

MINUTES OF THE SEPTEMBER 1, 1992 MEETING OF  
THE BELOW 1 GHZ LEO NEGOTIATED RULEMAKING COMMITTEE

1. The fourth meeting of the Below 1 GHz LEO Negotiated Rulemaking Committee (Committee) was convened at 9:30 a.m. on September 1, 1992 in the Commission's meeting room at the Federal Communications Commission (FCC), 1919 M Street, N.W., Washington, D.C.
2. The following Committee members were present:
  - Air Force - Nelson Pollack
  - Navy - William Cook
  - NASA - David Struba
  - ARINC - Richard Neat
  - LEOSAT - Brent Weingardt
  - FAA - Carroll Stumm
  - Army - Thomas Trimmer
  - FCC - Thomas S. Tycz
  - STARSYS - Alan Renshaw
  - NOAA - Richard Barth
  - ORBCOMM - Alan L. Parker
  - VITA - Joseph Sedlak
  - Facilitator - William A. Luther
3. The meeting was open to the public, and approximately 24 observers were present. A list of attendees is attached as Appendix A. No written remarks were submitted by the public.
4. Approval of agenda. Mr. Luther called for corrections or additions to the meeting's agenda, attached as Appendix B. Mr. Tycz noted that NASA had submitted a paper to be discussed under "Other Business". There were no further comments, and the agenda was approved by the Committee.
5. Opening remarks. Mr. Luther commented that the Committee appeared to be on the downhill slope of its mission, and encouraged the Committee members to continue their efforts to complete successfully these negotiations. He also spoke of flora, carnivores and close family relationships.
6. Approval of minutes. Mr. Pollack noted that the minutes of the meeting on August 24 now reflected accurately his statement regarding the government's definition of an "existing" system. There were no further comments or amendments and the minutes were approved by the Committee.
7. Selection of co-facilitator. Mr. Luther next addressed the selection of a co-facilitator to chair the final meetings of the Committee. Mr. Luther stated that a number of parties had been suggested by Committee members, and that one individual, Mr. Barth, was particularly qualified for the job. Mr. Weingardt supported the selection of Mr. Barth, and queried whether there would be any legal constraints on his election in light of his Committee membership. Ms. Kendall stated her belief that there would be none, and Mr. Barth was unanimously agreed upon by the Committee to assume the role of facilitator at the next Committee meeting.

8. Identification of additional record information. Mr. Parker submitted a Response of ORBCOMM to Leosat's Statements at the Negotiated Rulemaking Committee Meetings that will be appended to the minutes of this meeting as Appendix C. The minutes of the August 24 meeting were identified as LEOAC-35. There were no other documents suggested for inclusion in the record.

9. Report on progress (Informal Working Group (IWG)). Mr. Jacobs reported that the IWG had met once since the last Committee meeting, and had examined the sharing situation at 400 MHz. The group had also continued its discussions on the advisability of a "service availability" rule, but had reached no definite conclusions. In addition, the IWG has examined three additional footnotes to the international table of frequency allocations, and continued its discussions concerning emissions from user transceivers. Mr. Pollack commented that the LEO sharing proposal set forth in LEOAC-15 appeared to be the most feasible plan from the Air Force's perspective.

10. Report on progress (Editorial Working Group (EWG)). In view of the large number of EWG participants, Mr. Luther stated his intent initially to draft an outline of the final report structure for consideration. An EWG meeting will be called in the near future.

11. Discussion of IWG report (LEOAC-33). The Committee now returned to its discussion of LEOAC-33, a draft document presented for consideration by the full Committee at the previous meeting. Mr. Luther noted that international footnotes 599B and 609B had been recommended for inclusion in Part 2 of the FCC's rules, and called for comment on that recommendation. There were no comments offered. Mr. Luther then noted that the IWG does not believe it necessary to include the text of international footnote 608Z in the domestic allocation tables in Part 2. Mr. Cook stated that 608Z is published as part of the international radio regulations, and is binding on domestic applicants whether or not it is included in Part 2. Mr. Parker and Mr. Jacobs clarified the point that 608Z will be brought into the international table in Part 2, but that the IWG recommends that the note not be included as a domestic note. Accordingly, future applicants will have ample notice of the requirement in the FCC's rules, Part 2.

12. Mr. Luther next directed the Committee's attention to LEOAC-33, p.3, §25.401(b) and opened the discussions where they had left off at the previous Committee meeting. Specifically, section 401(b) proposes a service availability requirement for LEO systems. Mr. Parker stated that ORBCOMM will present a document to the IWG describing a possible method of determining service availability, but went on to comment that he is aware that such an availability rule has policy implications in addition to the technical elements. Mr. Luther noted that there seems to be some interest in examining further the advisability of imposing a service availability requirement, and asked Mr. Jacobs whether he felt such discussions could be fruitful. Mr. Jacobs stated his willingness to continue these discussions in the IWG as long as new information is presented.

