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Strategic review of satellite and space science use of spectrum

EUMETNET response (August 2015)

Question 1: Do you have any comments on our approach to this review?

No

Question 2: Do you have any comments on our broad overview of the satellite sector set out in this section? In particular, do you have comments on the completeness of the list of applications, their definitions and their use of the relevant ITU radiocommunications service(s)?

The list of FSS applications misses mentioning the distribution of meteorological data and products that is nowadays key to disseminate weather, water and climate related information, including disaster warnings to meteorological agencies and user communities. These applications are made through commercial payloads in the Ku-band (10.7-11.7 GHz) in Europe and in the C-band (3 400-4 200 MHz) on a worldwide basis, including Europe. It has to be stressed that a large part of the population, in particular in developing countries, is heavily dependent on the use of C-band satellites in areas where propagation conditions (e.g. heavy rain in tropical and equatorial zones) make the use of any other telecommunication support impractical.

To this respect, it is an absolute requirement to maintain relevant fixed-satellite service capacity and availability in the 3 400-4 200 MHz and 10.7-11.7 GHz frequency bands to allow for these meteorological data distributions.

Question 3: Do you have any comments on our broad overview of the space science sector? In particular, do you have comments on the completeness of the list of applications, their definitions and their use of the relevant radiocommunication service(s)?

Under section 3.8, the definition of EESS is not complete. The sensors applications under the EESS (active) and EESS (passive) are duly mentioned but the EESS also encompasses communication links (uplinks and downlinks) between satellites and Earth stations that are missing in the description. In addition, the Meteorological satellite service (METSAT) is a subset of EESS and also needs to be mentioned.

Similarly, under section 3.9, the bullet "those which are active" should not be limited to measurements (i.e. sensors) but should also include EESS and METSAT communications links.

Also, under section 3.10 "active applications", the last bullet is quite misleading when talking about "*Space science data communications (near earth missions)*". Indeed, the appellation "*near Earth*" is specific to the Space Research service (SRS) and is not relevant to the EESS and METSAT services. This paragraph should be redrafted to make a clear distinction. Also, this paragraph should mention the fact that these links are used for both uplinks and downlinks.

Finally, in Table 2 under section 3.11, the METSAT service is not to be listed under "*passive applications*" but should be included in the last row "*space science data communications*" together with EESS and SRS.

Question 14: Do you have any comments on our representation of the value chain for the space science sector? How do you think industry revenues are broken down between players at different positions in the chain?

For meteorological activities, the value chain needs to distinguish between industry on the one hand (equipment manufacturers, launch providers and somehow Earth station operators) that is making revenues for its activities and, on the other hand, the satellite operators (e.g. EUMETSAT), the service, content/application providers and most of the users that do not make revenue since they are mainly public services funded by the governments, such as the ECMWF (European Centre for Medium-Range Weather Forecasts, located in the UK) and EUMETSAT, the meteorological national services (e.g. the UK MetOffice), defence departments, universities, ...

Question 15: What is the extent of your organisations' role(s) in the value chain? Which space science applications (as summarised in Table 2 in section 3) does your organisation use, provide or help to deliver? Please list all applications that apply and your role in each in your response.

EIG EUMETNET is a grouping of 31 European National Meteorological Services from Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, FYROM, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Luxembourg, Montenegro, Netherlands, Malta, Norway, Poland, Portugal, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland and the United Kingdom and 3 other cooperating countries, Bulgaria, Lithuania and Romania.

It provides a framework to organise co-operative programmes between its Members in the various fields of basic meteorological activities. These activities include observing systems, data processing, basic forecasting products, research and development and training. It helps its Members to develop and share their individual and joint capabilities through cooperation programmes that enable enhanced networking, interoperability, optimisation and integration within Europe and also to enable collective representation with European bodies in order that these capabilities can be exploited effectively.

Within the value chain, EUMETNET is to be consider as a service and content/application providers as well as user.

The European meteorological services make use, either directly or indirectly (through the activities of EUMETSAT or other space agencies (NOAA, NASA, JAXA, CMA, CSA, CNES…)) of applications within the EESS (data links), MetSat, EESS (active), EESS (passive) services as well as of the FSS and RNSS services:

- Reception of observation data to main reception stations (MetSat, EESS);

- Reception of pre-processed data through GSO MetSat satellites to meteorological user stations (EESS);
- Reception of un-processed observation data from NGSO MetSat satellites to meteorological user stations (MetSat, EESS);
- Reception of data dissemination of pre-processed data in FSS C- and Ku-Band;
- Active and passive microwave sensors from NGSO satellites (EESS (active), EESS (passive));
- Radio occultation systems using RNSS (mainly GPS).

