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PRoPART

Precise and Robust Positioning for Automated Road Transports

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PROPART STATUS

RNN Stockholm, 2020-02-04

Stefan Nord

RISE Measurement Science and Technology

PRoPART Project Presentation and Highlights

- **Call**: Applications in satellite navigation – Galileo
- **Topic**: GALILEO-1-2017: EGNSS Transport applications
- **Budget**: ~3.5 M€
- **EU Grant**: ~3.0 M€
- **Project started: 2017-12-01**
- **Project ended: 2019-11-30**
- **Final Demo Event at AstaZero 2019-11-21**

Project acronym:	**PRoPART**
Project title:	**Precise and Robust Positioning for Automated Road Transports**
Grant Agreement Number:	**776307**
Programme:	**H2020-GALILEO-GSA-2017 (H2020-GALILEO-GSA-2017-1)**
Contract type:	**Innovation Action**
Start date of project:	**2017-12-01**
Duration:	**24 months**

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PRoPART Project Presentation and Highlights

- PRoPART has developed and enhanced an existing RTK (Real Time Kinematic) software solution developed by Waysure, by **exploiting the distinguished features of Galileo signals(*)** as well as **combining it with other positioning and sensor technologies.**

(*) Utilise Galileo specific features in combination with other GNSS systems. Particularly:

- Higher multipath mitigation because of Binary Offset Coding.
- Substantial improvement of the reliability of the carrier phase ambiguity resolution using E5AltBOC
- OS-NMA (anti-spoofing)

PRoPART has also investigated **a low-cost Ultra Wideband (UWB) ranging solution for redundancy** and robustness in areas where the coverage of GNSS is poor e.g. in tunnels or in urban canyons.

