COMSAT
Mobile Communications

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

By Hand

William F. Caton
Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Re: Ex Parte Submission in ET Docket No. 95-18

Dear Mr. Caton:

On Monday, May 22, 1995, COMSAT Corporation ("COMSAT") conducted a briefing for Michael Marcus, Charles Iseman, Sean White, and Fred Thomas of the Office of Engineering and Technology ("OET"). The primary purpose of the briefing was to discuss issues raised in COMSAT's Comments filed May 5, 1995, in the above-captioned proceeding. Attending the briefing from COMSAT were John S. Hannon, Jeffrey Binckes, David Weinreich, Sam Nguyen and the undersigned. During the briefing COMSAT presented the OET staff with copies of the three Appendices filed with COMSAT's Comments of May 5 and with a summary of COMSAT's alternative plan for the allocation of spectrum at 2 GHz for global mobile satellite services. Copies of these documents are attached to the original and one copy of this letter filed with the Secretary.

Respectfully submitted,

Nancy J. Thompson

Nancy J. Thompson

Attachment

cc: Michael Marcus
Charles Iseman
Sean White
Fred Thomas

No. of Copies rec'd 0+1
List A B C D E

COMSAT Presentation to FCC -- May 22, 1995

COMSAT'S ALTERNATIVE PLAN FOR MSS ALLOCATION AT 2 GHZ:

Phase I (1995-1998): All steps would proceed simultaneously with Step 5 completed by year-end 1995.

Step 1 Determine, based on computer simulations conducted by COMSAT LABS, that MSS and the terrestrial fixed services can share the WARC-92 MSS downlink band at 2160-2200 MHz. Terrestrial fixed operations, thus, would not need to be relocated to another part of the spectrum.

Step 2 Retune the BAS center frequencies and corresponding bandwidth of each of the seven BAS channels in the 1990-2110 MHz band. The result would be seven analog FM/TV BAS transmissions, 16 MHz each, in the 1998-2110 MHz band. This simple retuning would free 8 MHz of bandwidth at 1990-1998 MHz for global MSS use beginning in 1998. BAS operations would not have to be relocated to another part of the spectrum and there would be only minimal impact on BAS operational quality. BAS retuning costs are estimated at $35 million.

Step 3 Develop U.S. positions for WRC-95 which would ensure that at least a portion of the WARC-92 allocated spectrum for MSS (e.g. 1990-2010 for MSS uplink and 2170-2200 for MSS downlink) are available on a global basis by year 2000.

Step 4 Develop U.S. proposals for WRC-95 to begin the necessary studies within the ITU-R to determine the feasibility and arrangements to allocate the extended bands at 2010-2025 MHz and 2165-2170 MHz to global MSS at WRC-97, so that this additional MSS spectrum may become available in the year 2005.

Step 5 Allocate the bands 1990-2010 MHz and 2180-2200 MHz in the U.S. for MSS global services to become available for use in 1998. Entertain applications as soon as possible for use of this spectrum.

Phase II (1996-2005):

Step 1 Based upon the decisions at WRC-95, participate in studies within the ITU-R to determine the feasibility and arrangements to allocate the extended bands 2010-2025 MHz and 2165-2170 MHz to global MSS at WRC-97. Develop U.S. proposals to allocate additional spectrum to global MSS at WRC-97 consistent with these efforts.

Step 2 Assuming that the band 2010-2025 MHz is allocated for global MSS uplinks, require BAS to commence the transition to digital transmission to be completed by the year 2005 when the new global band for MSS becomes available. Digital operations will increase spectrum efficiency and enable BAS to operate effectively in a reduced BAS band at 2025-2110 MHz (e.g. 13 MHz in the first BAS channel and 12 MHz in the other six BAS channels).

Step 3 Allocate within the U.S., following WRC-97, the new MSS global bands allocated at WRC-97.

