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Before the
FEDERAL COMMUNICATIONS COMMISSION
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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the matter of

Proceeding to Address Satellite	)	DA 99-2601
Network Unwanted Emissions	)	RM-9740

COMMENTS OF THE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Administration ("NASA") hereby submits its comments in response to Public Notice DA 99-2601 addressing satellite network unwanted emissions.

Summary and Recommendations

NASA has reviewed the above mentioned Public Notice, as well as the comments received by the Commission as of December 20, 1999 and provides the following comments:

NASA believes that the Commission should refrain, at this time, from issuing an NPRM on this subject for the following reasons:

1. The Administration (NASA) is concerned that precipitous relaxation of the Commission's rules on unwanted emissions from satellite networks could result in harmful radio frequency interference thereby jeopardizing the safety of our Astronauts aboard the Space Shuttle

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and International Space Station as well as compromising data gathering and operation of other critical scientific and operational NASA missions.

2. Important international and national studies are currently in progress (TG 1/5, e.g.) to develop the needed technical bases for making informed decisions regarding the regulation of out of band emissions. It is important that the US remain cognizant of these activities prior to formulating long lasting resolutions.
3. It is likely that the WRC-2000 will address this issue and related issues. It would appear prudent for the Commission to avail itself of these deliberations.

In their responses to the Commission's Public Notice, NASA notes that several of the commenters in this proceeding have voiced similar concerns and have presented a number of ideas which appear to be reasonable from NASA's perspective. These are:

a) Most of the commenters stated that radio services must be protected from interference and that in-band operations should not be unduly constrained.
b) CCI International N.V. and Globalstar L.P. argued that no rulemaking procedure should be undertaken until after the ITU-R and WRC-2000 have concluded their deliberations.
c) Several commenters concluded that no decisions should be reached on changes in the Commission's rules until a thorough analysis of the technical issues involved has been performed.
d) Commenters such as Lockheed Martin, Virtual Geosatellite LLC and Motorola proposed that the most efficient manner of

addressing the technical issues involved in this complex issue would be to convene an informal Government/Industry working group whose purpose would be to develop specific proposals which would be submitted to the Commission for inclusion in an NPRM on the subject.

e) Most of the filings on this issue dealt with the need to protect radioastronomy observations from interference. It is imperative that these needs be understood.

NASA would like to express its support for each of the ideas and comments contained in a) through e) above. As a result, we believe that it is premature for the Commission to issue an NPRM on this subject at this time. Also, if or when the Commission decides to proceed with an NPRM, sincere technical attention must be paid to the needs of services in adjacent bands, which are very sensitive to radio frequency interference. These include the radioastronomy, earth exploration-satellite and space research services.

In the following sections, NASA presents detailed comments relative to this Public Notice.

I. INTRODUCTION

NASA operates sensitive receiving systems in the space research service, the earth exploration-satellite service and the radioastronomy service that could be adversely affected by an injudicious relaxation of the Commission's rules related to unwanted emissions from satellite networks.

The NASA Deep Space Network (DSN) is an international network of antennas that supports interplanetary spacecraft missions for the exploration of the solar system and the universe. Deep-space earth stations are highly vulnerable to line-of-sight interference such as that from space stations in other services. This follows as a consequence of the uncommon receive system sensitivity required for the highly signal-to-noise limited deep space-to-Earth links. A difference of over 90 dB inverse square spreading loss separates a source near Venus at closest Earth approach (42×10^6 km) from a space station at 1000 km.

Passive spaceborne microwave sensors measure the electromagnetic energy emitted and scattered by the Earth and constituents in the atmosphere. Passive sensors are radiometers - low noise receivers patterned after radio astronomy instruments. They are routinely providing atmospheric temperature profiles of great significance to weather forecasting and climate studies. They can also help determine soil moisture, sea state, surface temperature, salinity, rain, snow and environmental pollutants. The energy they measure is small and noise-like and their measurements can be totally corrupted by interference from both space stations and earth stations.

NASA also is engaged in radio and radar astronomy observations. Its DSN has been used for more than thirty years to study and characterize the microwave emissions from the atmospheres and magnetospheres of solar system planets. The combination of high precision and the extensive time-line is producing a unique data base that contributes to detailed studies of the thermophysics and chemistry of these atmospheres. Very Long Baseline Interferometry (VLBI) using the DSN contributes to observation of radio stars, quasars and a search for planets outside our solar system. The DSN participates in the VLBA operated by the NRAO as well as in space VLBI missions. Very sensitive 70 m antennas and ultra-low noise receivers are able to capture the extremely weak radio astronomy signals.