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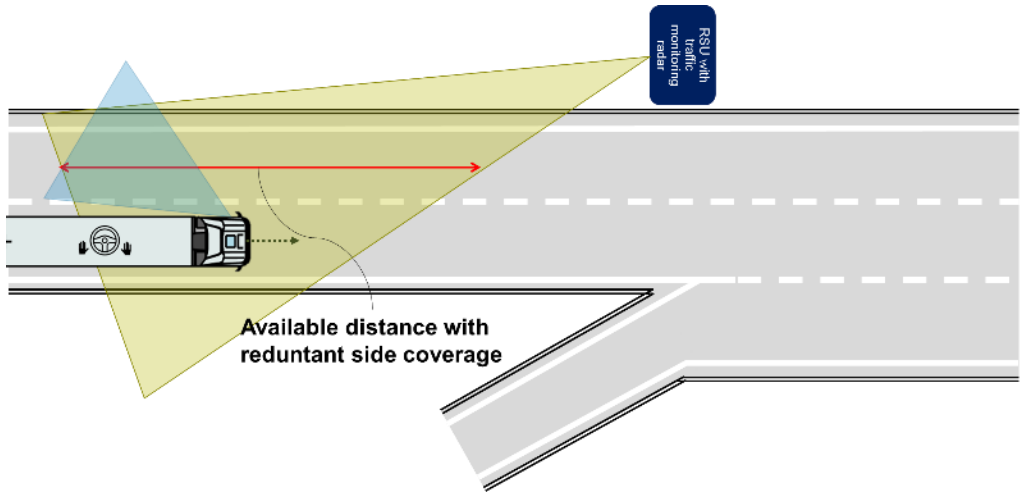
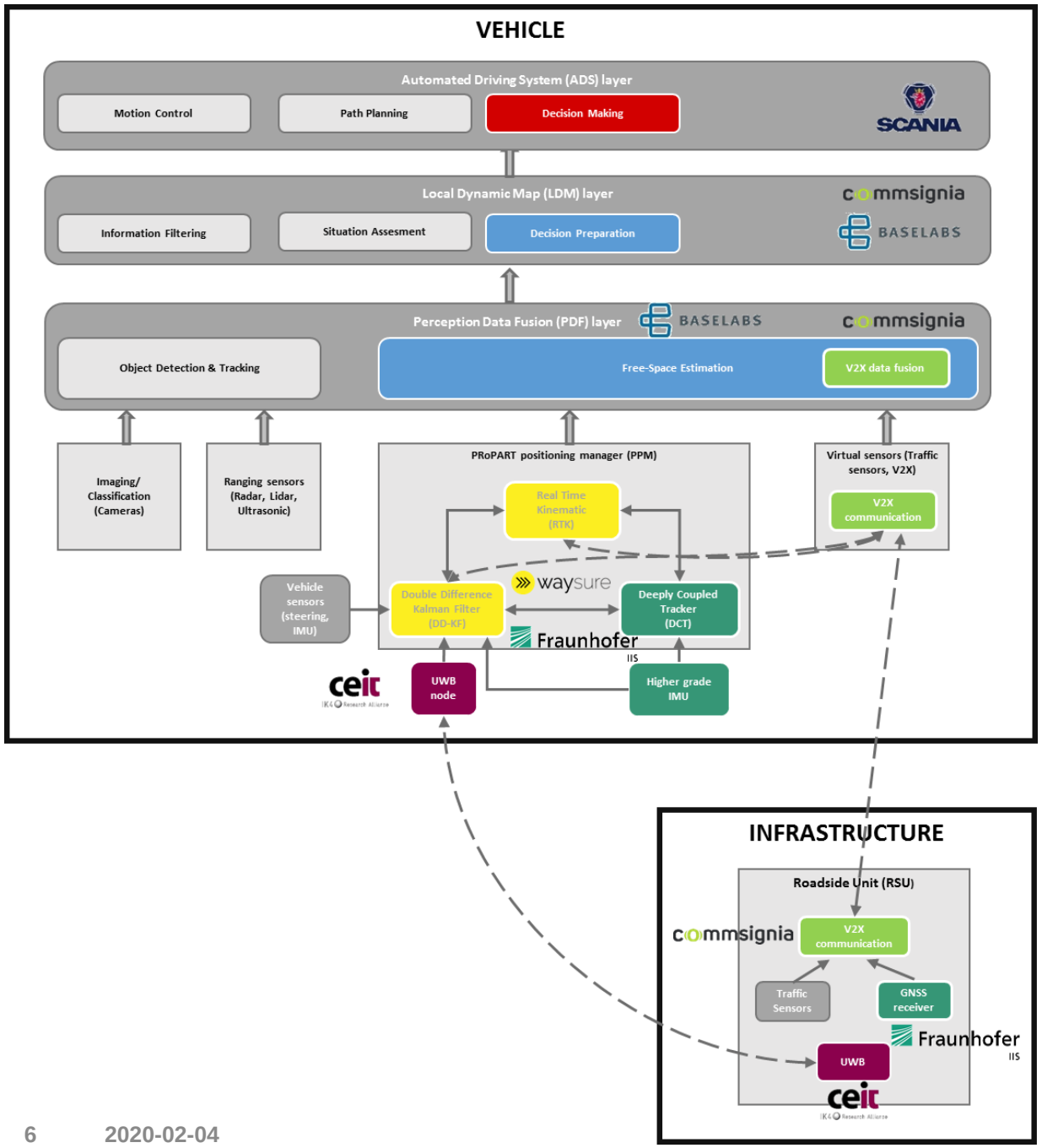
PRoPART Project Presentation and Highlights

- PRoPART has also implemented an **RSU (Road Side unit)** with high precision positioning that uses **both UWB and a traffic monitoring radar sensor** that supplies ranging, object perception **and EGNSS RTK correction data** via ETSI ITS-G5 to the connected automated vehicle so it can make safe decisions based on robust data.
- PRoPART **has also implemented perception layer sensor fusion** that uses information collected in the LDM (Local Dynamic Map) from the RSU:s as well as information from the on-board vehicle sensors and the high availability positioning solution.