Figure 1

FCC's Proposed Re-allocation of 2 GHz Bands

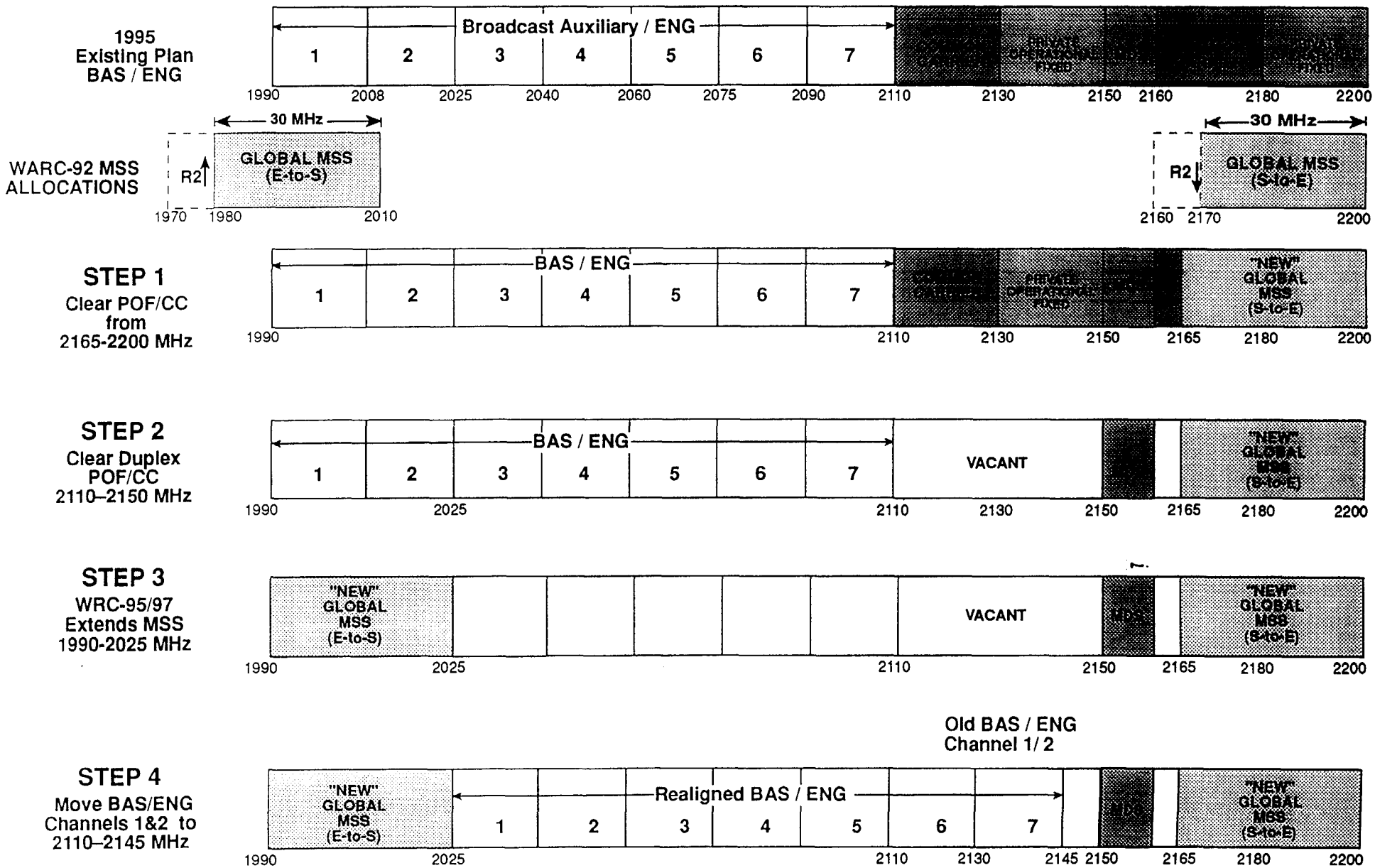
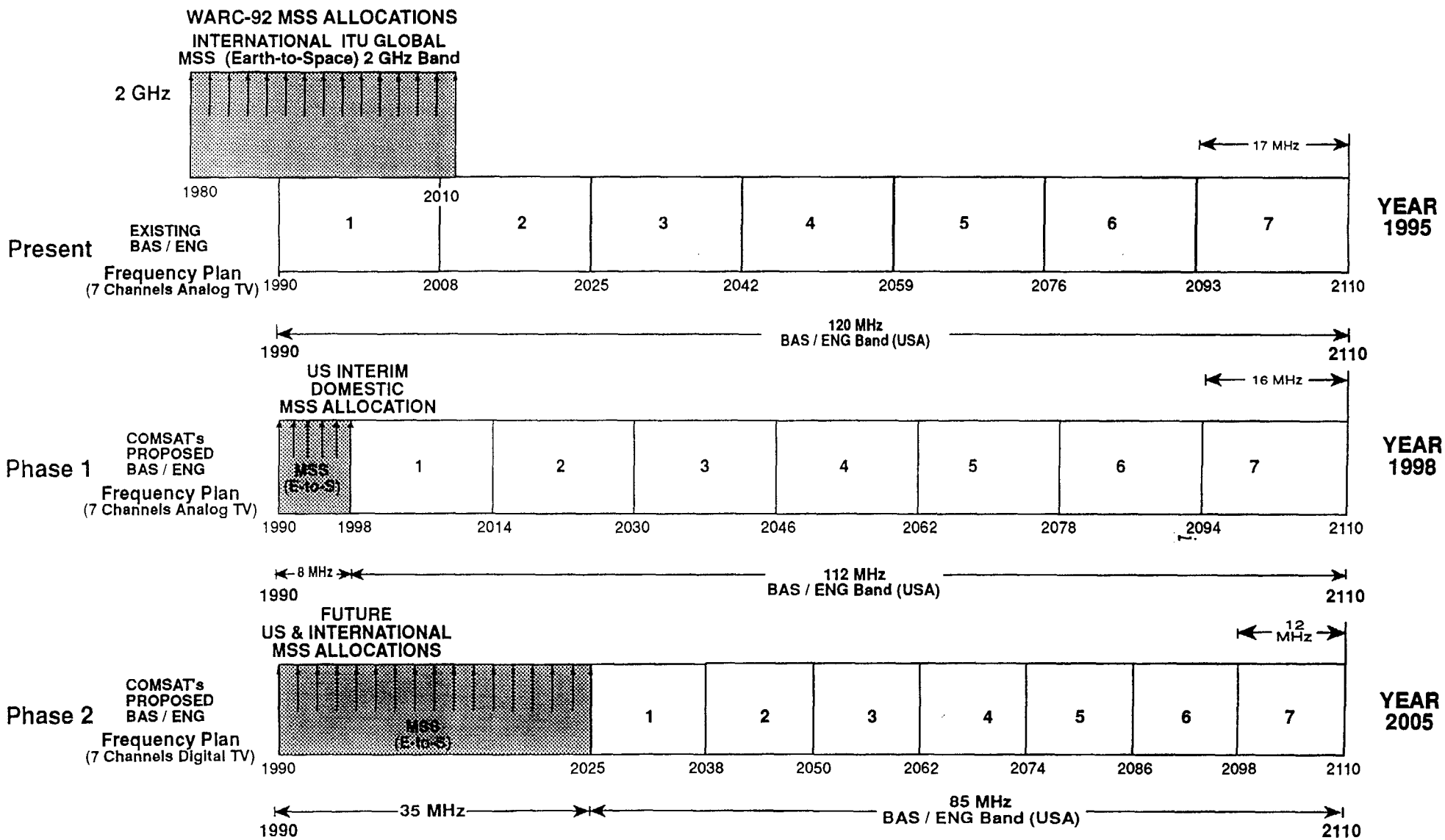


Figure 2

COMSAT's Proposed Rechannelization of the BAS 2 GHz Band



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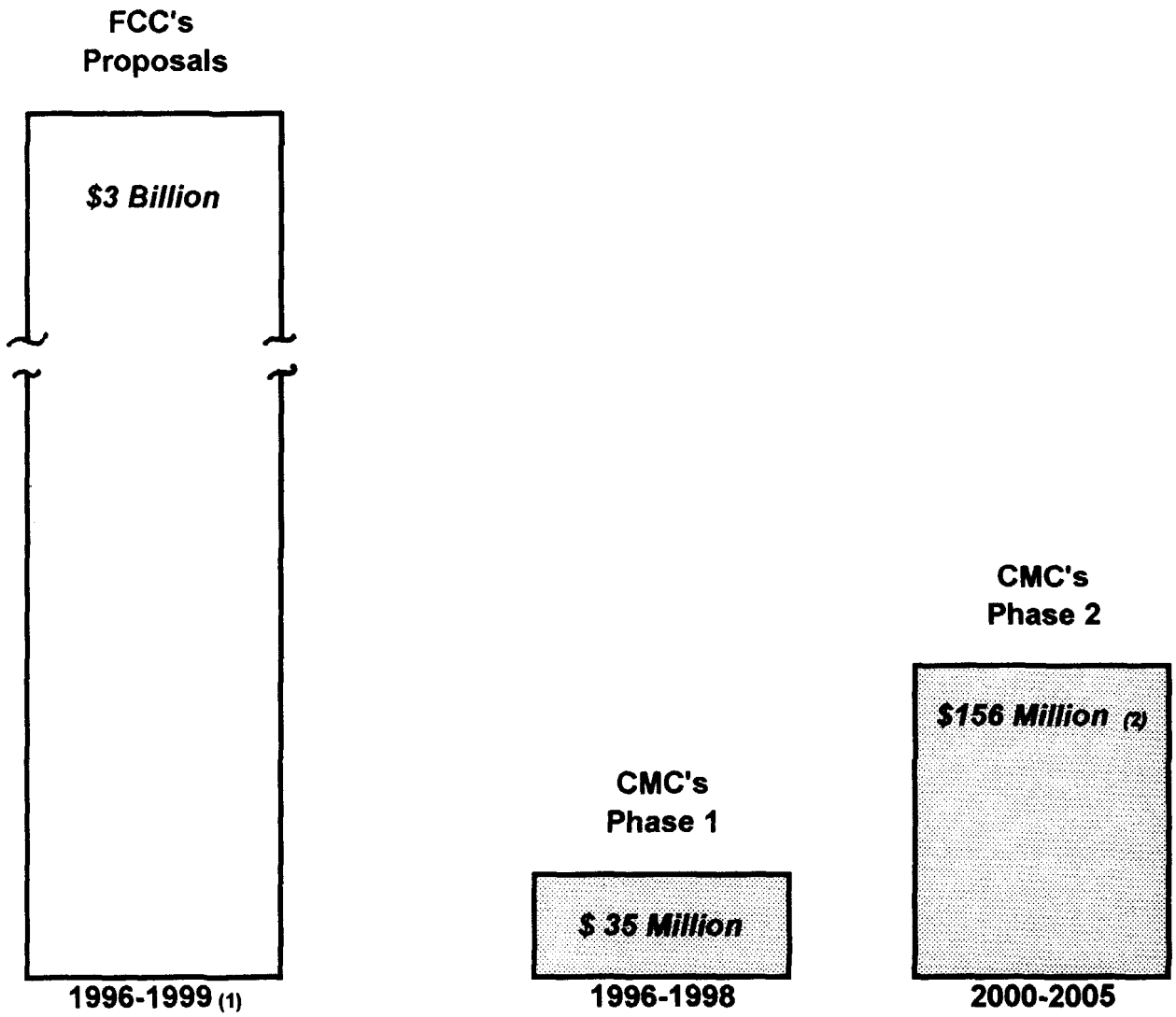
Cost Comparison of FCC's Proposals vs. CMC's Proposal



