User Consultation Platform
All EU Space Program components with an integrated market/user driven approach

Market & User Knowledge
- Extended Market and technology monitoring and forecasting
- Extended and synergic User Consultation Platform
- Better understanding the MS needs and adding Copernicus Other Users satisfaction survey

Demand Support & users
- A common market segments approach for all EU space downstream
- Extended key account with main players of the value chain

Offer Creation
- Creation of new “made in Europe” products and services.
- Large implementation of end-to-end solutions leveraging synergies.
- Supporting entrepreneurship, SME and start-ups

8 parallel sessions
- Agriculture and Forestry
- Environment
- Road and Automotive
- Rail
- Public Transport
- Space
- Resilient societies
- SST

Bodies influencing the market
- Navigation Signal Providers
- Chipset, receiver
- Devices
- Content & applications
- Users

Data and services provision
- Storage and processing
- Content & Applications
- Users

Content & applications
- Users
## Report on Public Transport User Needs and Requirements

### Sub-segments

<table>
<thead>
<tr>
<th>Sub-segments</th>
<th>Applications</th>
<th>Types of Application</th>
<th>Level of Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>Fleet Management</td>
<td>A</td>
<td></td>
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<tr>
<td></td>
<td>Passenger information</td>
<td>A</td>
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<td></td>
<td>Driver advisory systems</td>
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</table>

### Applications covered in 2023

- **Legend**
  - A: An in-depth investigation
  - B: A partial specification
  - C: Will be analysed in next versions

- **EO only application**
- **GNSS only application**
- **Hybrid/synergetic application (combined use of EO and GNSS)**
Public Transport session - Agenda
### Public Transport session - Agenda

<table>
<thead>
<tr>
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**KEY AREAS**
Session Guidelines
Public Transport Session - Guidelines

Timing rules
• We kindly invite all participants to respect the timing indicated in the agenda. Not respecting our time constraints would have major impacts on the overall event
• To this end, we will let speakers know when their interventions shall be ending
• Q&A/debate sessions duration may vary depending on the time available. Please feel free to kick-off and feed the debates as soon as the floor will be open, to take advantage of the time at our disposal
• Reminder
• Please remember to fill in your information on the list of participants that is being circulating in the room

ZOOM rules
• Raise your hand for questions (menu bar - “Reactions” button – “Raise Hand”) and simultaneously write your question in the chat (“To everyone”)
• Wait for one of the sessions’ moderators to give you the floor. Please note: due to time constraints, only some questions will be selected by the moderators
• Please remind to mute yourself once finished the intervention and lower your hand (“Lower Hand”)
• If you are not a speaker, please do not share your screen without moderators’ consent

Thank you for your cooperation!
Public transportation in Europe in a nutshell

• **60 billion of passenger journeys** are made by public transport every year
• **2 million** people are employed in the public transport sector at a local level
• **€130-150bn** is the public transport’s annual contribution to the economy (c. 1% of EU GDP)*

• Contribution to **green deal**:
  – Less congestion
  – Cleaner air
  – More green spaces
  – Less noise
  – More safe

*Source: UITP*
Galileo benefits for public transport

**Application areas**
- Fleet Management
- Passenger Information
- Driver advisory systems
- Driving monitoring
- Autonomous vehicle
- Transportation network planning and optimization

**GNSS Benefits**
- Coordination of public transport fleet/traffic
- Provision of accurate passenger information
- Gas emission reduction
- Reduction of maintenance and infrastructure cost
- Scheduling and optimization of passenger travel
- Reaction to real-time information

**Galileo added value**
- Interoperable and compatible with GPS
- Multi-constellation
- Multipath

At no additional cost compared to GPS only receivers!
Benefits of multiconstellation and multifrequency GNSS

- **Multi-constellation**: When buildings block the signal and reduce the number of visible satellites, the availability of more constellations ensures a **much more accurate final position**.

- **Multi-frequency** increases **robustness of the position against mass market jammers** because the interfering signal has a narrow bandwidth and the receiver can still calculate a correct position with the other GNSS signals. More so, it increases resistance to multipath and accuracy.

- **Multipath**: the strength of Galileo signal, together with an **advanced code modulations**, makes Galileo better mitigating multipath effects (especially in E5, but also E1: two times better than GPS L1*)

* Source: Broadcom tests
Prague – DPP success story

- All trams will be equipped with mult constellation Galileo-enabled receivers by the end of the year
- Test confirmed achievable accuracies of 2.7 meters along the entire network (Galileo-enabled receivers and IMU)
- Multiple applications enabled: from improved passenger information to automatic reduction of tram speed over the switches bringing tangible benefits to both users, service providers, network managers

“We have been using outdated satellite receivers in trams to determine the exact position of the vehicles for about 20 years, they work only on the GPS system. However, in the dense development in the centre of Prague, these devices very often showed and still show significant deviations from the actual position of tens to hundreds of metres.”

Milan Slunečko, head of the Tram Vehicle Management Unit of the DPP

- The benefits
  - Improved usage (better planification, reliability, etc) (also via 3rd party services such as google maps via GTFS RT data)
  - Service optimization
  - More customers
  - Less private cars usage
Our ambition

• EUSPA is committed to bring a Galileo receiver in each Public Transport vehicle in EU, so that relevant monetary and environmental benefits can be achieved

• To do so:

1. We have enabled the technology by partnering-up with ITxPT community to ensure that Galileo is featured in their standards architecture. As a result, the ITxPT standard specifications S0P03-GNSSLocation now includes the adoption of multi-constellation GNSS receivers to replace the previous ones requiring only GPS)

2. We are engaging public transportation operators in order to:
   - Introduce Galileo benefits
   - Understand if procurement activities are in the horizon so that we can influence for the EGNSS case

3. We support the development of products and services via R&D
### EUSPA Horizon Europe call of 2023 (HORIZON-EUSPA-2023-SPACE-01)

<table>
<thead>
<tr>
<th>Type of Action</th>
<th>Topic</th>
<th>Indicative budget (EUR mln)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>EGNSS - Transition towards a green, smart and more secure post-pandemic society</td>
<td>3.5</td>
</tr>
<tr>
<td>IA</td>
<td>EGNSS - Closing the gaps in mature, regulated and long lead markets</td>
<td>8</td>
</tr>
<tr>
<td>RIA</td>
<td>Copernicus-based applications for businesses and policy-making</td>
<td>7</td>
</tr>
<tr>
<td>RIA</td>
<td>Designing space-based downstream applications with international partners</td>
<td>6</td>
</tr>
<tr>
<td>IA</td>
<td>EU GOVSATCOM for a safer and more secure EU</td>
<td>10</td>
</tr>
</tbody>
</table>

Total budget: **34.5**

**Deadline: February 2024**

**Innovation action (IA)**

Activities to produce plans and arrangements or **designs for new**, altered or improved products, processes or services.