PRoPART System Diagram and partner contributions



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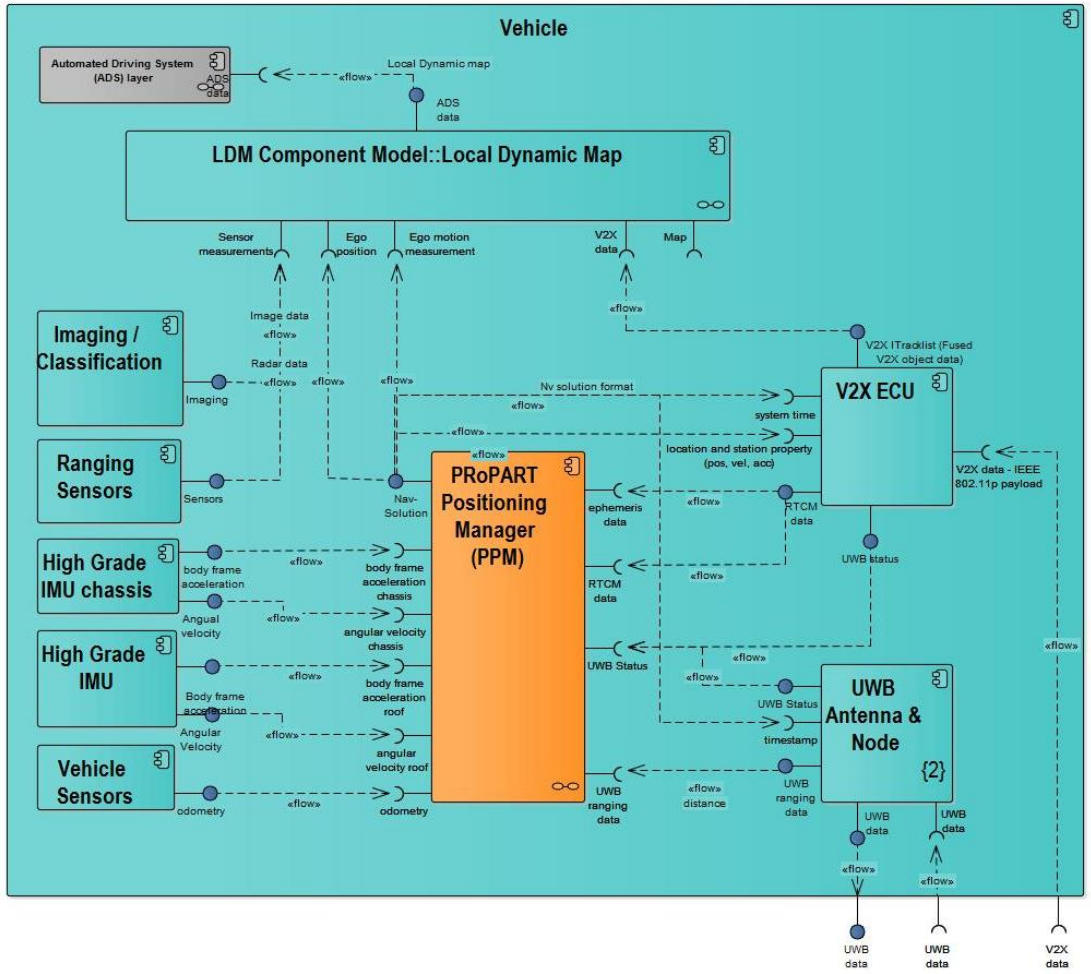
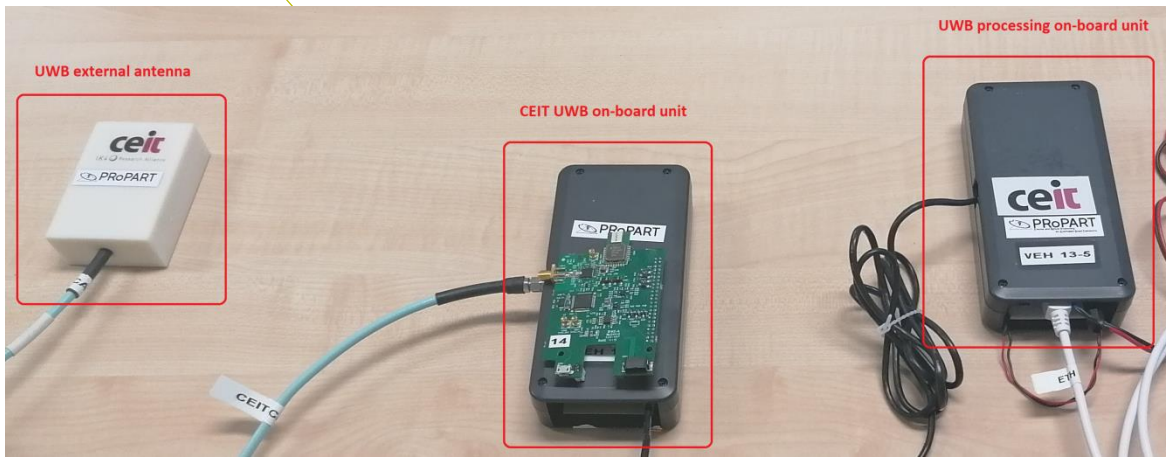
PRoPART Positioning Manager

