FSS Interference with DigiWave Communication Links

Link Budget Parameters

In order to perform the necessary Link Budget calculations, User Systems selected the Tel-Link 38 systems specifications for the link configuration. The Tel-Link system utilizes a 12" mini-dish antenna operating at 39 GHz with a power output of 17 dBm (-13 dBW). Operational ranges less than 8 km were analyzed in addition to considering each of the 4 available Tel-Link bandwidths (5, 15, 30 & 40 MHz). It was assumed that a minimum of 20 dB C/I ratio was required to ensure a 10^{-6} BER. Additional information on the input parameters to the Link Budget or assumptions are described in the course of the analysis.

The interfering FSS power flux density levels considered were (-115 to -105 dB W / (m^2 * MHz)). These are the levels permissible for FSS service under the ITU Regulations which Motorola has agreed to abide by. The Link Budget analysis assumes a "worst case" situation, that of the FS receiver looking directly into the FSS main lobe and encountering the maximum FSS PFD.

Clear Air Analysis

The Link Budget calculation results for the four operating bandwidths of the Tel-Link 38 are presented in Figures 1 - 4. The charts show the receive signal strength of FS signal in relation to that of the FSS interference and the natural noise background. For all cases, there would be no impact on FS service from FSS interference for the clear air situation. The separation between the signal curves and the uniform interference signal strength values represents the carrier to interference (C/I) ratio. For the 30 and 40 MHz bandwidth cases the C/I ratio approaches the 20 dB minimum (20.2 and 18.9 dB respectively) at 8 km range if competing with the higher FSS PFD of -105 dB W / (m^2 * MHz)). The higher interference signal strength is only encountered at elevation angles above 20 degrees. Since the PFD expected from the FSS service for long range (i.e. horizontal) links is closer to -115 dB W / (m^2 * MHz)), the C/I ratio in these cases

remains above the required 20 dB minimum. The situation assumes a FS transmitter operating at full power (17 dBm)[1].

Rain Faded Conditions

The next step was to examine how rain attenuation would effect the C/I ratios. Figures 1-4 include receive signal strength curves for expected rain attenuation in Washington, DC and Seattle, WA. The rain attenuation values were supplied by ART and are based on the Crane Global Rain Model for a path availability of 99.995%. For all bandwidth cases, the rain attenuation reduces the maximum antenna separation to between 1 - 2 kilometers for the FSS PFD of -105 dB W / (m^2 * MHz)) and 2 - 3 km for -115 dB W / (m^2 * MHz)) while maintaining a minimum 20 dB C/I ratio. This reduction is more than a kilometer shorter then would otherwise occur if the receiver simply needed to overcome the natural background noise level.

Here again, the transmitter is assumed to be operating at full power (17 dBm) with no system attenuation. According to ART, even links with ranges of up to 2 km are not operated at full power. All 38 GHz link systems can be operated at reduced power levels (or self attenuated) in order not to overwhelm the receiving link on certain link configurations. This self attenuation has a maximum value of approximately 25 to 30 dB depending on the manufacturer. **Under fully rain faded conditions links as short as 500 m which are configured with significant (15 dB or more) self attenuation would have less than the required 20 dB C/I ratio for 10^{-6} BER operation. These shorter links are also the links which are most likely to be set up at high elevation angles and therefore experience the maximum FSS PFD values.**

[1]According to ART, transmitters are very rarely operated at full power for: a) reliability reasons and b) in order not to over power the receiver in short (< 2 km) link configurations

Other FSS Interference Analysis

As part of the analysis into FSS interference into FS links, a review was made of the work performed by Gene Ax and Dale Hatfield[2] for WinStar Communication and that of Walter Sonnenfeldt and Ross Sorci[3].

Both of these analysis approach the interference problem "from the receiver end" by beginning with the receiver sensitivity level (RSL) (the received carrier level for a minimum quality objective), then adding an appropriate C/I for the desired 10^{-6} BER, and finally using this "threshold" to calculate the amount of FSS interference which could be tolerated.

