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Interference Problems and Techniques of Spectrum Sharing in Geo-Stationary Satellite Systems.

Muhammad Irfan
Arab Satellite Communication Organization
Riyadh, Saudi Arabia
mirfankk45@yahoo.com

Abstract—**The radio frequency spectrum used in Geo-Stationary Satellite System is limited in extent and the most useful parts of it are over- crowded. The rising demand for communication channels has led to increased number of Geo-Stationary satellite systems in the space for expanding the communication links and maximizing bandwidth to get higher quality particularly for mobility. This increase has introduced the interference problems with space and terrestrial services.**

Internationally applied strategy to resolve the problem of interference is based on System Filing and Frequency Coordination. System filing is a process of registering satellite system with International Telecommunication Union (which is an international regulatory body) in order to secure orbital locations along with Frequency Bands for satellite operators. The second most important part is Frequency Coordination which is a key activity in order to avert the frequencies of a satellite network from causing harmful interference to the networks of other countries. System filing and frequency coordination is crucial process for implementation of any kind of satellite system.

Due to sharing of same frequency bands among different satellites for different services and increase in demand of the Geo-stationary orbit, frequency coordination process has become very complicated involving detailed interference analysis in different scenarios and finding out mitigating factors/solutions for reaching coordination agreement with affected systems. Here this paper will discuss the interference problem and some of spectrum sharing studies in GSO satellite system.

Keywords-frequency coordination; interference in GSO satellite; spectrum sharing techniques

I. INTRODUCTION

The paper takes into account the compatibility study of GSO satellites which are 1° apart and examines the ~~conditions of~~ interference condition and the frequency sharing. This study investigates the interference caused by the a GSO satellite which is at 46°E (GEO_A) to the 47°E (GEO_B) GSO satellite system. It is considered that both systems provide the services in the 10950-11200MHz for Fixed Satellite Services. The calculations are made based on the ITU regulations that are declared applicable for the interim period

The objective of this paper is:

- Examine the nature of the interference between the systems sharing the frequency band [1]
- Using the methods and the limits proposed in the ITU regulations, calculate the level of interference between GSO satellite systems
- Undertake a simulation using VISUALYSE software to create a model and determine the C/I & C/N+I statistics
- To suggest the possible interference mitigation techniques and to come up with justification for any proposed scheme

II. SIMULATION WORK

VISUALYSE PRO is a Software package that has been used for designing the model and simulating the scenario for the co-frequency and co-coverage operation. In the simulations, links are defined for both satellite networks. Since the GEO_A (46ºE) is treated as interferer, the links are the transmitted link or the broadcasting links without defining any specific receivers. The broadcast link is recommended by the software for satellite to be treated as an interferer [2].

For the satellite GEO_B (47ºE), the link is designed as a fixed links assuming the intended receivers are stationed in small region and would not be changing position too much. These links start from the satellite and terminate on earth station. Thus, the situation modeled with main beam of each receiver directed towards GSO satellite.

After developing the system models, simulation files for the interference investigation were set up. In order to understand of the fluctuations in the interference level, five simulation files were developed with every file incorporating modifications in system parameters such as antenna radiation pattern, antenna size, polarization effects, and the beam isolation technique.

From the simulations, statistics of C/I were acquired for GEO_B downlink section. The C/I threshold level is set to be 15 dB, which is logical for digital receivers that incorporate moderate error corrections schemes. It is to be mentioned here that ITU also suggest the C/I threshold in ITU-R S. 741-2 for different analog and digital services to protect the victim emissions [3].

The results obtained from the simulations are presented in the following sections. Every section deals with the aggregate C/I results for GEO_B downlink section. It should be noted that statistics and results are obtained under clear sky condition in all cases and are valid only for clear sky condition. In practical cases, all modeled links may suffer significant signal degradation due to rainfall, humidity, dust, fog, storms, Faraday rotation, scintillation etc.