- The role of the PRoPART positioning manager is to deliver absolute position, velocity and orientation to the perception layer.
- The PPM takes in all positioning measurements to provide a single source.
- These estimates should be accurate, robust, authenticated, and have high integrity.



Physical Representation



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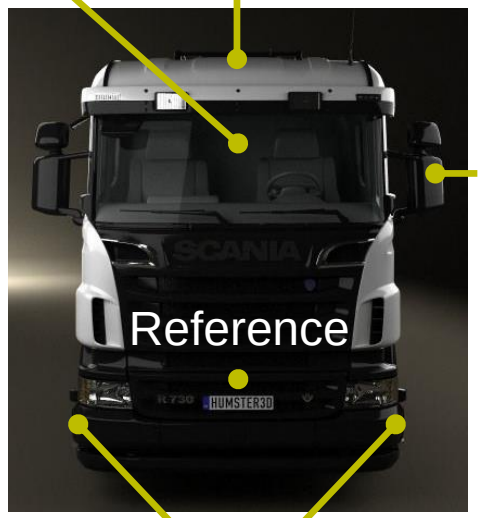
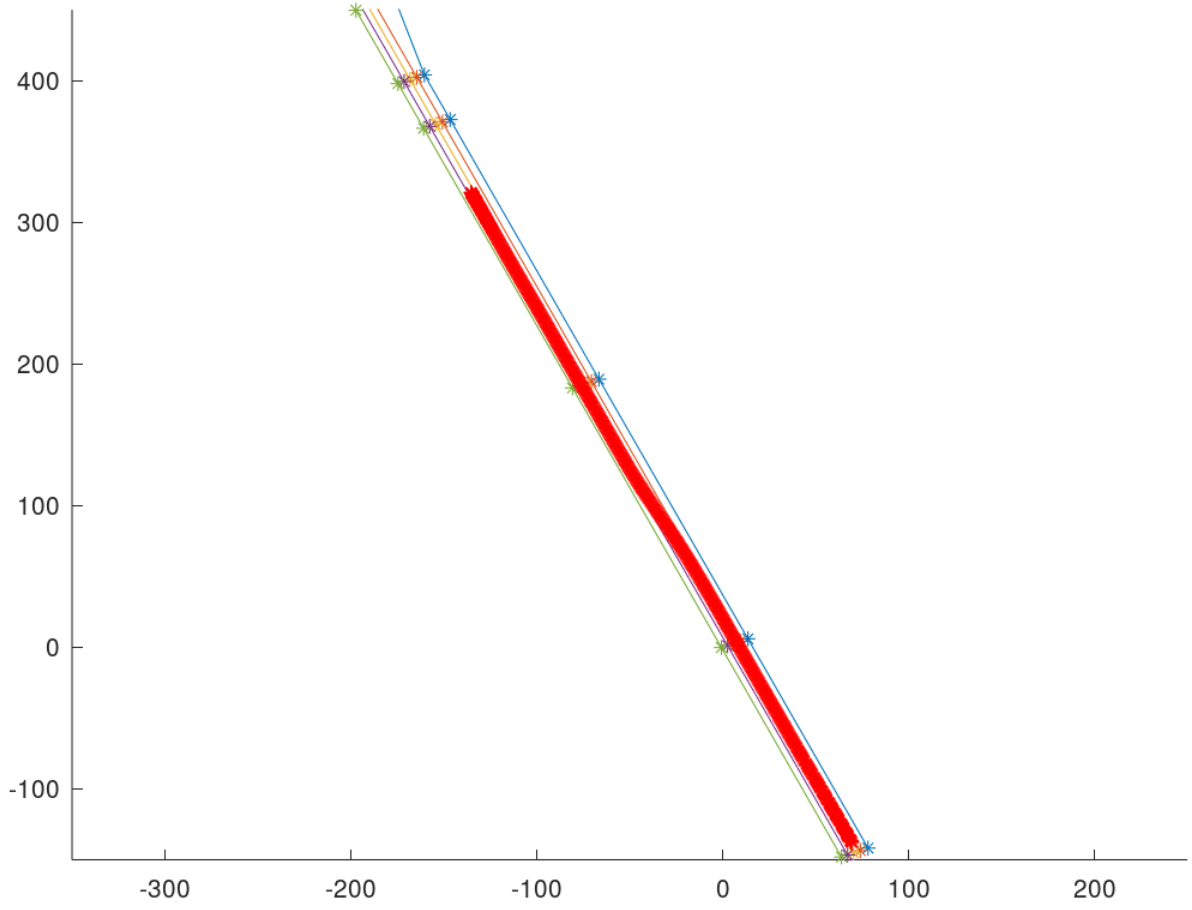
Installation