By definition, using the RSL plus a threshold C/I ratio, determines the weakest possible signal the FS receive antenna can collect while maintaining a certain BER. For the receivers considered by Ax and Sonnenfeldt the FS signal strength is -115 dBW and -133.5 dBW, respectively. For these FS signal strengths, the resulting FSS PFD interference which can be tolerated is near (or below) the natural background noise level (-129.3 & -139 dB W / (m^2 * MHz)), respectively. These FS signal strengths are also consistent with the FSS Interference analysis prepared by R. Chung of ART who considered a 38 GHz systems with a desired carrier strength of -120.8 dBW.

Table 1 presents a comparison of some of the relevant numbers which went into the various interference analyses. The analysis of Ax and Sonnenfeldt simply approach the interference problem beginning with the FS receiver instead of the transmitter. Both pieces of analysis are technically sound and are consistent with the RSL levels of the ART links.

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[2]Technical Considerations in Sharing Spectrum in the 37-40 GHz Band Between Fixed Satellite Service Downlinks and the Fixed Service, 18 June 1996.

[3]Annex 2 of Modifications to Draft Section 7.5 of the CPM Report to WRC-97: Identification of Frequency Bands Above 30 GHz for High Density Fixed Service Applications, 9 October 1996.

	Ax & Hatfield	Sonnenfeldt & Sorci	User Systems
Transmit Power (dBW)	Unspecified	-15	-13
Antenna Size (m)	0.6	0.6	0.3
Antenna Gain (dB)	44	44	38
Range (km)	Unspecified	2.9	< 8
Receive Signal Strength (dBW)	-115	-133.5	-61 to -133
RSL (dBm)	-85	-80.5	-88 to -69
Minimum C/I (dB)	18	23	20