13. The Committee had no comments on the proposed §§25.401(c) and (d)(1). Mr. Luther queried whether (d)(2) clearly indicated that "the" satellite

referred to in the second line of the text refers to one or more satellites of the applicant system. Mr. Jacobs indicated that this is clearly the intent of the IWG, and it was determined that the language should be clarified editorially. There was no further discussion of §25.401(d)(2), and the Committee did not discuss subsection (d)(3). A new discussion paper regarding this subsection will be considered at an upcoming IWG meeting.

14. Mr. Luther asked Mr. Pollack for his opinion regarding the need to cross-refer in §25.401 to §25.402 (LEOAC-33 refers to this section as 25.408). The discussion turned to substantive issues, however, and the issue of cross-reference was not resolved. Mr. Pollack stated his belief that §402 should direct applicants to show their compatibility with existing government systems. Because NASA represents the interests of the scientific community, Mr. Struba raised the point that non-government systems may also be authorized in the band, and a mechanism does not appear to be in place to coordinate such systems. Mr. Tycz pointed out that the FCC will address future coordination issues at such time as new applications are submitted for use of the bands.

15. The Committee expressed no disagreement with the introductory text of §402, nor with the text of subsections (a) or (b)(1). Mr. Cook suggested modification of subsection (b)(2) to include a requirement that applicants demonstrate that they will not cause unacceptable interference to authorized government users. Mr. Tycz noted that such a showing could not reasonably be required at the time of application because insufficient public information may be available to make such a demonstration. Mr. Jacobs commented that the IWG intended to put the eventual burden on the FCC applicant to make a showing of non-interference at some point, but it may not be until after filing of the application. Mr. Pollack reiterated his belief that most of the necessary information will be available to potential applicants, and that as a practical matter, an applicant will indeed seek such information in advance. Mr. Cook commented that he is aware of no information regarding Navy's use of the band that will not be readily available, and expressed concern that the word "evaluate" is not strong enough to convey the thought that an application for new service will not be approved if it is incompatible with existing government systems. Mr. Parker agreed with Mr. Pollack that it would behoove a potential applicant to discuss coordination with the government prior to submission of an application. He went on to note that, while an up-front "demonstration" of compatibility could slow down the licensing process, ORBCOMM has no problem with Mr. Cook's proposal as long as the company isn't subject to unnecessary burdens, such as flying satellites in advance to demonstrate compatibility. Mr. Renshaw commented that subsection (b)(2) places a burden on applicants to provide information that may not be possible if existing users fail to divulge operating characteristics. Mr. Tycz stated that the burden should not rest solely on the applicant to coordinate its system, and that in certain circumstances the government may be in a better position to amend its operations than the applicant. Mr. Pollack stated that the Air Force will present applicants with reliable information regarding its existing systems, and Mr. Luther noted that this will undoubtedly be true of all government agencies. In response to a suggestion by Mr. Struba, Mr. Tycz commented that, while the FCC will take the lead in coordination negotiations with NTIA, the FCC will rely heavily on the efforts of the applicants themselves to accomplish the coordination. Mr. Pollack expressed his support for the proposed

modification of subsection (b) (2) offered by Mr. Parker, which imposes burdens on both the applicant and existing users to show that they will not cause unacceptable interference to each other. The existing users (government) will provide the applicant with sufficient information to make that showing. There were no objections to Mr. Parker's modification, and the discussion moved to the last sentence of subsection of §25.402(b) (2).

16. Mr. Tycz proposed that the last sentence be modified to read "The frequency assignment and coordination of the satellite system shall be completed prior to grant of construction authorization." In response to a request for clarification from Mr. Pollack, Mr. Luther commented that grant of authorization by the FCC is comparable to entry into the government master file. There were no further comment regarding proposed section 25.402, and the discussion of LEOAC-33 was suspended.

17. Presentation on sharing. LEOSAT presented its views on spectrum sharing. The graphic representation of this presentation is attached as Appendix D, and an audio tape of this presentation is available for review upon request to the Committee's designated federal employee, Thomas S. Tycz.

18. Discussion of IWG report (cont.). The Committee then returned to the discussion of LEOAC-33. Mr. Luther suggested the addition of the following phrase to proposed subsection 402(b) (3); "and those frequencies used by" prior to the word "authorized" in the fourth line of text. Mr. Barth noted that the word "shared" may be equivalent to the word "used" and is a more simple change to produce the same effect. Mr. Pollack requested confirmation that this subsection applied to all occupied bandwidth, not just those frequencies authorized for use by the individual applicant. Mr. Barth confirmed that was his understanding. There were no objections and the word "shared" was substituted for "used." There was no further discussion of LEOAC-33.

19. Additional/revised tasks for IWG. The Committee suggested no modifications of the work program.

20. Agenda for next meeting. The Committee had no comments on the proposed agenda for the next meeting, and it was tentatively approved.

