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)

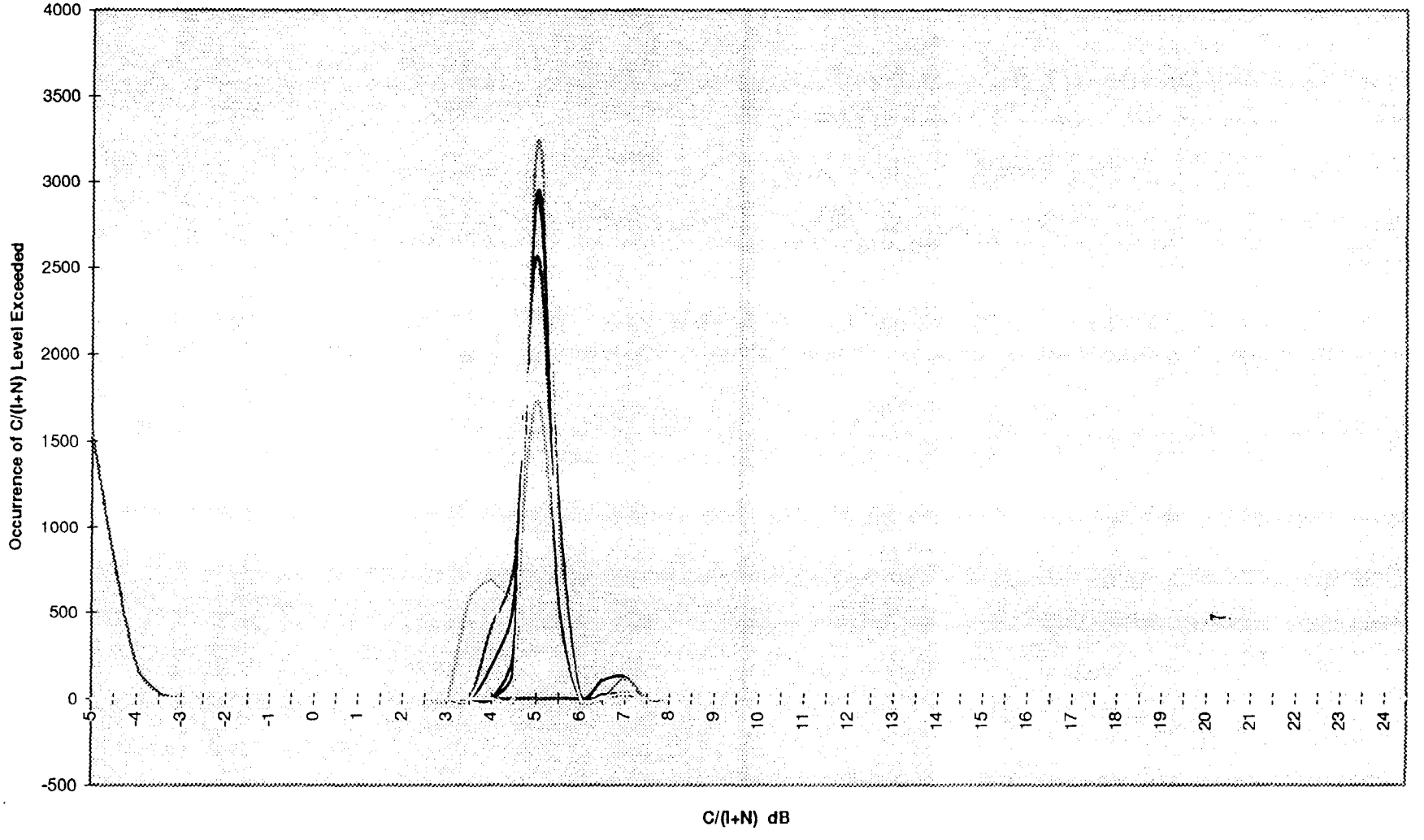


FIGURE 1-2. LOCATIONS OF 12 