INFRASTRUCTURE SESSION MOM

Meeting Date	08.10.2024	**Time**	09:15-13:00
Meeting Called By	EUSPA	**Location**	Online event
Minutes Taken By	Frederic Collomb, FDC Daan Allaert, EY	**Next Meeting Date**	N/A
Attendees	**Florent Kone, EUSPA, Session moderator** **Daan Allaert, Moderator of SatCom-related session** **Frederic Collomb, Moderator of EO-related sessions** **EU Space Programme representatives** Lorenzo Solari, European Environment Agency (EEA) Simone Balbo, European Commission Joint Research Centre (DG JRC) Jose Maria Sola Morena, EUSPA **Use Case presentations** Paul Haener, Office International de l'Eau / International Network of Basin Organisations (INBO) Stein Harstad, TSAT Telemaco Melia, EchoStar Mobile Candela Sancho, Detektia & Jorge Manuel Casás Bernal, Acciona Energia		
Distribution (in addition to attendees)	UCP Plenary, EUSPA, Public		

Agenda Items	Presenter
1. Welcome and introduction to the Infrastructure session	Florent Kone, EUSPA
2. Presentation of EU Space Programme components relevant to infrastructure	Lorenzo Solari, EEA Simone Balbo, DG JRC Jose Maria Sola Morena, EUSPA
3. EO for drinking water / wastewater management	Frederic Collomb, FDC Paul Haener, OiEau/INBO
4. Secure Satcoms for infrastructure management	Daan Allaert, EY Stein Harstad, TSAT Telemaco Melia, EchoStar Mobile
5. EO for Infrastructure management	Frederic Collomb, FDC Candela Sancho, Detektia Jorge Manuel Casás Bernal, Acciona Energia
6. Conclusions and closing remarks	Florent Kone, EUSPA

Summary

The Infrastructure panel of the User Consultation Platform (UCP) 2024 took place on 8th October 2024 as an online event.
The panel gathered a total of 58 participants coming from industry, infrastructure managers, research, public organisations as well as from European Institutions, covering the whole spectrum of the market segment.
Presentations of the EU Space components most relevant to the Infrastructure segment were given and concrete usages of Earth Observation (EO) and secure satcom were also introduced through a series of "use case" presentations.
These presentations enabled to initiate interesting interactions with the audience and to discuss main requirements, challenges, needs for R&I activities, market trends and needs for user/market uptake activities.
For the EO part of the main outcomes were the following:

- The needs and requirements presented during the session were globally confirmed but a few **additional requirements** were suggested. They took the form either of additional parameters to be monitored in the case of Drinking water / Wastewater management (e.g. River flow estimates, Biological contamination and Snow cover) or of technical requirements in the case of infrastructure management (e.g. more stringent update frequency for the monitoring of vegetation encroachment along railway tracks);
- The lack of awareness about the benefits that EO can bring to infrastructure management and the integration of EO data into existing workflows and decision-making processes were recognised as a main obstacle to the penetration of EO-based services in the Infrastructure management market;
- Several topics for further R&I activities were identified such as the use of satellite-based gravimetry to assess ground water, the use of satellite-based altimetry to estimate river flows or the development of techniques enabling to overcome cloud coverage and lighting limitations.

For the Satcom part of the session most commented topics were the following:

- End users need **Secure SLAs** that meet the stringent requirements of TSos for availability and security during emergencies.
- **Standardization and certification** of non-terrestrial networks (NTNs) across Europe are essential to ensure the growth and reliability of the Satcom market.
- Satellite communication must be cost-competitive with ground-based networks to be a viable option for users, thus addressing the need for **low-cost** satcom solutions.
- Stressing the importance of creating **intuitive** Satcom systems that are straightforward and manageable for users regardless of their technical expertise in satellite communications.

1 MINUTES OF MEETING

Agenda Item 1 - 1. Welcome and introduction to the Infrastructure session. Florent Kone, EUSPA

Florent Kone, Infrastructure segment leader at EUSPA, welcomed all participants to the User Consultation Platform (UCP) session and introduced his co-moderators, Daan Allaert (EY) and Frederic Collomb (FDC). He reminded that in the context of UCP, the Infrastructure segment and the use of EO for infrastructure management were addressed for the first time in 2022 and that the first Report on Infrastructure User Needs and Requirements" was published in 2023. Florent Kone then provided a brief overview of the session's scope and objectives, and presented the practical organisation of the session, with a first sub-session dedicated to the presentations of components of the EU Space programme particularly relevant to the Infrastructure segment, followed by three sub-sessions dedicated to (i) EO for drinking water / wastewater management, (ii) Secure Satcom for infrastructure management and (iii) EO for infrastructure management respectively.

