| | | |
|---|---|---|
| PFD Limit | -142 | $dBW/m^2/4kHz$ |
| Isotropic Factor ($4\pi/\lambda^2$) | 29.41 | $dB/m^2$ |
| Bandwidth Reduction (4kHz to 1 Hz) | 36.02 | dB |
| Received Power at Antenna | -207.43 | dBW/Hz |
| Antenna Gain | 3.0 | dB |
| Interference Density | -204.43 | dBW/Hz |
| Number of Systems | 3 | numeric |
| Total Interference Density (Io) | -199.66 | dBW/Hz |

The interference density of one system is -204.43 dBW/Hz. AMSC states a total interference density of -194 dBW/Hz. This 10.43 dB difference represents 11 units. Therefore, to get AMSC's figure of -194 dBW/Hz, one has to assume that 11 satellites are overlapping. With this kind of error evident in the simplest part of the AMSC analysis, it is evident that AMSC's analysis cannot be given any credence.

Moreover, using AMSC's methodology, LQSS's analysis shows that at least three other systems can operate, and still the LQSS satellite capacity would be calculated at over 2400 user circuits, which is the Globalstar satellite power capacity. Globalstar is designed with interference margin, and with three other overlapping beams operating at the PFD limit, Globalstar is still <u>power</u> limited, not interference limited.

Further, AMSC fails to take into account the fact that all the proposed CDMA systems do not operate in the same manner. For example, whereas Globalstar would reuse the entire 16.5 MHz frequency in each satellite beam, TRW does not. In assuming identical systems, AMSC's simplistic analysis cannot and does not give credible results.

Finally, the EIRP of the satellite is dependent upon the number of users that the satellite is serving. If the example satellite systems were interference limited and operating at less

than capacity, then they would not be generating an EIRP that would meet the PFD limit (assuming that the systems were designed to meet the PFD limit when operating at capacity). Inter-system interference would be reduced. With fewer users, the EIRP would be reduced, and more capacity would be available. In short, the system operators would not jam and thereby reduce capacity to zero. AMSC's conclusion of no or little capacity is simply wrong.[9/]

Band-sharing is a multi-level problem involving orbital dynamics, antenna beams, frequency assignment, user distribution, and modulation which AMSC's analysis does not account for. LQSS has developed a computer program (explained in CCIR paper No. USSG 8D-20, included as Appendix E) which takes these factors into account and shows that multiple LEO systems can operate simultaneously in the same band.

2. Uplink Capacity Calculation.

In its Technical Appendix (at 8), AMSC claims that the four CDMA systems operating at full capacity together would each have almost no uplink capacity. Since AMSC chose to supply neither the calculations nor the method utilized for this conclusion, its statements cannot be relied upon.

In attempting to reproduce AMSC's results, LQSS finds that the Globalstar CDMA system has a very high capacity limit when

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9/ See also LQSS Consolidated Reply Comments, Tech. App., at 8-11 (filed March 27, 1992).

operating alone. In actual operation, the system is designed to operate in both a thermal noise and an interference environment.

AMSC calculates only 87 users per spreading bandwidth (1.4 MHz in AMSC's example) per beam as the interference limited case for the example CDMA system. However, the AMSC analysis is incomplete and fails to show that eleven 1.4 MHz channels per beam could be accommodated within the 16.5 MHz allocated spectrum. This would lead to 957 users per beam, and for a six-beam satellite design almost 6,000 users per satellite with respect to AMSC's sample CDMA system.

Using a similar analysis for Globalstar, over 130 users per channel could be accommodated, which for thirteen 1.25 MHz channels per beam would be about 1,700 users per beam. For the Globalstar six-beam design this would allow a single satellite interference limit of over 10,000 users! As this analysis demonstrates, CDMA systems can operate in an interference environment and provide high capacity for each beam and satellite.

AMSC also references a Motorola 12 dB fade margin for a handheld user and argues that it would further reduce capacity. Again this is misleading since user uplink fade margins do not reduce capacity by 12 dB. For example, if a Globalstar CDMA user were to transmit a signal which is 12 dB higher than nominal power due to blockage, such transmission would have no effect at the Globalstar satellite since the purpose of the increase in user handheld transmit level with power control is to ensure that all Globalstar users are received at approximately the same signal level at the satellite. Therefore, the result would be no

reduction in capacity for Globalstar users.

Also, it is important to note that interference between CDMA systems is increased only a minor amount as a result of a significant increase in one user's transmit power compared to the interference impact of many users operating in the same frequency band. CDMA systems are designed to minimize user transmit power and operate in a combination of both thermal noise and an interference environment. This is a major advantage of CDMA operating systems, which AMSC simply ignores, or, as indicated by other errors in its analysis, simply gets wrong.

## III. MOTOROLA'S PROPOSED SYSTEM IS INHERENTLY INEFFICIENT AND SO SHOULD BE REJECTED AS DEMONSTRABLY INFERIOR.

In prior pleadings, LQSS has addressed the technical aspects of Motorola's claim that its system is "superior" to other proposed systems, and demonstrated that Motorola's system is spectrally inefficient and would provide less reliable and effective service to consumers than would other LEO systems such as Globalstar:

- Consolidated Opposition to Petitions to Deny, Tech. App. Section V (filed January 31, 1992).
- Consolidated Reply Comments, Tech. App. Section 2 (filed March 27, 1992).