TABLE I. LINK INFORMATION CONSIDERED

Link Information	Parameters
C/I Threshold	15dB
Investigated band	10950 - 11200 MHz
Interfering Bandwidth	27MHz (36MHz Transponder)
Center frequency	11176 MHz
EIRP of Victim Satellite (GEO_B)	47.6 dBW
EIRP of Interfering Satellite (GEO_A)	50 dBW
Victim Receiving Earth Station (Change Relatively)	0.8m (37.56 dBi)
Victim Receiving Earth Station Radiation patern	ITU-Rec-580-6 [4]
Polarization ~~(Change Relatively)~~	~~Linear Vertical~~(Change Relatively)
Service	FSS

A. *First Simulation*

Here the victim earth station (GEO_B Rx ES) is receiving unwanted emissions from GEO_A satellite transmission due to co-frequency and co-coverage. The Highlighted parameter defines the level of interference into the victim satellite earth station. The level defined here represent that the interference level is 10.94 times higher than the victims level. The receiving victim earth station antenna which is considered here is of 0.8m with 65% efficiency. Here the linear polarization is set for both of the link.

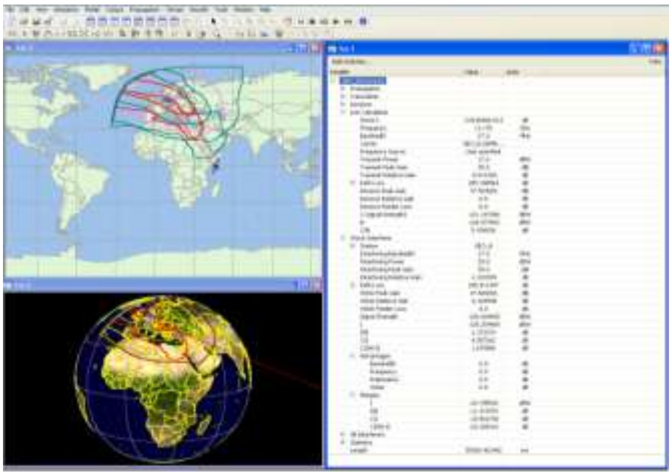

Figure 1. First Simulation

TABLE II. FIRST SIMULATION RESULT

Link Calculation		
Frequency	11.176	GHz
Bandwidth	27	MHz
Carrier	GEO_B (36M0GXX--)	
Frequency Source	User specified	
Transmit Power	17.6	dBW
Transmit Peak Gain	30	dBi
Transmit Relative Gain	-0.911269	dB
Path Loss	205.398964	dB
Freespace	205.281109	dB
676 dry	0.111297	dB
676 water	0.006557	dB
Receive Peak Gain	37.563026	dBi
Receive Relative Gain	0	dB
Receive Feeder Loss	0	dB
C (signal strength)	-151.147206	dBW
N	-126.577842	dBW
C/N	-24.569364	dB
Worst Interferer		
Station	GEO_A	
Group	none	
Antenna	Antenna	
Beam	Beam1	
Interfering Bandwidth	27	MHz
Interfering Power	20	dBW
Interfering Peak Gain	30	dBi
Interfering Relative Gain	-1.031899	dB
Path Loss	205.411497	dB
Freespace	205.291326	dB
676 dry	0.113485	dB
676 water	0.006686	dB
Victim Peak Gain	37.563026	dBi
Victim Relative Gain	-6.324098	dB
Victim Feeder Loss	0	dB
Signal Strength	-155.204468	dBW
I	-155.204468	dBW
I/N	-28.626626	dB
C/I	4.057262	dB
C/(N+I)	-24.575318	dB
Advantages		
Bandwidth	0	dB
Frequency	0	dB
Polarisation	0	dB
Other	0	dB
Margins		
I	5.204468	dBW
I/N	18.626626	dB
C/I	-10.942738	dB
C/(N+I)	-49.575318	dB

B. *Second Simulation*

In the second simulation situation is analyzed by changing the size of the Rx earth station antenna. In previous simulations results were generated with 0.8m for the victim earth station. The previous situation of the repositioned earth station is maintained and purpose of this section is to investigate further improvement if any, and it is observed that the C/I margins are improved up to 2dB

