

NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS

2101 Constitution Avenue Washington, D.C. 20418

BOARD ON
PHYSICS AND ASTRONOMY

(202) 334-3520
FAX: (202) 334-2791

June 3, 1991

Ms. Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

RECEIVED

JUN 3 - 1991

Re: File Nos. 9-DSS-P-91(87) FEDERAL COMMUNICATIONS COMMISSION
CSS-91-010 OFFICE OF THE SECRETARY
File No. 11-DSS-P-91(6)

In re Applications of)
Motorola Satellite)
Communications, Inc.)
and)
Ellipsat Corporation)
To Construct Satellite Systems to)
Operate in the 1610-1626.5 MHz Band)

Dear Ms. Searcy:

Transmitted herewith by the National Academy of Sciences-National Research Council's Committee on Radio Frequencies are an original and nine (9) copies of its Petition to Deny and Comments on the Application in the above-referenced proceedings.

If additional information is required concerning this matter, please communicate with this office.

Very truly yours,



Robert L. Riemer
Senior Program Officer

Enclosure

cc: Motorola Satellite Communications, Inc.
Ellipsat Corporation

BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

RECEIVED

JUN 3 - 1991

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In re Applications of)	
)	
Motorola Satellite)	File Nos. 9-DSS-P-91(87)
Communications, Inc.)	CSS-91-010
and)	
Ellipsat Corporation)	File No. 11-DSS-P-91(6)
)	
To Construct Satellite Systems to)	
Operate in the 1610-1626.5 MHz Band)	

PETITION TO DENY AND
 COMMENTS OF THE
 COMMITTEE ON RADIO FREQUENCIES
OF THE NATIONAL ACADEMY OF SCIENCES

NATIONAL ACADEMY OF SCIENCES
 Dr. Frank Press, President

June 3, 1991

Summary

The Committee on Radio Frequencies of the National Academy of Sciences-National Research Council requests that the Commission avoid assigning frequencies to Ellipsat or Motorola for uses that would be incompatible with radio astronomy operations. In particular, RDSS uplink transmissions in the 1610.6-1613.8 MHz band should comply with the requirements established for RDSS sharing with radio astronomy. In this connection, the protection area around observatory sites needs to be expanded.

Ellipsat has not satisfactorily demonstrated that it can protect radio astronomy observation in the 1610.6-1613.8 MHz band from harmful interference, and its application should not be granted until it does.

With respect to Motorola's application, MSS uplinks should not be allowed in this band, and no satellite downlink transmissions (RDSS or MSS) should be permitted.

Adequate filtering must be used in connection with Ellipsat's RDSS downlink transmissions from 2483.5-2500 MHz to avoid second-harmonic interference greater than $-241 \text{ dBW/m}^2/\text{Hz}$ to radio astronomy operations at 4990-5000 MHz.

Finally, in selecting 200 MHz of spectrum in the 22.55-23.55 GHz band for Motorola's intersatellite links, radio astronomy bands at 22.81-22.86 GHz and 23.07-23.12 GHz should be avoided.

TABLE OF CONTENTS

	<u>Page</u>
I. Ellipsat's System Must Meet the Requirements Established for Radio Determination Satellite Service Sharing with Radio Astronomy in the 1610.6-1613.8 MHz Band	2
II. Ellipsat's Proposal to Use the Band 2483.5-2500 MHz for Satellite Downlinks Creates a Potential Problem for Radio Astronomy Operations at 4990-5000 MHz	6
III. Motorola Should Not Be Permitted to Use the 1610.6-1613.8 MHz Band for Mobile Satellite Service (MSS) Transmissions	7
A. Motorola's RDSS Uplink Transmissions in the 1610.6-1613.8 MHz Band Must Comply with the Requirements Established for Sharing with Radio Astronomy	7
B. The Use of the 1610.6-1613.8 MHz Band Should Not Be Expanded to Include MSS Uplink Transmissions	9
C. The Band 1610.6-1613.8 MHz Should Not Be Used for Downlink Transmissions to Provide Either RDSS or MSS Service	11
IV. Radio Astronomy Bands Should Be Avoided in Selecting Frequencies for Motorola's Satellite-to-Satellite Link in the 22.55-23.55 GHz Band	13
Conclusion	13

Federal Communications Commission

WASHINGTON, D.C. 20554

JUN 3 - 1991

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In re Applications of)	
)	
Motorola Satellite)	File Nos. 9-DSS-P-91(87)
Communications, Inc.)	CSS-91-010
and)	
Ellipsat Corporation)	File No. 11-DSS-P-91(6)
)	
To Construct Satellite Systems to)	
Operate in the 1610-1626.5 MHz Band)	

PETITION TO DENY AND
COMMENTS OF THE COMMITTEE
ON RADIO FREQUENCIES OF THE
NATIONAL ACADEMY OF SCIENCES

The National Academy of Sciences through the Committee on Radio Frequencies ("CORF") of the National Research Council hereby petitions to deny and offers its comments on the above-captioned applications of Motorola Satellite Communications, Inc. ("Motorola") and Ellipsat Corporation ("Ellipsat").