In the technical portions of these comments, which are incorporated by reference herein, LQSS has demonstrated that Motorola would not use the RDSS/MSS spectrum as efficiently as Globalstar, that Motorola would provide substantially degraded service to consumers in comparison with Globalstar, and that Motorola's proposed system cannot share with other systems and so

would preclude competition, in short, that Motorola is not "superior" but rather inferior.

With respect to the comments filed on December 4, 1992, LQSS provides the following additional information:

**A. Bidirectional Operation in the L-Band Results in Self-Interference to Motorola's System.**

Motorola, in its comments, claimed that "Motorola's FDMA/TDMA system architecture, with its . . . bidirectional operations, is more spectrum efficient than any of the other LEO and GSO MSS satellite systems."[10/] This claim to so-called spectrum efficiency of the Motorola system has already been refuted by LQSS and other commenters.[11/] LQSS has also pointed out that there would be harmful interference generated by Motorola's bidirectional operation with a secondary downlink into other MSS systems and into other services.[12/] Motorola, the only proponent of bidirectional operation, has not yet refuted these problems nor demonstrated that its own system is feasible and would avoid self-interference.[13/]

Figure 1 illustrates one of the harmful interference situations caused by Motorola's proposed bidirectional operation. Figure 1 shows that harmful interference would be generated

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10/ Motorola Comments, at 11-12 (December 4, 1992).

11/ See, e.g., LQSS Consolidated Opposition To Petitions to Deny (filed January 31, 1992); LQSS Consolidated Reply Comments (filed March 27, 1991).

12/ LQSS Comments, at 12-14 (December 4, 1992).

13/ See TRW Comments, at 14-15 (December 4, 1992).

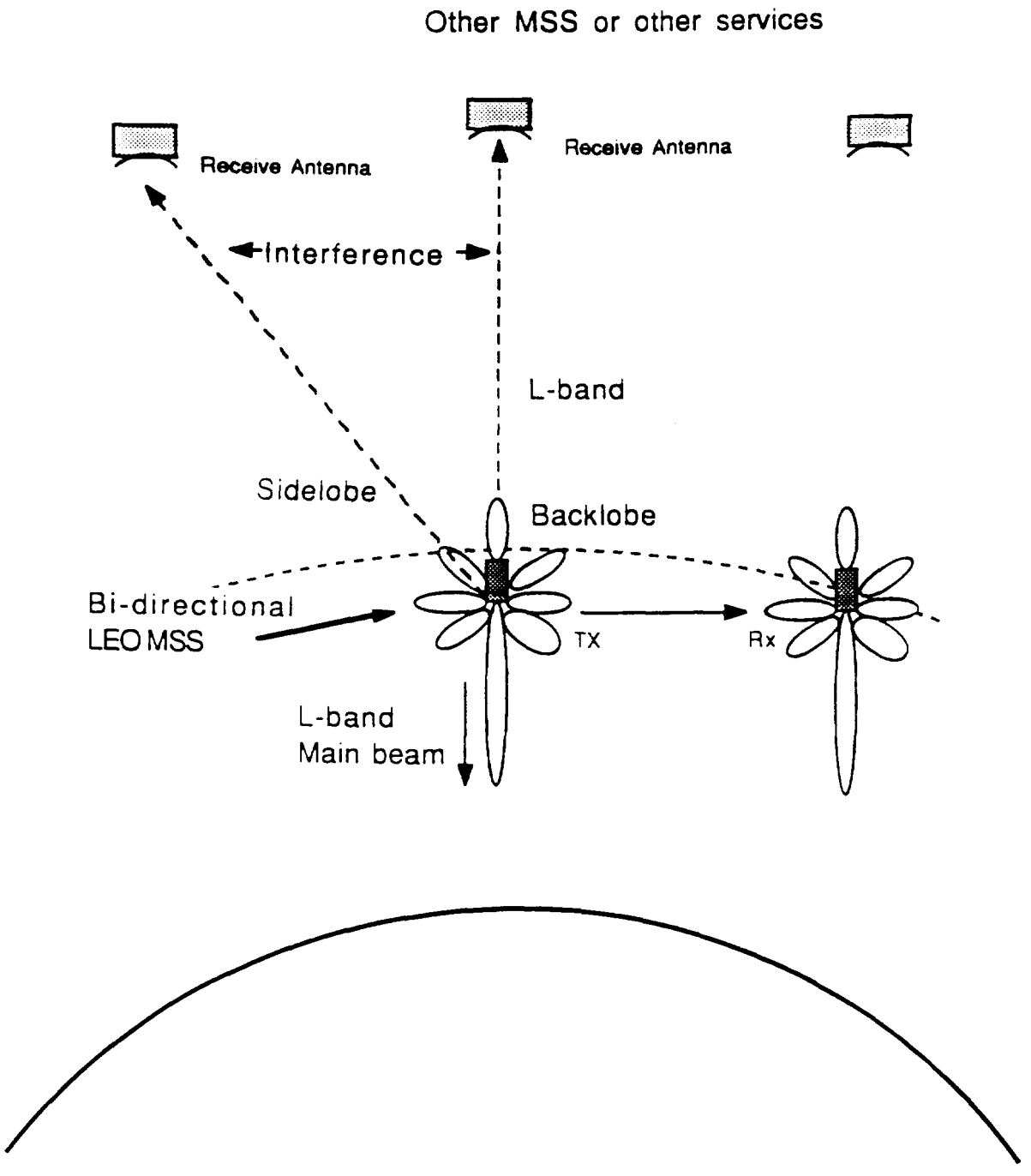



Figure 1. Backlobe and Sidelobe Interference from Motorola's bi-directional LEO MSS Satellites

