

European Global Navigation Satellite Systems Agency





PROPART FINAL DEMONSTRATION EVENT

Galileo role and benefits

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Role of Galileo in PRoPART Overview



- GOOSE* as a Galileo Receiver
- Time reference
- OS-NMA spoofing detection
- GNSS signals used
 - E1B, E5a, E5AltBOC
 - Code solution
 - Carrier solution
- Summary

Positioning results are given in: "PRoPART Positioning Manager Concept"

* GNSS Receiver with open software interface







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



• If you want to learn more, visit us at Fraunhofer booth







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

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Benefits of OS-NMA



- Open Service



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



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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 Positioning techniques



Double Difference





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Role of Galileo in PRoPART PRN Code correlation

- Distance measurement to at least 4 satellites
- Pseudorandom Noise sequence (PRN) must be synchronised with the receiver internal copy (replica) of the signal to bring it above noise floor
- Correlation between received signal and replica \rightarrow Peak if synchronous



Role of Galileo in PRoPART E5AltBOC

Spectrum of Galileo E5 Signals



Multi-Peak-Correlation









Role of Galileo in PRoPART E5AltBOC

- Live sky data using roof antenna at FhG
- Results of E5AltBOC (post-processing with RTKLIB single point solution on code ranges)
- Geometric dilution of precision (GDOP)
 ~ 2.0









Role of Galileo in PRoPART E5AltBOC

Results of E5AltBOC (post-processing with RTKLIB single point solution on code ranges)





E1: Position Error



Role of Galileo in PRoPART Code phase noise plots



*Double difference = Systematic error cancelled, Noise increased and correlated









*Double difference = Systematic error cancelled, Noise increased and correlated







Role of Galileo in PRoPART E5a

 Spectrum of Galileo E5a Signals with GPS overlap



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- Multi frequency RTK techniques for rapid initialisation use E5a with GPS L5.
 - Same centre frequency
 - Cross-constellation solution for multifrequency ambiguity resolving





Role of Galileo in PRoPART High-precision GNSS solutions

- One Code-Chip at CA-Code of GPS L1 is ~300 m
- One period of the carrier frequency is ~19 cm
 - Carrier phase measureable
 - No information which whole number of full cycles
 - This is the integer ambiguity of the carrier solution, which must be solved
 - Only possible in "error free" environment



Source: https://en.wikipedia.org/wiki/GPS_signals#/media/File:GPS_signal_modulation_scheme.svg



Source: http://kompendium.infotip.de/files/wdb/GRAFIK/2700_KOMMUNIKATIONSTECHNIK/2750_GNSS/ABB_2750_04_05_Phasenmessung.gif







Positioning techniques

Standard

Double Difference





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Positioning techniques

Carrier

Multi-frequency carrier, accurate code



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









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THANK YOU

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www.propart-project.eu