NASA also uses the 70 m antennas in the DSN in conjunction with cryogenically cooled low noise amplifiers for radar astronomy observations of near-Earth asteroids, comets, the planets Mercury, Mars and Venus and the satellites of Jupiter and Saturn. The statistics of orbital debris, a matter for concern of all users of space, are also being compiled through use of the DSN radar astronomy capabilities. Both radio astronomy and radar astronomy observations involve reception of extremely small signals (noise-like in the case of radio astronomy) that are particularly susceptible to interference from space station transmissions from space-to-Earth.

It is in the context of our interest in ensuring continued viability of these important NASA operations and a concern over potential interference to them that we comment on the instant proceeding.

II. UNWANTED EMISSION LIMITS SHOULD NOT BE RELAXED AT THIS TIME

Revisions to the FCC's rules on unwanted emission limits should be based on sound technical data, which are not yet available.

International studies

WRC-97 revised Recommendation 66[1] to recommend that ITU-R conduct studies of the maximum permitted levels of unwanted emissions. The WRC recognized that unwanted emissions from transmitters operating in space stations may cause harmful interference to safety services and to radio astronomy and space services using passive sensors.

ITU-R Task Group 1/5[2] has been established to study unwanted emissions and will hold its fifth meeting in January, 2000. The task group has not completed work on development of generic limits constituting a "safety net" based on the least restrictive Out-of-Band (OOB) emission limits used as national or regional regulations in areas having a high radiocommunications density and representing a significant portion of the radiocommunications manufacturing base. The task group recognizes that this approach means that the recommended limits will not ensure compatibility with other radio services[3].

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1. Recommendation 66 (Rev. WRC-97), "Studies of the Maximum Permitted Levels of Unwanted Emissions", Final Acts of the World Radiocommunication Conference 1997.

2. Draft Decision ITU-R 1/X, "Unwanted Emissions and the modification of Recommendation ITU-R SM.328-7 Concerning Out-of-Band Emissions", Chairman, Task Group 1/3, October 30, 1996.

With respect to protection of safety services and passive services, TG 1/5 expects the concerned ITU-R study groups to develop solutions which will then be "pulled together" by TG 1/5. The task group also intends to consider operational approaches to mitigating interference and to study the impact of proposed solutions on all affected services. These band-by-band studies have not even commenced and can, as of now, provide no basis for establishing relaxed or modified limits on unwanted emissions from satellite networks.

National studies

The National Telecommunications and Information Administration (NTIA) has announced a major new NTIA initiative on adjacent band interference[4] . NTIA recognizes that "[i]n general, many of the technical and regulatory aspects of adjacent band interference are not well defined." Tasks that NTIA has undertaken include "investigating the role that various voluntary and required spectrum standards play, including transmitter, receiver, and antenna standards".

The Institute for Telecommunication Sciences has studied the problem of determining what emission mask rules should be for flexible use of the spectrum when N contiguous channels are combined into a single channel or when a single channel is split into multiple channels[5]. Their work has not yet been completed but the goal is to define a mathematical function for an

3. "General Framework for the Work of Task Group 1/5 (Unwanted Emissions)", Task Group 1/5, August 19, 1999.
4. "Adjacent Band Interference - A Major New NTIA Initiative", NTIA Spectrum News, Fall, 1999.

[5] E-mail message from Robert Matheson to Rob Haines, December 9, 1999

optimized unwanted emissions mask that would be useful in defining rules for composite emission masks.

We firmly believe that band-by-band studies are needed to determine the sharing criteria that will protect deep space operations, passive remote sensing, radio astronomy and radar astronomy from interference while also allowing services in adjacent bands to satisfy their service requirements with minimal constraints. We are convinced that all parties, including industry, passive service operators, deep space operators and regulators will all benefit from having the results of these studies available in order to make informed decisions about adoption of appropriate regulations.

We conclude that it is premature to modify the Commission's rules pertaining to satellite network unwanted emissions pending completion of the extensive international and national studies that are currently underway.