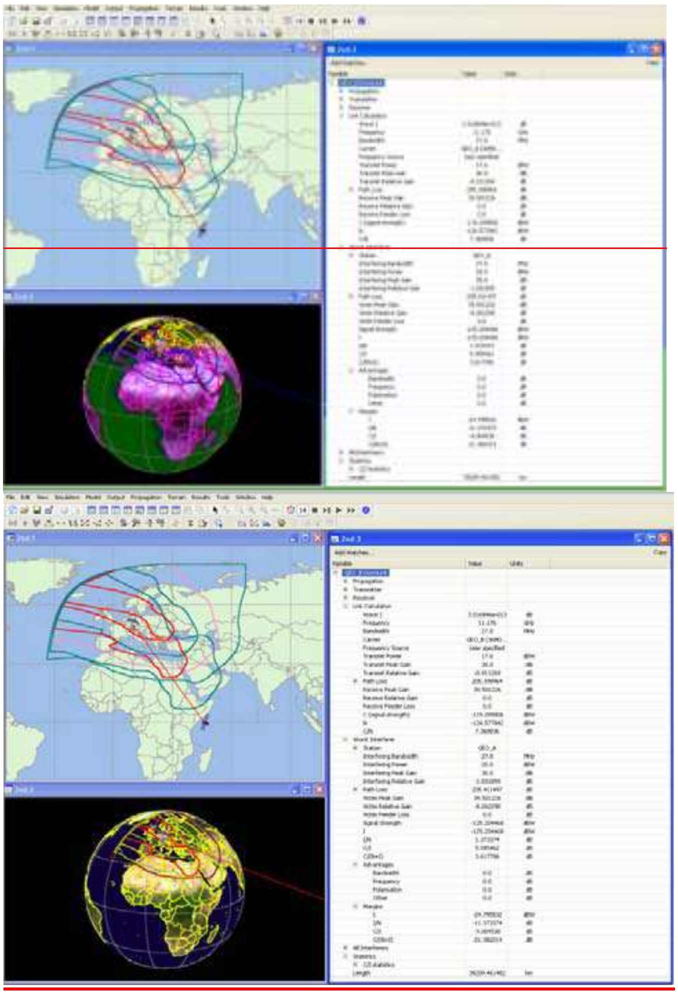

Figure 2. Second Simulation

TABLE III. SECOND SIMULATION RESULT

Link Calculation		
Frequency	11.176	GHz
Bandwidth	27	MHz
Carrier	GEO_B (36M0GXX--)	
Frequency Source	User specified	
Transmit Power	17.6	dBW
Transmit Peak Gain	30	dBi
Transmit Relative Gain	-0.911269	dB
Path Loss	205.39896	dB
Freespace	205.28111	dB
676 dry	0.111297	dB
676 water	0.006557	dB
Receive Peak Gain	39.501226	dBi
Receive Relative Gain	0	dB
Receive Feeder Loss	0	dB
C (signal strength)	-149.20901	dBW
N	-126.57784	dBW
C/N	-22.631164	dB
Worst Interferer		
Station	GEO_A	
Group	none	
Antenna	Antenna	
Beam	Beam1	
Interfering Bandwidth	27	MHz
Interfering Power	20	dBW
Interfering Peak Gain	30	dBi
Interfering Relative Gain	-1.031899	dB
Path Loss	205.4115	dB
Freespace	205.29133	dB
676 dry	0.113485	dB
676 water	0.006686	dB
Victim Peak Gain	39.501226	dBi
Victim Relative Gain	-8.262298	dB
Victim Feeder Loss	0	dB
Signal Strength	-155.20447	dBW
I	-155.20447	dBW
I/N	-28.626626	dB
C/I	5.995462	dB
C/(N+I)	-22.637118	dB
Advantages		
Bandwidth	0	dB
Frequency	0	dB
Polarisation	0	dB
Other	0	dB
Margins		
I	5.204468	dBW
I/N	18.626626	dB
C/I	-9.004538	dB
C/(N+I)	-47.637118	dB

C. Third Simulation

In the third simulation, GEO_A beam is steered towards the African region and it is observed that a quite reasonable improvement in the C/I margin is achieved. Here the polarization is same for both systems and also the antenna radiation pattern and the antenna size are not changed i.e 0.8m.

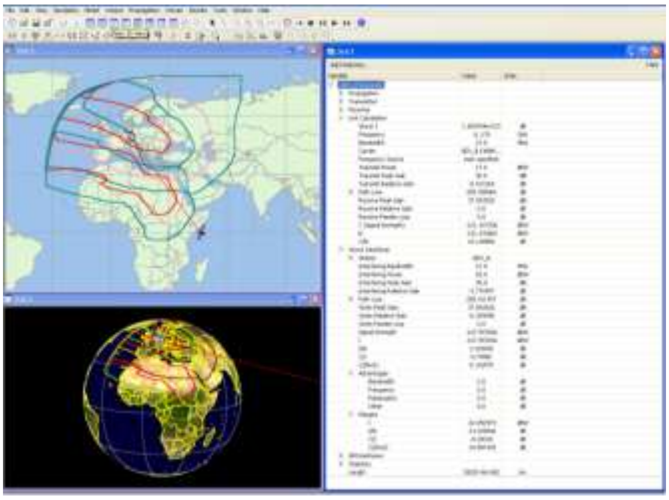

Figure 3. Third Simulation

TABLE IV. THIRD SIMULATION RESULT

Link Calculation		
Frequency	11.176	GHz
Bandwidth	27	MHz
Carrier	GEO_B (36M0GXX--)	