PERSONAL EARTH STATIONS FOR UPLINK INTERFERENCE

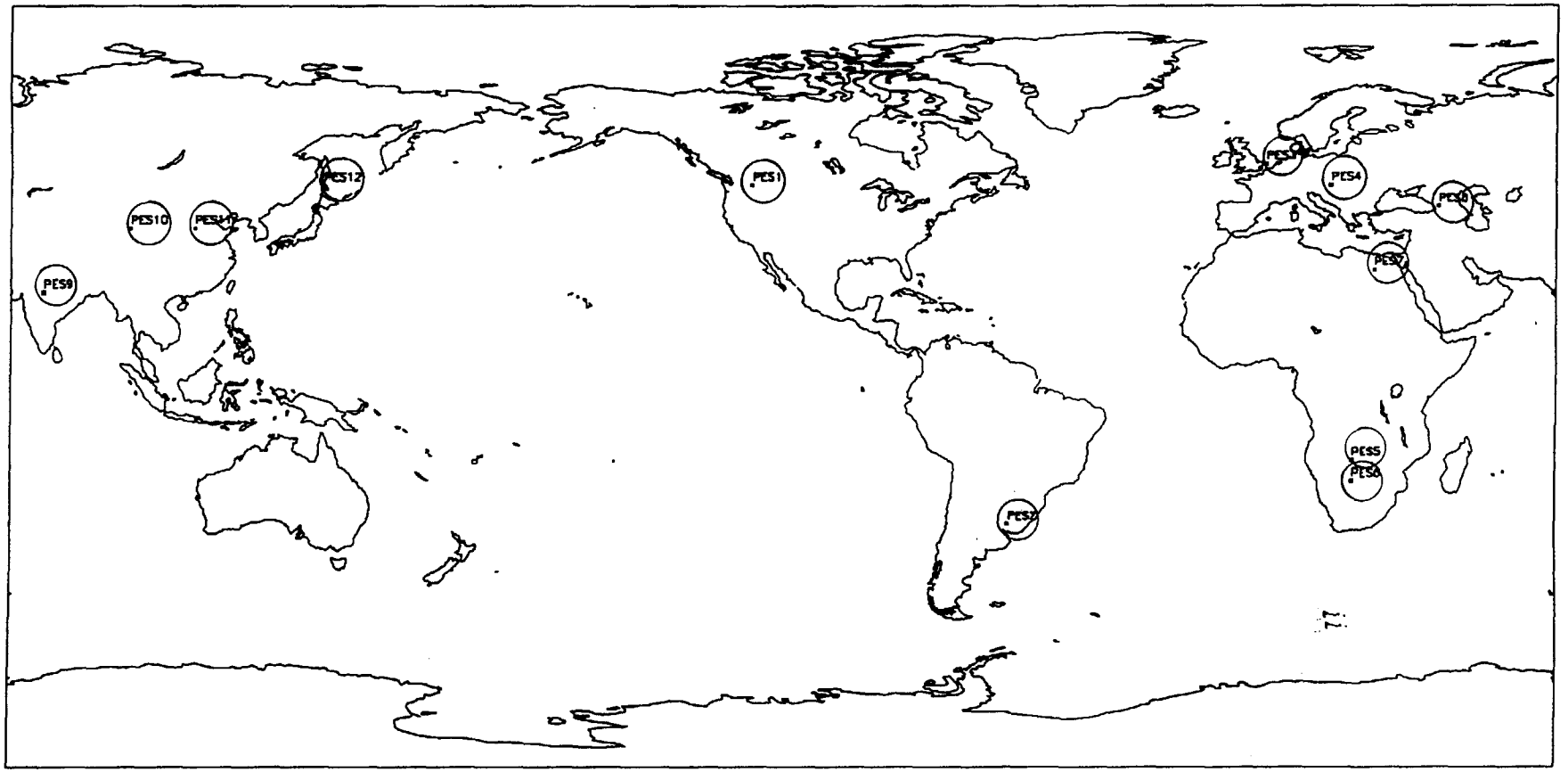
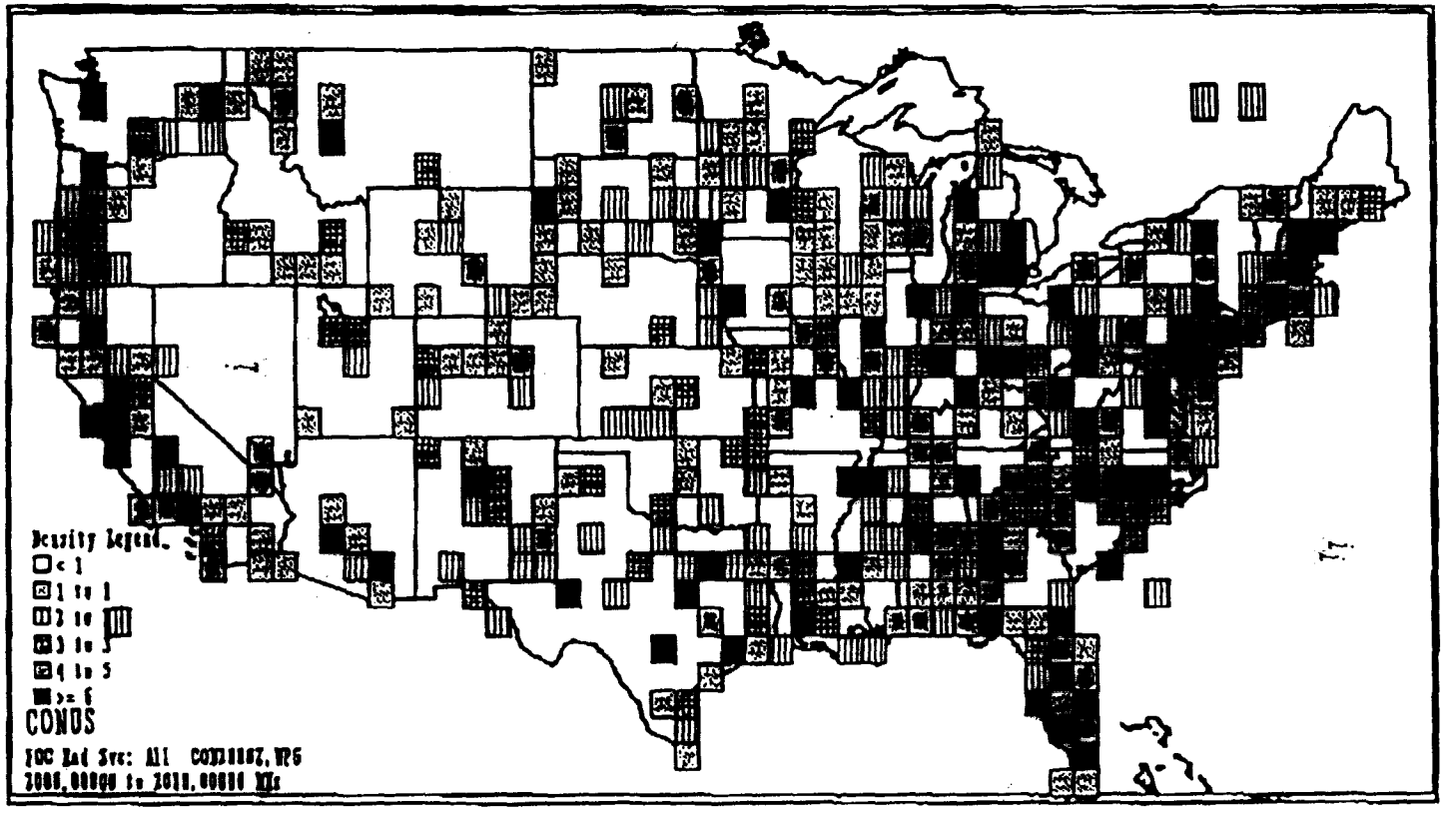


