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COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS
Board on Physics and Astronomy
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The Honorable Reed E. Hundt, Chairman
Federal Communications Commission
1919 M St., NW
Washington, DC 20554

Re: ITU-R Task Group 1-3 and Actions Affecting Protection of Radio Astronomy from Spurious Emissions

Dear Chairman Hundt:

This letter is written to express serious concern on the part of the National Research Council's Committee on Radio Frequencies (CORF) regarding an apparent weakening of the U.S. position on protection of the Radio Astronomy Service and other passive services from interference by spurious emissions of radiation, particularly emissions from satellites.[1] CORF's members are users of the Radio Astronomy Service, the Earth Exploration-Satellite Service, and the Space Research Service, and its concerns are shared by other users of the radio spectrum engaged in scientific research.

In this letter CORF recommends that the U.S. position ensure protection of the Radio Astronomy Service and other passive services at the required levels and that the U.S. position oppose relaxation of the limits on spurious emissions from the space services. The FCC is holding a meeting today on the U.S. position on issues under consideration by Task Group 1 of Study Group 3 (TG 1-3) of the International Telecommunication Union Radiocommunication Sector (ITU-R), and, with the prospect of a rapid increase in satellite system deployment and use, the need for action is critical.

The background and CORF's recommendations for action are described below. If you have any questions, please contact Dr. Robert L. Riemer, Senior Program Officer for the Committee on Radio Frequencies, at 202-334-3520 or at bpa@nas.edu.

BACKGROUND

Importance of the Radio Astronomy Service and Other Passive Services

Radio astronomy has produced many advances in our knowledge of the universe over the past three decades. These advances have covered every field of astronomy, from planetary science to studies of galaxies and quasars, and even the investigation of the cosmic background radiation-the radiation from the expanding universe about 150,000 years after the Big Bang. Through the use of radio astronomy, scientists have recently discovered the first planets outside our solar system. The 1993 Nobel Prize in physics was awarded to two radio astronomers for the detection of a binary pulsar and for using the data from that discovery in a manner that constitutes the most powerful validation to date of Einstein's theory of general relativity and gravitational radiation. In addition, radio astronomy has fostered a number of important technological developments (such as advanced receiver designs and signal processing techniques) that also find application in other fields. Passive radio studies of the Earth have similarly provided substantial advances in the science of our planet (such as monitoring the weather and climate) and the development of important new technologies.

Vulnerability of the Radio Astronomy Service to Interference from Satellite Transmissions

Because signals received from the cosmos are extraordinarily weak-usually less than a trillionth of a watt-radio astronomy requires the use of extremely sensitive receiving equipment. Thus radio astronomy systems are especially vulnerable to interference, and the levels of power at the threshold of degrading signals for radio astronomy are commonly 50 to 60 dB lower than those that interfere with communications services. In past decades, radio astronomers have been able to avoid interference largely by siting observatories in remote locations and taking advantage of the natural shielding from terrestrial transmitters provided by mountains. Unfortunately, this approach provides no protection from satellite transmissions, since line-of-sight propagation occurs from any satellite above the horizon. Radio astronomy cannot share frequencies with downlink signals from satellites, a fact that has been recognized in the frequency allocation process.

However, in numerous instances radio astronomy bands are adjacent to, or are only narrowly separated from, satellite downlink bands. In several cases the result has been actual or potential serious interference with radio astronomy systems. Examples of sources of such interference include the following:

- The Russian GLONASS satellites in the 1660-1670 MHz radio astronomy band;
- A broadcast satellite of Luxembourg that now prevents European observatories from using the 10.68-10.7 GHz radio astronomy band; and
- A U.S. multisatellite system to be launched imminently. Without special filtering, interference in the 1610.6-1613.8 MHz radio astronomy band will exceed for significant periods of each day the threshold of detrimental interference at major observatories.

In all of these cases, interference with radio astronomy systems is caused by spurious radiation that is emitted outside the band allocated to the satellite service. The cause of the spurious emission is either the use of digital modulation with sharp transitions between levels or intermodulation resulting from the nonlinear behavior of power amplifiers carrying several signal channels. These problems are exacerbated by satellites' inaccessibility after launch, and the resulting difficulty in mitigating interference when it occurs. Thus, spurious emissions from satellites pose a serious threat to the Radio Astronomy Service and to passive services in general.

