Status of Galileo SSV Characterization

UNOOSA ICG 9 – Working Group B

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esa

European Space Agency

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EGNOS

Navigation solutions powered by Europe

Outline

- Relevance of GNSS SSV for Europe and ESA
- Status of Galileo SSV Characterization
- GSAT0201/0202 Orbit Anomaly – Unique Opportunity for SSV Characterization
- Conclusions and Way Forward

GNSS Space Applications

- Main applications of GNSS in space:
  - Orbit determination
  - AOCS & Timing
  - Formation Flying & Rendezvous
  - Scientific instruments (RO, Reflectometry)

- GPS is used at LEO, MEO and GEO altitudes
- Several studies done at ESA-level identifying the benefits of adding the new GNSS systems
- Several GNSS technologies under development, new ASICs and receivers

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Relevance of Space Service Volume

- Relevance and added value of an interoperable GNSS Space Service Volume (SSV) is well noted
- Already today a large number of ESA and EU Member State space missions have GNSS space receivers embarked

GNSS spacecraft navigation applications and missions

Application		Mission Examples	Orbit
Absolute Navigation (Platform Rx)	LEO Orbit	PLEIADES, DMC, Earth Observation, GlobalStar, Proba-2, Demeter, EarthCare	LEO
	GEO/GTO/HEO Orbit	STENTOR, SkyLAN, IntelSat, GMP, SmallGEO, MTG, STE-QUEST	GEO/HEO
	Precise LEO Nav	SWARM, GMES Sentinels	LEO
	Re-entry	ARD, Pre-X	LEO to ground
	Launcher	Evolutions: ARIANE V, VEGA	Ground to GTO
Relative Navigation (Platform Rx)	Rendezvous	ATV	LEO
	FF	GRACE, PRISMA, Proba-3, MMS, TerraSAR-X, FF Xeus, Premier, NGGM	LEO/HEO GEO
EO/Scientific Instruments	POD	GOCE, SWARM, GMES Sentinels, CHAMP, GRACE	LEO
	At. Sounding, Reflectometry	MetOp, CHAMP, PARIS, UK-DMC, PostEPS	LEO HEO
Support to other subsystems	Attitude	PLEIADES, ROCSAT, ALPHABUS	LEO GEO
	Timing	GEO telecom, GlobalStar, Iridum, MTG	LEO GEO

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Status of Galileo SSV Characterization

- Galileo SSV characterization is currently ongoing following the conventions identified by ICG WG-B regarding
  - Relevant User Orbits
    - LEO (represented by sphere at 3000 km altitude above earth)
    - MEO (represented by sphere at 8000 km altitude above earth)
    - GEO/HEO (represented by sphere at 36000 km altitude above earth)
  - Availability Evaluation
    - Availability of 1 satellite and availability of 4 satellites
    - Availability evaluation done per user on a sphere at relevant radius over time
    - Availability to report is the minimum out of the best 95% of all user locations
  - SSV Characteristics Reporting
    - User received power (not necessarily constrained by data demodulation threshold) at GEO altitude and corresponding off-boresight angle
    - Availability evaluation at GEO altitude
    - Availability evaluation at MEO altitude (based on off-boresight angle specification for GEO altitude)