Figure 1-3 Population of ENG Stations In First Two Channels: 1990-2008; 2008-2025 MHz

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

APPENDIX II

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

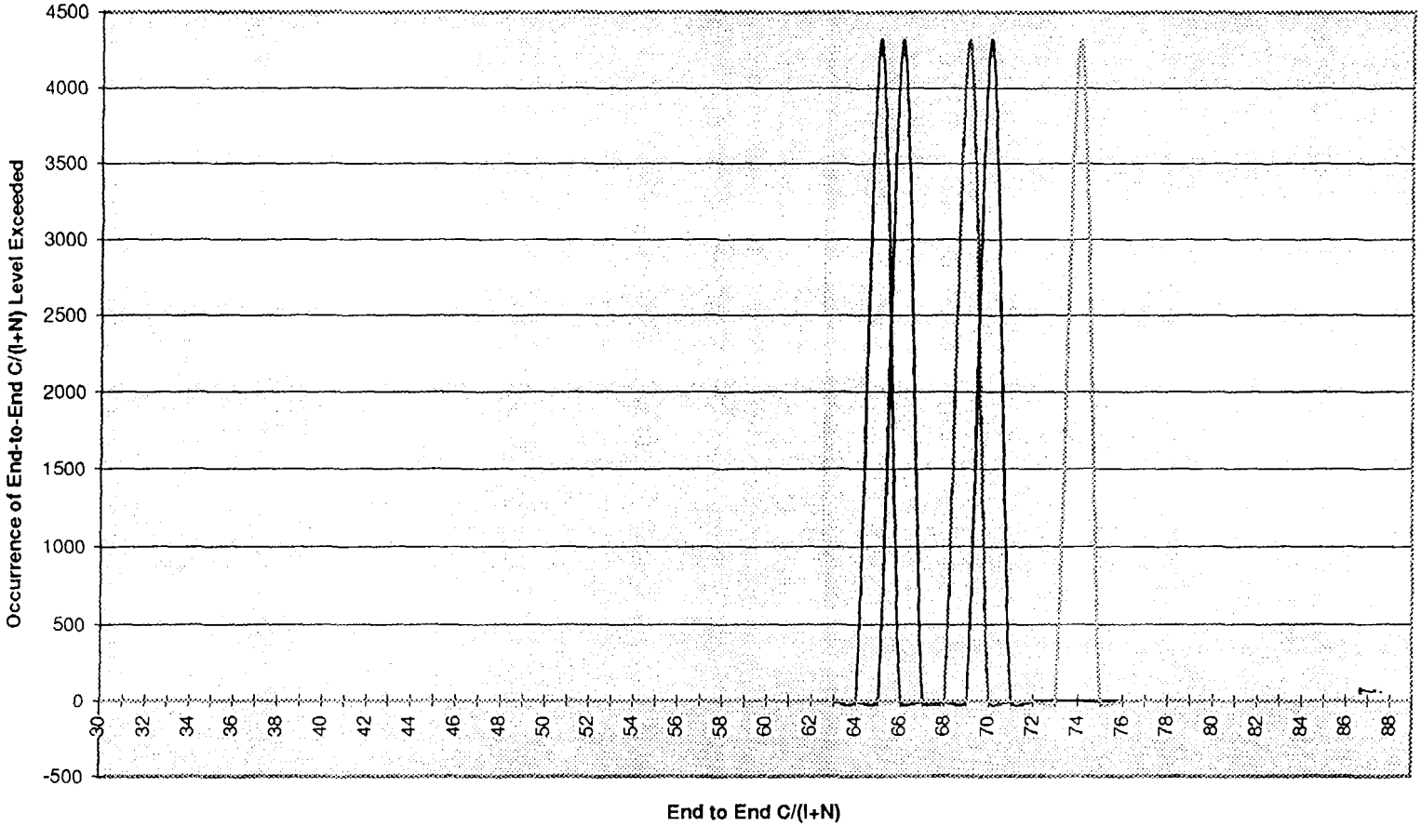


FIGURE 2-2. DOWNLINK INTERFERENCE TO 39 HYPOTHETICAL U.S. COMMON CARRIER FS SYSTEMS, 20 HOPS EACH; Noise Temp. = 850 ^{o} K

