ESA usage of the RF spectrum

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ESA and the UK

- The European Space Agency (ESA) is Europe’s gateway to space. Its mission is to shape the development of Europe’s space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.

- ESA is composed of 22 Member States.

- It started in 1964 as 2 separate organizations (ESRO and ELDO), that were later merged into ESA in 1974. The UK was among the founding countries of ESA.

- The current annual ESA budget is in the order of 4.5 BEuro. The UK is one of the main contributors to this budget.

- A new ESA centre (ECSAT) has been created recently in the UK in Harwell. ECSAT is focussing on new space applications.

Introduction and scope

- This presentation is intended to provide a high level view of the usage by ESA satellites and Earth stations of the RF spectrum in various areas and the main issues associated to this usage.

- All these activities are international by nature. This implies that the regulatory environment must be uniform internationally and no changes should be made by individual administrations in isolation without evaluating the impact of this to the international community.

- The satellite data are made available to users world-wide. Beneficiaries of these activities are governmental institutions as well as private industry exploiting the satellite data for commercial objectives.

Introduction and scope (cont).

- There is not a direct relationship between where a frequency band is used and who benefits from this usage. For example, not having an Earth station in a country doesn’t mean that the country should not be concerned by changes to the international regulations affecting those kind of stations. The result could be that the satellite data are not available anymore to the users world-wide. This should be kept in mind when viewing this presentation, since not all the frequency bands listed are necessarily used directly in the UK.

Note 1: This presentation does not include the aspects related to telecom satellites (FSS/MSS/BSS), since it would be outside the scope of this Workshop. Nevertheless it is to be stressed that, although ESA does not operate telecom satellite, it has also the mandate to promote the growth of a strong European telecom satellite industry. ESA is therefore interested in spectrum policies ensuring a suitable regulatory environment also for these satellite applications/services.

Note 2: The MetSat spectrum usage will be the subject of a different presentation by Eumetsat

Main application families

Space Research (SRS): Near-Earth and deep-space satellites.

TT&C + data transmission. Active/passive sensing only around planets.

Basic research of outer space. Some missions are in cooperation with other space agencies.

Earth Observation (EESS). Mostly NGSO polar satellites.

TT&C + data transmission. Active and passive sensing (atmosphere and Earth surface). Very large range of applications for scientists, governmental institutes, commercial companies. See the EU Copernicus web site http://www.copernicus.eu/ for examples of these applications.

Satellite data relay (Inter-satellite). Data relay between NGSO satellites and ground through a GSO satellite. Mainly Earth Observation data. EDRS project

Radionavigation by satellite (RNSS). Galileo project

Space Operations in general (SOS). Launchers control and other special applications

Satellite Telemetry, Tracking and Control (TT&C)

Main bands used for TT&C:

S-band (2025-2110 MHz up and 2220-2290 MHz down). TT&C for all the EESS missions, the Galileo satellites, EDRS, the launchers and legacy SRS missions.

Sharing with other services: Consolidated coordination procedures with FS, but criticality for coordination with mobile systems (e.g. ENG). Coordination among satellite users is complex because of the large number of filings (>1000) in this small band couplet. SFCG is providing a good mechanism for informal coordination among agencies. Nano-satellites in the future?

Main threat: Mobile systems replacing fixed systems in these frequencies. JTG concluded that sharing with high-density MS is not feasible. But also low-density MS systems may be critical.

X-band (7145-7235 MHz up and 8400-8500 MHz down). TT&C for all SRS missions interleaved with payload data. Bands segmented between SRS near Earth and deep space.

Sharing with other services: Similar situation as for S-band. Coordination among SRS users is a bit easier than for S-band because of the lower number of satellites operating here. But missions sharing common planetary targets (Mars, Moon) present coordination difficulties. Here too SFCG plays a central role in coordination.

Main threat: MS systems replacing FS and new telecom satellite allocations.

Satellite Telemetry, Tracking and Control (TT&C) (cont)

Ka-band 1 (22.55-23.15 GHz up, 25.5-27 GHz down). TT&C for some SRS missions requiring large data uplink and/or downlink capability, interleaved with TT&C functions.

Recent allocation, not yet exploited in full.

Sharing with other services: Similar considerations as for the X-band.

Main threat: Mobile systems replacing fixed systems in these frequencies. Improper use of the downlink band by commercial telecom satellites.

