SPACE USERS MARKET SEGMENT UCP 2023

Meeting Date	07.11.2023	**Time**	[10:00 – 15:00]
Meeting Called By	EUSPA	**Location**	Seville, Spain (hybrid event)
Minutes Taken By	Víctor Álvarez, FDC	**Next Meeting Date**	N/A
Attendees	**Giovanni Luchi, EUSPA, Session moderator** **Víctor Álvarez, FDC, Panel coordinator** **Presenters:** Ignacio Alcantarilla, Head of Sector Galileo and EGNOS Services and Evolutions European Commission Diego Escobar, Technical Director of SST & STM, GMV **User Community Representatives (UCRs):** • Jaume Sanpera, Chief Executive Officer, Sateliot • Charles Law, Director Flight Dynamics, SES • Samuele Fantinato, Head of Advanced Navigation Unit, Qascom • Francisco Sancho, Precise Orbit Determination and Flight Dynamics Engineer, EUMETSAT • Monika Adamczyk, Cybersecurity Expert, ENISA • Monica Diez Garcia, Head of Products and Services, Geosat		
Distribution (in addition to attendees)	UCP plenary, EUSPA, Public		

1 AGENDA ITEMS

Agenda Items	**Presenter**
1. Welcome and Introduction to the Space session	Giovanni Lucchi, EUSPA
2. EU Space Programme Components current state and future services for users	Ignacio Alcantarilla, European Commission
3. The new standard IoT satellite constellations and the role of the GNSS	Jaume Sanpera, Sateliot
4. Using GNSS for orbit determination in the O3b Medium Earth Orbit, Geostationary Orbit and during Electric Orbit Raising	Charles Law, SES
5. Future Navigation applications for Lunar missions	Samuele Fantinato, Qascom
6. GNSS for low Earth orbiting satellites: precise orbit determination and radio occultation at EUMETSAT	Francisco Sancho, EUMETSAT
7. Morning Conclusions	Giovanni Lucchi, EUSPA

8. Cybersecurity Threats in Satellite Systems	Monika Adamczyk, ENISA
9. GNSS and EO Synergies: a practical approach from GEOSAT	Monica Diez Garcia, Geosat
10. Enhanced SST Applications for Space Users through Synergies with GNSS services	Diego Escobar, GMV

The Space session of the User Consultation Platform (UCP) 2023 took place on 7th November 2023 as a hybrid event, with in-person venue in Seville, Spain. The panel gathered more than 100 participants physically.

The panellists gave in depth presentations of their applications, how they use GNSS satellite technologies and GNSS space receivers and what their specific needs and requirements are. This broad coverage generated interest from the participants.

2 Minutes of Meeting

Agenda Item 1 – Welcome and Introduction to the Space session. Giovanni Lucchi / EUSPA

Giovanni Lucchi from EUSPA welcomed all participants to the User Consultation Platform (UCP) session.

He provided an overview of all EU Space Program components with an integrated market/user driven approach explaining how the User Consultation Platform is a component of the first pillar, namely Market and User Knowledge, on which the Market Development and Innovation department at EUSPA is based on. Then he explained that the UCP is a process running continuously and that the session is meant to collect and adopt user needs and requirements; relevant for: Earth Observation (EO), Global Navigation Satellite System (GNSS), as well as the other space program components. He remarked as well the introduction of the new Space Programme Components, namely EO, Secure Satcom and SST with respect to the last Space UCP session held in 2020. As he mentioned that due to the ongoing evolution of the market and its user's needs, this event is more focused on presentations of applications preparing the baseline for the development of new ones oriented to benefit from synergetic use of different systems.

The agenda was then presented with a brief introduction to all speakers remarking the need to respect the time constraints due to the packed agenda.

The slides of this agenda item can be found as Attachment 1 in section 5.

Agenda Item 2 – EU Space Programme Components current state and future services for users. Ignacio Alcantarilla / European Commission

Mr Ignacio Alcantarilla, Head of Sector Galileo and EGNOS Services and Evolutions at DG DEFIS, provided an overview of the Space programme components, explaining how these are related to one single regulation (Regulation (EU) 2021/696 of 28 April 2021).

Then he debriefed the audience on the services provided by Copernicus, Galileo, EGNOS and SST programmes.

Mr Alcantarilla started the presentation introducing Copernicus, the Earth Observation (EO) program, indicating that its main three components are the space infrastructure, made up of the six Sentinel constellations, the In Situ sensors on ground to complement the satellites' data, and six services established around related thematic areas: Atmosphere, Marine, Land, Climate Change, Security and Emergency services.

Presenting the Galileo Open Service, he offered some hints on its performances e.g. Galileo ranging accuracy is the best compared to other GNSS constellations and in particular four times better than GPS, due to the very accurate clocks on-board the Galileo satellites and the higher refresh rates from ground. In addition, he mentioned the availability of an improved navigation message since mid-2023, allowing an improvement of Time-To-First-Fix (TTFF) performances.