REGULATORY ACTIVITY AFFECTING RADIO ASTRONOMY

Opportunities to Revise Regulations on Spurious Emissions

The increasing threat to radio astronomy from interference from spurious emissions has been recognized, and an opportunity to revise the regulations on spurious emissions was provided by amendments to ITU Recommendation 66 made at the World Administrative Radio Conference in 1992 (WARC-92). Revision of Appendix 8 of the Radio Regulations and Recommendation ITU-R SM.329-6, both of which are concerned with limits on spurious emissions, has consequently been initiated through TG 1-3. Recommendation 66 specifically states that interference from spurious emissions affecting the Radio Astronomy Service and the passive services should be taken into account in these activities.

The TG 1-3 held its third meeting in Sunnyvale, California, in 1995. Those attending the meeting appeared to be satisfied with the levels proposed for the general limits on spurious emissions,[2] including emissions of the space services, of 43 dB + 10 log P (watts), or 70 dB, whichever is less stringent. Full protection for radio astronomy requires levels of spurious emissions in the range from 20 to 40 dB lower than the proposed limits, but radio astronomers realize that such comparatively stringent levels may not be practicable as general limits on spurious emissions. Nevertheless, limits at the levels proposed in the third meeting provide some protection to the passive services in cases where there is sufficient separation in frequency between the transmitting service and a passive band. Protection is provided because the proposed limits establish a maximum level for spurious emissions close to the allocated band of the transmitting service, and the level of spurious emissions generally decreases further as frequency separation from the transmitter frequency increases.

Importance of Limiting Broadband Spurious Emissions

CORF emphasizes, on the basis of its members' experience with interference from satellite emissions, that in almost all cases the interference is of a broadband nature, i.e., spread over tens of kilohertz to many megahertz. For such emissions, the spectral power density (W/Hz) is the important quantity, and for radio astronomy bands this quantity must be kept as low as possible.

Recent Actions of Task Group 1-3

At the fourth TG 1-3 meeting in Paris in 1996, a special exception was proposed for the space services, for which the specified power limit was increased relative to the general case by up to 20 dB, and the measurement bandwidth was reduced from 1 MHz to 4 kHz. Thus for these services, the limit for narrowband interference was increased by up to 20 dB, and the limit for broadband interference (in terms of W/Hz) was increased by up to 44 dB (20 dB for the power level change and 24 dB for the bandwidth change).

The special exception proposed at the fourth TG 1-3 meeting comes close to an abandonment of regulation of spurious emissions from the space services and is inconsistent with the levels that would provide protection of the passive services. It is not clear whether such drastically weakened limits are acceptable within the U.S. position on spurious emissions, but no serious objection was raised by the U.S. delegates at the meeting.

Because of the broadband nature of spurious emissions from satellites, CORF notes that a decrease in the measurement bandwidth to 4 kHz, without a commensurate increase in the required attenuation, would permit levels of interference that would present serious problems for radio astronomy. On the other hand, an attenuation equal to that of the present FCC standards, but measured in a bandwidth of 100 kHz, would result in a limit of 93 dB W/Hz for broadband spurious emissions. CORF believes that this can be achieved by current engineering practice. Thus, CORF recommends strongly that, if there is to be any decrease in measurement bandwidth, the resulting bandwidth should not be less than 100 kHz.

THE NEED FOR STRONG U.S. SUPPORT FOR PROTECTION FOR THE RADIO ASTRONOMY SERVICE

The Proposed U.S. Position

CORF understands that the proposed U.S. position is based, at least in part, on the principle that limits on spurious emissions should be used to prevent only the very strongest unwanted radiation. With this approach the limits would not be set low enough to provide general protection against interference between the space services and the passive services. CORF understands that additional measures to prevent interference between the space services and the passive services would be necessary, and these measures would be based on a study of each particular case. CORF is seriously concerned by this position because it is not clear that measures other than limits on spurious emissions can be found for protection of radio astronomy. Further, even if such measures can be found and implemented domestically, U.S. radio astronomy observatories could still suffer from interference from satellite systems registered by administrations unwilling to implement additional protection measures.