Agenda Item 2 - Presentation of EU Space Programme components relevant to infrastructure. Lorenzo Solari, EEA / Simone Balbo, DG JRC / Jose Maria Sola Morena, EUSPA

The sub-session started with a presentation of the European Ground Motion Service delivered as part of the Copernicus Land Monitoring Service (CLMS) by the European Environment Agency (EEA). The presentation was given by Lorenzo Solari (EAA).

Lorenzo Solari started with an overview of the main objective of EGMS (i.e. to provide a Sentinel-1-based high-density, continental-scale map of ground motion, updated yearly). He then described with more details what EGMS is measuring and mapping (Land subsidence, landslides and slope phenomena, natural and anthropogenic uplift and movement of larger-scale infrastructure). Lorenzo Solari presented the three main types of products delivered by the service and their main characteristics. He then introduced the various domains of application of EGMS and insisted on those directly related to the infrastructure segment. These domains include the monitoring of highways, railways, bridges, buildings, cultural heritage in urban areas, etc. He concluded his presentation with information on data access (EGMS data can be downloaded from https://egms.land.copernicus.eu/) and provided links to a detailed service description on the CLMS website (https://land.copernicus.eu/en/products/european-ground-motion-service) and to an informative webinar (https://land.copernicus.eu/en/events/egms-a-general-introduction).

Q: Has EEA visibility on the way EGMS is used in the domain of infrastructure management?
A: First of all, as a Copernicus product, EEA guarantees that the EGMS products are quality controlled and then it is up to the stakeholders to use them. EEA organises events to present the product but there is a relatively low visibility on the way the products are used by downstream providers. That said, Lorenzo Solari indicates that he has already been contacted by several companies and infrastructure managers working with EGMS and which were enthusiastic about the use of EGMS data.

The second presentation was dedicated to the "Water Bodies" group of products delivered by DG JRC as part of the global land component of CLMS. The presentation was given by Simone Balbo (DG JRC).

Simone Balbo indicated that the European Directive on the resilience of critical entities (2022/2557) identifies water as one of the critical "entities" and specifically mentioned "drinking water" and

"wastewater" as part of the categories to be addressed. He provided a description of the main characteristics (incl. scope, temporal resolution, spatial resolution) of the various products delivered by DG JRC in relation to water management, namely "Water bodies" (corresponding to areas covered by inland water along the year), "Lake surface temperature (providing information about the temperature of water at he lake surface for about 2000 lakes all over the world), "Lake water level" (providing information about the absolute height of the reflecting surface of continental water bodies), "River water levels" (providing information about the absolute height of the reflecting surface of water for 22830 river locations, using the same technique as for lakes) and "Lake water quality" (providing information about turbidity, trophic state index and lake water reflectance for 4260+ lakes considering to be the largest or most "strategic" ones -natural lakes, reservoirs, closed lagoons).

In addition to the water bodies groups of products, Simone Balbo also introduced two products potentially relevant to water resource management: the snow products ("Snow Cover Extent" and "Snow Cover Equivalent", which respectively provide daily maps of the fraction of snow cover on ground in percentage and daily updates -for the Northern hemisphere only- of the equivalent amount of liquid water stored in the snowpack) and the soil moisture product ("Surface Soil Moisture" and "Soil Water Index", providing information about the water content and moisture conditions in the top centimetres of the soil). Simone Balbo concluded his presentation with data access information. He mentioned that the above products are available through the CLMS portal (http://land.copernicus.eu) and that in the course of the first quarter of 2025, they would also be available through the Copernicus Data Space Ecosystem (CDSE - https://dataspace.copernicus.eu/).

Q: During the presentation you mentioned large rivers, which size do these rivers correspond to? Is the minimum size of the monitored rivers directly related to the spatial resolution of the satellite data?
A: The minimum width of the river sections which can be monitored is around 300m and is indeed very related to the resolution of the satellite data used for this purpose.

The third and last presentation was dedicated to Govsatcom. The presentation was given by Jose Maria Sola Morena (EUSPA).

During the presentation, Jose Maria Morena from the Secure Communication department at EUSPA provided an introduction to the Govsatcom program. The initiative is a significant undertaking within the department, with the primary objective of establishing a centralized common union pool specifically designed to cater to the SatCom needs of governmental entities. The purpose of the session was to familiarize the audience with Govsatcom's mission, potential services for users, and to offer an update on the status of the procurement and development of the Govsatcom hub, which is the central part of the program.

Jose Maria Morena explained that Govsatcom is intended to serve governmental users who currently rely on a variety of services accessed through different resource or service providers. The centralized common union pool would allow public entities and member states to access diverse services through a single, organized platform. This platform is expected to list all available services, ensuring their security and providing relevant information, thereby easing access and safeguarding the availability and quality of services for governmental users.

The presentation highlighted that Govsatcom addresses three main segments: surveillance, which includes border, maritime, and military activities; crisis management, exemplified by maritime emergencies and humanitarian actions; and key infrastructure, which encompasses transport, nuclear

plants, space industries, and other critical sectors. Additionally, Govsatcom aims to extend its services to remote regions such as the polar areas.

