RECEIVED

JAN 22 1996

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

EX PARTE OR LATE FILED

FEDERAL COMMUNICATIONS COMMISSION
INTERNATIONAL BUREAU

Satellite and Radiocommunication Division
Satellite Policy Branch

To: Mr. William F. Caton, Acting Secretary

Date: January 19, 1996

From: Jennifer M. Gilsenan

DOCKET FILE COPY ORIGINAL

Re: Ex parte presentation
CC Docket No. 92-297

This will serve to indicate that on January 18, 1996 the International Bureau's Satellite and Radiocommunication Division convened a meeting with the participants listed in Attachment A to this memorandum. The participants discussed interservice frequency sharing issues in the 20/30 GHz frequency band. The attached documents formed a basis of the discussions.

No. of Copies rec'd 0
List ABCDE

RECEIVED

JAN 22 1996

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Attachment A

January 18, 1996

Name	Organization	Phone	Fax
Jennifer Gilsenan	FCC	418-0757	418-0765
Giselle Gorney	FCC	418-0755	418-0765
HARRY NG	FCC	418-0752	418-0765
THOMAS S. TYCZ	FCC	418-0735	418-0798
Karl Kensinger	FCC	418-0773	418-0765
Peter Hadinger	TRW	703.276.5156	703.276.5029
MIKE HORSTEIN	TRW	310-812-2603	~~310-814-4[illegible]~~
Hau H. Ho	TRW/odyssey	310-812-1656	310-814-140[illegible]
Roger Rusch	TRW	310-812-2424	310-814-140[illegible]
Steve Baruch	LS+L/TRW	202 416 6782	202 293 7783
PHIL MALET	S+J/Motorola	202-371-6893	202-842-3578
Barry Lambergman	Motorola	202-371-6929	202-842-3570
David Carroll	Motorola	602 732-4918	x 2305
Richard Stone	Motorola	(602) 732-3991 / 2305	

NGSO-NGSO Dynamic Sharing Analysis

Framework: The proposal for this simulation is to "fly" each satellite system in their intended orbits while allowing each satellite and earth station to track their respective aimpoints while taking into account the earths rotation.

(1) The simulation must be performed over a relatively long period of time such that all interference geometries are taken into account.

(2) At each time step the interference level is computed for all paths of interference.

(3) The expected result of the simulation is a graph of interference level vs. % time, therefore any interference criteria can be superimposed on the results.

Copyright © 1995 Motorola, Inc.
December 20, 1995

Assumptions:

(1) No power control - For simplicity it is assumed that neither system employs power control. The interference to noise ratio can be expressed as:

$$\frac{I_0}{N_0} = \frac{P_t}{BW_{tx}} G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 \frac{1}{k \cdot T}$$

$$= \frac{P_t}{BW_{tx}} \frac{\lambda^2}{4\pi} \frac{1}{k \cdot T} \frac{G_t G_r}{4\pi R^2}$$

where:

P_t	- Transmit power (Watts)	BW_{tx}	- Transmit bandwidth (Hz)
G_t	- Transmit gain (relative intensity)	G_r	- Receiver gain (relative intensity)
λ	- Wavelength of transmitter (m)	R	- Range (m)
k	- Boltsman constant	T	- Noise temperature (deg Kelvin)

Copyright © 1995 Motorola, Inc.

(2) Antenna Patterns - The antenna patterns defined in ITU Appendix 28 (Rec. S.580-5 & S.731) may be used. When detailed coordinations occur actual (or predicted) antenna patterns may be implemented.

where for values of $\frac{D}{\lambda} \geq 100$

$$G(\varphi) = \begin{cases} G_{max} - 0.0025\left(\frac{D}{\lambda}\varphi\right)^2 & 0 < \varphi < \varphi_m \\ G_1 & \varphi_m \leq \varphi < \varphi_r \\ 32 - 25\log\varphi & \varphi_r \leq \varphi < 48° \\ -10 & 48° \leq \varphi \leq 180° \end{cases}$$

and for values of $\frac{D}{\lambda} < 100$

$$G(\varphi) = \begin{cases} G_{max} - 0.0025\left(\frac{D}{\lambda}\varphi\right)^2 & 0 < \varphi < \varphi_m \\ G_1 & \varphi_m \leq \varphi < 100\frac{\lambda}{D} \\ 52 - 10\log\frac{D}{\lambda} - 25\log\varphi & 100\frac{\lambda}{D} \leq \varphi < 48° \\ 10 - 10\log\frac{D}{\lambda} & 48° \leq \varphi \leq 180° \end{cases}$$