through the sidelobes and backlobes of the transmitting antenna into the receiving beams of other LEO MSS systems. The interference signal would also be received by the other Motorola satellites in view through the sidelobes of its receiving beam. With the Motorola polar orbit constellation, the distance between two adjacent satellites in different orbital planes is constantly changing. Therefore, even assuming Motorola can achieve time division duplex synchronization between its satellites and the mobile terminals, it would be extremely difficult, if not impossible, to achieve L-band signal synchronization between the satellites in view in different orbital planes. Therefore, the transmitted signal from one satellite through the sidelobe of its transmit antenna would arrive at the receiving time slot of an adjacent satellite, also through the sidelobe of its receiving antenna. Figure 2 illustrates this self-jamming of Motorola's system. With Motorola's constellation, the distance between two adjacent satellites in different orbital planes can be relatively close (about 2,000 km above the equator and much closer at higher latitudes). Table 3 shows the estimated C/I ratio of Motorola's self-jamming satellites.

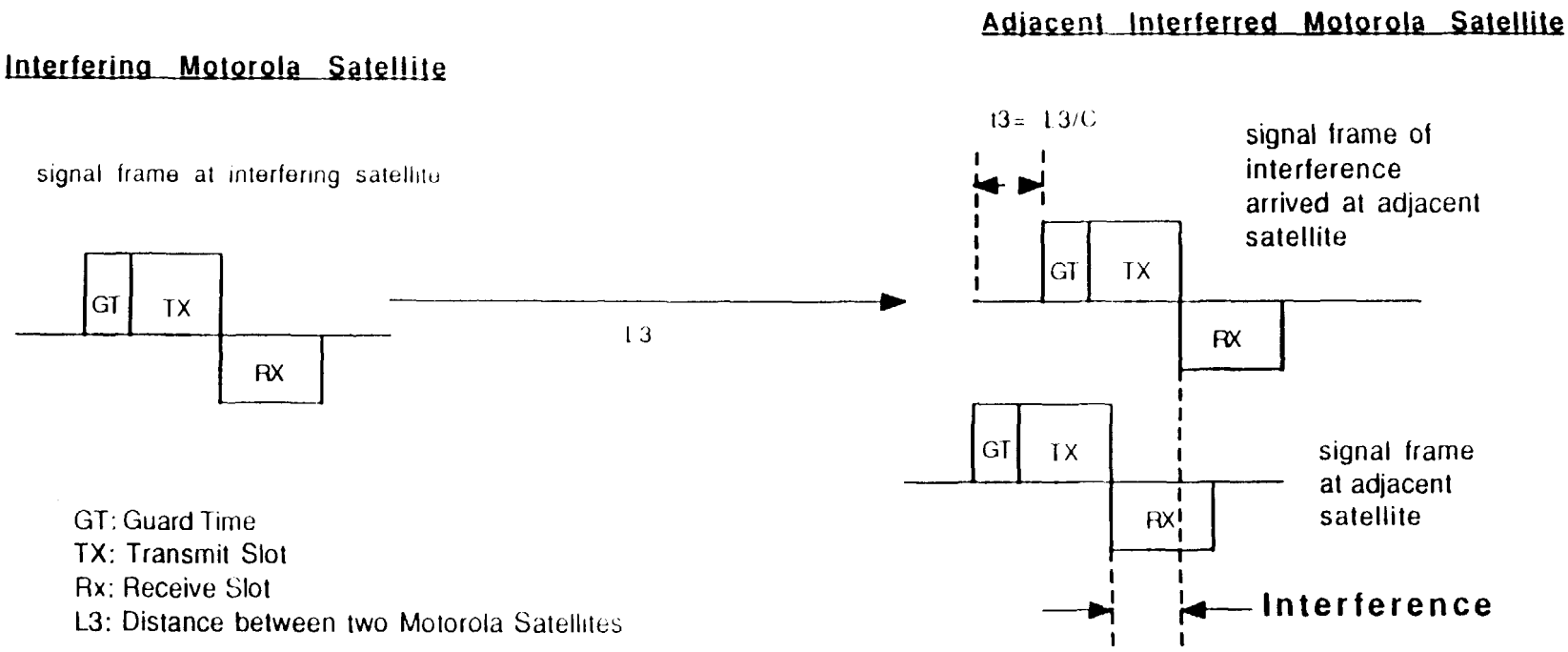



Figure 2. Self-Interference Created by the Motorola's Bi-Directional LEO MSS System