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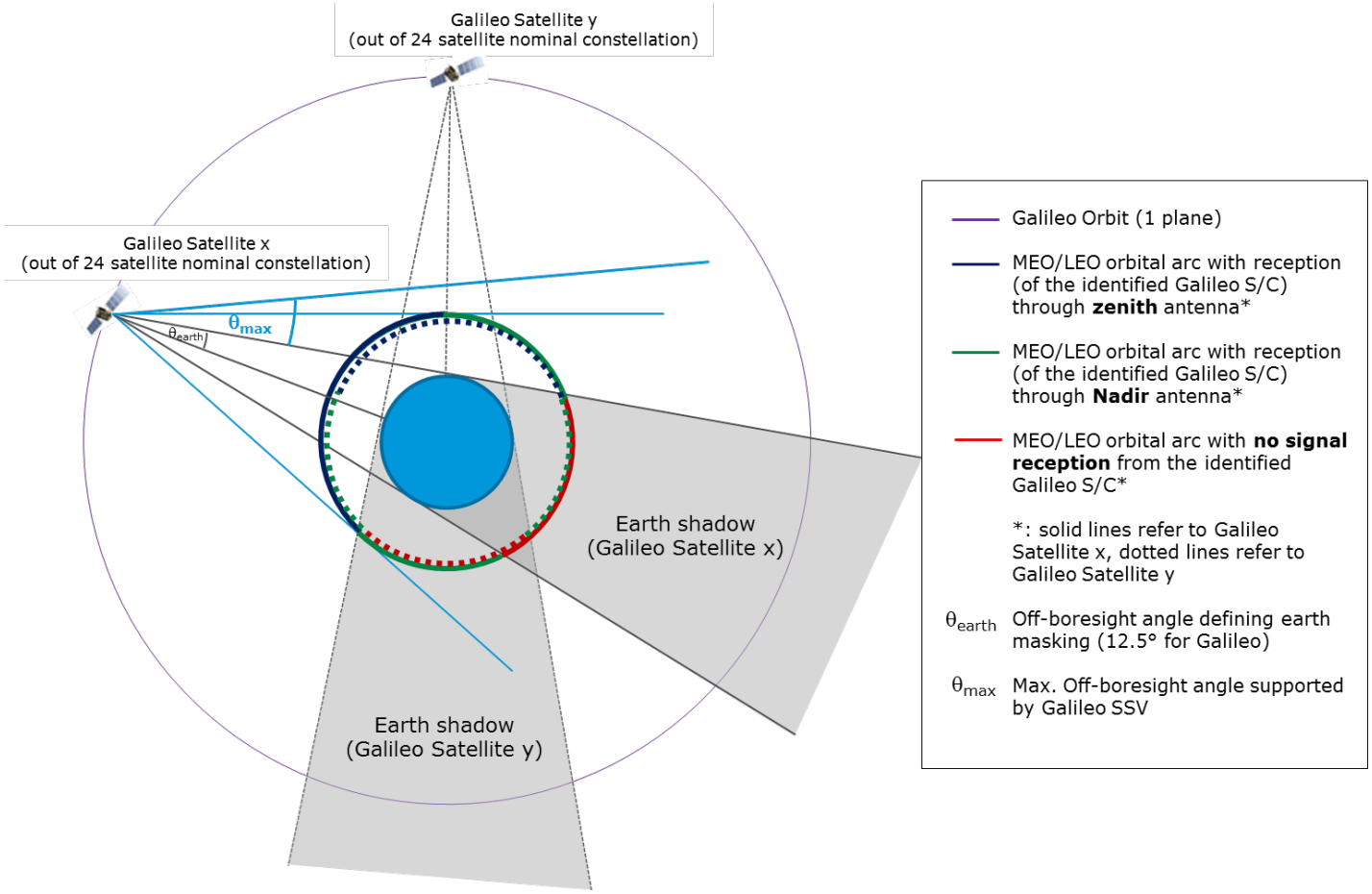
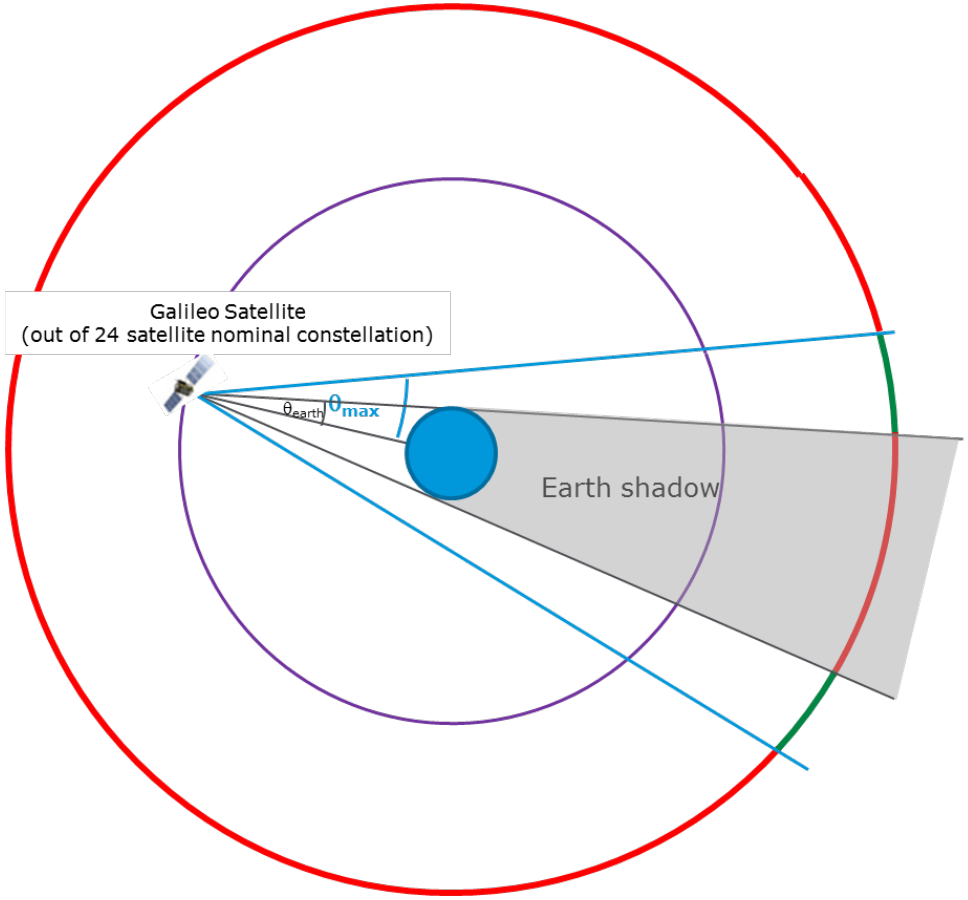
SSV Geometry for LEO/MEO