Impracticality of Other Measures for Protecting Radio Astronomy

With line-of-sight propagation from a satellite to an observatory, the only means of preventing reception of spurious emissions by radio astronomy antennas is by reducing the gain of the sidelobes. Indeed, there is a strong research motivation for radio astronomers to do so because it improves their observational results. Modern radio astronomy antennas are already built with reasonable attention to sidelobe levels, and in any case the best that can be achieved by this approach is an improvement on the order of 6 dB, which is too small an improvement to provide effective protection.

Time-sharing schemes based on the transmit/receive cycle of an interfering communications system may require blanking the radio astronomy receiver many times per second. In general, time sharing is an expensive and inefficient technique for avoiding the effects of spurious emissions and should be used only as a method of last resort. Radio astronomy systems incorporate switching sequences (e.g., switching between a beam and a calibration source, switching between different beams, or phase switching of interferometer fringe patterns) that are fundamental to their operation. Adding yet another layer of externally defined switching is difficult and in many cases is not practical. Effective time sharing would also involve suspending or curtailing operation by the interfering service for periods when radio astronomy observations were in progress.

Changes in frequency allocations of space service downlinks that are close to radio astronomy bands, to provide more spectral separation, could also be helpful in reducing interference, but changes in existing allocations would be very difficult, if not impossible, in most cases because of the investments that all users of the spectrum have already made. Thus it is difficult to envisage acceptable methods for protection of radio astronomy from spurious emissions that do not involve the use of some form of limits, at least within radio astronomy bands.

Conclusion and Request for Action

In conclusion, CORF finds that the proposed relaxed limits on spurious emissions from the space services developed at the Paris meeting of Task Group 1-3 present a serious problem for radio astronomy, particularly with regard to the 4 kHz measurement bandwidth. CORF strongly urges that the FCC support a U.S. position limiting spurious spectral power density to a level not greater than 43 dB W measured in a bandwidth of 100 kHz (or 57 dB W measured in a bandwidth of 4 kHz). For high-power transmitters, the required attenuation should be at least equal to the FCC's present limit of 70 dB on the space services.

CORF requests a clarification of the position to be taken by the United States on these matters at the next (fifth) meeting of TG 1-3, including the range of limits in power and power spectral density considered acceptable for protecting radio astronomy. At the least, the United States should support limits for spurious emissions from the space services that are no less stringent than the current FCC standards.

Moreover, if adoption of TG 1-3's proposed relaxed limits on spurious emissions from the space services is contemplated, CORF requests some demonstration and assurance that effective additional measures for protection of the Radio Astronomy Service from spurious emissions from satellites can be identified, that their effectiveness and practicality can be demonstrated, and that they can be widely implemented.

Lack of protection of the Radio Astronomy Service and other passive services from spurious emissions would seriously threaten scientific fields in which the United States has earned and maintained a position of leadership over the past three decades.

Sincerely,

Michael M. Davis
Chair
Committee on Radio Frequencies

cc: Scott Harris, Esq.Ms. Cecily C. Holiday, FCC
Mr. Richard Lancaster, NTIA
Mr. William Luther, FCC
Mr. Tom Tycz, FCC
Paul J. Feldman, Esq.
Dr. Donald C. Shapero, NRC
Dr. Robert L. Riemer, NRC

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[1] Spurious emission can be defined as emission at frequencies removed from the center frequency of the transmitter by more than 2.5 times the necessary bandwidth.

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[2] The official draft statement defines the level as the minimum attenuation (dB) below the power provided at the antenna transmission line. The minimum required attenuation is normally measured in the following resolution bandwidths:

1 kHz between 9 kHz and 150 kHz
10 kHz between 150 kHz and 30 MHz
100 kHz between 30 MHz and 1 GHz
1 MHz above 1 GHz

These bandwidths can be adjusted for measurement of spurious emissions as required to account for special modulation and emissions, particularly those that have a desired signal bandwidth very close to the spurious emission bandwidth.