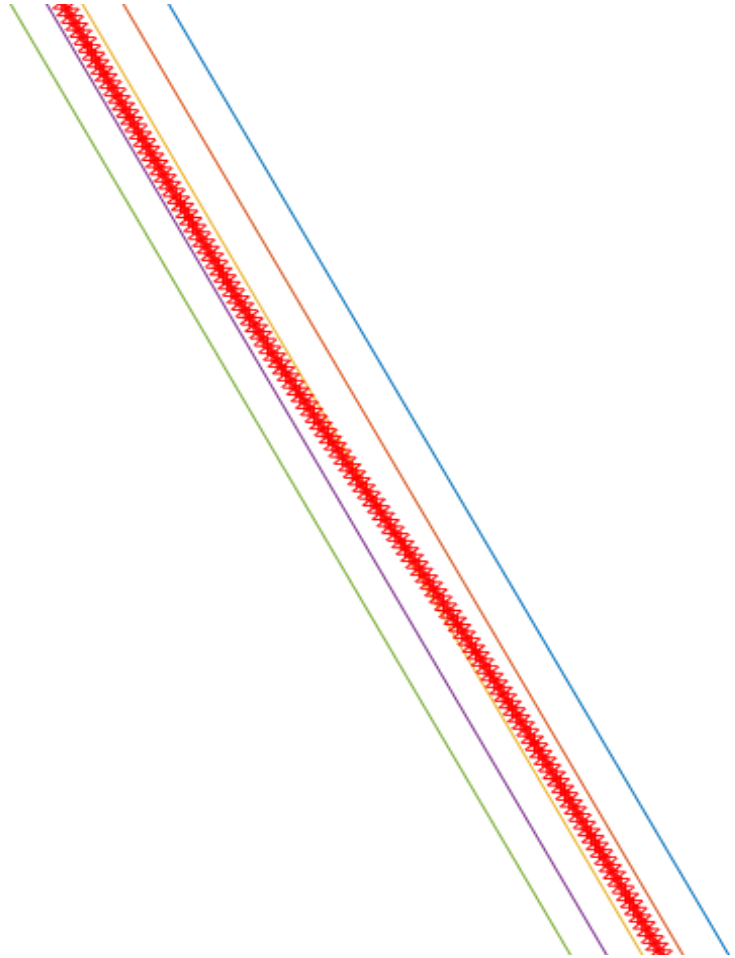


RTK and DD-KF Performance

- Time to First (Ambiguity Resolved) Fix
  - TTF(AR)F in good conditions varies between 3 to 10 seconds
- Time to Reacquisition (AR)
  - Instantaneous in good conditions after short outage
  - 3 to 10 seconds in good conditions
- Reference station handover between RSU data streams
- Positioning accuracy at RTK levels (circa 2cm horizontal by comparison to other RTK systems)
- Available throughout test scenarios

