# The Essential Need for Radio Frequency Management in Satellite Communication Development

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## ABSTRACT

Radio frequency spectrum is the factor that has primary importance for the activity in the satellite communication sector. Sufficient radio frequency spectrum is of important element for the activity and effective work in the satellite communication industry. Radio frequencies are a valuable and finite natural resource and the demands upon their use are increasing almost daily with every new digital technology that rolls out. Radio Frequency Interference continues to revolve the satellite communicationsindustry as owners/operators see an incremental unauthorized carriers, cross-polarization interference and some other issues with regard to errors. Management of the RF spectrum is a complicated policy issue, with various entities at the national and international level providing oversight and coordination. With growing numbers of space technology and applications being developed and used, RFI is a challenging task and responsibility in ensuring the sustainability of this scarce resources especially at the Geostationary orbit (GEO), which allocate huge numbers of communication satellites whether it's state owned and commercially operated.

**Keywords:** Radio frequency spectrum, Radio Frequency Interference (RFI), satellite communication.

## RADIO FREQUENCY INTERFERENCE FOR SATELLITE NETWORK

Since the launched of Sputnik-I, satellite industry has achieved steady growth in meeting radio frequency spectrum is the factor that has primary importance for the activity of satellite communication industry. Sufficient radio frequency spectrum is a very important element for the activity and effective work of the communication industry. Due to the growth and development of communication industry, especially using satellites, as well as the improved requirements needed to satisfy the demands of communication industry in general, the demand for radio facilities was significantly increased. That is why, one of the most important demands for the successful work and development of satellite communication sector to grow and developed is spectrum management and radio frequency management, consumption, and allocation. With recent years, Radio Frequency Interference (RFI) has become critical threat to satellite communications. Mostly the incidents caused by RFI had created obstacles for daily operations. The downstream users will pay a high price as the interference causing signal and transmission disruption though hindering business growth.

## RADIO FREQUENCY SPECTRUM

RF is a limited natural resource. It is part of the electromagnetic spectrum, usually up to about 3000GHz. Present technology, it is not yet practical to use spectrum above 40GHz (higher than Ka band). The wave is practically governed by the laws of physics and travel with the speed of light. It can't be confined to national boundaries or specific areas and are susceptibleto harmful interference. Propagation of radio waves has different characteristics in different frequency bands. Interference are being influenced by many situations and phenomenon inclusive of manmade radio noise, geographical terrain, climate change, inter-alia. It can't be owned but can only be shared amongst various countries, services, users, technologies, etc.

## RADIO FREQUENCY MANAGEMENT

### Regulatory Framework

A regulatory framework has been created to manage the RF spectrum as it needs to be shared by a many different applications and users. International Telecommunication Union (ITU)is the competent body for the management of the RF spectrum, including for space applications. The ITU Treaty and Conventions recognizes the RF spectrum and specific orbital region as limited resources and provides for their efficient and economic use, and equitable access.

Allocation of a frequency band designated is use for specific space or terrestrial applications. The ITU allocate frequencies either globally or in one of the three ITU regions. An allocated band can be further divided into allotments or channels that designate its use in one or more geographic areas. Nations that have acceded to the ITU treaty are required to designate an entity (public or private) as an administration to prove further oversight of the use RF spectrum at the national level. Through assignment, administrations authorize or license a specific terrestrial or satellite operator to use. Administration process happens after an advanced publication, coordination, notification and recording procedures applying the "first come, first served" principle. The Malaysia Communication and Multimedia Commission (MCMC) has been granted with the authority through

Multimedia and Communication Act1998 to govern, regulate, issuance of license and enforcing the RF spectrum utilizations and consumptionas per ITU conventions.

Communication satellites which reside in Geostationary Orbit (GEO), 35,786 km above the Earth equator, are all orbiting in close proximity to each other and many use the same or similar frequencies. To help reduce unintentional interference, the ITU allocated specific frequency bands for specific services according to three separate Region

**Radio Frequency Interference**

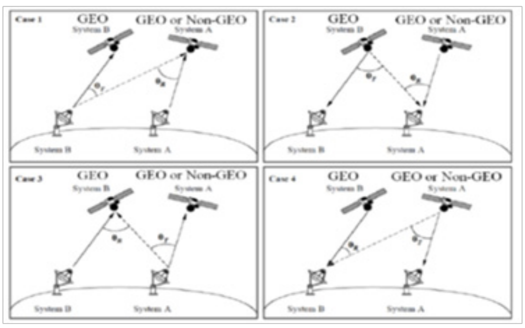
The ITU defined interference as the effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy. Harmful interference is defined by ITU as the interference which endangers the functioning of a radionavigation services or of other services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with ITU Radio Regulations.