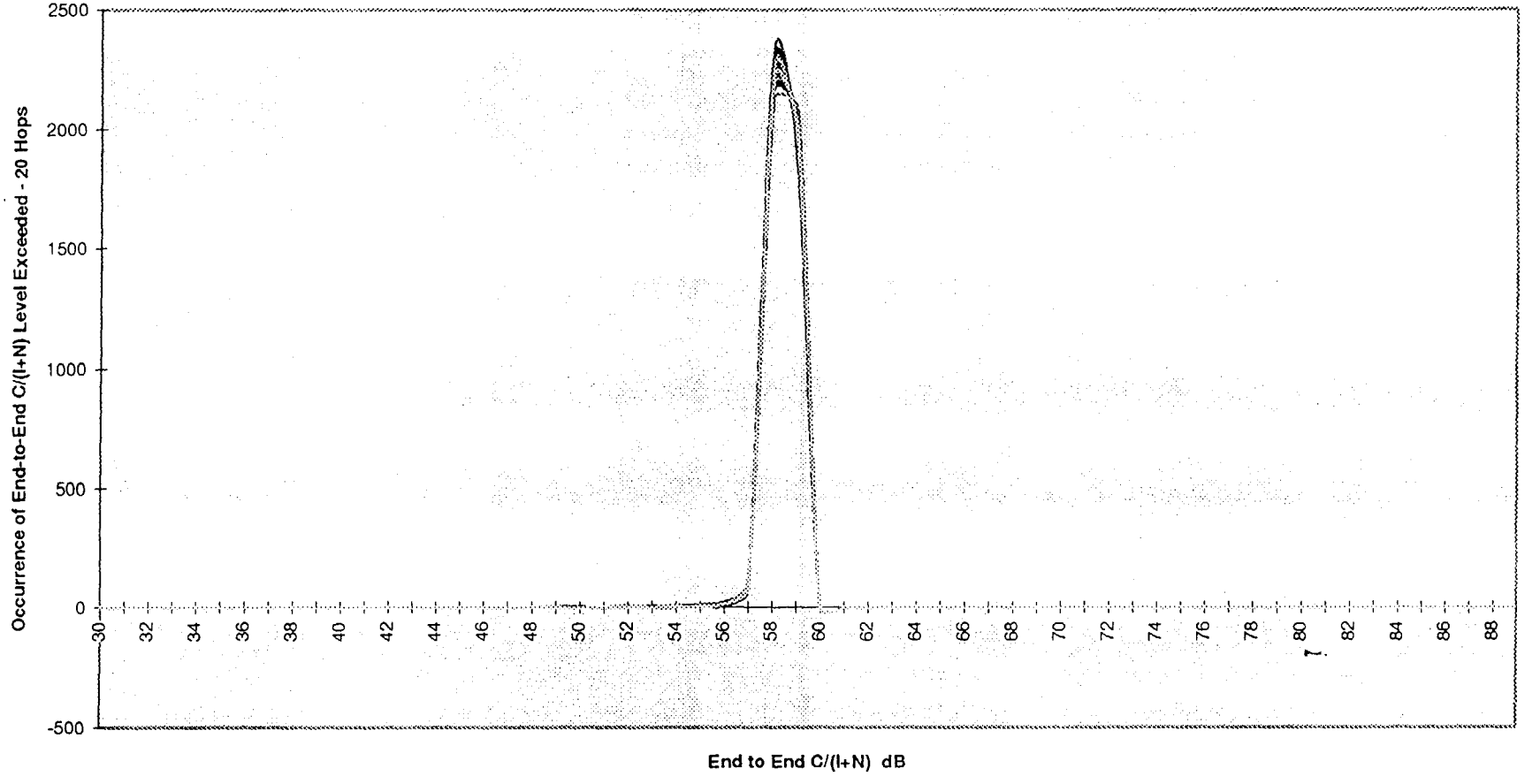


FIGURE 2-3. DOWNLINK INTERFERENCE TO 42 REAL U.S. FS POF SYSTEMS, 1 TO 3 HOPS; Noise Temp. = 850 ^{o} K

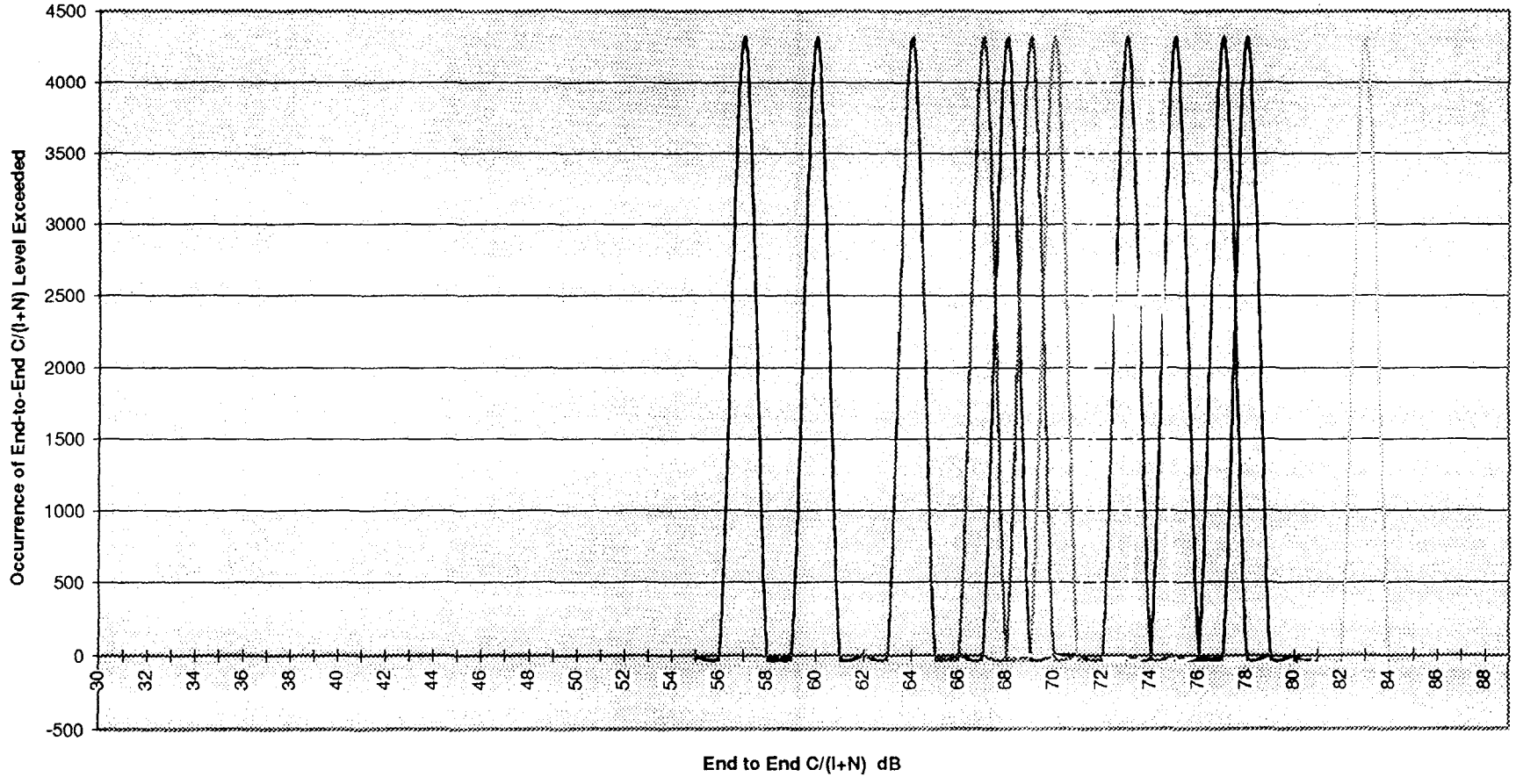