Ka-band 2 (31.8-32.3 GHz down and 34.2-34.7 GHz up). TT&C for SRS deep space missions requiring large data uplink and/or downlink capability interleaved with TT&C functions.

Sharing with other services: No criticality so far. But new services targeting these bands.

Q-band (37-38 GHz down and 40-40.5 GHz up). Currently used mainly for propagation studies, but planned to be used for future manned missions to the moon and beyond.

S-band deep space (2110-2120 MHz up and 2290-2300 MHz down). This band is now usable only in a few countries after the introduction of IMT in 2110-2120 MHz. Used by ESA only for some legacy missions.

Satellite payload data downlink

Main bands used for satellite payload data downlink:

S-band (2025-2110 MHz up and 2220-2290 MHz down). Used for EESS payload data downlink in combination with TT&C function. Only for missions with very limited payload data rate requirements. Otherwise used for TT&C only.

X-band SRS (7145-7235 MHz up and 8400-8500 MHz down). Used for SRS payload data downlink in combination with TT&C function. Bands segmented between SRS near Earth and deep space.

X-band EESS (8025-8400 MHz) Used for payload data downlink by nearly all the EESS satellites. Coordination in this frequency among EESS satellites is becoming critical because the earth stations are concentrated in certain areas.

Ka-band (25.5-27 GHz). Planned for use by EESS and SRS satellites with very large data rates requirements. Usage of this band is still limited at the moment, due to the need to develop the related terrestrial infrastructure. But substantial increase of usage is expected in the future.

Inter-satellite links

Main bands used for inter-satellite links:

S-band (2025-2110 MHz forward and 2220-2290 MHz return). Used for controlling NGSO satellites when not in visibility. Used also for some rendez-vous and docking operations.

Ka-band (22.55-23.55 GHz forward and 25.25-27.5 GHz return). Used for large data exchanges with NGSO satellites. It is to be noted that the usage of the return band is limited to EESS and SRS applications, but this limitation tends not to be respected by some satellite operators.

Main coordination and regulatory issues.