He informed users that position accuracy commitments (at user level) would be published soon, along with other Minimum Performance Level indicators.

Mr Alcantarilla, referring to the Extended Operations Mode, clarified it will be introduced soon to make the services more resilient in case of issues in the Ground Segment. That means that even in case of non-nominal operational mode, the accuracy of orbits and clocks will be anyhow more stable than what it is available now.

Then, he addressed Galileo differentiator services, namely the Open Service-Navigation Message Authentication (OS-NMA), the High-Accuracy Service (HAS), the Commercial Authentication Service (CAS) and the Emergency Warning (EWSS) Service.

About OSNMA, he explained it is aimed at authenticating the GNSS navigation message and thus to increase the protection of the signal against spoofing, and that Service Declaration is expected in Q1-2024. He announced also that Cryptographic data will be published by end 2023.

About HAS, he remarked it is operational since early 2023, with a committed service coverage which excludes East Asia and the Pacific due to the lack of Galileo Sensor Stations (GSS), where the HAS service is available anyhow.

Then he explained the main architecture of the Search And Rescue (SAR) service, including the Forward Link Service (FLS) and the Return Link Service (RLS). He reported also about how statistics are proving the added value of the RLS where, in case a person is in distress and gets the Acknowledgment, the chances to survive increase.

About the use of the RLS and the FLS, he introduced the future Remote Beacon Activation service, meant mainly for aviation and maritime users.

To conclude on the services provided by Galileo he mentioned that possible synergies are currently under exploration concerning the EU SST component for Collision Avoidance purposes.

Then he addressed EGNOS and its three main services were presented with a specific mention that SoL would also start being used in Rail and Maritime domains in next years.

In that respect, the importance of EGNOS was explained in three different transport domains.

In aviation, the PBN regulation establishes that all Instrument Runway Ends in Europe shall be provided with EGNOS-based instrument approach procedures (i.e. LPV approaches) by January 2024 and that by 2030, PBN (Performance Based Navigation), including LPV approaches, shall become the primary means for navigation and landing down to Category I approaches (other means of navigation could be used in case of contingency situations).

About Maritime, it is foreseen to have an initial service declared by 2024, with end to end solutions using also other EU space programme components and services (HAS, OSNMA and Copernicus).

For Rail, a new EGNOS service facing the challenge of rail safety standards is under preparation and will come after.

After the presentation of EGNOS, he moved to SATCOM mentioning the IRIS² regulation recently introduced where IRIS² is there to provide secured governmental services and commercial services, as satellites will be shared between private and public actors.

As last topic he addressed the EU SST component highlighting the transfer of its front desk to EUSPA starting the 1st of July 2023 and reminding the three main services provided. He took the opportunity to invite the audience at attending the dedicated session to SST in the afternoon, where more information and updates would be provided.

The slides of this agenda item can be found as Attachment 2 in section 5.

Agenda Item 3 – The new standard IoT satellite constellations and the role of the GNSS. Jaume Sanpera / Sateliot

Mr Lucchi briefly introduce Mr Jaume Sanpera, CEO at Sateliot, offering him the stage for presenting.

Mr Sanpera's presentation focused on Sateliot's use case, remarking the problem addressed, namely the lack of commercially viable satellite IoT connectivity, the solution proposed by Sateliot as the first 5G NB-IoT telecom operator from space, and the role GNSS plays within it.

He presented the company's approach to deploy their own constellation in LEO, based on widely recognised telecommunication standards and in a way that their satellites shall be compatible with less expensive IoT user equipment types (i.e. RF Module Costs). To be noted, that the standards-based approach to be used will be the NB-IoT one, designed for massive IOT and very capable of seamless roaming between terrestrial and space infrastructure.

Sateliot's intent is to make available a standards-based, low-cost, global coverage service based on roaming store & forward technology leveraging the benefits of a LEO constellation (e.g. compared to GEO one) for what concerns the visibility of satellites in complex environments with terrain blockage. In that respect, Sateliot does not pretend becoming an operator, but a provider to extend terrestrial networks from telecom operators. To be noted that key technologies have been already validated with operators like Telefonica. This means Sateliot's approach enables seamless end-user experience.