Frequency Source	User specified	
Transmit Power	17.6	dBW
Transmit Peak Gain	30	dBi
Transmit Relative Gain	-0.911269	dB
Path Loss	205.398964	dB
Freespace	205.281109	dB
676 dry	0.111297	dB
676 water	0.006557	dB
Receive Peak Gain	37.563026	dBi
Receive Relative Gain	0	dB
Receive Feeder Loss	0	dB
C (signal strength)	-151.147206	dBW
N	-131.276062	dBW
C/N	-19.871144	dB
Worst Interferer		
Station	GEO_A	
Group	none	
Antenna	Antenna	
Beam	Beam1	
Interfering Bandwidth	27	MHz
Interfering Power	20	dBW
Interfering Peak Gain	30	dBi
Interfering Relative Gain	-3.774457	dB
Path Loss	205.411497	dB
Freespace	205.291326	dB
676 dry	0.113485	dB
676 water	0.006686	dB
Victim Peak Gain	37.563026	dBi
Victim Relative Gain	-6.324098	dB
Victim Feeder Loss	0	dB
Signal Strength	-157.947026	dBW
I	-157.947026	dBW
I/N	-26.670964	dB
C/I	6.79982	dB
C/(N+I)	-19.880481	dB
Advantages		
Bandwidth	0	dB
Frequency	0	dB
Polarisation	0	dB
Other	0	dB
Margins		
I	7.947026	dBW
I/N	16.670964	dB
C/I	-8.20018	dB
C/(N+I)	-44.880481	dB

D. Fourth Simulation

Here Co-coverage situation is maintained. The radiation patterns and antennas size are also not changed. The only change made is in polarization. This time the GEO_B satellite is modeled with Right Hand circular polarization where as the GEO_A system carrier is set on Left hand circular polarization.

It is obvious that the polarization discrimination has significantly reduced the interference level and the interference level has been reduced to 6.026dB.

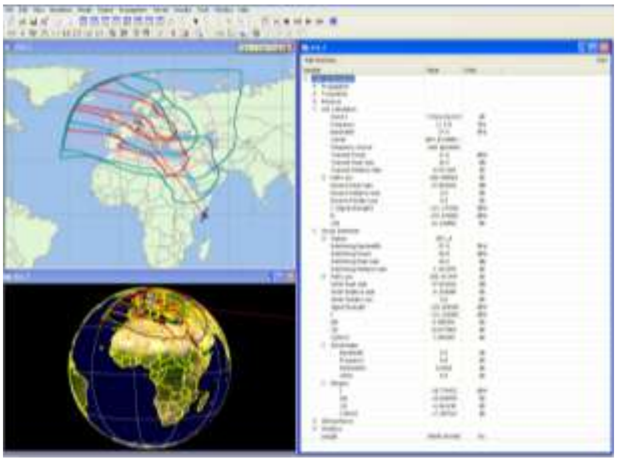

Figure 4. Fourth Simulation

TABLE V. FOURTH SIMULATION RESULT

Link Calculation		
Frequency	11.176	GHz
Bandwidth	27	MHz
Carrier	GEO_B (36M0GXX--)	
Frequency Source	User specified	
Transmit Power	17.6	dBW
Transmit Peak Gain	30	dBi
Transmit Relative Gain	-0.911269	dB
Path Loss	205.398964	dB
Freespace	205.281109	dB
676 dry	0.111297	dB
676 water	0.006557	dB
Receive Peak Gain	37.563026	dBi
Receive Relative Gain	0	dB
Receive Feeder Loss	0	dB
C (signal strength)	-151.147206	dBW
N	-131.276062	dBW
C/N	-19.871144	dB
Worst Interferer		
Station	GEO_A	
Group	none	
Antenna	Antenna	
Beam	Beam1	
Interfering Bandwidth	27	MHz
Interfering Power	20	dBW
Interfering Peak Gain	30	dBi
Interfering Relative Gain	-1.031899	dB
Path Loss	205.411497	dB
Freespace	205.291326	dB
676 dry	0.113485	dB
676 water	0.006686	dB
Victim Peak Gain	37.563026	dBi
Victim Relative Gain	-6.324098	dB
Victim Feeder Loss	0	dB
Signal Strength	-155.204468	dBW
I	-161.225068	dBW
I/N	-29.949006	dB

