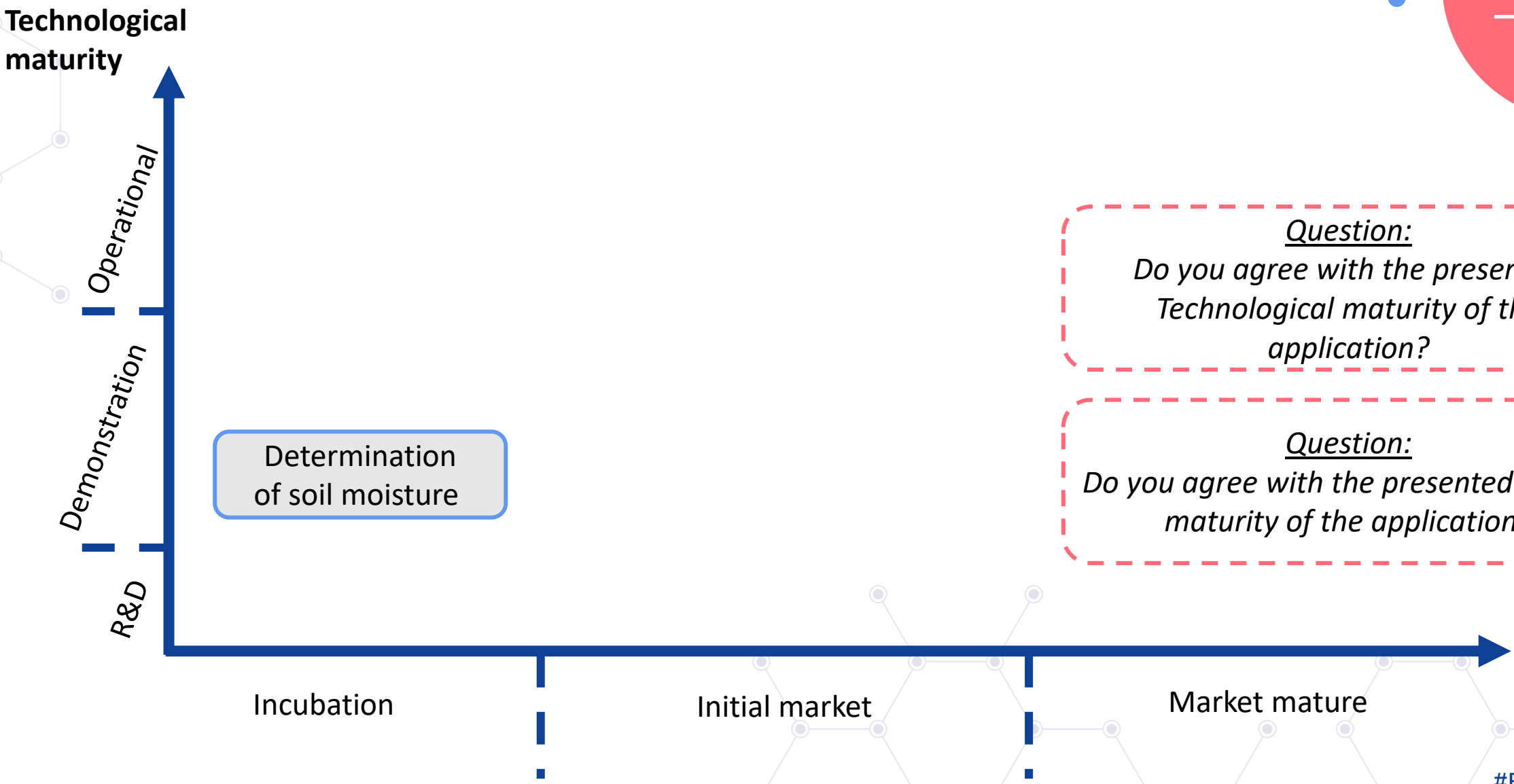
Technological & Market maturity level



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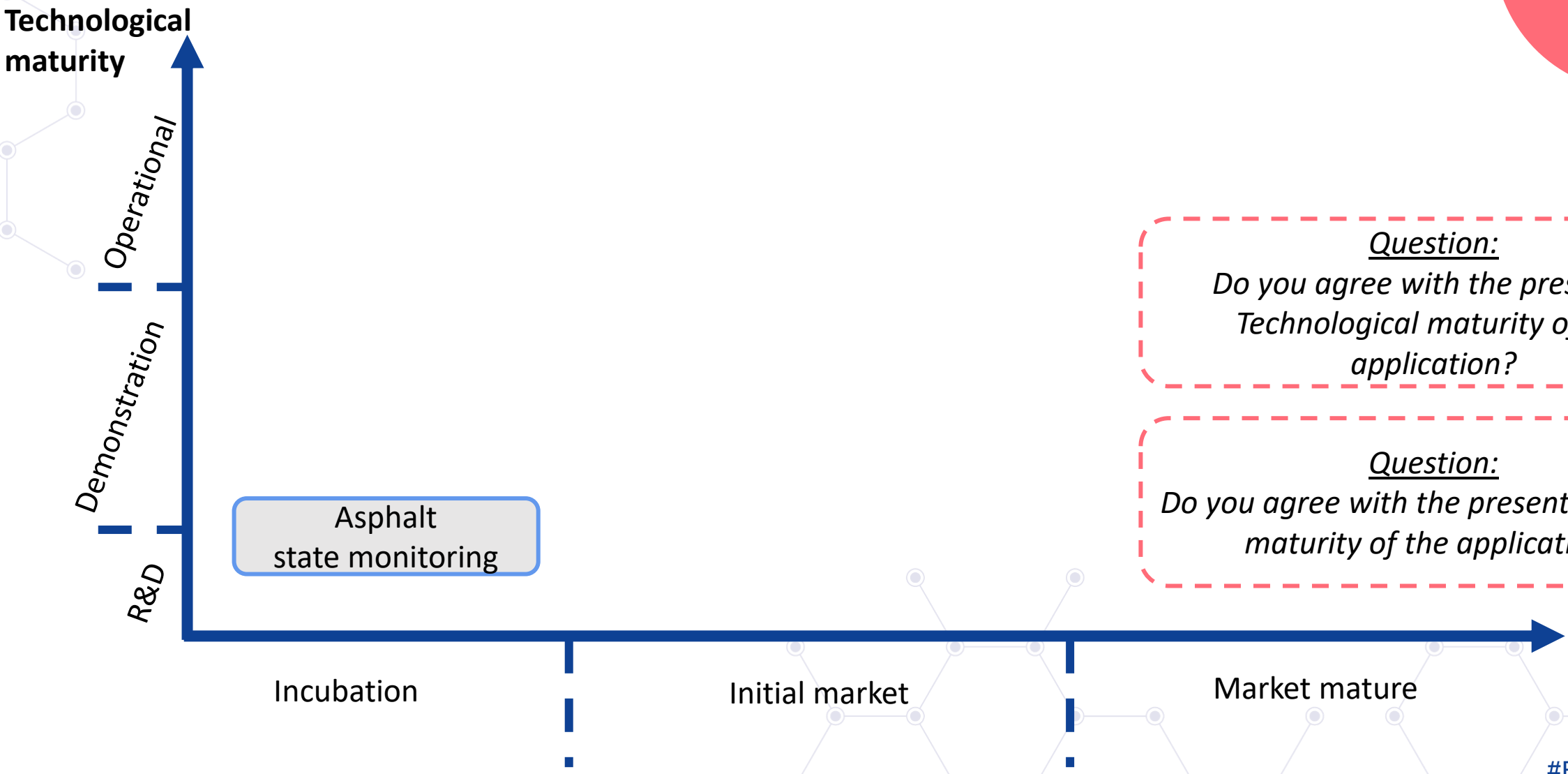
Technological & Market maturity level



Question:
Do you agree with the presented Technological maturity of the application?

Question:
Do you agree with the presented market maturity of the application?

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Additional Questions – Challenges and R&I & Barriers – Infrastructure Monitoring

- *Can you suggest any **improvement of EO services and data** necessary to better fulfil user requirements?*
- *Do you see **R&I gaps connected to the use of space technologies that funding programmes** could address?*
- *Is there **any other type of support** that EUSPA can provide to foster EO market uptake?*

UCP Infrastructure monitoring – next steps

→ This presentation will **be shared including a detailed annex** covering all the specific user requirements for all applications discussed today.

→ Any **feedback** amending or adding information is greatly appreciated!

→ Received feedback will be incorporated into the updated Road user requirements report

→ Feedback should be sent by November 24 to:

Rik.neirynck@be.ey.com

End of ITS and Infrastructures session

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CCAM R&I priorities in Europe

European Commission

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European Union Agency for the Space Programme

CCAM: Research and Innovation perspective

Dr Johanna Tzanidaki

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CCAM R&I priorities in Europe

Dr Johanna Tzanidaki

Chief Innovation Officer

ERTICO –ITS Europe

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ERTICO PARTNERS

ERTICO
ITS EUROPE

Public Authorities

NATIONAL

REGIONAL

CITY

Connectivity Industry

Research

Service Providers

Suppliers

Traffic and transport industry

Users

Vehicle manufacturers

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ITS
Intelligent Transport Systems

Automated driving

Drones

Data exchange

Traffic management

Artificial Intelligence

Mobility Apps

Mobility as a Service

Transport and Logistics

Navigation

Intelligent Infrastructure

Safety

Multimodality

Payment Systems

V2X Communication

eMobility

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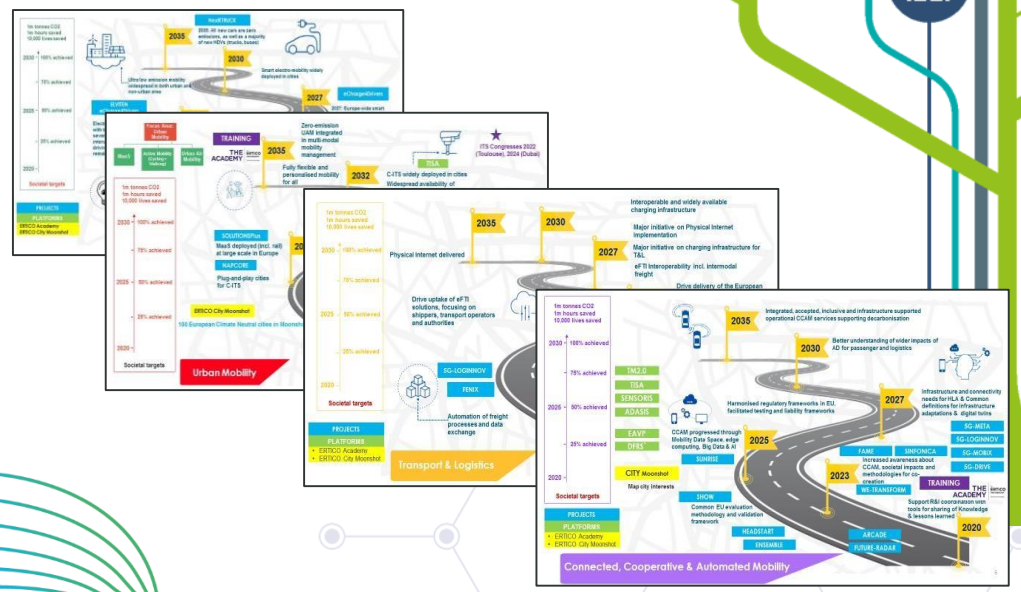
The bigger picture

- Decarbonisation
- Energy dependency
- Alternative fuels and energy dependency
- Trust and security
- Social inclusion



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ERTICO ITS EUROPE

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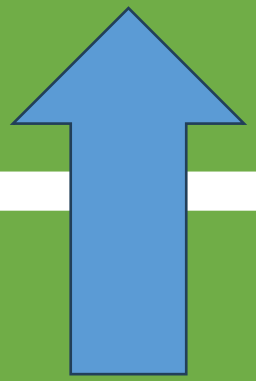
ERTICO approach to CCAM

targets



requirements

2023-2025

- Increased awareness about CCAM, societal impacts and methodologies for co-creation –>System approach
- CCAM progressed through Mobility Data Spaces, edge computing, Big Data & AI

2025-2027

- Harmonised regulatory frameworks in EU, facilitated testing and liability frameworks
- Infrastructure and connectivity needs for HLA & Common definitions for infrastructure adaptations & digital twins

2023-2035

- Better understanding of wider impacts of AD for passenger and logistics
- Integrated, accepted, inclusive and infrastructure supported operational CCAM services supporting decarbonisation

5G-MOBIX

5G for cooperative & connected automated MOBIlity on X-border corridors

https://www.5g-mobix.com/

Impact

Develop and test automated vehicle functionalities using 5G core technological innovations along multiple cross-border corridors and urban trial sites.

Activities

- Develop and test 5G-augmented automated mobility along two cross-border corridors & six trial sites
- Formulate requirements for 5G corridor deployments and business case
- Support standardisation and provide scenarios for EU-wide large-scale 5G x-border deployment

Facts and figures

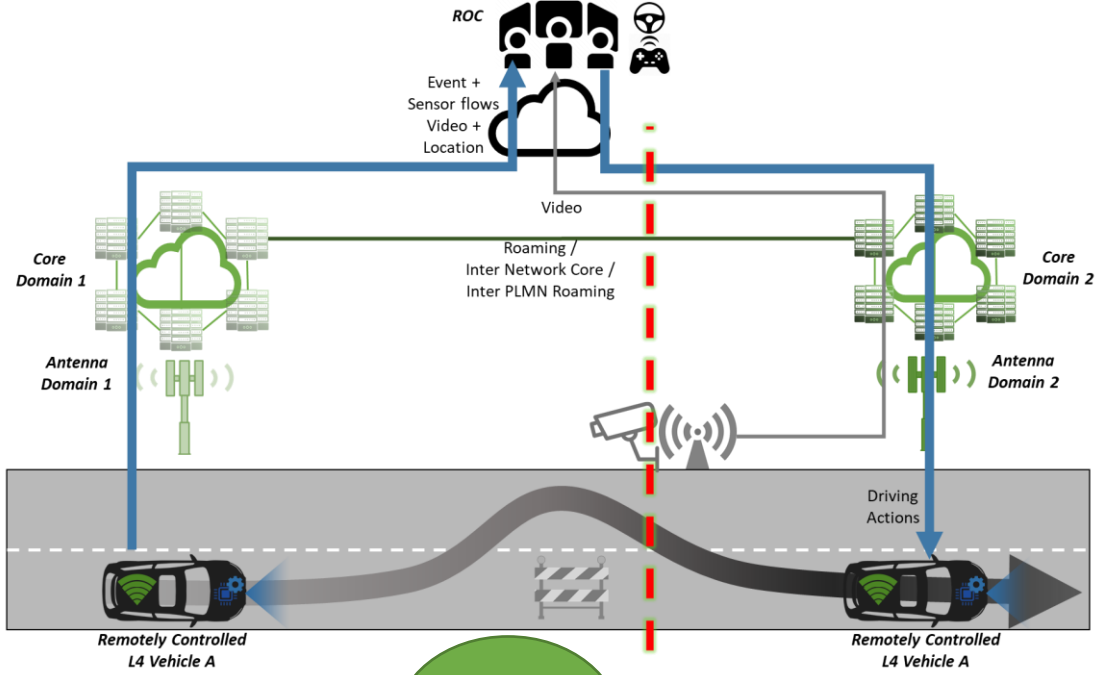
- Coordinator: ERTICO
- 58 Partners
- Budget: € 27M
- Start: 01 Nov 2018
- End: 31 Jul 2022

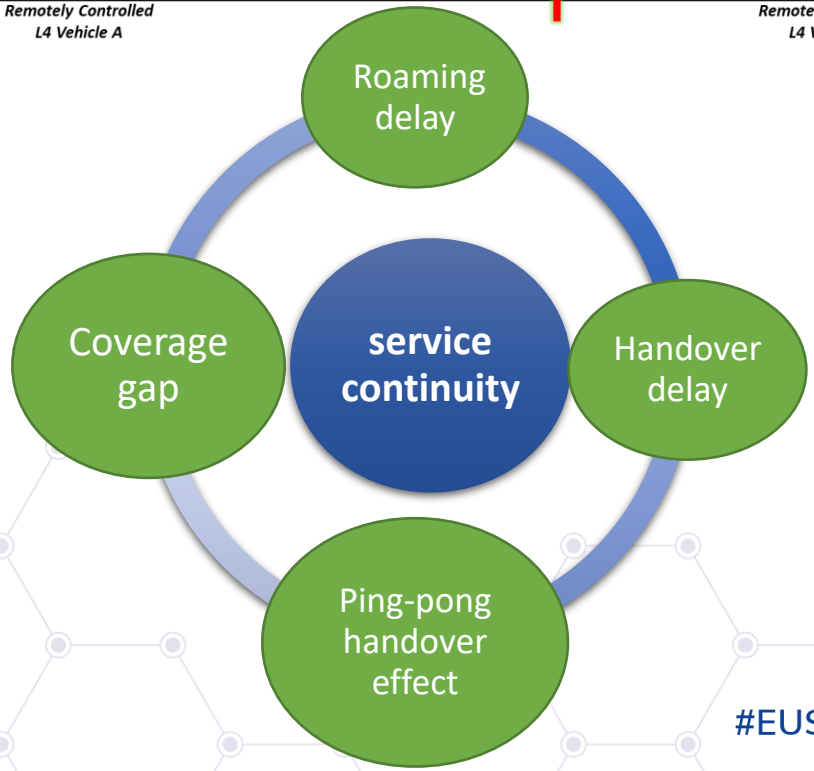
Trial Sites

- Spain-Portugal corridor
- Greece-Turkey corridor
- China Trial Site
- Finland Trial Site
- France Trial Site
- Germany Trial Site
- South Korea Trial Site
- The Netherlands Trial Site

Service continuity for CCAM applications

- Service continuity is a key requirement for 5G-Mobix applications, e.g., remote driving and advanced driving
- At the CBC environments, ensuring service continuity
  - Roaming delay
  - Handover delay
  - Coverage gap
- MNOs do not deploy sufficient 5G/4G infrastructure to CBC and rural areas ; this is currently not economically viable
  - SatCom may offer an economically viable alternative
- This is being investigated by MNOs such as Vodafone, BT and vendors such as Ericsson who are investing at NTN networks for remote and rural areas
- Activities on integration of NTN with 5G are happening since 2018