FIGURE 2-4. DOWNLINK INTERFERENCE TO 39 HYPOTHETICAL U.S. POF FS SYSTEMS, 3 HOPS EACH; Noise Temp. = 850 ^{o} K

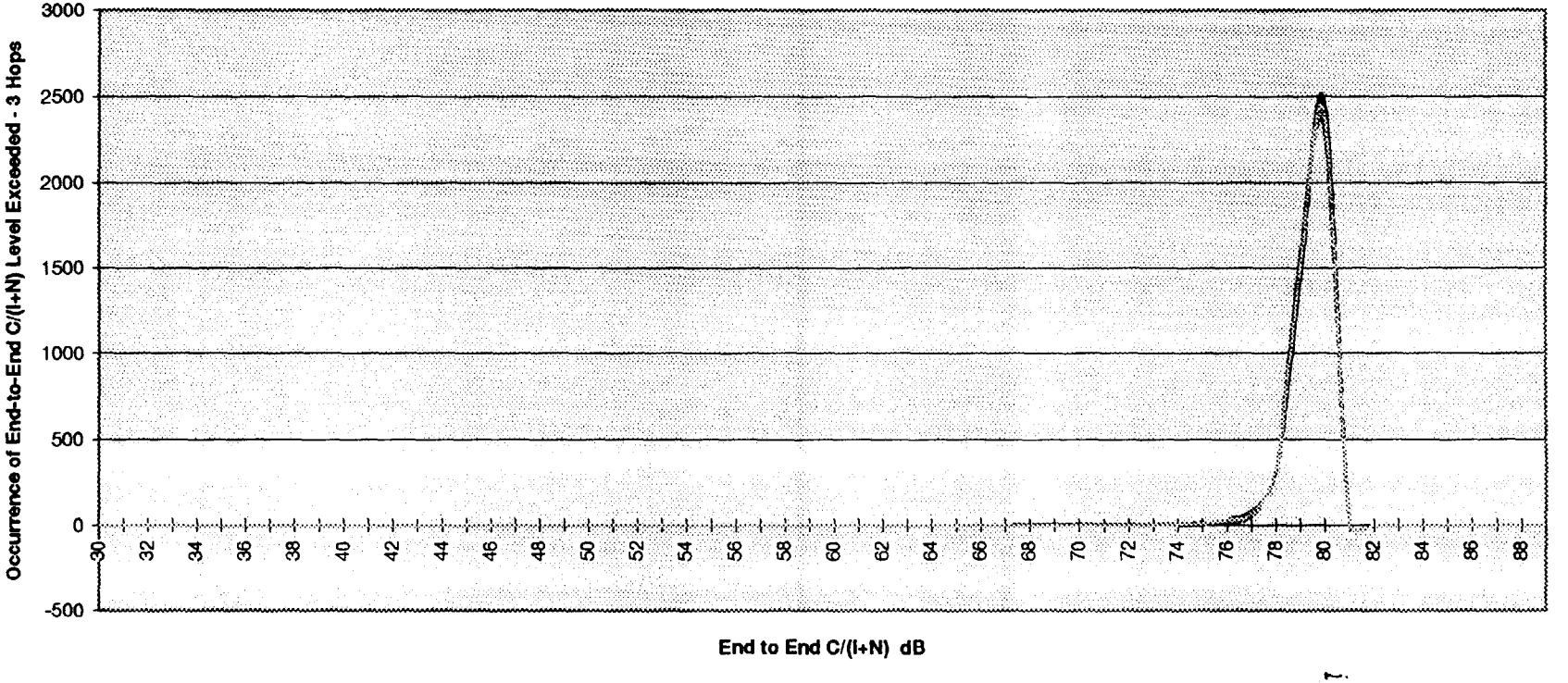