21. Other business. FCC staff requested that Mr. Luther bring to the Committee's attention §§321 and 359 of the Communications Act of 1934, as amended. Section 359 is for information only, as it relates to free carriage of distress communications from vessels in the maritime service. This is beyond the scope of the Committee and will be taken into account by FCC staff as Part 25 rules are assembled. Section 321, however, implies technical ability by LEO systems to insure priority access by maritime stations having distress communications. These sections are attached as Appendix E. Mr. Jacobs agreed to raise the issues presented by these sections in the upcoming IWG meeting. Mr. Luther next introduced Mr. Rinker, who presented a document on behalf of NASA dealing with the issue of orbit debris (attached as Appendix F). Mr. Rinker stated that this paper is provided as information to the Committee regarding ongoing policy discussions among the Department of Defense, the State Department and NASA. Mr. Luther noted that the issue of orbit debris is also being discussed in a number of international forums, and commented that

it is appropriate that the LEO system proponents be aware of U.S. concerns in this area. He also mentioned that this issue is not, however, within the scope of Committee deliberations. Mr. Luther next called for comments from the public. None were offered. Mr. Parker expressed the Committee's appreciation of Mr. Luther's leadership and judgment during his term as facilitator, and Mr. Luther, in closing, thanked the Committee members for their whole-hearted participation in expediting this rulemaking. There were no further comments, and the meeting was adjourned.

TO WHOM IT MAY CONCERN:

After examining the minutes of the September 1, 1992 meeting of the Below 1 GHz LEO Negotiated Rulemaking Committee, I certify that these minutes are accurate to the best of my knowledge.



William A. Luther  
Facilitator  
Below 1 GHz LEO Negotiated  
Rulemaking Committee

**ATTENDEES**  
**Below 1 GHz LEO Negotiated Rulemaking Committee**  
**September 1, 1992**

<u>Organization</u>	<u>Name</u>	<u>Phone</u>	<u>FAX</u>
ORBCOMM *	Alan L. Parker	703-631-3600	703-631-3610
VITA *	Joe Sedlak	703-276-1800	703-243-1865
STARSYS *	Alan Renshaw	301-459-8832	301-794-7106
ARINC *	Richard Neat	410-266-4143	410-266-2047
Commerce-NOAA *	Richard Barth	301-763-4640	301-420-0932
FCC *	Thomas S. Tycz	202-634-1860	202-653-8772
Facilitator	William A. Luther	202-632-7592	202-653-5402
US Army *	Thomas Trimmer	703-325-8233	703-325-8235
FAA *	Carroll Stum	202-267-9721	202-267-5901
LEOSAT *	Brent Weingardt	301-907-6879	301-907-0153
NASA *	David Struba	202-453-2000	202-426-6264
Navy *	William Cook	703-695-7284	703-695-0930
USAF *	Nelson Pollack	202-475-1807	202-475-7634
Orbital Sciences Corp.	Bruce Ferguson	703-818-2865	703-631-3610
FCC	Ed Jacobs	202-632-7597	202-634-7651
FCC	Kristi L. Kendall	202-634-7058	202-653-8772
FMA	Roger Porter	202-475-1678	202-475-7634
SFA INC (AF,NAVY)	Gerald Wiggen	301-839-5495	301-839-4995
FCC	Bruno Pattan	202-653-8153	
FCC	Marcus Wolf	202-632-7197	202-634-7651
VITA	Jonathan Wiener	202-429-4900	202-429-4912
STARSYS	Ken Newcomer	301-794-5203	301-794-7106
LEOSAT	Francois Giorgio	202-296-6104	202-296-6142
LEOSAT	Joseph Roldan	202-296-6104	202-296-6142
DOT/OCST	Randy Repcheck	202-366-2258	
NASA/ARC	Alan Rinker	703-834-5606	703-834-1094
OTA	Gregg Festa	202-228-6788	
NTIA/SEAD	Herb Kobayashi	410-224-4302	301-261-8006
Civil Air Patrol	Maurice Thomas III	301-292-2393	202-887-7279
Constellation Comm.	Ron Lepkowski	703-548-1435	703-684-6440
ORBCOMM	David Schoen	703-818-2846	703-631-3610
Loral Qualcomm	William D. Wallace	202-624-2500	202-628-5116
FCC	Harry Ng	202-634-1834	202-653-8772
FCC	Ray LaForge	202-653-8117	
COMM 21 CORP	Robert Filep	202-737-6789	202-728-6872
STARSYS	Stephen Baruch	202-429-8970	202-293-7783
ORBCOMM	Steve Goodman	202-371-9100	202-371-1497
ORBCOMM	Paul Locke	703-818-2871	703-631-3610
Mobile Satellite News	Charlie Hartley	301-340-2100	301-424-4297

\* Denotes Committee Member

AGENDA  
BELOW 1 GHz LEO NEGOTIATED RULEMAKING COMMITTEE  
September 1, 1992

1. Approval of agenda
2. Opening remarks
3. Approval of minutes
4. Selection of co-facilitator
5. Identification of additional record information
6. Report on progress of informal working groups
  - Informal working group
  - Editorial working group
7. Discussion of informal working group report (LEOAC-33)
8. Presentation on sharing (limited to twenty minutes)
  - LEOSAT
9. Discussion of additional/revised tasks, if any, for informal working group (Work program - LEOAC-2 (Rev.1))
10. Agenda for next meeting
11. Other business