**Research and innovation action (RIA)**

Activities to establish **new knowledge** or to **explore the feasibility** of a new or improved technology, product, process, service or solution.
## Public Transport session - Agenda

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## A new EU Space Programme

EU space activities **under one umbrella**

<table>
<thead>
<tr>
<th><strong>EGNOS</strong></th>
<th><strong>Galileo</strong></th>
<th><strong>Copernicus</strong></th>
<th><strong>GOVSATCOM</strong></th>
<th><strong>SSA</strong></th>
<th><strong>Others</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>EGNOS “Makes navigation signals more accurate and trustable for Safety-critical applications” Operational in <strong>400+ airports</strong> &amp; helipads in <strong>23 countries</strong></td>
<td>Global satellite navigation and positioning system (GNSS) More than <strong>3 billion Galileo receivers</strong> worldwide</td>
<td>Earth Observation (EO) and monitoring based on satellite &amp; non-space data <strong>Nr.1 world provider</strong> of space data and information (&gt;20TB/day)</td>
<td>Secure satellite communications for EU governmental actors Rapid support over crisis areas</td>
<td>Space Situational Awareness (SSA) Space Surveillance and Tracking (SST) Space Weather Events (SWE) Near-Earth Objects (NEO)</td>
<td>Access to Space Research &amp; Innovation Entrepreneurship Certification &amp; standardisation Capacity Building</td>
</tr>
</tbody>
</table>
Copernicus
Copernicus components

SPACE

IN SITU

SERVICES
Copernicus services

https://atmosphere.copernicus.eu/

https://marine.copernicus.eu/


https://climate.copernicus.eu/


https://emergency.copernicus.eu/
GALILEO and EGNOS
# Galileo and EGNOS Services

<table>
<thead>
<tr>
<th>Galileo Initial Services</th>
<th>EGNOS services</th>
</tr>
</thead>
<tbody>
<tr>
<td>are provided to worldwide users since December 2016</td>
<td>are provided to users since October 2009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open Service (OS)</strong></td>
<td>Freely accessible service for positioning and timing*</td>
</tr>
<tr>
<td><strong>Public Regulated Service (PRS) – Governmental Service</strong></td>
<td>Encrypted service designed for greater robustness and higher availability – secure satellite communication</td>
</tr>
<tr>
<td><strong>Search and Rescue Service (SAR)</strong></td>
<td>Locates people in distress and acknowledges that the distress signal has been received</td>
</tr>
<tr>
<td><strong>High Accuracy Service (HAS)</strong></td>
<td>Delivers high accuracy services, freely accessible</td>
</tr>
<tr>
<td><strong>Under preparation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Commercial Service Authentication (CS)</strong></td>
<td>Delivers authentication services for commercial applications</td>
</tr>
<tr>
<td><strong>Safety of Life Service (SoL)</strong></td>
<td>Providing a high level of integrity for users for whom safety is essential (e.g. civil aviation, in accordance with ICAO standards)</td>
</tr>
<tr>
<td><strong>Data Access Service (EDAS)</strong></td>
<td>Offering EGNOS data with greater added value through internet, intended mainly for professional or commercial use</td>
</tr>
</tbody>
</table>

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

• Galileo entered 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, in terms of ranging, positioning and timing.

• The Open Service ranging performance ranks first among all GNSS service providers.
Galileo Open Service

- Galileo OS users can already benefit from an improved navigation message, being broadcast by the Galileo constellation since mid-2023, which considerably boosts their performance in terms of 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)

- This updated OS SDD will also introduce the OS Extended Operation Mode, which is characterized by a gradually degrading ranging accuracy with respect to the nominal operational mode, even in case the Galileo Ground Segment is affected by certain issues, thus increasing the robustness of the OS.
Galileo OSNMA

Scope

OSNMA server at GNSS Service Centre (GSC)

Galileo Satellite

OSNMA signal

PUBLIC KEY

MESSAGE AUTHENTICATION CODES

TELSA KEY

DIGITAL SIGNATURE

NAVIGATION DATA

OSNMA enabled user receiver

CRYPTOGRAPHIC FUNCTION

is navigation data authentic?

No

Navigation data not authenticated

Yes

Navigation data authenticated

Trusted use for positioning
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
What is the Galileo HAS

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)
What comes next?

• 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

Galileo Search And Rescue

2000: Initial Discussions on SAR and Galileo
2006: Cooperation Agreement on Development
2016: Cooperation on Service Provision: Localisation of Distress Alerts
2020: Agreement on provision of Return Link Service

LEO, GEO, MEO Satellites

Distress Beacons at 406 MHz

MCC : Mission Control Centres

Receiving ground stations LEOLUT, GEOLUT, MEOLUT

Rescue Coordination Centres
Galileo SAR: Return Link Service
EGNOS Services

EGNOS services are provided to users since October 2009

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EGNOS System state-of-play

**EGNOS V2** is the current System in Operations

- Delivering SoL service for Aviation since 2011, based on GPS-only augmentation
- Constant improvement in answer to user needs (e.g. coverage extension, service for Maritime, robustness improvements)
- Need to extend the service provision of EV2 to ensure the handover with EV3 including risk of additional delay
- LIFEX 1&2 System Releases to be procured by EUSPA to TAS-F
- Security enhancement: initial SECMON capability at GSMC

**EGNOS V3** is the new generation of EGNOS

- Bringing Galileo use into EGNOS System and SoL services
- Augmenting both GPS and Galileo
- Improved performance and geographical coverage thanks to dual-frequency & dual-constellation
- Built-in security (with SECMON from GSMC)
- Future extensions to Africa and neighbourhood (e.g. Ukraine, North Africa)
EGNOS services perspectives

Primary means of navigation for Aviation in 2030
• Performance Based Navigation (PBN)
• Better availability (99.9%), more resilience, EU autonomy (with Galileo)
• New Airspace users (helicopters, small aerodromes, drones, ...)