III. POWER FLUX DENSITY (PFD) LIMITS ARE NEEDED TO PROTECT SERVICES IN ADJACENT BANDS

The only way to protect sensitive services in bands adjacent to bands occupied by space service transmitters is to adopt PFD limits for adjacent bands.

Passive spaceborne microwave sensors and radio astronomy receivers are sensitive to the total energy within their measurement bandwidth and, in order for these systems to function properly, interference power must be kept below the level defined by the relevant interference criteria. Interference criteria for these services have been vetted internationally and adopted as ITU-R recommendations.[6]

Transmitter masks defined in terms of dBc or dBs are fundamentally deficient in protecting passive services because to determine the power in a victim receiver more than the shape of a transmitter mask must be known. The power of the interfering system's transmitter, its modulation scheme, its antenna gain in the direction of the victim receiver and the distance between the interferer and the victim must also be known. Similarly, the PFD must be known (or the spectral PFD) to determine the potential for exceeding the interference criteria for deep space measurements.[7]

Use of PFD limits to facilitate sharing between services is not new. PFD limits have long been used within shared bands and are the principal tool,

[6] For radio astronomy, interference criteria are found in Recommendation ITU-R RA.769-1. Passive sensor interference criteria are contained in Recommendation ITU-R SA.1029-1.
[7] Interference criteria for deep space research are found in Recommendation ITU-R SA.578.

for example, that allows the fixed service and the fixed satellite service to share common frequency bands. Section 25.208 of the Commission's rules states the PFD limits in various shared bands.

The concept of a PFD limit to protect services in adjacent bands is also not new. Section 25.213 of the Commission's rules limits the out-of-band PFD in the band 1610.6-1613.8 MHz that mobile earth stations may produce at radio astronomy observatories. The same section limits the spurious emissions of space stations in the mobile satellite service operating in 2483.5-2500 MHz band such that a spectral PFD of -241 $w/m^2/Hz$ is not exceeded in the 4990-5000 MHz band.

PFD limits also can be used to limit interference at points in orbit. For example, WRC-97 limited, in certain bands, the PFD produced at the geostationary-satellite orbit by a non-geostationary-satellite system. The WRC also adopted PFD limits in certain bands that apply to the inter-satellite service at altitudes from 0 km to 1000 km above the Earth's surface in order to prevent interference to passive spaceborne sensors in the earth exploration-satellite and space research services.

Experience has shown that PFD limits imposed on satellite systems provide an effective method to control the amplitude of both in-band and adjacent band emissions from satellite networks.

IV. ONE SIZE LIMIT WILL NOT FIT ALL SITUATIONS

The impact of adjacent band emissions depends on the characteristics of the systems in the adjacent bands. On the one hand, a generic, "safety net" limit might be suitable when similar systems are considered but would be totally ineffective for protecting sensitive systems from interference. On the other hand, adoption of a common limit capable of preventing interference to the most sensitive system would be an unnecessary burden on most satellite networks.

Out-of-band emission limits must be tailored to the allocation table. Where non-geostationary orbit mobile satellites, for example, are in a band adjacent to a radio astronomy band tight control of out-of-band emissions will be needed to protect radio astronomy observatories from interference. Conversely, if the fixed service, for example, is allocated in the same band as the fixed-satellite service as well as in the adjacent band, only nominal control of out-of-band emissions from fixed-satellite networks would be needed to ensure compatibility.

We recommend that when the Commission does revise its rules on unwanted emissions from satellite networks it consider adopting rules on a band-by-band basis taking into account the services in bands adjacent to those allocated for satellite services. We believe that satellite networks will realize significant benefits if this process is followed because in many bands it may prove feasible to relax the existing rules. At the same time, this process would provide better protection for services sensitive to low levels of interference than they are afforded under the present rules.

V. FEATURES RECOMMENDED FOR INCLUSION IN ANY REVISION OF THE CURRENT COMMISSION RULES

As we have previously stated, we believe it is premature to revise the Commission's rules on unwanted emissions from satellite networks. However, we believe that the rules should contain certain features when they are eventually changed.

Out-of-band emission limits should include PFD limits where necessary to protect deep space research, spaceborne passive sensing and radio astronomy from interference.

The current Commission rule Section 25.202 (f) (4) gives the Commission authority to require greater attenuation of out-of-band emissions than specified in paragraphs (f) (1), (2) and (3). This provision gives the Commission the ability to deal with special and unique situations and should be retained in any revision of the rules.

