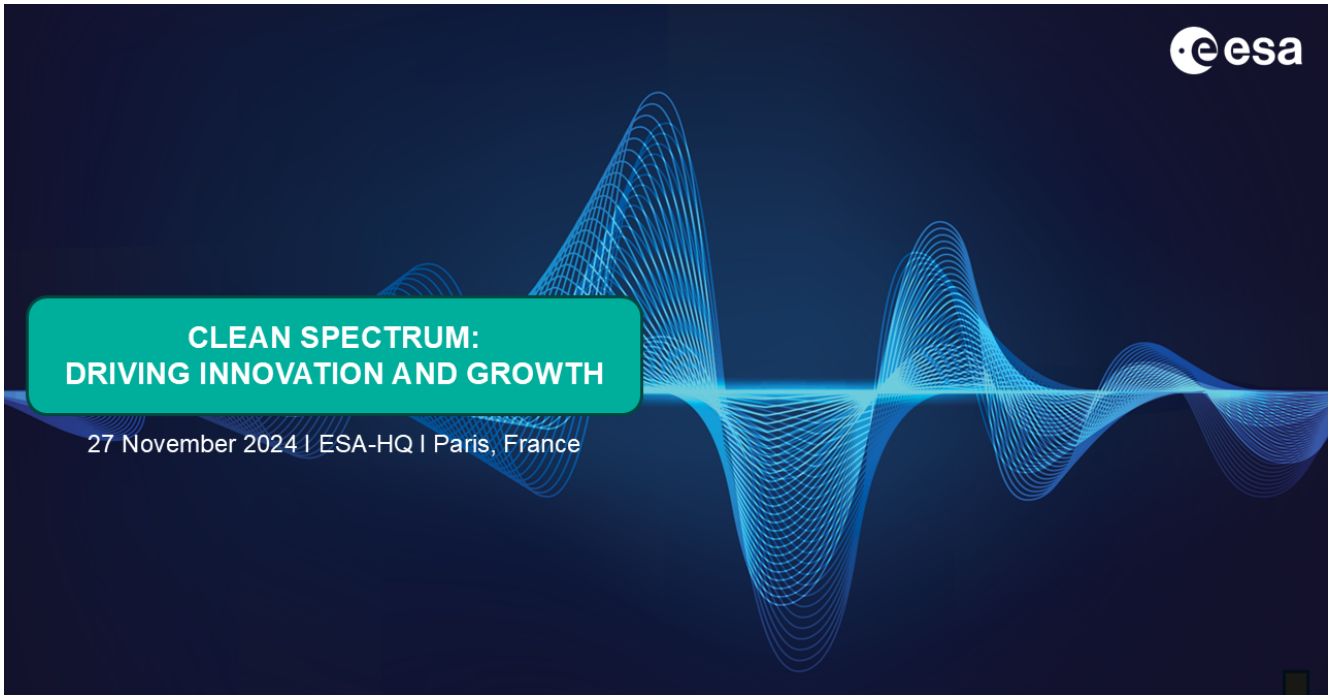


Workshop report

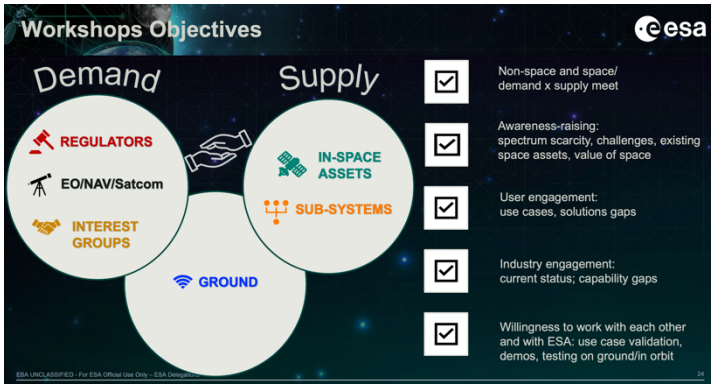
December 2024

Key messages and index

1. ABOUT THE CLEAN SPECTRUM WORKSHOP: AN ESA-ORGANISED MULTI-STAKEHOLDER REFLECTION

The ESA Directorate of Connectivity and Secure Communications (D/CSC), in collaboration with the ESA Directorates of Navigation (D/NAV) and Earth Observations (D/EOP), organised the workshop Clean Spectrum: Driving Innovation and Growth. The event was held at ESA HQ (Paris, France) on 27 November 2024.