Then Mr. Sanpera explained the GNSS component of their proposed solution and how it helps solving the hereafter mentioned problems. He clarified that the GNSS part is composed by two elements, namely the GNSS receiver on-board the satellite and the GNSS user equipment (UE). The adoption of GNSS helps solving, as first the frequency shifting due to Doppler effects caused by the satellite's high-speed, having this compensated thanks to the GNSS on-board the S/C and the GNSS UE. By the fact, the applicable requirements at S/C level are hereafter reported:

- There shall be access to UTC time, position and velocity with frequencies of 1 Hz and latencies of 0.5 – 0.75 seconds;
- Position Accuracy below 10m
- Velocity Accuracy below 0.03 m/s
- UTC Time Accuracy below 200 ns

As second benefit provided by GNSS, Mr. Sanpera explained how GNSS can help addressing signal coverage gaps for users on ground during the rollout of the constellation/s, during the nominal operation of low-density constellations, or during satellite outages. The problem is inherent to the Non-Terrestrial Networks (NTN) NB-IoT and shall be handled to avoid service degradation and extraneous UE power consumption. Mr Sanpera presented an example based on a 16 satellites constellation, with access duration of less than 100 seconds sometimes, explaining how a coverage prediction based on GNSS positioning (via broadcast ephemeris) allows implementing energy management strategies in the IoT device, extending battery life.

Mr Sanpera concluded the presentation mentioning that Sateliot's patent pending technology ('Roaming store & forward') will allow the company to start providing services with a low-density, 4-satellites, constellation to non-time sensitive applications.

The slides presented by Mr Sanpera item can be found as Attachment 3 in section 5.

Q&A Session – Verbal interventions

No questions were registered.

Validation of requirements *(See draft user requirement tables for GNSS in Attachment 10)* Mr Álvarez from FDC then presented the GNSS Real-Time Navigation requirements for "LEO Telecom Mega-constellations", aiming attendees to comment them. The requirements were validated without comments from the audience.

Agenda Item 4 – Using GNSS for orbit determination in the O3b Medium Earth Orbit, Geostationary Orbit and during Electric Orbit Raising. Charles Law / SES

Mr Lucchi briefly introduced Mr Charles Law, Director Flight Dynamics at SES, offering him the stage for presenting.

Mr Law started the presentation mentioning that SES had been a user of GNSS for over 10 years in their MEO fleet and that, more recently, GNSS was adopted onboard GEO satellites as well. He explained this is due to GNSS provides very good services for fleet management and orbit determination purposes.

He continued the presentation introducing the main services provided by SES, namely Data and Video, to different types of users including governmental ones.

These services are provided via a unique combination of MEO and GEO satellites (SES does not operate LEO satellites). Mr Law remarked how the SES MEO constellation is a differentiator as it helps reducing latency and providing high data throughput. Then he added that next SES MEO's generation (O3b mPOWER) will have SDR payloads, allowing more flexibility in operations and being fully configurable.

Then Mr Law made some considerations about the use of the most modern electric propulsion platforms for GEO satellites, and how these are operated during the Geostationary Transfer Orbit (GTO). He remarked that due to lower thrust capabilities, the duration of the GTO's are extended (sometimes for up to 6 months). This implies that for such a long time it is needed to know with high accuracy the positioning and velocity of the GEO in GTO. GNSS provides that information at a lower cost than in the past and that the dual station tone ranging is not needed anymore.

Mr Law continued the presentation describing the excellent performances achieved with both MEO and GEO remarking that GNSS brings more regular information about the GEO orbit despite it is not always available due to interferences.

Then, he clarified that on ground, the GEO satellite's position is filtered during those gaps as necessary, and he proposed to improve the GNSS coverage toward GEO's.

He finished his presentation declaring GNSS simplifies operations and provide a reduction in TT&C ground infrastructure requirements and operational costs.

The slides presented by Mr Law can be found as Attachment 4 in section 5.

Q&A Session – Verbal interventions

Q: Could you please elaborate a bit more on the number of new satellites you plan to deploy?
A: We currently have 3 GEOs under production and manufacturing. In MEO we have 4 mPOWER satellites in orbit but we have a plan for 13, so there are 9 various phases of manufacturing to complete the constellation, with some indeed to be launched next week. We are also involved in the IRIS^2 consortium.

Q: The velocity performances achieved seem to be very precise. Could you please elaborate on that?
A: Ours is a filtered solution, not necessarily the one measured on-board. We filter out a lot of velocity measurements and the presented one are the remaining measurements we keep.

Q: Related to interference issues, could you please elaborate?
A: There is not much I can say except that it happens. We have had where GNSS receivers could not lock satellites and we are investigating it.

Q: Could please clarify the constellations and frequencies that are used to get the results? Do you investigate different combinations to maximise results?
A: We use Galileo and GPS. We do also use traditional tone ranging, so we have a back-up. During some phases we use both GNSS and tone ranging measurements. But as can be observed from the results, errors are in the similar order of magnitude, so adding tone ranging to the final result is not of much added value.