One should also mention that European meteorological services make use of a number of other radio applications within the radiolocation services (weather radars, wind profilers) and meteorological aids services (Metaids such as radiosondes). Although not considered as space science services, these applications allow for in-situ atmospheric measurements that are essential for the calibration of measurements performed by satellites.

Question 16: For each of the space science applications you use, provide or help deliver (as identified in Question 15), and taking into account your role in the value chain, where applicable please provide:

- the specific spectrum frequencies used, distinguishing between the frequencies used for the science application, the frequencies use for downlinking data and, for TT&C;

See excel file embedded below :

Microsoft Excel
97-2003 Worksheet

- whether the application is limited to use of specific frequencies and why (e.g. due to fundamental characteristics of the phenomena being measured and/or availability of technology designed for that frequency);

By principle, all radio applications used for meteorology are performed in specific bands allocated to the corresponding service in Radio Regulations (RR).

Among of these, passive measurements represent a special case since they are made in bands allocated to EESS (passive) representing specific molecular resonance (water vapour, oxygen, …) that are dictated by law of physics. These frequencies cannot hence be changed or ignored, nor are these physical properties able to be duplicated in other bands. Therefore, these frequency bands are an important natural resource. To this respect, **RR N° 5.340** is an essential provision to ensure protection of these measurements and as such needs to be strictly applied by all national radio authorities.

Concerning EESS (active), it should be stressed that the history of measurements over long period of time within one specific band represent an important background element to understand and process the corresponding data. To this respect, any change of frequency for these measurements, although technically feasible in theory, could have important detrimental impact on the quality and availability of the data, in particular in climate change monitoring.

- whether the applications use continuous or intermittent measurements;

- the geography this use extends over (e.g. land or sea, and regional or global);

Meteorological activities for most weather, water and climate applications and services are dependent upon full global data coverage and availability in particular to feed Numerical weather prediction (NWP) models.

All measurements are hence performed on a continuous and global basis and disseminated globally to the numerous receiving Earth stations dispatched all over the world.

- the typical resolution and associated measurement bandwidths, including an indication of any implication for spectrum requirements;

This information are duly described in the corresponding ITU-R Recommendations and Reports from the RS and SA series.

- the location of the gateway station(s) for TT&C and downlinking data;

Not applicable for EUMETNET for TT&C, although indirectly through EUMETSAT activities.

For downlinking data, several hundred stations spread all over Europe and UK.

- the estimated number of users.

Beyond the fact that meteorological services benefit to the European and UK populations as a whole, meteorological services are essential for multiple economic and societal activities (agriculture, energy, transport, defence and security,…) and the safety of life and property. This obviously represent millions users from governments, policy makers, disaster management organisations, commercial interests and the general public.

Concerning radio stations per say, several hundreds of stations are deployed Europe-wide, see details in embedded Excel file above.

Question 17: For each of the space science applications you provide, please could you indicate how UK consumers and citizens benefit from their use? Where possible please also provide an indication of the scale of the benefits (either qualitatively or quantitatively).

Radio-frequencies represent scarce and key resources used by National Meteorological and Hydrological Services to measure and collect the observation data upon which analyses and predictions, including warnings, are based or processed, and to disseminate this information.

This meteorological process is to be seen as a global system, in particular through the WMO (World Meteorological Organisation) Integrated Global Observing System (WIGOS) and it is not possible to identify the benefit of each application and/or frequency band.

On a more global basis, it is necessary to highlight the conclusions of the European Union RSPG (Radio Spectrum Policy Group) Report and Opinion on "*A coordinated EU spectrum approach for scientific use of radio spectrum*" (October 2006) and of the Recent ITU-R Report RS.2178 on "*The essential role and global importance of radio spectrum use for Earth observations and for related applications*" (October 2010) :

> *"The considerable societal value of Earth observation can directly be translated into terms of societal weight and economic value of the radio-spectrum which is used for these Earth observation activities. Most of the data retrieved from the use of this spectrum are directly dedicated to the benefit of every citizen.*
>
> *Most of this societal value is incommensurable in financial terms, as it relates to preventing large losses of lives or threats to socio-political stability and security. Scientific use of spectrum has also a direct impact in many economic areas, which can be estimated, by producing spin-offs in technology and economic developments in energy, transportation, agriculture, communications, etc. The benefits thereof relate to society as a whole, may be difficult to foresee and may be realised over very long periods of time."*

More specifically, the WMO has estimated that overall economic benefits of modern meteorological services typically outweigh the national cost of maintaining such services by a ratio of as much as 10 to 1. This would represents several tens billions Euros every year for Europe only.