FIGURE 2-5. DOWNLINK INTERFERENCE TO 39 HYPOTHETICAL U.S. POF FS SYSTEMS, 20 HOPS EACH; Noise Temp.= 850 ^{o} K

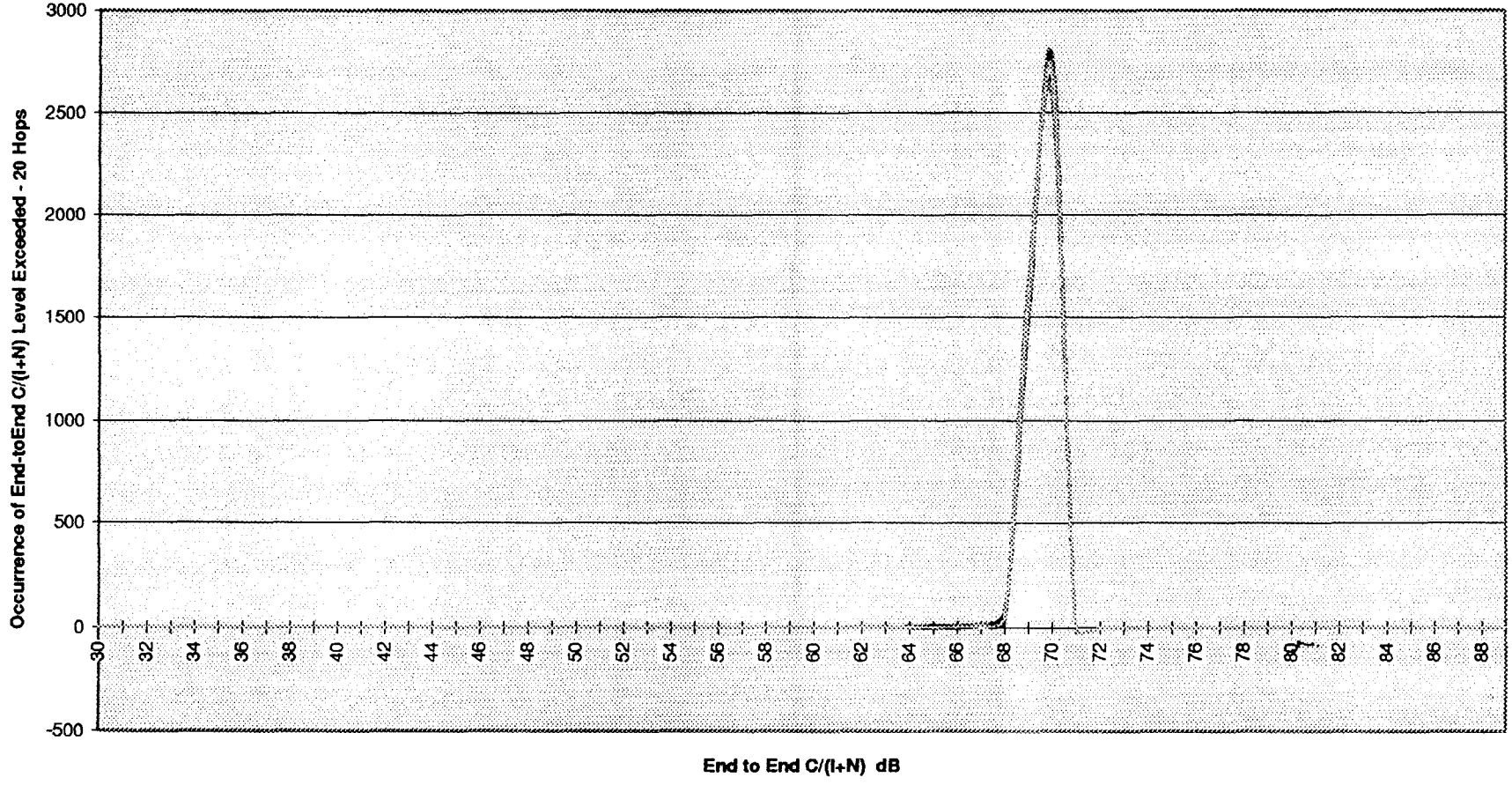
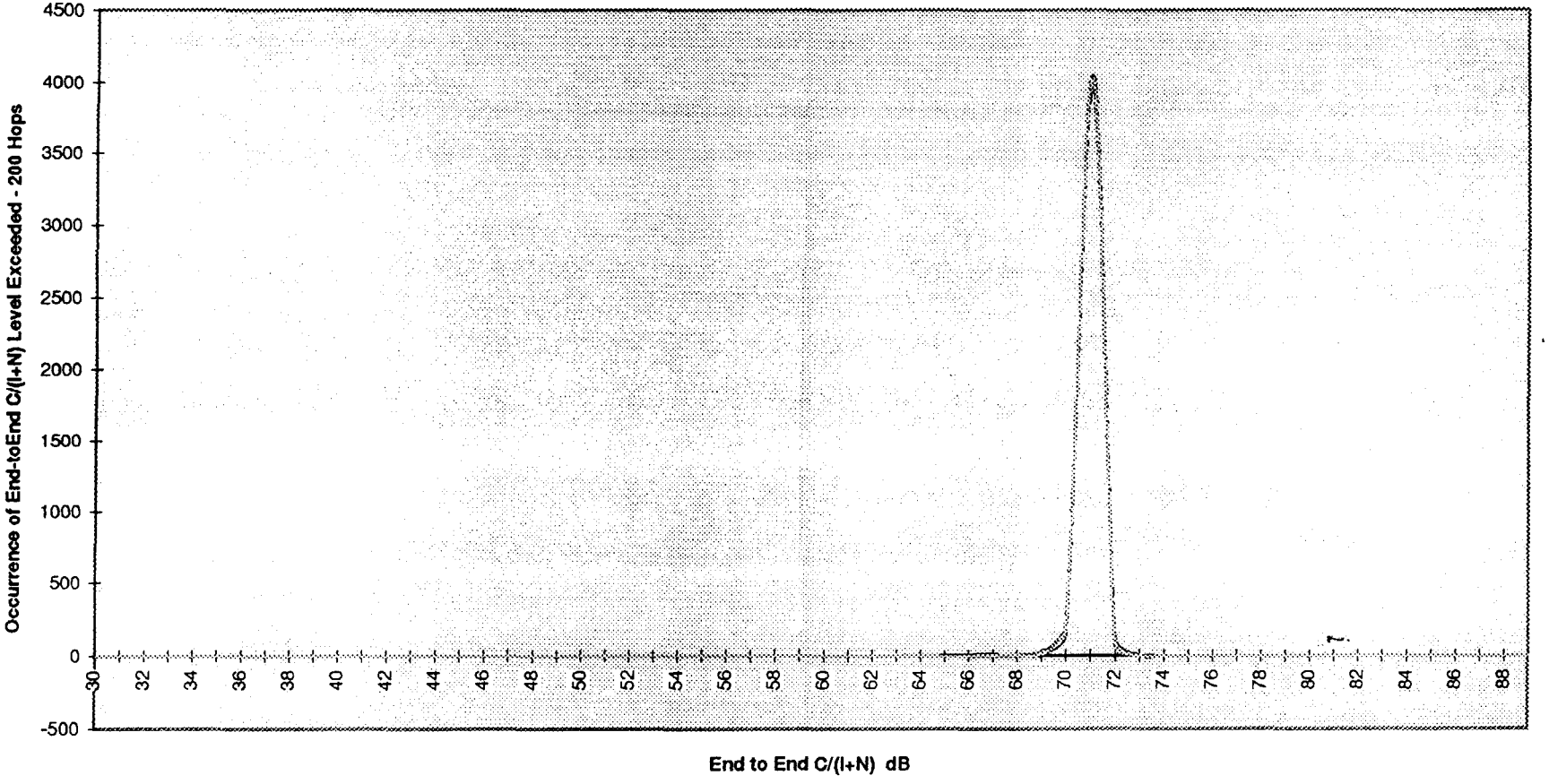


