GENESIS
Stakeholder Workshop
20 March 2018, DG GROW, Brussels

Report

A report for the European Commission by:

space·tec PARTNERS

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1. INTRODUCTION

1.1 Context and background

The European Commission has set-up a process for the definition of Galileo Second Generation (G2G) with the objective of expanding the number of services offered as well as enhancing those already provided.

Within this context, a Galileo Space Service has been identified as one of the most promising for implementation in G2G. The goal of the Service is to ensure that the Positioning, Navigation and Timing features provided by Galileo are suitable for space applications. This should foster the uptake of Galileo within the Space User community and increase the share of European receivers manufactures in this growing market sector.

Examples of main GNSS Space applications include:

- Precise Orbit Determination (POD)
- POD for Formation Flying (FF)
- POD for Rendezvous and docking (RD)
- GEO Station Keeping (GS)
- Launcher Trajectory monitoring (LT)

In order to properly define the Galileo Space Service, the European Commission launched a dedicated initiative under the Horizon 2020 Framework Programme for Research and Innovation.

The project, named **GENESIS (GalilEo iNnovativE Space ServIce Solution) "R&D for a Galileo Space Service"**, was awarded to a Consortium led by Thales Alenia Space, with the support of SpaceTec Partners. In order to collect and analyse user needs, a stakeholder consultation process has been designed and put in place, including the following dedicated online surveys:

- For space industry and space agencies: https://www.surveymonkey.com/r/Space_industry
- For GNSS receiver/ user terminal manufacturers: https://www.surveymonkey.de/r/GNSSReceivers

Within this context, a dedicated GENESIS **Stakeholder Workshop for Galileo Space Service Definition** has been held **on 20th March 2018** (9:30 – 17:00 at EC premises in Brussels).

The objective of the GENESIS workshop, to which this document refers to, was to engage with key stakeholders. The workshop agenda is presented in Annex II. The list of workshop attendees is included in Annex I.

1.2 Document scope

This report summarises the main outcomes and takeaways of the GENESIS stakeholder workshop (held at DG GROW on 20 March 2018), taking advantage of the fruitful discussion/exchange between the audience, the EC and the GENESIS team. Links to all presentations are provided in Annex III.

2. KEY OUTCOMES AND TAKEAWAYS FROM THE WORKSHOP

2.1 User needs driving the Mission Level requirements

The central role of the user needs as a fundamental first step in support to the design of the Galileo Space Service was presented by EC and acknowledged by the meeting attendees. Within the GENESIS context, the user needs gathered will drive the Mission Level requirements definition. It is therefore essential to validate the needs with key stakeholders to the best extent possible.

In this respect, the main message from the representatives from the user community was the importance of having commitments from the GNSS providers in terms of PNT performance in the regions of interest for the main applications.

In terms of applications, the analysis should be mainly driven by LEO, MEO, HEO, and GEO requirements, while requirements for interplanetary missions (including Cis-lunar ones) have a second priority.

2.2 The importance of long-term commitments

The user community (e.g. Satellite Operators) considers the **long-term service commitment**, as the most important requirement. In this respect, the suggestion is for the GNSS providers to declare commitments towards the Space users with a validity that is sufficient to cover the future missions (from mission conception, e.g. next 20+ years).

2.3 Antenna pattern characterisation

Aside from the commitments in terms of Service performance, users are eager to have **access to Galileo satellites' full antenna pattern characterisation**.

It was clearly indicated that this information is useful in any case, regardless of the PNT service commitments, and it can be applied in many analyses as soon as it is available. This would also give an advantage for the use of Galileo.

2.4 GNSS interoperability

The UN ICG-WG-B has been conducting activities to show the added value of an interoperable multi GNSS Space Service Volume (SSV). A UN ICG-WG-B SSV Booklet is being prepared for publication by mid-2018. An overview debrief of the booklet was provided by ESA, where analyses are performed by taking into account information provided by the individual GNSS constellations.

2.5 The cost in relation to the adoption of GNSS SSV solutions

For some key players, the total cost, including impacts on operations, of embarking a GNSS receiver compared to legacy solutions is the fundamental key driving requirement to switch from current solutions.

2.6 The user receivers

User receivers play a pivotal role since, together with the user requirements linked to the different applications, they drive the mission requirements.