CORF's comments are limited to a discussion of some of the frequency bands these applicants propose to use. These bands include the 1610.6-1613.8 MHz band, the 2483.5-2500 MHz band, and the 22.55-23.55 GHz band.^{1/}

^{1/} Motorola proposes to use the following bands:

Earth-to-space and Space-to-earth	1610-1626.5 MHz
Intersatellite cross-links	22.55-23.55 GHz
Satellite to fixed gateway/ control downlink	18.8-20.2 GHz
Fixed gateway/control to satellite uplink	27.5-30.0 GHz

Ellipsat proposes to use the following bands:

Earth-to-space (uplink)	1610-1626.5 MHz
Space-to-earth (downlink)	2483.5-2500 MHz

I. Ellipsat's System Must
Meet the Requirements Established
for Radio Determination Satellite
Service Sharing with Radio Astronomy
in the 1610.6-1613.8 MHz Band.

Ellipsat proposes to provide Radio Determination Satellite Service ("RDSS") using six miniature satellites (the "Ellipso I" system) in elliptical orbit. Ellipsat would use the 1610-1626.5 MHz band for uplink transmissions from mobile terminals and fixed ground control stations. Ellipsat also proposes to use part of the 1610-1626.5 MHz band for a downlink signalling channel.

1. RDSS Uplinks Part of the 1610-1626.5 MHz band is allocated on a secondary basis in Region 2 by footnote 734 to the Radio Astronomy Service for spectral line observations (1610.6-1613.8 MHz). Footnote 734 urges administrations to take "all practicable steps to protect the radio astronomy service from harmful interference." Footnote 734 notes, inter alia, that "[e]missions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service."

In order to permit RDSS uplinks to share the same band with radio astronomy observations around 1612 MHz, the Commission requires, in Section 25.382(g) of its Rules, that "[a]ll authorizations in the radiodetermination satellite service shall be subject to" Appendix D of the Commission's Report and Order^{2/}

^{2/} Report and Order in Gen. Dkt. Nos. 84-689 and 690, In re Amendment of the Commission's Rules to Allocate Spectrum For, and to Establish Other Rules and Policies Pertaining to, a Radiodetermination Satellite Service, 50 Fed. Reg. 39101, 58 RR 2d 1416 (1985) (hereafter "RDSS Report and Order").

establishing allocation policies for RDSS. Appendix D of the RDSS Report and Order requires RDSS licensees to restrict their transmissions to occur within the first 200 milliseconds following the 1-second time markers of Coordinated Universal Time when users enter Radio Astronomy Regions during a period of radio astronomy observation in the 1610.6-1613.8 MHz band. Knowing in advance when such transmissions are likely to take place, radio astronomers are able to employ blanking techniques to avoid contamination of the cosmic signal by the terrestrial one.^{3/} Sharing these frequencies is possible only where such geographic and time-separation techniques can be implemented.

Furthermore, it has become clear, as a result of further study since the Appendix D Coordination criteria in the RDSS Report and Order were adopted, that the current definition of Radio Astronomy Regions (circles around radio astronomy observatories with radii of 150 kilometers for airborne transmissions and 25 kilometers for ground-based transmissions) is inadequate to protect radio astronomy from airborne uplink transmissions and may be inadequate to protect radio astronomy from ground-based uplink transmissions. As Section 3.3 and Table II of CCIR Report 1126 demonstrate, for a system of the Geostar type, the minimum distance necessary for protection from airborne

^{3/} The insertion of blanking time adds overhead to the astronomical observations: when the detection of a radio signal is blanked, that portion of time is lost to the observational experiment.

transmissions is about 500 kilometers, assuming an aircraft height of 10 km with 1° terrain shielding around the observatory.