The objectives of this event and the questions it raised were:



- **Strategic aspects**: to understand factors of pressure on the use of radiofrequency spectrum in the current technological and socio-economic context: how do they impact companies and citizens today and in the future?
- **Use cases and added value of space**: to take stock of the spectrum management problems as shared by regulators, satellite communications operators, scientific mission operators; where do satellite solutions add value with respect to existing solutions based solely on ground infrastructure?
- **European supply technology and commercial maturity**: To understand the readiness of the European industry to serve such demand and the maturity levels of the technologies and services currently available.

The event brought together the demand and supply side of the value chain: i.e. users of RFI (Radio Frequency Interference) detection and spectrum use optimisation solutions, including the ITU and national regulators; ground-based commercial solution providers; space-based solution providers, decision makers and academia.

More than 80 participants attended the workshop in person (on-line participation was not made available). They included the ITU, National Regulators, satellite operators, commercial ground-based solution providers, space solution providers, ESA Directorates, MNOs, vendors, software solution providers and research institutions from 18 European countries.

The role of ESA in supporting how ESA may support its this ecosystem was explored.

2. STRATEGIC CONSIDERATIONS ON SPECTRUM USE: A PARADIGM SHIFT THAT REQUIRES EVOLVING INSTRUMENTS

Regulators and other users present recognised that spectrum management has never been more complex; this is due to the exponential multiplication of transmitters, sensors and receivers on ground, in air (drones, balloons, planes and so on…), and in space whether in LEO, MEO or GEO, leading to an increasing mesh of terrestrial and non-terrestrial connectivity, including D2D.

The responsibility of National Regulators and other decision-makers in this context is made harder by the need to reconcile sometimes competing imperatives; on the one hand, they need to protect the current licensees by offering a stable regulatory framework, ensuring a reliable environment for the delivery of critical services towards citizens and consumers. On the other hand, regulators need to make room for innovation and new services, all of which depend on spectrum availability in an increasingly crowded and limited space. The timing for regulatory and enforcement decisions is critical: act too early, to the detriment of stability; act too slow, with the risk of stifling innovation and investments.

Regulators and other users could therefore benefit from better knowledge of the usage of radiofrequency spectrum, leading to better decisions, in the interest of companies, governments and citizens, on the short and the long term.

3. USE CASES: INTERFERENCE IS FREQUENT, EVERYWHERE, AND IN ALL BANDS; SPECTRUM USE COORDINATION CAN BE IMPROVED

In terms of radio spectrum interference, various panellists outlined a steep increase in interference cases in the last few years. For example, 45% of the respondents to a questionnaire carried out by the Satcom Innovations Group (SIG) experience RFI at least multiple times a week. 75% of respondents report that over 40% of the time RFI is caused by human error. Deliberate interference as a very special politically-motivated case, increased after the Russian invasion of Crimea in 2014. All interference cases too require constant and time-consuming attention to log, characterize, geolocate, understand, report, escalate and manage incidents. Satellite operators have the choice to either accept the interference, work around it, or remove the affected customer altogether – i.e. the worst outcome for both operator and customer.

ESA's Directorate for Earth Observations presented the example of the protection from RFI of the ESA SMOS (Soil Moisture and Ocean Salinity) mission for the first 12 years of the mission. SMOS operates in a frequency band reserved for passive use of the spectrum, i.e. where all emissions are prohibited (see Footnote 5.340 of the ITU Radio Regulations). However, measurements showed a very large number of emitters present, with the potential to cause disruption to the SMOS data thousands of km away from the emitter's location.

RFI in SMOS can originate from a variety of equipment, such as airport radars, DECT phones, wireless cameras, etc. Even small equipment can cause significant RFI due to very high sensitivity of EO radiometers such as SMOS. In fact, while the background noise is a nuisance for communication systems, EO radiometers are able to measure tiny variations in that background noise, and extract geophysical parameters from those variations.

The SMOS team dedicated significant time and effort to detect, localise and report (via ITU) RFI sources. As a result, many RFI sources have been switched off. However, new RFI continuously appear. In the last couple of years, a significant increase in RFI contamination was observed near the Ukraine-Russia border and in Myanmar.