The logic should be as follows:

- Each application is linked to specific user requirements
- Fulfilment of user requirements needs to consider specific receiver requirements/reference performance, involving hardware performances (sensitivity, etc.) and interface

As a consequence, the mission requirements satisfying specific user requirements have to be linked and traced to specific requirements/reference performance on the receiver side. This ensures robust and trustable results.

Discussion on user receivers' sensitivity and GNSS signals availability

The performance of a spaceborne GNSS receiver is typically a balanced mix of Hardware and Software implementation: both concur in defining the final PVT performance for the user and mission needs.

With regard to the Hardware implementations, the GNSS signals "availability" at the level of the receiver depends on:

- GNSS antenna types (as well as their position on the satellite);
- The GNSS sub-system design (including cable length and the various elements specifications)
- Receiver Acquisition threshold

Also, the mission impacts the overall GNSS satellites visibility.

A conservative assumption for the acquisition threshold is 20 dB-Hz (see ICG-WG-B presentation in Annex III). Values close to 15 dB-Hz can still be considered as realistic.

2.7 Specific uses of GNSS information on-board missions

In the general context of on-board use of GNSS, different implementation levels of GNSS information (i.e. positioning, ranging, timing) lead to different architecture: for example, the use of GNSS PVT information as primary source for AOCS subsystem or the fusion among other sensors information may require different receiver interfaces, and eventually different design.

2.8 Use of GNSS for Timing consistency at Global scale

The global time scale, Coordinated Universal Time (UTC), provides the underlying common reference.

Today each GNSS has its own System Time and each individual GNSS System Time is linked to Coordinated Universal Time (UTC). To generate a multi-constellation PVT it is mandatory to obtain the relative time offsets between the GNSS. GNSS time offsets are provided as relative offsets between GNSS (e.g. Galileo GPS Time Offset - GGTO). To calculate PVT, the receiver time is referred to a time realisation of a single GNSS time.

On the other hand, at ICG the concept of a unique GNSS time, to be called “Multi GNSS Ensemble Time (MGET)”, or GNSS Time Coordinated (GTC) has been introduced. Different approaches are under discussion at ICG-WG level. Significant challenges have to be overcome. Nevertheless, GNSS can potentially be used to ensure timing consistency at Global scale, i.e. a Global real-time timescale.

The performance requirements in terms of timing accuracy for space users call for a sub-microsecond down to few hundred nanoseconds accuracy.

2.9 Consolidated user requirements to date

The GENESIS team gathered user requirements based on literature review, direct user consultation (e.g. web survey and interviews). Users were requested to provide information about their required:

- Application and orbit (e.g. Real-Time POD for Formation Flying in LEO)
- PVT requirements
- % of non-availability of the service

Moreover, relevance was given to upcoming and/or planned missions with respect to past ones, since those better reflect user requirements which would be applicable also in the timeframe of G2G.

Amongst the requirements presented during the workshop, the participants expressed positive feedback for the following:

- Real-Time POD in LEO
    - Position accuracy: 1 m or better (3 sigma)
    - Velocity accuracy: 1 cm/s 3D RMS or better
    - Timing accuracy: 50 ns RMS or better
- GEO Station Keeping
    - Position accuracy: 30 m (3 sigma)
    - Velocity accuracy: 1 cm/s 3D RMS or better
    - Timing accuracy: 750 ns or better

For what concerns all other requirements gathered, a consolidation process is currently on-going and will be completed within the context of the GENESIS project.

2.10 Overall conclusions

Key takeaways of the stakeholder workshop include the following:

- A potential Galileo Space Service is seen as very useful by the community and would be a differentiator for Galileo.
- As part of the Space Service, Long term service commitments up to GEO orbits would be needed.
- The Galileo service evolution for the Space Service will be driven by the user needs
- Space users stressed the need to have specific commitments from GNSS providers in the Space Service Volume. Those commitments should be long term (e.g. 20+ years), covering
    - Availability and performance continuity
    - Power level and Accuracy
- Availability/Continuity may be fulfilled either through Galileo only or by means of multi-GNSS.

- Irrespective of the definition of a Space Service, users are demanding the information on the antenna patterns of the Galileo satellites (and all satellites), possibly covering all azimuth and off-boresight angles with a resolution TBD. Publishing the data would provide an advantage for the use of Galileo.