$G(\varphi)$ - Antenna Gain (dBi)

D - Antenna diameter

G_{max} - Maximum gain of Antenna (dBi)

$G_1 = 2 + 15\log\frac{D}{\lambda}$ - Gain of the first sidelobe (dBi)

$\varphi_r = 15.85\left(\frac{D}{\lambda}\right)^{-0.6}$ - End of first sidelobe (degrees)

φ - Off-axis angle of the antenna, in degrees

λ - Wavelength (same units as D)

$\varphi_m = \frac{20\lambda}{D}\sqrt{G_{max} - G_1}$ - Start of first sidelobe (deg)

$\frac{D}{\lambda} \approx 10^{(G_{max} - 7.7)/20}$ - Approx. of antenna diameter

Copyright © 1995 Motorola, Inc.
December 20, 1995

Required Input Data

The required input parameters for each of the two communication systems are:

Orbit parameters:
- Number of Satellites
- Number of Planes
  - Orbit altitude
  - Inclination of plane
  - Right ascension of the ascending node
  - Anomaly of first satellite in each plane

Antenna parameters:
- Space vehicle
  - Maximum Transmit Gain (dBi)
  - Maximum Receive Gain (dBi)
- Ground Station
  - Maximum Transmit Gain (dBi)
  - Maximum Receive Gain (dBi)
  - Location
    - North Latitude
    - West Longitude

Communication Parameters:
- Maximum Transmit Power (dBW)
- Receiver noise temperature (K)
- Transmit Bandwidth (MHz)

Operational parameters:
- Minimum elevation angle for communication
- Simulation time end
- Simulation time start
- Simulation time increment

Copyright © 1995 Motorola, Inc.

SHARING CONDITIONS

- NO LMDS OR OTHER SERVICES IN THE 29.1 - 29.25 GHz PORTION OF THE BAND
- BAND LIMITED TO IRIDIUM & ODYSSEY
- IRIDIUM HAS EXCLUSIVE RIGHTS TO GATEWAY & SCS LOCATIONS WHICH IT HAS IDENTIFIED

SHARING CONSTRAINTS

- POWER CONTROL ON UL & DL
- CROSSPOLARIZATION BETWEEN SYSTEMS
- INTERFERENCE CRITERIA
  - Short Term, -1 dB, .01% of Time, Cumulative U/L & D/L
  - Long Term, Not applicable

IRIDIUM/ODYSSEY CONSTRAINTS (continued)

- RELATIVE TO IRIDIUM EARTH STATION LOCATIONS
  - EXCLUSION ZONE (800 km)
  - COORDINATION ZONE (1000 km)

IRIDIUM SITES IN THE U.S.

- PHOENIX, AZ (Definite)
- OAHU, HI (Definite)
- MONTPELIER, VT
- RALEIGH-DURHAM, NC
- ATLANTA, GA
- SAN JUAN, PR
- MIAMI, FL
- SPOKANE

ODYSSEY

TRW

Co-Directional Frequency Sharing Between The Odyssey™ and the Iridium Feederlink Systems in The 29.1 - 29.4 GHz and 19.3 - 19.6 GHz Bands

P. Cress
H. Ho
M. Horstein
R. Rusch

January 18, 1996

RECEIVED
JAN 22 1996

Orbital Parameters

Parameters	Odyssey (NGSO MSS)	Iridium (NGSO MSS)
Number of satellites	12	66
Number of orbital planes	3	6
Number of satellite/plane	4	11
Altitude	10355 Km	787 Km
Inclination angle	50°	86.4°
Orbit	Circular	Polar
Period of orbit	5.98 hours	1 hour and 40 minutes

Satellite Communication System Parameters (Feederlinks)