Maritime
• Initial service in 2023 for maritime and in-land navigation
• Towards autonomous vessels navigation and zero-emissions shipping
• Not only EGNOS: end to end solutions using HAS/OSNMA and Copernicus

Rail
• Making ERTMS accessible on all lines
• R&I substantial investment to prepare railway operators and signalling industry
• A new service under preparation, facing the challenge of Rail safety standards
Secure Satcom
Regulation 2023/588 in force since 20 March 2023
Governmental Satellite Communications
Space Surveillance and Tracking (SST)
EUSPA manages and operates the **EU Space Surveillance and Tracking (SST) Front Desk**

The Agency cooperates with the **SST Partnership** to provide **space safety services**:

- **Collision Avoidance (CA)**: risk assessment of collision between spacecraft or between spacecraft and space debris
- **Re-entry Analysis (RE)**: risk assessment of uncontrolled re-entry of artificial space objects into the Earth’s atmosphere
- **Fragmentation Analysis (FG)**: detection and characterization of in-orbit fragmentations, break-ups or collisions
Space Surveillance and Tracking (SST) Front Desk

- Services and Coordination Platform: portal.eusst.eu
- Performance Reporting
- SST Helpdesk: sst.helpdesk@euspa.europa.eu
- SST Taskforce
- User Consultation Platform: 7th Nov 2023 afternoon
- Communication
**Public Transport session - Agenda**

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Contents

• Introduction of UITP
• Challenges of Urban Mobility
• Future of mobility: sustainable, resilient, human centric
• GNSS as main enabler of Position based services in Public Transport
  – Passengers information
  – Fleet management
  – location-referenced operations
  – On Demand Transit
  – Automation
• GNSS receivers
  – IT Standard Architecture on-board (ITxPT)
• Galileo benefits for GNSS requirements of PT
The only worldwide network to bring together all public transport stakeholders and all sustainable transport modes.

+1,900 member companies

From 100 countries

14 offices
2023 TOPICS & PRIORITIES

<table>
<thead>
<tr>
<th>Committees and Platforms</th>
<th>Projects</th>
<th>Policy and Knowledge Papers</th>
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<td>Addressing the transformation of the labour market</td>
<td>Public transport business model</td>
<td>Transition to Net Zero</td>
</tr>
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<td>Redefining public transport</td>
<td>Digital Transformation</td>
<td>Promoting women in public transport and engaging with women in the promotion of public transport and decarbonisation</td>
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</tbody>
</table>
Challenges of Urban Mobility

• OLD Mobility Challenges
  – Climate crisis, Local Pollution, Noise, Congestion, urban space scarcity

• “NEW” Mobility Challenges
  – Sanitary crisis, security, energy scarcity, financial crisis

• Change of mobility needs…
  – Different mobility patterns, more personalized mobility solutions, high quality of service
The Future of Mobility towards more sustainable, resilient and human-centric urban mobility system

- Traditional Mass public transport services alone do not meet all citizens’ needs

- The Mobility of the Future requires the intelligent use of Multimodality to support Citizen health, decarbonisation, urban space scarcity, road safety, funding crisis...
  - combination of different modes in their optimal area of service: from soft modes (bike, walking) to shared and mass transport solutions,
  - integrating all aspects of mobility into Sustainable Urban Mobility Plans; from governance and policy to physical and digital integration and finance.
  - answering the needs of all type of users (implementing “Mobility for All”)

- Geolocalisation is a key enabler of Urban Public and Shared Mobility

Several reference papers about Multimodality

- UITP Policy papers
- ERRAC RIA on Multimodality (in preparation)
- ERTRAC/ERRAC/ALICE Roadmap on Urban Mobility
Information & services for travelers

• At the Bus stops
  – Near real-time arrival time

• In personal navigation applications
  – Journey planning (door to door)
  – Real time information of vehicle position

• On board vehicles
  – Touristic and commercial information
  – Selected fare
Vehicles & Fleets Operation

• Fleet monitoring and management
  – Status of vehicle operations (planned service, timetable...)
  – SOC and forecast of consumption (traffic, auxiliaries, occupancy rate...)
  – Help planning and dynamically use the chargers, by regulating vehicle access according to SOC and vehicle relevant information

• Remote diagnostic and predictive maintenance

• Location based operations
  – Switch propulsion based on Geolocalisation
  – Review / Adaptation of operation profile
  – Smart navigation and Precise docking
Shared and on-Demand Responsive Transport

- Personal mobility is moving more and more towards Shared and On-Demand mobility solutions

- Geolocalisation used for service booking, billing and control (business area)

- Match position of user and vehicle
  - Shared mobility solutions: moving user vs static vehicle
  - On-Demand Transport: moving vehicle vs (ideally) static user
Automated Shuttles and Buses

• Integration of GNSS with other sensors on board and in the infrastructure (ex; traffic management)

• SHOW project: GNSS technologies have been used at the demo locations of automated shuttles in Europe.

• In particular technology of GNSS Real-Time Kinetics (RTK) for precision improvements for automated shuttles has been testing by using different digital links to deliver RTK signals:
  - Radio Technical Commission for Maritime Service, or Real-Time Correction Message (RTCM) over V2X, cellular lines and satellite links, or NTRIP

• Plan is to use Galileo High Accuracy Services (even complementing RTK) in Karlsruhe, Gothenburg/Lindholmen, Trikala, Geneva sites

• An analysis has been performed to evaluate performances in Galileo-only use (no other GNSS Constellations).
GNSS Receivers and on-board Standard

- **GALILEO enabled receivers are well on the market**
  - New buses very often install Galileo-enabled receivers
  - Considered also during the Bus IT refurbishment moment (around half-lifetime)

- **Approaches (vehicle level)**
  - No-standardized IT architecture brings a Proliferation of antennas, one for each IT equipment
  - Standardised IT architecture (ITxPT) brings positioning as a service shared to different systems for the development of IT applications
    - no need for multiple receivers
    - GNSS Information shared on CAN interface
  - ITxPT Technical Specifications provides Operators and Authorities with recommendations and requirements to support the purchase and integration of IT systems, that can be used as Reference for tendering process
Main outcomes and lessons learned from past R&D

• The incorporation of Galileo positively impacts existing applications of GNSS in urban mobility services and measurable increases in the quality of the service provided have been proven
  - TMB, Since 2016 more than 1,000 buses equipped with multi-constellation on-board equipment.
  - The positioning error in the most challenging sections of the route went down from 40/60m to 2/5m.
  - Higher accuracy in the location of the fleet in real-time allows an optimisation the service provided.