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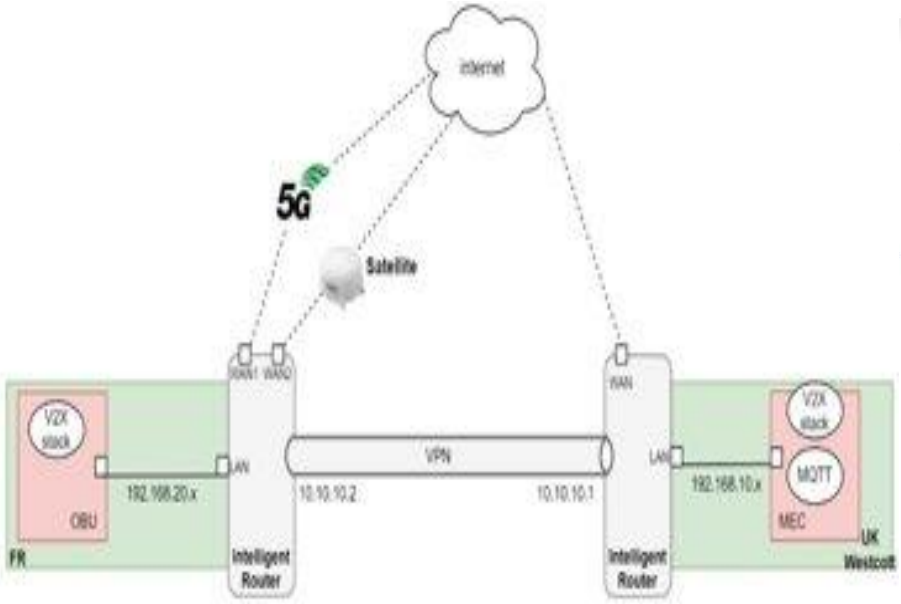
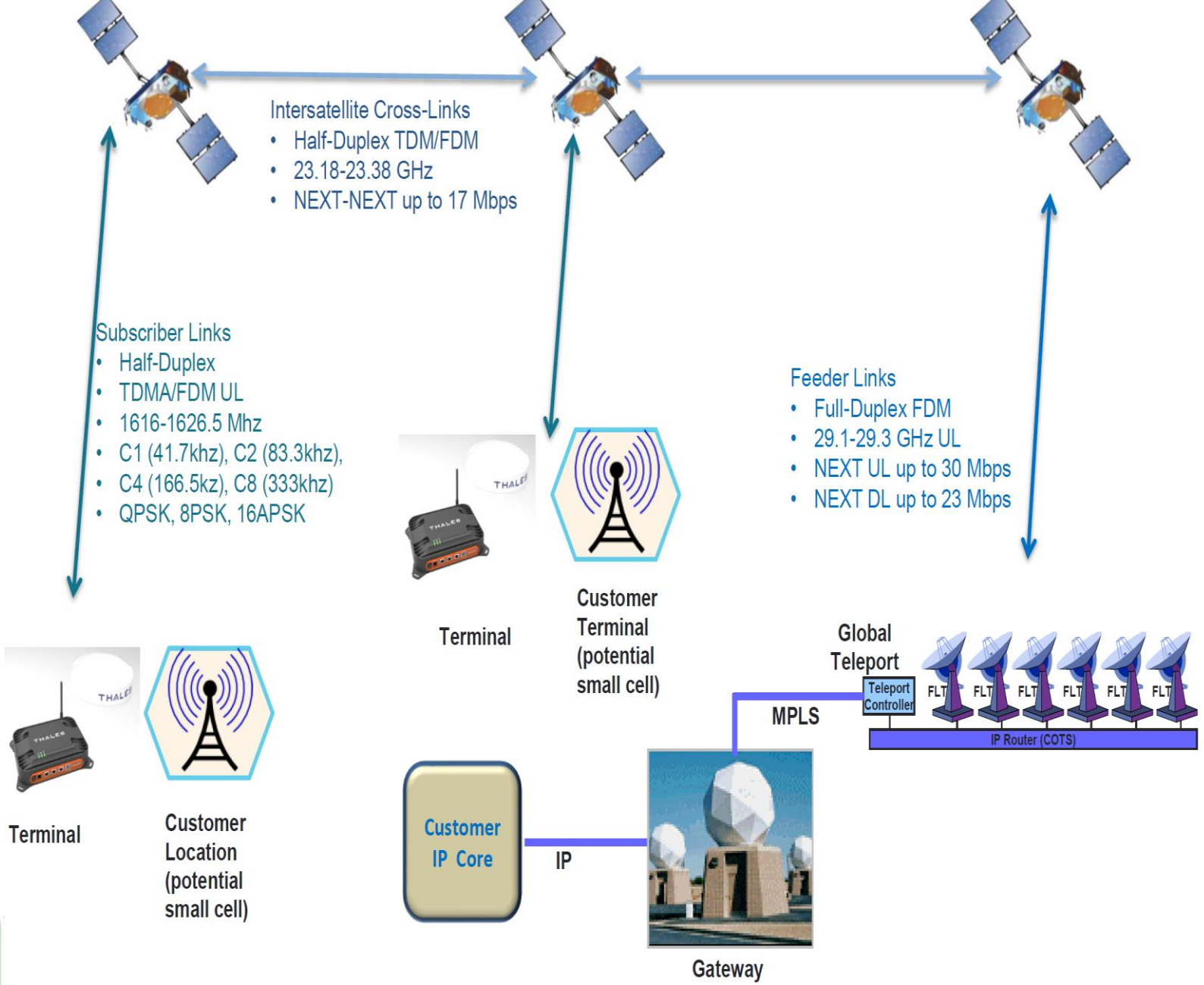
Technical Details (study on sat integration)

- Currently one GW in the States
- Point to point IP links (2022)
- Satellite latency way better than CBC roaming delays
  - → technical feasibility – Backhauling 5G concepts with innovative satellite backhaul (first time)





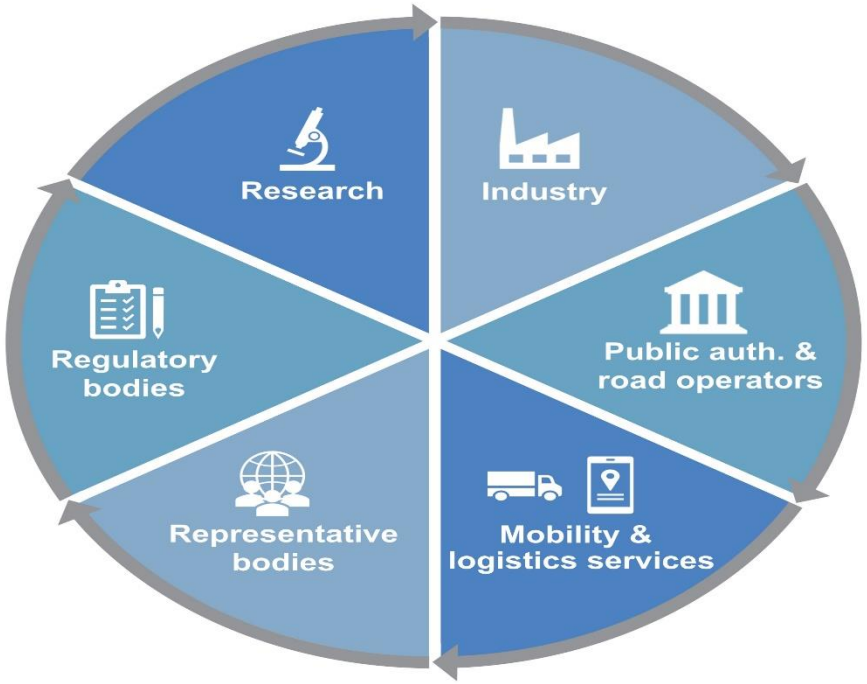
CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

EUROPEAN LEADERSHIP IN SAFE AND SUSTAINABLE ROAD TRANSPORT THROUGH AUTOMATION

- Strengthen Competitiveness of European Industries
- Increase Safety in road transport
- Reduce negative impact from road transport on environment
- Ensure inclusive mobility and good access for all

ccam.eu

MEMBERSHIP and Co-creation



- 214 member companies / organisations

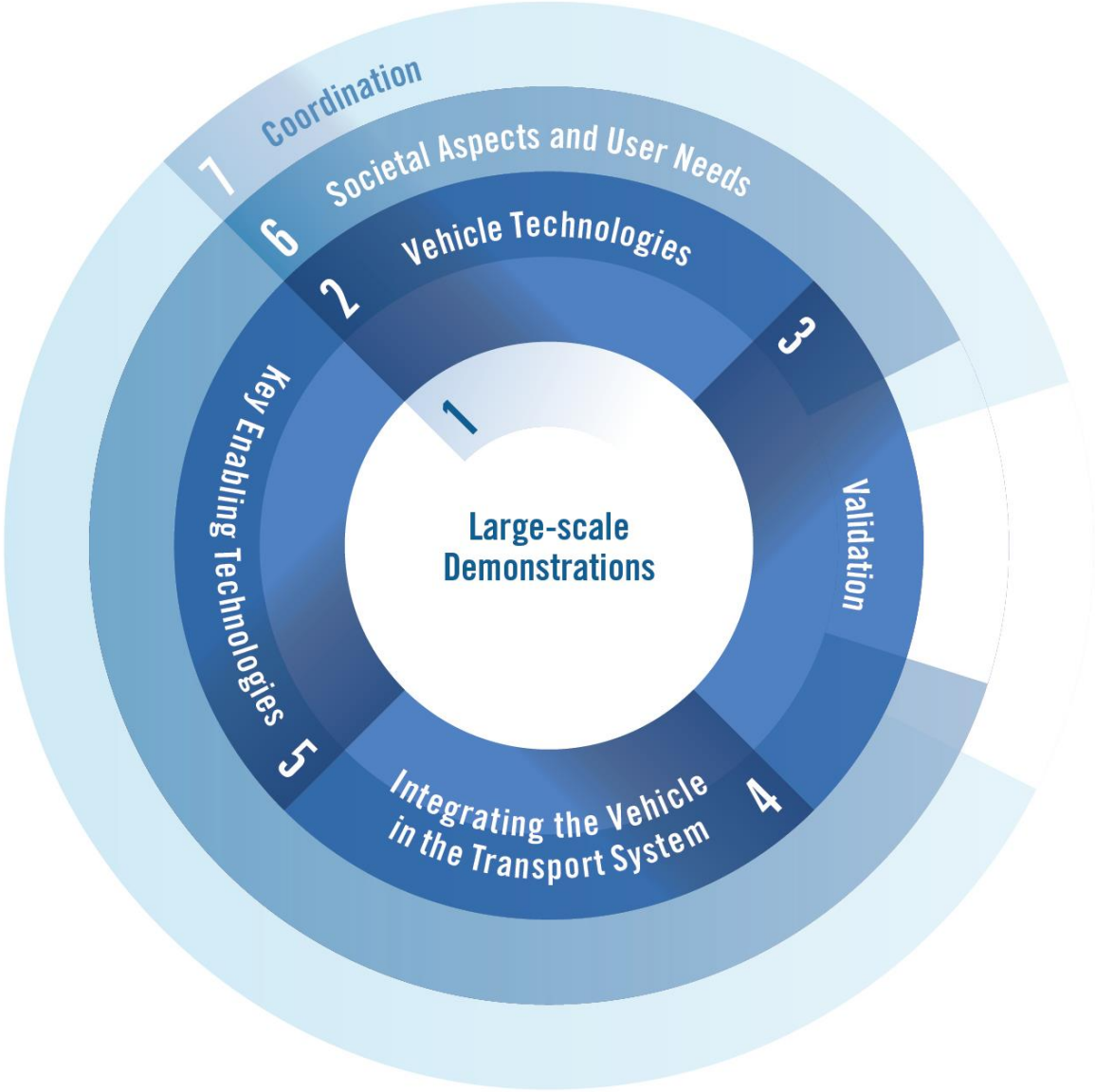
https://www.ccam.eu/members/

CCAM CLUSTERS

Successful implementation requires understanding:

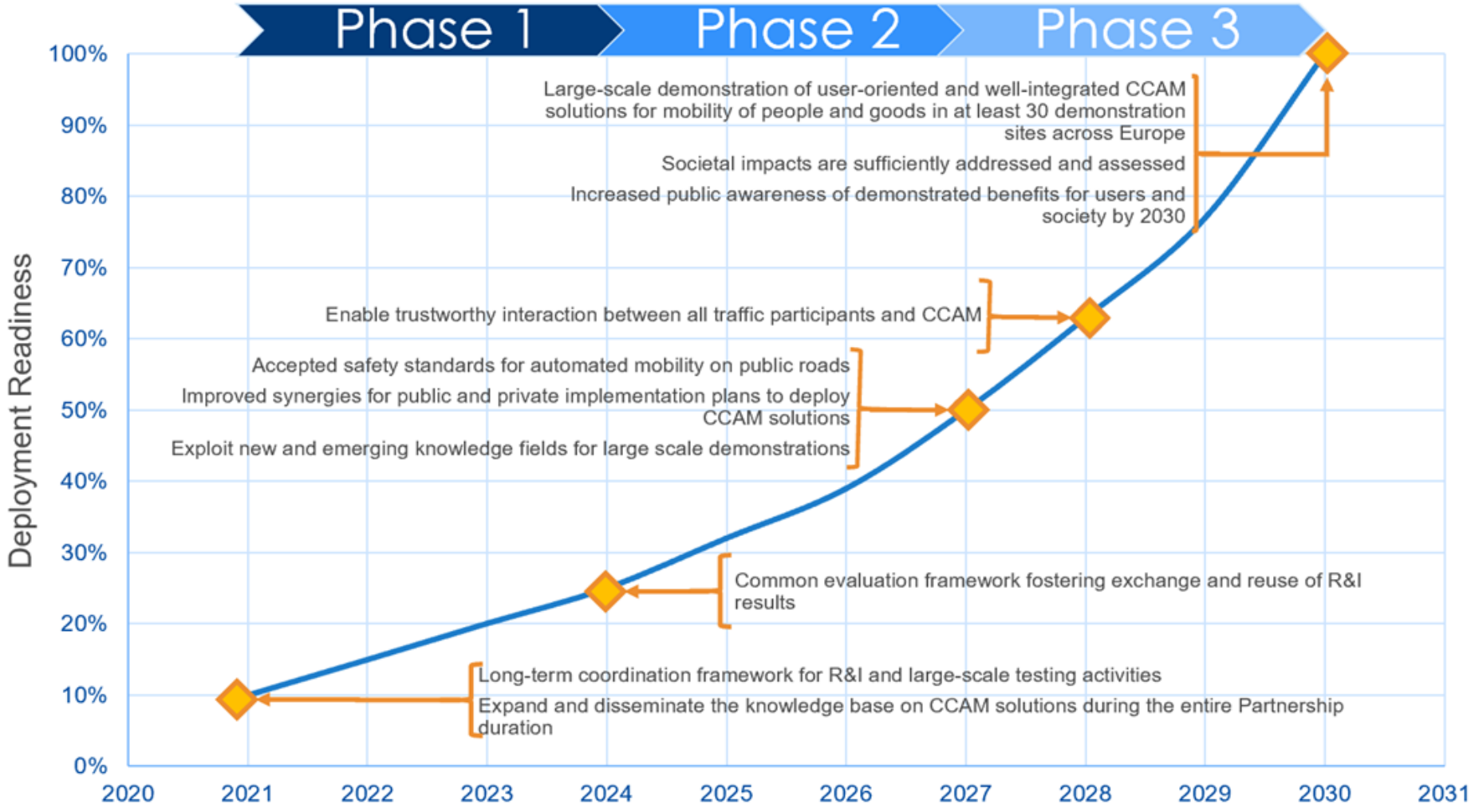
- the **people needs and societal aspects** of mobility
- technical details, contributions, requirements and risks from **key enabling technologies**
- the overall **transport system** requirements and set-up
- what **vehicle technologies** are required and how to implement them
- how to **validate** safe system functioning

Finally **demonstrate** all aspects at a **large scale**



Planning for CCAM implementation 2021-2030

- Phase 1 – Developing the building blocks
- Phase 2 – Advancing technical maturity
- Phase 3 – Trials and living labs all over Europe



Draft SRIA 2025

"certain research and innovation issues related to CCAM require **global cooperation** by definition, for example, the question whether the intelligence of CCAM should be located in each single vehicle or in the cloud, or **how earth orbit satellites may be used to support CCAM**, e.g. by teleoperation, or on the role of physical and digital infrastructure"

Remote Management as a Research Priority in 2025-2027

→situational awareness of the V in the system and of the surrounding vehicles too!