FIGURE 2-6. DOWNLINK INTERFERENCE TO 39 HYPOTHETICAL U.S. POF FS SYSTEMS, 20 HOPS EACH; Noise Temp.= 300 ^{o} K



APPENDIX III

MEASUREMENTS OF VIDEO AND AUDIO QUALITY FOR BROADCAST AUXILIARY SERVICE CHANNELS WITH REDUCED BANDWIDTH

APPENDIX III

MEASUREMENTS OF VIDEO AND AUDIO QUALITY FOR BROADCAST AUXILIARY SERVICE CHANNELS WITH REDUCED BANDWIDTH

Introduction

COMSAT Mobile Communications (CMC) is acutely aware of the potential for interference from transmitting stations in the Broadcast Auxiliary Service (BAS), primarily from stations participating in Electronic News Gathering (ENG) activities, and spacecraft receivers operating in the Mobile Satellite Service (MSS) in bands that are currently jointly allocated to both Services. CMC has actively participated in the FCC Industry Advisory Committee (IAC) on the 1995 World Radio Conference (WRC'95) and its associated Informal Working Groups (IWGs). CMC has in fact led a subsidiary ad-hoc group of IWG-3 on 2 GHz Transition Plans. This ad-hoc group has considered frequency sharing issues and means that could be used to accommodate the use of common frequencies by the various services.

As a part of the deliberations by the ad-hoc group on 2 GHz Transition Plans, CMC has proposed that the lower edge of the current BAS allocation be moved from 1990 MHz to 1998 MHz. This liberation of spectrum would be made possible by decreasing the allocated channel bandwidth for each ENG carrier from either 17 or 18 MHz to 16 MHz.

The purpose of this Appendix is to report on experimental results which demonstrate that a degradation of no more than 1.4 dB in video and audio Signal-to-Noise ratio (S/N) is caused by the change in modulation parameters necessary to accommodate this new allocated channel bandwidth. The experimental method along with the results are described and the conclusion that the minimal degradation can be overcome with the use of modified existing equipment is substantiated.

Description of Experiment

Experiments were conducted at COMSAT Laboratories to determine the effects of reducing the bandwidth of the BAS channels. A reduction in bandwidth in an FM system implies a reduction in the frequency deviation, in order to still meet FCC requirements. Currently BAS systems for ENG use a peak deviation of 4 MHz. A reduction in bandwidth from 17 MHz to 16 MHz implies, according to Carson's Rule, a reduction in deviation from 4 MHz, peak, to 3.5 MHz, peak. Current operational procedures call for the use of different bandwidth receive filters in the equipment based upon the adjacent channel interference environment. BAS receivers are available with receive filter bandwidths ranging from 10 to 30 MHz in bandwidth. Receive filter bandwidths of 15 and 20 MHz were

considered in this investigation since these bandwidths are those most affected by the reduction in deviation from 4 MHz, peak, to 3.5 MHz, peak. Filters with bandwidths of 30 MHz are not used in the USA and filters with only 10 MHz of bandwidth allow only the use of one audio sub-carrier and thus would be used only under the most adverse terrestrial interference conditions.

