USER CONSULTATION PLATFORM 2020

MINUTES OF MEETING OF THE *SPACE USERS* PANEL

Meeting Date	02.12.2020	**Time**	14:00-18:00
Meeting Called By	GSA	**Location**	Online event
Minutes Taken By	Eliott Moreau (FDC)	**Next Meeting Date**	UCP 2022
Attendees	**Juan Pablo Boyero** (European Commission), **Speaker** **Prof. Dr. Werner Enderle** (European Space Agency), **Speaker** **Samuele Fantinato** (Qascom), **Speaker** **Omar Valdés** (GSA), **Panel moderator** **Eliott Moreau** (FDC), **Panel coordinator** **User Community Representatives**[1] Heinz Reichinger (RUAG), **Panel representative to the plenary** Georges Bernede (ATOCA Consulting SAS) Samuele Fantinato (Qascom) José Fernandes Vasconcelos (Deimos Engenharia) Achillia Giasmin Machfount Georgakopoulou (CGS) Livio Marradi (Thales Alenia Space Italia) Matthias Overbeck (Fraunhofer IIS) Hilmar Pirker (RUAG) Ignacio Viñuela Rodríguez (FH Aachen, University of Applied Sciences) Artur Wieczynski (Łukasiewicz Research Network) Alberto ZIN (Thales Alenia Space) Total audience: 76 attendants		
Distribution (in addition to attendees)	UCP Plenary, GSA, Public		

Agenda Items	**Presenter**
Opening: an overview of the market segment and applications	**Omar Valdés** (GSA)
Discussion: Space Segment User Needs & Requirements - *including specific intervention on Launchers applications by Elisabeth Raynaud (Ariane Group)*	**Omar Valdés** (GSA)
Q&A Session	**Omar Valdés** (GSA)
Galileo OS-NMA	**Jean-Pierre Barboux** (GSA)
Galileo HAS	**Omar Valdés** (GSA)
EGNSS Research & Development	**Omar Valdés** (GSA)
The Galileo SSV Service	**Juan Pablo Boyero** (EC)

[1] User Community Representatives who gave their agreement for their names to appear in this publicly available document

"*The Interoperable Global Navigation Satellite Systems Space Service Volume Booklet*" - Preparation of the next issue, to be published by the United Nations Office for Outer Space Affairs	**Prof. Dr. Werner Enderle** (ESA)
R&D projects' pitch: ENSPACE	**Samuele Fantinato** (Qascom)

Summary

A quick poll carried-out at the beginning of the session provided the following apportionment across the value chain and applications (16 votes):

- Spacecraft integrators (6%)
- Spaceborne GNSS receivers' manufacturers (31%)
- Launchers operators (6%)
- Scientific & EO applications (6%)
- Institutional (31%)
- Other (19%)

The functional and performance requirements discussed during this session were documented through the application-based segmentation proposed below. Note that as this session was the first ever edition of the *Space Users* UCP forum, the requirements discussed were not taken from an existing "*Report on User Requirements (RUR)*".

- Precise Orbit Determination (POD)
  - Precise Orbit Determination - LEO
  - Precise Orbit Determination - CubeSats
  - Precise Orbit Determination - GTO
  - Precise Orbit Determination - HEO
- Formation Flying
- Rendezvous and Docking
- GEO Station Keeping
- Radio Occultation
- Reflectometry/scatterometry
- Timing
- Launchers
- Attitude determination
- Transversal (covering more than one application domain)

The segmentation was not challenged; it was therefore considered as **adopted** with the addition of the following applications:

- Space Situational Awareness
- Space debris removal
- Lunar and Cislunar applications

The latter were mentioned as applications to consider, not only from a requirements point of view, but also as an R&D topic. Such missions also drive the definition of an extended **interoperable Space Service Volume (SSV)**, which should cover space activities from LEO to cislunar trajectories.

Broadly speaking in terms of performances requirements, the discussion on 3D positioning accuracy allowed to agree on the fact that **3.5 meters, 3-sigma** could be considered as a key requirement as it covers most of the applications considered in as many categories of spacecraft as possible.

Security related aspects were also discussed at different occasions, starting with its criticality for launchers applications and GNSS-based operations in LEO.

Minutes of Meeting

Election of the users' representative for the Plenary
Heinz Reichinger (GNSS product manager for RUAG in Vienna) volunteered and was sustained as representative for the Plenary session.

