

GALILEO PROGRAMME UPDATE

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Galileo Workshop Status en Toepassingen 11 October 2019

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Galileo Today



- 26 satellites in-orbit (22 operational)
- Ground Segment deployed in 23 sites worldwide
- Global PNT and SAR services since Dec 2016
- Over 1 billion Galileo-enabled chips sold every year
- Best ranging performance of all GNSS (GPS, Glonass, Beidou, Galileo)
- Leader in dual-frequency sub-meter accuracy market
- Leader in Search-and-Rescue satellite-based services within COSPAS SARSAT
- Active in 5G Location-based services standardization
- Galileo (with GPS) is the only FCC-licensed GNSS in the USA



The Actors in Europe







- Defined, designed, developed, deployed and validated EGNOS and GALILEO infrastructures.
- Procurement agent for all contracts.
- Co-funded early programmes phases.





EU is owner and funder and has delegated to the European Commission the overall responsibility for the programmes, i.e. managing and overseeing the implementation of all programmes activities.



GSA

The European Global Navigation Satellite System Agency (GSA) ensures the operations and seamless provision of both **EGNOS** and **Galileo** services.

Preparing for the successful commercialisation and exploitation of the systems, and high market penetration but also ensuring the security accreditation of the system.

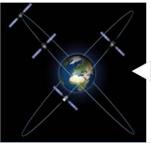
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Galileo Moving Ahead ...





2005
DEVELOPMENT
SYSTEM TESTBED
GIOVE A/B



2013
IN-ORBIT VALIDATION
4 satellites
initial ground
infrastructure



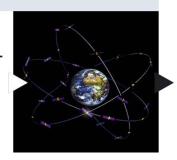
2015/2016
INITIAL GALILEO SERVICES
OS, SAR, PRS, CS demonstrator

2017/2019 EXPLOITATION PHASE FOC1 System



FULL OPERATIONAL
CAPABILITY
24 operational
satellites
and complete ground
infrastructure

2020



After 2020 TOWARD GALILEO 2nd GENERATION

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Galileo based services



OPEN SERVICE

FREE TO AIR - MASS MARKET **POSITION – VELOCITY – TIME**



Currently complementing GPS on Galileo enabled receivers

COMMERCIAL SERVICE

COMMERCIAL/PROFESSIONAL MARKET HIGH ACCURACY – AUTHENTICATION



Under development

SAFETY OF LIFE SERVICE

OPEN SERVICE + EGNOS INTEGRITY



EGNOS V3 under development will complement Galileo

PUBLIC REGULATED SERVICE

ACCES CONTROLLED FOR GOVERNMENT AUTHORISED USERS



SEARCH AND RESCUE **SERVICE**

COSPAS SARSAT MEOSAR INCLUDING RETURN LINK



Available since December 2016 Return link service in 2019

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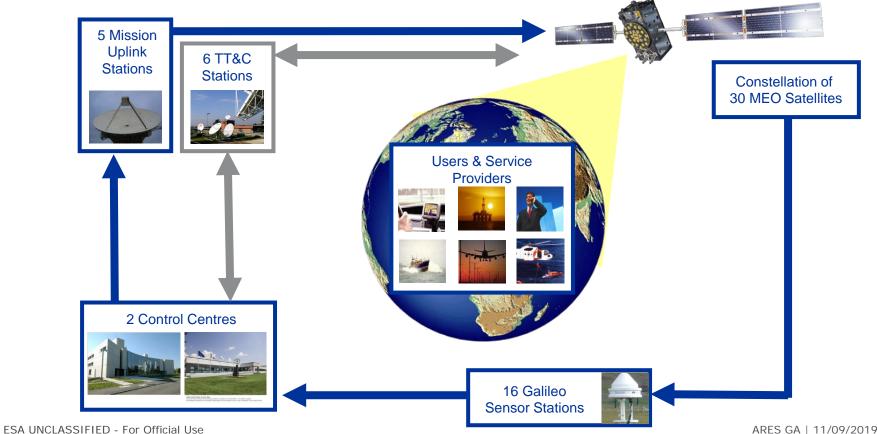






