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Electronic Communications Committee **WG SE**

88th WG SE meeting

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Source:	**CRAF**
Subject:	**Aggregate interference into RAS bands**

Group membership required to read? (Y/N) N

Summary:

In the Liaison Statement SE(21)025, FM44 informs WGSE about some of the aspects of protecting RAS from aggregate emissions from satellite constellations. In Item 3 of this LS, FM44 expresses the potential need for a new <5% trigger based on measurements by RAS or satellite monitoring stations. Furthermore, FM44 requests technical analysis on the feasibility of this method.

Considering that:

1. The number of satellite networks planned to operate during the next decade is enormously increasing (Not only for S-PCS systems but also for other types of FSS and MSS networks).

2. Assigning frequencies to a service or licensing a system is mainly based on studies seeking to prevent interference to the other incumbent services. Preventing interference based on monitoring cannot be the most efficient method given that the potentially offending systems will be already launched and fully operating by then. Once satellite systems are deployed it is very difficult to remedy interference.

3. Most radio telescopes are mechanically not able to track low earth orbit satellites for monitoring measurements and cannot dedicate the significant amount of observing time and resources needed for this purpose. It is also noted that there is still an absence of an agreement on a common satellite monitoring approach at CEPT.

4. Recommendation ITU-R RA. 1513-2 defines a data loss limit (5%) from aggregated interference that the RAS has to accept. However, no clear procedures have been established on how to implement this and whether it is by a first come-first served basis or via a consensus on mitigation measures from all the networks generating the interference.

5. While satellite filings are done at ITU-R level, aggregated effects (even from satellites) are often a regional consideration, e.g. a Region 2 or 3 satellite service would rarely generate interference into a Region 1 RAS receiver. At the same time, it will invariably be more than a simple national concern as the beams of the satellites, or their side lobes, are likely to illuminate wide areas that

can reach neighbouring countries (especially for the CEPT case).

Proposal:

- Initiate studies through a new work item to develop a Toolbox/Report/Recommendation to define a methodology to assess the aggregate effect of satellite systems into existing RAS bands/stations in Europe. These studies could be the driver towards introducing the suitable regional regulations and procedures to keep the aggregated interference levels below the 5% threshold.

Background:

1. Without any possibility of terrain shielding, interference from satellite systems can be particularly harmful for radio astronomy observations. Line of sight distances to Low Earth Orbit is in the order of thousands of kilometres, and while the main beam of a satellite might not be directly pointing towards a radio astronomy station, due to RAS sensitivity it can be equally susceptible to transmissions from the sidelobes of satellite antennas, this renders the protection of the RAS from satellites a cross-border issue in most of the cases. The rapid increase in deployment of satellite systems in low Earth orbit use (especially of large satellite constellations) highlights the need to consider aggregate interference into RAS frequency bands.

2. Satellite system compatibility with other services is often studied by means of the so-called equivalent-power flux density method (EPFD, see Rec. ITU-R M1583-1), in particular when systems with a larger number of satellites are involved. The EPFD methodology not only pays attention to the transmitted power of one individual satellite but incorporates the statistical distribution of satellites over the victim receiver (with varying distances), the different pointing position that the receiver can have (impacting the Rx gain), and the fact that the effective antenna gain of the satellite with respect to the receiver station depends on the geometry, which changes with time. The aggregated, i.e., sum of all received power contributions is then compared with the RAS thresholds (Rec. ITU-R RA.769-2). For the power received from all satellites of *a single system*, a data loss of 2% has to be accepted by the RAS, while *for all systems in a given band*, the aggregate power must not exceed 5% (Rec. ITU-R RA.1513-2).
The EPFD cannot be measured directly in practice, as the RA.769 levels are very low: an interferer must not add more power than 10% of the radiometric noise of a cryogenically cooled receiver after 2000 s of integration. This is very low threshold but necessary to avoid an impact of the interference onto the astronomical measurements, which are often of statistical nature as the cosmic signals of interest can have tiny power levels.
If – for simplicity – it is assumed that an interferer could be detected and identified when it produces a signal with 5 x the standard deviation above noise floor, it follows that to detect a signal that has 10% of the noise after 2000 s, one must integrate 2500 x longer, i.e., 1388 hours. While this may theoretically be possible, it is completely impractical for a number of reasons. First, to our knowledge there is no equipment, which provides the necessary stability over such a long time period (e.g., by means of Allan variance). Second, the observatories are over-subscribed, i.e., even today there is a much higher demand for observing time than actual time available. Such an enormous amount of time for an EPFD in-situ measurement would effectively deny the station's primary purpose: radio astronomical research and would not be acceptable for the astronomical community or the public funding agencies of radio astronomical research. It is noted that the same arguments would also apply for a satellite monitoring station. This is why satellite measurements

can only be performed as PFD measurements, where a single satellite is tracked with the main beam of the monitoring station for a given period. With several individual PFD measurements, which allow us to estimate the typical distribution of conducted powers at the satellite antenna port, one can then feed an EPFD simulation.

3. Satellite PFD measurements cannot usually be performed by RAS stations. Most of the larger satellite constellations, which are relevant for the RAS, are operating in low-Earth orbit. The angular speeds of individual satellites are too high to be tracked by a large RAS antenna, because the mechanical structure and telescope drives are not meant for those velocities. But even if a RAS station was able to track a satellite, it would again directly compete with astronomical observations. CRAF is of the view, that a better use of the (expensive) facilities can be achieved, if satellite monitoring is left to monitoring stations and astronomical observations are left to RAS telescopes.
4. Due to the impossibility of performing hardware modifications, and the safety/reliability issues with firmware modification of in-orbit satellites, early detection of potential interference through simulations is critical in satellite systems. CRAF is of the view that while measurements are a very important tool for controlling and enforcing regulations, compatibility studies (with proper understanding of the assumptions and limitations they have) should be the considered as the fundamental tool to ensure an efficient and interference free use of the radio spectrum.