• Improvement in the quality of the service has been demonstrated in DRT, bike-sharing, micromobility services, tramways...
Conclusions

- Geolocalisation is more and more important in Urban Mobility and Public Transport services
  - To enable personalized, more sustainable and resilient services
- Needs from the PT sector about Geolocalisation
  - Robust, reliable, secure information and services
  - Easy to integrate data and services from different sources and sensors
  - Taking into account all EU strategies guiding the mobility transition
  - Supporting the mobility transitions with added value and a positive ratio benefits vs cost
- GNSS is the key enabler of positioning function, alone or jointly with other sensors providing more precision or covering areas not served
- EGNSS is proven to provide added value to mobility transition
GNSS “Best Application” is the one that is "coming tomorrow"

THANKS FOR YOUR ATTENTION!

Umberto Guida
Head of UITP Projects Strategy
umberto.guida@uitp.org
Public Transport session - Agenda

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KEY AREAS
Agenda

• Public transport systems landscape
• Standardizing IT systems in public transport
• GNSS related research projects
• The JULIA project
• Conclusion and outlook
INIT at a glance

- **+1,100** employees worldwide
- **+30** locations worldwide
- **+40** years of experience
- **+1,100** transport providers

- **+130** ITCS/RTPI-systems
- **+200,000** vehicles equipped
- **+140** ticketing systems
- **+300** passenger counting systems
INIT at a glance

- Montreal/Canada: 2,200 vehicles
- Birmingham/UK: 1,600 vehicles
- Stockholm/Sweden: 2,300 vehicles
- Berlin/Germany: 1,000 vehicles
- Bavaria/Germany: 4,000 vehicles
- Dusseldorf, Duisburg, Essen & Mülheim/Germany: 1,600 vehicles
- Portland/OR/USA: 1,100 vehicles
- Seattle/WA/USA: 2,600 vehicles
- Denver/CO/USA: 1,500 vehicles
- Houston/TX/USA: 1,300 vehicles
- Vancouver/BC/Canada: 1,600 vehicles
Public transport systems landscape
**Public transport systems landscape**

**Vehicle equipment**
- Onboard unit (OBU)
- Cabin cameras
- Fast Ethernet in the vehicle
- Train LAN Modem
- IP-Communication gateway
- Traffic signal priority request (TSP)
- Passenger information displays
- Ticket vending machine
- Automatic passenger counting (APC) systems
- Bluetooth and Wi-Fi
- GNSS services

**Station and track equipment**
- Passenger information displays
- Ticket vending machine
- Bluetooth and Wi-Fi

**Communication**
- Data transmission
- Radio
- Telecommunication (3G | 4G | 5G | 1XRTT)
- Voice-over-IP
- Wi-Fi and Bluetooth

**APIs**
- Ticketing platforms
- Data hubs
- Web apps and REST APIs
- Mobile Apps
- Standards: ITxPT, SIRI, VDV, ISO etc.

**ITCS Intermodal Transport Control System**
- Center data broker

**Planning Systems**
- Depot Management
- Transport planning systems
- Personnel planning

**Data statistics and reporting**
- Data Science
- Workflow- and event management
- Reporting
- Spatial Analysis
- System Monitoring
- Accounting and ticketing
- Business Management
Public transport systems landscape
Public transport systems landscape
Standardizing IT systems in public transport

- Many standards already exist (national, EU, international).
- ITxPT (Information Technology for Public Transport) was launched in 2021 by the UITP (now over 160 members).
- Aims at a standardized specification of IT architecture with open interfaces that enable interoperability.
- Next to commercial projects, several related research projects to ITxPT implementation exist:
Standardizing IT systems in public transport

Technical specification

**S 01**
Installation Requirements
- Power Supply Interface
- FMS interface
- Other interfaces (audio, antenna, wireless, etc.)
- IP network
- Space
- On-board IP
- Harness

**S 02**
On-board
- 0 Protocols DNS and Mqtt
- 1 Module Inventory
- 2 Time service
- 3 GNSS Location
- 4 FMS2oIP
- 5 VEHICLEtoIP
- 6 AVMS
- 7 APC
- 8 MADT
- 9 MQTT Broker

**S 03**
Back-Office
- TRANS3MODEL ecosystem
- NeTEx (Network Timetable exchange)
- SIRI (Service Interface for Real-time Information)
- OJP (Open Journey Planning)

**S03P01** - TICR (Telediagnosis for Intelligent Garage in Real-time)

IP network and hardware layer

- Inventory
  - to be provided by
  - to be subscribed to

Useful protocols
- Governed by CEN
- Facilitated by ITxPT

https://wiki.itxpt.org/images/5/57/ITxPT_Vehicle_with_IP_network.png
ITxPT and GNSS location services

• GNSS Location specification
  – Raw/pre-processed data is consumed and provides in UDP protocol (multicast)

• Multi-constellation GNSS receivers at processing rate of 1/s or 2/s

• Defined ITxPT use cases:
  – Location algorithms use the geolocation data to calculate the position of the vehicle on the public transport network
  – Fleet Management applications use the geolocation data to monitor the vehicles position on the public transport network
  – Passenger Information modules use geolocation data to display vehicle location on the public transport network and next stop onboard the vehicle.
INIT GNSS processing pipeline

GNSS Satellites

- Odometer
- Calibration Data (stored)
- Antenna
- Direction

Advanced Calibrating Handling

GNSS Position

Anti Spoofing

INS Filter (Automotive Model)

Automotive Dead Reckoning Model

OSRM Map matching

- Waypoints to Reset Odometer
- Early Departure Control
- Vector matching
- Off-route detection
- Terminal mode
- Depot detection
- Opposite stop detection
- Loop detection
- Blind alley detection
- Off route detection
- Course over Ground (Heading Information)

Map matched and validated GNSS Data

Network Data

Navigation Data (OSRM)

Exceeed Path Information

Door

Odometer

Driver Backup

GNSS Receiver with Automotive Dead Reckoning

3D Gyroscope

3D Accelerometer

Lever Arm configuration

Odometer

IMU

INS Filter

Validated GNSS Data

INIT Filter

INIT Logical Positioning Engine

Map matched and validated GNSS Data

GNSS coordinates with Dead reckoning
GNSS related research projects

Research Roadmap

Ongoing

- **LogIKTram (3 yrs.)**
  ITC platform for integration of cargo services

- **KARL (4 yrs.)**
  AI to support the work of dispatchers

- **ANYMOS (3 yrs.)**
  Competence cluster anonymization for networked mobility systems

- **JULIA (2.5 yrs.)**
  Use of EGNSS services and data for precise positioning in public transport

- **regioKArgo TramTrain (5 yrs.)**
  Integration of delivery services into public transport operations

- **ABSOLUT-II (3 yrs.)**
  Autonomous driving without a safety driver on board

- **DaKiMo (3 yrs.)**
  Data and AI as enablers for sustainable, intermodal mobility