Jose detailed the three types of satcom services offered by Govsatcom: raw capacity, which involves providing satellite capacity; anchored capacity, which includes booking antenna capacity for end-user use; and end-to-end services, which cover the complete provision of services, potentially including user terminals.

The structure of the common union pool was described, consisting of four parts: fixed allocation for known needs and ongoing services, prepaid services for anticipated needs that have been paid for in advance, a crisis reserve for urgent and unforeseen situations, and dynamic on-demand services for needs not identified in advance but required during the service provision period.

The Govsatcom hub ecosystem was outlined, with resource providers supplying the hub with a list of services based on their available capacity. The Competent Govsatcom Authority (CGA) in each member state is responsible for controlling access to the hub and ensuring compliance with security requirements. End users, such as firefighters or police, access services through the CGA. The hub's role is to assist users in finding the most suitable services and ensuring they are booked and meet security requirements. However, the services are provided directly from the resource provider to the users, not through the hub.

The hub's services and functionalities include ensuring end-to-end secure communication, offering a service portfolio, providing an automated environment, anonymization, prioritization, service monitoring, help desk support, billing capabilities, user terminal management, and security monitoring.

CGAs can manage participant accounts, select services, access help desk support, monitor service performance, report security risks and threats, utilize a service selection wizard, and manage billing.

The evolution of Govsatcom services is planned in three main stages: initial services are expected by the end of the current year, followed by Full Operational Capabilities (FOC) within two to three years, and subsequently, the inclusion of IRIS2 services which will further enhance the hub's capabilities.

In terms of procurement, Jose shared that an innovation partnership procurement approach is being managed by EUSPA. Initially, three different contracts ran in parallel for several months, covering the engineering process from requirements definition to preliminary design. In July of the current year, the winning consortia were selected, and the project entered stage two, which involves the actual development, deployment, and initial services of the Govsatcom hub. This stage also includes working on the FOC infrastructure. The target for the initial services is December of this year, and the team is working to have the Govsatcom hub ready by then.

In conclusion, Jose's presentation provided a clear understanding of the Govsatcom program, its services, and the current progress towards achieving its goals. The audience was left with a sense of anticipation for the upcoming launch of the initial services and the future developments of the Govsatcom hub.

Q: Does a CGA need to be tech expert on SatCom to be able to help the users or is it just and admin. Manager?
A: Ideally the more the person knows about satcom the better but it is not a must. The helpdesk can also help to guide you.

Q: Which kind of synergies in terms of services with IRIS2 will we have?

A: IRIS2 is ongoing so I don't know much about it. But the requirements for both IRIS2 and Govsatcom are prepared bearing in mind a future synergy.

Agenda Item 3 - EO for drinking water / wastewater management. Frederic Collomb (FDC)

Frederic Collomb introduced the sub-session on "EO for drinking water / wastewater management". He reminded that because of climate change, population growth and economic growth, there was an increasing need at global scale for water in general and for drinking water in particular. He also mentioned that in addition, drinking water resources were exposed to different types of pollution. He indicated that the risks of drinking water shortage and drinking water pollution should be continuously monitored and that EO had a role to play, thanks to its capacity to support both water quantity and water quality monitoring.

Frederic Collomb then mentioned the main objectives of the sub-session: to discuss user needs and requirements, to identify the main challenges associated to the use of EO for the management of drinking water resources and wastewater resources, to identify areas in which more Research and Innovation would be needed, and last but not least, to identify main market trends and relevant market uptake activities that would deserve to be carried out.

He then introduced the first use case presentation of the Infrastructure session, entitled "Spatial hydrology applied to the monitoring of urban waste water discharges" and presented by Paul Haener, Head of International Projects on Water Information Systems at the International Office for Water (OiEau), and active member of the permanent technical secretariat of the International Network of Basin Organisations (INBO).

Use case presentation

After a short introduction of OiEau and INBO, Paul Haener presented the MARU project, a 22-month project carried out in collaboration with several basin agencies and committees in Brazil, with the objective to reinforce the monitoring of the urban waste water discharges and their impact on the water resources in order to improve the identification of actions aiming to protect the quality of water resources and aquatic environments. In particular, he described the role of Sentinel-2 data in the project in supporting the identification of the main pollution points and provided an overview of the obtained results: monitoring of four different water quality parameters (Turbidity, Chlorophyll-a, Suspended solids and Dissolved organic matter) for 90+ "virtual quality stations" using 28-month Sentinel-2 data archives. Paul Haener also presented an example of integration in Africa of satellite data (coming from the SWOT mission) and in-situ station data in a platform for data sharing with hydrological datasets visualisation. He then summarised the main benefits of using EO for water management (Reduction in production costs of data necessary for resource management, contribution to trust building by supporting the exchange of border-agnostic and transparent data between neighbouring countries, and ability to cover difficult-to-access areas) as well as key challenges (lack of awareness of water resource managers about the benefits of using EO, lack of training and pilot projects, difficulties to integrate EO datasets into data production procedures and decision-making processes. He also suggested several topics to be considered for future R&I activities such as (i) automatic identification of the main points of pollution sources, (ii) interpolation and data complement when there is a lack of data due to clouds, (iii) forecasting the evolution of the 4 parameters observed in the MARU project (Turbidity, Chlorophyll-a, Suspended solids, Dissolved organic matter) by simple propagation for the coming days and (iv) analysing the impact of the rain on the above-mentioned parameters, with simulation/forecasting for the coming days.