Finally, it can also be expected that these benefits will further increase taking into account enhanced forecast accuracy and warnings following observations and numerical models improvements, as well as the increasing vulnerability of our societies to weather and related hazards that are likely to be more frequent in our changing climate.

Question 18: From your perspective, what high level trends will affect the space science sector in the coming years?

There is a trend for increased accuracy of weather forecasts, climate monitoring and other meteorological products that, together with improvements of Numerical Weather Prediction (NWP) models, will lead to the need for higher measurement resolutions.

This will therefore lead to higher data throughputs from satellites that will have to be accommodated in bands where higher bandwidth are or will be available. This will also require the highest level of availability in bands used by sensors (active and passive) and hence the best efforts from national radio authorities to ensure their protection from interference.

Question 19: For each of the space science application(s) your organisation uses or provides, what are the a) current trends; and b) likely future drivers of demand for spectrum? Please include in your response:

> **- the scale of the demand drivers;**

- **the reason for additional demand (e.g. higher resolution radar data rates/bandwidth required) and whether this increased demand is for data delivery or for the taking of measurements;**

- **whether increased demand can only be met at specific frequencies and why;**

- **any variations in demand drivers by geography (i.e. regional or global), and why; and**

- **whether future demand is expected to be temporary or intermittent, and the reasons for this.**

In your response, please provide any evidence which supports your position on the drivers of demand (e.g. forecasts, studies and statistics).

The next generation of NGSO and GSO MetSat systems are currently under development by EUMETSAT and represent several Billions Euros of public funding by European countries to support future improved meteorological products performed by National Weather services (e.g. UK Metoffice) and the ECMWF.

These satellites will make use in full of the bands currently available for data downlinking under the Metsat and EESS services, namely the 7750 – 7900 MHz, 8025 – 8400 MHz and 25.5 – 27 GHz bands. It can also be noted that these bands will also be used on meteorological and EESS satellites developed by other space agencies (NOAA, NASA, CMA, …) which data will consistently be received by European weather services.

Considering the long development timeframe of such systems and their lifetime, representing all together several decades, it is of the highest importance that national radio authorities take these considerations into account to ensure the long term availability and protection of these frequency bands.

This long-term availability and protection requirements of course also apply to the frequency bands used for sensing, either active or passive (see embedded excel file), that are known to be driving the impressive progress made in the recent years in weather and climate analysis and forecasts, including warnings for dangerous weather phenomena (heavy rain, storms, cyclones) that affect all populations and economies.

In this context, the establishment of international programmes such as the Group on Earth Observations (GEO) and European Copernicus programme (European response to GEO) is to be highlighted (see in particular ITU-R Report RS 2178 and WRC Resolution 673 on "*The importance of Earth observation radiocommunication applications*").

From the initialization of GEO (and Copernicus) leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS), radio frequency protection has been recognized as a critically important issue for Earth observations, in particular in frequency bands where passive sensing measurements are performed. Early in the development of the GEOSS 10-Year Implementation Plan, the ad hoc GEO subgroup on data utilisation stressed a specific goal of the GEOSS initiative to ensure that these radio frequencies are protected.

The essential and important role of the GEOSS was clearly stressed at the Earth Observation Ministerial Summit (Cape Town, November 2007) in the so-called "Cape Town Declaration", raising in particular the necessity to ensure availability and protection of radio frequencies and welcoming, to this respect, the adoption of WRC Resolution 673.

At the exception of some EESS (passive) frequency bands above 200 GHz (already allocated of identified for passive sensing) that will start to be used by next generation satellites, there is no new requirements for bands used for passive and active sensing but the existing bands (e.g. passive bands at 1.4 GHz, 18 GHz or 24 GHz…. and active bands at 5 GHz and 13 GHz) are all currently used and will continue to be used in full and their availability and protection is essential.

Question 20: Taking into account the drivers you have identified in your response to Question 19 above, what (if any) challenges is your organisation concerned about in meeting potential future demand? Please provide the information by application and band, along with any supporting evidence, if available.

Without any doubt, the biggest challenge for EUMETNET and European meteorological services is to maintain availability and interference free of the bands currently or planned to be used by meteorological satellites from EUMETSAT but also other space agencies, either for TT&C, data downlinking and sensing (active and passive).