- **ÖV-Leitimotif-KI (2.5 yrs.)**
  Public transport: standards for control system connectivity of automated vehicles using AI

- **U-hoch-3 (4 yrs.)**
  Occupancy prognoses
  Object recognition

**2023**

**2024**

**2025**

**2026**

**2027**
GNSS related research projects

- Assistive mobility
  - MAVIS / ASSISTIVEtravel

- Passenger information
  - MobileDataFusion / Uhoc3

- Multimodal transport systems
  - regioKArgo
GNSS related research projects

**MAVIS / ASSISTIVEtravel**

- Personalized travel companionship according to the user profile
- App design optimized for impaired users
- Bus driver notification
- Inside and outside speaker announcements
- T-Loop system for hearing aids
GNSS related research projects

MAVIS / ASSISTIVEtravel

Level 1

App
Exterior vehicle loudspeaker
Passengers with special needs

Level 2

T-Loop

Onboard unit
Driver
MobileDataFusion (MDF)

- **Goal**: Determination of precise data on demand and passenger flows (passive)
- WiFi and Bluetooth probe requests
- Data Fusion: APC, GNSS, probe requests, weather, booking system requests
- Goal: More precise revenue splitting, better passenger information
GNSS related research projects

U-hoch-3

- **Goal:** Increased attractiveness of PT in urban areas
- **Extended passenger information:**
  - Punctuality
  - Real-time occupancy data
  - Real-time occupancy of multipurpose areas
  - Occupancy prognoses for future trips
- **Data fusion approach:** weather, event calendar, timetable information requests, spatial data
GNSS related research projects

logIKTram and regioKArgo

• **Goal:** Integrating delivery services into public transport through a common ICT-platform

• Combining logistics with public transport operational systems of planning, booking and operation control

• Development of physical loading unit and carriage for combined transport of passengers and goods

• Putting the concept into real operation in regioKArgo
GNSS related research projects

logKTram and regioKArgo
The JULIA project

- **JULIA**: Joint developments for Urban resilience connecting users to public transport through space technology
- Funded by HORIZON-EUSPA (IA) starting in December 2023 (30month)
- Aim:
  - Integrating Galileo (E)GNSS services for increased accuracy (HAS-PPP), availability (multi-constellation GNSS), and authentication (OSNMA)
  - Application and Demonstration in bus, light rail and shared mobility transport
- **Pilot sites**: Barcelona, Spain, Ljubljana, Slovenia, Athens, Greece
Conclusion and outlook

- GNSS localization and spatial data are at the core of public transport operations
- Location Based Services (LBS) play an important role
- New applications required reliable and accurate positional data
- Standardized open-data and services are needed (or need to be expanded)
- Public transit can be a valuable input / enabler for future applications (e.g. smart cities)
Thank you

Dr. Jochen Wendel
INIT Group

jwendel@initse.com
# Public Transport session - Agenda

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ERTICO- Deploying Innovation

• Deploying innovation is central to make mobility smarter, safer and cleaner, working with ERTICO Partners across four priority areas: **Connected, Cooperative & Automated Mobility, Urban Mobility, Clean and Eco Mobility** and **Transport & Logistics**

• And Innovation is at the heart of ERTICO’s activities as evidenced through our participation and leadership in a great number of emblematic European Commission R&I projects
Active Projects in 2023

We currently manage or actively contribute to more than 23 research, pilot, and deployment projects. Projects active in 2022/23 had a joint multi-annual budget of EUR 310m. There are 2 new projects in the year to come.

ERTICO Partner’s EC funding - 75m

Projects in 2022

We currently manage or actively contribute to more than 17 research, pilot, and deployment projects. Projects active in 2022 had a joint budget of EUR 250m. There are 8 new projects in the year to come.

28 Projects in 2022 / 2023

Companies: SGLOGINNOV, SGMOBIX, SGMETA, INNOCCAM, ARCADE, modales, Boostlog, HEADSTART, PRIVATEER, SUNRISE, CART, solutionsplus, weTransform, ProgELEcMobility, NEXT, EIRUCK, PRIVATEER, INNOCCAM, IGAF, STORM.
4 focus areas of mobility

➢ Clean and Eco-Mobility Roadmap

Reduction in environmental impact

Accelerating automation and connectivity for safer and smarter mobility

➢ Urban Mobility Roadmap

Delivering seamless mobility for all

Creating the digital infrastructure for freight transport and logistics operations

➢ Transport & Logistics Roadmap

Integrating intermodal and cross-border transport networks

Creating the digital infrastructure for freight transport and logistics operations
Roadmap - CCAM

1m tonnes CO2 saved
1m hours saved
10,000 lives saved

2030
100% achieved

2030
Better understanding of wider impacts of AD for passenger and logistics

2027
Infrastructure and connectivity needs for HLA & Common definitions for infrastructure adaptations & digital twins

2025
50% achieved

2025
Harmonised regulatory frameworks in EU, facilitated testing and liability frameworks

2023
25% achieved

2023
Increased awareness about CCAM, societal impacts and methodologies for co-creation

2020
Societal targets

2020
Map city interests

Connected, Cooperative & Automated Mobility

Projects and Platforms
- ERTICO Academy
- ERTICO City Moonshot

Support R&I coordination wnn tools for sharing of Knowledge & lessons learned
Aside from providing navigation solution to self-driving cars, GNSS/PNT offers numerous opportunities to:

- **plan** new infrastructure and improve the existing one based on measuring traffic flows – e.g. longitudinal traffic flow data informing future infrastructure investment decision
- **decrease** CO₂ emissions coming from the transportation vehicles – e.g. smart bus stops and efficient phasing of traffic lights
- **ensure** safety based on citizens’ reports from certain locations – e.g. combining citizens’ emergency reports with CCTV data
- **improve** infrastructure monitoring, optimize maintenance intervals and reduce the costs for upkeep – e.g. combining data on the use of bridges and sensor-provided status of various elements.
Partners’ ITS related activities/use cases

• Combined 4G/5G/satellite architecture to utilise the advantages of satellites- regarding ubiquitous connectivity- to realise the always-connected aspect of CCAM (Satellite and 4G/5G-driven autonomous vehicles),

• Car on vehicle sensors networked to the OEM’s premises via satellite to constantly monitor vehicle’s parameters; over-the-air updates, which would lead to smart update solutions for the entire vehicle, from the powertrain to infotainment systems

• Next generation positioning OBU for enabling highly automated driving such as the development of a precise positioning system for high levels of automated driving SAE-L4 and L5 for many vehicle types (e.g. cars, buses, trucks)