Q: Are SWOT images global? Is SWOT integrated into Copernicus?
A: SWOT has a global coverage. It is not a European satellite. It is a joint mission of the French and American Space Agencies (CNES and NASA). SWOT is not part of the Copernicus Programme.

Q: The MARU project has exploited 28 months of historical data coming from Sentinel-2. Are there any plans to operationalize the service by developing or establishing a service that would continuously monitors the basins covered in MARU?
A: The has been an opportunity for CNES to calibrate and test "on the field" an algorithm they were developing. A service is now being developed which will give the possibility to download and process the data coming from Sentinel-2 images. The service should become available in 2025. OiEau/INBO are now preparing a new project where it is planned to have an automatic integration of the results of the processing.

Interaction with participants

Frederic Collomb provided an overview of the two main applications considered for the gathering of user needs and requirements for the use of EO for drinking water management and waste water management, and of the four "operational scenarios" associated to these applications (see figure below). This overview included the list of parameters to be monitored through EO: turbidity, eutrophication, chlorophyll-A, nutrients, suspended matter, dissolved organic matter, water temperature and water levels.

Application "**Water resource monitoring**"(*)	Application "**Monitoring of impact of human activities on water resources**" (*)
Operational scenarios • **Sc1:** Water quality monitoring • **Sc2:** Water quantity monitoring • **Sc3:** Support to the assessment of Wastewater Treatment Plant (WWTP) performance	**Operational scenarios** • **Sc1:** Water pollution detection and source tracking

Figure 1: Applications and scenarios related to the use of EO for drinking water management and waste water management

Frederic Collomb then presented a summary of the needs and requirements identified for the above-mentioned scenarios (see corresponding slides). He mentioned in particular that in most cases hydrologist need the "global picture" and that the need is to monitor water resource at basin scale and not only at local scale. He also insisted on the fact that daily updates are generally required. He then asked participants about their views about the parameters to be monitored and about the presented needs and requirements.

The identified parameters were all considered as relevant (as illustrated by the statement made by one the participants: "well selected and cover most of topics of interest"). A few additional parameters were mentioned by participants as being of interest:

- "River flow estimates" (which is consistent with one of the topics identified later in this document as relevant for further R&I activities: "Use of satellite-based altimetry to estimate river flows");
- "Biological contamination" such as algal contamination (Note: this can be monitored through Chlorophyll-A monitoring);
- "Snow cover" as it can have an impact on water resource.

Another participant mentioned that knowing more about the causes and frequencies of floods and droughts might also be relevant but he also indicated that the direct consequences on water resources would be monitored through the operational scenario dealing with “water quantity monitoring”. It was also suggested that monitoring the evolution of imperviousness might be of interest.

No specific comment was made on the summary of needs and requirements presented during the session.

Frederic Collomb provided an overview of the main challenges and/or obstacles identified so far for the adoption of EO in the water management sector:

- Lack of awareness of end users about the actual potential of satellite-based monitoring;
- Integration of data coming from a large variety of data source, which may induce lack of homogeneity, difficulties to compare data together, etc;
- Availability of data for small water bodies (lakes and rivers);
- Integration of remote sensing data into existing data processing workflows and into decision-making processes;
- Lack of training and knowledge transfer towards end users.

Among the above list, the lack of awareness of end users about the actual benefits that EO can bring to the sector was recognised as the most common one.

Frederic Collomb suggested a list of topics which might deserve further R&I activities:

- Use of satellite-based gravimetry to assess ground water resources (e.g. aquifers monitoring);
- Techniques (e.g. cloud-penetration algorithms, data fusion with radar imagery) enabling to overcome cloud coverage in regions with frequent cloud cover;
- Use of satellite-based altimetry to estimate river flows;
- Improvement of algorithms for analysing water quality parameters (e.g. turbidity, pollutant concentrations).

Florent Kone reminded the audience that the feedback received through the UCP can have a great impact on where EUSPA decides to funnel some innovation budget in the coming years, through the funding mechanisms that the agency can use (e.g. Horizon Europe).

A few additional topics were proposed by participants:

- How to improve the capacity to observe rivers below the canopy (mainly in tropical regions);
- How to optimally combine satellite imagery with drone imaginary;
- Use of AI-based processing techniques.