There are many ways in which other RF sources or natural events can interfere with or disrupt RF communications. Generating RF signal is never a perfect process, and a signal always includes some power in frequencies other than the main one. A more powerful signal can drown out a weaker one, or two signals on the same frequency being broadcast near each other can make it difficult for a receiver to pick out the correct one. This can occur in the active GEO region if a transmitting satellite drifts past another transmitting satellite or a satellite has its transponders misconfigured. Unintentional RFI can also occur if an uplink antenna on the ground is pointed at the wrong satellite in orbit.

Another source of unintentional RFI can be the best result of overlap or interference between signals used to communicate with satellites and those used for terrestrial networks such as mobile phone systems. As the demand for high-speed wireless networks grows, a growing number of countries are looking to repurpose or share spectrum originally allocated to satellite communications with terrestrial applications. This is extremely challenging to do, as even terrestrial signals next to a satellite RF band can create problems by raising the signal-to-noise ratio (SNR) or spilling over into satellite band, either of which makes it harder to receive the satellite signal. Nature can also interfere with satellite communications. Transmissions in certain frequencies such as Ku and Ka bands can experience interference from heavy rain or snow. Energetic particles and radiation from the Sun, especially during solar storms, can create periodic outages or even permanently damage satellites.

The ITU-R Recommendations recognizes four principal RF interference paths between Fixed Satellite Service (FSS) networks as shown in Figure 1. The solid lines represent the desired links and the dashed lines represent the interference paths. As depicted, Case 3 and Case 4 for the second operator are mirror images of Cases 1 and 2 for the first operator.

The ITU has also identified four unique cases of interference between Inter-Satellite Services (ISS) and GEO Fixed Satellite Service (FSS)-to-Earth communications as shown in Figure 2 (revised for readability). We have given these cases unique numbers to differentiate between those in Figure 1. Communications satellite operators carefully monitor RFI incidents and their causes. In addition to the eight paths for interference previously discussed, operators track general statistics as shown in Figure 3 for the type and frequency of occurrence for such incidents by signal type and other factors. As these sample annual statistics show for one operator, the most common sources of interference are from Adjacent Satellite Interference (ASI), Co-Pol and Cross-Pol. Co-Polarized (Co-Pol) interference occurs when one of an operator's own customers radiates the satellite with the intended polarization but either at the wrong time, frequency or satellite. Cross-Polarization (Cross-Pol) is interference from improperly-configured or misaligned polarization which leaks energy into services located on the opposite polarization. In an effort to map such RFI incidents into a more meaningful metric, communications satellite operators devised a way to weight such RFI incidents by the affected bandwidth and time to resolve, as depicted in Figure 4.



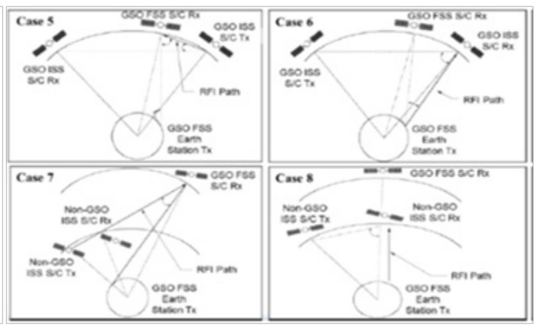
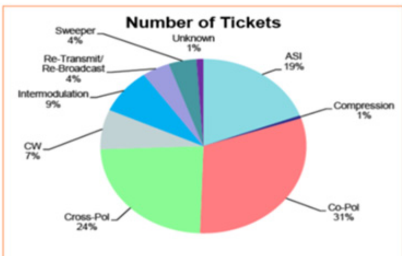




**Figure 1:4 cases of Ground-to-satellite RFIFigure 2:4 cases of ISS/FSS RFI**

As Figure 4shows, 84% of all communications lost to RFI incidents are attributable to ASI, Cross-Pol and Co-Pol issues. Since Cross-Pol and Co-Pol issues originate within the operator's own customer base, those issues tend to be rapidly addressed by improved coordination and communication with communication customers, equipment installer training, identifying and fixing configuration issues and clarifying communications schedules, transponder allocations, etc.

ASI (i.e., ITU Case 1 and Case 3) is the single most detrimental and worrisome RFI issue facing communications operators. ASI occurs when an interfering signal (whether legitimate traffic to an adjacent satellite or from an intentional jamming source) interferes with a satellite's legitimate communications traffic as shown in Figure 5.



