Adjacent Satellite Interference in Mobile/VSAT Environments

INTELSAT
General Corporation

Introduction

A number of recent government and commercial RFPs have included language which specifies that bidders must propose bandwidth which is “free of interference”. For a variety of reasons expounded below, complete freedom from interference is practically impossible in an operational environment. However, in most cases interference levels are kept low enough, by careful coordination with adjacent operators and services, and by careful terminal selection and pointing, that they can be overcome. More accurate RFP language would request bandwidth which is “free of service-impacting interference levels”.

Any satellite user may significantly contribute to Adjacent Satellite Interference (ASI), Adjacent Channel Interference (ACI), and Cross-Polarization Interference (XPI) by using too much uplink power, using too small of an antenna for the application, and/or by failing to properly peak and set polarization of their terminals.

Figure 1: Smaller Antennas Receive & Cause More ASI

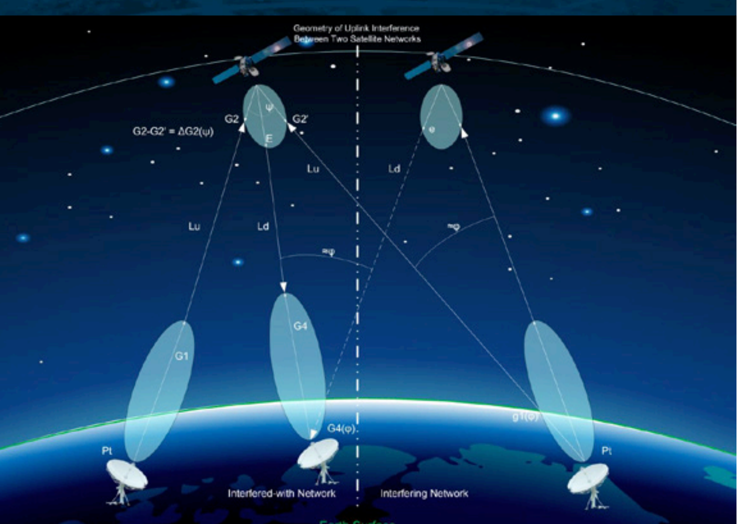


Figure 2: ASI Paths

ASI Types

Two types of ASI can occur, Downlink ASI in which the ground receiving antenna beam width is large enough to receive significant signal levels from adjacent satellites, and Uplink ASI in which adjacent satellites receive and re-broadcast strong uplink signals from ground antennas which are either too small / wide pattern, improperly pointed, or both as shown in Figure 1. Uplink ASI paths, as detailed in Figure 2, are often more difficult to overcome.

Recommendations based on ITU-R-S.1323-2, ITU-R -S.735-1, and related documents have long called for users and satellite operators to allow for at least 20% of total noise power (~1.0 dB) allocated to ASI. Most satellite operator analyses follow this recommendation in link designs unless actual levels of ASI are known and calculated for specific links. Regulators and satellite operators are clearly aware of these latent levels of interference, but most customers have not noticed because link design margins are usually more than sufficient to overcome the low levels of ASI and XPI normally encountered on nominally separated satellites.

ASI Between Closely-Spaced Satellites

Higher levels of ASI may be encountered when the separation between satellites is less than 2.0° longitude, when the adjacent satellites have overlapping beams and frequency ranges. ASI occurs because the terminal antenna gain in the direction of the adjacent satellites increases when the orbital separation between adjacent satellites is reduced. This effect is further compounded when smaller antennas are used because at a given frequency, a smaller antenna will have a wider beam width than a larger antenna. This is why small mobile and portable terminals often suffer the most from, and simultaneously contribute the most to the ASI environment. This has been frequently observed in the densely packed Indian Ocean Region (IOR) between 70.5 East and 76.5 East where at least five Ku-Band satellites are located, in some cases with as little as 1° of separation as shown in Figure 3.