(1) Assume three year negotiation period
(2) Assume a four-fold reduction in cost by 2000 for a digital TV codec and modem unit

APPENDIX I

SIMULATION OF INTERFERENCE BETWEEN TRANSMITTERS OF THE BROADCAST AUXILIARY SERVICE AND INTERMEDIATE CIRCULAR ORBIT SPACECRAFT OPERATING IN THE MOBILE SATELLITE SERVICE

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SIMULATION OF INTERFERENCE BETWEEN TRANSMITTERS OF THE BROADCAST AUXILIARY SERVICE AND INTERMEDIATE CIRCULAR ORBIT SPACECRAFT OPERATING IN THE MOBILE SATELLITE SERVICE

Introduction

COMSAT Mobile Communications (CMC) is acutely aware of the potential for interference between terrestrial stations operating in the Broadcast Auxiliary Service (BAS) and spacecraft operating in the Mobile Satellite Service (MSS) in portions of the bands currently jointly allocated to both Services. DoPEStically CMC is an active participant in the FCC Industry Advisory Committee on WRC '95 and its associated Informal Working Groups (IWGs) which are dealing with these important interference issues.

Based upon this participation, CMC has conducted studies of the effects of interference and the possibilities for sharing frequency bands between the MSS and the BAS. CMC has determined that frequency sharing is not possible between transmitting stations operating in the BAS and receiving spacecraft operating in the MSS and has performed computer simulations to confirm this allegation. The purpose of this Appendix is to describe the work performed by CMC, explain the conclusions reached in the execution of that work and substantiate the frequency sharing conclusions.

Description of Simulation

A computer simulation effort was mounted in order to determine the effects of interference from BAS terrestrial transmitters on a receiving I-CO spacecraft operating in the MSS. Briefly, the simulation program assumes a configuration of BAS transmitting stations and a constellation of receiving MSS spacecraft and evaluates the amount of interference received by each MSS spacecraft as a function of time.

Current frequency allocations based on WARC'92 grant co-primary status to the BAS and the MSS Earth-to-space in the 1990 - 2010 MHz band. As MSS spacecraft must use sensitive receivers in order to provide service to low power handheld earth terminals, relatively powerful transmitters operating in the BAS represent a significant interference source to these spacecraft. The computer simulation was used to assess this interference threat.

The BAS is utilized primarily for Electronic News Gathering (ENG) and as such the transmitters are portable and may be directed in any orientation in order to provide the best transmission quality between a late breaking news event and one

of several fixed receiving sites. To model the interference environment, the computer program randomly establishes the location of a number of BAS transmitters based upon a number of transmitters per given area in the USA. In this case the transmitter density was one transmitter per 2200 square miles. Transmitting azimuths are chosen at random and all of the transmitters are assumed to be directed at the horizon and have a 0° elevation angle. The characteristics of the transmitters are given in the next section.

The I-CO satellites are assumed to be in a specific set of orbits and form a constellation, in this case, 10 satellites in two orbital planes each inclined 45° from the equator. As opposed to Geostationary spacecraft, which appear from the earth's surface to remain stationary, spacecraft in an ICO will move across the sky in a set pattern. As the spacecraft move across the sky their various spotbeams will be irradiated by the terrestrial BAS. The relevant baseline spacecraft parameters are summarized as follows:

# of Satellite Planes	2
# of satellites per plane	5
Orbit Height	10355 km
Orbit Inclination	45°
# of transmitting beams	121
Boresight Separation	3.96°
Allocated Bandwidth	25 kHz
Occupied Bandwidth	22.5 kHz
EIRP per Carrier	36.2 dBW
Maximum # of Carriers/Beam	80
Center Frequency of all Beams	1990 MHz

After the generation of the BAS transmitter locations, the simulation program calculated the interference into each spacecraft receiver as the MSS spacecraft constellation progressed across the sky. Interference calculations were made for each MSS satellite receiver for a simulated time interval of 20 seconds for a total for 4320 intervals, which simulated one day of operation. This period of time is sufficient to evaluate the interference for stations in the USA since it covers the passage of at least four satellites over the country.

The output of the simulation is a record of the Carrier-to-Interference plus Noise ratio (C/N+I) for the MSS receiving spacecraft. This quantity is arrived at by establishing a reference MSS link using one Personal Earth Station (PES). In the simulation program, 12 PESs are active at one time. The program determines which PES is in the appropriate service area and then determines which satellite beam is servicing this link. Once the beam is determined, the amount of BAS interference impinging on that beam is calculated. The simulation assumes a distribution of BAS transmitters spread over a geographical area and further assumes that only one third of these transmitters are active at any given time. Once the level of interference in known, the C/I is computed directly. The C/N is computed by determining the noise power at the spacecraft receiver from the input bandwidth of the spacecraft and the noise temperature of the spacecraft receiver. Combining the C/I and the C/N on a power basis results in the C/(N+I). The C/(N+I) results are presented in the next section.