→safety and perception of safety

→Advancing communication – **Non-terrestrial Networks as a complement to 5G terrestrial networks** to enable seamless CCAM services deployment, CCAM requirements **towards the development of 6G**

ERTICO Partnership needs and interests

On providing technical and socioeconomic insights on CCAM and PNT Requirements

→Stakeholder engagement to support the advance of PNT data to support and drive CCAM for more efficient, safer and sustainable roads and vehicles

→ Use Cases:

- Ubiquitous and High Performance PNT for CCAM
- Perception 360 for CCAM
- PNT Monitoring and over the air updates for CCAM
- PNT for Clean Mobility
- Testing for CCAM

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7 - 9 November - Sevilla, Spain

Needs and challenges for localisation information in the Automotive domain

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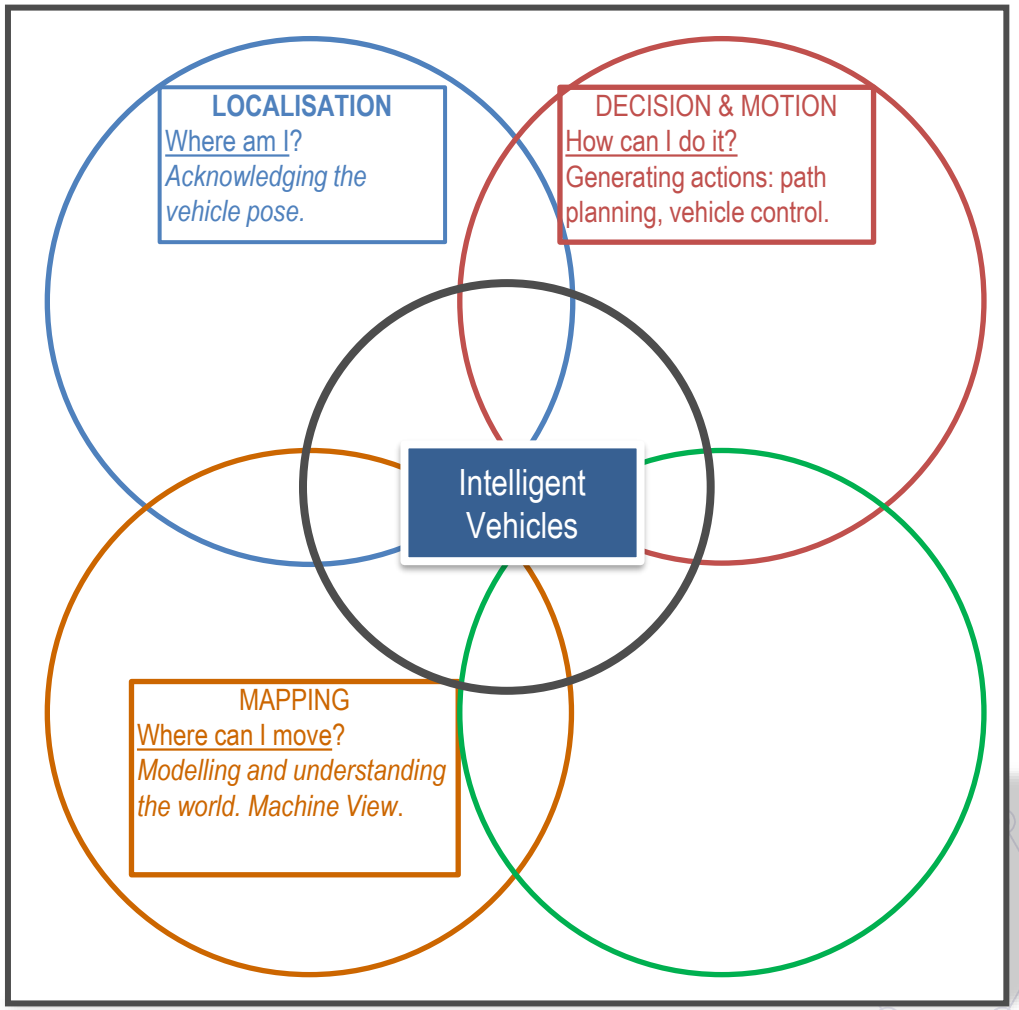
Javier Ibanez-Guzman PhD 5Renault Group)

Vehicle Navigation

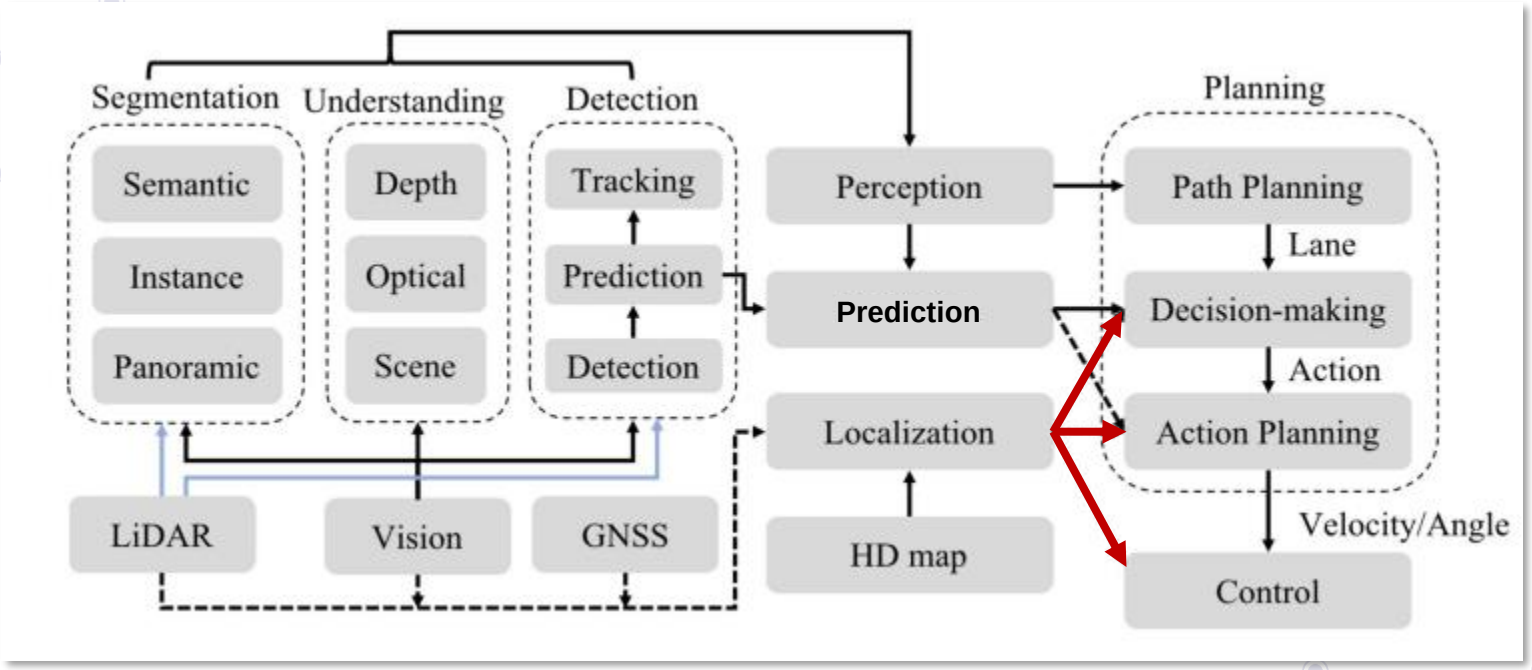


"Position information is the lighthouse in the sea of uncertainty, guiding us to our destination."

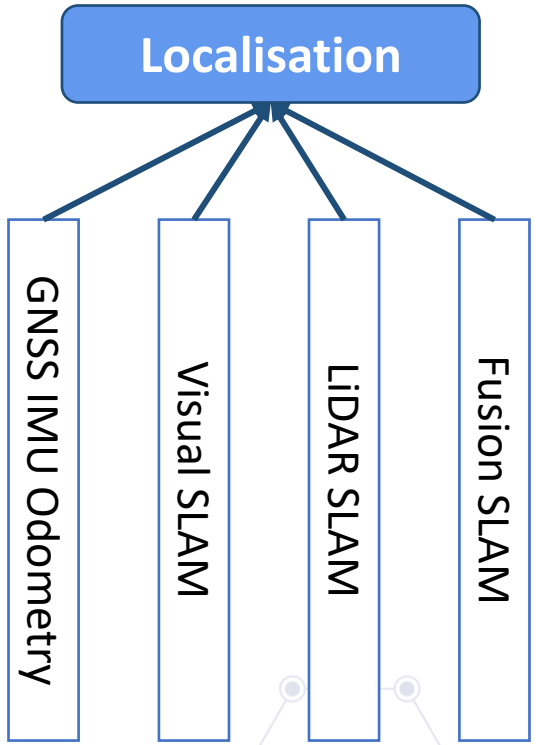
Localisation is used for:

- Routing
- Advanced Driving Assistance Systems
- Autonomous Vehicles

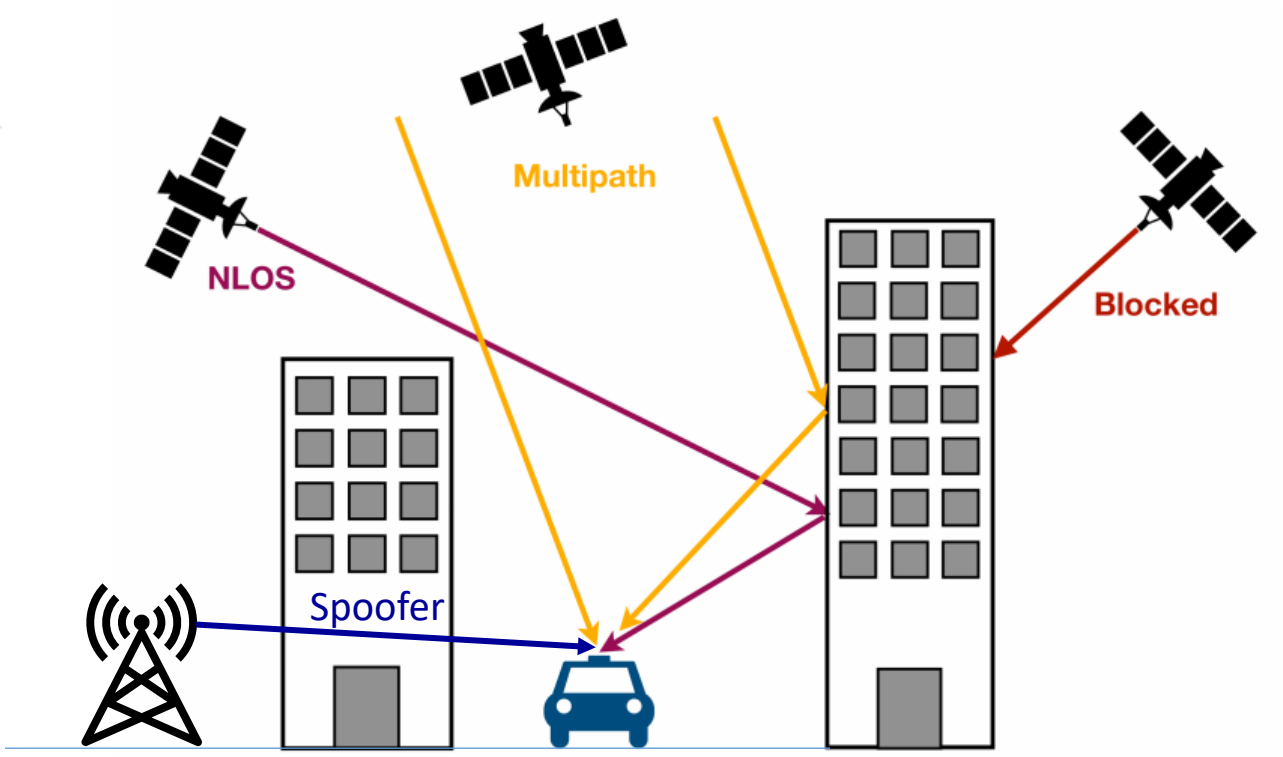
GNSS information within the context of Intelligent Vehicles



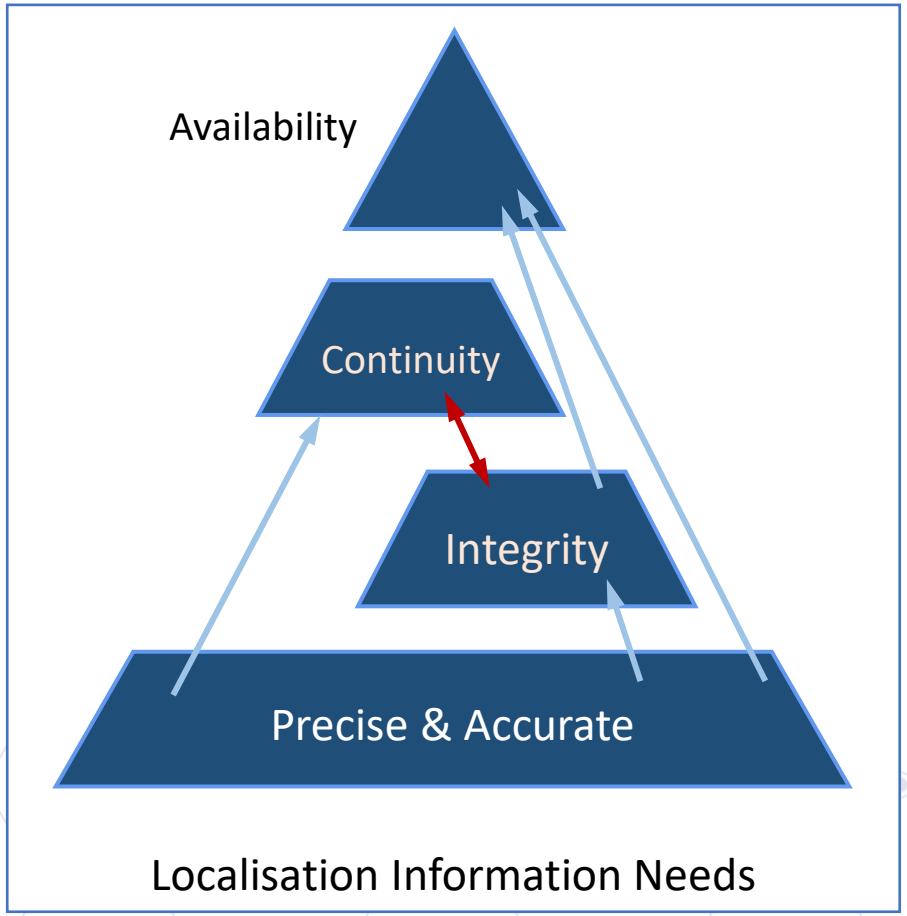
L. Chen *et al*., "Milestones in Autonomous Driving and Intelligent Vehicles—Part II: Perception and Planning," in *IEEE Trans. on Systems, Man, and Cybernetics: Systems*, Oct 2023



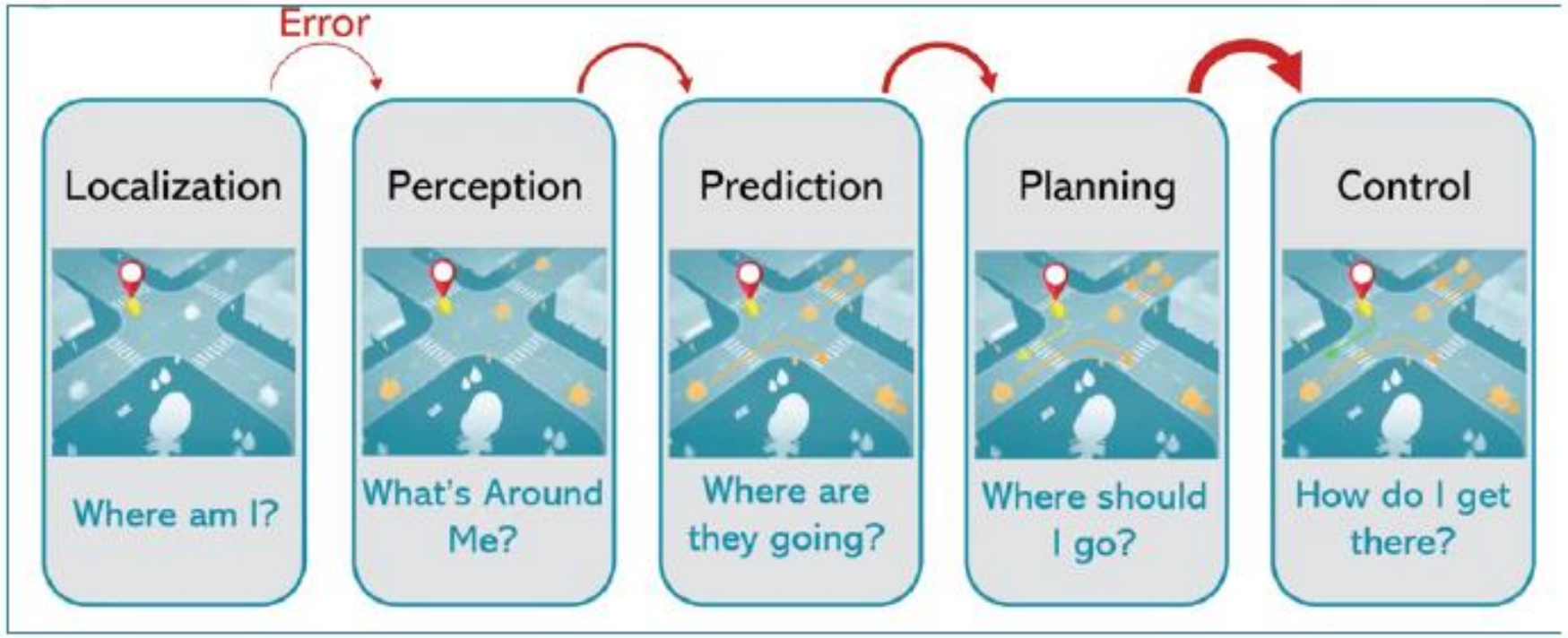
GNSS Signals for on board vehicle usage



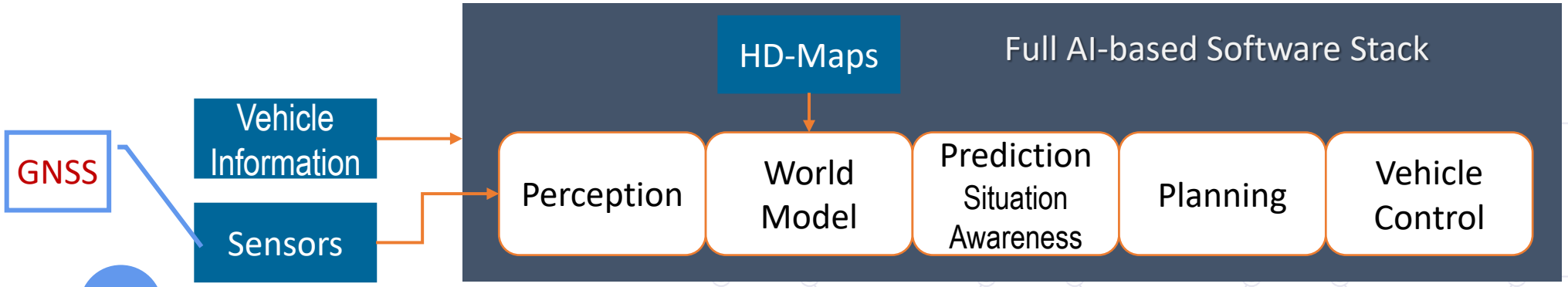
Challenging signal propagation in urban environments