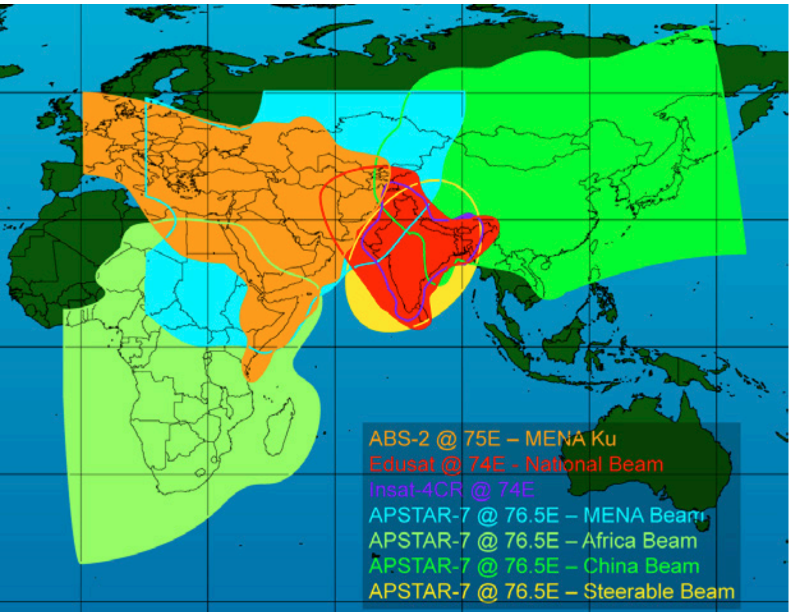


Figure 3: Examples of Adjacent Satellite Beam Overlap
(Illustration based on published footprints)

A number of variables interact to determine the severity of a given ASI environment, including:

- Satellite orbital slot spacing, especially where < 2° latitude
- Amount of beam footprint & frequency overlap between Adjacent Satellites
- Terminal location within multiple satellite beams
- Small terminal size / wide beamwidth / antenna pattern not meeting 29-25*log(.) mask
  – most ASI interference occurs when the antennas transmit and receive within the main lobe or first side lobe to/from the adjacent satellites
- Poor terminal pointing accuracy or polarization alignment (peak/pol)
- High uplink EIRP
- High transponder sensitivity (lower, more negative SFD) when receiving uplink ASI

An ASI situation is more difficult to overcome when there are deficiencies in more than one of these factors.

Mitigating ASI – Inter-Satellite Coordination

Satellite fleet operators with spacecraft in adjacent slots are well aware of operational constraints resulting from close satellite spacing, and work together to develop coordinated uplink and downlink power density limits and expected ASI levels for each satellite, as well as a terminal protection strategy which may specify the minimum size terminals which will be protected from ASI, and to what degree. An example of coordinated ASI levels between E70B and IS-20 is shown in Figure 4.

Additional joint planning between Capacity Management teams allows for a coordinated capacity allocation approach in order to place services on the adjacent satellites in the most compatible fashion with the least risk of causing or receiving harmful interference. For example, a strong forward carrier from a large hub antenna may be placed in an impacted frequency range with higher authorized power in order to overcome interference, while a weaker, more power-limited return carrier is placed on a frequency with less ASI potential.

INTELSAT 20 AT 68.5°E Ku-Band Uplink Power Densities

Transmit E/S Location	Maximum Power Density (dBW/Hz)* (13.75-14.5 GHz)
Anywhere	-46