The current rules impose limits on emissions (Section 25.202 (f)) and make no distinction between out-of-band and spurious emissions. We believe this is a strong point in the current rules and one that should not be lost in a future revision.

We note that protection areas are defined for geographic regions on the surface of the Earth where meteorological satellite systems are receiving signals from low earth orbiting satellites. NASA operates earth stations, which receive signals from low orbiting earth exploration-satellites. Important environmental data are received and we feel that these NASA stations should also be included in appropriate protection areas.

VI. HOW SHOULD THE COMMISSION PROCEED WITH THIS PETITION FOR RULEMAKING?

Basically, NASA takes the position that the Commission should not, at this time, issue a notice of proposed rulemaking (NPRM) on this matter for the reasons already stated. There is no basis at the present time for relaxation of the rules on unwanted emissions.

Should the Commission choose to proceed to issue an NPRM in spite of these concerns, protection of deep space research, passive spaceborne sensors and radio astronomy must be considered. All of these services have established interference criteria, which appear in ITU-R recommendations. The preferred method to insure protection would be to adopt PFD limits in the frequency bands allocated to these services and apply the limits to the composite interference from both out-of-band and spurious emissions.

Should the generic out-of-band (OOB)mask be in dBc, dBs, or PFD units or some combination?

NASA believes that a combination approach would be most appropriate.

A generic out-of-band (OOB) mask by itself will be of little value to protect all the Services involved.

A generic OOB mask would be adequate only when similar (homogeneous) systems are considered. In a broad sense, similar systems would be those with similar antennas, operating system noise temperatures, and most probably belonging to the same service.

PFD limits (or preferably spectral power density limits in the case of deep space research) should be used to insure compatibility between systems based on analysis of specific bands taking into account OOB emission masks and other relevant parameters.

Because the PFD produced by an emission is a function of the e.i.r.p. toward and the distance to the reference location, a mask based on PFD levels does not, in itself, establish a standard for the performance of a transmitter. We believe, therefore, that OOB masks for transmitters in space services are also necessary to provide standards for their design, testing and operation.

Very sensitive receivers used in the DSN, in passive spaceborne sensors and in radio astronomy observatories as well as safety of life applications such as the RNSS will require more stringent limits than those normally needed for other services. From appropriate PFD limits, and considering the dynamics and probabilities involved, the appropriate OOB emission mask can be defined. An OOB mask has benefits in that manufacturers during the design of transmitters can use it as a performance criterion and direct measurement of the output spectrum of the emission can determine adherence to the mask.

Either dBc or dBs would be suitable for transmitter masks because they would be uniquely related to the fundamental requirement of PFD limits to protect systems in adjacent and nearby bands.

Where bands occupied by transmitters of satellite networks are well removed from bands allocated for sensitive services it may be sufficient to impose only an OOB mask on the transmitter.

> Should the emissions of a multi-carrier system with a wideband frequency allocation be treated differently than those of a system with a single broadband carrier?

The answer to this question depends on the approach adopted for out-of-band limits. If the approach is to adopt PFD limits in adjacent bands there is little need to differentiate between multi-carrier systems and those having a single broadband carrier. In this scheme, use of spectrum efficient modulations can minimize the out-of-band emissions of a single broadband carrier and both multi-carrier and single carrier systems would need to meet the same PFD limits.

The current practice of limiting out-of-band emissions imposes a mask with limits determined by the bandwidth of the carrier. Here treatment of multi-carrier systems as single wideband carriers would extend the permitted region of out-of-band emissions and would not be advisable.

> Should the mask be defined as a function of authorized bandwidth (FCC approach) or necessary bandwidth (ITU approach)?

Adoption of PFD limits for protection of services in adjacent bands would make the distinction between masks based on authorized or necessary bandwidth of little importance.

Necessary bandwidth seems like it might be preferable to authorized bandwidth because authorized bandwidths might be greater than necessary bandwidths with the consequence that the region of out-of-band emissions would be unnecessarily large. On the other hand, TG 1/5 is finding that necessary bandwidth for some modulations is not well defined.

Should a generic mask be used for all space service allocations unless otherwise specified?