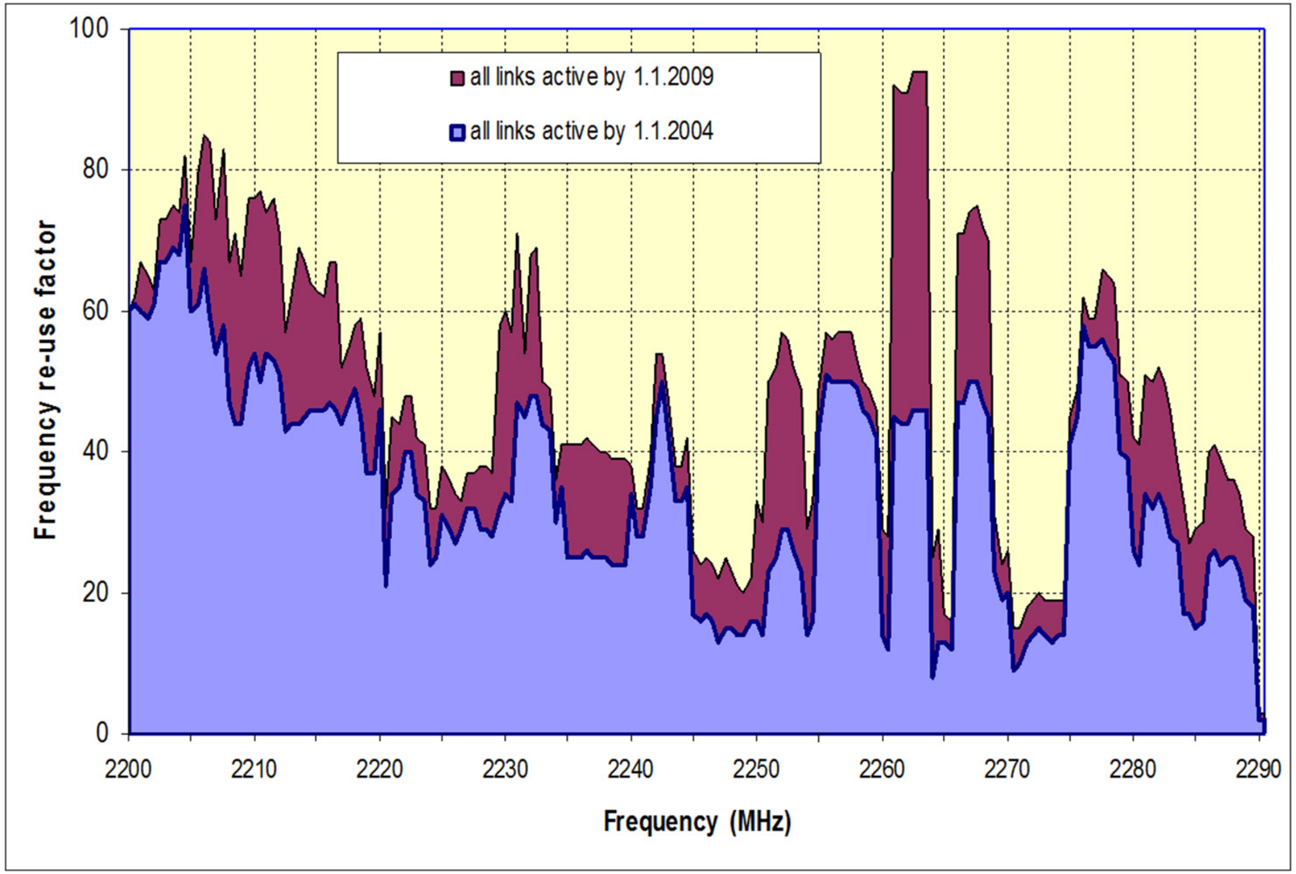
1. The main threat to the protection of the ESA **Earth stations** (TT&C and data reception) is represented by the **difficulty in coordinating with terrestrial mobile systems**. Because of their mobile nature, the well established coordination mechanisms used for the FS systems do not work. While a mobile system may implement techniques for detecting another interfering system and hopping to a different frequency, this doesn’t work for an Earth station receiving data from a satellite.
2. **The concept of an Earth station licence is not uniform across administrations**. Some administrations associate to the licence for an Earth station the verification that the relevant frequencies are protected from other nearby users. But others do not grant receiving licences and consequently do not offer any associated protection guarantee. In other cases a formal licence is offered, but any post-launch coordination issue is left to the involved parties to be solved. Only the first situation is suitable for ESA planning of future missions.
3. For what is relevant to the **coordination among satellites**, while the SFCG is offering an effective mechanism to coordinate among space agencies, only the ITU mechanism is left for coordinating with all the other satellite users. This mechanism is not working very well because of the lack of information typical of many API sent to the ITU. If the large number of nano-/pico-sat or the recent very large satellite constellations will start using some of the very crowded bands (e.g. 2 GHz), the situation may quickly degrade. These users will be out of the SFCG control and, in some cases, may not even be known to the ITU.

Main coordination and regulatory issues (cont)

4. **Different regulatory environments in different countries** create problems to international services like the ones provided by ESA. If, for example a given country has national limitations on the satellite usage of a given frequency band or of part of it, the mission designers cannot use an Earth station in that country. This because otherwise they would not be able to use that band for the same satellite at any other Earth station in the world.
5. In view of the many new filings associated to nano-/pico-satellites as well as to large NGSO constellations, it would be useful if administrations ensure that the relevant API's contain **the maximum level of accurate information** and refuse generic filings covering all possible design options.
6. ESA has noticed a number of attempts of using bands allocated to EESS or SRS for satellite applications that do not belong to those services. It would be very useful if administrations exercise a good control on their filings (and those of other administrations) to **ensure that the service allocations are respected in full.**

Main coordination and regulatory issues (cont)

2200-2290 frequency range reuse factor



Satellite RF sensors

EESS and SRS satellite RF sensors can be:

Passive: reading low natural radiations from the Earth surface or the atmosphere or

Active: reading the reflection of pulse trains generated by the satellite and interpreting the distortions introduced by the reflecting elements on the surface or in the atmosphere