No additional comments were made by participants with regards to market trends and no suggestion was made for potential support activities that EUSPA could undertake to foster market uptake.

Agenda Item 4 – Secure Satcoms for infrastructure management. Daan Allaert, EY

Daan Allaert introduced the second part of the UCP event, which for the first time explores and discusses SatCom. He noted that this subsection has a different structure compared to the subsection about earth observation, as it does not tackle operational scenarios but instead dives directly into two different use cases: smart water management and protecting critical infrastructure from environmental events. After each use case, there will be a discussion on user needs and requirements, and the section will conclude with an open discussion about key challenges, gaps, and market trends.

After the introduction, Daan Allaert presented ten requirements identified for SatCom, along with their definitions. He highlighted two requirements that needed extra explanation:

1. Link Type: This refers to the type of communication, which can either be a uni-directional communication link or a bi-directional one.

2. Security Protection: This is about the measures taken to protect data and information from unauthorized access, ensuring that the information remains unchanged, accurate, and accessible to those who need it.

Daan Allaert then passed the floor to Stein Harstad, who presented the use case ‘Smart water management and the use of SatCom.

Stein Harstad, representing the Norwegian firm TSAT, which specializes in satellite communications solutions, presented a use case focused on smart water management. He began by introducing himself as the managing director of TSAT, with nearly thirty years of experience in the company. TSAT was established in 1995 in Oslo, Norway, with the basic technology developed under contracts with the European Space Agency in the 1990s. The company's mission is to develop a satellite narrowband communication system dedicated to SCADA (Supervisory Control and Data Acquisition) and utility applications for mission-critical infrastructure.

Stein Harstad explained that TSAT operates in various verticals, including hydroelectricity production, electricity distribution, oil and gas pipelines, offshore installations, seismology, and water and wastewater management. The company's role is to provide the communication part only, facilitating the transmission of data from remote sites to central control centres. TSAT has a global presence, with over three hundred networks and many thousands of terminals installed worldwide.

The specific use case Stein Harstad presented involved a water and wastewater service provider in the UK, which covers a large geographical area and manages extensive water infrastructure. The provider faced challenges in improving operational efficiency due to pressures from regulators and communities. Stein highlighted the various communication technologies that compete in this space, including copper lines, radio communication, mobile data communication, and other satellite communication technologies.

One of the main concerns with shared network services is the lack of control and potential issues with reliability, latency, contention, and security. To address these concerns, TSAT proposed a closed, private network solution that is fully owned and controlled by the operator. This approach allows for a perfect adaptation of bandwidth to actual needs, resulting in a more reliable, faster, and secure communication system.

Stein Harstad emphasized the benefits of a private network, including the absence of sharing, which eliminates the need for backhaul and reduces operational costs. The system is designed with inherent security measures, such as access control, secure boot systems, encryption, and other security protocols to prevent unauthorized access and ensure data integrity.

After Stein Harstad's presentation the audience asked 3 questions.

Q: Could you explain the term SCADA?
A: SCADA stands for Supervisory Control and Data Acquisition, a system used by utilities to control and monitor their remote assets, such as monitoring water levels and controlling valves.

Q: How will AI security impact TSAT' approach to 5G?
A: TSAT only provides communication and does not process data, AI is not relevant to their current operations.

Q: An end user, stressed the need for high SLA (Service Level Agreement) and secure communication solutions that work during a crisis. The end user stressed the importance of having backup solutions and the difficulty in securing SLAs with satellite operators and asked TSAT about their opinion.
A: TSAT acknowledged the importance of SLAs and explained that TSAT' equipment is designed to be redundant and secure, meeting the SLA requirements seen in the market. He also mentioned that they incorporate availability figures from satellite operators into their calculations. Further the market officer from EUSPA advised the end user to get in touch with the competent Govsatcom authority in Belgium to find out more about Govsatcom hub and how it can meet the needs of TSOs like Ellia.

After the first use case Daan Allaert gave the floor to Telemaco Melia, who presented the use case 'Protecting critical infrastructure against environmental events'.

Telemaco Melia from EchoStar Mobile presented on the use of SatCom in protecting critical infrastructure against environmental events. He began by introducing EchoStar Mobile, which operates its own jurisdictional asset satellite in the S band (2.1 gigahertz) and provides mobile satellite services and IoT services. The company has been pushed to develop new solutions due to an increased demand for satellite connectivity for small, battery-operated objects that need to be deployed in nature.

Telemaco Harstad explained that EchoStar's journey in satellite services did not start two years ago but has a long history with EchoStar Corporation based in Denver, which has extensive experience in operating satellites. The current service in the S band is most seen in the form of direct-to-device devices.

The focus of the presentation was not on the technology itself but on the use cases that the technology enables. Telemaco Harstad emphasized that they would not be focusing on the different flavours of modulations and protocols but rather on what the technology can do in the context of protecting critical infrastructure.