Table 1 FSS Interference Analysis Comparison

FSS Interference on DigiWave Operation

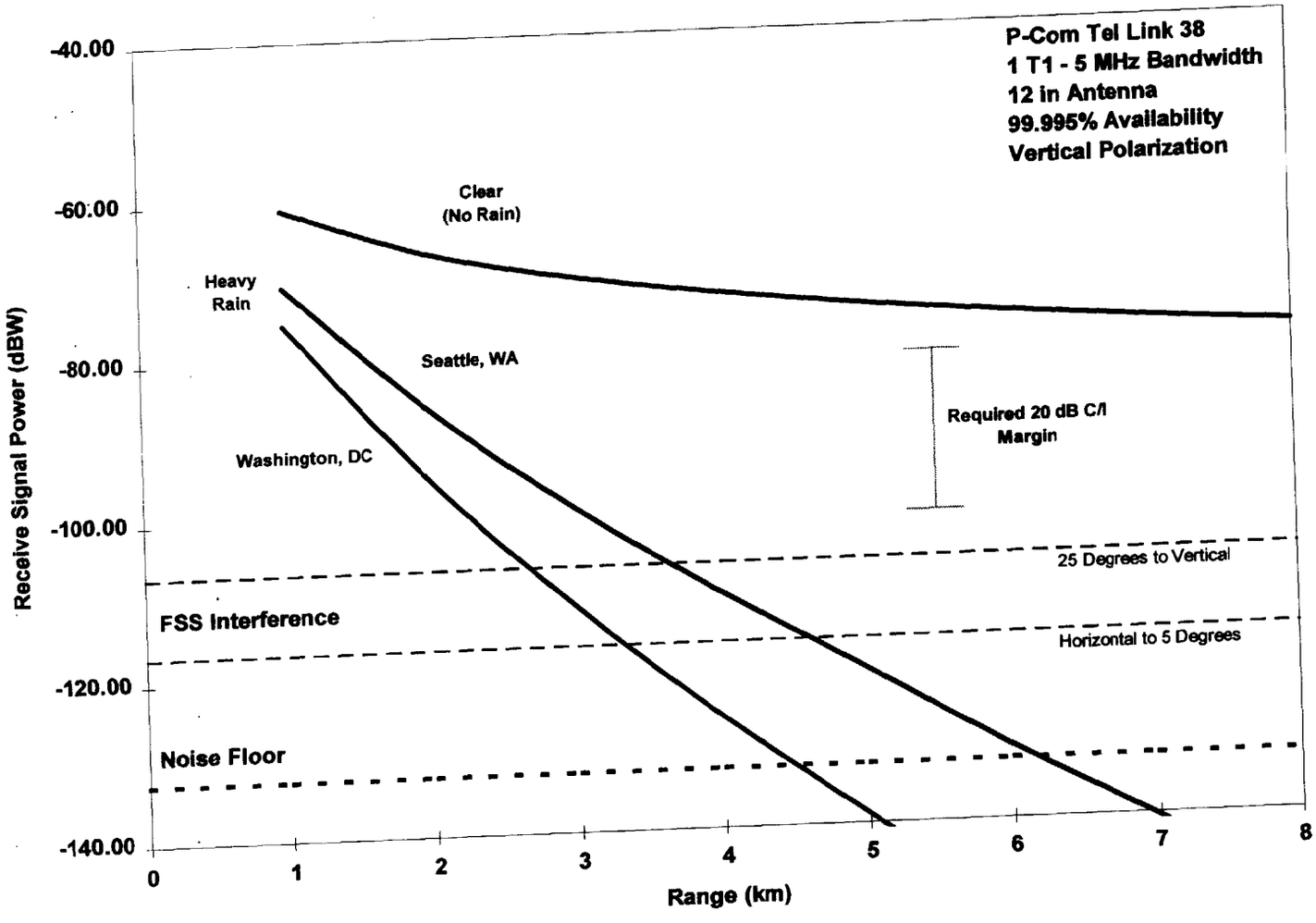

Figure 1

FSS Interference on DigiWave Operation

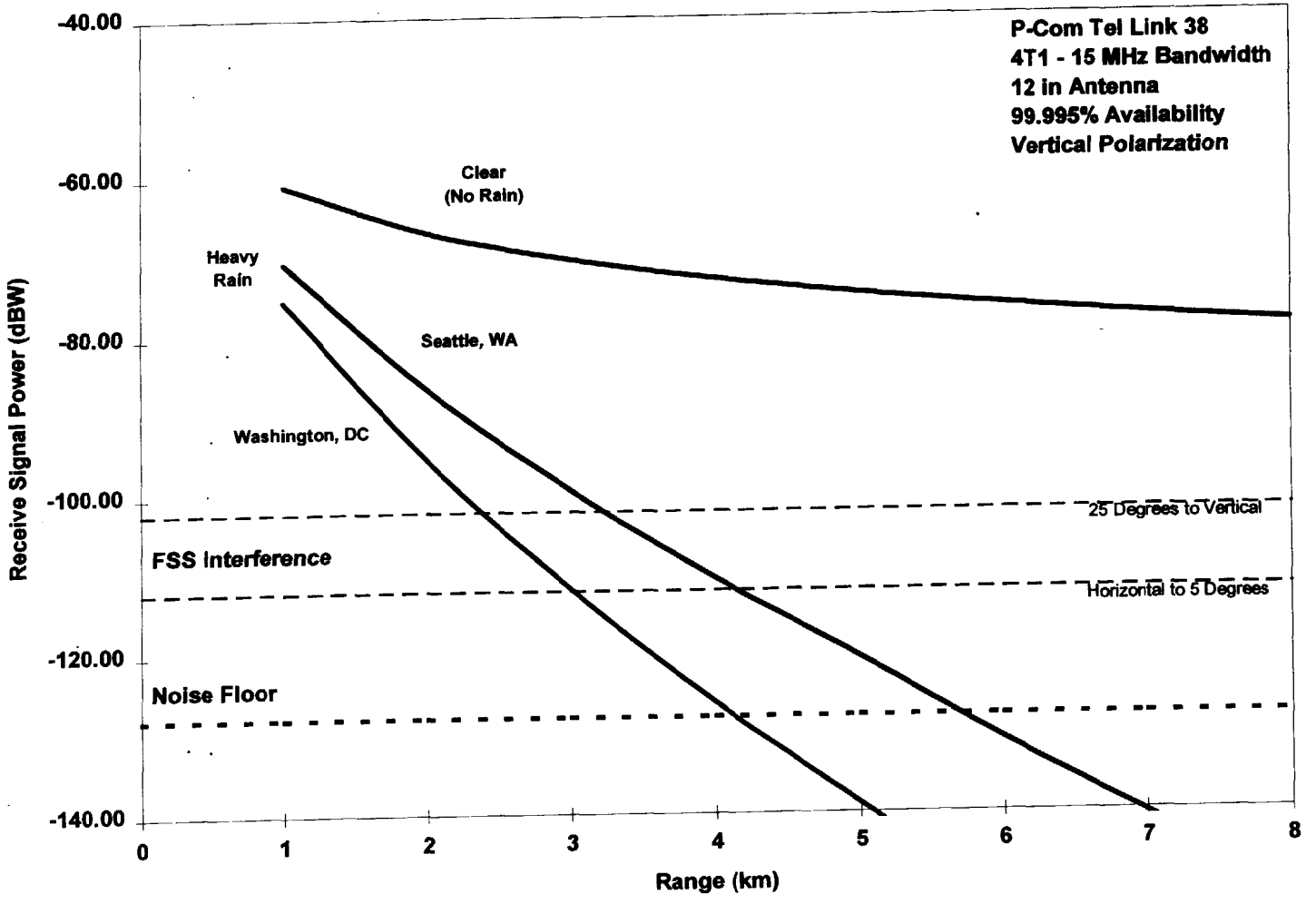

Figure 2

FSS Interference on DigiWave Operation

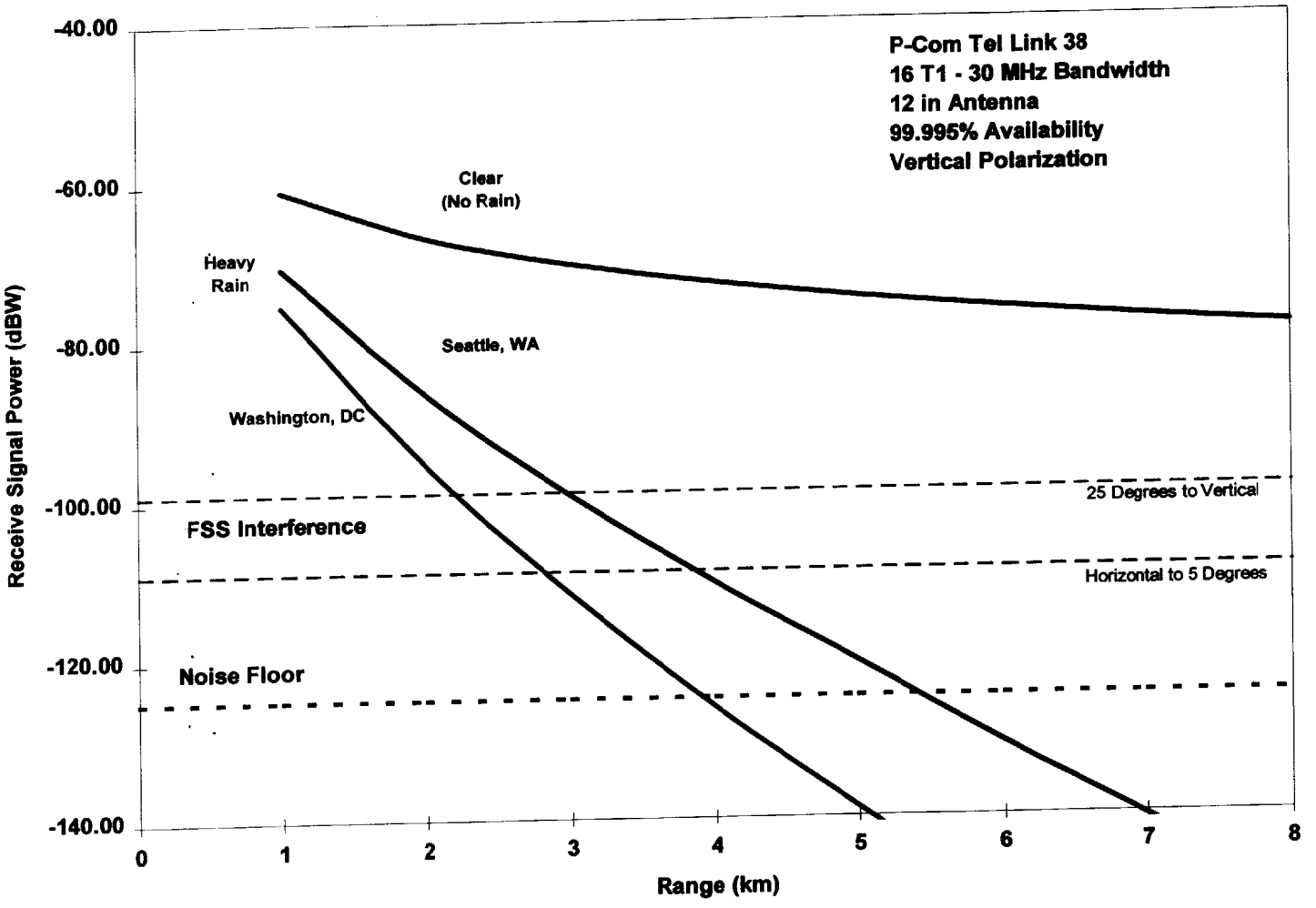

Figure 3

FSS Interference on DigiWave Operation

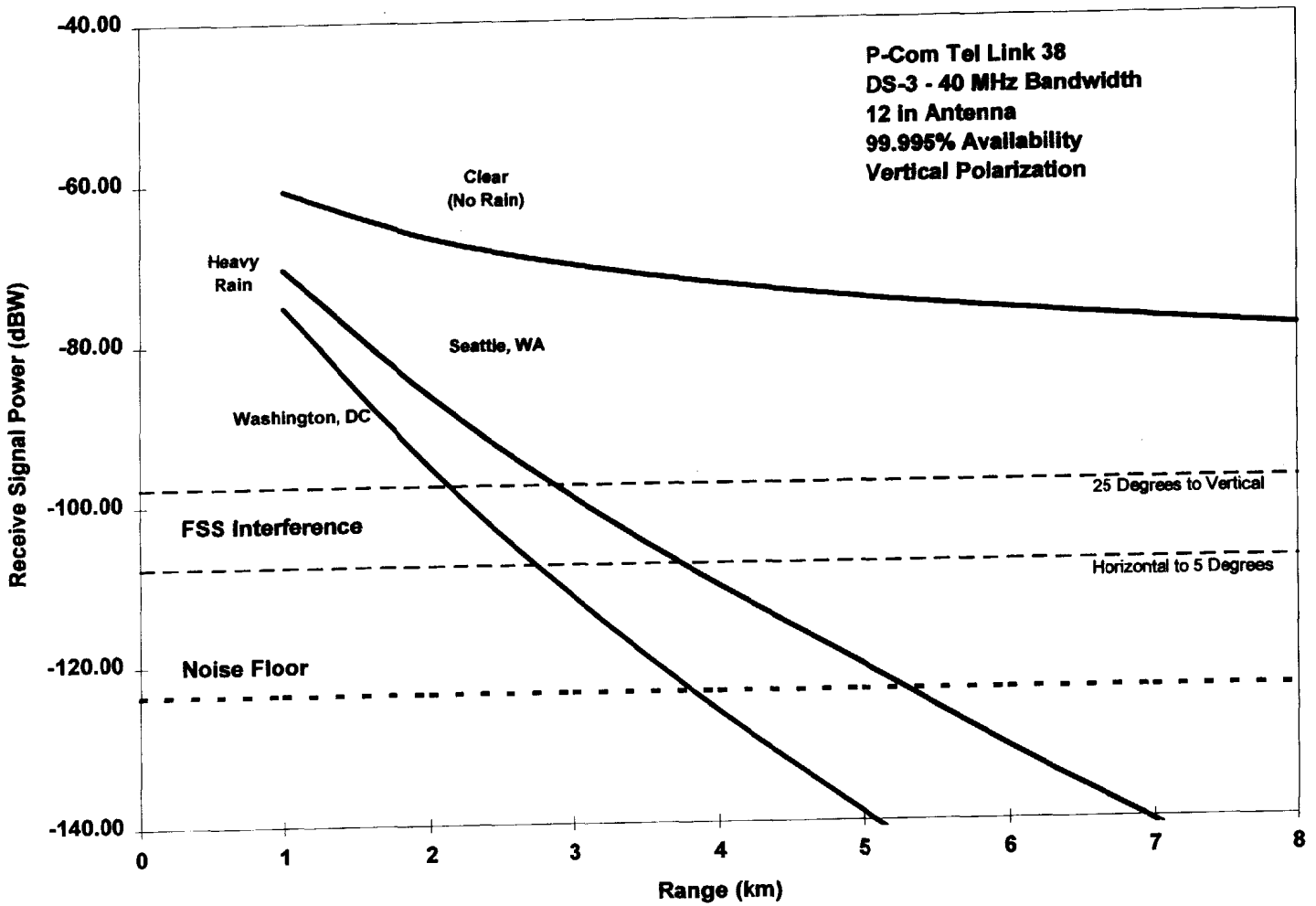

Figure 4

USER SYSTEMS INCORPORATED

User Systems Incorporated (USI) was established as a Virginia corporation in 1978 to perform **microwave systems analysis (communications, navigation and remote sensing),** design and applications support services for many of the major US aerospace companies, government and civil technology development organizations, and commercial enterprises.

USI focuses on the development of microwave communications, navigation and remote sensing systems, placing special emphasis on **the end-to-end systems design including transmission, reception, on-board storage, signal conditioning, and information processing.