Results of UPLINK Simulations: ENG Transmitters into MSS Uplinks

COMSAT used the simulation software described above to determine the aggregate effects of interference from a number of ENG-mobile van transmitters--those which would be "visible" to satellites/beams carrying handheld links--into the MSS (receiving system) uplinks. Specifically, we entered into the simulation model the uplink parameters of the I-CO Non-GSO/MSS satellite network and ran these parameters against the typical RF characteristics of the ENG mobile van stations. The simulation of the resulting C/(I+N) statistics were generated for twelve (12),separate reference I-CO Personal Earth stations (PESs) or handheld terminals, being used at various locations around the world. The parameters for ENG transmit stations and the I-CO uplink receiving system, respectively, are listed below:

ELECTRONIC NEWS GATHERING (ENG) TRANSMIT STATIONS

EIRP	33 dBW; 1432 ENG Stations active simultaneously
Peak Gain	21 dBi; beamwidth = 15 degrees baseline
Gain pattern	ITU-R Rec. 699-2 radiation pattern (roll-off)
FM/TV RF Bandwidth	17 MHz (Carson Rule Bandwidth)

I-CO SATELLITE CHARACTERISTICS (UPLINK PARAMETERS)

P-terminal receive power	-154 dBW (fixed)
Satellite Gain pattern	WARC-88 standard sat-antenna pattern
Peak spot beam ant-gain	31.77 to 29.99 dBi (after feed losses)
Satellite Sys. Noise Temp.	396.4 K to 247.8 K
P-terminal tracking mode	select highest elevation angle satellite
Number of PES links tested	12,at various locations around the world

COMSAT has conducted two types of output simulation runs using the above-mentioned P-terminal satellite tracking strategies: 1) terminal communicates with the highest elevation-angle satellite visible to its location; and 2) terminal communicates with any of the various visible satellites, with the choice determined by random selection.

For the purpose of the instant filing, we have displayed the output of the maximum elevation-angle satellite tracking mode, because this tracking algorithm is the most likely one to be used in the I-CO hand-overs operationally. The output is shown in Figure 1-1. This plot shows the frequency of occurrence that a particular C/(I+N) value is exceeded. The histograms for all 12 PESs are overlaid on one plot.

COMSAT notes that, in general, the population of C/(I+N)'s range in very low values, from a low of -5 dB to the best cases of approximately +3 to +7 dB, as shown in Figure 1-1. The C/(I+N) curve which exhibits a peak at around -5 dB represents that for a PES located in the USA. For this USA based PES, the background sidelobe radiation from 100s - 1000s of ENG transmit stations is extremely high and totally dominates the wanted carrier from the PES. The other curves show the impact of main-beam and/or aggregate sidelobe ENG interference to uplinks from PESs located elsewhere in the world.

Of course, these values would not represent acceptable performance to I-CO handheld users, because they would generally corrupt voice signals a large percentage of the time, which would be intolerable to the average customers expecting cellular telephone voice quality on the satellite system. A minimum acceptable C/(I+N) value would be in the range of +13 to +15 dB to achieve the voice/data performance objectives.

It is important to emphasize that in these uplink interference simulations we have assumed a better antenna pattern for the ENG transmit stations than the antenna systems actually used in BAS commercial operations. (ITU-R Rec 699-2 has

better sidelobe rejection characteristics than the radiation pattern typically employed by ENG stations with "orange-peel" mast-mounted antennas, known by the trade name SILHOUETTE.)

Conclusions

These results confirm the assertions made by the Commission that MSS cannot share uplink frequenciews with ENG carriers. The data show that the aggregate effect of sidelobe radiation and/or main-beam intercepts from a typical number of active ENG stations "on-the-air" simultaneously is more than enough to cause unacceptable performance to a high-gain satellite system such as I-CO. The results confirm the vulnerability of non GSO satellites--working with very low-power uplinks from handheld terminals--to aggregate interference from high-power terrestrial links.

It is noteworthy that all of of the "test" PES links except one which were used in our simulations were links originated from PESs located outside the United States. (See Figure 1-2, a map of the world depicting the locations of the 12 PES handheld terminals). Ironically, the PES terminals in the U.S. are more likely to suffer mainly sidelobe illumination, because the PES links are being carried on I-CO satellites traversing U.S. territory at high elevation angles; whereas, the PES terminals in, for example, Europe "see" ENG illumination at very low angles of arrival, which are close to the main beams of the ENG stations, will also experience ENG mainbeam "hits" giving rise to C/Is less than typically 0 dB.

COMSAT notes that further ENG/MSS interference simulations could be undertaken in the reply period in the instant proceeding in order to provide additional detailed information. However, further simulations, on the basis of the above of the above or similar assumptions, are unlikely to alter the basic conclusion that MSS uplink communications from handheld PES terminals cannot operate compatibly with high density ENG usage within the bands 1990 - 2010 in the USA. Figure 3 depicts on a map of the USA the actual density of ENG stations that was used in the simulation runs presented here.

FIGURE 1-1. UPLINK INTERFERENCE FROM U.S. ENG SYSTEMS TO 12 PES SYSTEMS (Tracking Sat. W/ Max. Elev. Angle)

