Why is Training Critical to the Commercial Satellite User Community?

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Introduction

Consider the following hypothetical, but realistic, scenarios:

- A mission commander plans to deploy a UAV over a certain zone. The mission must be canceled because available bandwidth in that zone is contaminated with interference.
- A broadband service provider's customers are suffering from dropped packets. No hardware faults can be found and all transmitters are operating at their assigned power levels. The cause is traced to interference from another VSAT network on the oppositely-polarized transponder.
- A VSAT network is operating perfectly until suddenly certain nodes experience outages and lost packets, due to interference created by an incorrectly-installed terminal. The installer of that terminal is unaware that he caused other links to be degraded.

In this paper, we will explore why these situations can happen and why field technician training can prevent them.

Commercial geostationay satellite capacity is a shared environment

Commercial geostationary satellites are shared by diverse users, including military (UAV, COTM, tactical, voice, data, imagery, etc.), commercial Internet access and backhaul, wireless communications backhaul, video contributions (SNG), and Direct-to-Home TV.

For these diverse uses, a variety of types of ground terminals is employed, such as VSATs in managed networks, manually configured SCPC or SNG terminals, and large gateways and teleports.

Because commercial geostationary satellites use simple analog repeater transponders, interference can be generated by improper installation or operation of terminals. Such interference can have severe consequences:

- Commercial service outages
- Throughput degradation
- Reduced available satellite capacity ("no-man's land" spectrum)
- Mission compromise

The inherent characteristics of commercial geostationary satellites lead to five main reasons for interference.

Interference reason #1: Spectrum sharing

Commercial satellites are shared, wideband analog repeaters ("transponders"), which amplify any and all signals they receive. Transponders have limited aggregate power capability. A transponder can support multiple users who are not aware of each others' existence (Figure 1).

Signals in a transponder must not overlap in frequency, or destructive interference will result. In a VSAT network, the network management system must be correctly configured to command the remote VSAT to the correct frequency and bandwidth. Alternatively, in a manually-operated ground station (e.g. SCPC, SNG, or gateway), the terminal operator must manually adjust frequency, bit rate, and other settings to match the frequency slot assigned by the satellite operator.

Solution: Train field technicians to correctly set modem frequency and other signal settings.

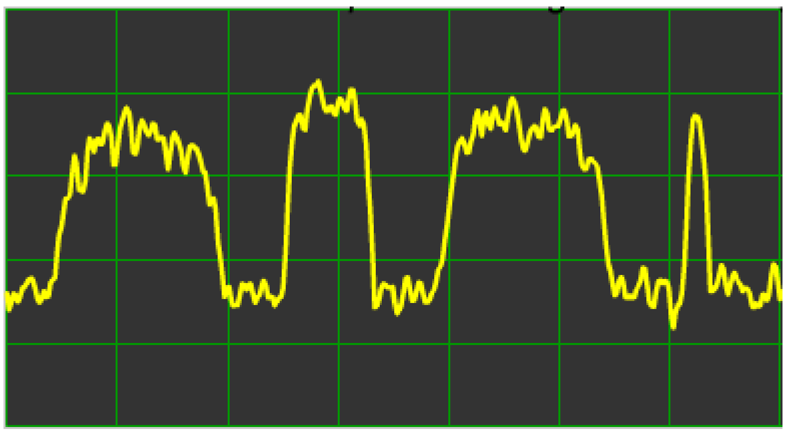

Figure 1 Typical transponder spectrum showing multiple independent users

Interference reason #2: Retransmission

All ground terminal hardware has broadband, high-power uplink capability. Any signal in the 1-2 GHz range present on the transmit cable will be amplified and upconverted, and will appear on the satellite. Local broadcast signals, and wireless services, and even the ground station's own downlink signals can potentially leak into the transmit cable and be uplinked to the satellite. Such signals appear as spurious interference in the satellite. In order to prevent this leakage, cables must be have good shielding, be of high quality, and have connectors correctly attached (Figure 2).

Solution: Train field technicians to correctly attach connectors and use the correct cable types.

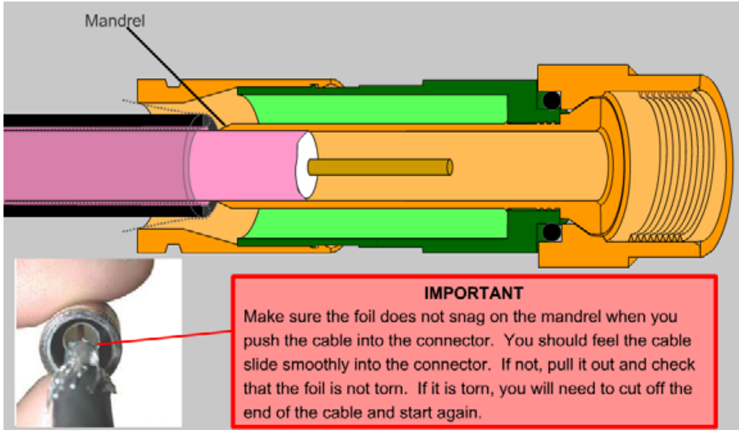

Figure 2 Correct procedures must be followed when attaching coaxial cable connectors

Interference reason #3: Power sharing
Every transponder is, in effect, a bandpass filter followed by a power amplifier. Therefore each transponder has a limited aggregate signal power budget. However, signal power is completely controlled by the ground terminal, not the satellite; the transponder simply amplifies whatever signals are present at its input but a constant gain.