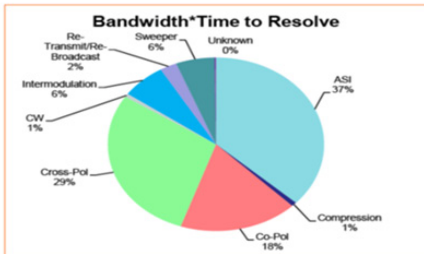




**Figure 3: RFI Incidents Categorized By TypeFigure4: RFIs by Type, Weighted by Bits Lost**

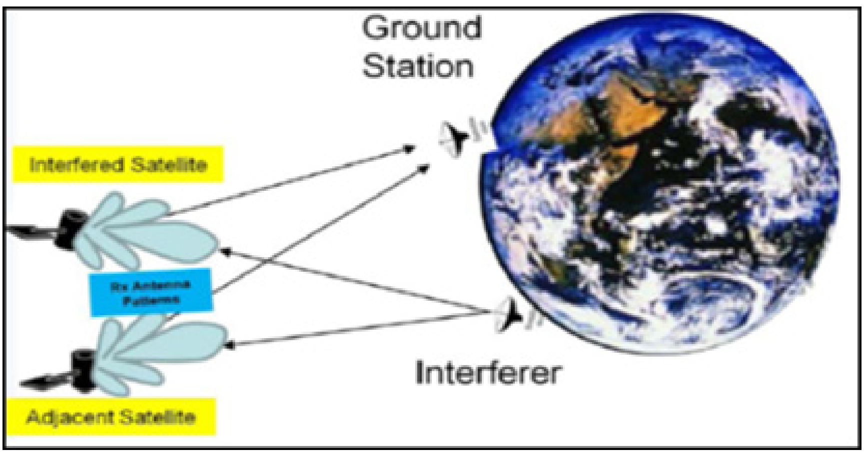



**Figure 5: Adjacent Satellite Interference geometry**

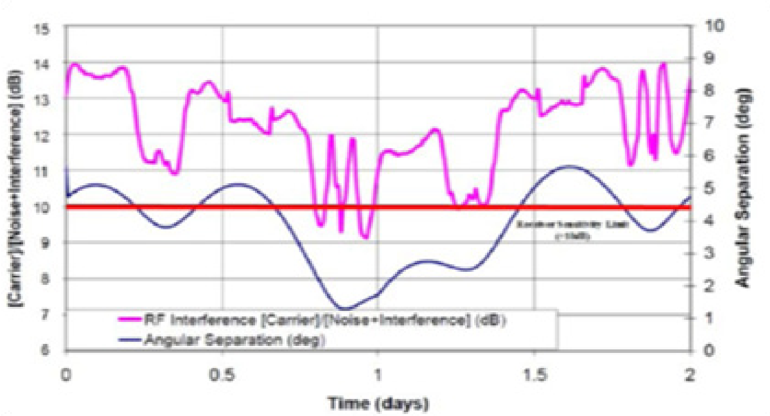



**Figure 6: Sample C/ [N+I} and Angular Sep vs Time**

Received carrier signal levels that are less than 10 dB above the combination of (noise + interference) may be susceptible to interference with reduced operational performance below a 10-6 BER, as shown in a sample evolution of the ratio of [Carrier] to [Noise + Interference] using an actual parabolic dish antenna pattern in Figure 6

. Note that angular separation between the two adjacent satellites is a rough indicator of potential RFI, but detailed antenna patterns and computation of [Carrier] to [Noise + Interference] is required to best identify potential RFI times.

Most interference sources span international borders, where all participants must conform to the ITU-Radiocommunication (ITU-R) recommendations governing potential interference. The methodology use concluded as technical approach to assess permissible vs unacceptable levels of interference.

Coordination is required in the bands:

(i) 3400-4200 MHz, 5725-5852 MHz (Region 1) and 5850-6725 MHz where the trigger orbitalseparation is 10deg or less.

(ii) 10.95-11.2 GHz, 11.45 – 11.7 GHz, 11.7-12.2 GHz (Region 2), 12.2-12.5 GHz (Region 3), 12.5-12.75 GHz (Region 1 and 3), 12.7-12.75 GHz (Region 2) and 13.75 – 14.5 GHz where the trigger orbital separation is 9deg or less.

(iii) 17.7 – 20.2 GHz and 27.5-30 GHz where the trigger orbital separation is 8deg or less.

Delta T/T procedure estimates the likely interference caused by an "interfering" network by estimating the increase in system noise temperature that this network might cause to a 'wanted' satellite network.

$$\Delta T = \frac{p'eg'1(\theta)g2(\delta e')}{kl\mu}$$

$$\Delta Te = \frac{ps'g3(\eta e)g4(\theta t)}{kld}$$

$$\Delta T = \gamma \Delta \mathrm{T}s + \Delta \mathrm{T}e$$

Since the noise temperature of the wanted network is known then the value of Delta T/T is easily calculated. If the value of Delta T/T exceeds 6% then coordination is required by the party affected in the satellite network filing. In some cases the uplink and downlink can be treated separately.

**CONCLUSION**

Demands on spectrum are increasing as it manifold for variety of satellite communication applications. Managing the radio frequency at its component level is critically important for satellite communication or geostationary orbit satellite networks. Some interference is managed by sharing constraints but others require detailed bilateral coordination.

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