Q: In selected occasions or periods, do you switch off the GNSS receivers as a means to save some energy?
A: All the satellites have been designed to have the GNSS receiver to be 'ON' continuously, but in Space the environment is harsh so there could be occasions when satellites do not perform as desired and does not have enough power for everything. So there are times when we do it, but then for critical

activities is always on. We start them with enough advance to make sure we will have a good PNT solution when the need comes.

Validation of requirements *(See draft user requirement tables for GNSS in Attachment 10)* Mr Álvarez from FDC then presented the GNSS requirements for "GEO Telecom satellites", aiming attendees to comment them. He highlighted the fact that Mr Law had provided achieved performances rather than requirements, and that for this reason requirements established during UCP 2020 were also shown in the slide. The requirements were validated without comments from the audience.

Agenda Item 5 – Future Navigation applications for Lunar missions. Samuele Fantinato / Qascom
Mr Lucchi introduced Mr Samuele Fantinato, Head of Advanced Navigation Unit at QASCOM, offering him the stage for presenting.

Mr Fantinato started his presentation with an overview of the main updates on Lunar exploration plans, where hundreds of commercial and institutional missions are planned in the next decade. He underlined how the ''Moon Business' is a reality and that within this context there are significant opportunities concerning secure satellite communications and GNSS means. In respect of above-mentioned missions and support systems need he focused on the Lunar Communications and Navigation initiatives under definition by NASA and ESA.

He continued his presentation with a summary of the PNT technologies to be applied in the Lunar scenario, highlighting that Lunar PNT systems and services and GNSS will cooperate for Moon exploration from 2025 onwards. The future applications around the Moon in need of PNT include Early Technology Demonstrators (CubeSats), Lunar Spacecraft, Rovers, Astronauts and Landers.

Mr Fantinato remarked, in the case of landers and astronauts, that it would very complicated for them to only rely, or even use GNSS, because of the need for carrying and pointing an antenna towards the Earth to properly receive GNSS signals. For this reason, these two groups of users will be expected to rely on Lunar Communication and Navigation Systems.

Then, he presented the two main activities carried out by Qascom to develop GNSS receiver technologies for Moon applications: the LuGRE experiment and the GEYSER project.

As first activity, Mr Fantinato commented that the GNSS payload of the LuGRE (Lunar GNSS Receiver Experiment) will be equipped by the Firefly Blue Ghost Mission 1 (BGM1). This payload is an adaptation of Qascom "QN-400" space Software Defined Radio (SDR) receiver, based on Commercial-Of-The-Shelf Electrical, Electronic, and Electromechanical (COTS EEE) hardware. The LuGRE receiver was designed to be upgradeable via uplink commands during flight and to be able to work in two modes: real time and sample capture modes (the latter for scientific experiments on the ground). In addition, he mentioned that during the 1-hour experiments that will be conducted, the spacecraft GNSS antenna will have to be pointed towards Earth with an accuracy of 1deg. He concluded by presenting the performances expected to be achieved, resulting from the simulations. To be noted that, in worst cases and due to the bad geometry of visible satellites for a user located on the Moon's surface, these were above 20 km.

As second activity, he presented the GalilEo cYber SpacE Receiver (GEYSER) project, where Qascom benefited from the lessons learnt gathered during the development of the LuGRE payload. Thanks to the lessons learnt Qascom added cybersecurity features on the receiver. In particular, a key element of the GEYSER receiver is the implementation of OS-NMA, which will help fighting against anti-spoofing attacks. Together with the implementation of anti-jamming techniques and Dual Frequency Precise Orbit Determination (POD), the final outcome of the project will be a GNSS receiver tailored to New Space users. Mr Fantinato then elaborated on the specific evolutions (both hardware and software) that will be incorporated in the GEYSER receivers, initially targeting LEO satellites, to make it suitable for Moon Applications.

He finished his presentation by providing very relevant conclusions on both the GNSS and Lunar PNT requirements applicable for each type of Moon user.

The slides presented by Mr Fantinato can be found as Attachment 5 in section 5.

Q&A Session – Verbal interventions

Q: You presented that there should be a way to provide updated ephemeris to the GNSS receiver. Could you please elaborate more on why it is needed?
A: Getting the navigation message around the Moon is very complicated due to the very low signal-to-noise ratios. So it is fundamental for these missions to receive some assistance from the ground, or via Satcom systems, which will provide updated data from GNSS. This will allow speed up the acquisition process since the receiver will know which satellites are in view, and the computation of the position will be faster.

Validation of requirements *(See draft user requirement tables for GNSS in Attachment 10)* Mr Álvarez from FDC then presented the GNSS requirements for "Lunar Applications". No feedback for such advanced applications was collected from the audience. The requirements were validated without comments from the audience.

Agenda Item 6 – GNSS for low Earth orbiting satellites: precise orbit determination and radio occultation at EUMETSAT. Francisco Sancho / EUMETSAT
Mr Lucchi introduced Mr Francisco Sancho, Engineer at EUMETSAT, offering him the stage for presenting on behalf of EUMETSAT's Radio Occultation (RO) and Precise Orbit Determination (POD) teams.