Response of ORBCOMM to Leosat's Statements  
at the Negotiated Rulemaking Committee Meetings

To correct the record in this negotiated rulemaking proceeding, ORBCOMM is taking this opportunity to respond to Leosat's statements at previous LEO Advisory Committee meetings. ORBCOMM has entered and participated in this proceeding in good faith, and we strongly resent Leosat's implications to the contrary. Leosat's statements indicate that it has failed to understand the Jointly Filed Comments of ORBCOMM, STARSYS and VITA, or to pay attention to the ongoing discussions at the meetings of the Committee and the Informal Working Group, or has chosen simply to ignore and mischaracterize what has been presented.

The sharing proposal of the three applicants was an attempt by the parties with concrete proposals to develop a means of coexisting in the limited spectrum made available; it was not an attempt to freeze out future applicants, because as we have made clear in these proceedings, additional entrants may be accommodated in the spectrum proposed to be allocated by the Commission. The sharing proposal does not "accommodate only three (3) competitors," Leosat's assertions notwithstanding.

As we have also indicated, the coordination efforts among the bona fide applicants have been made difficult as a result of the fact that our sharing must also occur in the context of coordination with the known and unknown current users in these bands, because this is not unassigned spectrum. In such an environment, it would be an academic and largely irrelevant exercise to attempt to calculate a "theoretical envelope" as to how many LEO "systems" could be provided. Thus, Leosat's cramped reading of the Commission's notice of the task assigned to this Committee to glean an intent to accommodate at least five systems is beside the point, since hundreds of "systems" could be accommodated, although none of them would prove viable or provide reliable service. Indeed, vigorous competition that can satisfy the Commission's goals can be met with as few as two systems, although as ORBCOMM and STARSYS have shown, additional commercial systems are possible in the spectrum proposed to be allocated to this service.

The exclusion of Leosat from our discussions was a very straightforward matter. Putting aside their legal infirmity of a filing past the cut-off window, because they had never submitted a concrete proposal, including them in the discussions would have endlessly delayed any attempt to resolve the difficult sharing issues as Leosat attempted to design a system "on the fly." Moreover, Leosat as a dismissed applicant has no rights superior to any other potential applicant that may respond to a future cut-off notice. Accommodation of Leosat's current version of its hypothetical system would deny other future applicants equal consideration, and would confer a status on Leosat that has been denied by the Commission.

ORBCOMM has yet to see anything resembling a concrete system design from Leosat. So far we have seen an initial proposal for a FDMA system with anywhere from 2 to 55 satellites, a notion that they will use CDMA set forth in their comments on the Commission's proposal to allocate spectrum to this service, a press release announcing use of "SDMA", an indication in this proceeding that they will amend their application significantly after this proceeding, and now based on their statement of August 18th, an indication that they are "on record for the use of full CDMA." In this regard, ORBCOMM is puzzled by Leosat's assertion in that statement that there are two parties on record for use of full CDMA, since STARSYS' initial application proposed two options including FDMA and CDMA, and Leosat's application was for FDMA, although they have also subsequently touted CDMA and SDMA. STARSYS has explained in these proceedings that its shift to a hybrid CDMA/FDMA design is the result of a good faith effort to accommodate the current users and the other applicants, and is consistent with their application. We still do not have any idea what Leosat is proposing to use as a modulation scheme. We are anxiously looking forward to Leosat's technical sharing presentation scheduled for today's Advisory Committee meeting to see what their system design has "evolved" to at this point in time.

ORBCOMM also wants to correct the record with respect to Leosat's charge that we have claimed that "it is not the responsibility of these private parties to provide for future sharing." What we have said is that it is not possible to develop a workable sharing scheme among LEO systems and between LEO systems and current users without specific LEO system parameters. The task is further complicated by the fact that no one knows yet what usage already exists in these bands throughout the world, although the ORBCOMM experimental program is attempting to obtain the necessary data. We believe that additional systems can be accommodated in the spectrum proposed to be allocated by the Commission, and we have shown some of the ways that can occur. We also believe, however, that the appropriate role for the Negotiated Rulemaking Committee is to provide technical assistance to the Commission, not to provide engineering services to Leosat. It is toward this goal of assisting the Commission that ORBCOMM will continue to strive.