C/I	10.077862	dB
C/(N+I)	-19.875536	dB
Advantages		
Bandwidth	0	dB
Frequency	0	dB
Polarisation	6.0206	dB
Other	0	dB
Margins		
I	11.225068	dBW
I/N	19.949006	dB
C/I	-4.922138	dB
C/(N+I)	-44.875536	dB

E. Fifth Simulation

In the last simulation the combined effect of the above discussed mitigation factors are simulate and it is observed that a quite reasonable improvement in the C/I margin is achieved.

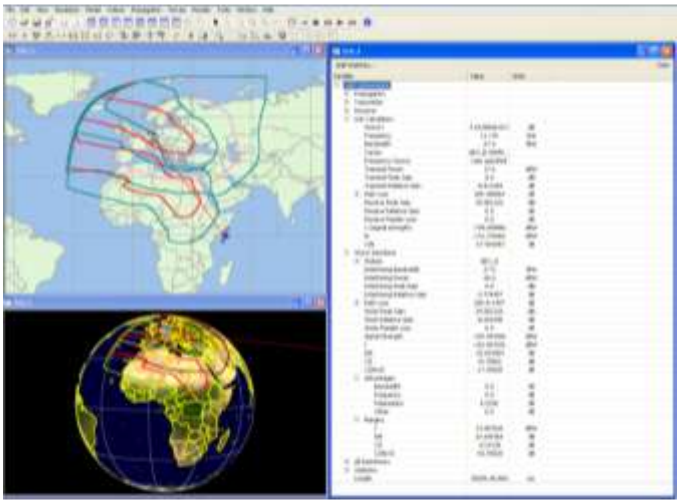

Figure 5. Fifth Simulation

TABLE VI. FIFTH SIMULATION RESULT

Link Calculation		
Frequency	11.176	GHz
Bandwidth	27	MHz
Carrier	GEO_B (36M0GXX--)	
Frequency Source	User specified	
Transmit Power	17.6	dBW
Transmit Peak Gain	30	dBi
Transmit Relative Gain	-0.911269	dB
Path Loss	205.398964	dB
Freespace	205.281109	dB
676 dry	0.111297	dB
676 water	0.006557	dB
Receive Peak Gain	39.501226	dBi
Receive Relative Gain	0	dB
Receive Feeder Loss	0	dB
C (signal strength)	-149.209006	dBW
N	-131.276062	dBW
C/N	-17.932943	dB
Worst Interferer		
Station	GEO_A	
Group	none	
Antenna	Antenna	
Beam	Beam1	
Interfering Bandwidth	27	MHz
Interfering Power	20	dBW
Interfering Peak Gain	30	dBi
Interfering Relative Gain	-3.774457	dB
Path Loss	205.411497	dB
Freespace	205.291326	dB
676 dry	0.113485	dB
676 water	0.006686	dB
Victim Peak Gain	39.501226	dBi
Victim Relative Gain	-8.262298	dB
Victim Feeder Loss	0	dB
Signal Strength	-157.947026	dBW
I	-163.967626	dBW
I/N	-32.691564	dB
C/I	14.75862	dB
C/(N+I)	-17.93528	dB
Advantages		
Bandwidth	0	dB
Frequency	0	dB
Polarisation	6.0206	dB
Other	0	dB
Margins		
I	13.967626	dBW
I/N	22.691564	dB
C/I	-0.24138	dB
C/(N+I)	-42.93528	dB

III. CONCLUSION

It has been investigated that how GEO satellite systems at 1° Orbital Separation, under the frequency sharing and co-coverage situation, cause harmful interference to one another operation and what possible mitigation techniques are available to manage this interference situation. The results obtained and analyzed in the preceding sections suggest that how C/I value may be improved by using the different mitigation technique in order to ensure successful operation, to avoid interference between the GSO satellite systems, and to observe the procedures of the ITU Radio Regulations [5].

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