Mr. Sancho introduced the contents of his presentation together with an overview of EUMETSAT and its role in several and very relevant EO missions in LEO and in GEO. He clarified the subset of satellites corresponding to the so-called "Mandatory Programmes", where all EUMETSAT Member States must participate, these being currently the METEOSAT -9&-10&-11, METOP-B&C and MTG-I1 missions.

He then explained that EUMETSAT makes extensive use of GNSS data in their Radio Occultation (RO) and Altimetry missions. On RO, he firstly explained the concept and what it consists on, mentioning that RO computations and in particular bending angles are made in-house at EUMETSAT. From these bending angles, atmospheric profiles (pressure, temperature, humidity) are obtained to feed numerical weather models. Mr Sancho clarified that to get accurate bending angles and produce accurate profiles, two types of GNSS data are used: GNSS orbits and clocks, obtained from external parties, and LEO satellite orbit and clock, derived from POD performed in house and based on GNSS measurements taken by the on-board receiver.

A similar explanation was provided for Altimetry missions, which use LEO satellites to measure mean sea levels and its evolution over time. These measurements require an accurate knowledge of the satellite's orbit, which is derived from POD performed by external parties and is usually based on GNSS measurements taken by the GNSS receiver on-board the LEO satellite.

He then presented the EUMETSAT missions which make use of GNSS for RO or Altimetry purposes, and carefully indicated where the GNSS antennas and instruments are physically installed for the Metop, Sentinel-3 and Sentinel-6 satellites. Indeed, Mr Sancho explained that Metop started to use GNSS in 2006 and that Sentinel-6 is equipped with separate packages (meaning receiver and antenna) for Altimetry POD and for RO, being the first European-made and the second American-made. According to him, such approach allows conducting comparisons on the quality of all data sets. He finished this part commenting that RO instruments will be installed on-board Metop Second Generation spacecraft, with some others still under discussion.

Mr Sancho then presented the operational needs for GNSS data, starting with RO Near Real Time (NRT) products, which need to be delivered to users within 1 or 2 hours after measurement. Besides introducing the constellations used on-board each mission, he remarked how with next generation LEO satellites more GNSS constellations will be used to take measurements. He explained that RO measurements have a huge impact on numerical weather prediction models and that these models are still far from being saturated with RO measurements data. To increase the number of RO measurements they will try to make use of as many GNSS constellations as possible and increase the amount of data already being bought to commercial providers of RO data.

He then listed the different sources of GNSS orbits and clocks data and provided an overview of applicable requirements to those:

- Accuracy of GNSS orbits: < 2cm, RMS, in any direction
- Accuracy of GNSS clocks: < 0.05ns, 1σ
- Latency: < 5 minutes
- Availability: > 99.5%

He explained that the use of Galileo HAS via NTRIP might be explored in the future and that its availability and accuracy performances would have to be assessed against the abovementioned requirements.

Besides the NRT RO, Mr Sancho mentioned that EUMETSAT also does operational Non-Time Critical (NTC) RO processing, with products delivered 3 or 4 weeks after measurements. This is being done for Sentinel-6, where the NRT RO computations are performed by the US Jet Propulsion Laboratory (JPL) and EUMETSAT is in charge of NTC products. He indicated that accuracy requirements are similar to the NRT ones, except for delivery and latency requirements.

Regarding Altimetry, he explained that NRT, NTC and also Short Time Critical (STC) processing, the latter being 1-2 days delivery time, are also included. GNSS data is also used for the procured external POD service, but is not directly used by EUMETSAT. He then listed the requirements applicable to such procured POD service.

Post-meeting clarification by speaker: Altimetry requirements presented in the slides were not the latest ones. The following are the latest ***position accuracy requirements*** *(radial RMS in all cases):*

- *NRT: < 8cm for Sentinel-3, < 5cm for Sentinel-6.*
- *STC: < 3cm.*
- *NTC: < 2cm.*

To be noted: performances of the external POD service are currently well below these requirements.

Mr Sancho then addressed other, non-operational needs, that EUMETSAT has for GNSS data. He clarified that these correspond to future missions, not yet launched, or to certain types of data processing that are not (yet) part of the current committed operations.

For NRT he presented the needs for Sentinel-6 (currently by JPL) and Commercial RO missions, focusing on their intentions of having data available for all global GNSS constellations (GPS, Galileo, Beidou and GLONASS). He provided a similar overview for STC processing, but in this case he included the needs applicable to the Metop and Metop-SG missions, besides to Sentinel-6.