Recall: errors propagate … Compromising Safety



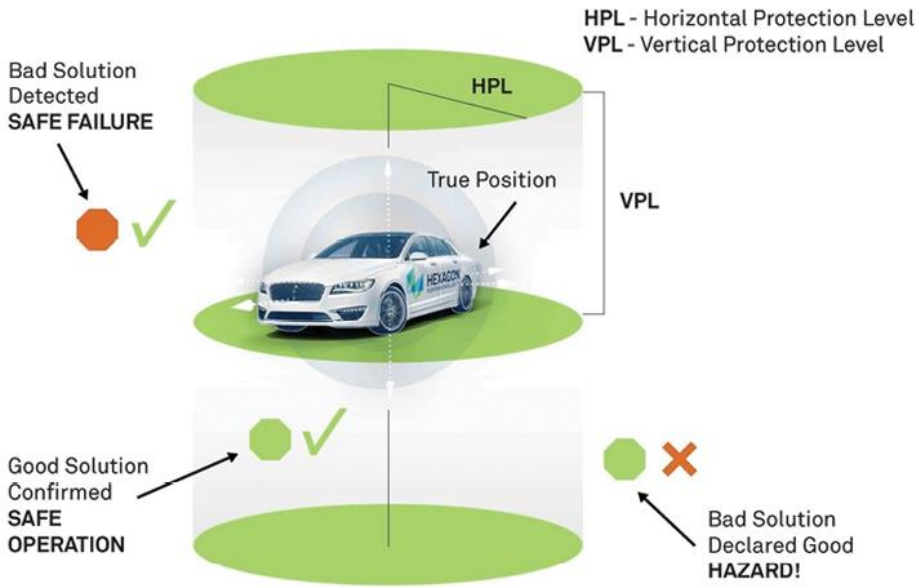
After ION 202X

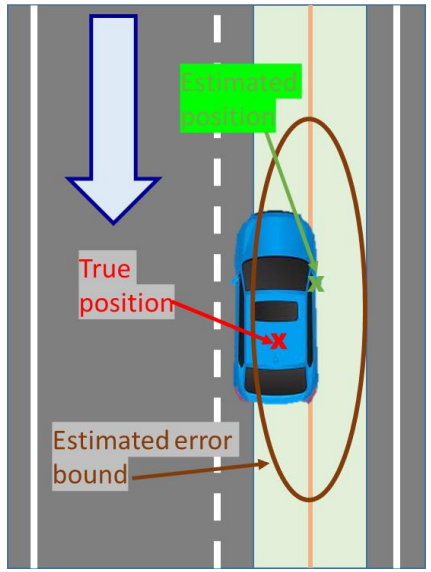


Bounding the Localisation Errors

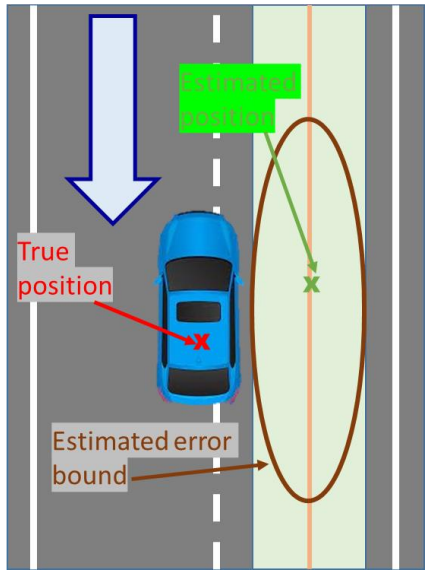
Integrity and Vehicle Localisation

Integrity. The system's ability to provide accurate and reliable positioning information, along with an indication of the confidence or trustworthiness associated with that information.





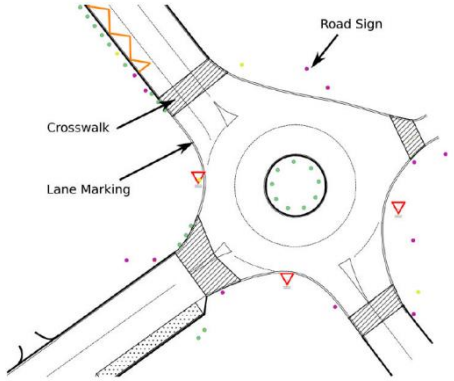
Nominal case e<PL<AL
Error correctly bounded; OK
Bound is in the limit → *use*



A situation of
Misleading information
Can lead to an accident
Error **NOT** correctly bounded
Bound is in the limit → *use*

Localisation Integrity: ADAS & AD

- Two major EUSPA sponsored projects: ESCAPE & ERASMO
- Both dedicated to integrity using Galileo Signals, PPP, HD-maps, …
- Development of several modules: localization engine and Integrity measurement
- ERASMO incorporate advances in machine learning methods for vision aided localisation
- Use of close to production components
- Extended trials and dataset generation for further development



HD map

Conclusions

- ADAS Vehicle applications
  - Lane keeping assist
  - Contextual ACC
  - Automated
- Connected vehicle applications
  - Crowdsource maps
  - Advanced hazard warning
  - Cooperative vehicles
- Highly Automated Vehicles
  - Level 3 passenger vehicles
  - Level 4 shuttles
  - Level 4 robotaxis; logistic vehicles

- GNSS information the only source for absolute localisation information
- Tangible progress exists with relative localisation methods, they are insufficient
- Integrity measurement improves operational assurance, it is being extended to maps, perception, etc.
- The Galileo GNSS satellites can augment our localisation capabilities to ensure use of localisation in safety critical situations

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Automotive value chain user perspective, Tier1

Road and Automotive

Ramsundar Kandasamy - Valeo

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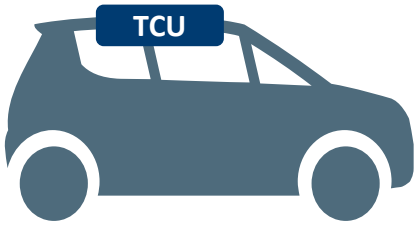
Telematics Control Unit (TCU)

Cloud-based connected services

GNSS-based positioning

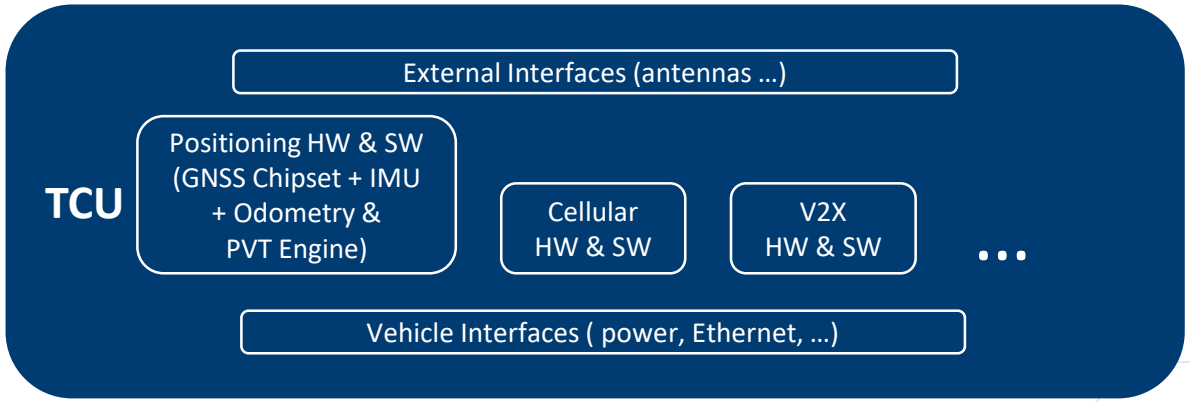
V2X (V2V, V2I, V2P)

5G



GNSS Applications

- Emergency Call (eCall)
- Navigation
- Vehicle to everything (V2X)
- Automated Driving
- Positioning as a Service
- Stolen vehicle tracking
- Fleet management



aaS – as a service
HW – Hardware
IMU – Inertial Measurement Unit
PVT – Position Velocity Time
SW – Software
V2I – Vehicle to Infrastructure
V2P – Vehicle to Person
V2V – Vehicle to Vehicle

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GNSS system in vehicle architecture

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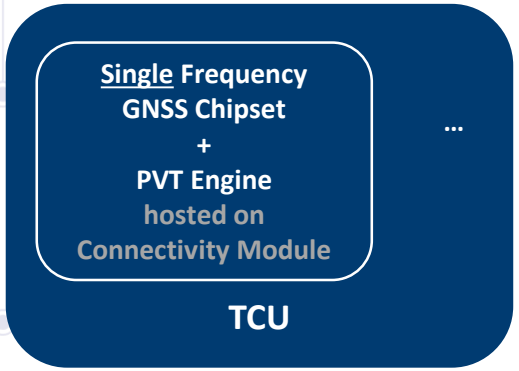
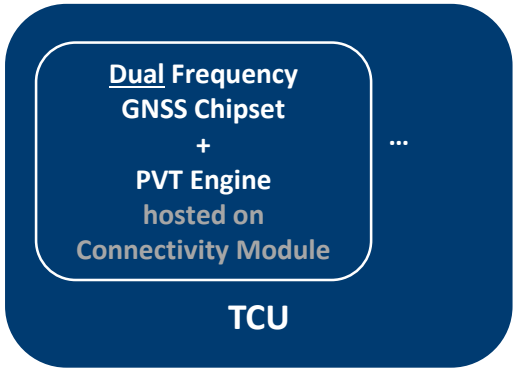
Past



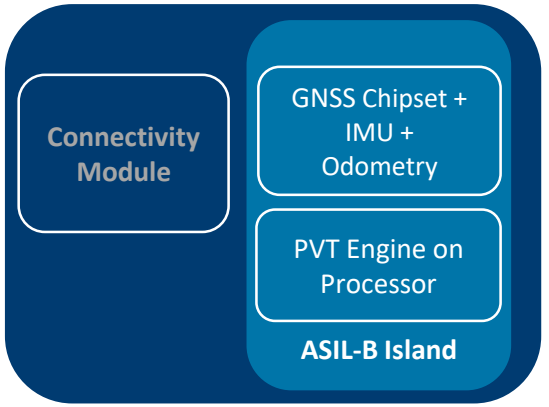
Single Frequency GNSS on TCU

Present

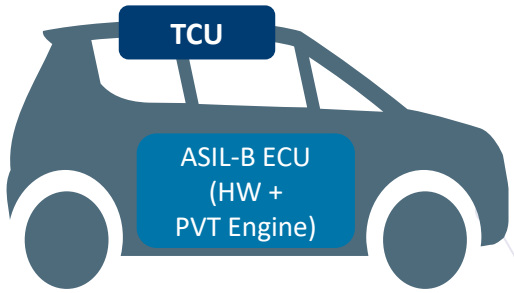


Dual Frequency GNSS on TCU

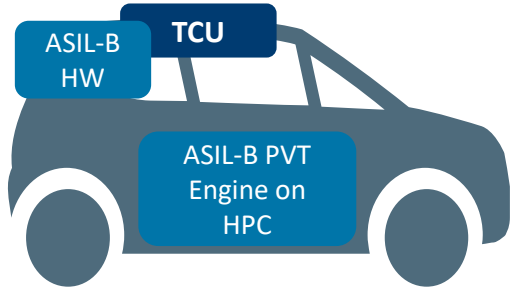
Possible next evolution



ASIL-B Island on TCU



ASIL-B Positioning ECU



ASIL-B Split Architecture

ASIL – Automotive Safety Integrity Level
ECU – Electronic Control Unit

HPC – High Performance Computer
IMU – Inertial Measurement Unit
PVT – Position Velocity Time

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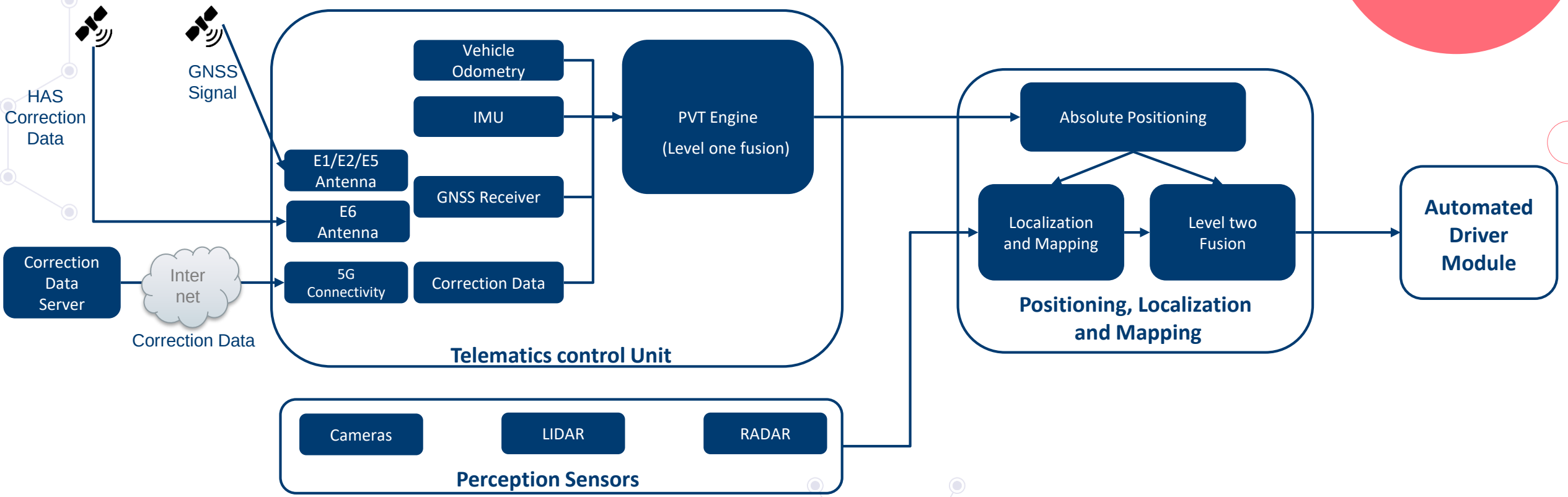
GNSS and Sensor Fusion



HAS – High Accuracy Service
IMU – Inertial Measurement Unit
LIDAR – Light Detection and Ranging
PVT – Position Velocity Time
RADAR – Radio Detection and Ranging

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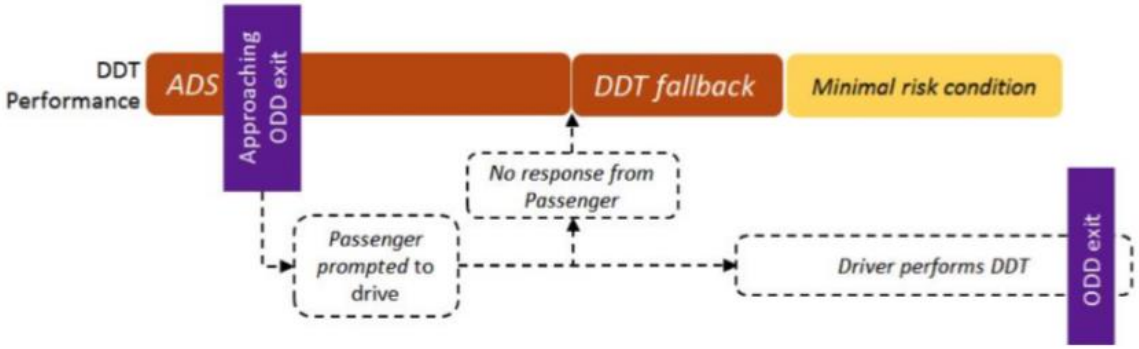
Positioning Requirements

- **Functional Safety (Integrity) Requirements**
  - Automotive Safety Integrity Level (ASIL)
  - ASIL A to ASIL D
  - ASIL Decomposition: Absolute positioning as ASIL B(D) system
  - Applies to HW + SW + Correction Data

- **Functional and Performance Requirements**
  - SAE L2+ up to L4
  - High integrity lane level automated driving
  - ODD validity
  - Accuracy 20-30 cm (1-2 sigma)
  - TTFF 10-20 seconds
  - Alert limits and Protection levels



ADS – Autonomous Driving System
DDT – Dynamic Driving Task

ODD – Operational Design Domain
QM – Quality Management

SAE – Society of Automotive Engineers
TTFF – Time to First Fix

Future Outlook

- **Galileo High Accuracy Service (HAS)**
  - Key benefits
    - Accuracy
    - Convergence time
    - E6: redundancy, reduced data consumption and cellular blackspots
  - Ecosystem HAS readiness
  - Non safety critical use cases such as lane manual navigation, V2X
- **OSNMA**
  - Automation requires a high level of resilience to spoofing

Gracias! Thanks!

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Automotive value chain user perspective, Tier2

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HEXAGON

User Consultation Platform: Road and Automotive

Dr. Paul Verlaine Gakne, Senior Product Manager, Enterprise Positioning
Hexagon

Who is Hexagon?

Critical applications served








What positioning services mean?

Excellence in positioning

Bring innovation and quality together to provide best in class positioning services

Industry and technology leader

Set the standard for what is possible in autonomy & positioning

Commitment to research and innovation

Push the limits to explore and solve complex positioning problems

Quality services

Focus on what matters most: reliable, trustworthy services for positioning any time, anywhere

User focus

Understand what technology users need, and how they want to use it

Automotive problem we help solve

Where am I?

GNSS positioning for accuracy and operation

What's around me?

Perception for autonomy and safety

How do I get there?

Guidance for machine control, planning & monitoring

GNSS positioning and challenges

- Vehicles need position data to navigate safely, securely, reliably and efficiently
- Global Navigation Satellite System (GNSS) technology provides the most accurate absolute positioning
- GNSS plus visual-based technologies and sensor fusion provide complete, precise and uninterrupted location, navigation and timing

Few features: ✓ GNSS ✕ Few objects to see

Adverse weather: ✓ GNSS ✕ Objects difficult to see

Dense urban areas: ✕ GNSS challenges ✓ Many objects easily seen

HEXAGON

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GNSS for autonomous vehicles – Req.