Satellite Parameters	Odyssey (NGSO MSS) (Feederlinks)	Iridium (NGSO MSS) (Feederlinks)
Receive frequency range	29.1 to 29.4 GHz	29.1 to 29.3 GHz
Receive bandwidth	300.0 MHz	200.0 MHz
Receive Polarization	LHCP	RHCP
Receive antenna gain (Peak)	38.5 dBi	30.1 dBi
3 dB beamwidth	2.2°	5.0°
Receive total system noise Temperature	780° K	1295.5° K
Transmit frequency range	19.3 to 19.6 GHz	19.4 to 19.6 GHz
Transmit bandwidth	300.0 MHz	200.0 MHz
Transmit Polarization	RHCP	LHCP
Transmit EIRP (Peak)	46.4 dBW	4.5 to 23.7 dBW/ per channel
Transmit antenna gain	35.7 dBi	26.9 dBi
3 dB beamwidth	3.0°	7.4°
Transmit power density into antenna	-65 dBW/Hz (peak)	-88.8 to -69.9 dBW/Hz

Earth Station Communication System Parameters

Earth Station/ User Parameters	Odyssey (NGSO MSS) (Feederlinks)	Iridium (NGSO MSS) (Feederlinks)
Transmit frequency range	29.1 to 29.4 GHz	29.1 to 29.3 GHz
Transmit bandwidth	300.0 MHz	200.0 MHz
Transmit Polarization	LHCP	RHCP
Transmit EIRP	85.9 dBW (peak)	68.3 dBW (peak)
Transmit antenna gain	64.8 dBi	56.3 dBi
3 dB Beamwidth	0.11°	0.24°
Transmit power density into antenna	-55.49 dBW/Hz (peak)	-54.4 dBW/Hz (peak)
Receive frequency range	19.3 to 19.6 GHz	19.4 to 19.6 GHz
Receive bandwidth	300.0 MHz	200.0 MHz
Receive Polarization	RHCP	LHCP
Receive antenna gain	60.8 dBi	53.2 dBi
3 dB Beamwidth	0.17°	0.36°
Receive antenna noise temperature	666.5 ° K	731.4° K