Galileo Navigation System Architecture

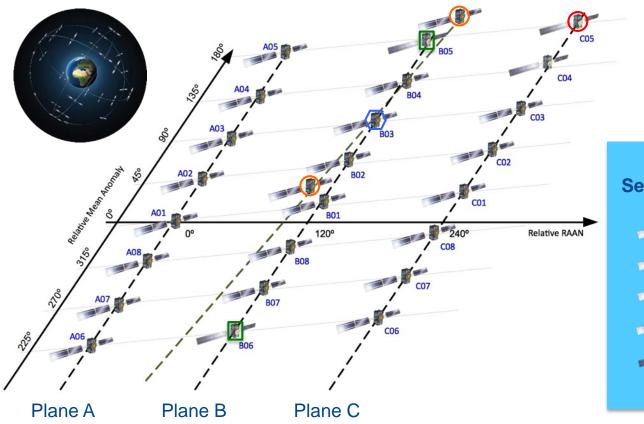




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Galileo Constellation Status





Navigation (22 in service)
Search and Rescue (23 in service)

26 satellites in orbit



2 in testing (NAV P/L only)



1 spare



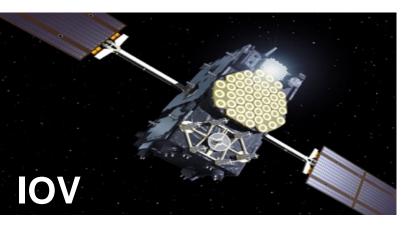
1 unavailable (NAV P/L only)



2 no SAR (by design)

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Galileo Satellites

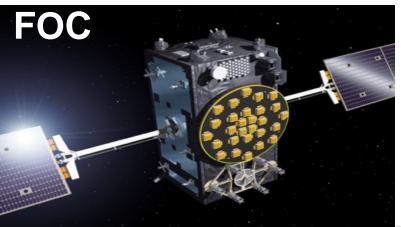




All 4 satellites in-orbit

Mass at Launch
Power Consumption
Dimensions
Orbit Injection
Attitude Profile

700kg 1420W 2.7 x 1.6 x 14.5 m Direct into MEO orbit Yaw Steered



S/C Prime Contractor OHB Systems GmbH P/L Prime Contractor SSTL Ltd All 22 satellites in-orbit

Mass at Launch Power Consumption Dimensions Orbit Injection Attitude Profile

733kg 1900 W 2.5 x 1.1 x 14.7 m Direct into MEO orbit Yaw Steered



















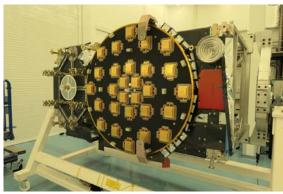


Batch 3 Satellites











12 additional FOC satellites currently under production, ready for launch end 2020

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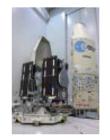






Launches





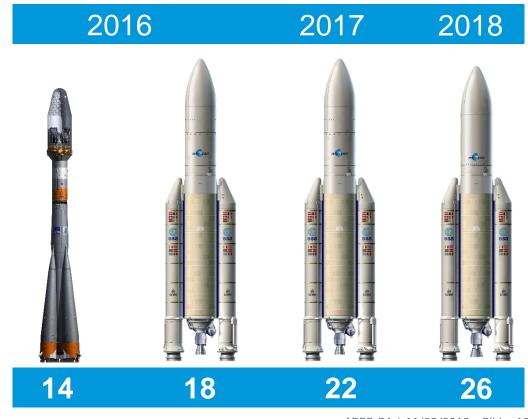








12 FOC satellites launched with **Ariane 5**



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Launch #10 (Ariane 5) - 25 July 2018





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Future Launch services





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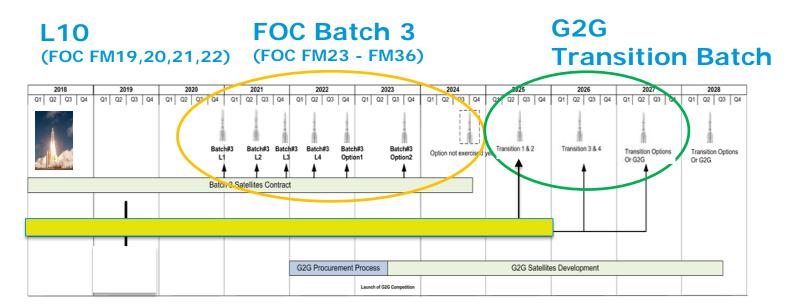