Table 3
C/I Estimate of the Self-Jamming Motorola System

| | | | Remarks |
|---|---|---|---|
| Transmitted Signal EOC EIRP/User | 27.7 | dBw | Table R-A-2, Motorola Amendment, 8/8/92 |
| Peak-to-edge ratio | 8.0 | dB | Figures R2 to R5 |
| Frequency Reuse factor | 8.4 | dB | 10 log (48/7) |
| Peak-to-sidelobe ratio | (30.0) | dB | |
| Interference EIRP | 14.1 | dBw | |
| Space loss of 2,000 km | (162.7) | dB | |
| Receive Antenna EOC Gain | 23.9 | dB | Table R-A-3, ibid. |
| Peak-to-edge ratio | 8.0 | dB | |
| Peak-to-sidelobe ratio | (30.0) | dB | |
| Received Interference Strength | -146.7 | dBw | |
| Received signal strength | -150.3 | dBw | Table R-A-3, ibid. |
| C/I | -3.6 | dB | |

Table 3 illustrates that even when two adjacent Motorola satellites are separated by 2,000 km, the resulting signal-to-interference ratio is -3.6 dB, which means that the interfering signal (unwanted signal) is much stronger than the wanted signal. Unlike CDMA systems, Motorola's TDMA system cannot operate in a negative C/I environment. The Motorola system is self-jamming. When the adjacent satellites are at higher latitudes, the distance between the interfering satellite and the interfered-with satellite will be much less and the self-interference will be much worse.

The above example illustrates only one of the interference situations created by sidelobe coupling. It is also possible that the main transmit beam can be coupled into the main receive beam of another Motorola satellite, over the rim of the earth. See Figure 3. In this case, the self-interference of Motorola's satellite is much more serious. This interference situation is

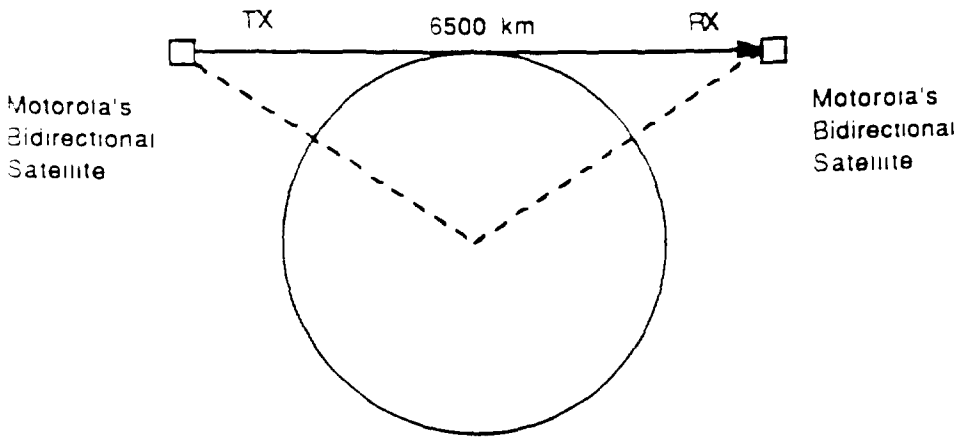



Figure 3. Main-beam to Main-beam Coupling of Motorola's Satellites

more than likely than not to exist as a result of Motorola modifications to system design in August 1992. In its August system modification Amendment, Motorola increased its beam number to 48 to cover areas with only an 8.2-degree elevation angle.[14/] The main beam of Motorola's antenna in Ring 4 already spills over the edge of the earth (see Figure 4, a reproduction of Motorola's Figure R5) and could be coupled into the main receive beam of another Motorola satellite.