- Important note: It is assumed that the user has capability to receive signals from
  - NADIR direction and
  - Zenith direction

SSV Geometry for GEO/HEO



Galileo Orbit

HEO/GEO orbital arc with reception (of the identified Galileo S/C)

HEO/GEO orbital arc with **no signal reception** from the identified Galileo S/C

θ_{earth} Off-boresight angle defining earth masking (12.5° for Galileo)

θ_{max} Max. Off-boresight angle supported by Galileo SSV

★ Important note: It is assumed that the user has capability to receive signals from NADIR

GSAT0201/0202 Orbital Anomaly (1/2)

- First two Galileo FOC satellites (GSAT0201/0202) launched in August 2014 face orbital anomaly

	Nominal Galileo Orbit	Current GSAT0201/0202 Orbit
Semi Major Axis (SMA) [km]	29600	26180
Eccentricity	0	0.23

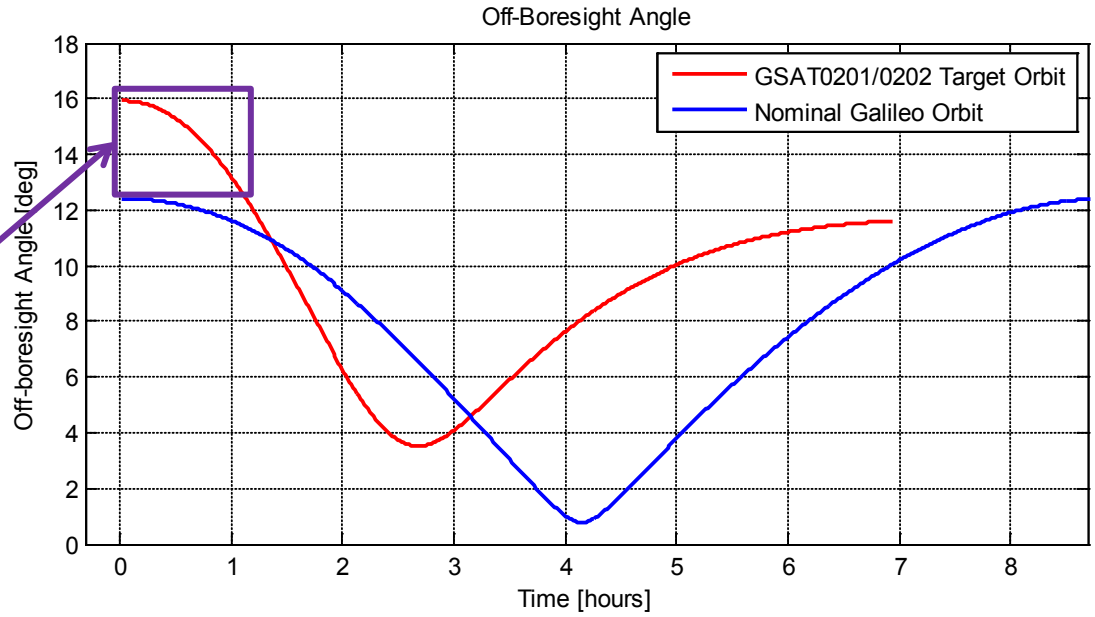
- Plans are existing to raise orbit, reduce eccentricity and conduct In-Orbit Testing

- Eccentricity and lower SMA provide unique opportunity
  - Characterization of SSV-relevant antenna off-boresight range from ground!

GSAT0201/0202 Orbital Anomaly (2/2)

- Off-boresight angles expected during In-Orbit Testing (IOT) of GSAT0202/0202

SSV-relevant off-boresight angle range that can be characterized on ground for GSAT0201/0202



- Assuming future Galileo satellites in Nominal Orbit with very similar Antenna pattern: Galileo SSV characterisation **up to altitude of 2100 km (LEO)** is supported by ground measurements!

Conclusions and Way Forward

- Importance of an interoperable GNSS SSV is fully recognized
- Characterization of Galileo's contribution to an interoperable GNSS SSV is currently ongoing
- Planned In-Orbit Testing (IOT) of GSAT0201/0202 gives unique opportunity to characterise SSV-relevant antenna off-boresight range from ground
- Results of GSAT0201/0202 need to be awaited before Galileo SSV characteristics are published
- Publication of Galileo SSV characterization for FOC satellites can be expected for Spring 2015

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