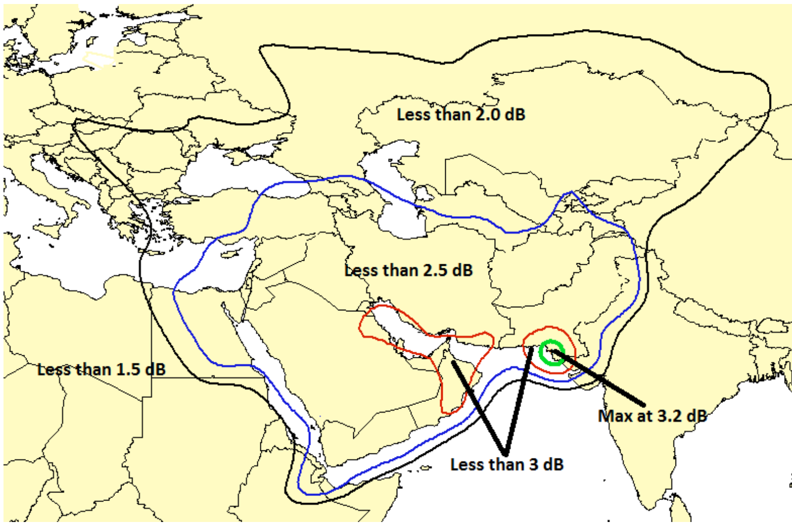


Figure 4: Coordinated Uplink Power Density & ASI Levels on IS-20 @ 68.5°E from Antennas Operating on E70B @ 70.5°E

*Assuming E/S with transmit sidelobe of 29-25 log (theta)

Mitigating ASI – Satellite User Contribution

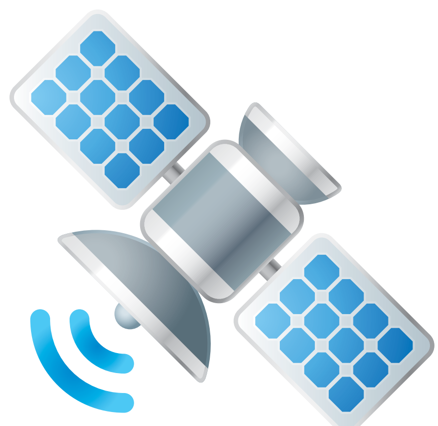
When operating in an orbital slot with known close-spacing of adjacent satellites, satellite users should employ the largest practical antenna sizes with the least necessary RF power, and observe coordinated power density limitations. In order to reduce ASI incidents caused by pointing errors, users should configure mobile remotes to stop transmitting if the hub's signal is lost, or if pointing errors become too great. Users should also configure remotes to begin network acquisition at a low power level and gradually step power up, rather than coming in too hot and stepping power down.

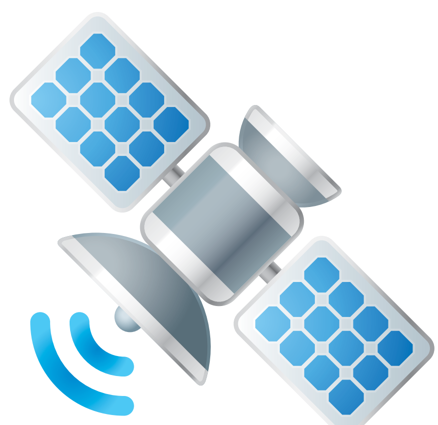
It is very important for all satellite users to carefully follow proper satellite access procedures, and contact the satellite operator's RF Operations Center (ROC) whenever preparing to access or de-access the satellite. The ROC will help to verify correct terminal pointing, polarization, and power levels which may prevent an ASI incident. Do not rely solely on automatic-acquisition antenna controllers; always contact the ROC to verify pointing and polarization before beginning any transmissions.

Users should note that mobile remotes may require antenna controller calibration whenever antennas are installed, modified, or re-installed on a ship, aircraft, or ground vehicle. Particular attention should be given to any antenna azimuth vs. vehicle heading offsets. Vehicle inertial measurement units (IMUs) and/or flux-gate compass may require zeroing or calibration as well. Also, aeronautical terminals are susceptible to loss of pointing accuracy or even complete loss of satellite lock when making fast turns or banking. Whenever possible, these maneuvers should be minimized while return data links are active.

Conclusion

Satellite users should not assume that bandwidth is completely free of interference since low-level sources are ever-present and virtually unavoidable. In the vast majority of instances however, interference can be mitigated by careful terminal selection, link design, grooming & coordination of capacity, and by setting and following appropriate operating constraints. Satellite operators and customers can and have successfully worked together to reduce and overcome even high levels of ASI in closely-spaced orbital locations.





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General Corporation

FOR MORE INFORMATION
7900 Tysons One Place, Ste. 12
McLean VA 22102-5979
703.270.4200
www.intelsatgeneral.com