ORBCOMM also believes that Leosat's procedural objections to this advisory committee are unfounded. Under the Federal Advisory Committee Act (5 U.S.C.S. Appendix), which controls negotiated rulemaking committees (5 U.S.C. § 585(a)), the charter must be filed prior to the initial meeting of the committee (Federal Advisory Committee Act § 9(c)). That charter must include a termination date if it is less than two years from the date of the committee's establishment (Federal Advisory Committee Act § 9(c)(I)). Thus, Leosat's objection to the "imposition of a charter especially the termination date" without consulting the Committee as unlawful is without merit, since the Committee could not have met prior to the filing of the charter. Moreover, as

the subsequent progress of the Committee evidences, the time schedule set for completion of the Committee's work appears to be reasonable, and ORBCOMM anticipates the Committee being able to fulfill its responsibilities by September 16th. To that end, ORBCOMM will continue to work in a good faith manner, as should all of the participants, in order to conclude this Committee's work fully and expeditiously.

# **LEOSAT**

**Corporation**

**Multiple System Frequency Sharing Plan  
for LEO-MSS below 1 GHz**

**Presented to:  
Federal Advisory Committee**

**September 1, 1992**

**CRITICAL ISSUES TO BE SOLVED**  
**BY THIS COMMITTEE**

- **Which modulation method should be employed by the parties in order to co-exist with other satellite and terrestrial systems in the band.**
- **The extent to which the spectrum may be shared by future applicants.**

## ORIGINAL APPLICATION

STARSYS: CODED DIVISION MULTIPLE ACCESS- CDMA

ORBCOMM: FREQUENCY DIVISION MULTIPLE ACCESS-  
FDMA  
DYNAMIC CHANNEL ACTIVITY ASSIGNMENT  
SYSTEM- DCAAS

LEOSAT: CARRIER SENSE MULTIPLE ACCESS - CSMA

VITA: FDMA OR CDMA

CSMA IS A PROPOSED TECHNIQUE WHEREBY THE UPLINK IS SCANNED  
IN A MANNER SIMILAR TO THE ORBCOMM DCAAS APPROACH.  
THIS TECHNIQUE HAS YET TO BE PROVEN.

## **CDMA MODULATION TECHNIQUE**

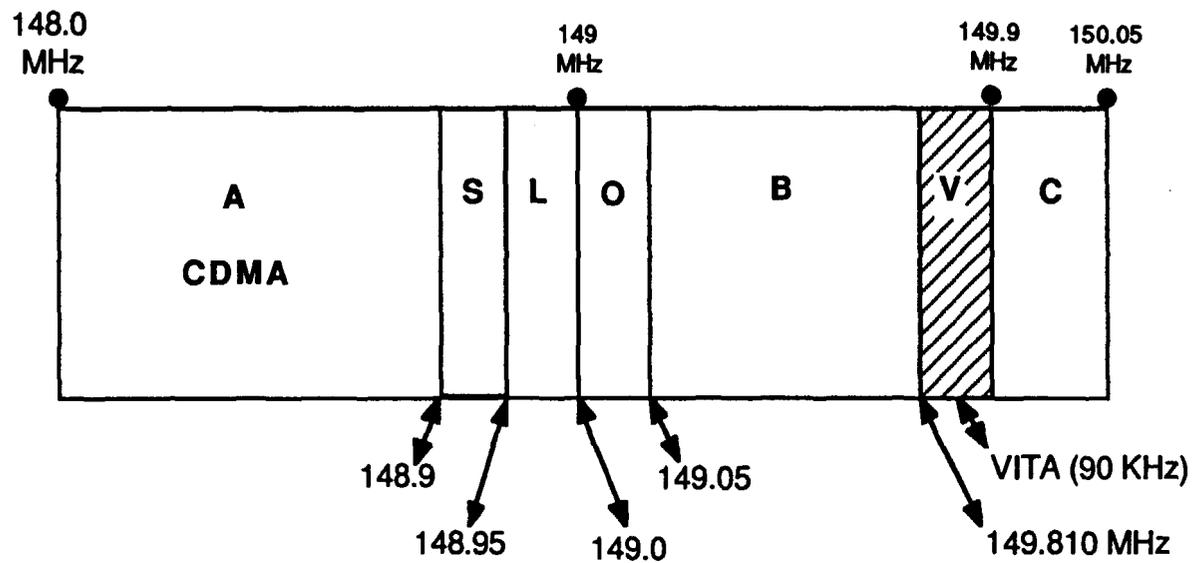
- Spread spectrum is the modulation of choice for severe interference environments.
- Several CDMA LEO MSS systems can share the same frequency band with each other and existing services due to the low power flux density (PFD).
- Several CDMA systems can operate without coordination with the "space operation", METSAT, radiosondes, or radio-theodolite transmissions services.
- The use of CDMA increases the potential for sharing of the limited frequency band.
- Improvements in throughput and increases in robustness against interference can be achieved by newer techniques being developed presently for this application.

Source of Data: Dept. of Canada LEO Spectrum Sharing Study.

## **FDMA MODULATION TECHNIQUE**

- This modulation technique may be able to share the band with other services, provided a dynamic channel allocation assignment approach is used.
- DCAAS represents such approach, but has yet to be proven.
- Sharing between FDMA systems can be done only through geographical and temporal separation.
- FDMA cannot share the same band with CDMA systems due to unacceptable interference from FDMA system to CDMA system.
- Sharing between LEO FDMA and existing systems will require the allocation of exclusive frequency bands for connecting links and space to earth links, complicated management of inter-band frequencies left by existing services, and coordination with existing services and METSAT aids.