Telemaco Harstad discussed the various types of critical infrastructure, such as roads, railways, and pipelines, which are long and skinny and deployed over hundreds or thousands of kilometres. These infrastructures are critical for day-to-day operations and face dangers from environmental conditions and human behaviours. He provided examples of recent environmental disasters, such as wildfires and landslides, which could have been mitigated or predicted with proper monitoring and satellite technology.

EchoStar Mobile has been working with developers to create sensors capable of monitoring infrastructure integrity, such as detecting vibrations, inclinations, and power line conditions. These sensors, combined with a backend infrastructure capable of processing the data, can provide early warnings and potentially prevent disasters.

Telemaco Harstad also highlighted the importance of flood warning systems, which can monitor soil conditions and predict flooding events. He mentioned the need for awareness and evangelization of satellite IoT technology, which can provide valuable data for monitoring critical infrastructure.

Following Telemaco Melia's presentation, Daan brought the Secure SatCom subsession to a close, noting that the session had run over the scheduled time. In his concluding remarks, Daan identified several critical research gaps within the field that need further investigation. He stressed the urgent need for Europe-wide standardization and certification of non-terrestrial networks (NTNs), pointing out that the current lack of these standards is impeding market expansion. Certification is particularly vital to ensure that new technologies conform to European safety, reliability, and compatibility standards, which is essential for the safeguarding of critical infrastructure.

Daan Allaert then talked about the importance of finding a balance between reducing capital and operational expenditures and maintaining the integrity of solutions. This balance is crucial for meeting end-user demands for affordable solutions without sacrificing quality, a challenge that Stein had also touched upon in his talk.

Finally, Daan Allaert addressed the need for the smooth integration of SatCom with both current and forthcoming IoT technologies. Such integration is fundamental to crafting comprehensive solutions that harness the strengths of satellite communications alongside the innovative potential of IoT.

With these points highlighted, Daan wrapped up the sub-session, setting the stage for the next segment of the event, which would focus on EO for infrastructure management.

Agenda Item 5 - EO for infrastructure management. Frederic Collomb (FDC)

Frederic Collomb introduced the sub-session on “EO for infrastructure management”. He indicated that the term “infrastructure” was referring to built infrastructure (civil engineering, ports and airports, dams, railway infrastructure, etc.). To set up the scene, he mentioned that EO had not become yet a commodity in the Infrastructure sector but was nevertheless increasingly used and had the potential to serve at all stages of the infrastructure life cycle: from the selection or characterisation of a construction site up to the monitoring during the maintenance phase.

Frederic Collomb then mentioned that the main objectives of the sub-session were the same as for the session dealing with “EO for drinking water / wastewater management”: to discuss user needs and requirements, to identify the main challenges associated to the use of EO for the management of drinking water resources and wastewater resources, to identify areas in which more Research and Innovation would be needed, and to identify main market trends and relevant market uptake activities that would deserve to be carried out.

Frederic Collomb introduced the use case presentation entitled “Impacting infrastructure management with satellite radar technology” and presented by Candela Sancho, CEO and co-founder of Detektia, a Spanish company specialised in InSAR based ground deformation monitoring.

Use case presentation

Candela Sancho started with a few words about Detektia’s core business (to monitor infrastructure from space, integrating the latest radar satellite technologies known as InSAR with machine learning)

and indicated that Detektia makes an extensive use of synthetic aperture radar data from Sentinel-1. She presented three different success stories illustrating different applications of InSAR-based monitoring: use of InSAR during the construction of an urban highway in Mexico City by the Mexican construction company ICA, integration of InSAR-based structural health indices for historical buildings within the digital twin of the city of Cordoba in collaboration with the Cordoba City Council and Entity Data (a company integrating advanced technologies into digital twins), and InSAR-based monitoring of dams located in mountainous areas and operated by Acción Energía, a Spanish company and global leader in renewable energy.

Concerning the first example, Candela Sancho indicated that the construction of the urban highway took place in an area subject to string subsidence (from five millimetres per year in the western part of the construction site to 25 centimetres per year in the eastern part). An analysis of historical data was performed and monthly updates were provided during the construction phase. InSAR enabled to characterise the subsidence process in the influence area of the project and this information was crucial for improving the foundation of bridges and viaducts. She also mentioned that carrying out this type of analysis using traditional methods would have required tremendous effort in topographic surveys with personnel and equipment on the ground to obtain just a few dozens of points while the use of InSAR enabled the processing of several tens of thousands of measurement points.

The second example, focused on the historic centre of Cordoba, consisted in integrating InSAR data in a digital twin of the historical centre to help answer important questions that will have a very positive impact on the management of areas with unvaluable historical assets. The objective was to answer questions such as “Which historical buildings, areas, or infrastructure have experienced or are currently experiencing unexpected deformations?”, “Are there stability issues in certain areas or buildings within the city and what is the magnitude of the problem?”, “When anomalies occur, are they caused by natural events such as precipitation or by urban construction projects?” or “What has been the exact impact of an urban construction project such as tunnelling or any underground work on the surrounding buildings and infrastructure?”.