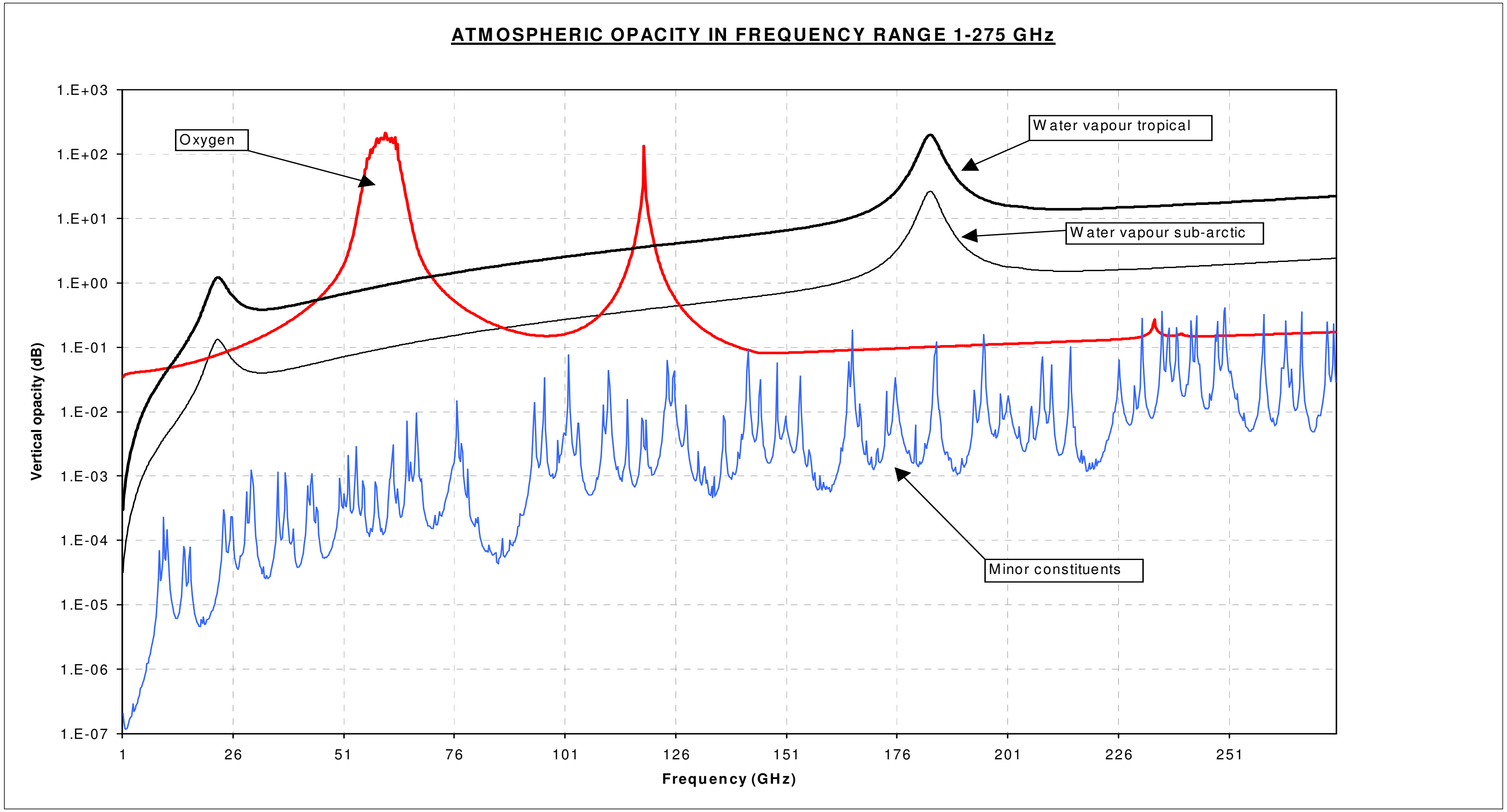
The **SRS sensors** are not discussed here since they operate on or around planets and therefore do not present sharing issues.

The **EESS passive sensors** must operate at given frequencies where the natural radiations happen. The measurement resolution is linked to the bandwidth available for signal integration.

The frequencies required for **EESS active sensors** are linked to the degree of Earth surface penetration required by the application. Low frequency sensors allow measurements like biomass or ice sheets. Higher frequency sensors are more oriented to all-weather Earth surface imaging.

It is not possible to establish real priorities among the satellite sensing frequency bands, because of the vast range of different applications. Surely the oxygen and water bands for passive sensors and the C-, X- and Ku-bands for active sensors are the first essential bands to be protected, but there are many other bands that provide very useful information not just for science but also for our daily life.