General discussion notes

Market Overview
Key market trends were first provided by the GSA, highlighting the extending range of space users and the fact that space activities are becoming increasingly commercial, which is both a driver and consequence of a faster, cheaper and easier access to space. The increasing development of mega constellations and its impact on the total number of satellites orbiting the Earth (in particular on the Low Earth Orbit) were mentioned. This evolving market pushes many stakeholders to find smaller, lighter and lower-cost technological solutions, significantly increasing the interest for spaceborne GNSS receivers.
The main benefits of the use of spaceborne GNSS receivers were identified as potential savings on mission costs, improved navigation performances, new mission's opportunities and the possible increase of satellites on the valuable GEO belt.
As a prerequisite to the requirements-related discussion, Galileo differentiators were reminded (i.e., authentication, multi-constellation capability, innovative modulation characteristics, high accuracy, multi-frequency).

Segmentation
The segmentation to be used to characterize the space users' market was initially discussed. A first segmentation was proposed by the GSA, based on a mix of 3 possible approaches (per applications, per orbit, per spacecraft category) and reflecting the user requirements to be discussed (taken from the EC GENESIS Project outcomes).

The audience was invited to comment the proposed segmentation and was asked whether some applications should be added to this initial segmentation. The segmentation was not challenged. It was therefore considered as adopted. Several participants also stressed-out the need to include lunar and cis-lunar missions to the analysis, as well as space situational awareness activities (in particular space debris removal). Altimetry and GNSS scatterometry were also listed.

Launchers
The case of launchers was discussed specifically, in particular thanks to the intervention of **Elisabeth Raynaud (Ariane Group)**. It was highlighted that all major launchers operators claim the use of GNSS in their user manuals with the notable exception of the European family (Ariane 5, 6 and Vega). It was explained that this is because GNSS does not satisfy enough performance requirements and the availability of well-established legacy solutions.
Three possible applications were discussed:

- **(i)** Get an in-flight localisation for safety purposes: GNSS allows to obtain a positioning independently from the on-board navigation unit, providing an independent verification method (the launcher must be destroyed if there is an anomaly in the trajectory). This is under implementation for Ariane 5 and will be used for Ariane 6.
- **(ii)** De-orbitation (especially for upper stages of the launchers so they do not pollute Earth

orbits). GNSS is particularly interesting in this case because a precise position is required after a very long time in orbit (not always possible with other systems).

(iii) The navigation of the launcher during trajectory does not use GNSS today. The return of investment was not interesting for Ariane 6. It's not linked to the receiver performances but rather to their cost.

Security-related requirements were also addressed. The need for reliability at every calculation step was stressed-out. Launchers have real-time requirements that do not apply to satellites. The receiver must also be fault-tolerant (failure rate extremely low) in all atmospheric conditions and different flight conditions. Some phases of the launch being very dynamic (e.g., lift off, stages separation that generate a lot of plasma around the vehicle) can have an impact on the GNSS signal. Finally, the signal must be secure (not jammed, not spoofed).
The 3D positioning accuracy requirements presented with regards to Launchers were validated.

Refinement of existing functional requirements
4 functional requirements were discussed.

- PNT system shall use **multi-frequency.**

The need for multi-frequency was initially expressed for: POD, Formation Flying, Rendezvous & Docking, Radio Occultation and Reflectometry.
The panel demonstrated its desire to also link this requirement to the following applications: GEO Station Keeping, Timing, Launchers, Attitude Determination, Space Debris Removal, GNSS Altimetry. **For GEO Station Keeping, though, it was recommended to conduct a study about the gains obtained by multi-frequency at this orbit.**
One participant also highlighted the importance of multi-frequency for secure military activities.

- PNT system shall provide **access to UTC.**

The need for an access to UTC was initially expressed only for Timing applications.
The panel demonstrated its desire to also link this requirement to the following applications: GEO Station Keeping, Timing, Launchers, as well as (future) LEO PNT systems.

- PNT system shall provide **precise ephemeris in real-time.**

The need for precise ephemeris in real-time was initially expressed for POD on LEO as well as for Rendezvous & Docking.
The panel demonstrated its desire to also link this requirement to the following applications: GEO Station keeping, Timing, Launchers and Attitude Determination.

- PNT system shall provide **precise clock products in real-time.**

The need for precise clock products in real-time was initially expressed only for Rendezvous & Docking.
The panel demonstrated its desire to also link this requirement to the following applications: Timing, Launchers, Attitude Determination, as well as GNSS Altimetry.