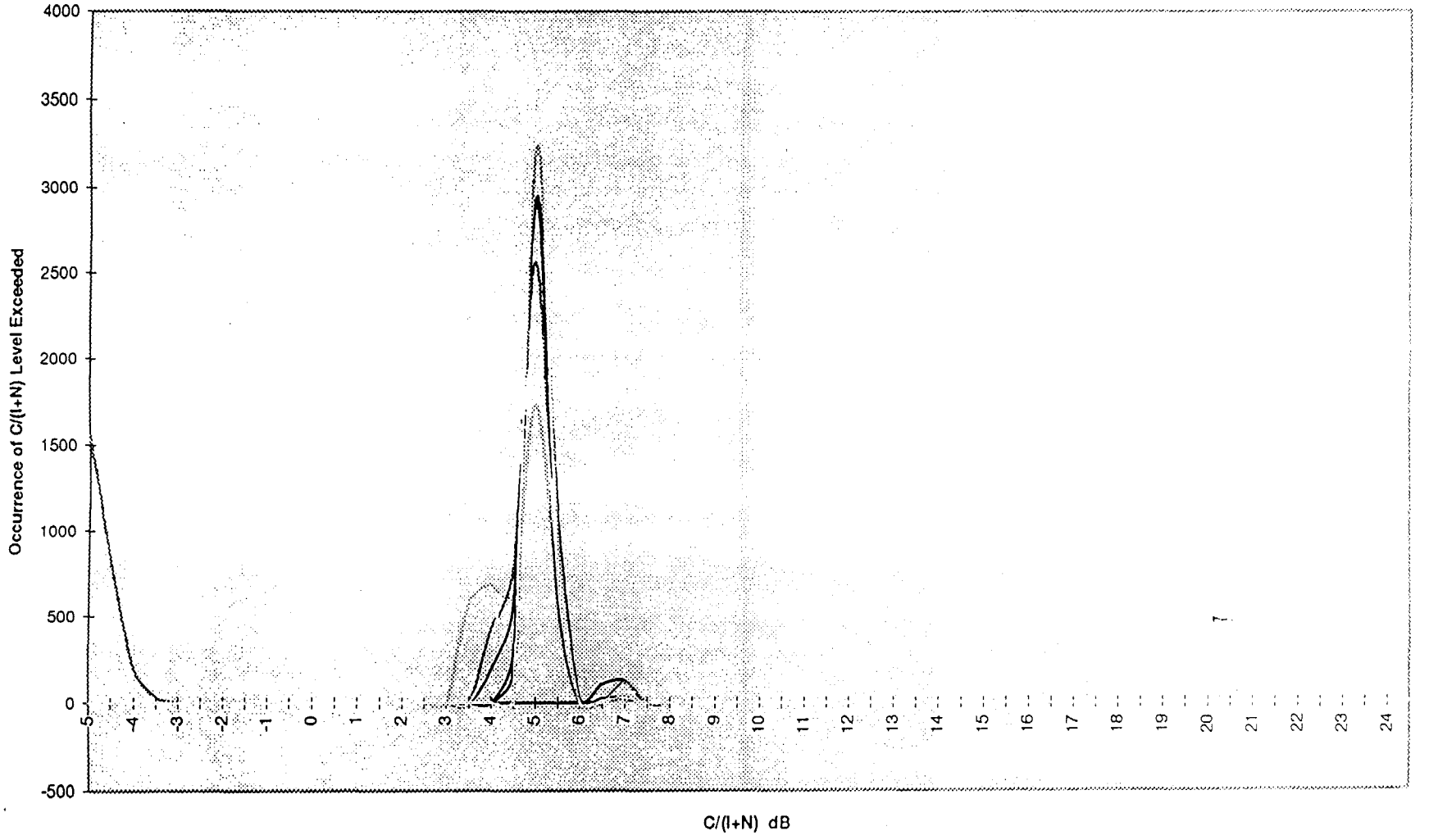


FIGURE 1-2. LOCATIONS OF 12 PERSONAL EARTH STATIONS FOR UPLINK INTERFERENCE

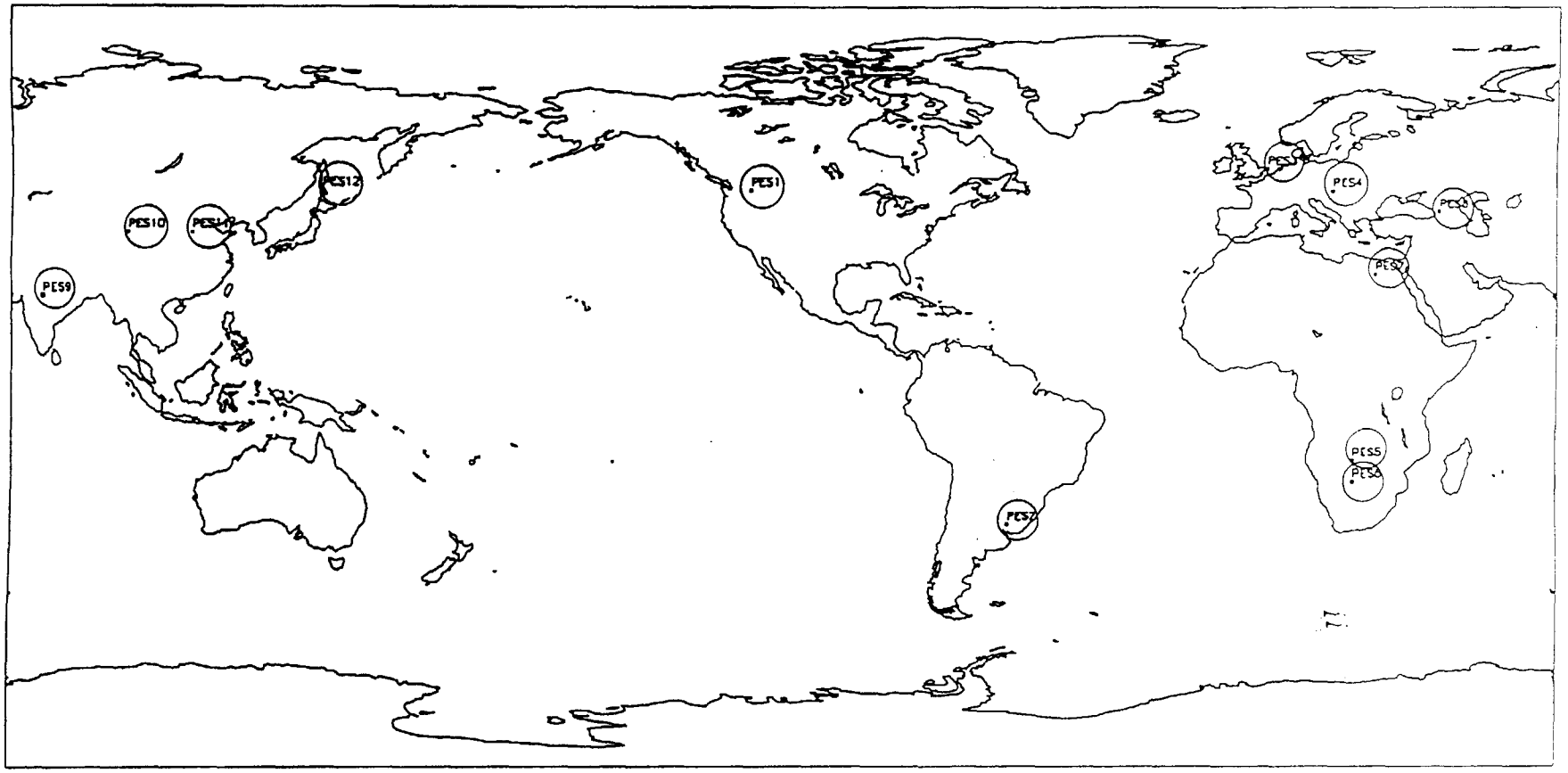
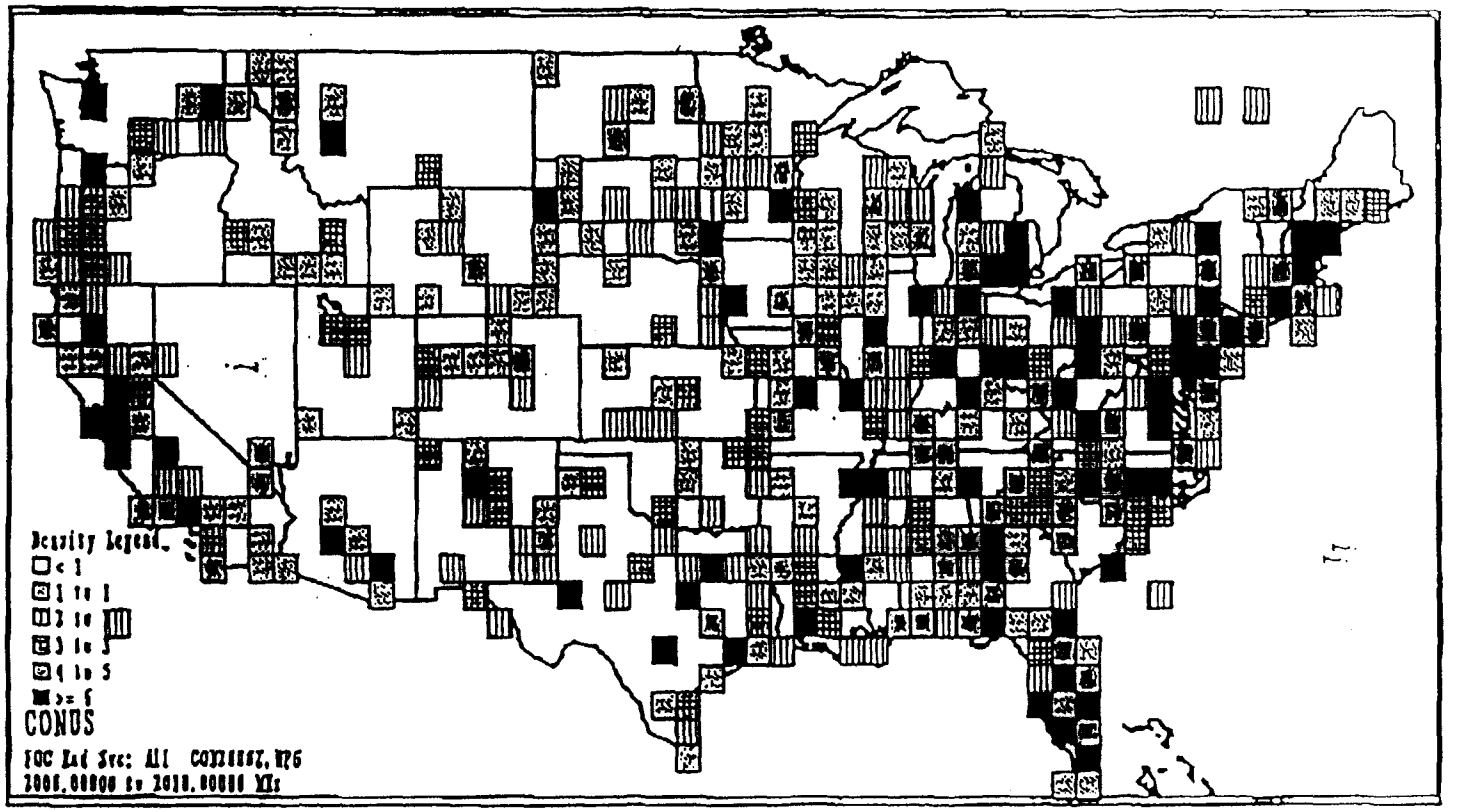