• Use of vehicle cameras and Intelligent image processing algorithms, as part of an integrated multi-camera system) –to provide an all-around view (360-degree visibility) of the vehicle environment from a bird’s eye perspective; bird’s eye view perspectives provided by satellites could enable cars of the future to identify a motorcyclist approaching rapidly from behind and the system could warn the driver or even prevent the vehicle from changing lanes as planned
(Selected) ERTICO Projects

5GMOBIX

An emblematic 3-year H2020 project, led by ERTICO, with 55 partners from 10 countries

• Evaluated the benefits of 5G within the Cooperative Connected Automated Mobility (CCAM) context

• Developed and tested automated vehicle functionalities using 5G core technological innovations

• Implemented Edge Computing solutions at six different cross border trial sites
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
(Selected) ERTICO Projects

SHOW in a nutshell

Deployment of shared, connected and electrified automated vehicles to advance sustainable urban mobility

- Coordinated by UITP
- 70 partners from 13 EU-countries
- January 2020 – December 2023
- 30 Mio. EUR funding from European Commission (GA No. 876630)
Expected Impact – Key Strategic Impacts

- SHOW aims to be the Game Changer in the path of urban mobility automation. Targeting at:

- Becoming the bigger ever showcase and living lab for AV fleets by transporting over 1500000 people and 350000 containers of goods through a combined AV fleet of over 70 vehicles (bus, shuttle, pod, car) in 17 cities across Europe.

- Setting the relevant Industrial standard, by enrolling the vast majority of AVs OEMs and operators (13 in total) in a single project and in some cases in the same Pilot site (i.e. Transdev and KEOLIS in French and Swedish sites); thus resulting in a commonly accepted open system Architecture, widely adopted standardisation and policy recommendations and de facto proven interoperability protocols.

- Involving the full value chain of autonomous PT mobility services throughout the project and in each of its Pilot sites.
Always-On Connectivity

enabling always-on, everywhere connectivity and associated services: Infotainment, Vehicle Management, and Data Analytics.

Connected and autonomous vehicles are not the future, they are the present. As consumer expectation for on-demand data services increases, the new market differentiators become: Access, Data rate, & Reliability.

Despite the deployment and rollout of 4G/5G, still huge areas where autonomy and critical services will not be accessible unless we harness the entirety of the connectivity that surrounds us, including satellite data, cellular and wi-fi.

Source: Continental
EGNSS for Public Transport Survey (selected) PTA/PTO responses

- Bus fleet use the GNSS to geolocate the position in real time to manage and control the routes, prevent incidences, provide real time estimations for our bus users and plan new needs.

- Live bus tracking for waiting time information on bus stops

- The GNSS system is mainly used in freight wagons to know their position and to know the kilometres travelled.

- Buses are equipped with satellite navigation receivers. Processing this real-time information (all types of transit data such as timetables, bus stops, and journeys) these data is then transmitted to the displays at the stops, and even on their smartphone application. Passengers can see immediately if the bus is late and long waiting times at bus stops can be avoided.

- Vehicle positioning, Tyre positioning

- Autonomous vehicles tracking
(Selected) R&D Use Cases and Applications
EGNSS enabled

Rural areas with high car ownership and low usage of conventional public transport services from railway stations, resulting in low demand for the service

- Improve the geolocation on-board system for better time-of-arrival information to public transport users.
- EGNSS-based train positioning system, to provide a reliable and efficient solution for railway operations. It will allow for real-time tracking of the train, providing accurate and up-to-date information to both the operator and the passengers.

**Accurate vehicle tracking with Galileo**

**Effective DRT pick-up process enhanced by Galileo**

**Safety of cycle routes connecting trips in public transport for the first and last mile and extending towards a wider part of the network.**

**AI- and computer vision-enhanced cycle lane assessment for safety with Galileo and Copernicus**
(Selected) R&D Use Cases and Applications
EGNSS enabled

• Demand-Responsive Transport (DRT) to connect semi-urban or/and suburban areas with the multimodal transport system.

• Copernicus-based real-time air quality assessment and forecast analysis in urban environment

AI algorithms for optimal transport planning and operation leveraging Galileo

Accurate vehicle tracking with Galileo

Effective DRT pick-up process enhanced by Galileo

Air-quality-based mobility decisions in public transport with Copernicus A-10. Climate-change monitoring in urban areas with Copernicus

• DRT service to connect low density areas with a suboptimal access to public transport with the regional bus network - promote multimodality by enabling the transfer to the train, regional bus, or the City Urban transport

Seamless public transport validation with Galileo

AI algorithms for optimal transport planning and operation leveraging Galileo
(Selected) R&D Use Cases and Applications
EGNSS enabled

- Safety of cycle routes connecting trips in public transport for the first and last mile, producing a full report of the safety of the cycling infrastructure and a decision-making dashboard for mobility planners.

Evaluation of autonomous shuttle routes with Galileo
AI- and computer vision-enhanced cycle lane assessment for safety with Galileo and Copernicus.
# Public Transport session - Agenda

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**KEY AREAS**
Index

1. Presentation EMT València.
2. Trust your Mobility.
3. GNSS Clock & Position Reliability, Synchronization, and Standardization.
4. Sensing, Data Capture, and Exploitation System for Vehicular and Environmental Data.
# Presentation:

#1
The Empresa Municipal de Transportes (EMT S.A.U.) has, as its main activity, the organization and provision of the public service of urban, collective passenger transport in Valencia City (mainly 487 buses, 1721 employees, over 100 million passengers carried yearly).
Projects in which we have collaborated with EUSPA and others from which we have learned and shared experiences.

**WE Transform** – TRANSFORMATION AGENDA FOR TRANSPORT AUTOMATION EU 101006900 analyzes the impact of Automation and Digitalization on Human Resources, Employee Relations and the knowledge and training requirements of mobility companies in the future.
#2 Trust your Mobility
An interesting fact:

The **Acceleration** of Industrial Revolution was possible through **Railroad Timetables, Clock Reliability, Synchronization, and Standardization**.
Secret of our business: *Trust your Mobility:*

• I want to go from a convenient **point A** to a convenient **point B** ... *for me*
  
  *(multi stage, multi modal) if ... convenient)*

• **Life is to short** ... travel time should be also.

• **Mobility** should be Available, Reliable, Accessible, Frequent, Regular, Comfortable, Easy to use, Amiable, with efficient Station and On-board Services, Efficient, Sustainable, Safe & Secure, Socially Concerned, Gender Sensitized, and ... Environmentally Aware.