Long-Term Constellation Deployment





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Galileo Ground Segment Overview

































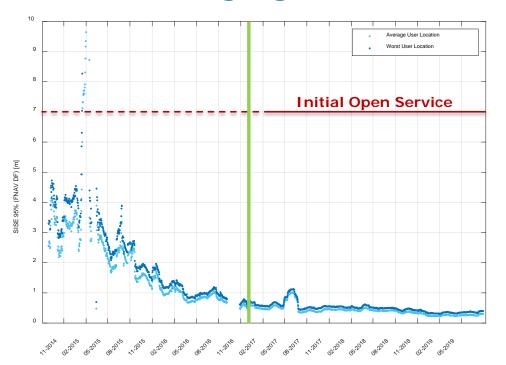






As-observed Ranging Performance





25 cm

- Decreasing Ranging Error trend due to increasing number of Satellites and G/S improvements
- Ranging accuracy 0.25m (95%) all satellites in June 2019 (F/NAV)

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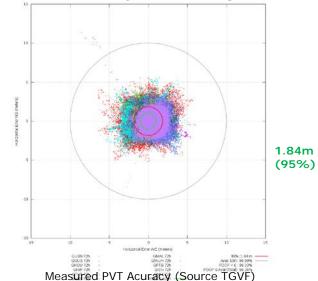




Positioning Performance & Availability



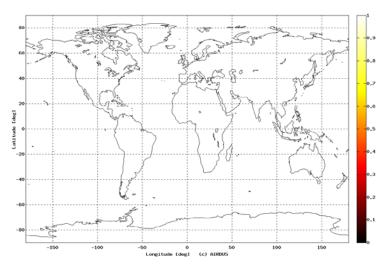
- 4 more satellites operational since February 2019
- Satellites in operational constellation: 22
- Availability of H. Accuracy < 10 m
- Global PDOP <=6 availability
- Availability for Timing Service



100% (Average User Location)

99.99% (Average User Location)

100%



Availability of Horizontal Position Accuracy < 10 m for 22 satellites

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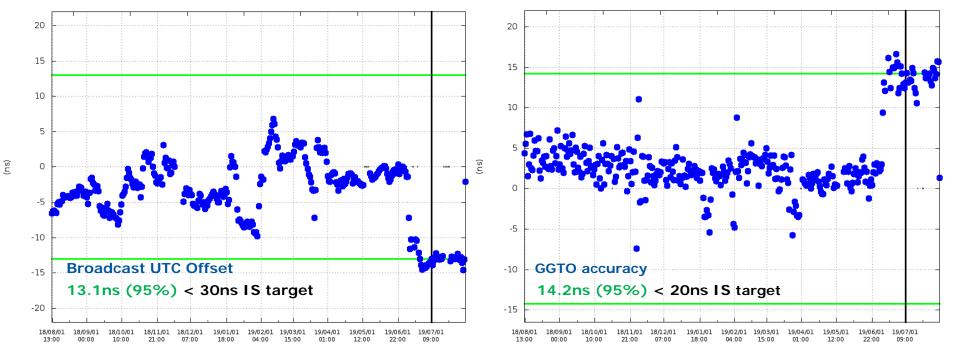






Galileo Timing Performance





- → Evaluated with calibrated timing GPS/Galileo receiver operated in UTC(k) laboratory (PTB, INRIM)
- → 10-15ns bias since mid June 2019 caused by residual calibration offset in GSS-PTF D1.

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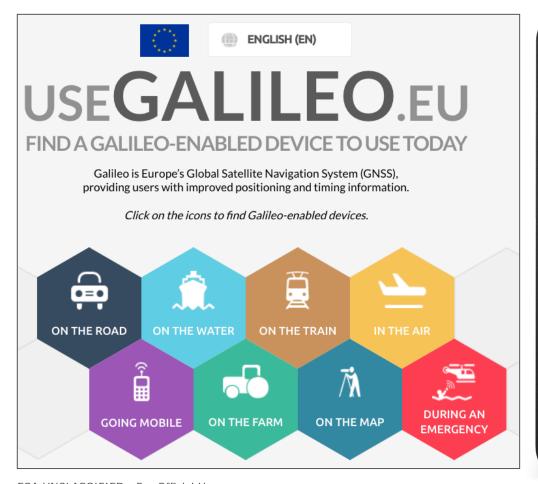
