A particular kind of processing that he mentioned as well was the regular 'reprocessing' of data, meaning that from time to time EUMETSAT also conducts a reprocessing of all historical climate data records, so as to have a consistent set of historical data with the most up to date version of their RO processor. For these, the needs were also expressed in terms of GNSS orbits and clocks for all constellations.

He then explained the needs, again in terms of GNSS orbits and clocks, to conduct offline POD processing for Sentinel-3 and -6 missions, clarifying that this POD is conducted at EUMETSAT only for monitoring purposes and with no offline Altimetry processing. He finished by introducing some thoughts about the use of GNSS data for other future purposes, such as ionosphere and plasmasphere monitoring, the development of Electron Content maps or GNSS Reflectometry missions.

Mr Sancho finished his presentation highlighting the extensive use that EUMETSAT already does of GNSS data, their wish to explore the use of Galileo HAS in the future as an alternative to external service providers (for which addition of the GLONAS and Beidou to Galileo HAS would make it more attractive to EUMETSAT) and suggesting that EUSPA could, in the future, provide a POD service for the EC Copernicus missions.

The slides presented by Mr Sancho can be found as Attachment 6 in section 5.

Q&A Session – Verbal interventions

Q: In your opinion, which advantages or differential aspects, does GNSS-R bring with respect to current Altimetry payloads, such as the SARs on-board Sentinel-3 or -6?
A: For altimetry, right now GNSS-R is not a competitor, especially to measure sea levels. Still, they can be useful for other applications such as sea wave frequencies and heights or cryosphere properties. One advantage of GNSS-R is that you can sense, simultaneously, several measurements from different points on Earth.

Q: You mentioned briefly that perhaps you could create TEC maps with GNSS. Will those maps be 3D (with information on the vertical component), or 2D?
A: Unfortunately, for the time being they will be 2D maps, although high-resolution. The possibility is not closed in any case: EUMETSAT is getting more and more involved in satellite weather activities.

Validation of requirements

(See draft user requirement tables for GNSS in Attachment 10)

Mr Álvarez from FDC then presented the GNSS requirements for "Radio Occultation". No feedback for such advanced applications was collected from the audience.

The requirements were validated without comments from the audience.

Agenda Item 7 – Morning Conclusions. Giovanni Lucchi / EUSPA

Mr Lucchi finished the morning session thanking all attendees for their contributions and presenters for their participation and mentioning that the Minutes of the Meeting would be distributed as soon as possible, with the Report on User Needs and Requirements of Space following later.

Q by EUMETSAT: Several requirements were presented by various speakers during the morning, understanding that this would be inputs to evolve the services provided by Galileo. Since some of these requirements were quite challenging, it looks like there is a gap between what is currently provided and the needs expressed. Therefore, we would like to know which is the implementation plan in terms of dates and technical activities foreseen so as to achieve the requirements, for example for RO or at GEO altitudes. Comments on that would be appreciated.

A by Mr Lucchi: The intention of the UCP is to collect and discuss user requirements, most of them need to go through certain standardisation or regulation processes which take long. The plan, on one side, has to consider EC regulations and expected standardisation processes. And then, depending on the services and in some cases, we are able to have some plans published regularly via official documents.

Today we try to set-up those that are missing, and that is why we are talking about a process. Indeed, we need to reach more users because in the past two years we were also injecting Earth Observation requirements and this year we are also injecting SATCOM. So there are a number of new users potentially with synergies between the systems.

The UCP process has evolved and the number of market segment has dramatically increased, in such a way they are addressed every two years. Finally, keep in mind that plans are presented via official documents.

A by Mr Álvarez: when it comes to performances, the ones expressed today have mostly focussed on accuracy, as it looks like the main request from the community. In this sense, Galileo HAS was also mentioned and we should keep in mind that EUSPA already has a roadmap explaining the foreseen evolutions of this service. New ground infrastructure will be placed and performances should improve accordingly. Then, on the other hand, for the easier use of GNSS in space, efforts are on-going to publish information on the Galileo antenna patterns. EUSPA has escalated this particular request from users since several months ago, and the document where the information will be published is under review.

The Space community should also express their needs in terms of what reporting is expected from EUSPA. For example, EC presented new KPIs to be soon reported for the Galileo Open Service. Today, there is no KPI specifically dedicated to the Space users community. If you have any in mind, please say so and then plans could be set-up.

LUNCH BREAK

Agenda Item 8 – Cybersecurity Threats in Satellite Systems. Monika Adamczyk / ENISA
Mr Lucchi introduced Ms Monika Adamczyk, Cybersecurity Expert at ENISA, offering her the stage for presenting.

She introduced ENISA, the European Union Agency for Cybersecurity, and its mission "*to achieve a high common level of cybersecurity across the Union in cooperation with the wider community*".