Attention needs to be paid to the definition of "real time." **From the point of view of a general delivery of information to the user 1-10s is a good interval.** However, there is a strong dependency on the applications. For example, for rendezvous or launchers 10s might be too long; **for GEO station keeping even 30/60s would be ok, whereas for real-time for safety-related aspects it has to be "strict" real time, i.e., in the order of 1 s.**
New functional requirements

The panel was solicited to express additional functional requirements, in particular with regard to security and integrity. The following needs were expressed: Reliability, Authentication, Anti-jamming and Anti-spoofing receivers, Security and Robustness both to failure and spoofing (in particular for launchers – in line with earlier Elisabeth Raynaud presentation), Data on Tx antenna patterns, Fail-safe designs (high dependability and internal auto-validation), Wide Space Service Volume.

Refinement of existing **3D positioning** accuracy requirements

14 requirements were presented to the panel in terms of 3D positioning, ranging from 150m to 10cm, for 8 different applications (listed from the less stringent to the most stringent - POD on GTO, POD on HEO, Launchers, GEO Station Keeping, POD on LEO, POD CubeSats, Formation Flying, Radio Occultation). 10 of these 14 requirements would be covered by an accuracy of **3.5 meters, 3-sigma** (therefore identified as the key 3D positioning requirement for Space Users), while the 4 more stringent requirements are for a 60 cm or below.

A member of the panel expressed an additional requirement of 100m for manoeuvre planning (also covered by the 3.5 meters key requirement).

Although not quantified, other applications were mentioned as requiring relatively stringent 3D positioning, namely: Launchers Re-entry, Landing Capabilities (e.g. Space X), Rendezvous with uncooperative target (e.g. space debris capture), Collision Avoidance.

Refinement of existing **3D velocity** accuracy requirements

6 requirements were presented to the audience, ranging from 0.2 m/s to 1 mm/s, for 6 different applications (listed from the less stringent to the most stringent – Launchers, POD on HEO, POD for CubeSats, GEO Station Keeping, Formation Flying, POD LEO).

A participant stressed that for GNSS altimetry, the vertical component is more critical than the lateral one.

Refinement of existing **Timing** requirements

5 requirements were presented to the audience, ranging from 750 ns to 50 ns, for 5 different applications (listed from the less stringent to the most stringent – GEO Station Keeping, Time-Stamping, Formation Flying, POD on LEO, POD for CubeSats). It was noted that expect for the last one (POD for CubeSats), all of these requirements are already covered by Galileo (30 ns).

One participant asked whether the expressed figures were taking into account relativity effect when occultation by the Earth occurs (in particular for radio occultation). GSA answered that normally, time requirement figures do take into account relativity effects (although it is to be confirmed whether it requires some specific parametrisation of the receivers). The timing requirements figures should be explained further in the upcoming RUR document.

Q&A session

Panel question – @Elisabeth Raynaud: *Is there a signal generator scenario available, which you could provide, for your harsh acceleration requirements to test if the own receiver could track the satellites continuously?*

Answer – Yes, we could provide kind of a typical speed and acceleration profile of the vehicle over the time to see the changes.

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Galileo OS-NMA

Galileo's OS Navigation Message Authentication (OS-NMA) service was introduced by guest speaker Jean-Pierre Barboux, consultant at the GSA. The role of authentication and its main principles was reminded. Galileo OS-NMA characteristics were presented to the panel as well as its development roadmap.
In the context of Space Users activities, the panel was asked what would be the most appropriate performance parameters to define authentication (e.g., update rate, availability, location, etc.). Participants raised the following points: latency availability, update rate (in particular due to high dynamics), TTA. The audience was asked to provide any inputs to these questions to ucp@gsa.europa.eu following the meeting.

Panel question – *Is there a website where schedules of introduction of new services?*

→ Answer: The authoritative site when it comes to Galileo is the European GNSS Service Centre: www.gsc-europa.eu. If the information you are looking for is not available there, you may open a ticket with the helpdesk and they will investigate it.

Panel question – *Wouldn't be the Galileo Commercial Authentication Service (CAS) the right authentication service for higher dynamics space applications instead of OSNMA? Or would the key to CAS be the problem?*

→ Answer: CAS is real time, OS-NMA has a latency and a limited update rate. However, CAS is authenticating ranges only, and we still need the Clock and Ephemeris Data (CED). OS-NMA has indeed limitations, but as you know, the CED info is valid for approximately 4 hours. So, the conops might be to authenticate them only when the TOE changes. Regarding CAS, it is based on spreading code encryption, i.e. symmetric keys (secret key in the receiver) so the receiver has to be tamperproof. To overcome this problem, the European Commission is proposing an "assisted CAS" conops, introducing asymmetry but relying on OSNMA.