Lane-level accuracy - 3D decimetre level absolute positioning with rapid convergence

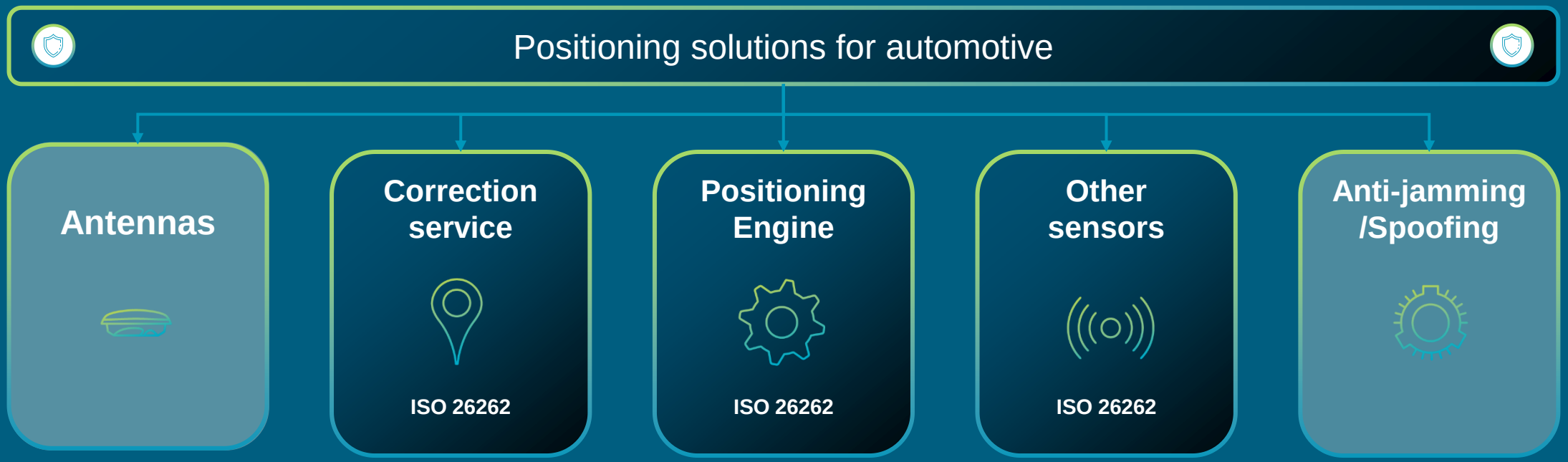
Multi-frequency, Multi-constellation receiver and antenna

- Improves overall accuracy
- Increases available measurements

High availability through sensor fusion with other sensors

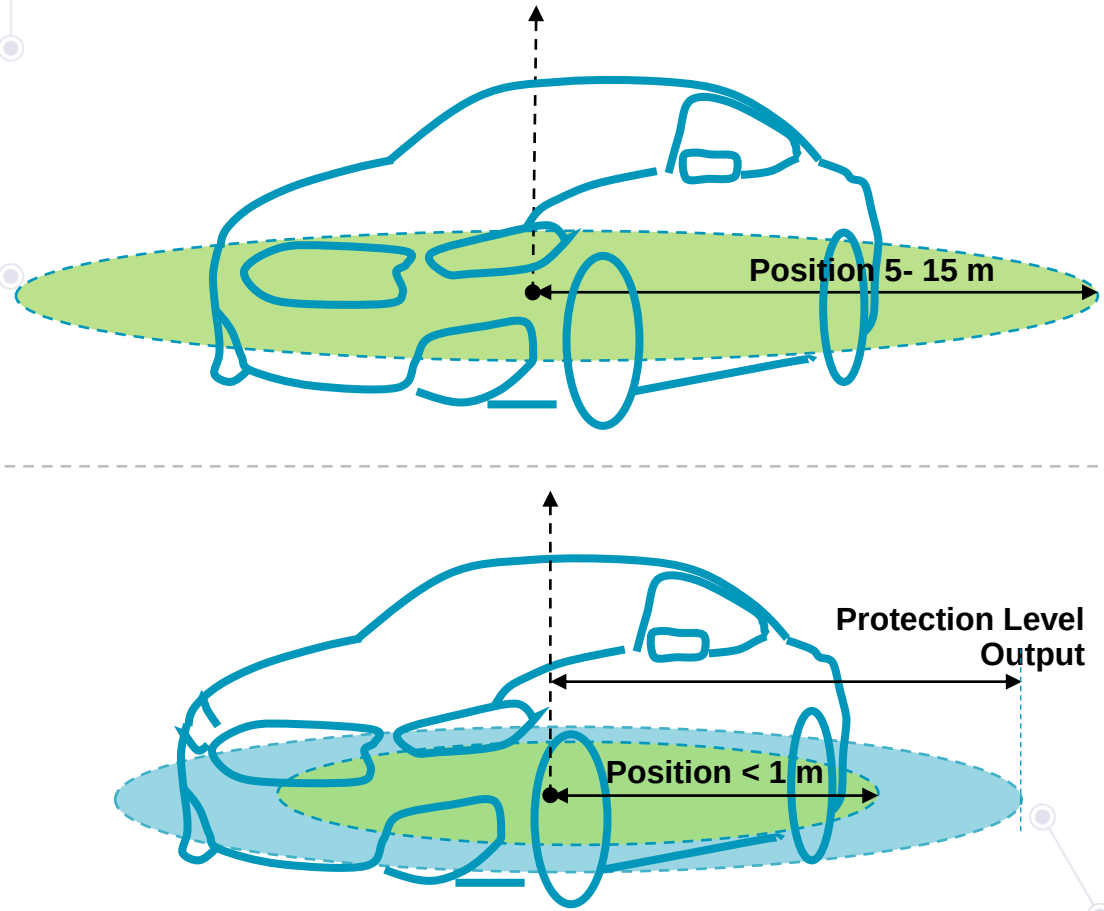
Functional Safety ISO26262 Development at ASIL B

Positioning needs for automotive and trends



Automotive Correction Services (CS)

Benefits of CS for positioning



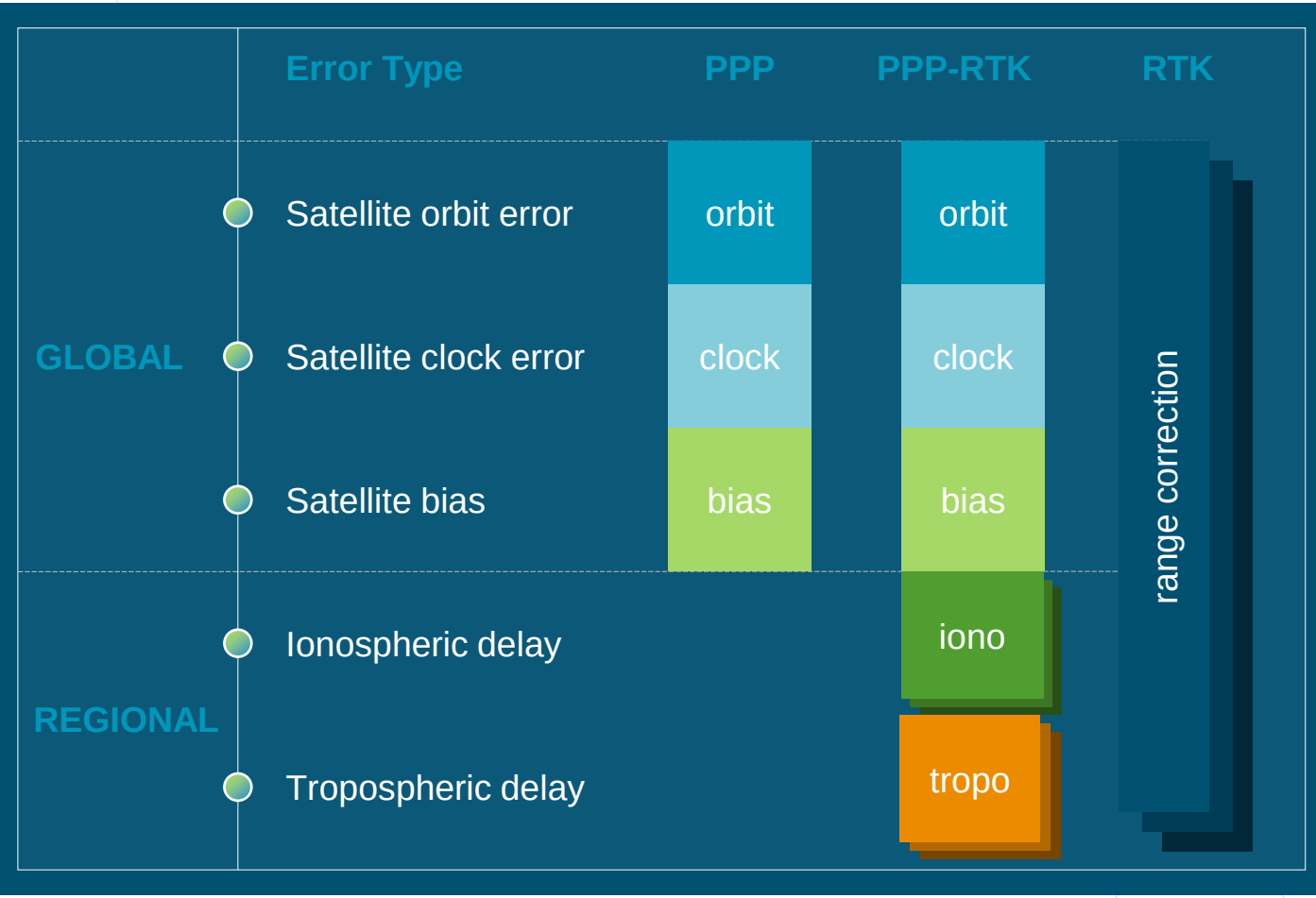
Traditional single frequency GNSS solution

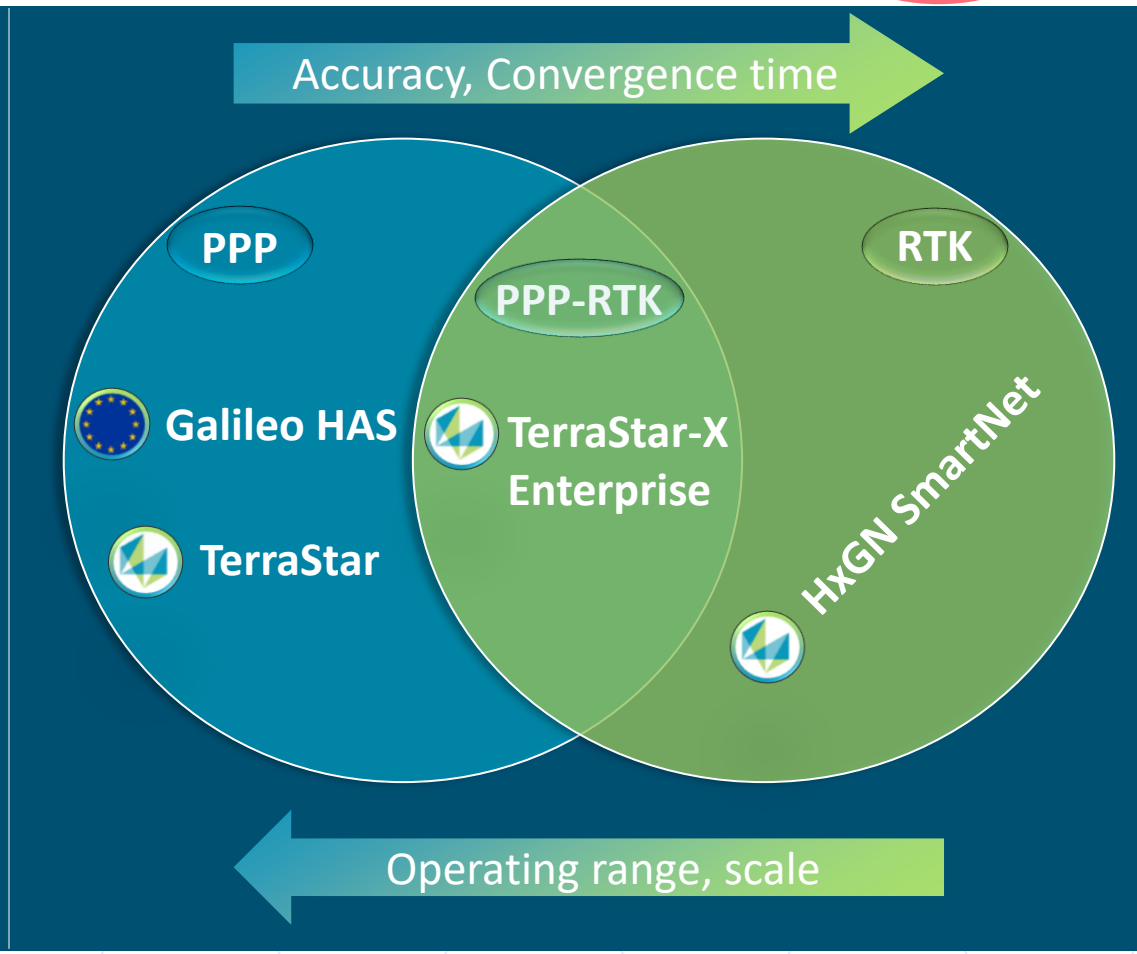
- Accuracy of 5 to 15 m in the best conditions
- Does not include any functional safety standards or protection level algorithms (RAIM)
- Only suitable for navigation

Dual frequency GNSS positioning solution with correction services

- **Improved position accuracy, availability and reliability**
- **Functional Safety**
  - Certified Protection Level output from RAIM algorithm
  - Complete integrity analysis
  - ASIL B(D) certified
  - ISO26262 functional safety compliance
  - Safety Certified Corrections Network via CIM (Corrections Integrity Monitor)

Correction services: PPP, PPP-RTK, RTK





Automotive correction service: TerraStar-X Enterprise

Hardware-agnostic correction services designed for instantaneous lane-level accuracy, functional safety applications and large scale connected vehicles and devices.

https://novatel.com/terrastar-x

Correction services requirement

Performance

- **Convergence**: rapid convergence
- **Accuracy**: lane-level using automotive-grade hardware

Functional Safety

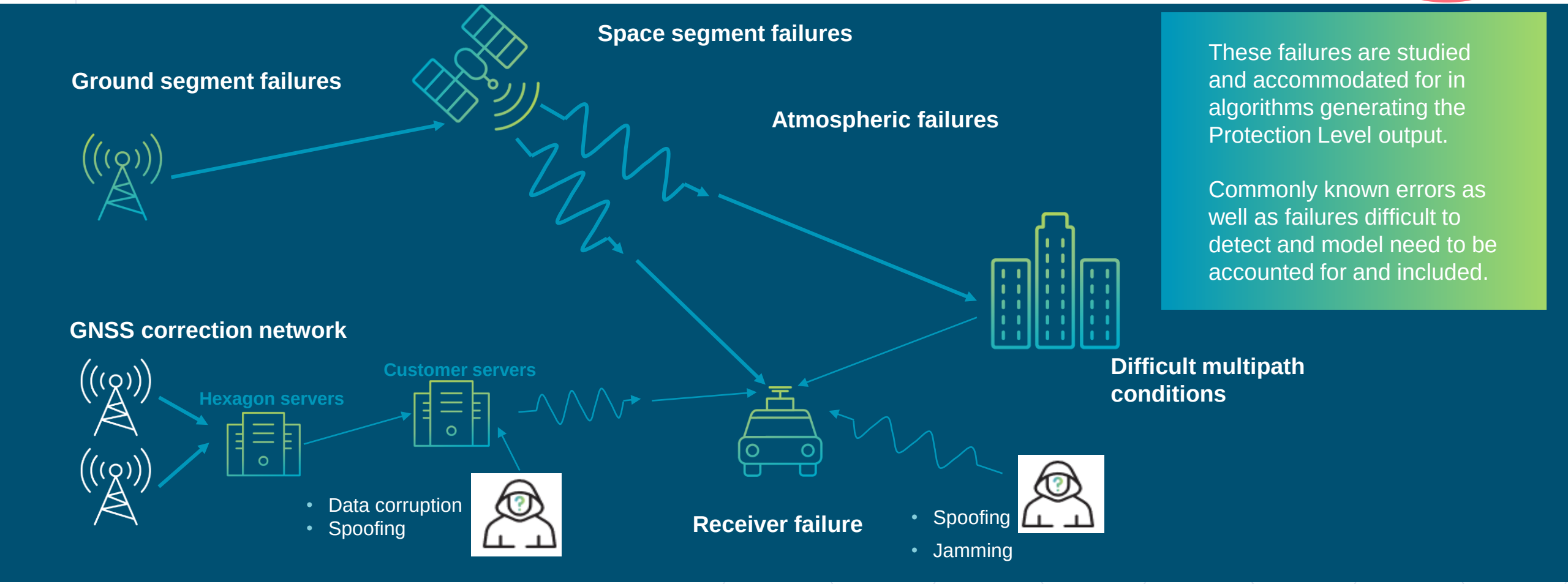
- **Integrity**
- **ASIL Compliant**

Business Model/Delivery

- **Mass Deployment**: for large-scale deployment
- **Delivery**: IP or other delivery methods
- **Standard or proprietary formats**

Integrity and Safety

Introduction to safety concept



These failures are studied and accommodated for in algorithms generating the Protection Level output.

Commonly known errors as well as failures difficult to detect and model need to be accounted for and included.

Trends and Innovations

Future trends: LEO PNT

LEO constellations offer a new avenue of assuring PNT by providing stronger signals with satellites closer to the Earth and improved positioning accuracy with rapidly changing geometry.