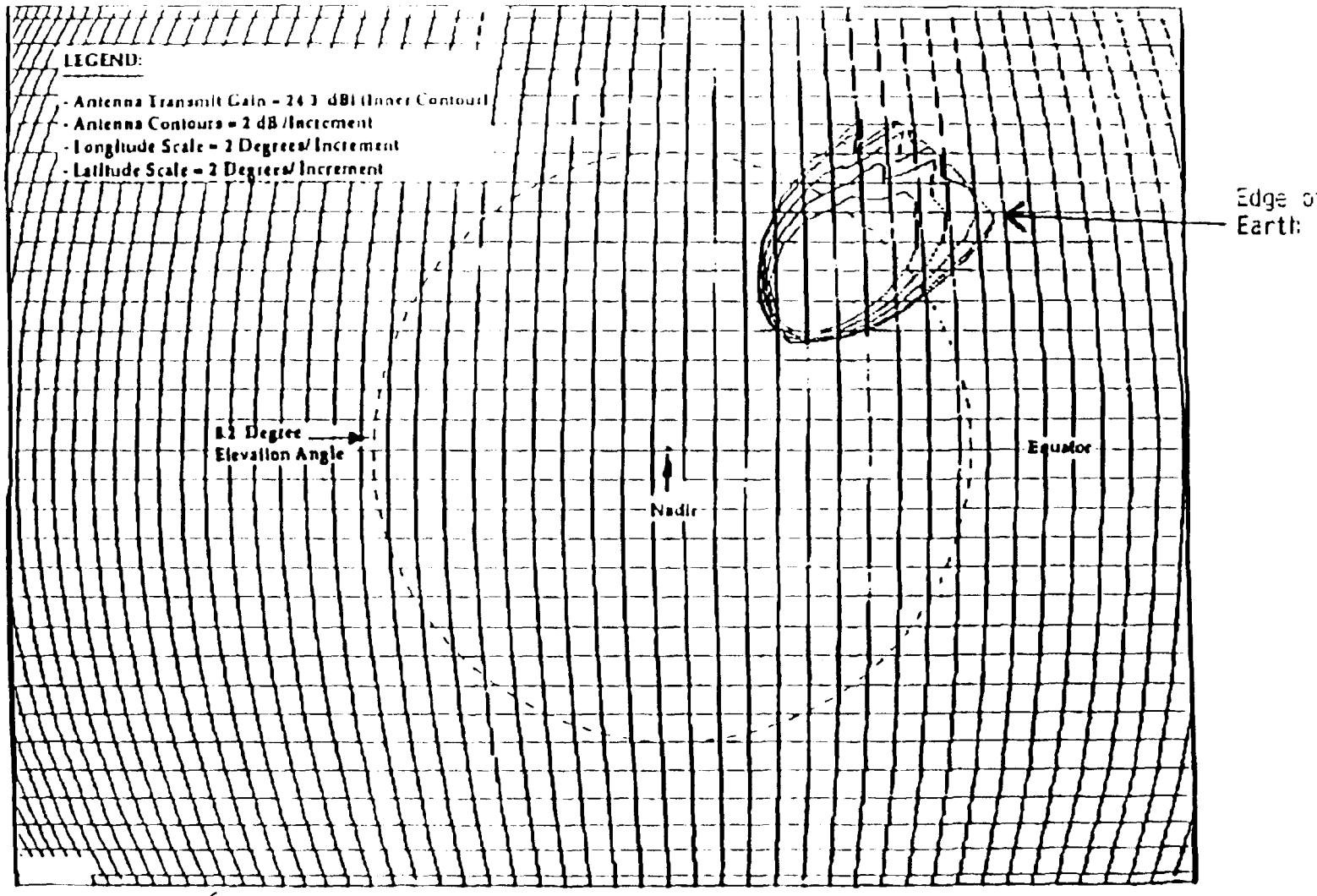
Table 4 shows the estimated C/I ratio of Motorola's self-jamming satellites when they have main-beam coupling.

Table 4
Estimated C/I of Motorola's Self-Jamming System
Through Main-Beam Coupling

| | | | Remarks |
|---|---|---|---|
| HPA Burst Power | 5.5 | dBw | Table R-A-2, Motorola Minor Amendment, 8/8/92 |
| Xmtr Ckt Loss | (2.1) | dB | ibid. |
| Xmt. Antenna Gain @ Coupling point | 20.3 | dB | Figure R-5, ibid. |
| Interfering EIRP | 23.7 | dBw | |
| Space Loss of 6500km | (172.8) | dB | |
| Rcvr Antenna Gain | 20.3 | dB | Figure R-5, ibid. |
| Received Interference Strength | -128.8 | dB | |
| Received Signal Strength | -150.3 | dBw | Table R-A-3, ibid |
| C/I | - 21.5 | dB | |

The Motorola system requires an Eb/Io of 18 dB to close its links. With the interference signal 21.5 dB (141 times) stronger than the

14/ Motorola Amendment, Figure R5 (August 8, 1992).




(Figure R-5 Representative Pattern for Cells in Ring 4)

Figure 4. Main Beam Spill Over the Edge of Earth

received signal, the Motorola system cannot even close these links. The Motorola system is a self-jamming system.

The above example shows only the main-beam coupling of two Motorola satellites. In fact, one Motorola satellite will "see" many other orbiting Motorola satellites with its main-beams, sidelobes and backlobes. Figure 5 illustrates such a situation, with the view of the earth and other orbiting Motorola satellites, relative to Motorola satellite No. 24 at the center. In this situation, Motorola satellite No. 24 "sees" fourteen (14) other orbiting satellites, among which there are two satellites with main-beam to main-beam coupling. A computer simulation indicates that in another time instance, there can be four to five cases of main-beam coupling. Therefore, the Motorola self-jamming is very much more serious than shown in the above example.

Motorola should not be authorized to deploy its bidirectional system, and should be precluded from causing harmful interference into other MSS systems with its secondary space-to-earth link.

## IV. BAND SEGMENTATION WOULD ENSURE INFERIOR SERVICE AND SO SHOULD BE REJECTED IN FAVOR OF BAND-SHARING THROUGH CDMA.

LQSS has previously demonstrated that Motorola's proposal to split (and take the best and lion's share of) the RDSS/MSS frequencies between itself and other applicants is not feasible because it would provide Motorola with a monopoly in that portion of the band and severely disadvantage any other applicant which attempted to use the remaining band remnants.