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Galileo HAS

A few slides were dedicated to the presentation of the Galileo High Accuracy service (HAS), in particular its main characteristics, its 3-phase development roadmap and its interest for Space Users (e.g., for POD, Attitude Determination, Launchers).
Participants were invited to answer a survey on different HAS-related topics (i.e., target applications, performances, dissemination channels, support Functions, barriers and incentives).
Link to the survey: https://ec.europa.eu/eusurvey/runner/HAS_SurveyUCP2020.

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EGNSS Research & Development

GSA manages the R&D funds of the EU for downstream applications. The importance of the opinion of potential users of those funding schemes for the definition of EGNSS downstream funding priorities was stressed, and an invitation was launched to answer a survey on the topic (link to the survey: https://www.gsa.europa.eu/european-gnss-downstream-research-innovation-priorities-and-consultation-results-0). In addition, a few questions were addressed live during the session.

Question 1: *What are the emerging EGNSS applications that are using synergies with Earth Observation (e.g. altimetry already mentioned a lot during the session, reflectometry)?*

The only answer provided was: Disaster Management.

Question 2: *What financing tools could be used to support further market uptake of applications in your market segment? (e.g. Grants, Innovation procurement, acceleration, help to move projects into production)*

Participants agreed to answer that innovation is really important and that procurement, grants and any innovation projects funding are essential. One participant also stressed the importance of venture capitals as well as the availability of testing facilities (usually very expensive for space applications) that can be real enablers. Joint tenders with other Space Agency (e.g., ESA) was also identified as a good way to foster innovation.

Question 3: *What large implementation projects are emerging in your market segment?*

The three key mentioned areas were: mega constellations, cis-lunar missions as well as space debris clean-up operations. Contribution to mathematical background for coronavirus research was also mentioned.

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The Galileo SSV Service

Juan Pablo Boyero Garrido delivered a presentation on the Future Galileo Space Service Volume, providing insights on the context (in particular GPS SSV and work of the ICG), the definition and the validation of a Galileo SSV. Due to the growing interest for GNSS amongst space users and the rapid development of spaceborne GNSS receivers, the Galileo programme put in place in 2015 the process to move towards G2G, including the definition of a Galileo SSV (project published by the EC in 2016 – H2020 «Innovative Mission Concepts: R&D for a Galileo Space Service»).
The future Galileo SSV is defined as three volumes, in which commitments have been defined: Lower SSV (up to 5000km – user needs should be fulfilled with Galileo alone), Intermediate SSV (up to 8000km – commitment in terms of visibility of minimum 4 Galileo satellites), Upper SSV (up to 36000 km – commitment in terms of visibility of minimum 4 GNSS satellites, incl. at least 1 Galileo satellite). Can take benefit that Galileo orbits are higher than GPS, increasing the region of commitment with Galileo alone. The H2020 IOD/IOV mission was also presented. Expected to start in 2022, it will embark a Galileo space receiver, processed on the ground by the JRC in Ispra, with the objective to validate the Galileo SSV.

Panel question: *What is the status of the IOD/IOV mission? Are providers present at this forum still on time to participate in such missions?*

→ Answer: A call for tenders will actually open soon for the Galileo Rx that the mission will embark. The EC is also looking for opportunities to discuss the availability of data (from other missions that will embark Galileo receivers in space) and use it to characterize the Galileo SSV commitments. Participants are invited to contact Werner or Omar in this regard

Panel question: *Is there a link available for further information on the IOD IOV mission?*

→ Answer: So far, the overall IOD/IOV mission has been published through ESA EMITS system. For the Galileo Space Receiver EC will publish the Call for Tenders following the procedure applicable to EC procurements (through the Official Journal).

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"The Interoperable GNSS SSV Booklet" - UNOSSA

Werner Enderle (Head of navigation support office at ESA) delivered a presentation on the upcoming update of the GNSS SSV Booklet to be published by the UNOOSA (initial version of the document available at https://undocs.org/st/space/75). Today, only GPS and Galileo have defined an SSV. The interoperable multi-GNSS SSV offers enormous benefits for space users and can be seen as a real enabler for future advanced missions. Updating the signal availability is already a thing, but it's the navigation performances that would really jump forward. The booklet update (release in 2021) is the core of the 2019-2020 plan, including the different GNSS constellations updates as well as flight experience and Geometric Dilution Indicators. GNSS is expected to become the prime navigation technologies from LEO to Cis-lunar (e.g. a high number of satellites enables real-time PVT for gateway, which is impossible with ground-based orbit determination). The ICG recently adopted a recommendation regarding the expansion of the multi-GNSS SSV for exploration to cislunar space and beyond.