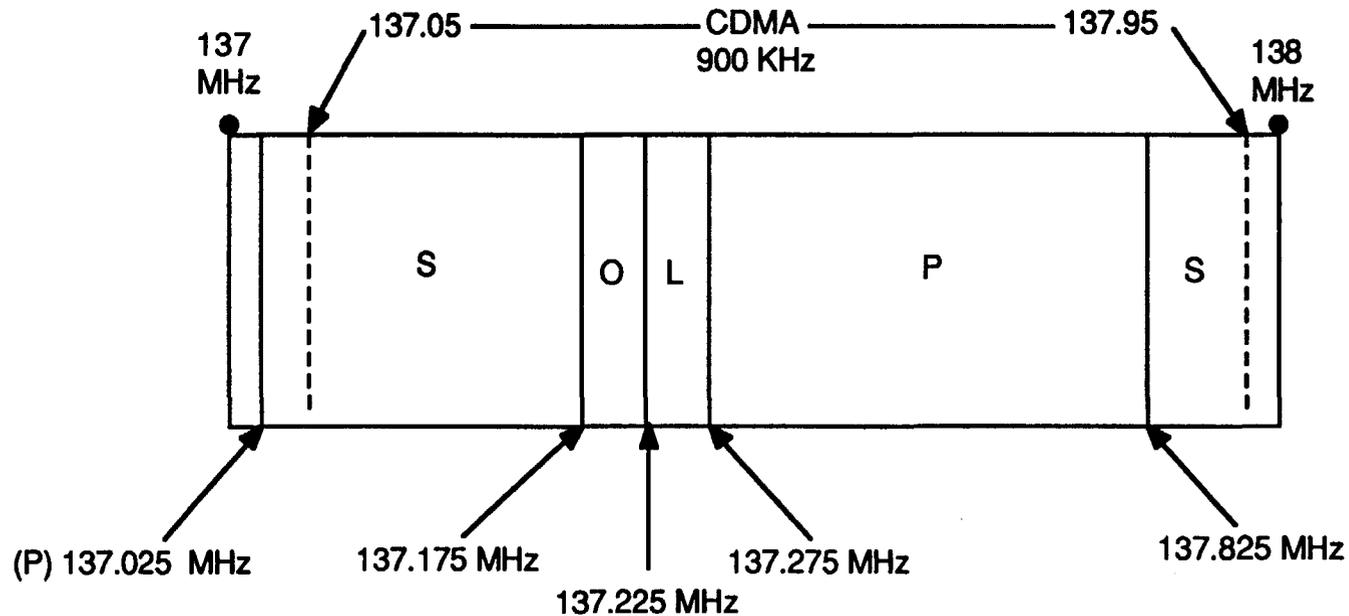
# LEOSAT PROPOSED UPLINK



- S= STARSYS NB FWD Link, BW 50 KHz
- L= LEOSAT NB FWD Link, BW 50 KHz
- O= ORBCOMM NB FWD Link, BW 50 KHz
- A= CDMA      BW= 900 KHz
- B= Not Used      BW= 760 KHz
- C= Not Used      BW= 150 KHz

Available on secondary basis until January 1, 1997

# LEOSAT PROPOSED DOWNLINK



- S: Secondary Allocation
- P: Primary Allocation
- O: ORBCOMM 50 KHz
- L: LEOSAT 50 KHz
- CDMA limited to 900 KHz BW to match uplink
- STARSYS 50 KHz and VITA 90 KHz downlinks located in center of 400.15 to 401.0 MHz band.

## RECOMMENDATIONS

In order to develop technical rules that will allow multiple licensees (up to 5) to participate in the below 1GHz services LEOSAT recommends that:

- DCAAS-FDMA not be used because of DCAAS technical risk and difficulty in sharing of frequency band with other systems.
- CDMA be used as the required modulation technique for the reasons previously described.

**CDMA will allow for maximum service availability and the maximum flexibility in the integration of smaller CDMA systems as they are licensed.**

DISTRESS SIGNALS AND COMMUNICATIONS

SEC. 321. [47 U.S.C. 321] (a) The transmitting set in a radio station on shipboard may be adjusted in such a manner as to produce a maximum of radiation, irrespective of the amount of interference which may thus be caused, when such station is sending radio communications or signals of distress and radio communications relating thereto.