Consistent with the above, measurements of video and audio signal characteristics were made at both deviations and the differences were recorded.

A block diagram of the experimental setup is shown in Figure III-1. Referring to that Figure, a video baseband signal was created by a Video Generator. This signal was combined with two audio sub-carrier signals. These audio sub-carriers were generated at frequencies that are dependent upon the bandwidth utilized. The greater of the two frequencies were used with a 20 MHz receive filter and the smaller of the two frequencies were used with a 15 MHz receive filter. For example, with a 20 MHz receive filter, audio sub-carrier frequencies of 6.6 and 8.3 MHz were used. For a receive filter bandwidth of 15 MHz, audio sub-carrier frequencies of 5.8 and 6.8 MHz were used.

After the combination of the video baseband signal and the audio sub-carriers, the composite signal was pre-emphasized according the ITU-R Recommendation 405 and this signal was input to an FM modulator. The signal level into the FM modulator was adjusted to provide the correct video deviation of 3.5 or 4 MHz, peak. The injection level of the audio sub-carriers was set at 17 dB to reflect the maximum allowable sub-carrier injection level. The FM modulated signal at 70 MHz was filtered by a 20 MHz filter to eliminate out-of-band signal components. This signal was then combined with Gaussian noise to simulate a typical link. The signal plus noise was passed through a bandpass filter with either 15 of 20 MHz bandwidth and then input to an FM demodulator. The levels of the signal and noise were monitored at the output of the bandpass filter in order to maintain a Carrier-to-Noise Density ratio (C/N_O) of 102.7 dB at the input of the FM demodulator. This C/N_O corresponds to a Carrier-to-Noise ratio of 30 dB which is typical for ENG links.

The output of the FM demodulator was amplified, de-emphasized and split to allow analysis of the video and audio components. The video portion of the signal was fed to a Tektronix VM 700A Video Analyzer and the audio portion was fed to a frequency converter system and a sub-carrier demodulator. The output of the sub-carrier demodulator was fed to an audio analyzer for measurement of the Signal-to-Noise ratio (S/N) and harmonic distortion. The frequency conversion system was required to convert the 8.3 MHz audio sub-carrier frequency to the sub-carrier demodulator input frequency of 6.8 MHz. This was necessary since only a 6.8 MHz sub-carrier demodulator was

available. Only the higher frequency audio sub-carrier was analyzed since this is the one that would experience the greatest amount of degradation.

The Tektronix VM 700A Video Analyzer performs a myriad of complex video tests automatically. This instrument is recognized as a standard by the television industry and is valued for the consistency it provides in video testing. This instrument was used to make all of the video performance measurements reported here.

Experimental Results

This section presents the results of the experimental investigation for a C/N_0 of 102.7 dB, receiver bandwidths of 20 and 15 MHz, and video deviations of 4.0 and 3.5 MHz. It is important to keep in mind that the absolute values of the audio and video parameters are not as important as the difference between the values for the deviations of 4.0 and 3.5 MHz.

Table I indicates the video performance, for a representative set of parameters at the de-emphasized output of the FM demodulator. Note that there was little difference between the values for the 4.0 and 3.5 MHz deviations for reception through the 20 MHz filter while for reception through the 15 MHz filter, the performance for 3.5 MHz deviation is slightly better than that for 4.0 MHz deviation. This is to be expected as reception through the narrower 15 MHz filter results in the signal being "over deviated" as compared to the Carson's Rule bandwidth.

TABLE I

Video Performance

Video Parameter	20 MHz Filter 4.0 MHz Δf	20 MHz Filter 3.5 MHz Δf	15 MHz Filter 4.0 MHz Δf	15 MHz Filter 3.5 MHz Δf
Amplitude Response	<1.8 IRE p-p	<1.4 IRE p-p	<1.3 IRE p-p	<1.9 IRE p-p
Chrominance/ Luminance Gain	101.2%	101.3%	96.9%	97.4%
Chrominance/ Luminance Delay	8.2 nS	9.3 nS	9.1 nS	9.4 nS
Field Time Distortion	2.1%	2.1%	2.4%	2.2%
Line Time Distortion	2.1%	2.1%	1.6%	2.0%
Short Time Distortion	0.9%	1.0%	1.1%	0.9%
Luminance Non-Linearity	0.45%	0.74%	0.27%	0.65%
Differential Gain	1.05%	0.86%	1.06%	1.23%
Differential Phase	0.48°	0.39°	0.82°	0.53°
Chrominance/Luminance Intermodulation	0.1 IRE	0.1 IRE	0.1 IRE	0.1 IRE
Chrominance Non-Linear Gain	0+0.1 IRE	0 IRE	-0.2-1.5 IRE	+0.1-1.0 IRE
Chrominance Non-Linear Phase	0.3°	0.3°	0.3°	0.1°

With the exception of the Line Time performance, all of the video performance values measured are within the Medium Haul performance specifications of EIA Standard RS-250C. These measurements indicate that the video performance will not be significantly affected by the ENG channel bandwidth reduction proposed by COMSAT Mobile Communications.