Hexagon | NovAtel's receivers to support new Xona commercial LEO constellation

NovAtel has signed a Memorandum of Understanding (MoU) with Xona to collaborate in developing PNT for the new LEO constellation.

https://novatel.com/about-us/news-releases/memorandum-of-understanding-signed-by-hexagon-novatel-xona-space-systems-assured-precision-pnt

Autonomous platooning

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Safe and Reliable Positioning for Autonomous Driving

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Cooperative, connected and automated mobility (CCAM)

Ilaria Martini, Principal Research Engineer Integrity Tech Lead, U-blox

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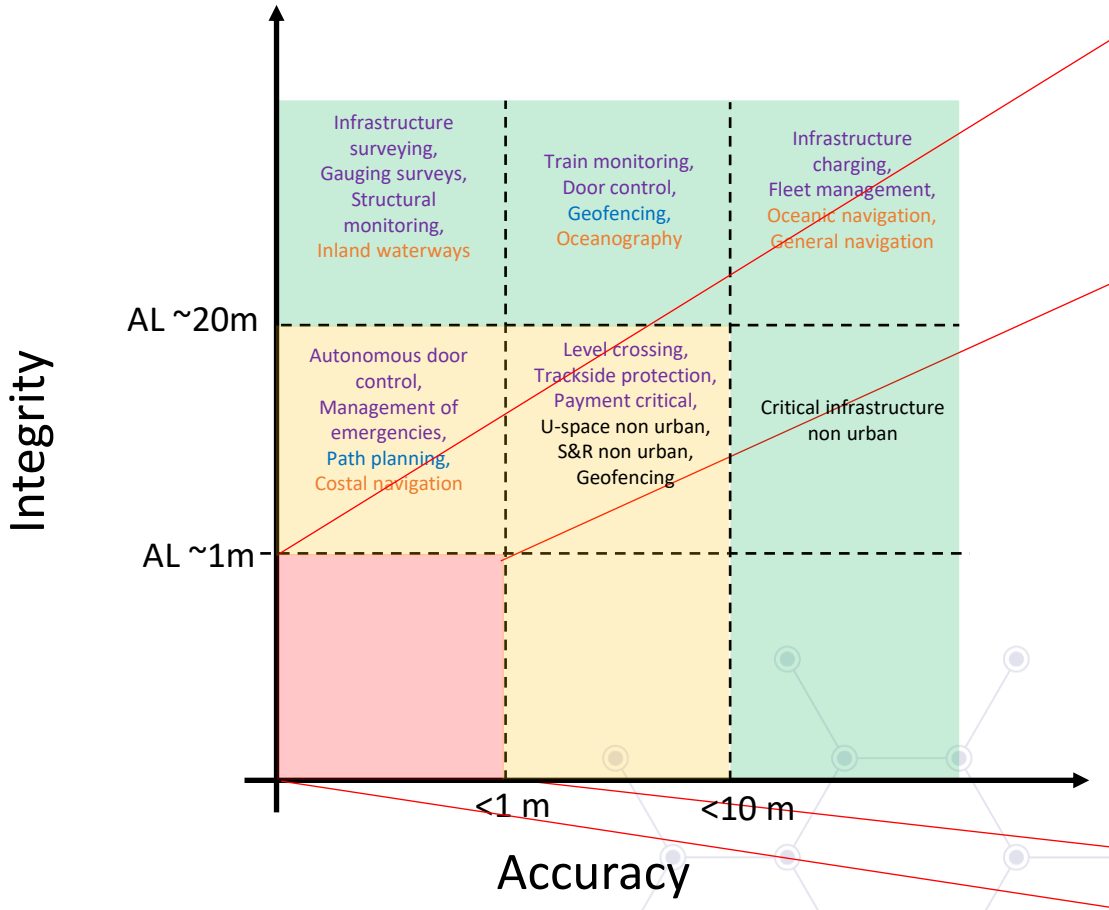
ublox Reliable. Smart. Secure.

Introduction: needs and challenges

Autonomous Transportation Needs



- Cold movement
- Track identification
- Cargo monitoring
- Autonomous driving
- Autonomous emergency braking
- Crossroad passing
- Visual impairment
- Trajectory prediction
- Lane change
- Multilayer bridge
- Lane identification
- Platooning
- Constructions
- Ports
- Hydrography
- Bridge operations
- Collision warning
- Docking
- Port operations
- U-space non-urban
- Critical infrastructure
- Search&Rescue urban
- Geofencing

Source: EC/EUSPA GNSS Market Report and UCP (https://www.euspa.europa.eu)

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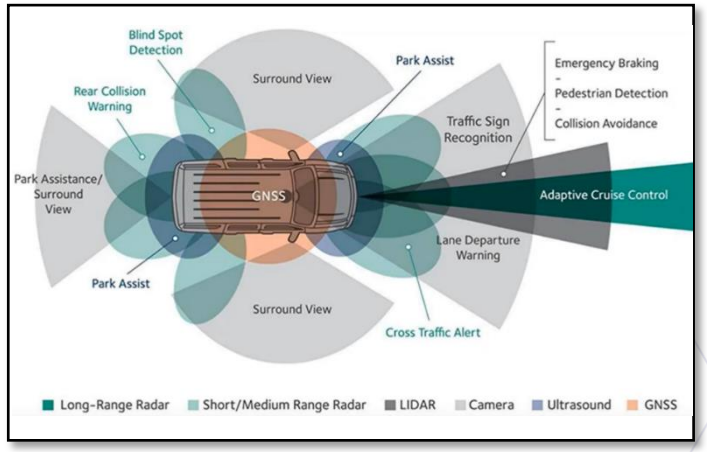
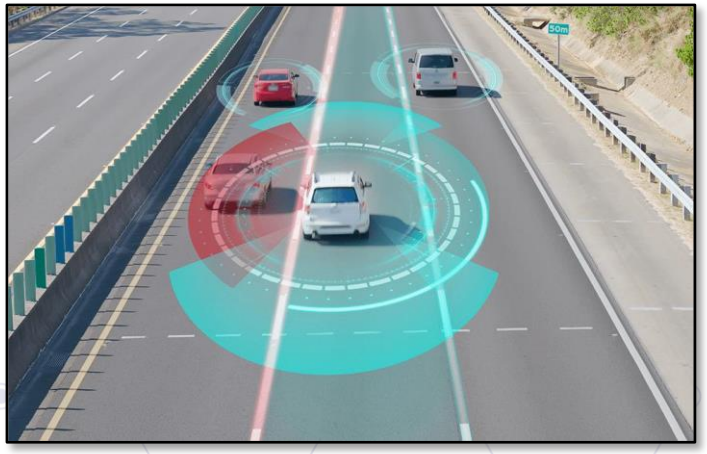
Autonomous Driving: Challenges and Trends

Challenging Needs
- Alert Limit 2m
- Target Integrity Risk up to 10e-7/h
- Standard ISO26262, ISO21488, ISO 21434, SOTIF

Sensor Fusions
- High grade and safety compliant Inertial
- Wheel Speed Sensors
- Camera
- Lidar
- Radar





Autonomy
- Lane-accurate positioning for ADAS level 2+ to 5, including functional safety
- Cm-accuracy (95%)

Cooperative positioning
- V2X and V2I standard
- RTCM, ETSI, 5GAA, 3GPP, C2C
- Perception, prediction and planning

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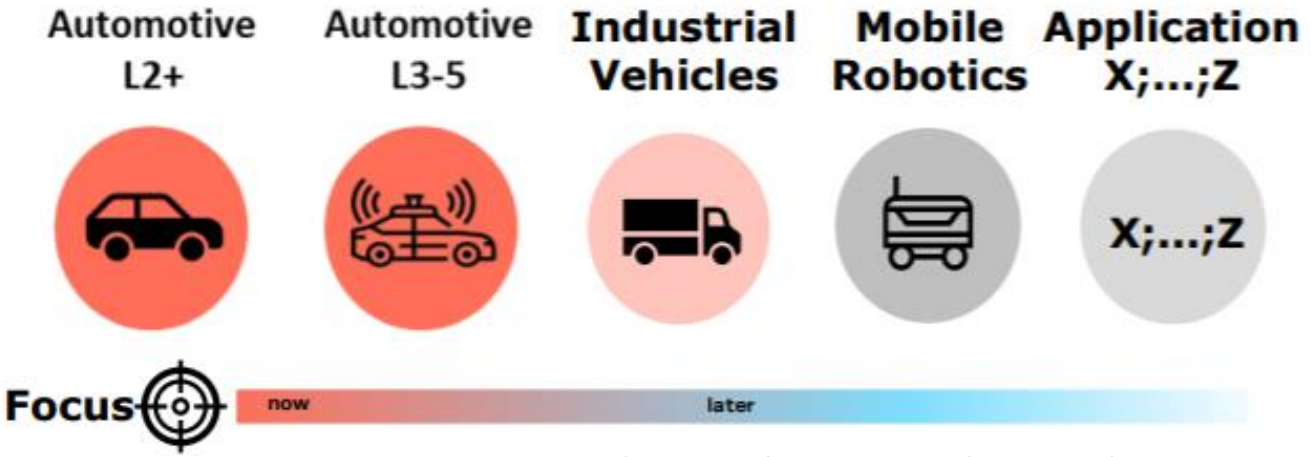
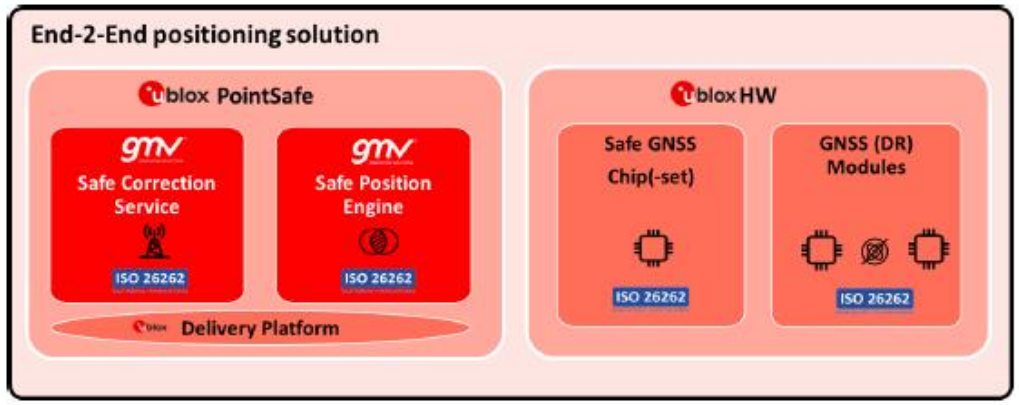
Safe Positioning

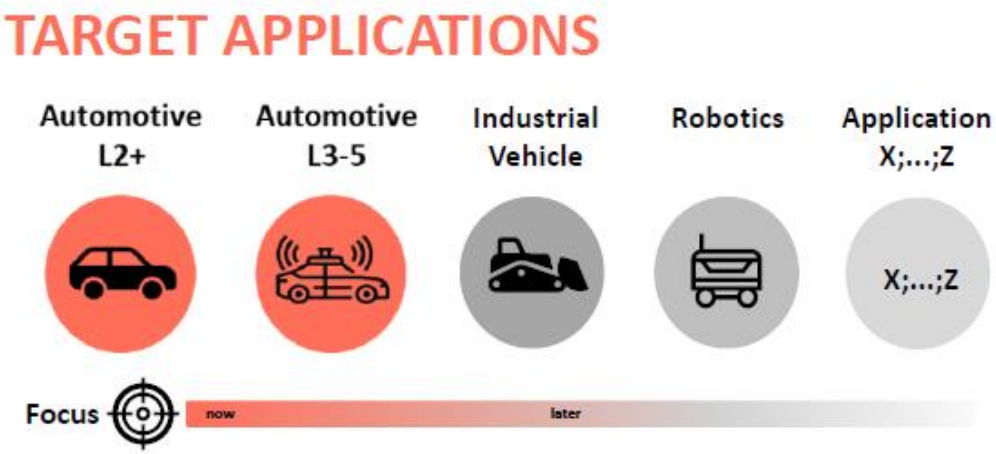
Safe positioning means providing **High-Accuracy + High-Integrity PVT** positioning solutions complying application-specific KPI's and **SOTIF & Functional Safety & Cyber Security** requirements (FuSa ISO26262, SOTIF ISO21448, Security ISO21434)

Emerging target applications



U-Safe: End-2-End Solution





https://www.u-blox.com/en/usafe

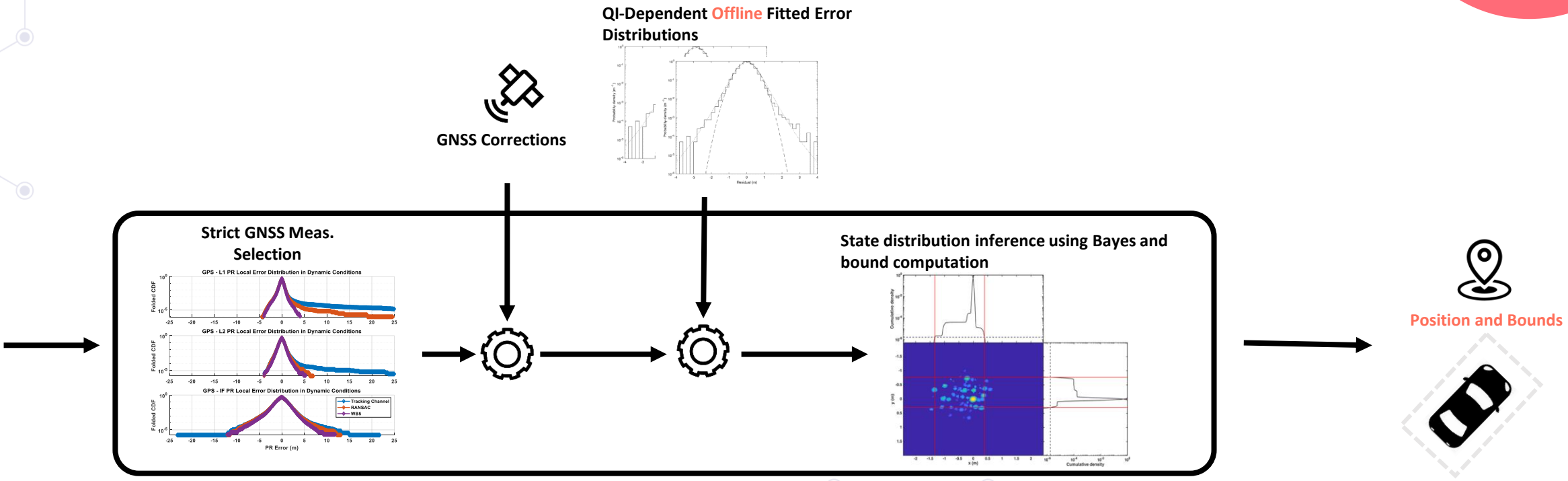
Solutions for a safe and reliable position

Traditional Integrity Concepts and Change of Perspective

- Space Errors
  - In 2018 EU-US bilateral cooperation led to the definition of **constellations commitment** for aviation and ICAO approved in 2022 standards including integrity parameters such as satellite fault probabilities and error bounds[1].
  - Satellite accuracy is expected to improve over time but new satellites, modernized signals challenge the integrity improvement especially in automotive (**AL one magnitude order smaller than for aviation**).
  - **Correction Service** can mitigate this contribution, but error bounds are needed.
- Atmospheric Errors
  - Ionosphere due to high solar activity pick poses the need for optimizing the **Correction Service messages**.
- Local Errors (multipath, interference, NLOS)
  - Most significant contributions. Receiver is the major responsible and requires **robust integrity detection mechanism**.

[1] https://www.euspa.europa.eu/newsroom/news/international-civil-aviation-organisation-approves-new-standards

Single Epoch Positioning Bound (SEPB)



- Key Characteristics:
  - Tightness of bounds
  - Fitting of measurement models to avoid conservatism of Gaussian overbounding
  - Uses of phase without fixing ambiguity

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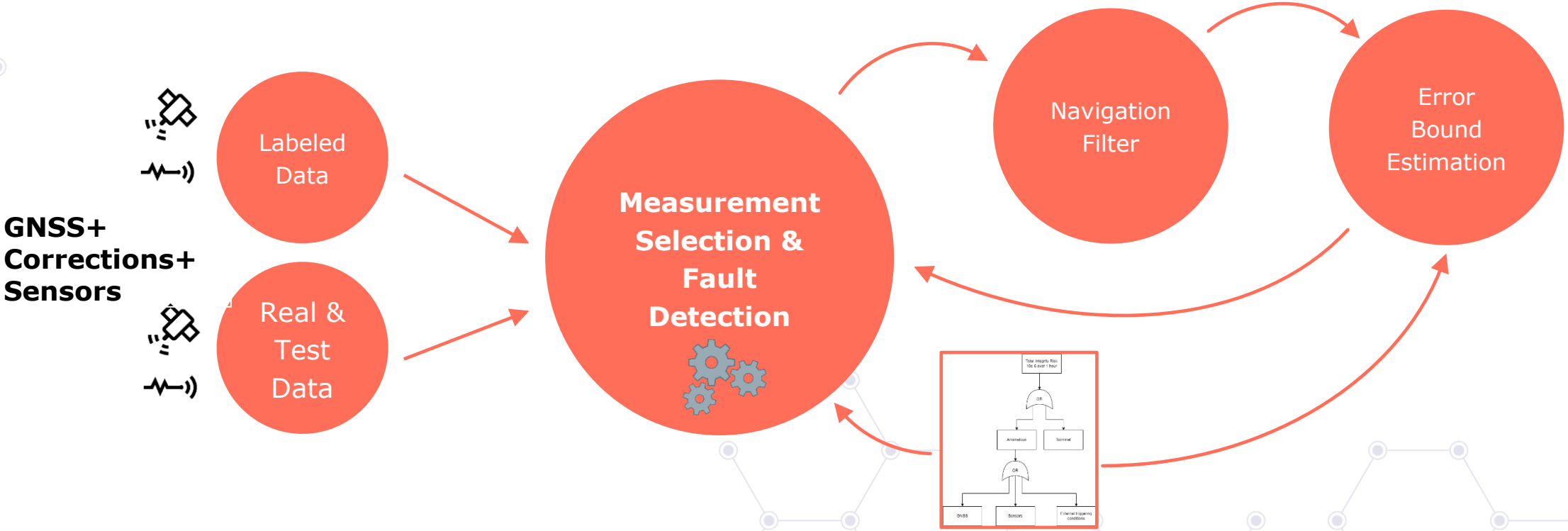
Measurement Selection and Fault Detection