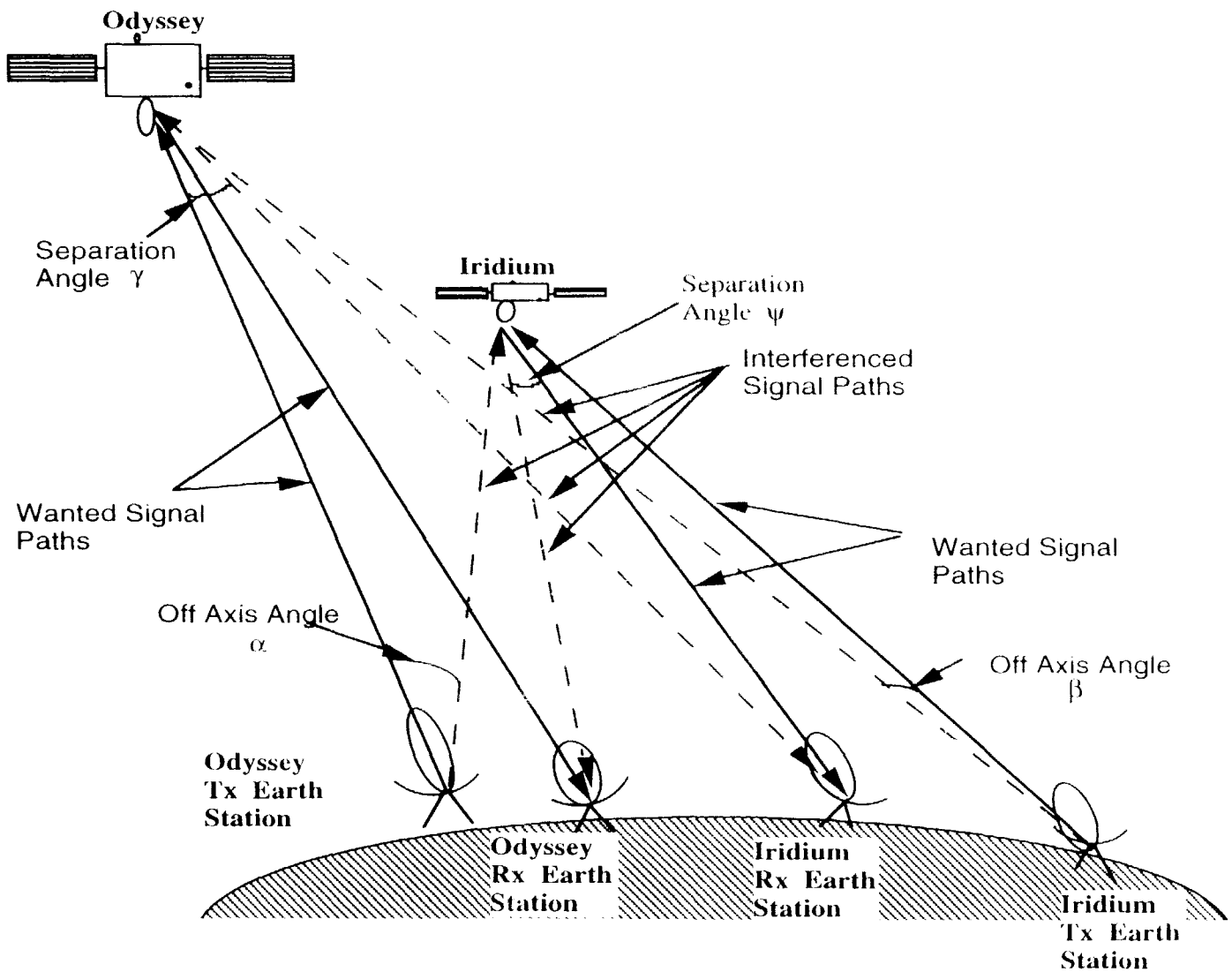
Interference Analysis

- Uplink interference
  - The Odyssey feederlink transmit earth station interfering with the Iridium satellite receiver
  - The Iridium feederlink transmit earth station interfering with the Odyssey satellite receiver
- Downlink interference
  - The Odyssey satellite transmit antenna interfering with the Iridium earth station receiver
  - The Iridium satellite transmit antenna interfering with the Odyssey earth station receiver
- In each case, the calculated interference level is based on the following assumptions:
  - In the Unites States, it was assumed that the Iridium system would have five earth station facilities. The candidates evaluated were:
    - » Spokane, Washington
    - » Kansas City, Kansas
    - » Montpelier, Vermont
    - » Las Vegas, Nevada
    - » Atlanta, Georgia
-

Interference Analysis

- The Odyssey potential earth stations are:
  - » San Luis Obispo, CA - USA
  - » Portland, Maine - USA
  - » Buenos Aires, Argentina
  - » Capetown, South Africa
  - » Ahmadabad, India
  - » Marseille, France
  - » Shanghai, China
  - » Sydney, Australia
- Only the earth station at San Luis Obispo and Portland were used for purposes of illustration
- The calculated uplink and downlink interference were based on the following:
  - » The estimated earth station transmit & receive antenna patterns were based on CCIR Rec. 580
  - » The estimated satellite antenna patterns were based on the CCIR Rec. 558-4
  - » The earth station transmit and receive antenna cross polarized patterns were based on the CCIR Rec. 731

Interference Geometry



Interference Geometry (Cont.)

α : Angular separation between the Odyssey satellite and the Iridium satellite as viewed by the Odyssey earth station

β : Angular separation between the Odyssey satellite and the Iridium satellite as viewed by the Iridium earth station

γ : Angular separation between the Odyssey earth station and the Iridium earth station as viewed by the Odyssey satellite

ψ : Angular separation between the Odyssey earth station and the Iridium earth station as viewed by the Iridium satellite

Interference Link Budgets

- At the Iridium Satellite Receiver
  - We assumed the following:
    - » $I/N_T = 0.79$
    - » Iridium satellite receive total system noise temp = 1295.5°K
    - » Since the cloud height is only 5 Km, then both wanted signal path and interfering signal path experience the same propagation condition.
  - The interference level I_o at the Iridium satellite receiver can be calculated as:

$$I_o = 10\text{Log}(0.79) + 10\ \text{Log}(NT) = P_t + G_t(\alpha) - L_{pathloss} - L_{other} + G_r(\psi)$$
$$- \text{Net\_Isolation}(XPD_{Tx}, XPD_{Rx}, XPD_{atm}) + 228.6$$

Where:
- P_t : Odyssey E/S transmit power density
- $G_t(\alpha)$: Odyssey E/S transmit antenna gain
- $L_{pathloss}$: Path loss
- L_{other} : Other loss (Atmosphere, Scintillation Loss)
- $G_r(\psi)$: Iridium satellite receive antenna gain

$\text{Net\_Isolation}(XPD_{Tx}, XPD_{Rx}, XPD_{atm})$: Net Cross- Polarization Isolation

  - Clear Sky
    - » P_t = -73.5 dBW/Hz
    - » If $\alpha = 0°$

Then $G_r(\psi)$ - Net_Isolation() = 1.2 dB then $\psi = 5.9°$

Interference Link Budgets (Cont.)