• It must have a reasonable and justified price... and the User **must be able** and have the tools/means to make the **payment**.
What we do to **EnTrust** your Mobility?

• The **Acceleration** in **AI Revolution & Mobility** is possible through **GNSS Clock & Possition Reliability, IoT, Sensoring, Synchronization, and Standarization**
What we do to **EnTrust** your Mobility.
Valencia puebla un sistema de monitorización de la contaminación atmosférica con una tecnología innovadora para coches eléctricos.

Los autobuses de la EMT utilizan una tecnología innovadora para coches eléctricos.

Valencia ha presentado este año ocho coches eléctricos con una cantidad de 18 unidades que llegarán a la ciudad el próximo año. Estos vehículos se unirán a la flota de 20 coches eléctricos que actualmente circulan por el centro de la ciudad. La tecnología de estos coches se ha adaptado a las necesidades de la flota diurna, permitiendo un mayor rendimiento en el uso de la energía.

Los autobuses de la EMT utilizan una tecnología innovadora para coches eléctricos.
GNSS Clock & Position Reliability, Synchronization, and Standardization.
So … Where is the problem?

GNSS Clock & Position Reliability, IoT, Sensoring, Synchronization, and Standarization
So ... How we solve the problem?

**GNSS Clock & Possition Reliability, Synchronization, and Standarization**

- **Authentication**: the ability of the system to assure users that they are utilising signals and/or data from a trustworthy source, and therefore that they are protected from spoofing threats.
- **Robustness to spoofing and jamming**: a qualitative parameter that looks at the type of attack or interference which the receiver is capable of mitigating.
- **Accuracy**: the difference between the real and computed position or time.
- **Availability**: the percentage of time that the position or timing solution can be computed by the user.
- **Continuity**: the ability to function without interruption once the operation has started.
- **Integrity**: the measure of trust that can be placed in the correctness of the position or time estimate provided by the receiver.
- **Time To First Fix (TTFF)**: a measure of a receiver’s performance covering the time between activation and output of a position within the required accuracy bounds.
So ... *How can we solve even other or future problems?*

- **Galileo EGNSS Added Value:** An authenticated signal *(TimeStamp / GeoStamp)* not only provides more robustness, but it can even serve as legal evidence of the correctness of the GNSS position for liability issues.

- **Insurances costs, Accidents, Incidents, Ticketing System, Salaries, Customer Assistance, Users Complaints, Penalties in contracts, reliability, and maintenance. ...**
Sensing, Data Capture, and Exploitation System for Vehicular and Environmental Data.
Sensing, Data Capture, and Exploitation System for Vehicular and Environmental Data: €1.2 million

This project will enable the capture and sensing of external and internal environmental (NO₂, O₃, CO, Temperature, Humidity, Noise and PM-2.5) and vehicular data in 250 hybrid buses and 20 electric buses, within the context of the strategic lines for enhancing public transportation.

The goal is to achieve an improvement in air quality in urban environments through measurement and optimization of urban transport, among other objectives.
Hardware

**OTROS DISPOSITIVOS**

- Sensores de temperatura/temperatura & humedad/temperatura & humedad & luz bluetooth.
- Sensores de temperatura y humedad por cable.

**AIR QUALITY STATION**

- Sensor de combustible.
- Sensor inductivo.
- Sensor de apertura y cierre de puertas.
- Sensor de iluminación.
- i-Button.
- etc.
Available Data:

- Average, instantaneous, maximum speed, and speed intervals.
- Total kilometers traveled.
- Engine and key state activity times.
- Idle times.
- RPM intervals.
- Acceleration/brake, brake/acceleration events.
- Consumptions.
- Fuel level.
- AdBlue level.
- Total/average consumption per hour/and every 100 km.

Example of proposed alarms for MAN A37 Hybrid buses:

- Alarm for errors in Combustion Engine.
- Alarm for errors in Electric Motor.
- Alarm for errors in Inverter Systems.
- Alarm for errors in Battery System.
- Alarms for errors in Instrumentation.
- Alarms for errors in Electrical Leakage System.
- Alarms for errors in Central Computer.
- Alarms for errors in Emission Control System.
- Alarms for errors in Door Systems.
- Alarm for low-quality AdBlue.
- Alarm for brake wear: If the percentage of remaining brake pads read every X minutes by the T-VOD unit is less than the configured percentage.
- Alarm for low battery voltage: If the battery voltage read by the T-VOD unit when activating the ignition or during the journey is less than or equal to X V.
- Alarm for excess battery temperature: If the battery temperature read every X minutes by the T-VOD unit exceeds the configured value.
- Annual maintenance alarm. An alarm is set for annual maintenance, and a warning will be given with the configured period in advance of the expiration.
- Engine oil and filter change alarm. An alarm is set for maintenance, configurable by time, kilometers, and engine hours. A warning will be given with the configured period, kilometers, and engine hours in advance, alerting when either of them reaches the set margin first.
- Gearbox oil and filter change alarm. An alarm is set for maintenance, configurable by time, kilometers, and engine hours. A warning will be given with the configured period, kilometers, and engine hours in advance, alerting when either of them reaches the set margin first.
- Alarm for replacement of flow sensor ref. MAN 51.09413-6000. An alarm has been set with a maintenance interval of X km. A warning will be given with an advance notice of the configured kilometers.

... and so on ...
Calidad del aire

- Estaciones de calidad del aire tanto interiores como exteriores.
- Introduce la posibilidad de capturar, monitorizar y analizar datos medioambientales en tiempo real.
- Los indicadores ofrecidos por cada DEM (Dispositivos Embarcados Medioambientales) dependen de los sensores que se incluyan.

 Ejemplos de indicadores interiores:
- Temperatura.
- Humedad.
- Partículas en suspensión 2,5.
- Ruido.