The term "satellite networks" is used primarily in reference to the fixed satellite service and, by extension, to the mobile satellite service. Other space services have characteristics that are quite different from these two services. A generic mask for the fixed satellite and mobile satellite services might not be appropriate for other services. Masks for space services other than the fixed satellite and mobile satellite services should be considered separately.

Should the FCC Rules incorporate out-of-band values agreed in Recommendations of the ITU-R?

Interference criteria for deep space research, passive spaceborne sensors and radio astronomy have been developed over a period of several years. These criteria have been subjected to international scrutiny and have been incorporated into ITU-R recommendations. Recommendation ITU-R SA.578 contains the interference criteria for deep space and Recommendation ITU-R SA.1029-1 contains the interference criteria for spaceborne passive sensors. Similarly, Recommendation ITU-R RA.769-1 contains interference criteria for radio astronomy. The criteria contained in

these recommendations represent the protection requirements of these sensitive science services and should form the basis for PFD limits in bands allocated to these services. It would be appropriate for the Commission to incorporate these values in revised rules pertaining to out-of-band emissions.

We note, as previously stated, it is also important for the Commission to retain the power[8] to require greater attenuation than specified in any rule on emission limitations in order to handle unique harmful interference situations not resolved by the rules.

[8] Section 25.202 (f) (4) of the Commission's rules.

VII. SUMMARY AND CONCLUSIONS

NASA is concerned that precipitous relaxation of the Commission's rules on unwanted emissions from satellite networks would result in harmful interference to critical mission operations. We operate the Deep Space Network, which must capture the extremely small signals transmitted from millions of miles in outer space. Passive spaceborne sensors, a unique resource for gathering vital data for weather forecasts, climate studies and assessment of the health of the environment, measure the weak natural noise-like radiation emitted and absorbed by the Earth and its atmosphere. Noise-like signals received from the depths of the universe by radio astronomy observatories are, by nature, very weak. All of these applications are vulnerable to interference from satellite networks in adjacent and harmonic bands.

In NASA's opinion, unwanted emission limits in the Commission's rules should not be relaxed at this time. Important international and national studies are currently in progress to develop the needed technical bases for making informed decisions regarding regulations on out-of-band emissions. Until the results of this important work are available, it is simply premature and unwise to proceed with a notice of proposed rulemaking. Further, there is no urgency to precipitously change rules that have served industry and Government adequately for more than twenty-five years.

Revisions to the Commission's rules on unwanted emissions will be welcomed at the appropriate time when the necessary information is available to make informed decisions. NASA would welcome the

opportunity to participate in a Government/Industry working group to study the technical issues, which will aid the Commission in its deliberations.

NASA believes that the only way to properly protect sensitive services in adjacent bands to space service transmitters is to adopt PFD limits for adjacent bands. PFD limits both at the surface of the Earth and at satellite orbits have long served to enable in-band sharing between services. They have also been applied to prevent harmful interference in certain adjacent bands.

We believe that OOB masks for transmitters in space services are also necessary to provide standards for their design, testing and operation. Either dBc or dBs would be suitable for transmitter masks because they would be uniquely related to the fundamental requirement of PFD limits to protect systems in adjacent and nearby bands.

We believe that it will not be possible to define one generic limit suitable to protect sensitive services from interference without placing an unnecessary burden on satellite networks in those bands not adjacent to bands allocated to deep space research or passive services. Rather, out-of-band emission limits must be tailored to the allocation table. In this way, the emission rules can be relaxed where warranted while also providing better protection for services sensitive to low levels of interference than they are afforded under the present rules.

On the question of how to treat emissions of multi-carrier systems, there is little need to differentiate between multi-carrier systems and those having a

single broadband carrier if PFD limits are adopted to control interference in adjacent bands. Similarly, adoption of PFD limits for protection of services in adjacent bands would make the distinction between masks based on authorized or necessary bandwidth of little importance.

We recommend that a generic mask for "satellite Networks" comprising the fixed satellite service and the mobile satellite service be considered separately from possible masks for other satellite services.

Interference criteria for deep space research, passive spaceborne sensors and radio astronomy have been developed and incorporated in ITU-R recommendations. It would be appropriate for the Commission to incorporate these values in revised rules pertaining to out-of-band emissions.

Finally, we reiterate that we believe the Commission should not issue an NPRM on the matters contained in its Public Notice at this time.

Respectfully submitted,

By:

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January 20, 1999