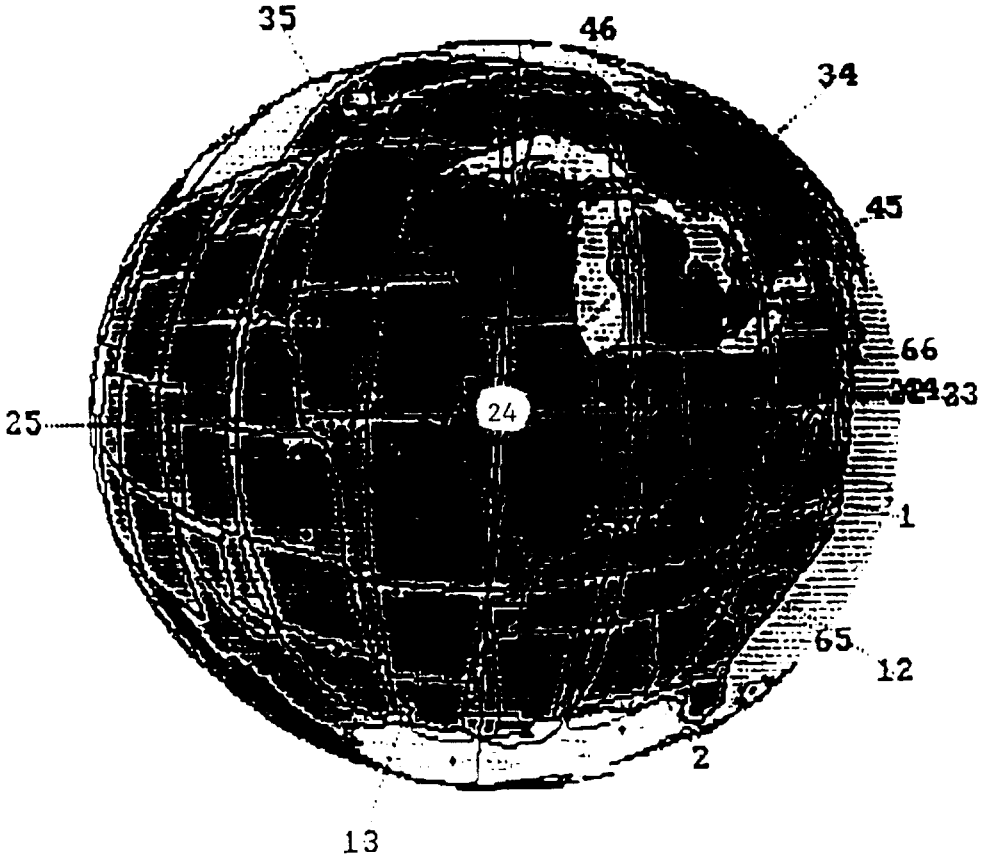



Figure 5. Self Interference from other Motorola Satellites into Motorola's Satellite No. 24.

- Consolidated Reply Comments, Tech. App. Section 4 (filed March 27, 1992).
- Opposition to Petition for Expedited Action (filed June 24, 1992).

These comments are incorporated by reference herein with respect to the issue of band segmentation.

## V. LOW EARTH ORBIT SATELLITE SYSTEMS PROVIDE SUBSTANTIAL SERVICE AND TECHNICAL ADVANTAGES WHICH WOULD BENEFIT CONSUMERS.

In prior pleadings, LQSS provided technical discussions of the advantages of low-earth orbit satellite systems in contrast to AMSC's current proposal to use the RDSS/MSS bands with its geostationary satellite system:

- Petition to Deny, Tech. App. Sections I-IV (filed December 18, 1991).
- Consolidated Reply Comments, Tech. App. Section 5 (filed March 27, 1992).

In these comments, which are incorporated by reference in this Technical Appendix, LQSS has demonstrated that its Globalstar system would provide significantly greater capacity than AMSC's current proposal, that operation of the AMSC system in the RDSS/MSS band would cause crippling interference into LEO systems, precluding sharing, and that AMSC cannot provide service to hand-held units until more than a decade after the proposed LEO systems.

With respect to the comments filed on December 4, 1992, LQSS provides the following additional information:

A. LEO Satellite Systems Are Cost Efficient.

LEO satellites system are cost efficient when compared on an equivalent service basis to geostationary systems. The mobile market is for predominantly hand-held portable devices. The current sales of cellular telephone devices is on the order of 90 percent handheld; thus, one should compare the cost per user per MHz to systems providing these services. While AMSC's GSO system can provide some capacity to vehicle mounted units, it admits that handheld service must wait until its second generation about 18 years from now.[15/]

A comparison on an equivalent basis of the cost of the satellites and launching of a GSO system to a LEO system and a review of the total market that can be served reveal that the cost per hand-held user served for LEO systems is a mere fraction of that of a regional GSO system. GSO satellites which could deliver handheld performance equivalent to that of LEO satellites would cost at least $120 million each on a recurring basis plus about $50 million in research and development of the payload, which must include very large unfurlable reflectors. Further, launches of these satellites would cost about $80 million and require launch insurance of about $30 million. Therefore, the total cost in orbit for a two satellite system is about $400 million. (Two are required since the launch or in-orbit failure of one satellite would destroy the company's ability to generate revenue to pay for the up front costs of development.)

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15/ AMSC Comments, Tech. App., at 12 (December 4, 1992).