In the January 29, 1991, amendment to its application, Ellipsat states (at Appendix H) that it would fully protect radio astronomy activities in the 1610-1613 MHz band. Ellipsat states that it will create ten channel segments, each 1.4 MHz wide, in the 1610-1626.5 MHz band. Because of this band segmentation, Ellipsat states that, if required, it can completely avoid using the band 1610.6-1613.8 MHz during periods of radio astronomy observation. It also states that it can restrict user transmissions during these periods.

CORF appreciates Ellipsat's willingness to protect radio astronomy operations from harmful interference in this band, but based on the following considerations, does not believe Ellipsat has demonstrated that this can be accomplished.

First, Ellipsat, unlike Geostar, is not proposing to provide merely position-location service with limited ancillary messaging capability. Ellipsat is proposing voice telephony services as well.^{4/} Such continuous telephone conversations will make it impossible for Ellipsat to use time-separation techniques, as Geostar planned to do, to protect radio astronomy operations. Thus, frequency separation will have to be used.

Using frequency separation means that to avoid causing interference to radio astronomy operations in the 1610.6-

^{4/} Ellipsat application at 18 et seq.

1613.8 MHz band, Ellipsat's mobile terminals must be prevented from transmitting in this band when in the vicinity of radio astronomy observatories; i.e., Ellipsat will have to be able to prevent the mobile uplinks from using the band upon entering a radio astronomy region. It is not clear to CORF from Ellipsat's application that Ellipsat's system will have this capability.

The modulation scheme Ellipsat proposes also creates a problem involving interference to radio astronomy observations from out-of-band emissions that must be addressed. Radio astronomy observations in the 1610.6-1613.8 MHz band need to be protected to a level of $-237 \text{ dBW/m}^2/\text{Hz}$ (CCIR Report 224).

Ellipsat proposes to use direct sequence binary phase shift key (BPSK) modulation.^{5/} Without filtering, the first sideband of BPSK modulation will be only about 13.4 dB less than the power flux density in the main spectral lobe. Filtering must therefore be provided for the mobile units so that the signal level in the radio astronomy band from 1610.6-1613.8 MHz is no greater than $-237 \text{ dBW/m}^2/\text{Hz}$ to a radio astronomy antenna from a transmitter at the edge of the coordination zone.

CORF is not confident that it is practicable for Ellipsat to build mobile terminals that will provide this level of filtering. Although welcome, Ellipsat's statement that it would protect radio astronomy is perfunctory. Accordingly, unless Ellipsat provides a detailed technical plan to show how it would avoid

^{5/} January 29 amendment at Appendix B, p. 2.

harmful interference in the 1610.6-1613.8 MHz band, Ellipsat's application should be denied.

2. RDSS Downlinks Ellipsat proposes to use some of the frequencies in the 1610-1626.5 MHz band for "downlink signalling channels."^{6/} RDSS downlinks are not authorized in the 1610-1626.5 MHz band. If the Commission decides to permit such downlinks signalling channels they should not be located in the 1610.6-1613.8 MHz band and should be adequately filtered to avoid out-of-band interference to radio astronomy observations in the 1610.6-1613.8 MHz band (See Ellipsat application at p. 11).

II. Ellipsat's Proposal to Use
the Band 2483.5-2500 MHz for
Satellite Downlinks Creates a
Potential Problem for Radio
Astronomy Operations at 4990-5000 MHz.

Ellipsat's proposal to use the 2483.5-2500 MHz band for RDSS service downlinks raises a potential problem inasmuch as the second harmonic of these downlink transmissions would fall in the 4967-5000 MHz band. The 4990-5000 MHz band is allocated on a primary basis to radio astronomy and is used extensively for continuum studies. CCIR Report 224 establishes the threshold for harmful interference in the 4990-5000 MHz band at $-241 \text{ dBW/m}^2/\text{Hz}$. CORF recognizes that footnote US74 to the Table of Allocations (47 C.F.R. §2.106) protects radio astronomy in this band from

^{6/} See Ellipsat application at p. 11.

extraband radiation only to the extent that such radiation exceeds the level that would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates. However, CORF believes that it is feasible, and Ellipsat and any other RDSS operators should be required, to provide adequate filtering in the satellite, in order to reduce interference to this radio astronomy band to below the levels specified in CCIR Report 224.

III. Motorola Should Not
Be Permitted to Use the
1610.6-1613.8 MHz Band for
Mobile Satellite Service
(MSS) Transmissions.

Motorola proposes to construct a 77 low-earth-orbit satellite system (called Iridium) to provide RDSS and mobile satellite services ("MSS"), including two-way digital voice and data communications. Motorola proposes to use the 1610-1626.5 MHz band for both uplink and downlink transmissions.