Figure 1-3 Population of ENG Stations In First Two Channels: 1990-2008; 2008-2025 MHz

Total Number of Stations (CONUS) = 1394

Source: FCC EMELF Data File



APPENDIX II

SIMULATION OF INTERFERENCE BETWEEN INTERMEDIATE CIRCULAR ORBIT SPACECRAFT OPERATING IN THE MOBILE SATELLITE SERVICE AND TERRESTRIAL STATIONS IN THE FIXED SERVICE

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SIMULATION OF INTERFERENCE BETWEEN INTERMEDIATE CIRCULAR ORBIT SPACECRAFT OPERATING IN THE MOBILE SATELLITE SERVICE AND TERRESTRIAL STATIONS IN THE FIXED SERVICE

Introduction

COMSAT Mobile Communications (CMC) is well aware of the potential for interference between spacecraft operating in the Mobile Satellite Service (MSS) and terrestrial stations operating in the Fixed service (FS) in bands currently jointly allocated to both Services. CMC has actively participated in the various international groups, sponsored by the International Telecommunications Union (ITU), which are studying these interference issues, including Task Group 2/2 and the Conference Preparatory Meeting (CPM) for the 1995 World Radio Conference (WRC'95). Domestically CMC is an active participant in the FCC Industry Advisory Committee on WRC '95 and its associated Informal Working Groups (IWGs).

Based upon this participation, CMC has conducted studies of the effects of interference and the possibilities for sharing frequency bands between the MSS and the FS. CMC is fully convinced that frequency sharing is possible between transmitting spacecraft in the MSS and receiving stations operating in the FS in bands around 2 GHz and has performed work to demonstrate this fact. The purpose of this Appendix is to describe the work performed by CMC, explain the conclusions reached in the execution of that work and substantiate the frequency sharing conclusions.

Description of Simulation

A computer simulation effort was mounted in order to determine the effects of interference from an I-CO spacecraft operating in the MSS into receiving stations operating in the FS. Briefly, the simulation program assumes a configuration of FS receiving stations and a constellation of transmitting MSS spacecraft and evaluates the amount of interference received by each FS station as a function of time.

Different simulation runs were performed to reflect the equipment difference between the Private Operational Fixed systems which primarily use analog equipment and have an allocation from 2180 - 2200 MHz and the Common Carrier systems which primarily use digital equipment and have an allocation from 2160 - 2180 MHz.

Describing the interfering spacecraft transmitters first, a simulated set of satellite transmitters was created by the computer program. The I-CO satellites are assumed to be in a

specific set of orbits and form a constellation, in this case, 10 satellites in two orbital planes each inclined 45° from the equator. As opposed to Geostationary spacecraft, which appear from the earth's surface to remain stationary, spacecraft in an I-CO will move across the sky in a set pattern. As the spacecraft move across the sky their various spotbeams will irradiate terrestrial FS stations with varying amounts of power. The relevant spacecraft parameters are summarized as follows:

# of Satellite Planes	2
# of satellites per plane	5
Orbit Height	10355 km
Orbit Inclination	45°
# of transmitting beams	121
Boresight Separation	3.96°
Allocated Bandwidth	25 kHz
Occupied Bandwidth	22.5 kHz
EIRP per Carrier	36.2 dBW
Maximum # of Carriers/Beam	80
Center Frequency of all Beams	2185 MHz

The simulation program further assumes some rather pessimistic conditions for the satellite downlink. These are:

- All satellite beams are fully loaded with 80 carriers
- All of the beams on one satellite use the same center frequency
- All of the visible satellites are using the same center frequency

It is unlikely that these conditions would exist but since they insure a worst case downlink interference situation, they are used in the simulation to provide conservative results.

The FS station locations are derived in either of two ways. In the first case actual station locations were selected from an FCC database. The numbers of stations forming a system was limited due to difficulties with sorting the database, thus the number of receiving stations using actual locations was limited to five. These five stations comprised a system made up of four hops. Representative FS stations were chosen throughout the USA from the FCC Enhanced Microwave Environmental Link File

(EMELF) Database in the case of Private Operational Fixed (POF) networks, which occupy the 2180 - 2200 MHz band, and the FCC Part 21 database for the Common Carrier Networks, which occupy the 2160 - 2180 MHz band.

Simulations were also run for FS systems made up of 20 hops. In this case, sorting problems with the FCC databases and time constraints dictated letting the computer program randomly generate the locations of the FS stations. For these situations, the computer program randomly picked the start of the 20 hop system to be somewhere in the USA, randomly chose direction for the trend line and an angular deviation from this trend line. Station locations were then generated by randomly choosing a transmission azimuth within the trend line constraints, assigning a path length based upon an average and a maximum deviation and progressing from one station to the next until a total of 20 was reached.

A critical FS station parameter is the antenna pattern. In order to provide a conservative analysis, the characteristics of either 4 foot diameter or 6 foot diameter, so called "Class B", antennas were used due to their poor sidelobe discrimination. Simulations were conducted for receiver noise temperatures of 850 K and 300 K. It was felt that 850 K represented a conservative assumption since older equipment would have a noise temperature that was considerably higher and the 300 K temperature represented a pessimistic case since few stations would be this sensitive. The FS station characteristics are summarized in the following Table.