Odyssey Tx Power density (dBw/Hz)	Separation Angle ψ (Deg)
-73.5	5.9°
-71.5	7.8°
-69.5	8.6°

» **If $\psi = 0°$ -----> $G_t(\alpha)$ - Net_Isolation() = 35.9 dB**

» **Then $\alpha = 0.05°$**

Odyssey Tx Power density (dBw/Hz)	Off Axis Angle Angle α (Deg)
-73.5	0.05°
-71.5	0.05°
-69.5	0.05°
-67.5	0.1°
-65.5	0.1°
-61.5	0.15°

Rain: 18 dB margin:

» **If $\alpha = 0°$ then $\psi = 8.3°$**

» **If $\psi = 0°$ then $\alpha = 0.15°$**

Interference Link Budgets (Cont.)

- At the Odyssey Earth Station Receiver
  - Iridium satellite transmit power density P_t = -69.9 dBW/Hz
  - Odyssey E/S Rx total system noise temperature N_T = 666.5°K
  - In this case, we assumed that the wanted signal path encounters rain and interfering signal path is clear (worst case)
    - » If $\alpha = 0°$ then $\psi = 8.6°$ *
    - » If $\psi = 0°$ then $\alpha = 0.1°$
- At the Odyssey Satellite Receiver
  - Odyssey satellite Rx total system noise temperature N_T = 780°K
  - Iridium E/S transmit power density
    - » Clear P_t = -78 dBW/Hz
      - If $\beta = 0°$ then $\gamma = 0°$
    - » Rain P_t = -54.4 dBW/Hz
      - If $\beta = 0°$ then $\gamma = 0.72°$
      - If $\gamma = 0°$ then $\beta = 0.3°$

* In this case, in order to meet $I/N_T = 0.79$, the received interference signal at the Odyssey E/S receiver must be reduced by 3.4 dB. However, all the calculations are based on the worst case condition. If the actual antenna patterns are used in the calculation, then the interference level will be reduced significantly.

Interference Link Budgets (Cont.)

- At the Iridium Earth Station Receiver
  - Odyssey satellite transmit power density P_T = -65 dBW/Hz
  - Iridium E/S Rx total system noise temperature N_T = 731.4°K
    - » If $\beta = 0°$ then $\gamma = 0°$

Conclusions

- **In order to meet interference level I_o at the Iridium satellite receiver or at the Odyssey earth station receiver, the off axis angle α or the separation angle ψ must be greater than or equal to the following values**

Parameters	**At the Iridium Satellite Receiver** The Odyssey transmit earth station causes interference to the Iridium satellite receiver	
	Off axis angle from the Odyssey E/S α	Separation Angle @ Iridium S/C ψ
Clear Sky * Normal transmission (-73.5 dBW/Hz) * 4 dB more power (-69.5 dBW/Hz)	0.0° 0.05° 0.0° 0.1°	5.9° 0.0° 8.6° 0.0°
Rain: 18 dB margin	0.0° 0.15°	8.3° 0.0°
	At The Odyssey Earth Station Receiver The Iridium satellite causes interference to the Odyssey Earth Station	
Worst case	0° 0.1°	8.6° 0°

Conclusions

- **In order to meet interference level I_o at the Odyssey satellite receiver or at the Iridium earth station receiver, the off axis angle β or the separation angle γ must be greater than or equal to the following values**

Parameters	**At the Odyssey Satellite Receiver** The Iridium transmit earth station causes interference to the Odyssey satellite receive	
	Off axis angle from the Iridium E/S β	Separation Angle @ Odyssey S/C γ
Clear Sky * Normal transmission (-78.0 dBW/Hz) * 10 dB more power (-68 dBW/Hz) * Tx at the full power (-54.4 dBW/Hz)	 0° 0° 1.15°	 0° 1.5° 0°
Rain: 23.8 dB margin	0° 0.3°	0.75° 0°
	At The Iridium E/S Receiver The Odyssey satellite causes interference to t Iridium Earth Station	
Worst case	0°	0°