Lane change



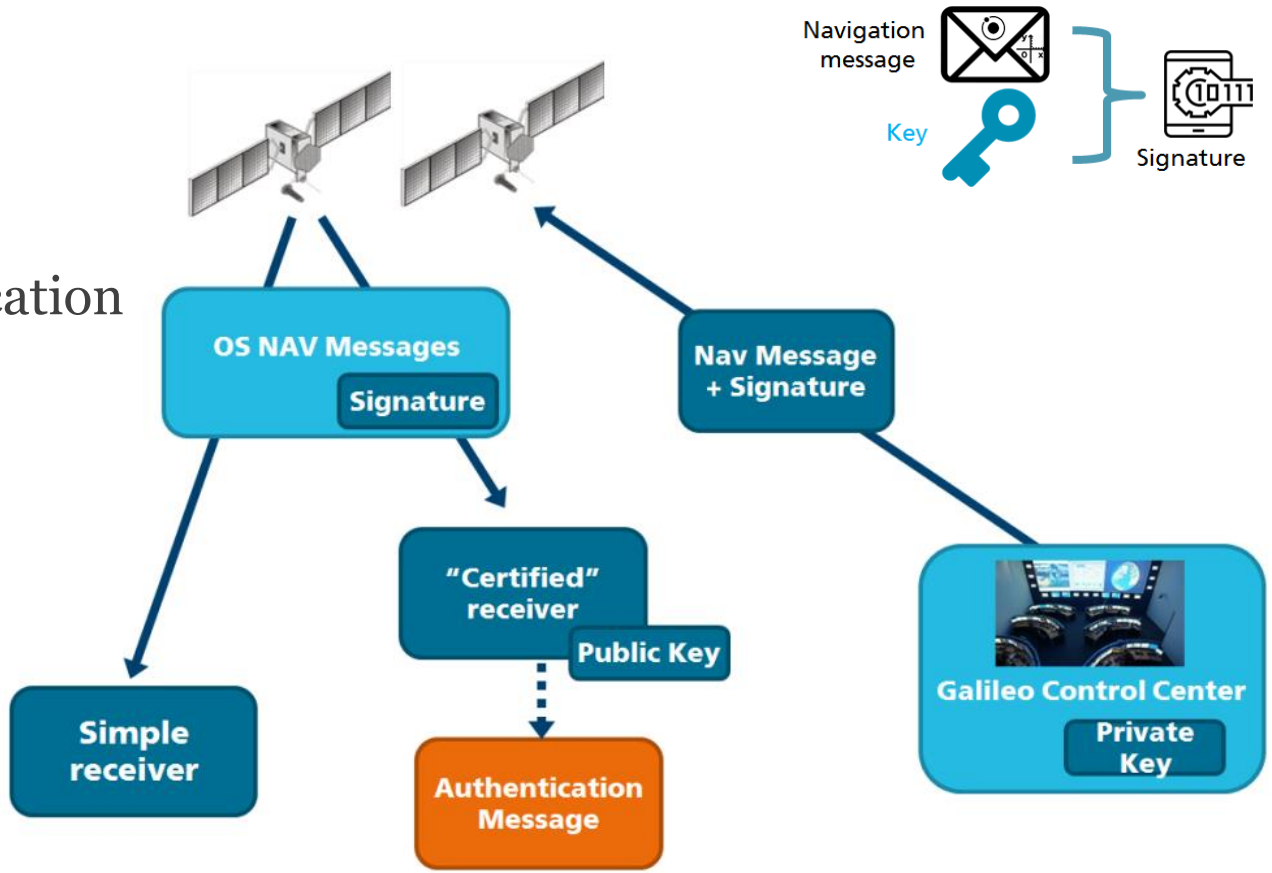


Role of Galileo in PRoPART
GOOSE as a Galileo Receiver

- GOOSE Receiver uses Galileo time as its reference
  - Configurable between systems (Galileo, GPS, …)
  - Distributed to other subsystems through Precise Time Protocol (PTP)
- Acquisition strategy prioritises Galileo satellites
- OS-NMA for continuous authentication
- GOOSE includes Galileo E1B, E5a, E5AltBOC as well as GPS L1, L2, L5
  - E5AltBOC
    - More robust against multipath as shown in a railway scenario (no position jumps)
    - Low noise code measurements (10cm) without carrier ambiguity resolving -> high availability
    - Rapid ambiguity resolution

Role of Galileo in PRoPART
Galileo OS-NMA

- Open Service – Navigation Message Authentication
  - Protection against malicious attacks
  - Orbit parameters and SV clock corrections
  - Rejection of all data from erroneous source