Facing the increasing pressure on radio spectrum from telecommunications operators and manufacturers, it is of the outmost importance that national radio authorities duly understand the requirements from the meteorological community that, although somehow less visible, represent as important economical and societal interests as those of commercial use of spectrum, and respect their commitments and obligations in term of frequency management.

These commitments from national radio authorities encompass spectrum policy decisions (e.g. at WRC or CEPT), market surveillance (e.g. 5 GHz RLAN vs meteorological radars) as well as interference management.

Recent experiences have shown that any wrong decision or lack of action in these fields can have tremendous impact on the availability of meteorological data and products and that it is far easier to take into account these potential impacts before making a decision than to try solving the difficulties when they appear:

- Numerous worldwide Interference events to the ESA satellite SMOS (passive sensing at 1.4 GHz) among which a number are still unresolved 6 years after the satellite launch,
- Large interference over the UK in the passive band 10.6-10.7 GHz that have not seen any evolution although the case was raised in 2006,
- Numerous and increasing cases of interference all over Europe (including the UK) from RLAN 5 GHz to meteorological radars mainly due to non-compliant RLAN equipment put on the European market without and that European radio authorities (ECC, EU, national radio authorities) currently fail to solve and do not show national that

Over the future years, EUMETNET will certainly appeal all national radio administrations and in particular OFCOM to take recent experiences into account in their decision-making process to avoid detrimental impact on our applications and activities, in particular for the essential availability of the 5350-5470 MHz band for EESS (active) and Copernicus programme (Sentinel 1, 3 and 6 series) or in strictly keeping the purely passive bands covered by **RR 5.340** free from interference, i.e. in supporting out-of-band mandatory limits in WRC Resolution 750.

Question 21: Are there any future developments, such as the radio astronomy SKA, that could reduce the demand for space science spectrum in the UK?

No

Question 22: Do you have any comments on the list of potential mitigations we have identified? What likely impact would each of the mitigations have on spectrum demand? To what extent do you believe that these mitigations apply only to certain applications?

On a general basis, EUMETNET and the meteorological community are well placed to talk about the difficulties related to the applications of mitigation techniques to improve sharing conditions pertaining to certain bands.

Indeed, over the last decade, following decision made at WRC-03, most European meteorological services, in particular the UK Metoffice, have experienced interference from RLAN 5 GHz to meteorological radars and such interference continues to occur, with obvious failure in the specification and/or application of the so-called "Dynamic Frequency Selection" mitigation technique by RLAN 5 GHz, expected to ensure protection of radars.

These experiences have shown how difficult it is to specify the detailed conditions pertaining to any advanced mitigation technique (as DFS) and it took several years and a lot of efforts to EUMETNET to ensure modifications of the ETSI standard EN 301 893 to include relevant DFS specifications compatible with meteorological radars wave forms.

To this respect, it is important to stress that to ensure a satisfactory solution, these modifications also imposed conditions on the meteorological radars operations and in particular limitations in their potential emitted signals, hence somehow freezing their future developments.

More critical, this situation has shown that most of the interference cases are due to non-compliant RLAN 5 GHz equipment, as depicted in ECC Report 192 and confirmed by an enquiry from the ADCO/TCAM highlighting a ratio of more than 50% non-compliant equipment on the European market, some of them even not implementing the required mitigation technique.

From the EUMETNET perspective, it seems that European radio authorities (ECC, EU, national radio authorities), including UK OFCOM, are currently unable to solve this problem and ensure compliance of RLAN 5 GHz with the regulations and relevant Standard. This is of high concern for the meteorological community, in particular with 5 GHz RLAN that are of a mass-market nature, hence leaving very low possibility for national radio authorities to locate the high number of non-compliant equipment and make cease all interference. To this respect, the current case of the Czech Republic as depicted in ECC Report 192 shows that the RLAN 5 GHz situation is definitively not anymore under control of the radio authority.

In this context, envisaging any new possible mitigation technique to share bands used by space science service (e.g. in the EESS (active) band 5350-5470 MHz) without proposing real solutions to solve the current non-compliance issues for RLAN 5 GHz would be incomprehensible and hard to accept .

Beyond this essential issue, specific elements in response to OFCOM consultation are given below:

Section 5.12:

this section is highly misleading since it gives the impression that spectrum used by space science is mostly exclusive. The situation is totally reverse, as mentioned in particular in ITU-R Report RS.2178, since most of the spectrum used by space science already achieves a significant degree of sharing with other services. Actually, only purely passive bands covered by RR 5.340 benefits of an exclusive usage, due to their very specific nature (molecular resonance). EUMETNET would be highly concerned if UK OFCOM was willing to impose sharing in these frequency bands.