 Ejemplos de indicadores exteriores:
- CO.
- NO2.
- O3.
- Temperatura.
- Humedad.
Datasheet: Where is Galileo ... 😐?
because the most important thing ... is just You!!
## Public Transport session - Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Presenter</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Daniel Lopour</td>
<td>EUSPA</td>
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<td>EMT Valencia</td>
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<td>User Requirements Discussion &amp; validation</td>
<td></td>
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</tr>
<tr>
<td>16:45–</td>
<td>Conclusions and next steps</td>
<td></td>
<td></td>
</tr>
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</table>
Debate objectives

➢ To support the development of the GNSS and EO public transport community
➢ To collect user needs and requirements
➢ To address the main gaps and barriers
➢ To gather suggestions on possible solutions
➢ To establish priorities for future

The outcomes of this session will be published in the User Requirements Report, which is a public document.
Participants survey

Join at menti.com use code 8932 6934
EO role in public transport
Debate topics

<table>
<thead>
<tr>
<th>Discussion</th>
<th>Application</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO role in Public Transport</td>
<td>Transportation network planning &amp; optimization</td>
<td>1. Are you aware of the use of EO for transportation network planning and optimization?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. What are the main challenges of EO use for this application?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. What do you think is lacking for EO to be more used with this purpose?</td>
</tr>
</tbody>
</table>

- Do you know any other Earth Observation public transport application?
- Do you see the use of Copernicus as a potential disruptive technology to improve public transport services?
GNSS applications
Public Transport Sub-sections

- Bus
- Urban rail
- Tram
GNSS Bus Applications

➢ Fleet Management
➢ Passenger Information
➢ Driver advisory systems
➢ Driving monitoring
➢ Autonomous vehicle
Fleet Management

➢ **Real-Time Bus tracking**: GNSS allows operators to track the real-time location of each bus.

➢ **Route Optimization**: GNSS data is used to optimise bus routes and resource management by analysing historical travel patterns and real-time traffic conditions.

➢ **Maintenance**: GNSS usage enables tracking of buses usage and performance, facilitating predictive maintenance scheduling.

➢ **Safety**: real-time tracking improves passengers and drivers safety. In the event of an incident, authorities can quickly locate and respond to the affected bus.
Passenger Information

➢ **Real-Time Bus Tracking:** GNSS enables real-time communication of the vehicle’s location to passengers, facilitating features such as dynamic trip planning through mobile apps.

➢ **Arrival and Departure Predictions:** GNSS data helps to calculate real time arrival and departure predictions based on the current buses location and traffic conditions.

➢ **Service Alerts:** GNSS is used to develop automated alerts in case of delays, detours, or service disruptions.

➢ **Bus Stop Announcements:** inside the bus, GNSS is used to communicate automated announcements of upcoming bus stops.
Driving monitoring

➢ **Real-time Bus Tracking:** GNSS enables the tracking of buses' position contributing to calculating optimal driving routes and managing traffic congestion.

➢ **Energy-Efficient Driving:** GNSS enables DAS to give advice on energy-efficient driving. With the analysis of the real-time bus information, such as speed and location, DAS will recommend the necessary adjustments to minimise fuel consumption and reduce emissions.

➢ **Safety:** GNSS enables DAS to provide real-time alerts to drivers about potential hazards, accidents, and adverse weather conditions.

➢ **Data Analytics:** GNSS contributes for the collection of driver behaviour data helping the identification of driving trends and areas for improvement.
Driver advisory systems

➢ **Driver Behaviour Analysis:** GNSS equipped systems continuously monitor driver behaviour, including speed, acceleration and braking. With the analysis of these data, operators can identify unsafe driving practices.

➢ **Route Compliance:** the use of GNSS ensures that bus drivers comply with predefined routes. If a driver deviates from the designated path, the system can generate alerts.

➢ **Safety:** GNSS equipped monitoring systems can send real-time alerts to the driver and the central control centre in the event of unsafe driving behaviours, such as speeding.

➢ **Emergency:** in the event of an accident, GNSS data can provide information related, for example, to the location and speed of the bus at the time of the event.

➢ **Reporting:** with GNSS data operators can develop reports on driver performance, evaluating variables like routes and schedules compliance, and fuel consumption.
Autonomous vehicles

➢ **Bus Positioning:** GNSS provides high-precision location data, allowing autonomous buses to know their exact position on the road.

➢ **Real-Time Mapping:** GNSS continuously updates digital maps of the buses surroundings, helping to prevent collisions by providing data on road layouts, traffic signs, vehicles, pedestrians, etc.

➢ **Geofencing:** GNSS allows autonomous buses to stay within predefined operational areas.
### GNSS Bus Applications

<table>
<thead>
<tr>
<th>Bus applications</th>
<th>Use Cases</th>
<th>Questions to debate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleet Management</td>
<td>Real-Time Bus tracking, Route Optimization, Maintenance and Safety</td>
<td>• Are you using GNSS in any of these applications?</td>
</tr>
<tr>
<td>Passenger Information</td>
<td>Real-Time Bus tracking, Arrival and Departure Predictions, Services Alerts, Bus Stop Announcements</td>
<td>• Why are you using GNSS for these applications?</td>
</tr>
<tr>
<td>Driver Advisory Systems (DAS)</td>
<td>Real-Time Bus tracking, Energy-Efficient Driving, Safety and Data Analytics</td>
<td>• Which gaps and barriers have you identified in these applications?</td>
</tr>
<tr>
<td>Driving Monitoring</td>
<td>Driver Behavior Analysis, Route Compliance, Safety, Emergency and Reporting</td>
<td>• What would be your suggestions to address what is missing?</td>
</tr>
<tr>
<td>Autonomous shuttle</td>
<td>Bus positioning, Real-Time mapping and Geofencing</td>
<td></td>
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GNSS User requirements
### Methodology – User requirements

<table>
<thead>
<tr>
<th>Availability</th>
<th>Accuracy</th>
<th>Reliability</th>
</tr>
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<tbody>
<tr>
<td>Position fix availability</td>
<td>Horizontal accuracy</td>
<td>Position Integrity</td>
</tr>
<tr>
<td>Position fix rate</td>
<td>Vertical accuracy</td>
<td>Time-to-Alert</td>
</tr>
<tr>
<td>GNSS Time accuracy</td>
<td></td>
<td></td>
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# User Requirements for GNSS Bus Applications

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<th>Availability</th>
<th>Position fix availability</th>
<th>Better than 99.9% (High)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Position fix rate</td>
<td>&lt;10Hz</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Horizontal position</td>
<td>m-level</td>
</tr>
<tr>
<td></td>
<td>Vertical position</td>
<td>m-level</td>
</tr>
<tr>
<td></td>
<td>GNSS time</td>
<td>1us</td>
</tr>
<tr>
<td>Reliability</td>
<td>Position Integrity</td>
<td>Medium-High</td>
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<tr>
<td></td>
<td>Time to Alert</td>
<td>10-30s</td>
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Conclusions and next steps

CONCLUSIONS

Thank you for your active participation to the Public Transport User Consultation Platform!

Your feedback and inputs are of key importance to us, as they will feed into the Report on Public Transport User Needs and Requirements. The report will be published in early 2024 (on EUSPA website)

NEXT STEPS

• The minutes of today’s session will be soon made available online