In terms of spectrum monitoring and inventorying in support for regulators, the monitoring ground stations currently used only measure the downlink occupancy of the allocated spectrum. For example, satellite downlink measurements by the Leeheim ground station showed a rather limited occupancy in certain mobile satellite bands over 24 hours, despite being fully occupied on paper. This means there are opportunities for increased use, making room for additional providers of spectrum-reliant services. However, ground stations are unable to monitor the uplink occupancy: airborne or space monitoring would be required for that. Consequently, we only have information about the downlink occupancy.

Further (and future) needs and challenges outlined during the event included multi-orbit interference and next generation antennas, including flat panel antennas. For instance, the SIG quoted the results of an ESA-funded project by Austrian companies Space Analyses and The Impressive Company Wanewewa which documented interferences between NGSO constellations which might lead to a reduced service availability. These problems are likely to be exacerbated in the context of the rise of Direct-to-device connectivity, where cellular and satellite systems will increasingly interfere, making it difficult to measure spillover from one satellite to another on the ground.

This kind of service unavailability caused by interference was considered critical for future use cases as well. Although they remain to be fully substantiated, panelists mentioned use cases for critical infrastructures, including airports, energy grids, disaster response services, and logistics and mobility sector as it moves to autonomous driving and connected devices and sensors more generally: any lapse in signal quality in those cases may lead to catastrophic consequences, such as crippling airports, putting energy grids at a standstill, blocking oversea shipping of critical goods and so on. In the PPDR sector, there is interest in quickly assessing the operational status of mobile networks in disaster situations. Monitoring 4G and 5G spectrum use by mobile networks is another use case of potential interest to investors in connectivity infrastructures.

4. ADDED VALUE OF SPACE: SATELLITE-BASED SOLUTIONS CAN COMPLEMENT AND ENHANCE EXISTING GROUND-BASED SERVICES

Having outlined the problems resulting from inefficient use of spectrum and RFI, panelists proceeded to discussing any limitations in current ground-based monitoring systems, as well as the possibilities for space to complement or enhance the current solutions. The following was concluded:

Most RFI and spectrum optimization measures today are reactive rather than proactive. The example of science missions operated by D/EOP showed, for instance, that many operate in frequencies used by other users – a reality to be accepted as such, a given. All the same, within the existing constraints, the value of very costly and strategic scientific missions benefit by early satellite-based inventorying and RFI measurements of frequencies intended for use, ensuring that calibrations and operations are undertaken in areas as clean of interference as they can be, around the globe.

Monitoring from space will add value when different mobile satellite systems use the uplink and downlink respectively of the same frequency, to monitor spill-over interference from one to the other. Satellite operators cooperate to coordinate their spectrum usage – but that assumes that they always find an agreement and there is a willingness to cooperate. In case of unresolved differences, there is no third-party source to substantiate claims in any direction. Satellite evidence could provide such a way to support interference claims in these instances. This kind of evidence is thus also useful to regulators when enforcing license policies. While the radio regulation rules cover these kinds of instances, in reality it happens that regulators do not have the means to verify that they are in fact applied. Knowledge of spectrum occupancy as complemented by space-based measurements and monitoring can improve spectrum management outcomes.

Furthermore, companies with plans to invest can themselves use such information when requesting spectrum access, by for instance deriving the parameters needed for a waveform to operate at or verifying emission power levels – by complementing theoretical assumptions with evidence derived from actual spectrum interference observations from space and ground.

When detecting ground interference sources, satellite solutions also play a role in reducing the perimeter of the likely location of the interferer, with the last mile of the identification to be carried out by other means – thereby improving reaction times and reducing costs. Satellites can also complement the large gaps in between ground monitoring stations. Moreover, at sea and in the absence of terrestrial coverage, satellite remains the only available means to detect interference. This is also of particular interest in PPDR (Public Protection and Disaster Relief): when terrestrial towers are down, satellite can offer a quick way to understand if any networks remain active and operational at all and potentially locating victims if their phone is still emitting, for instance.

5. GAPS AND FUTURE DEVELOPMENT AREAS: A DYNAMIC NASCENT INDUSTRY, BUT DEMAND AND SUPPLY HAVE YET TO MEET

The Clean Spectrum workshop featured a significant array of companies with interest in demonstrating the added value of space, in catering to the identified use cases, and more generally to this market. A number of them are already flying in-space capabilities and/or possess ground capabilities.

Nevertheless, this is still an emerging market: users and suppliers present equally declared that they whole stakeholder community would benefit from further exploring use cases, deriving and formulating requirements – those dictated by the integration of space solutions in the operational environment of the end-users as well as those of the ground-solution providers. A number of technologies will require further developments to be in line with expectations from fully operational mature commercial services by European providers in the civil domain.