156 models of Galileo-enabled smartphone/ tablets available today (11 Sep. 2019)

























Open Service Planned Evolutions

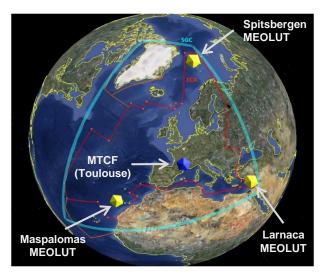


- IMPROVEMENT OF THE OS NAVIGATION MESSAGE
 - Faster Time-to-First-Fix and data demodulation robustness.
- AUTHENTICATION will be based on:
 - Short term: Navigation Message Authentication integrated as part of current E1 OS signal. Target: consumer users, free-of-charge
 - Future: Commercial Service Authentication based on E6C Spreading Code Encryption
- HIGH ACCURACY SERVICE (HAS) based on PPP transmission in E6B
 - Gradual introduction, free of charge
 - ICD under final consolidation

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Galileo Search and Rescue









- ★ 3 MEO Local User Terminals (MEOLUTs) on European territory
- ★ 1 MEOLUT under preparation in Indian Ocean Region
- MEOLUT Tracking and Coordination Facility (MTCF) at CNES/Toulouse, France
- ★ Return Link service development



MEOSAR



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Public Regulated Service



PRS Signal-in-Space Evolution

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 Early next year introduction of the Galileo Security Monitoring Centres (responsible for security monitoring and PRS access control) in France and Spain

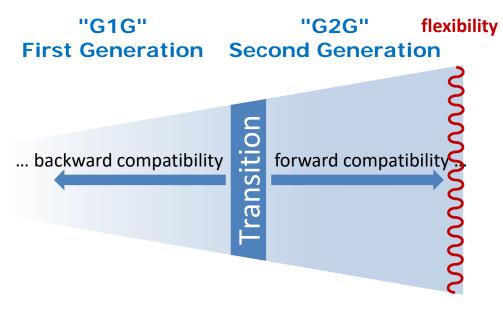


★ In the next years deployment of PRS 'Points of Contact' deployed at Member States' Competent PRS Authorities

European Space Agency

Need for transition





Transition: ensuring service continuity while validating new concepts in orbit

- Automated operations
- Increased lifetime
- Increase reliability
- Security threats
- Optimize receivers
- Lower costs

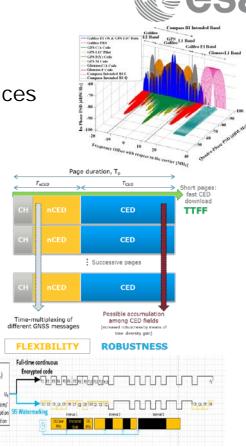
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G2G Transition High Level Objectives

- Ensure continuity of Legacy services over 2025-2030
- Incremental introduction of new system features and services towards G2G
 - ★ Open Service capabilities
 - ★ PRS robustness
 - Transmit power
 - System and SIS in-orbit flexibility / in-orbit reconfiguration
 - Inter-Satellite Links
 - ★ SAR 2nd Generation Beacons
 - Security resilience
 - Operability
 - Technology refresh and obsolescence management



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G2G Transition workplan 2019



G2G Mission Requirements consolidation in close cooperation with the FU Member States

- Infrastructure:
 - Satellites Transition Batch: Procurement on-going
 - Transition Ground Segment: Phase B studies on-going Phase C/D Procurement actions to start in 2020 in support of Transition satellites command & control and legacy mission





















EGEP & H2020 AS EVOLUTIONS ENABLERS





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Conclusions



- → Galileo is operational with **excellent** performance
 - Part of the Single Frequency mass-market
 - De facto standard for Dual Frequency applications
- → 26 Galileo satellites in orbit
 - → Additional 3rd Batch of 12 Galileo satellites to be deployed end 2020 onwards
- → Galileo Ground Segment deployment continues to support stable and continuous availability of Galileo Signal-in-Space to users
- → New and improved services to be provided in the near future
- → Galileo 2G and Evolution Programmes well underway

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