Overall, the Workshop confirmed that **a Galileo Space Service is seen as very useful by the community and would be a differentiator for Galileo. Long-term service commitments up to GEO orbits would be needed**.

ANNEX I: LIST OF WORKSHOP ATTENDEES

The following table contains the list of meeting attendees.

Table 1: List of attendees

Surname	Name	Affiliation	Role
Biard	Arnaud	National Centre for Space Studies (CNES)	Head of "Innovation Projects"
Boyero	Juan-Pablo	EC / DG GROW	Policy Officer Galileo and EGNOS
Delpuech	Jean-Paul	ArianeSpace	Head of Software and Missions department
Enderle	Werner	European Space Agency (ESA)	Head of Navigation Support Office
Fenech	Hector	Eutelsat	Director Future Satellite Systems
Fernández	Jaime	GMV	Head of the Galileo Operational Systems Division
Filotico	Carla	SpaceTec Partners	Partner
Giordano	Pietro	European Space Agency (ESA)	Radio Navigation Engineer
Guyader	Eric	EC / DG GROW	Policy Officer Galileo and EGNOS
Lequeux	Gilles	EC / DG GROW	Policy Officer Galileo and EGNOS
Mittnacht	Michael	Airbus Defence and Space	GNSS receiver technology
Monsky[1]	Anneke	OHB	Engineer

[1] Attended remotely

Ostolaza	Javier	GSA	EGNOS Exploitation - User Segment Engineer
Paggi	Francesco	Thales Alenia Space Italy (TAS-I)	GNSS System Engineer
Paonni	Matteo	EC / DG JRC	Scientific/Technical Project Officer
Perez-Carro	Andrea Julia	Centre for the Development of Industrial Technology (CDTI)	Spanish Delegate at ESA for CDTI
Pica	Udrivolf	SpaceTec Partners	Senior Consultant
Reichinger	Heinz	RUAG Space	Engineering and GNSS Product Manager
Sgammini	Matteo	EC / DG JRC	Scientific/Technical Project Officer
Silva	Pedro	DEIMOS Engenharia	Head of GNSS and Flight Systems dynamics
Treier[1]	Tiiu	Estonian Space Office	Project Manager
Unwin[1]	Martin	SSTL	Head of the GNSS team
Valdes Solorzano	Omar Ignacio	GSA	Project Officer
Zin	Alberto	Thales Alenia Space Italy (TAS-I)	TAS-I GNSS Space Receiver Product Line Focal Point

ANNEX II: WORKSHOP AGENDA

Table 2: Workshop agenda

Time	Topic	Whom
9:00 – 9:25	Registration	All participants
9:25 – 9:30	Welcome and agenda presentation	SpaceTec Partners
9:30 – 9:45	EC Introduction: G2G and H2020 context	EC GROW/JRC
9:45 – 10:00	GENESIS Project Overview	JRC/ Thales Alenia Space
10:00-10:30	Interoperable GNSS Space Service Volume activity in the context of UN ICG	ESA
10:30-11:00	Galileo Space Service Market perspective	GSA
	Consultation Results and Discussion	
11:00-12:00	Presentation of Galileo Space Service user requirements - introduction	Facilitated Discussion by SpaceTec Partners
12:00-13:00	Lunch break	All
13:00-14:00	Presentation of Galileo Space Service user requirements – LEO missions	Facilitated Discussion by SpaceTec Partners
14:00-14:45	Presentation of Galileo Space Service user requirements – GEO/HEO/MEO missions	Facilitated Discussion by SpaceTec Partners
14:45-15:15	Coffee break	
15:15-15:45	Presentation of Galileo Space Service user requirements –Interplanetary missions	Facilitated Discussion by SpaceTec Partners
15:45-16:45	User terminal needs	Facilitated Discussion by SpaceTec Partners
16:45-17:15	Conclusions and Wrap-up	JRC and Thales Alenia Space

ANNEX III: LINKS TO DOWNLOAD THE PRESENTATIONS

Please find here the links to download the workshop presentations:

1 Introduction by the European Commission

2 GENESIS project overview by TAS-I

3 ICG WG-B on Interoperable GNSS SSV by ESA

4 Receiver user requirements by DEIMOS Engenharia

5 The GENESIS User Requirements collection process and analysis

6 Galileo Space Service market perspective