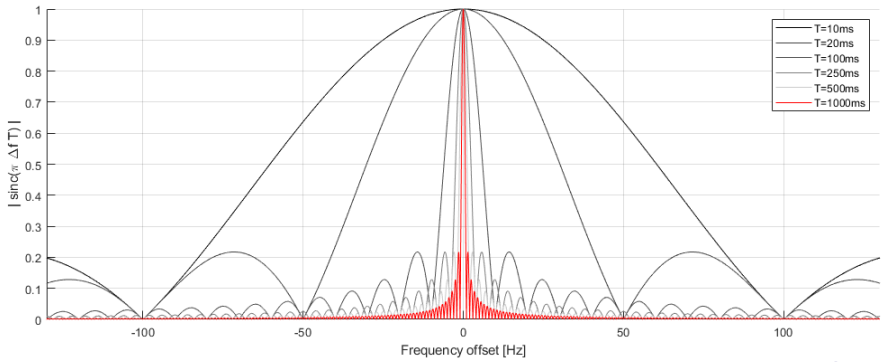
- Satellite selection methods and fault detection based on a-priori knowledge of fault profile and its probabilities using Correction Service and Supervised Machine Learning techniques

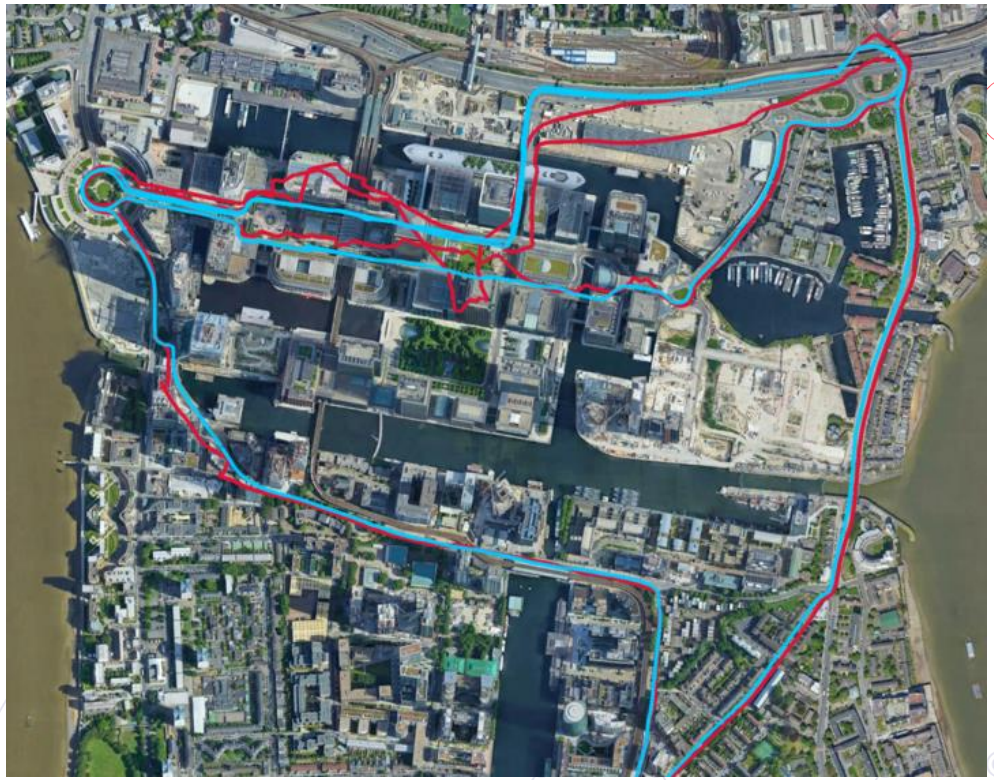


Martini et al., "PPP and Galileo High Accuracy Service with Satellite Selection Strategies for Kinematic Applications," ITM ION GNSS+ 2022, Colorado, September 2022
Martini et al., "Galileo High Accuracy Service Performance and Anomaly Mitigation Capabilities, 13 June 2023, Journal GPS solutions available at https://doi.org/10.21203/rs.3.rs-3039272/v1

Local Threats Mitigation:
Multipath, Spoofing, Interference

- Doppler frequency resolution is inversely proportional to the correlation period. Long coherent integration allows to
- discriminate between signals with different Doppler frequencies (e.g. spoofing)
- mitigate multipath which typically has a different Doppler when the antenna is moving





Supercorrelation vs standard non-U-blox GPS chipset (L1 only)

Cellular handset, GPS/Galileo/BDS L1, without IMU aiding

FocalPoint S-GNSS, IMU for supercorrelation, no strapdown mode

https://www.youtube.com/watch?v=WDATFeVTUHs&t=3s

Conclusions

Conclusions

- U-blox provides End-2-End solution for safe autonomous transportation
- Providing safe position in autonomous transportation is challenging but exploiting new technologies and changing perspective are essential to meet the user requirements
- Research and innovation are needed to address challenges and improve performances:
  - Tight position bound estimation based on phase measurements and single epoch estimation
  - Selection and fault detection based on advanced approaches (e.g. machine learning) exploiting large number of measurements available
  - Local threat mitigation based on Super-correlation with long coherent integration can be exploited to mitigate multipath and spoofing threats.

https://www.u-blox.com/en/usafe

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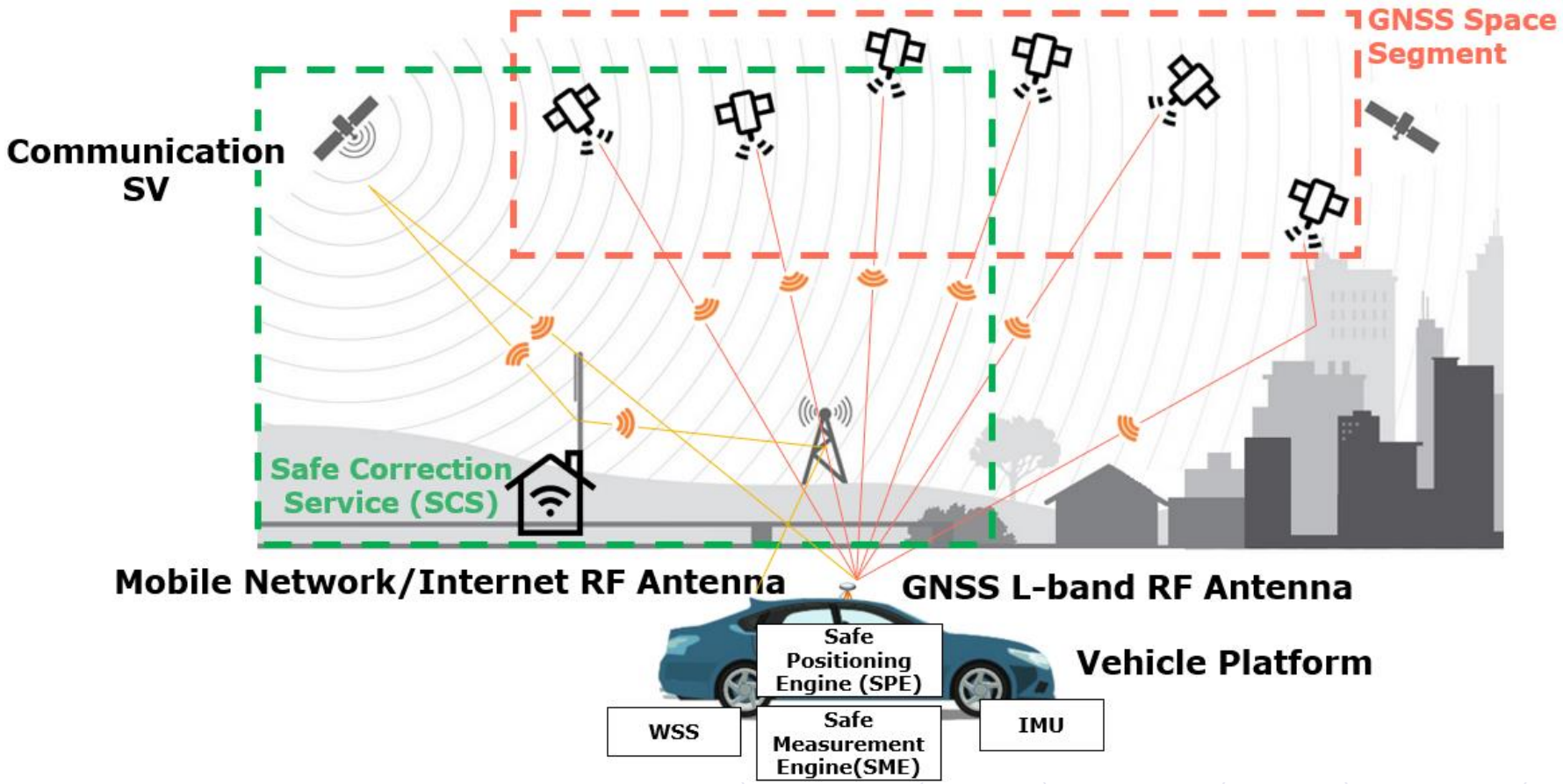
u-blox
Reliable. Smart. Secure.

Safe Positioning System

Safe Positioning System (SPS) provides a GNSS-based end-to-end (E2E) positioning solution



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CCAM

Marco Bolchi – Executive Director – EY Belgium

From ADAS functions to full automation

Examples of automotive functions according to the automation level				
Level 0-2			Level 3	Level 4-5
Traffic queue warning	Blind spot lane change warning	Emergency electronic brake light	Automatic Driving	Autonomous Car
Obstacles on the road	Pedestrians in crossroads	Emergency brake assist system, forward collision avoidance		
Work zone warning	Wrong way driving	Oversized vehicle warning		
Weather based hazards	Cooperative intersection collision avoidance	360 all around view		
Curve speed warning	Automatic speed limitation			

Question: *Are there any other important, already* ***existing or emerging CCAM functions using GNSS*** *that should be considered because of the specificity of their requirements?*

Consensus on operational requirements at vehicle level

- Several papers (e.g. Localization Requirements for Autonomous Vehicles, presented by Ford in 2019*, or Milestones in Autonomous Driving and Intelligent Vehicles, published by IEEE** have tried to consolidate framework for the operational requirements on vehicles taking into account the key elements (vehicle, road network, etc.)

Vehicle Type	Width [m]	Length [m]	Height [m]
Passenger (P)	**2.1**	**5.8**	**1.3**
Single Unit Truck (SU)	2.4	9.2	3.4 – 4.1
City Bus	2.6	12.2	3.2
Semitrailer	2.4 – 2.6	13.9 – 22.4	4.1

Road Type	Design Speed [km/h]	Lane Width [m]	Minimum Radius** [m]
Freeway	**80 – 130**	**3.6**	**195****
Interchanges	30 – 110	3.6 – 5.4	15 – 150
Arterial	50 – 100	3.3 – 3.6	70**
Collector	50	3.0 – 3.6	70**
Local	**30-50**	**2.7* – 3.6**	**10****
Hairpin / Cul-de-Sac	< 20	6.0	7
Single Lane Roundabout	< 20	4.3	11

Vehicle Type	Accuracy (95%)				Alert Limits				Prob. of Failure (Integrity)
	Lat. [m]	Long. [m]	Vert. [m]	Att* [deg]	Lat. [m]	Long. [m]	Vert. [m]	Att* [deg]	
Mid-Size	0.24	0.48	0.44	0.51	0.72	1.40	1.30	1.5	10^{-9} /mile (10^{-8} /h)
Full-Size	0.23	0.48	0.44	0.51	0.66	1.40	1.30	1.5	10^{-9} /mile (10^{-8} /h)
Standard Pickup	0.21	0.48	0.44	0.51	0.62	1.40	1.30	1.5	10^{-9} /mile (10^{-8} /h)
Passenger Vehicle Limits	**0.20**	**0.48**	**0.44**	**0.51**	0.57	1.40	1.30	1.5	**10^{-9} /mile (10^{-8} /h)**

Illustrative

- **Question**: Is there a document that you consider as a widely accepted reference for such operational requirements, worldwide and/or in EU?

*Reid, Tyler & Houts, Sarah & Cammarata, Robert & Mills, Graham & Agarwal, Siddharth & Vora, Ankit & Pandey, Gaurav. (2019). Localization Requirements for Autonomous Vehicles.
** L. Chen et al., "Milestones in Autonomous Driving and Intelligent Vehicles—Part II: Perception and Planning," in IEEE Trans. on Systems, Man, and Cybernetics: Systems, Oct 2023

The role of GNSS for vehicle positioning

- Automated vehicles are equipped with a combination of sensors (LiDAR, radar cameras, IMUs, …), collecting data about the vehicle and its surroundings to map the environment and support automated operations.
- By offering absolute positioning, GNSS fills the gap to achieve full operability.
- In the industry there are different approaches to the types, number, and the combination of sensors, including GNSS.

Question: *What are the main technological strategies to solve the vehicle positioning issue for CAD, and how do they influence the role of GNSS (and expected requirements)?*

User requirements of AD – Accuracy (1/2)

Our assessment indicates the required positioning accuracy for **the most demanding functions and use cases** to be in the range of decimetre level ("half a wheel"). However, as highlighted in the discussions, there is no full consensus on the required accuracy.

- ***Question:*** *What is the (horizontal) positioning accuracy required at vehicle level?*
  - *A. 10 cm (95%)*
  - *B. Better than 10 cm (95%)*
  - *C. Worse/lower than 10 cm (95%)*

- ***Question:*** *How does this requirement translate into GNSS (horizontal) positioning accuracy requirements?*
  - *A. 10 cm (95%)*
  - *B. Better than 10 cm (95%)*
  - *C. Worse/lower than 10 cm (95%)*

User requirements of AD – Accuracy (2/2) – Galileo High Accuracy Service

- ***Question:*** *Do you consider* ***Galileo High Accuracy Service (HAS)*** *as a potential contributor to achieve the required accuracy performance?*
- ***Question: How could HAS be used*** *as a complement to other existing services?*
- ***Question:*** *Do you foresee any potential* ***barriers to the implementation of HAS*** *in your system?*
- ***Question:*** *What is the more* ***effective dissemination of the HAS messages****? (i.e. via Internet or satellite?)*

User requirements of AD – GNSS Integrity (1/2)

The integrity of the positioning/navigation function is widely recognised to be of key importance. The main KPIs are **integrity risk** and **alert limits.**

***Question**: What is the required **alert limit** for the **most demanding functions**?*

A. Below 2m
B. Between 2m – 2.5m
C. Between 2.5m and 5m

***Question:** What is the target **integrity risk** for the **most demanding functions**?*

A. Up to $10e^{-6/h}$
B. Up to $10e^{-7/h}$
C. Up to $10e^{-8/h}$

User requirements of AD – GNSS Integrity (2/2)

- ***Question:*** *What technical solutions are you considering using in order to fulfil the positioning integrity requirements?*
- ***Question:*** *Do you see any gaps that would need to be filled in terms of available solutions and services?*

Questions – Connected and Automated Driving cybersecurity

Several recent regulations lay out provisions at international level (e.g. UN Regulation 155), concerning the (type) approval of vehicles in relation to the challenges and threats related to the advent of CAD.

Questions:

- *Regarding the **cybersecurity of the car**, and in particular to GNSS-related threats such as spoofing, what is your strategy to deal with security of GNSS positioning, and notably authenticity of GNSS data?*
- *Are you aware of Galileo OSNMA and to what extent do you foresee it can be helpful with compliance with the UN155?*
- *Do you see any potential barriers related to the implementation of OSNMA?*

Satcom and Secure S nication

In progress

- EUSPA is starting to investigate the role of secure satcom for CAD. We have identified **four relevant** use cases:
    1. Transition between 4G/5G and satellite communication for V2X **-> Under development**
    2. Satellite IoT connectivity **-> Under development**
    3. Satellite communications as back up for terrestrial networks, e.g. in case of emergency and disaster management **-> Under development**
    4. Tracking of dangerous and/or valuable goods -> **mature use case**

Questions: *Which are the most relevant use cases in terms of market potential and importance to support CCAM uptake? Are you working / active on any of these use cases?*

Are there any other important, already ***existing or emerging use cases of the use of Secure SatCom for Road*** *that should be considered?*

Additional Questions – Challenges and R&I & Barriers

- *Can you suggest any **improvement of GNSS services and data** necessary to better fulfil user requirements?*
- *Do you see **R&I gaps connected to the use of space technologies in connected and automated driving that funding programmes** could address?*
- *Is there **any other type of support** that EUSPA can provide to foster GNSS market uptake?*

End of CCAM session

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MICROMOBILITY

USE CASES AND CHALLENGES FOR GNSS TECHNOLOGY

User Consultation Platform: Road and Automotive

DOTT

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DOTT, THE RESPONSIBLE MICROMOBILITY PARTNER

Dott is the chosen partner for cities & regions who are seeking a trustful operator to build sustainable and responsible micromobility solutions.

WE ARE RESPONSIBLE

In-house employees deliver reliable operations.