(b) All radio stations, including Government stations and stations on board foreign vessels when within the territorial waters of the United States, shall give absolute priority to radio communications or signals relating to ships in distress; shall cease all sending on frequencies which will interfere with hearing a radio communication or signal of distress, and, except when engaged in answering or aiding the ship in distress, shall refrain from sending any radio communications or signals until there is assurance that no interference will be caused with the radio communications or signals relating thereto, and shall assist the vessel in distress, so far as possible, by complying with its instructions.<sup>122</sup>

<sup>122</sup> This section was amended to read as above by "An Act to amend the Communications Act of 1934, etc." Public No. 97, 75th Congress, approved and effective May 20, 1937, 50 Stat. 191. Section 321(a) formerly read as follows:

SEC. 321. (a) Every radio station on shipboard shall be equipped to transmit radio communications or signals of distress on the frequency specified by the Commission, with apparatus capable of transmitting and receiving messages over a distance of at least one hundred miles by day or night. When sending radio communications or signals of distress and radio communications relating thereto the transmitting set may be adjusted in such a manner as to produce a maximum of radiation irrespective of the amount of interference which may thus be caused.

SEC. 359.<sup>150</sup> [47 U.S.C. 357] (a) The master of every ship of the United States, equipped with radio transmitting apparatus, which meets with dangerous ice, a dangerous derelict, a tropical storm, or any other direct danger to navigation, or encounters subfreezing air temperatures associated with gale force winds causing severe ice accretion on superstructures, or winds of force 10 or above on the Beaufort scale for which no storm warning has been received, shall cause to be transmitted all pertinent information relating thereto to ships in the vicinity and to the appropriate authorities on land, in accordance with rules and regulations issued by the Commission. When they consider it necessary, such authorities of the United States shall promptly bring the information received by them to the knowledge of those concerned, including interested foreign authorities.<sup>151</sup>

(b) No charge shall be made by any ship or station in the mobile service of the United States for the transmission, receipt, or relay of the information designated in subsection (a) originating on a ship of the United States or of a foreign country.

(c) The transmission by any ship of the United States, made in compliance with subsection (a), to any station which imposes a charge for the reception, relay, or forwarding of the required information, shall be free of cost to the ship concerned and any communication charges incurred by the ship for transmission, relay, or forwarding of the information may be certified to the Commission

<sup>149</sup> This section was enacted without a subsection (b). See note 131.

<sup>150</sup> See note 131.

<sup>151</sup> Subsection (a) was amended to read as above by Public Law 89-121, approved August 13, 1965, 79 Stat. 511. It formerly read as follows:

(a) The master of every ship of the United States equipped with radio transmitting apparatus, on meeting with dangerous ice, a dangerous derelict, a tropical storm or any other direct danger to navigation, shall cause to be transmitted all pertinent information relating thereto, to ships in the vicinity and to the appropriate authorities, in accordance with rules and regulations issued by the Commission, which authorities of the United States shall, when they consider it necessary, promptly bring the information received by them to the knowledge of those concerned and foreign authorities interested.

for reimbursement out of moneys appropriated to the Commission for that purpose.

(d) No charge shall be made by any ship or station in the mobile service of the United States for the transmission of distress messages and replies thereto in connection with situations involving the safety of life and property at sea.

(e) Notwithstanding any other provision of law, any station or carrier may render free service in connection with situations involving the safety of life and property, including hydrographic reports, weather reports, reports regarding aids to navigation and medical assistance to injured or sick persons on ships and aircraft at sea. All free service permitted by this subsection shall be subject to such rules and regulations as the Commission may prescribe, which rules may limit such free service to the extent which the Commission finds desirable in the public interest.

MAR 16 '92 12:04 FROM NASA HQ WASH DC

LEOAC-36  
Appendix F  
PAGE.002

National Aeronautics and  
Space Administration

Lyndon B. Johnson Space Center  
Houston, Texas  
77058

**NASA**

Att: SN3-92-54

6 March 1992

Mr. Dan Jacobs  
Code XIB  
NASA Headquarters  
Washington, D.C. 20546

Dear Dan:

As we discussed in our phone conference with the Federal Communications Commission last Friday, we are providing you with a list of questions the FCC can submit to satellite constellation programs applying for FCC license. I believe we should establish a formal working relationship with the FCC in this area so we can adequately support them in assessing the information they will receive from the applicants.

Sincerely,



Donald J. Kessler  
Senior Scientist for Orbital Debris Research  
NASA/Johnson Space Center

**ORBITAL DEBRIS RELATED COMMENTS FOR  
FCC CONSIDERATION OF SATELLITE CONSTELLATION LICENSES**

**Subject: Orbital debris background of the applying organization.**

1. Describe any studies conducted by the applying organization that address issues of reliability against impact with debris or the potential orbital debris consequences of placing the constellation in the space environment.

**Subject: Data needed to evaluate debris issues for the proposed constellation.**

2. What is the number of spacecraft and number of orbital planes for the constellation.
3. For the constellation spacecraft, what is:
  - (a) the size and mass
  - (b) the orbit altitude, tolerable altitude range, and inclination of the orbits
  - (c) the mass, pressure, and location of pressurized fluid systems
  - (d) the mass and location of fuels and oxidizers
  - (e) the area and orientation of surfaces sensitive to submillimeter debris; examples are optical surfaces, wiring harnesses, pressurized fluid lines, and radiators.