Role of Galileo in PRoPART
OS-NMA

- PRoPART as a use-case

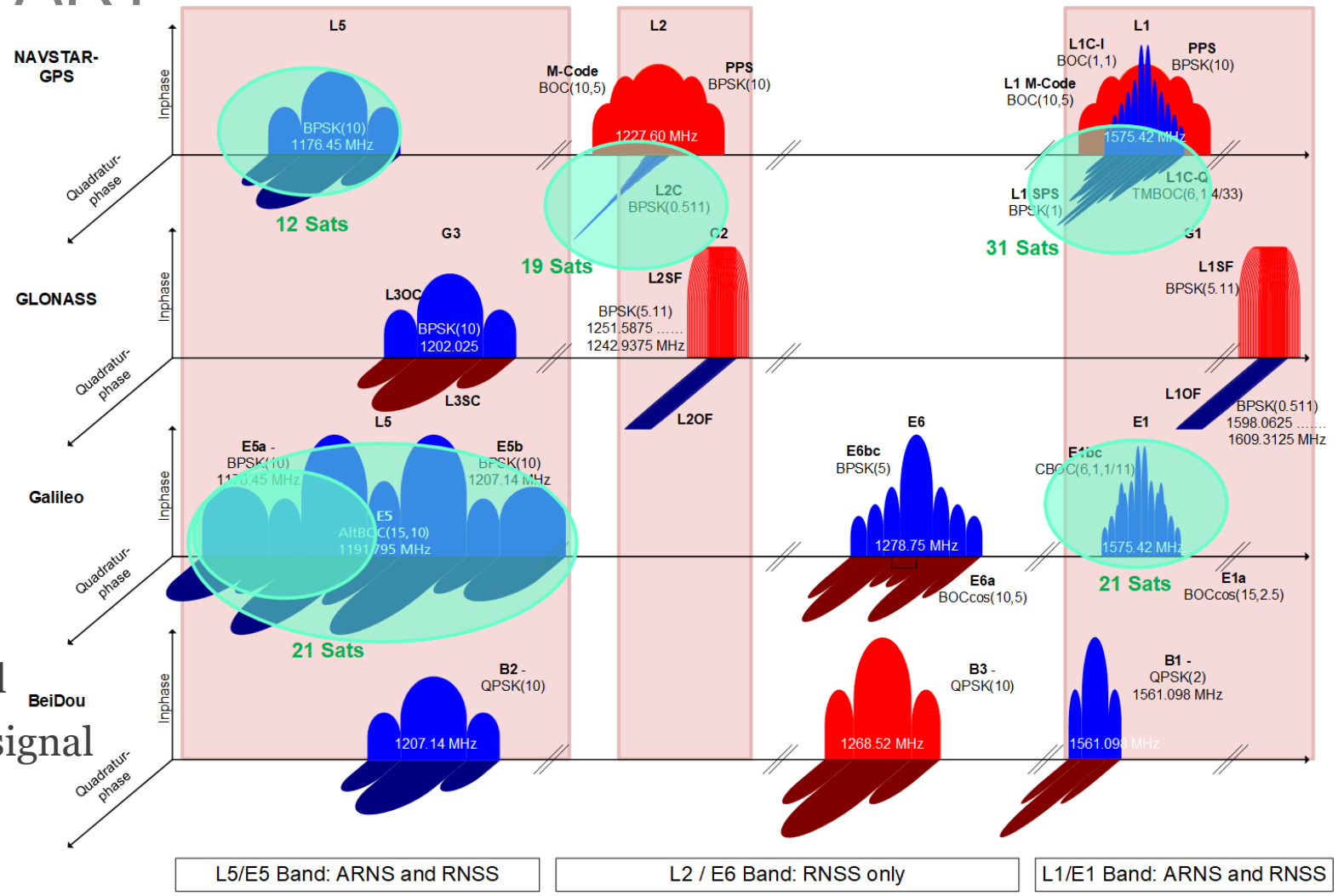
[1] Receiver Independent Implementation of the Galileo Open Service Navigation Message Authentication,
Zubizarreta, Fraunhofer IIS (Germany), et al., ITSNT, Toulouse, 2018

- Benefits of OS-NMA
  - Open Service
  - Secure nav. Msg.
  - Firmware update only
  - Low impact on TTF(A)F
    - Slowest case ca. 420 seconds (only one Galileo satellite available)
    - Best case ca. 10 seconds
    - After first authenticated fix, continuous authentication

Role of Galileo in PRoPART
GNSS signals

- Signals used in PRoPART
  - Galileo E1B, E5a, E5AltBOC
  - GPS L1, L2C, L5

- Galileo: 21 operational satellites
- GPS: 31 operational satellites
  - 12 satellites with L1 civil signal
  - 7 satellites with L1, L2C civil signal
  - 12 satellites with L1, L2C, L5 civil signal



Role of Galileo in PRoPART
Summary

- Galileo time as time reference
  - Configurable in GOOSE between systems (Galileo, GPS, …)
  - Distributed to other subsystems through Precise Time Protocol (PTP)
- OS-NMA for continuous authentication
  - Average 30 s initialisation
- Galileo E5AltBOC
  - More robust against multipath
  - Low noise code measurements (10cm) without carrier ambiguity resolving -> high availability
  - Rapid ambiguity resolution

More info

- Public deliverables and presentations from Final Demonstration Event 2019-11-21 can be found at the project web site: www.propart-project.eu
- LinkedIn page with more material including the movie: https://www.linkedin.com/company/propart-project/
- Link to the movie: https://youtu.be/hFVcxoYMYoY

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THANK YOU!

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RISE Measurement Science and Technology

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