The third and last example addressed the monitoring of four mountain dams located in hard-to-reach areas of the Pyrenees. All these dams were built over 50 years ago and historical and periodic deformation measurements using traditional topographic methods were therefore available. The project enabled a comparison between traditional topographic measurements with those obtained from InSAR. The same deformation patterns were observed, in both vertical and planimetric aspects. Candela Sancho mentioned that InSAR offered a much higher temporal resolution, allowing for more detailed and frequent deformation time series compared to traditional topography. This increased resolution enabled to establish stronger correlations between external factors, such as temperature and reservoir levels and displacement trends.

She also mentioned that InSAR is particularly valuable for monitoring slope movements and areas that typically lack instrumentation of comprehensive data on dam behaviour. The comparison between InSAR data and data measured by inclinometers installed on purpose revealed to be successful and the integration of InSAR with the inclinometers made possible to evaluate the extent and the magnitude of the movements across the entire slope. Candela Sancho indicated that integrating InSAR into dam monitoring systems requires careful case-by-case analysis and considering factors such as image availability, vegetation cover, and the dam's location or orientation, all of which affect the density of InSAR data. She also provided an overview of the main limitations of InSAR-based monitoring. For example, it does not measure movements along the axis that civil engineering professionals are typically used to work with. The spatial location accuracy is not as precise as when working with topographic surveys or instrumentation. Moreover, InSAR has limitations when it comes to measuring north-south movements, due to the inherent geometry of the satellite system. Candela Sancho

concluded her presentation saying that in spite of the above-mentioned limitations, the advantages of the InSAR technology should make it a key tool in the civil engineering sector, unlocking use cases such as monitoring large infrastructures or even entire cities.

Q: Was there an assessment of SAR observations through a comparison with *in situ* data/findings?
A: Yes, there was a public network of GNSS stations available in the area. In general, the first time a client wants to work with InSAR, there is a need to verify that InSAR measurements give the same results as GNSS-based measurement. In the case of the concerned example, an assessment with three GPS stations located nearby was successfully performed.

Q: In the case of Cordoba's project, did you combine InSAR techniques with BIM methodology for the simulation of buildings?
A: Detektia did not design the model used for BIM and the metrics produced by Detektia were directly injected in the model, using APIs. It therefore not possible to say what kind of integration took place.

Q: Could you say a few words about the trade-off between using Sentinel-1 data, which is free of charge but has a relatively resolution, and using commercial SAR data offering a better resolution, but at a cost?
A: The main "issue" regarding the use of Sentinel data is the low spatial location accuracy, due to the size of the pixel compared with those provided by commercial mission (the pixel can be like 2 by 2 or 3 by 3 metres in case of commercial mission). But Detektia has solved that issue with a specific algorithm and once you have solved this limitation, 90% of of needs can be met using Sentinel data. So, unless you want to study a specific building in detail (then you need commercial data), Sentinel-1 is generally sufficient.

Interaction with participants

Frederic Collomb provided an overview of the five main applications considered for the gathering of user needs and requirements for the use of EO for infrastructure management, and of the twelve "operational scenarios" associated to these applications (see figure below). He mentioned that these scenarios cover the whole lifecycle of infrastructure, from the initial selection of a site in case of construction projects, to the monitoring of construction operations during the construction phase, and up to the maintenance phase, which enables, for instance, to monitor the risk on the structural health of infrastructure thanks to ground deformation monitoring, and in more specific cases like for linear infrastructure, to monitor potential problems related to vegetation encroachment.

Application " **Infrastructure site selection and planning**"	Application " **Vulnerability Analysis**"	Application "**Construction operations (monitoring)**"	Application "**Post-construction operations (monitoring)**"	Application "**Monitoring of impact of human activities on infrastructure**"
Operational scenarios • **Sc1:** Site characterisation • **Sc2:** Risk assessment wrt. ground deformation • **Sc3:** Risk assessment wrt. natural hazards • **Sc4:** Risk assessment wrt. climate change	**Operational scenarios** • **Sc1:** Vuln. analysis wrt. ground deformation • **Sc2:** Vuln. analysis wrt. natural hazards • **Sc3:** Vuln. analysis wrt. climate change	**Operational scenarios** • **Sc1:** Construction progress monitoring (alignment with schedule) • **Sc2:** Construction stability monitoring	**Operational scenarios** • **Sc1:** Ground deformation monitoring (risk on structural health) • **Sc2:** Vegetation encroachment monitoring	**Operational scenarios** • **Sc1:** Land cover / land use change monitoring (in the surroundings)

Figure 2: Applications and scenarios related to the use of EO for infrastructure management