	Private Operation Fixed	Common Carrier
Modulation Type:	Analog/FM	Digital/PSK/QAM
Allocated Bandwidth:	800 kHz	3.5 MHz
Transmitted Power:	36.3 dBW	33.0 dBW
Receiver Temperature:	300K/850K	850K
Antenna:	4 foot diameter 6 foot diameter	4 foot diameter 6 foot diameter
Average Hop Length:	24.2 ±3 km	28.6 ±3 km

After the generation of the FS station locations, the simulation program calculated the interference into each FS station as the MSS spacecraft constellation progressed across

the sky. Interference calculations were made for each FS station for 4320 simulated time intervals of 20 seconds each which simulated one day of operation. This period of time is sufficient to evaluate the interference for stations in the USA since it covers the passage of at least four satellites over the country.

The output of the simulation is a record of the Carrier-to-Interference plus Noise ratio (C/N+I) for the FS receiving station. The carrier power at the FS receiver is computed using the FS transmit power, the path length and the receiving antenna gain. The noise power at the receiving station is computed from the bandwidth and the receiver noise temperature. The interference is computed using the satellite transmit power, the path length, and the receiving antenna gain in the direction of the satellite. These three results are then combined to yield the C/N+I.

An example of a basic calculation of C/I+N is demonstrated in the following. This assumes a Private Operational Fixed terrestrial system using 4 foot diameter antennas.

$C/(N+I) = C/N + C/I$ where the addition is done on a power basis

$$C/N = C_{TERR} - P.L. + G_{ANT} - 10\log(kT_{rx}B_{rx})$$

where: C_{TERR} = Terrestrial Transmitter EIRP, dBW

$P.L.$ = Free Space Path Loss, dB

G_{ANT} = Terrestrial Receive Antenna Gain, dB

k = Boltzmann's Constant, 1.38×10^{-23} W/Hz K

T_{rx} = Terrestrial System Noise Temperature, K

B_{rx} = Receive Bandwidth, Hz

$$C/N = 36.3 - 126.3 + 26 - (-140.3) = 76.3 \text{ dB}$$

- - - -

$$C/I = (C_{TERR} - P.L. + G_{ANT}) - (C_{SPC} - P.L._{SPC} + G_{ANT}(\alpha))$$

where: C_{SPC} = Spacecraft Transmitter EIRP, dBW

$P.L._{SPC}$ = Free Space Path Loss from Spacecraft, dB

$G_{ANT}(\alpha)$ = Terrestrial Receive Antenna Gain in the Direction of the MSS Spacecraft, dB

$$C/I = (36.3 - 126.3 + 26) - (51.4 - 181.5 + 8.5) = 57.6 \text{ dB}$$

$$C/(N+I) = C/N + C/I \text{ summed on a power basis}$$

$$= 76.3 + 57.6 = 57.5 \text{ dB} \quad \text{for a } 10^\circ \text{ elevation angle}$$

For elevation angles of 20° and 40° the C/(I+N) is 61 dB and 62.9 dB respectively. These C/(I+N) show that sharing bewteen MSS downlinks and the FS would be feasible. Also notable is the enviable C/N of the terrestrial system of approximately 76 dB.

Results of DOWNLINK Simulations: I-CO-P Satellite into U.S. Fixed Service Stations (Common Carrier and Private Operational Fixed)

Configuration of Fixed Links (both CC and POF) in Simulations

The general features of the downlink simulation model described above apply to all the cases presented herein. However, for purposes of realism and validation of our assumptions, as well as ease of computation, two different approaches were used to input the parameters of the U.S. based FS systems (Common Carrier and Private Operational Fixed microwave networks). It is helpful to bear in mind these two approaches in order to appreciate the interpretation of the results of the downlink simulation runs delineated below. For the reader's reference, we designate these two approaches as: 1) "Real" FCC FS-station Link Data Base; and 2) "Hypothetical" (computer- constructed) FS-stations. The logic of the two approaches follows:

Approach No.1 - Inputs Using of Real (FCC License) FS Stations

In the first approach, actual FCC FS-station data base information was input from the FCC's ELMF data base to create a pool of real, existing stations to be "exposed" to I-CO downlink interference in the simulation runs. However, typically these cases are comprised of single hop and multi-hop microwave systems up to 3 or 4-hops (4 to 5 terrestrial stations in tandem per microwave system).

Approach No.2 - Inputs Using Computer-Generated FS Stations

As a second approach, COMSAT used "hypothetical", computer-generated multi-hop microwave links for networks of more than 4 hops. The reason that this second approach was developed is that COMSAT found that certain limitations; i.e, data entry management problems and a limit (due to software source code itself) on the maximum number of antennas that can

be included in one simulation run using data generated from the FCC's ELMF data files, precluded our running downlink simulations of interference into FS links with microwave networks of more than about 4 hops per system.

Because of these constraints, COMSAT found it necessary to use the computer itself to "create" multi-hop terrestrial systems, for networks of 5 hops up to 20 hops. This is accomplished by selecting a prototype characteristic station with parameters identical to actual FCC ELMF file data and then laying out "hypothetical" multihop microwave links to represent as closely as possible to real systems, but using computer-generated geographic locations, trend lines, and (various) path lengths, which "hypothetical" links are not actually found in the FCC license files. We tested 3-,4-hop microwave links in parallel simulations of "real" vs "hypothetical" stations to confirm that their performance in the presence of downlink interference from I-CO was comparable. This confirmation enabled us to run the simulations for microwave systems with up to 20 hops--with the confidence that such "hypothetical" stations would provide as reliable a gauge of performance, under MSS interference as those experienced by "actual" CC and POF stations whose locations/trend lines are registered in the FCC's license files.

Common Carrier Simulation Results

CASE I

Figure 2-1 shows the resulting C/(I+N) performance of nine, separate 5-station (3 to 7 hops) common carrier networks, using real input data from different common carrier systems simulated in this interference run.

These common carrier stations were run with a receiving system noise temperature of 850 K. As can be seen from the distribution of the occurrence of end-to-end C/(I+N) values, the thermal noise really dominates in these systems, as compared to the additive noise from MSS satellite downlinks. The results show a distribution of C/(I+N) from a low of about 65 dB to a high C/(I+N) of 74 dB. This level of interference results in negligible noise to common carrier facilities in this band.

CASE II

This is one of numerous multi-hop common carrier hypothetical links that were simulated. We show in this case of a collection of 39, 20-hop common carriers systems, using 850K equivalent receiving system noise temperature. These results are shown in Figures 2-2. 4. In this case, we see a very narrow dispersion in the spread of statistical data representing the frequency of occurrence of C/(N+I) values. They are all centered on C/(I+N) values in the vicinity of 57 dB to

approximately 60 dB. These values of C/(I+N) indicate that sharing with the FS is feasible.

Private Operational Fixed Simulation Results

CASE III

Figure 2-3 shows the simulation results of 42 actual (real license file systems), which are 1 to 3-hop POF systems with system noise temperatures of 850K. Again, these results are very similar to the common carrier case above for a real license file microwave systems. The C/(N+I) values range from a levels of 56 dB to 79 dB, which shows once again that sharing with MSS downlinks would not be a problem.