Further development areas could concern, for instance, the requirement for 24/7 monitoring with global coverage, geolocation accuracy of up to 10m, furthering interference detection and classification techniques, and, leveraging other technologies such as AI or synthetic emulate/simulate environments to obtain a broader and more detailed view on spectrum occupancy, with a view to its optimal, sustainable use.

All these developments will benefit from a process of rapid feedback loops and agile testing involving the users themselves, as well as intermediary providers, i.e. commercial ground segment operators.

6. ROLE OF ESA: A NEUTRAL AND EXPERT ENABLER

During the event, panellists formulated the following wishes and expectations of ESA.

Acknowledging that bringing regulators, ground-based solution providers and space solution providers together was a useful first, and that these communities typically do not speak to each other, participants encouraged ESA to continue acting as a neutral and expert facilitator between them. They highlighted the role of ESA in making spectrum part of the reflection on space sustainability through such fora as this workshop.

Users acknowledged the need to evolve currently used tools and appreciated the potential of space-based solutions to help. In this context, they expressed interest in engaging with ESA to convey needs and requirements, to test and assessing new solutions based on space, and verify the paths for their eventual integration in their operational environment. Given the fact that the space domain is unfamiliar and a “new ground”, they called on ESA to act as a trusted and neutral partner in enabling this process, in particular acting as a facilitator of interactions with the supply side.

Space industry appreciated that the spectrum management domain presents a strategic emergent commercial opportunity, and invited ESA to continue opening doors to user communities, as a neutral facilitator. They acknowledged that the path to full technology maturation and fully operational, commercial services is still at an early stage: hence this is the very moment in the process where industry would benefit most from institutional and funding support as that provided by ESA, not only to mature technologies, ease

their way into the operational environment of users, but also more generally to solidify a European industrial base and a strategically critical capability of RFI detection and efficient use of spectrum.

7. WORKSHOP PARTICIPATING ORGANISATIONS

Aalyria,United, Kingdom

Aerospacelab, Belgium

Akkodis, Netherlands

Alén Space,Spain

Antwerp Space, Belgium

Commercial Satellite Spectrum Management Association, Luxembourg

Darwin Satcom, Spain

Detecon International Gmbh, Germany

Deutsche Telekom AG, Germany

EDGX, Belgium

Elettronica S.p.A., Italy

Elt Group, Italy

Ericsson,France

European Space Agency, Netherlands

European Space Policy Institute (ESPI), Austria

Finnish Transport And Communications Agency - Traficom, Finland

Fraunhofer IIS, Germany

GMV, Spain

GSMA, United Kingdom

Hellenic Telecommunication & Post Commission (EETT), Greece

Helsing, France

Institut Luxembourgeois De Régulation, Luxembourg

Integrasys Sa,Spain

ITU

Lasting Software, Romania

LEOBLUE, France

LOFT ORBITAL, France

MBI S.r.L., Italy

Mediatek, United Kingdom

Methera Global, United Kingdom

National Authority For Regulation And Spectrum Management - Ancom,Romania

National Media And Infocomunications Authority, Hungary

Norwegian Space Agency, Norway
Novamint, France
OFCOM, United Kingdom
OHB Group, Belgium
Ohb Luxspace, Luxembourg
Ohb Se, Germany
Orange, France
Quadsat, Denmark
Rohde And Schwarz Gmbh, Netherlands
Romanian Inspace Engineering, Romania
Satcoms Innovation Group, United Kingdom
Satelio IoT Services S.L., Spain
Sateliot, Spain
SES, Luxembourg
Space Norway As, Norway
Starion Group, United Kingdom
Startical S.L., Spain
TTP PLC, United Kingdom
Unseenlabs, France

8. PROGRAMME OF THE WORKSHOP

The workshop programme is available for consultation here:

https://connectivity.esa.int/clean-spectrum-driving-innovation-and-growth

9. ACKNOWLEDGEMENTS AND NEXT STEPS

ESA D/CSC is grateful to the workshop participants and especially the speakers, all of whose insights helped shape this reflection.

The conclusions of this event and upcoming, further stakeholder interactions, will feed ESA's reflection on new activities supporting the maturation of RFI detection and spectrum optimization, including the CleanWaves Initiative proposal at the ESA Ministerial Council of 2025.