Panel question – *The audience expressed interest on jamming prevention for space users. Has it been discussed on the context of ICG?*

→ Answer: The topic was considered within the ICG subgroup but choice has been explicitly made not to address it because it is a topic discussed in a specific subgroup on signal robustness.

Panel question – *Solution (in terms of security) on the ground applicable in space?*

→ Answer: Really driven by the application itself. For example, launchers (referencing to Elisabeth Raynaud's discussion) are really driven by that, but for specific missions, this level of protection would be very interesting but not needed at the time being.

Panel question – *Given that a receiver has limited resources (channels). For a Cislunar mission would you recommend to exploit Multi-constellation (>2) rather than dual frequency?*

→ Answer: Yes, but it depends on the application and the necessary level of accuracy. The general recommendation is to use multi-GNSS, even for CubeSats or any type of mission because that makes a very robust solution. Preferably with dual-frequency but even with single-frequency it can be sufficient depending on the requirement. Recent example is Sentinel 6, using GPS Galileo dual frequency receiver, which showed really good performances.

Panel question – *How the space weather can affect the observations? Is there any website from which one can get information on space weather effects and how it affects signals inside the Space Service Volume?*

→ Answer: There are different effects affecting the accuracy of the signal, the main one being the ionosphere (up to 1000 km but with a peak at 400 km). So, depending on the flying altitude, the effects are different. The impact of the ionosphere is a very dominant one on the error budget (up to 90%). Considering a very limited multipath, a dual frequency receiver allows to compensate this specific problem with a linear combination (no ionosphere error of first order).
Three sources of data were provided with regards to space weather effects. Archives from ESA, putting also data in on missions and receivers. ESA and IGS provide information on the impact of the ionosphere, as well as prediction on ionospheric effects. EUMETSAT or NOAA also publish certain type of data.

Panel question – *How to be part of the "flight experience" for the 2021 booklet if there is a GPS/GALILEO European receiver in GEO orbit on a commercial mission since July 2020?*

→ Answer: Contact Werner or Omar about it. Would be very interested. In line with the initiative to extend flight experience in the booklet, demonstrating contact with user communities.

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R&D projects' pitch: ENSPACE

Samuele Fantinato, Head of Advanced Navigation at Qascom, delivered a 20 minutes presentation on the ENSPACE (Enhanced Navigation in SPACE) project, launched by GSA end of 2016, part of H2020 program. Main objective is to develop a software suite for GNSS processing in space and to develop a space receiver with a high degree of configurability of GNSS processing, on LEO, GEO and lunar trajectories. ENSPACE receiver now flying on board a CubeSat mission sponsored by NASA. The receiver embeds most of the space GNSS key trends. It also supports a wide range of HW products. Qascom will complement the ENSPACE receiver with new added value functionalities to realize a close-to-market space receiver, aiming for the compatibility with COTS, targeting new applications (i.e. cybersecurity and robust PNT, dual-frequency POD for collision avoidance and station keeping, high dynamics navigation).

Panel question – *Which applications do you think your receiver would be suitable for (e.g. POD, Attitude Determination, Rendezvous, etc.)? In particular, is it suitable for scientific and Earth science application?*

→ Answer: It is a SW-defined receiver, so it can be potentially customized for very different mission needs, based on different types of interfaces, supporting several experiments (including some for scientific purposes). The use of this receiver for altimetry purposes was not foreseen, however, thanks to the receiver SW architecture, this could be introduced as SW user defined application plug-in.

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GAMMA Project

The GAMMA (GAlileo-based Multifrequency Multipurpose Antenna) project was rapidly presented and the participants were invited to answer a related survey. Link to the survey: https://ec.europa.eu/eusurvey/runner/GAMMA-Project#page0 •

Conclusions
The first edition of the *Space Users* UCP session is successfully closed by the GSA. Key results of this working session were highlighted during the plenary UCP session on December 7th, 2020 by Heinz Reichinger (RUAG).

Other Notes & Information
With the contribution of: Speakers European Commission, esa (European Space Agency / Agence spatiale européenne), Qascom (Trust is Nice, Control is Better.), arianeGroup Minutes Reviewers deimos (elecnor group), Łukasiewicz PIAP, Together ahead. RUAG, ThalesAlenia Space (a Thales / Leonardo company)

Annexes & Attachments
UCP2020_SpaceUsers_Moderator_Presentation_Omar-Valdes
UCP2020_SpaceUsers_EC_FutureGalileoSSV_JuanPablo-Boyero
UCP2020_SpaceUsers_ESA_ICG-GNSS-SSV_Werner-Enderle
UCP2020_SpaceUsers_Qascom_ENSPACE_Samuele-Fantinato

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