CASE IV

Figures 2-4 represents an ensemble of 39 POF microwave systems, each with 3-hops. These networks were constructed with hypothetical stations, instead of real POF station, as described above (850K noise temperature) in CASE III. In these data, we see that the spread of statistics is very tight; but, nevertheless, the C/(N+I) values are still extremely high; all in the 77 to 81 dB range indicating successful sharing with the MSS.

CASE V

Figure 2-5 portrays the same type of data for POF links as CASE IV, except that in this case the networks each contain 20 hops. Again, these multi-hop systems were constructed using 850K hypothetical stations. As was observed for the 3-hop POF links, the C/(N+I) values are still extremely high, 68-71 dB. As one might expect, the values are somewhat lower than the 3-hop case, no doubt because of the greater number of hops in tandem (20 hops versus 3 hops). Neverless, no sharing problems with the MSS would result from this performance.

CASE VI

In order to test the sensitivity of our model and these interference simulations, COMSAT also arbitrarily lowered the receiving system noise temperature of the POF microwave stations to 300K, instead of using the more realistic assumption of 850K. This lower thermal noise for POF microwave receivers was used to deliberately create a more pessimistic set of conditions for "victim" microwave systems.

As expected, there is a detectable improvement in the performance of these links in the presence of MSS downlink interference. Thus, these 20-hop systems (again 39 microwave systems were simulated, the same parameters were used except for the change in noise temperature) show a narrow range of C/(N+I) values from 69 dB to 72 dB, with the majority of values falling

in the 70-71 dB "bins." Thus the impact of downlink MSS interference reamins essentially the same for the more sensitive microwave stations.

Conclusions

In summary, COMSAT finds that none of common carrier or Private Operational Fixed systems that were set up in simulation runs--using either "Real" FCC license file links or computer-generated "hypothetical" systems, with hops from 1-3, 4-6, or even 20 hops--experienced anything less than extremely excellent performance. This is evidenced by the very high C/(N+I) values that are shown in the accompanying Figures 2-1 through 2-6, inclusive. We have no reason to believe that these data would represent anything less than very satisfactory, if not excellent performance for common carrier and Private Operational Fixed networks.

In retrospect, these simulation results are better than results COMSAT obtained with FS parameters of microwave networks in other countries. Inspection of the detailed characteristics and transmission parameters of the U.S. based microwave systems in the 2 GHz bands reveals that the links have shorter path lengths and higher transmit powers than the microwave systems typically found in other countries. This explains why U.S. common carrier and POF links have excess margin, which margin enables them to cope extremely well with downlink interference from NGSO systems like I-CO P.

These data supports our assertion that there is no need to relocate any of the existing FS stations in the space-to-Earth 2 GHz MSS bands, as pertaining to terrestrial microwave stations having characteristics equivalent to existing CC and POF services, such as those found today in the United States.
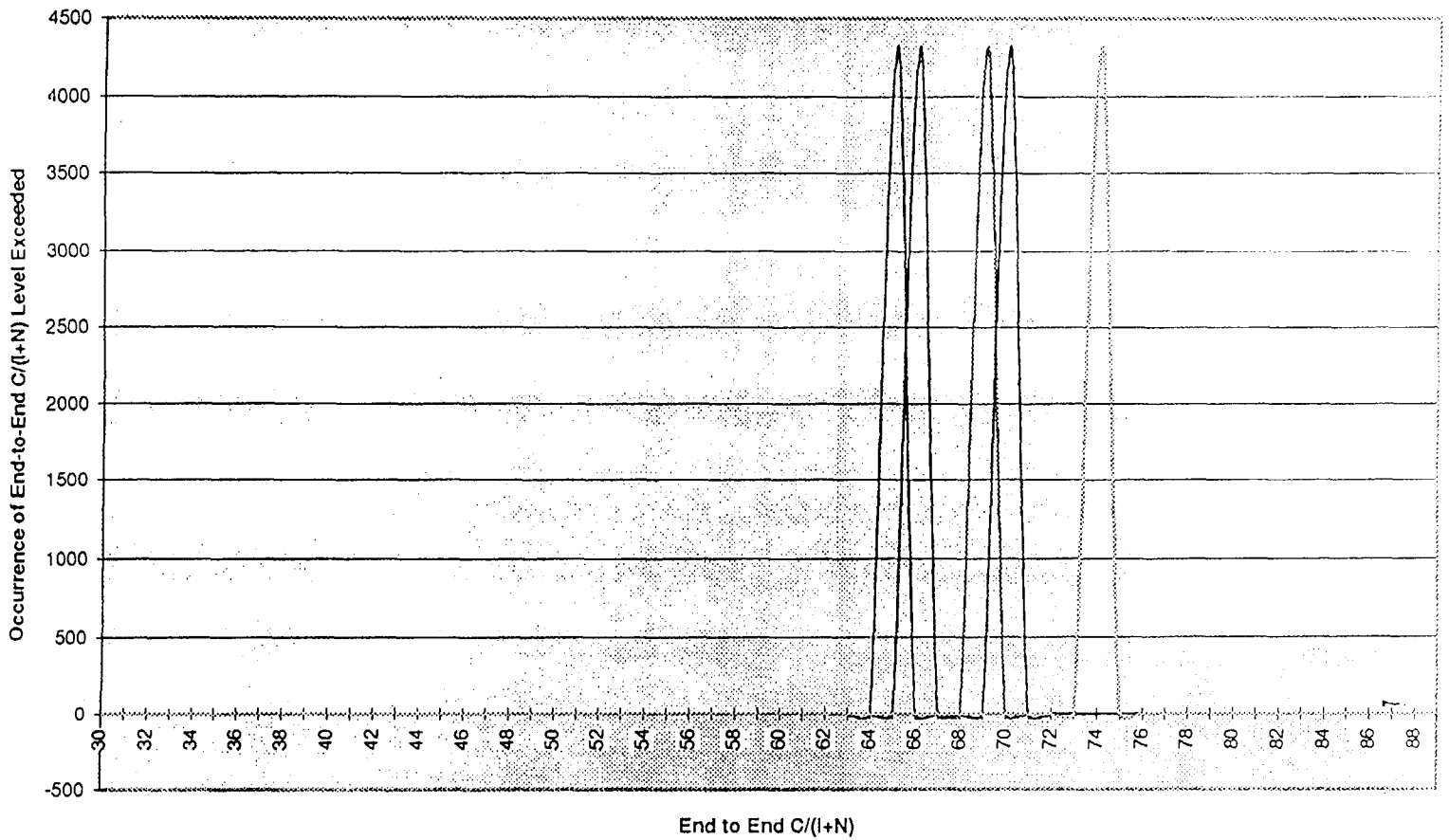
FIGURE 2-1. DOWNLINK INTERFERENCE TO 9 REAL U.S. COMMON CARRIER FS SYSTEMS, 3 TO 7 HOPS; Noise Temp. = 850 ^{o} K