On the other hand, a LEO system would cost much less. The LQSS application shows a satellite build and launch cost of $370 million in satellites and $242 million in launch costs for a total of $612 million. Assuming that the LEO system has the same capacity as the GSO system (which they do not, LQSS's system has more capacity), and the ability to cover population centers around the world, one can easily show that the LQSS system is preferable. To calculate this cost per subscriber served, the value of 1.8 million subscribers is used (as defined in the LQSS application). Since a LEO system can supply communications to potentially wide areas of the world, it can be shown that the cost to provide a circuit is significantly less for a LEO system. This means that the cost to the United States public is significantly reduced. As shown in Table 5, the cost to establish North American coverage for AMSC's second generation is on the order of $222 per user.[16/] The LEO cost on the same basis is nearly 7 times less. Even when corrected for the difference in satellite life expectancies, the difference is a factor of 5. These differences will have to be reflected in the subscriber fees that will be charged, making the much more costly AMSC system not in the public interest.

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16/ This figure uses current costs, which will certainly be greater by 2010 when AMSC plans to launch its second generation.

Table 5
GSO versus LEO cost per subscriber

| Market Served | Type | Users (millions) | Cost (millions) | Cost per subscriber |
|---|---|---|---|---|
| North America | GSO | 1.8 | $400 | $222 |
| North America | | 1.8 | | |
| South America | | 1.8 | | |
| Europe | | 1.8 | | |
| Middle East[1] | | 1.8 | | |
| Africa | LEO | 1.8 | $612 | $37 |
| Australia[2] | | 1.8 | | |
| India & S.E. Asia | | 1.8 | | |
| Indonesia[3] | | 1.8 | | |
| Asia[4] | | 1.8 | | |
| | | 16.2 | | |

[1]Including areas east to Pakistan.

[2]Including New Zealand.

[3]Including Miconesia, New Guinea & The Philippines.

[4]Including China, Mongolia, Korea & Japan.

## VI. LEO SYSTEMS SUCH AS GLOBALSTAR WOULD BE ABLE TO COORDINATE SUCCESSFULLY WITH GLONASS AND RADIOASTRONOMY OBSERVATORIES.

In response to claims made by Motorola and AMSC, LQSS has filed with the Commission technical discussions demonstrating its ability to coordinate successfully with other users of the RDSS/ MSS bands, including GLONASS and Radioastronomers:

- LQSS Application, App. 6 (filed June 3, 1991).
- Consolidated Opposition to Petitions to Deny, Tech. App. Section IX (filed January 31, 1992).
- Consolidated Reply Comments, Tech. App. Section 6 (filed March 27, 1992).

These discussions are incorporated by reference in this Technical Appendix and show that, contrary to the claims of AMSC and

Motorola, LQSS would be able to avoid harmful interference into existing users of the band from Globalstar transmissions.

## VII. HAND-HELD UNITS PROPOSED FOR USE WITH LEO SYSTEMS WOULD NOT CAUSE A RADIATION HAZARD.

AMSC claims that hand-held units pose a significant potential radiation hazard. However, this analysis is seriously flawed because it is premised on incorrect, inapplicable data and information applicable only to terrestrial cellular telephones: "a 3 watt terrestrial cellular vehicular-mounted terminal using an 11 inch antenna and terrestrial cellular hand-held terminal using a 5 inch antenna."[17/] This statement is of no relevance to the LEO MSS systems because the frequencies are different (900 MHz compared to 1620 MHz), and the antennas used in terrestrial cellular service are different. AMSC analyzes the situation incorrectly as discussed below.

AMSC states: "Most of the non-geostationary MSS hand-held devices require antenna input power greater than 600 milliwatts; it appears likely that the power density of these MSS hand-helds would be somewhere between the levels of the terrestrial vehicular and hand-held units."[18/] Even if the 600 milliwattage were correct (which it is not), this statement is inaccurate. Because the antennas are different, the near-field and far-field radiation patterns are different for LEO MSS than for terrestrial cellular. Both the terrestrial cellular antenna examples that AMSC uses have

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17/ AMSC Comments, at 12 (December 4, 1992).

18/ Id.

radiation patterns that are in the near-field at the distances shown in AMSC's Table 4. However, a typical patch antenna at L-Band has a far-field radiation pattern at 1 inch. So, AMSC's near-field calculations do not use the correct equations for LEO MSS. Far-field calculations must be used. Loral's analysis of the use of hand-held antennas shows that there would be no RF radiation hazard.

Also, AMSC has also neglected to use the six minute averaging that is used in the ANSI, OSHA and IEEE radiation standards. This is important because with LQSS's CDMA implementation the user terminal's EIRP varies over the six-minute period depending upon whether the user is talking, how much information is actually being transmitted during the speech, as well as being dependent upon power control. The average EIRP rather than the peak EIRP must therefore be used in these calculations.

LQSS's hand-helds would not pose a significant potential radiation hazard as they operate within the radiation standards set by the ANSI and IEEE.

Washington

District of Columbia

AFFIDAVIT

I hereby certify that I am the technically qualified person responsible for the preparation of this Technical Appendix; that I am familiar with Part 25 of the Commission's Rules and Regulations; that I have either prepared or reviewed the technical information contained in this Technical Appendix; and that it is complete and accurate to the best of my knowledge and belief.

Robert A. Wiedeman

Vice President, Engineering
Loral Aerospace Corp.