The OFCOM consultation also gives the feeling that mitigation techniques should be developed only to allow commercial services to use spectrum of other services. To EUMETNET knowledge, most of the spectrum used by the commercial mobile service (e.g. 3G, IMT, …) is on an exclusive basis, tending to show that it is mostly unable to share.

Section 5.13:

- *Receiver filtering and new signal processing*

Interference free operations from space science services is essential and satellites and sensors are designed with high care taking into account the most advanced and up-to-date techniques, including improved filtering and new signal processing.

However, the implementation of any of such techniques should not be made to the expense of degraded data availability and quality.

- *global database*

This issue has already been discussed in length in the framework of WRC-15 agenda item 1.1 and the potential introduction of RLAN in the 5350 - 5470 MHz band. Although not finalised, the current status of this work in ITU-R WP5A depicts a number of challenges and unresolved issues. These elements are detailed in particular in attachment 7 of annex 8 of last WP5A chairman's Report (document 5A/736) but one can stress some key points:

  - The issue of non-compliant equipment (as mentioned above) is currently fully unresolved. If users currently tamper with DFS in existing bands, why shouldn't they do the same with the database, since the impact of repetitive switch-off of the RLAN operation will be an obvious constraint for users ?
  - One single or very few RLAN can interfere with an EESS sensor. Building upon the experience of interference to meteorological radars for which it takes long time to Administrations to find single RLAN sources (for long time interference) and for which Administrations are not able to locate sources for short-term interference, it appears that administrations will more than likely not be able to handle future potential interference in urban/suburban areas. Any interference will represent a dead-end for EESS (active).
  - Due to the global nature of EESS (active) measurements, such a database would require international overview and will have to be developed and maintained by a suitable international organisation taking responsibility for it. How to regulate such usage at international level ? Which international organisation will be responsible for the operation and maintenance of this database ? Who will pay for this task ? Who will be legally and economically responsible for interference and the related loss of data ?

- This database depends upon accurate localisation of all single RLAN (expected to be several hundred millions only in Europe). Which localisation mean could be used ? How to localise the indoor equipment ? How to make sure that users do not tamper with the system to fake their localisation ? Disclosure of the exact location of an equipment could also be against the law in number of countries.
- The database concept can only be ensured if all equipment are duly connected to the internet. How to impose this on a regulatory basis ? What about other types of Mobile applications (Peer-to-Peer, Video surveillance, …) ? Is this compatible with technological neutrality imposed in Europe ?

Overall, from the EUMETNET perspective, although interesting on a purely theoretical basis, the database concept does not pass the wall of reality and will not be able to ensure protection of space science services.

- *better coordination with other users*

Such coordination is typical for Metsat and EESS datalinks and has been successful over the time to improve sharing with terrestrial services or other space services, either civil or military.

On the other hand, such geographical coordination is not appropriate for EESS active and passive sensors that perform measurements on a global basis.

Question 23: What other mitigation opportunities do you foresee that we should consider? For what applications are these likely to be applicable and what scale of improvement are they likely to deliver?

As far as Metsat and EESS are concerned, EUMETNET does not foresee additional mitigation techniques than those currently implemented as part of satellite and sensor designs or frequency coordination as appropriate. In any case, mitigation techniques cannot be implemented by these systems to the expense of any degradation of the data quality and availability.

Concerning the other services, it is not the role of EUMETNET to propose mitigation technique, but, in any case, it would be totally illusive to consider any mitigation technique before proposing real solutions to solve the current non-compliance issues for RLAN 5 GHz.

Question 24: Beyond the activities already initiated and planned for the space science sector (e.g. as part of WRC-15), do you think there is a need for additional regulatory action that may, for example, help your organisation to address the challenges it faces?

In your response, please indicate what type of action you consider may be needed and why, including any evidence to support your view.

EUMETNET does not consider any need for additional spectrum, at least within a foreseeable future.

On the other hand, EUMETNET would require European national radio authorities and OFCOM in particular to ensure that current regulations are fully applied to preserve the availability of current frequency bands used by space science services (datalinks and sensing). This could require additional regulatory actions, either at WRC or ECC level.

Among others, ensuring interference free operations in passive bands covered by RR 5.340 bands is of the outmost importance and could require the specification of mandatory limits, consistently with WRC Resolution 750.

Also, working toward real solutions to solve the current non-compliance issues for RLAN 5 GHz should become a priority for European Regulators and OFCOM in particular.