** The companies founder, Samuel W. McCandless, Jr. has forty years of experience beginning as Test Director for the Surveyor-1 satellite that pioneered in-situ lunar data collection and NASA's SEASAT satellite that set the stage for very high bandwidth data collections from the first Synthetic Aperture Imager in space. Staff members come with aligned experience and skills gained at the California Institute of Technology and MIT's Lincoln Laboratory. This combined capability has complied 19 years of hands-on experience providing microwave systems and software for many diverse applications and clients.

Current work includes feasibility and design trade-off assessments for many civil and government communications and remote sensing systems such as DBS satellites and advanced microwave remote sensing systems on satellite and airborne platforms. Recently, USI was selected by NASA to produce marine winds products for commercial weather broadcasts using space-based radar scatterometry data. At present we are also providing finished hardware/software "turn-key" information processing systems for NASA's Goddard Space Flight Center Search and Rescue Program and for the Military Open Skies Treaty Verifications systems which use airborne data collection platforms.

USI serves leading government and private technology development organizations including: Science Applications International Corporation (SAIC), Dynamics Technology Inc. (DTI), Sandia National Laboratories (SNL), Naval Research Laboratory (NRL), the Applied Physics Laboratory (APL), Battelle, the Jet Propulsion Laboratory (JPL), the Goddard Space Flight Center (GSFC), Langley Research Center (LaRC), and the Stennis Space Center (SSC). **Systems development organizations served by User Systems include**: System Planning Corporation (SPC), IBM, Lockheed/Martin (including GE/RCA), E-Systems, Aerojet, Bendix, Rockwell International, TRW, Hughes, Technology Service Corporation (TSC), and Alcatel Espace.

User Systems has developed and **teaches courses in satellite systems design and application to communications, navigation and remote sensing.** USI has also developed and markets three top-level satellite and airborne microwave systems design and analysis programs: MICROCALC a microwave systems design program; RADARCALC a radar design program; and ALLSAT a full-range (large and small) satellite design program. ALLSAT is fully compatible with the Air Force Satellite Cost Model, providing input directly to the model.

Tentative Band Segmentation Plan

As Described by FCC Staff

on

December 17, 1996

Details of Tentative Band Plan

- 37.5-38.6, 40.5-41.5, and 48.2-50.2 GHz would be available to FSS exclusive of FS
- 38.6 to 40.0 GHz would be preserved for FS exclusive of FSS
- 47.2-47.5 and 47.9-48.2 GHz would be made available for terrestrial fixed services

Tentative Band Plan (cont.)

- An unspecified amount of spectrum between 36 and 37.5 GHz "could" be made available for "flexible" terrestrial services
- This spectrum, and currently unused portions of the 38.6-40.0 GHz band would be auctioned

Tentative Band Plan (cont.)

- Plan assumes the possibility that FSS (and implicitly FS) services could utilize different frequency bands in different parts of the world
- Plan would safeguard current 38 GHz terrestrial spectrum again FSS, and would give Motorola 2 of the 3 GHz of uplink and downlink spectrum it requests

Tentative Band Plan (cont.)

- Plan also requires the resolution of encroachment on existing broadcast satellite service allocation that the FSS allocation in the 40.5-41.5 GHz band would produce

Tentative Band Plan (cont.)

- Unspecified amount of spectrum between 41.5 and 47.2 GHz would be made available for Sky Station-type services
- According to staff, plan contemplates development of international allocation proposal for these services