TEC SHARING DAYS

GNSS SPACE SERVICE VOLUME (SSV)

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OUTLINE

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INTRODUCTION 1/2

A few years ago

- two **Global Navigation Satellite Systems** (GNSS) fully operational: **GPS** and **GLONASS**.
- GNSS were designed to provide support to users on ground and on Low Earth Orbits (LEO).

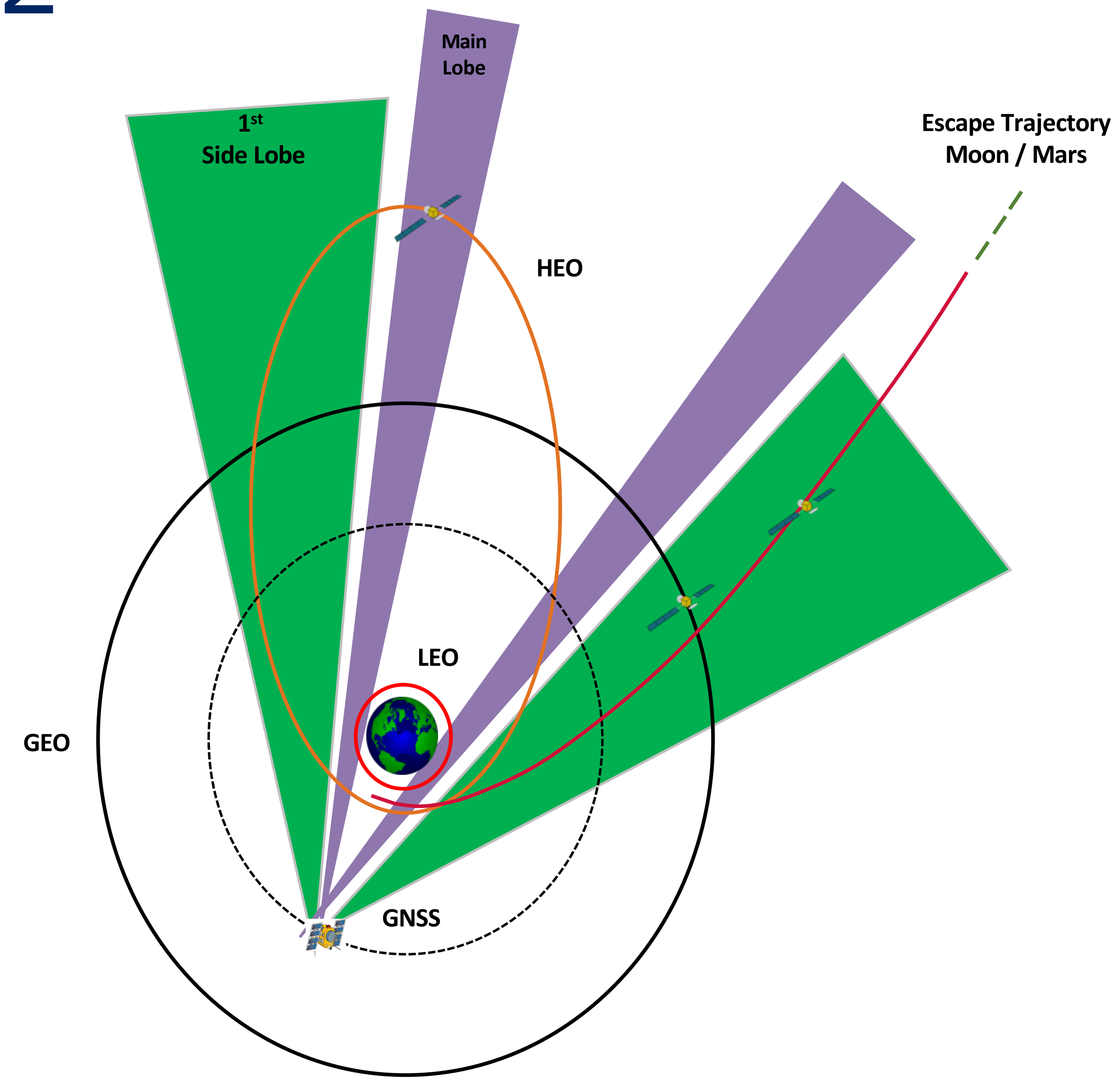
Today

- Currently there are two more global operational systems: Galileo and BeiDou, and two regional systems, the QZSS and IRNSS, with a total of more than 120 GNSS satellites for potential users, each with at least three civil frequencies and more than two types of signals.
- In the frame of the International Committee on GNSS (ICG), in 2014, all GNSS service providers confirmed their commitment to support the so-called Space Service Volume (SSV) extension.
- SSV is the volume of space, from low MEO to GEO, on which GNSS could provide service to future space users.
  This allows exploiting the interoperability among the different GNSS to maximize the satellites in view.
- The GNSS SSV extension will change the entire approach for Precise Orbit Determination (POD) concepts related to LEO, MEO, GTO, GEO and HEO satellite missions, with a significantly increased number of GNSS observations due to the increased number of satellites and signals.
- The GNSS SSV extension will also impact the evolution of the on-board GNSS receiver technology, ground segment designs, space operations and communications.