**Subject: Minimizing debris associated with deployment.**

4. What are the plans for minimizing operational debris, i.e. debris associated with staging and deployment.
5. What are the plans for disposition of upper stages. Will upper stages be vented of pressurized liquids or gases and fuels?

**Subject: Prevention of direct or indirect debris generation during operational life.**

6. Is there potential from accidental explosion of a spacecraft during operations (from fuels or pressurized liquids or gases). If so, what measures will be taken to prevent these from occurring, and what is the reliability of these preventive measures?
7. What will be done to keep the constellation elements from colliding with each other or with large objects in the US SPACE COMMAND satellite catalog?
8. What is the reliability of the spacecraft for failure leading to loss of control during operational life? Was impact with small debris considered in determining this reliability?

**Subject: Constellation logistics.**

9. What launch vehicles or upper stages are being considered for constellation deployment and replacement?
10. What is the logistics plan for maintaining the constellation? What is the expected replacement rate? Where are replacement satellites stored?
11. What is the disposal plan for spacecraft approaching the normal end of life or spacecraft which are damaged but controllable and need to be replaced?
12. What is the disposal plan for spacecraft for which control is lost before the expected end of operational life?

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# Orbital Debris Environment for Spacecraft in Low Earth Orbit

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The results of measurements and modeling have been combined to describe an orbital debris environment model that can be used to evaluate spacecraft reliability vs shielding losses. Recent measurements by ground radars and telescopes, combined with analysis of recovered spacecraft surfaces, have provided some measurements of the environment over most of the size spectrum from micron size to the size of spacecraft. These measurements are consistent with models that assumed that smaller debris resulted from the breakup of satellites. Recent efforts to minimize satellite breakups will reduce the projected environment and delay the time period when satellite breakups from random collisions become important. However, there still remains a significant uncertainty in the current environment, and an even larger uncertainty in the projected environment. Uncertainties in the current environment will be reduced as a result of planned measurements. The future environment will mostly depend on future debris control measures taken and, to a lesser extent, on the amount of traffic to orbit.

## Introduction

THE natural meteoroid environment has historically been a design consideration for spacecraft. Sizes smaller than about 1 cm in diameter were the major concern. Meteoroids are part of the interplanetary environment and pass through Earth orbital space.<sup>1</sup> Earth orbiting payloads and spent rocket stages act as sources of orbiting objects smaller than 1 cm. Mathematical models have predicted, and measurements have confirmed, that a small but significant fraction of the Earth orbiting mass is found in sizes smaller than 1 cm. This paper will review modeling and measurement results that have been used to formulate an environment model that can be used for the engineering design of spacecraft. Even though our understanding of the current environment has been improving somewhat, and is expected to improve even more in the near future, a very large uncertainty exists in the projected environment.

## Analysis of Earth-Based Sensors

Early in the space program, there was a general perception that the North American Aerospace Defense Command (NORAD) was tracking "all man-made objects." However, during tests with NORAD's Perimeter Acquisition and Attack Characterization System (PARCS) radar, in 1976 and 1978, NORAD detected between 7 and 18% more objects than were being tracked.<sup>2</sup> Although this was not a large number, it did change the general perception. The new perception was that NORAD was tracking most objects in low Earth orbit larger than 10 cm. NORAD's exact limitations have never been released to the general public; however, the limitation of 10 cm was based on the fact that most NORAD radars operated at 70 cm wavelength; consequently, objects smaller than 10 cm would have very small radar cross sections. In addition, very few tracked objects at low altitudes had radar cross sections corresponding to objects smaller than 10 cm, and this limiting size increased with increasing altitude. These three considerations lead to the capabilities illustrated in Fig. 1.

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The responsibility for maintaining orbital element sets has been transferred from NORAD to U.S. Space Command. These element sets can be used to calculate flux as a function of altitude,<sup>3</sup> as shown in Fig. 2, where both the total tracked population and only the catalogued population are plotted for January 1987. The large peaks at 800, 1000, and 1500 km are the results of a combination of satellite breakups and heavy usage at these altitudes.

The effects of satellite breakups can be modeled to predict an uncatalogued population, if the nature of the breakup is understood. Figure 3 illustrates two breakup mass distributions from two different types of breakups. These two distributions are compared to an upper limit, which assumes that all of the fragment mass goes into some preferred size. This comparison shows that most of the mass from the Atlas missile explosion went into fragments slightly larger than 10 cm, with a very small amount of mass going into 1 mm to 1 cm fragments. The hypervelocity test also shows that most of the mass went into larger fragments; however, a significant fraction of the mass also went into 1 mm to 1 cm fragments. By fitting these types of distributions to known satellite breakups, the uncatalogued population can be predicted. An analysis in 1981<sup>4</sup> assumed that most of the satellite breakups followed the Atlas missile explosion data, and predicted a 10-cm population that was about twice the catalogued population. This analysis was inconsistent with the PARC's radar tests,