WE ARE MULTIMODAL

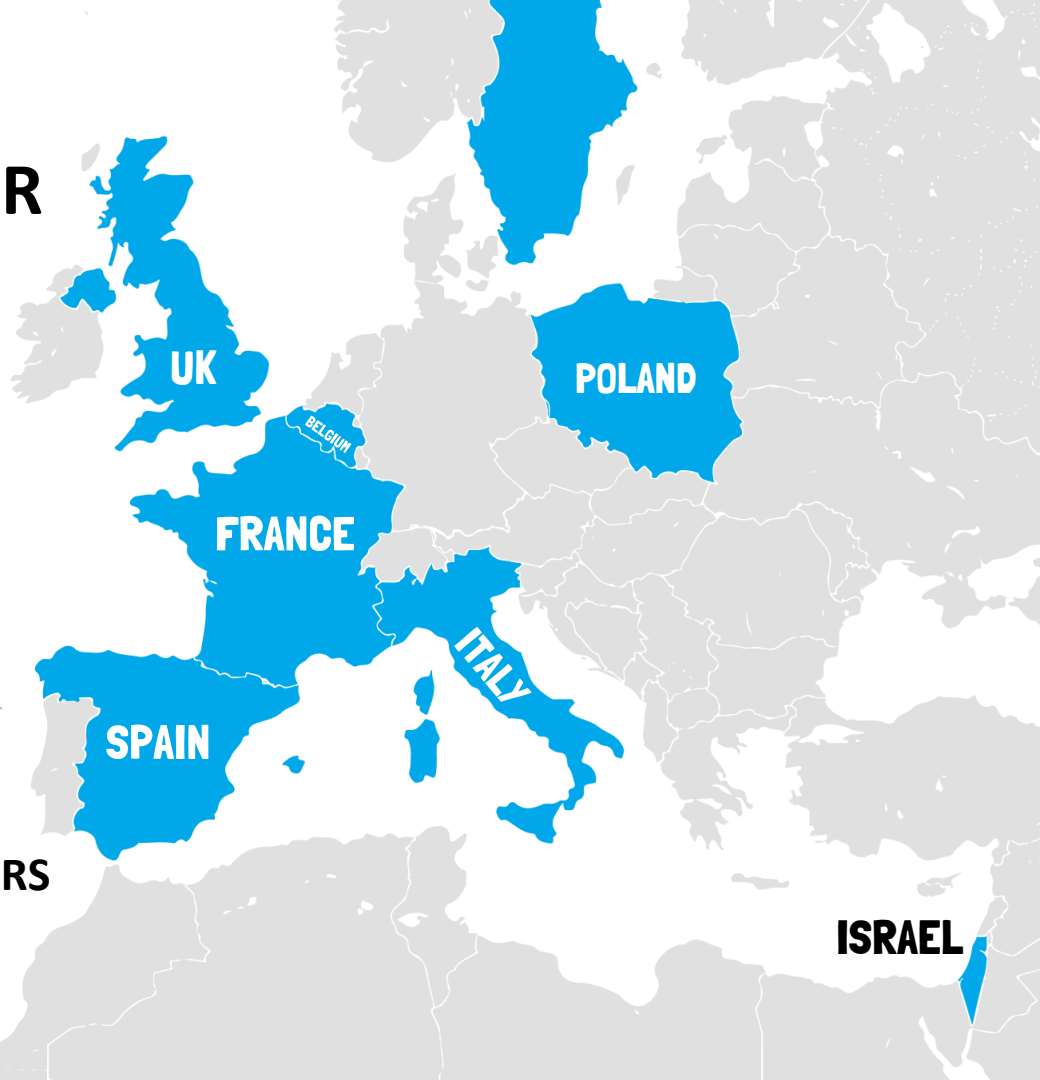
+50,000 e-bikes and e-scooters.

WE ARE INTEGRATED

Embedded locally to amplify public transport.

BACKED BY EU ESG INVESTORS

Aligned social and environmental goals.



HOW DOTT WORKS -
GNSS USE CASE #1 - FIND VEHICLE

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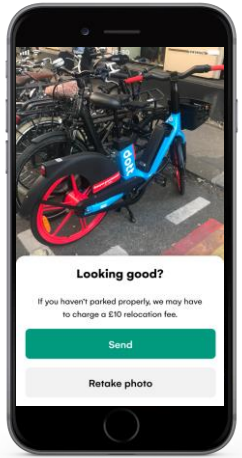
1.

Spot a Dott

2.

Ride Safely

3.



Park Responsibly

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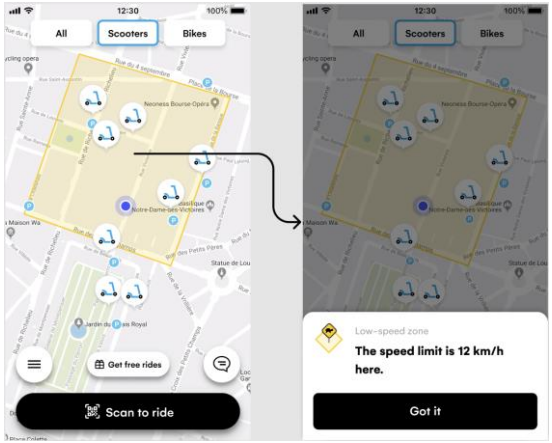
FROM FREE FLOATING TO FIXED PARKING - GNSS USE CASE #2 - PARK CORRECTLY

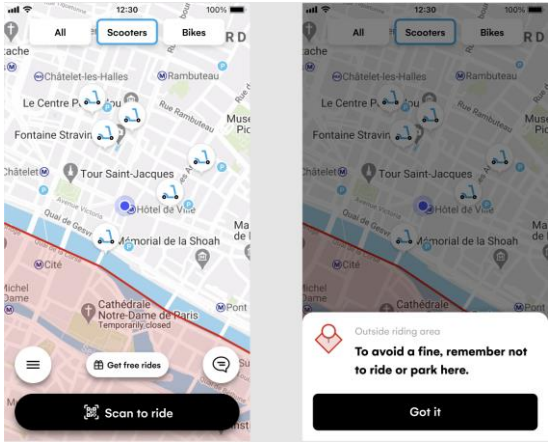
FREE-FLOATING

FIXED PARKING

HOW IT WORKS - DIGITAL MANAGEMENT OF PUBLIC SPACES – GNSS UC #3 - POLICY ZONES COMPLIANCE



NO-GO / LOW-SPEED ZONES (Geofencing)



SERVICE BOUNDARIES

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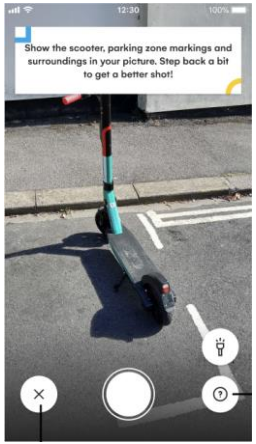
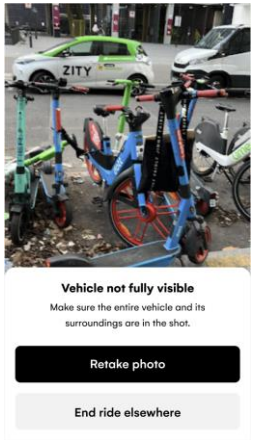
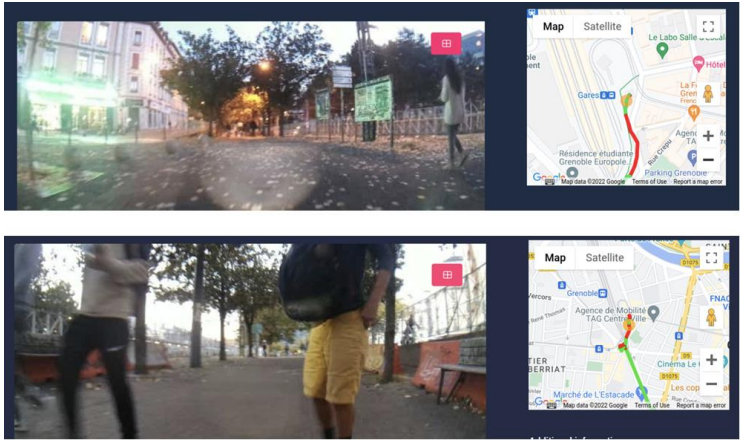
CURRENT CHALLENGES - GOING BEYOND SATELLITE LOCALISATION





PARKING ACCURACY



PAVEMENT RIDING

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Thank You

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Mobility as a Service
Case MaaS Global / Whim

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MaaS Session

Sampo Hietanen

What would it take for you to give up your own car?

Freedom subscription

900 € /month

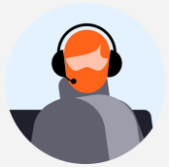
Freedom of all-inclusive mobility with a monthly carbon budget (50kg CO2) encourages to keep the carbon footprint in a sustainable level.

1. Move within the carbon budget

Use all the available modes of transport within the monthly carbon budget.

2. Gain rewards of saved CO2

Get upgrade reward points of each saved kg. Exceeding the carbon budget costs 20 CHF / additional kg.

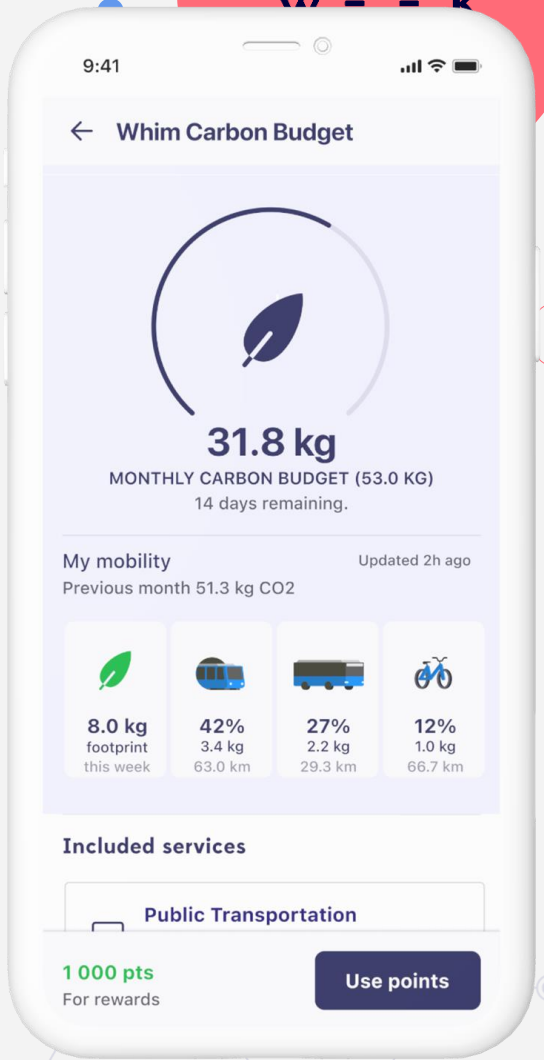


Get assisted

Assistant in all journeys just one click away

Insured journeys

Unified insurance coverage over all modes



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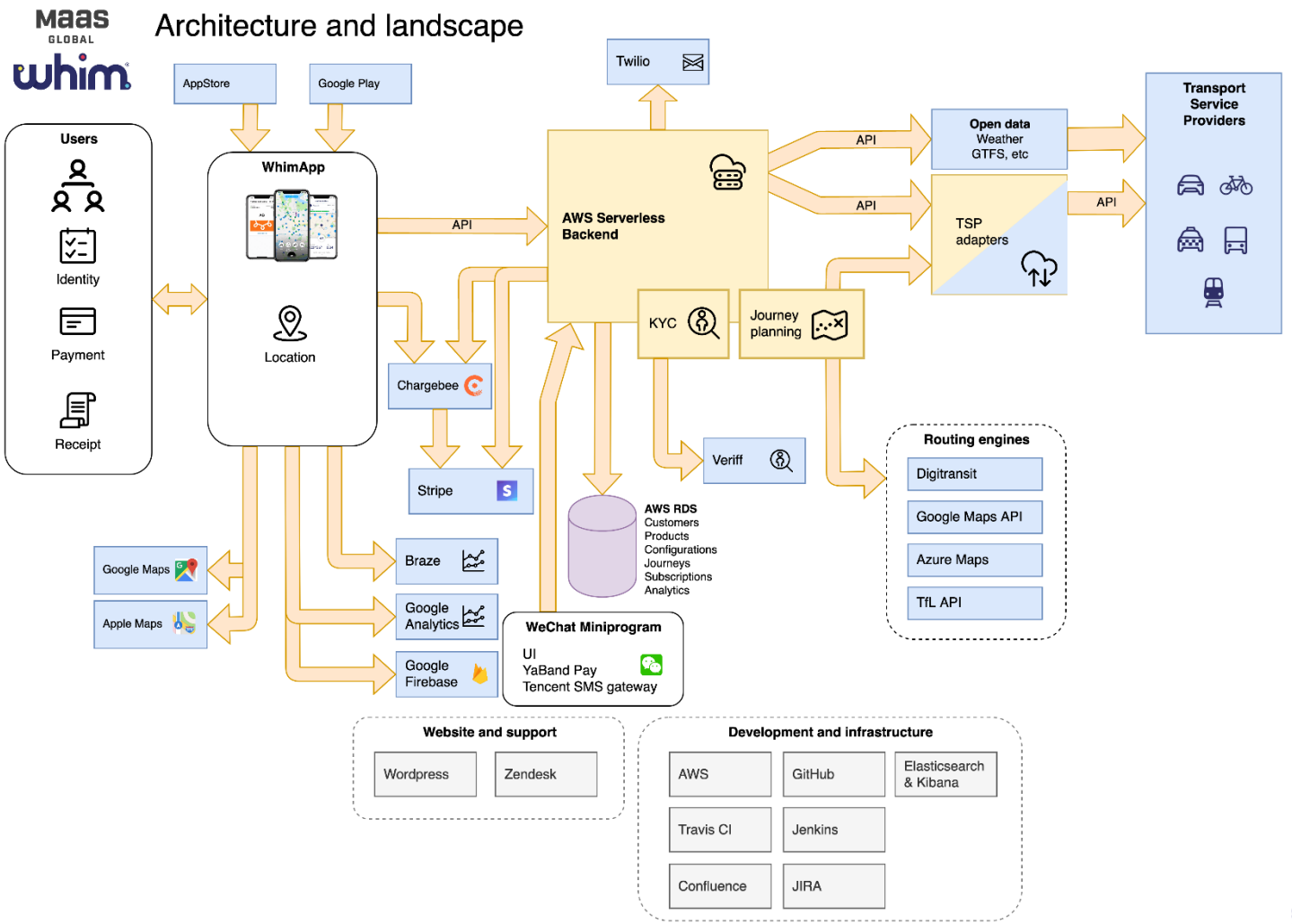
Complex platform functions rely on positioning in numerous occasions



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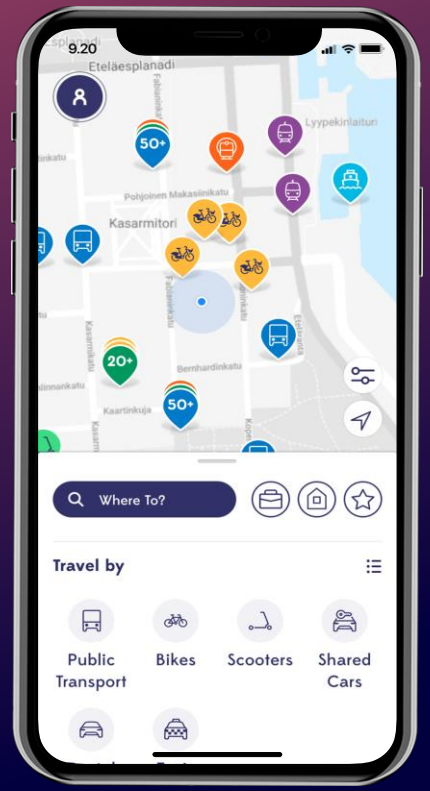
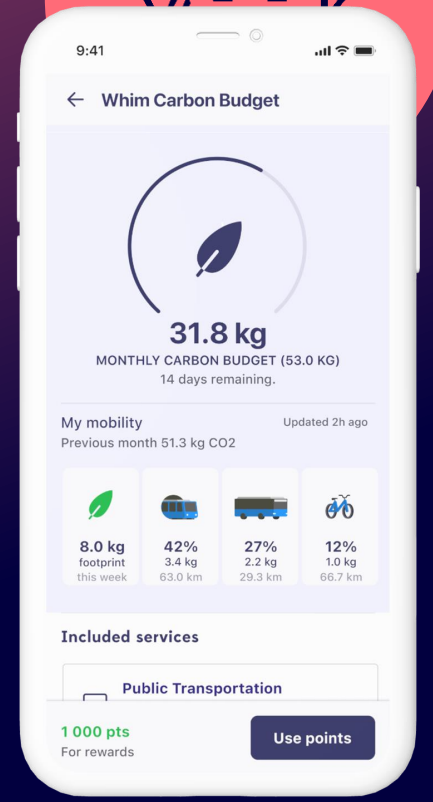
Positioning in the core of offering

- Mode detection without app on
- Guidance easily to any asset
- Unlocking of any mode seamlessly
- Ability to price by whatever parameter (all-inclusive, co2-based etc.)
- Payment of usage according to tracking (no need for integrations)





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Mobility as a Service

Marco Bolchi – Executive Director – EY Belgium

GNSS FOR MOBILITY AS A SERVICE (MaaS)

GNSS for MaaS Use Cases

Road fleet management

- GNSS and data transmission through a communication system.
- Continuous monitoring of the location of all resources.
- Data transmitted to a server and displayed through a Geographic Information System (GIS).

Micromobility

- User: GNSS allows to locate nearby vehicles, plan routes and navigate to the destination.
- Providers:
  - Asset management
  - Geofencing
  - Parking
  - Deter theft and track stolen vehicles

Can you think of any other needs related to the provision of your services that could be fulfilled by space technologies?

GNSS User requirements for MaaS

Accuracy and availability are the most important requirements for four specific MaaS applications: **Locating the vehicle**, **geofencing, parking and pavement riding**:

Question: *Are the following* ***Accuracy requirements*** *correct given their application?*

- *For* ***Locating the vehicle****: Between 1 and 10 meters*
- *For* ***Zoning compliance (Geofencing)****: Between 1 and 10 meters*
- *For* ***Parking****: Less than 1m*
- *For* ***Pavement riding:*** *Less than 1m*

Question: *What are the positioning availability needs for:*

- ***Locating the vehicle***
- ***Zoning compliance (Geofencing) Geofencing***
- ***Parking***
- ***Pavement riding?***

→ *What availability do you* ***expect from GNSS positioning****, more specifically?*

Question: *are you combining GNSS with other positioning technologies to fulfil your accuracy and availability requirements?*

Additional Questions – Challenges and R&I & Barriers

- *Can you suggest any **improvement of GNSS services and data** necessary to better fulfil user requirements?*
- *Do you see **R&I gaps connected to the use of space technologies in MaaS that **funding programmes** could address? Is there **any other type of support** that EUSPA can provide to foster GNSS market uptake?*

End of MaaS session

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