She listed various types of satellite-based electronic communications services and indicated that, in this context, cybersecurity refers to the full cycle of the service's delivery, including the supply chain, and not only to the physical satellites themselves. As a first example, she mentioned that when analysing the ground segment, both the control segment and the user segment infrastructures are included and that this must be kept in mind for analysing the threats. As a second example, she reminded that today's digital systems are very complex and often built using COTS HW and SW from 3rd party suppliers, and that therefore the cybersecurity analysis must cover these too, as they are prone to cyberattacks.

She then gave an overview of threats against satellites including both malicious and non–malicious examples, clarifying that these are not always space specific, since threats over terrestrial networks or the supply chain can also translate into attacks against the satellites. She then provided a few examples of known cybersecurity incidents related to satellite systems, including spoofing and jamming ones.

Her final conclusions included a reminder that satellites are today providing global publicly available electronic communications services, often <u>used in critical services</u>. They can be used as <u>dual-use systems</u>, either by design or de facto. She reminded that most known attacks on satellite systems aim to <u>disrupt or deny access</u> to the communications service and that satellite systems are exposed to both <u>"standard" terrestrial and space dedicated threats</u> (against specifics of satellite systems engineering, communications and operations). Despite the fact that, the satellite elements are located <u>thousands of kilometres away</u> from Earth, they are <u>exposed to cyber-attacks</u>, therefore they need adequate cybersecurity protection.

The <u>slides presented by Ms Adamczyk can be found as Attachment 7 in section 5</u>.

Q&A Session – Verbal interventions

In this occasion, it was not possible to address them as the session had run out of time.

Agenda Item 9 – GNSS and EO Synergies: a practical approach from GEOSAT. Monica Diez Garcia / Geosat
Mr Lucchi introduced Ms Monica Diez, Head of Products and Services at GEOSAT, offering her the stage for presenting.

She firstly presented GEOSAT, an SME based in Spain and Portugal dedicated to provide EO info and services tailored to customer needs on a 24/7 basis, with delivery times down to 30min after acquisition. She indicated that such short delivery times are achieved thanks to the availability of Ground Stations located in many places around the world. She pointed out that, indeed, GeoSat is one of the only two providers of optical VHR data in the EU, with a resolution of 40-75 cm very-well suited for defence and governmental users.

She then presented the fleet of satellites currently operated and the GNSS devices on-board them. On GeoSat-1, she clarified that the single GNSS receiver onboard the spacecraft is not operational anymore and that orbit definition is being supported by Two Line Elements. On GeoSat-2, on the contrary, the GNSS capability was redundant from design and the accuracy is, indeed, far superior. The monitoring of GNSS parameters for GeoSat-2 is done thanks to telemetry data, and when a large number of tracked GNSS satellites is lost, it can have an impact on the products. She mentioned that GeoSat would like not to suffer from these glitches in the performances, but unfortunately their satellites are equipped with GPS-only receivers; that is why they expect to incorporate multi-constellation capability in next platforms they will launch.

Later, she explained why GNSS is used to produce their EO products and the benefits it brings, being the main one that GNSS brings a good reference for making sure the satellite acquires images where it is supposed to do so. In addition, she mentioned that the capability of GNSS to become a sensor for attitude determination would be very well welcomed and that in the future they would like to make use of GNSS for that as well, since it also is power effective.

Ms Díez then addressed the requirements of their future missions. For change detection products, she mentioned the need for having worldwide coverage between latitudes 60°N and 60°S and a service availability above 99%. As for the requirements stemming from Optical VHR data, she listed the following:

- Orbit accuracy of 0.75m (3σ)
- Velocity accuracy of 1-10 mm/s (RMS)
- Attitude Accuracy of 0.1° per axis (3σ)
- Timing Accuracy of <0.75 ns

The final goals of these were to obtain time and position information at lower costs, lower power consumption and lower weight on the satellites.

Ms Díez ended her presentation by providing an overview of the on-going actions for the New Space Portugal 2025 initiative, where GEOSAT would like to have all GNSS requirements covered as it would have an impact in the overall performance of the initiative.

The slides presented by Ms Díez can be found as Attachment 8 in section 5.

Q&A Session – Verbal interventions

Comment from EUMETSAT. They commented that the relationship between attitude and orbital accuracies seemed a bit contradictory, since a 0.1° pointing error on the satellite would induce large errors on where the image is taken.

Validation of requirements *(See draft user requirement tables for GNSS in Attachment 10)* Mr Álvarez from FDC then presented the GNSS Real Time Navigation requirements for “LEO Optical Sub metric imagery”. The requirements were validated without comments from the audience.

Agenda Item 10 – Enhanced SST Applications for Space Users through Synergies with GNSS services. Diego Escobar/ GMV

The last presentation of the day, aimed at bridging space users of GNSS to SST, was provided by Mr Diego Escobar, Technical Director of SST & STM at GMV. In particular, his presentation focused on introducing four different Collision Avoidance applications/use cases where GNSS works in synergy with SST.