A. Motorola's RDSS Uplink Transmissions
in the 1610.6-1613.8 MHz Band
Must Comply with the Requirements
Established for Sharing with
Radio Astronomy.

With respect to the portion of Motorola's proposal that proposes RDSS uplinks in the 1610.6-1613.8 MHz band, the basic

criterion of keeping interference below $-237 \text{ dBW/m}^2/\text{Hz}$ must be observed in the vicinity of radio astronomy telescopes.

Sharing between radio astronomy and Geostar-type RDSS systems is possible in the United States because RDSS has the characteristics of (1) precise knowledge of the location of RDSS mobile units at any time, so that the procedures established in Appendix D can be implemented when these mobile units enter a Radio Astronomy Region (the "position-location requirement"), and (2) ability to operate in a burst mode, which permits RDSS operators to limit transmissions from mobile units to precise time intervals when operating in Radio Astronomy Regions (the "blanking requirement").

Although it appears that Motorola's system will have position-location capability, it is not clear that Motorola intends to utilize time-sharing (blanking) even if its system has blanking capability. Rather, although Motorola never explicitly so states, it appears that Motorola would protect radio astronomy telescopes from uplink transmissions by avoiding use of the 1610.6-1613.8 MHz band by mobile units in the vicinity of radio astronomy sites. This assumes that the Motorola system has the capability to prevent the mobile user from use of these frequencies when the mobile user is in the vicinity of a radio astronomy observatory. None of this is explicit in Motorola's application. Motorola needs to explain exactly how it expects to

provide protection to radio astronomy from mobile uplink transmissions before its application can be granted.

There is less possibility of interference to radio astronomy from sidebands of transmitters in channels outside the radio astronomy band (1610.6-1613.8 MHz) with Motorola's proposal than with Ellipsat's proposal because, unlike Ellipsat, Motorola does not plan to use spread spectrum modulation. Nevertheless, Motorola's mobile terminals would have to contain sufficient filtering to comply with the $-237 \text{ dBW/m}^2/\text{Hz}$ standard with respect to out-of-band emissions as well.

B. The Use of the 1610.6-1613.8 MHz Band
Should Not Be Expanded to
Include MSS Uplink Transmissions.

The band from 1610.6-1613.8 is not allocated for MSS uplinks. Therefore, before Motorola's application can be granted, the Commission must decide whether the band should be authorized for MSS uplink transmissions. CORF does not believe that it is in the public interest for this band to be used for MSS uplinks, for the reasons that follow.^{2/}

As a general proposition, mobile (as opposed to fixed) uplinks operating in radio astronomy bands present a major problem to radio astronomers because of the difficulty of preventing them from operating in the vicinities of radio

^{2/} To the extent Ellipsat proposes to provide MSS communications rather than RDSS communications, the same applies with respect to Ellipsat.

astronomy sites. When these uplink transmissions to satellites originate from aircraft (as opposed to terrestrial mobile uplinks), the problem is compounded because they cause interference to any radio astronomy observatory within a wide area around the aircraft, and terrain shielding offers no protection. Thus, as a general proposition, MSS uplinks are highly incompatible with co-channel radio astronomy observations.

These problems were theoretically resolved with Geostar-type RDSS systems by taking advantage of the particular capabilities of that system. However, time sharing (blanking) is not possible with mobile satellite services, such as voice telephony. The alternative is to frequency-share, i.e., avoiding use of the 1610.6-1613.8 MHz band for MSS in the vicinity of radio astronomy sites. This assumes that the Motorola system is capable of preventing mobile users from operating in this band when they enter the region around a radio astronomy site. However, Motorola has not shown that its system can prevent mobile users from using the band in this fashion.

Even if Motorola's system can protect radio astronomy observatories, non-geostationary satellites are inherently international, and other countries may authorize similar systems that may not provide this protection.

Any MSS system operating in this band would have to have the capability to protect new radio astronomy observatories as they are established and discontinue protection for those that no longer use these bands.

Finally, if MSS uplinks are permitted in the 1610.6-1613.8 MHz radio astronomy band, the use of the band can be expected to increase dramatically, vastly increasing the potential for interference to radio astronomy observations.

For all these reasons, CORF believes that MSS uplinks should not be permitted in the 1610.6-1613.8 MHz band. Starting MSS services above 1613.8 MHz would give Motorola and any other company that is authorized to provide MSS services in the 1610.6-1613.8 MHz band 12 megahertz of spectrum, from 1614 to 1626 MHz. If additional spectrum is needed for new MSS uplinks, it should be found in a band other than 1610.6-1613.8 MHz.