INTRODUCTION 2/2

Changing GNSS Landscape

GNSS in 2000	GNSS in 2020 +
2 operational Global Systems	4 opearional Global Systems
2 Freq 1 Civil Signal	Multi Freq Multi Civil Signals
0 Regional Systems	2 Regional Systems
60 GNSS Satellites	> 120 GNSS Satellites
Space User: mostly LEO	Space User: From LEO to Moon and beyond
Interoperability - NO	Interoperability – YES



STUDY OBJECTIVES

Analyse the impact of the GNSS SSV extension on	Identify the drivers for
• existing GNSS POD concepts for satellite missions in LEO, MEO, GEO, GTO, and HEO	• potential changes of the on-board technology
• existing GNSS software designs for space users	• potential new POD concepts for satellite missions in LEO, MEO, GEO, GTO, and HEO
• existing operational concepts for space users	• potential new operational concepts for space users that will perform OD, POD based on GNSS and/or users that will have GNSS receivers as an integral part of the AOCS
• ground operations	• communication demands between the ground and the space segment
	• potential changes of ground segment operations

The above objectives should take full advantage of the extension of the GNSS signal availability

STUDY RESULTS

The main outcome of his study was the identification and detailed analysis of the top drivers: these are the elements most impacted by the space service volume extension, that will require further development to achieve the best POD performances in every orbital regimes (from LEO to Moon/Mars Navigation).

1. The development of Artificial Intelligence algorithms for GNSS
2. The availability of public services providing GNSS corrections for space users: Galileo High Accuracy Service (HAS) and TDRSS Augmentation Service for Satellites (TASS)
3. The exploitation of interoperability on GNSS
4. The development of autonomous navigation subsystems based on GNSS
5. The popularization of Chip Scale Atomic Clock (CSAC) in future on-board receivers
6. The requirement to achieve cm level accuracy on-board in LEO or equivalent accuracies in higher orbital regimes
7. The development of Moon/Mars Relays satellites or beacons to extend the GNSS coverage
8. The development of technology based on quantum effects (Interferometers for ranging, Inertial Sensors, Security and Computing)
9. The development of optical Inter-Satellite Links optical clocks for communication, ranging and time-transfer
10. The development of high-sensitivity tracking systems

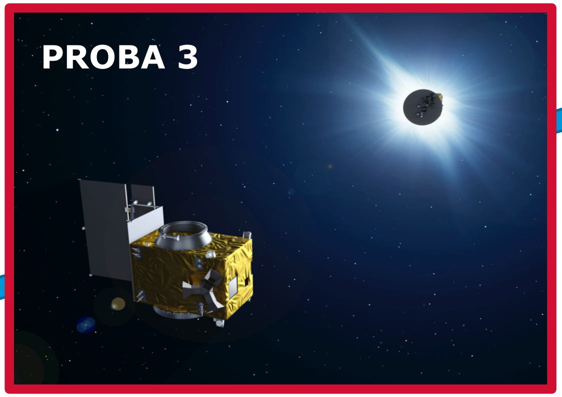
UTILIZATION IN ESA MISSIONS

ISS
GAL/GPS Receiver on-board the ISS
First E5a/L5 only position fix in space

2018 - 2019

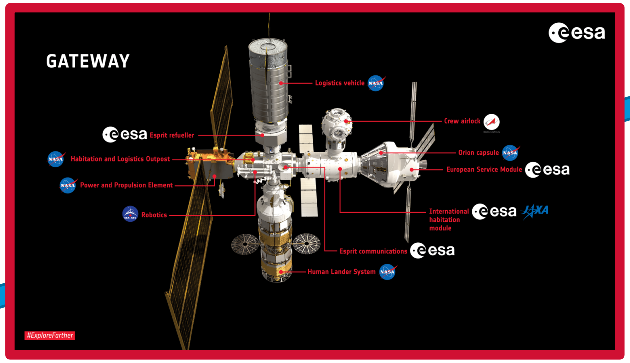
Sentinel – 6
Precise Orbit Determination based on dual freq. GAL/GPS Receiver

2020



PROBA - 3
absolute and relative Precise Orbit Determination based on dual freq. GAL/GPS Receiver

2023



GATEWAY
On-board navigation and Precise Orbit Determination based on GAL/GPS Receiver

GNSS as an integral future infrastructure element for Space missions to Moon and Mars

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