He started with *Autonomous Collision Avoidance*. In this already-in-operations application, the spacecraft takes Collision Avoidance Manoeuvre (CAM) decisions autonomously thanks to collision information received from ground and the most updated, GNSS-based, PNT solution available on-board. Starlink satellites, for example, are already taking such decisions based on Conjunction Data Message (CDM) data sent from ground.

He continued with the *Late Collision Avoidance Manoeuvre command*, a concept under evaluation where the primary objective is to delay as much as possible the commanding of CAMs. The availability of a continuous communication channel with the satellite, allowing to send late commands, would help avoiding unnecessary CAMs. In this context, research has been done on the possibility to use Galileo as a relay system, via its Return Link Message (RLM), reducing considerably the time to communicate with the satellite from ground, allowing much later decisions. There is however work to be done yet: provided such implementation in Galileo's RLM would happen, it is still necessary to detail the message's structure, develop and install capable receivers on-board spacecraft and define the Concept of Operations for such transmission.

The next application focused on Space Traffic Management, and *Space corridors* in particular, also under evaluation today. In this application, the use of on-board GNSS receivers in closed-loop with the propulsion subsystem would allow keeping the satellite within a previously agreed space corridor. This would reduce the uncertainty of the objects' trajectories, and thus contribute to improving the assessment of Collision Avoidance operations. The next phase will be to conduct a feasibility study to assess what sizes should these space corridors have so as to guarantee the separation of the satellites.

Finally, he presented the *Trajectory broadcasting using on-board GNSS receivers*. Similarly to what happens in aviation ADS-B, in this case satellites would automatically broadcast their own GNSS PNT solution and receive the solutions broadcast from others. Based on the onboard PNT solution and the PNT solutions obtained from other satellites, the very near future encounters could be assessed so as to take CAM decisions without ground intervention. The concept, as said, is under evaluation and the next steps should include a technological study to assess which sensors and processing power would be required on-board.

The slides presented by Mr Escobar can be found as Attachment 9 in section 5.

Q&A Session – Verbal interventions

Q: In the last use case, it looks like there is some sort of communication between satellites. Would that consist on some type of intersatellite link, or would it be done via ground infrastructure?
A: In this one, there is no involvement of the ground segment. Indeed, the idea is to make satellites as autonomous as possible. The technology for the communications channel to broadcast orbital information and the sensors to be used are yet to be decided.

***Q: Regarding the Late Collision Avoidance Manoeuvre Command,* you provided an example where Galileo assists by sending a message. Is this just an idea, or something that will be a reality, because it may require a profound re-structure of the signal? And how would you upload the catalogue of objects?**

A: In this use case, no orbital information of objects, or even state vector, is uploaded. Only the CAM command to perform a manoeuvre is uploaded via the RLS.

To do this, Galileo signal already has spare bits, today still reserved, to accommodate new services, like this one.

Q: One of the main limitations of Autonomous CAM is the case where two satellites belonging to different constellations / operators, both equipped with such capability, are close to each other. So how do they know what the other is planning to do? Perhaps a broadcast of those could be a solution, and they should agree on the procedure.
A: Actually, what you just described is very relevant. One of the current hot topics in SST and STM is "the rules of the road"

3 Conclusions

The Space UCP session was successfully closed by M. Lucchi from EUSPA.

Some outcomes from this working session were highlighted during the plenary UCP session on 8th November, 2023 by Carmen Aguilera from EUSPA.

These results are summarised below as well:

- The needs from Space users vary and today are much focused on accuracy requirements: LEO Radio Occultation missions require centimetric positioning as well as sub nanosecond time accuracy, while decametric positioning is enough for GEO and MEO telecom satellites.
- New space is driving today's market, with reduced costs and an increased use of GNSS.
- Secure satcom has the potential to contribute increasing the safety and security of space infrastructure.

4 Other Notes & Information

With the contribution of:

5 Annexes & Attachments

Annex 1: List of Attendees
Attachment 1: Session Agenda presentation, EUSPA
Attachment 2: Space EU Space Programme Components, EC
Attachment 3: The new standard IoT satellite constellations and the role of the GNSS, SATELIOT
Attachment 4: Using GNSS for orbit determination, SES
Attachment 5: Future Navigation applications for Lunar missions, QASCOM
Attachment 6: GNSS for Low Earth Orbiting satellites, Precise Orbit Determination and Radio Occultation, EUMETSAT
Attachment 7: Cybersecurity Threats in Satellite Systems, ENISA
Attachment 8: GNSS and EO Synergies, GEOSAT
Attachment 9: Enhanced SST Applications for Space Users through Synergies with GNSS services, GMV
Attachment 10: Space user needs and requirements, EUSPA