Signed and sworn before me this 5th day of January, 1993

Laura L. Yarme
Notary Public
My Commission Expires May 14, 1997

B

CCIR FACT SHEET

Study Group: WP 8D

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Document: USSG 8D-36 (Rev. 3)

Ref.: Doc. USSG-8D-15 (September 13, 1991)

Document Title:

# METHOD FOR EVALUATING E.I.R.P. LEVELS FROM TRANSMITTING MSS SATELLITES IN THE 1613.8-1626.5 MHz BAND TOWARD RECEIVING SATELLITES IN THE BAND


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Purpose/Objectives:

To provide an annex to Doc. 8D/TEMP/10 that describes the interference situation involving emissions from the backlobes and sidelobes of transmitting MSS satellites toward receiving MSS satellites, and to establish a method for evaluating interference to MSS uplinks from MSS downlinks.


Abstract:

Since the relative positions and antenna pointing of geostationary (GSO) and non-geostationary (LEO) satellites change constantly, and because LEO MSS satellite constellations may have various altitudes and orbital inclination angles, it is possible that transmitting and receiving satellites operating in the 1613.8-1626.5 MHz band may be located relatively close to one another. It is also possible for transmitting and receiving satellites to be located in a plane tangent to the Earth such that neither satellite antenna provides high discrimination. Thus, MSS system design and operating guidelines may be needed to prevent unacceptable interference between transmitting and receiving satellites. In expanding on Doc. USSG 8D-15, which was submitted to the last Working Party 8D meeting, this paper provides a method for assessing MSS satellite EIRP density constraints that may be needed to prevent harmful interference to MSS uplinks. These constraints are derived from Earth-based equivalent EIRP density levels from mobile earth stations. Further study is needed in several relevant areas.


Fact Sheet Preparer: Tom Sullivan

Documents
CCIR Study Groups
Period 1990-1994

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# METHOD FOR EVALUATING E.I.R.P. LEVELS FROM TRANSMITTING MSS SATELLITES IN THE 1613.8-1626.5 MHz BAND TOWARD RECEIVING SATELLITES IN THE BAND

(Question 83/8)

## 1. Introduction

WARC-92 allocated the band 1613.8-1626.5 MHz to the Mobile Satellite Service (MSS) in the Earth-to-space direction on a primary basis and in the space-to-Earth direction on a secondary basis. CCIR studies of the sharing criteria for this band are invited by Resolution 46 (COM5/8), which was adopted by WARC-92. Because MSS downlinks in the 1613.8-1626.5 MHz band may cause interference to MSS uplinks, guidelines are needed for assessing this interference situation. An initial review of this problem for the case of low-Earth-orbit (LEO) transmitting satellites sharing with uplinks to geostationary satellites was made in Doc. 8D-29, which was considered at the Working Party 8D meeting of 11-20 December, 1991. This paper provides a more general method for calculating an Earth-based equivalent value of equivalent isotropically radiated power (e.i.r.p.) density produced in the 1613.8-1626.5 MHz band by a LEO MSS (space-to-Earth) network. The equivalent Earth-based value of satellite e.i.r.p. density is compared with a single entry value of e.i.r.p. density from MSS uplinks in order to assess the potential for harmful interference to MSS (Earth-to-space) networks using satellites in any orbit.

## 2. General approach

If space stations in multiple networks are receiving Earth-to-space transmissions from a common coverage area, the interfering signal level produced by one such network (i.e., single entry) into another is related to the total uplink e.i.r.p. density produced by the interfering network in a reference bandwidth averaged over a geographic area:

$$\overline{E} = E_{up} + 10 \log N_{user} - 10 \log (B/B_{ref}) \qquad (1a)$$

where:

$\overline{E}$: single entry uplink e.i.r.p. density level (dBW/4 kHz) within the Earth-to-space antenna beam coverage area;

$E_{up}$: e.i.r.p. (dBW) per transmitting earth station in the interfering network (further study is needed on the potential effect of uplink power control and the need to apply an average e.i.r.p. level);

$N_{user}$: number of uplink transmissions in the interfering network in the bandwidth B in the geographic area covered by the interfered-with space station antenna beam (further study is needed on the potential effect of voice activation and variations in the antenna gain of the receiving satellite toward the interfering earth stations);

B: bandwidth occupied by the interfering signals (kHz);

$B_{ref}$: reference bandwidth (4 kHz).

Equation (1a) assumes that the interfering mobile earth stations use omnidirectional antennas (i.e., no antenna discrimination is available toward the receiving satellite). In order to ensure that secondary MSS interferers produce less interference than primary MSS interferers, the e.i.r.p. density levels produced by a transmitting MSS satellite should be held to a percentage of the total e.i.r.p. density levels allowed in an MSS Earth-to-space network in the same band:

$$E' = \overline{E} - 10 \log (p/100) \qquad (1b)$$

where:

E': equivalent Earth-based level of single entry interfering e.i.r.p. density (dBW/4 kHz) that may be produced by space-to-Earth transmissions of one network;

p: maximum permissible percentage of the uplink single entry e.i.r.p. density level that may be caused by secondary space-to-Earth transmissions of one network.

Use of Earth-based equivalent e.i.r.p. density as the basis for satellite e.i.r.p. density evaluation is valid for situations where the transmitting satellite is located in a conical volume subtended by the Earth, the vertex of which is a receiving satellite. That is, the interfering signals are propagating along Earth-to-space signal paths in this model. Figure 1 illustrates the applicable geometry's.