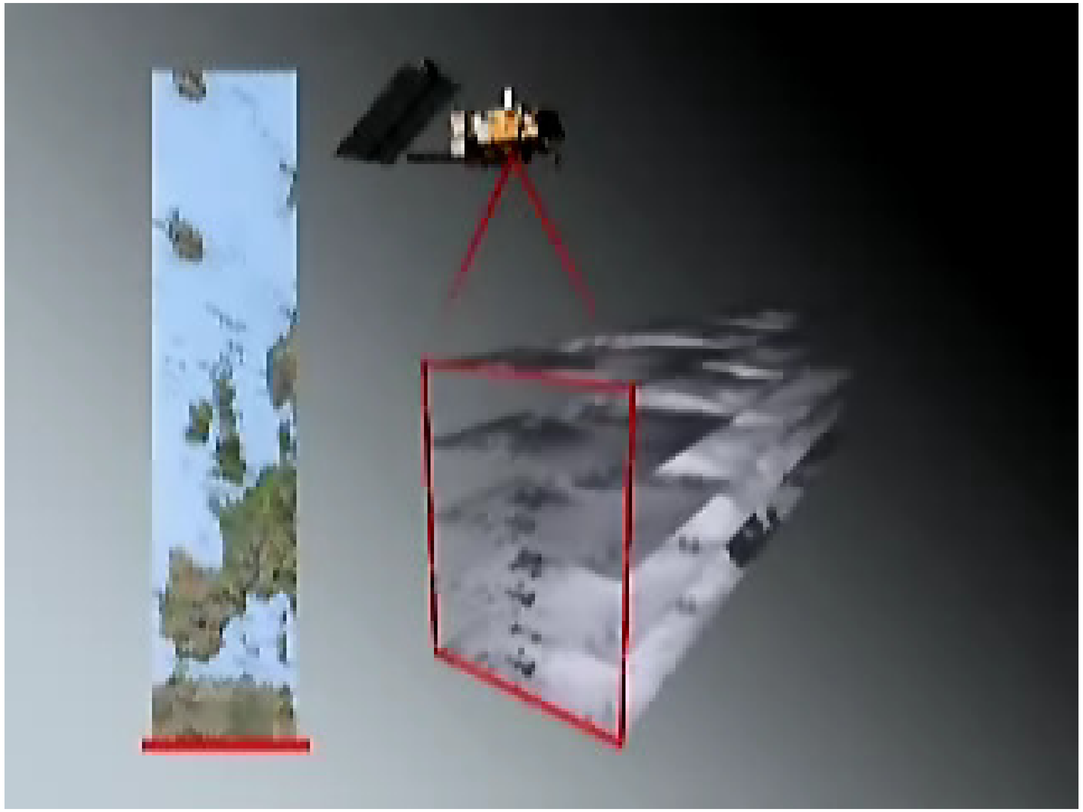
Atmospheric opacity curves



EESS passive sensor example

Multi-frequency scanning
for MetOp MHS sounder.

Reading natural microwave emissions.



Example of active sensor

Sentinel SAR

Sending a train of pulses and reading the "rebound".

Satellite RF sensors (cont)

Main frequency management considerations about satellite RF sensors

1. Non-natural emission by active systems may distort the sensor measurements.
2. A passive sensor has no means to distinguish natural emissions from non-natural man-generated interference, unless the interference is so strong to result in an out-of scale value and the measurement is therefore discarded.
3. RFI to an active sensor can be partly mitigated only if the interference source is a single signal. Multiple RFI sources in the footprint cannot be mitigated and result in distortions.
4. In general distributed sources of interference are a major hinder to RF sensing.
5. Given the very low levels of the measured signals, also unwanted emissions from adjacent bands may play a role.
6. Given the technology evolution, the trend is for higher resolution sensors for new applications. This implies higher sensitivity to interference.
7. Many of the EESS applications require global measurements that can be achieved only if all administrations ensure the protection of these measurements over their territory. In other words, satellite sensing, even if not associated to any national licencing process, should be protected for the interest of all countries.

Conclusions

Conclusions

- ESA is using a large and diversified range of frequency bands. The usage of these bands is optimized for getting the maximum exploitation of the available bandwidth.
- The number of users for some of the key bands is quickly growing.
- Protection of the existing allocations is the main target rather than new allocations
- The protection of these bands is essential for guaranteeing the availability of the satellite data to the many users (governmental, commercial and, indirectly, common citizens).
- National regulations differing from the ITU RR represent a serious problem/threat. Our services are of international nature and must be able to operate world-wide.
- New regulatory trends like spectrum dynamic usage can, in many cases, lead to unmanageable sharing scenarios for our satellite systems.

Conclusions

Questions?