Frederic Collomb presented the tables used to characterise requirements and presented a summary of the needs and requirements identified for the above-mentioned scenarios (see corresponding

slides). He mentioned in particular that when looking at needs and requirements, a distinction should be made between “localised” infrastructure (e.g. ports, airports, bridges, dams, etc.) and linear infrastructure, which can spread across very large areas (e.g. railways lines, electricity lines, pipelines). He asked participants about their views about the presented needs and requirements. Three comments were made by participants about the requirements. The first one concerned the operational scenario “Site characterisation (Land cover / Land use, topography, geological evaluation...)”, for which a participant suggested that Digital Surface Models (DSM) should also be mentioned as part of the “other requirements”. The second one concerned the operational scenario “Risk assessment wrt. climate change” for which a participant suggested that the spatial resolution should be better to monitor risks related to urban heat islands. The third one concerned the operational scenario “Vegetation encroachment monitoring”, for which another participant suggested that in the case of railway track monitoring, daily updates would be required. The participant also mentioned that an AI-based processing of historical data to get better information.

In a comment, a participant mentioned that drones were often use for the monitoring of railway tracks or high voltage transmission lines but that their use was facing limitations due to airspace regulation, and that the use of EO would be a way to overcome these limitations.

Frederic Collomb provided an overview of the main challenges and/or obstacles identified so far for the adoption of EO in the infrastructure management sector:

- Limited knowledge of end users about the potential of satellite-based information and in particular of InSAR;
- Comparability of InSAR ground displacement measurements with in-situ measurements (e.g. absence of North/South displacement information with InSAR);
- Comparability of SAR data when historical analysis must be carried over long periods (e.g. if terrain and scatterers/reflectors have changed);
- Lack of digitalization of data in the infrastructure sector and limited use of advanced digital tools;
- Absence of a certification or "quality" label for the use of satellite-based information.

No other main challenge was identified by participants.

Frederic Collomb suggested a list of topics which might deserve further R&I activities:

- Techniques enabling to overcome cloud coverage and lighting limitations (e.g. cloud-penetration algorithms, data fusion with radar imagery);
- Advanced image processing techniques (e.g. AI –based) to improve automatic detection and classification of infrastructure defects or changes;
- Improvement of temporal coherence in dynamic urban areas, or areas with rapid infrastructure changes;
- Integration of multiple data sources (e.g. in situ sensors, drones and IoT data).

No other R&I activity was identified by participants.

As far as market trends are concerned, a participant underlined that in the case of transport infrastructure, GNSS and EO should be very well integrated and provide better benefits.

Concerning potential support activities, a participant suggested that more training sessions on what EO can do for Infrastructure management should be organised. Frederic Collomb indicated that this would indeed be fully in line with one of the main identified adoption barriers (the one related to the lack of awareness of end-users on the real benefits of earth observation).

Florent Kone mentions a EUSPA initiative called the "Space Academy" and aiming at establishing a "knowledge centre". This Space Academy should go live relatively soon, providing tutorials, lectures made by professionals etc. in order to disseminate information on what can be achieved with each component if the EU space programme, and to stimulate market uptake.

Agenda Item 6 – Conclusions and closing remarks. Florent Kone, EUSPA.

In conclusion, Florent Kone, Daan Allaert and Frederic Collomb thanked all the speakers and participants.

Florent Kone insisted again on the importance of the feedback gathered at the occasion of the UCP because it helps to steer development of and innovation for the EU space programme components. He reminded participants that plenary UCP session would take place during the International Astronautical Congress (IAC) in Milan on the 14th of October. Florent Kone also indicated that contributions to the infrastructure session would help to update the Report on User Requirement (RUR) to be published in 2025.

Florent Kone also encouraged participant to contact him for any further bilateral discussions they would like to have.

2 Other Notes & Information

The session gathered a total of 58 different participants but the session being split into three sub-sessions addressing very different topics (EO for drinking water/wastewater management, Satcoms for infrastructure management and EO for infrastructure management) the average number of attendees at a given time was around 28-30 participants.
Among these participants, ~34% were from the public sector (including EUSPA), ~48% from the private sector and ~7% from the research sector. Approximately 16% of the previously mentioned participants were end-users.

3 Annexes & Attachments

Annex 1: List of Attendees

Attachment 1: "UCP 2024 Infrastructure session" slides, EUSPA/EY/FDC
Attachment 2: "European Ground Motion Service" slides, EEA
Attachment 3: "The water global-products offered by Copernicus Land Monitoring Service" slides, DG JRC
Attachment 4: "GovSatCom" slides, EUSPA
Attachment 5: "Spatial hydrology applied to the monitoring of urban waste water discharges" slides, OiEau/INBO
Attachment 6: "Water Management Use Case" slides, TSAT

Attachment 7: “How Environmental Monitoring Helps Protecting Critical Infrastructure” slides, EchoStar Mobile
Attachment 8: “Impacting infrastructure management with satellite radar technology” slides, Detektia
Attachment 9:

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