C. The Band 1610.6-1613.8 MHz
Should Not Be Used for
Downlink Transmissions to
Provide Either RDSS or MSS Service.

Motorola's proposal to use the 1610-1626.5 MHz band for downlinks is inconsistent with the Table of Allocations, both domestic and international. CORF believes that, at least with respect to the 1610.6-1613.8 MHz band, no satellite downlink transmissions, either for RDSS or MSS, should be permitted.

Co-channel satellite downlinks are incompatible with radio astronomy observations because they transmit signals down into extremely sensitive radio telescopes that are pointed at the sky. Terrain shielding provides no protection from such satellite signals.

In CORF's opinion, there is no practical way to protect radio astronomy observation sites around the world from co-channel RDSS or RDSS or MSS downlinks in the 1610.6-1613.8 MHz band.

Motorola believes that it could avoid interference to radio astronomy sites simply by not using the frequencies 1610.6-1613.8 MHz in downlink beams that cover areas in which radio astronomy sites are found. The problem with Motorola's proposal is that in practice the transmissions from Motorola satellites in cells that do not directly cover a radio astronomy site would leak into adjacent cells that do include radio astronomy sites. Given the widespread nature of the potential interference and the number of observatories around the world observing in the 1610.6-1613.8 MHz band^{8/}, as a practical matter it would be difficult for MSS satellites to use the frequencies from 1610.6-1613.8 MHz for downlinks anywhere without potentially interfering with radio astronomy observations.

CORF is also concerned that if the U.S. permits Motorola to operate satellite downlinks in this band, other countries may also authorize non-geostationary satellite downlinks in this band. Because low-earth-orbit satellites are inherently international in their service, even if Motorola could protect

^{8/} U.S. astronomers do collaborate with astronomers in other countries on research involving foreign radio telescopes and therefore have an interest in protecting those observatories as well as those in the United States.

radio telescopes in the United States, other countries' satellite downlinks might not.

For these reasons, CORF opposes the use of RDSS or MSS downlinks in the 1610.6-1613.8 MHz band.

IV. Radio Astronomy Bands Should
Be Avoided in Selecting Frequencies
for Motorola's Satellite-to-
Satellite Link in the
22.55-23.55 GHz Band.

Motorola proposes to use 200 MHz of spectrum out of the 1-GHz-wide band from 22.55-23.55 GHz for satellite-to-satellite links.

If this proposal is adopted, the 200 MHz assigned to Motorola should not include two 50-MHz-wide radio astronomy bands, from 22.81-22.86 GHz and 23.07-23.12 GHz (see footnote 879 to the U.S. Table of Allocations, 47 C.F.R. §2.106). Since Motorola only needs 200 MHz of spectrum from a band that is 1 GHz wide, it should be possible for the Commission to avoid these radio astronomy bands in assigning frequencies to Motorola.

Conclusion

The Commission should avoid assigning frequencies to Ellipsat or Motorola for uses that would be incompatible with radio astronomy operations. In particular, RDSS uplink transmissions in the 1610.6-1613.8 MHz band should comply with the requirements established for RDSS sharing with radio astronomy. In this

connection, the protection areas around observatory sites need to be expanded.

Ellipsat has not satisfactorily demonstrated that it can protect radio astronomy observations in the 1610.6-1613.8 MHz band from harmful interference, and its application should not be granted until it does.

With respect to Motorola's application, MSS uplinks should not be allowed in this band, and no satellite downlink transmissions (RDSS or MSS) should be permitted.

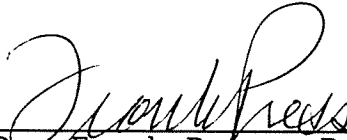
Adequate filtering must be used in connection with Ellipsat's RDSS downlink transmissions from 2483.5-2500 MHz to avoid second-harmonic interference greater than $-241 \text{ dBW/m}^2/\text{Hz}$ to radio astronomy operations at 4990-5000 MHz.

Finally, in selecting 200 MHz of spectrum in the 22.55-23.55 GHz band for Motorola's intersatellite links, radio astronomy bands at 22.81-22.86 GHz and 23.07-23.12 GHz should be avoided.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

By:



Dr. Frank Press, President

June 3, 1991

Direct correspondence to:

Dr. Robert L. Riemer
Committee on Radio Frequencies
HA-562
National Research Council
2101 Constitution Ave., N.W.
Washington, D.C. 20418

Tel: (202) 334-3520
Fax: (202) 334-2791