Therefore, the level of every signal must fall within a tightly-constrained power window, or the transponder will distort all the signals and generate wideband intermodulation distortion products (Figure 3), resulting in degraded signal quality for ***all*** users .

In a VSAT network, the network management system must be correctly configured to command the remote VSAT to the correct power. In a manually-operated ground station (e.g. SCPC, SNG, gateway), the operator must manually adjust uplink power to achieve a target level measured by the NOC

Solution: Train field technicians to correctly adjust transmit power; train VSAT network managers to correctly set system power levels.

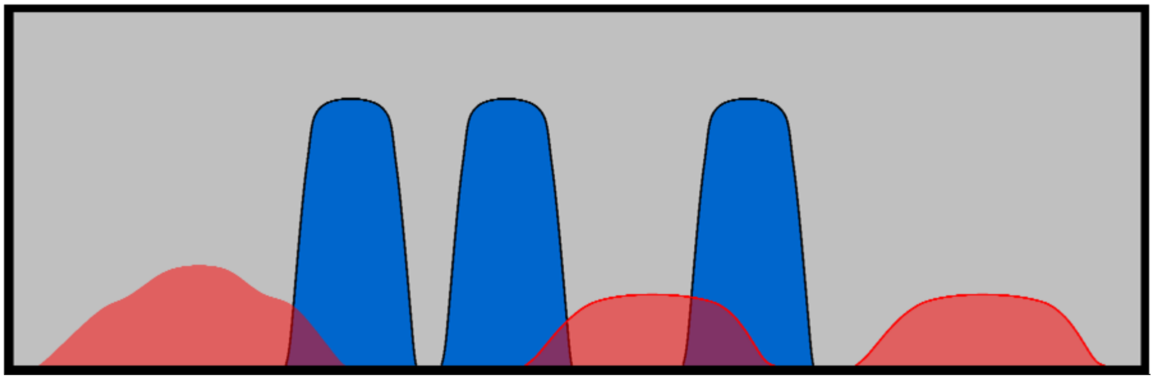

Figure 3 Intermodulation interference due to excessive signal power

Interference reason #4: Polarization sharing

Re-use of frequencies by polarization separation is employed on the vast majority of satellites. Almost every frequency channel is shared by two transponders using opposite polarizations. The ground equipment must be designed to suppress transmitted leakage on the opposite polarization typically 30 dB or more compared to the assigned signal.

Two polarization schemes are possible: circular and linear. Circular pol is used on most Ka-band and international C-band satellites, whereas linear polarization is used on U.S. domestic C-band satellites and almost all Ku-band satellites, which carry the bulk of VSAT services.

For linear polarization (unlike circular polarization), the every ground station antenna must be adjusted to within 1-2° feed rotation angle (Figure 4), otherwise destructive cross-pol interference will result. This presents a serious challenge to field technicians because it can only be accurately determined by having the network operations center monitor the level of a test signal in a "cross-pol" transponder while the antenna is being adjusted.

Misunderstanding of, or incomplete, linear polarization alignment of VSAT antennas is one of the most significant root causes of transponder interference.

Solution: Train field technicians to correctly adjust feed polarization.

Figure 4 Linear polarization adjusted by physically rotating the feed assembly

Interference reason #5: Orbit sharing

In order to remain stationary as viewed from the ground, a satellite must be placed precisely on a ring 22,300 miles above the equator – the "geostationary arc." There is tremendous demand for slots on this arc, which are coordinated by the ITU and spaced as closely together as practical (Figure 5).

The beamwidth of any ground station must be narrow enough discern the desired satellite. If beamwidth is too wide, the ground station's signal will be received by neighboring satellites on either side and will interfere with other users on the same frequency on those satellites. This is known as Adjacent Satellite Interference (ASI).

The *smaller* the ground station antenna, the *wider* its beamwidth. For example, at Ku-band, a 2.4m diameter antenna has a beamwidth of 0.6°, whereas a 0.75m diameter antenna has a beamwidth of 1.8°, which is almost as wide as the common spacing between satellites (2°). The lower limit for antenna size for interference-free use of geostationary satellites is determined by satellite spacing -- not by technology or arbitrary regulations.

Small antennas (under 2m for Ku-band) must be accurately pointed, otherwise destructive adjacent satellite interference (ASI) will result. Because of the broad shape of the center of their beams, small antennas cannot be accurately pointed by simply peaking the signal. The beam must be centered to minimize signal strength towards the neighboring satellites on either side.

Solution: Train field technicians to correctly adjust antenna pointing using the "beam balance" method to center the beam on the target satellite while minimizing ASI.

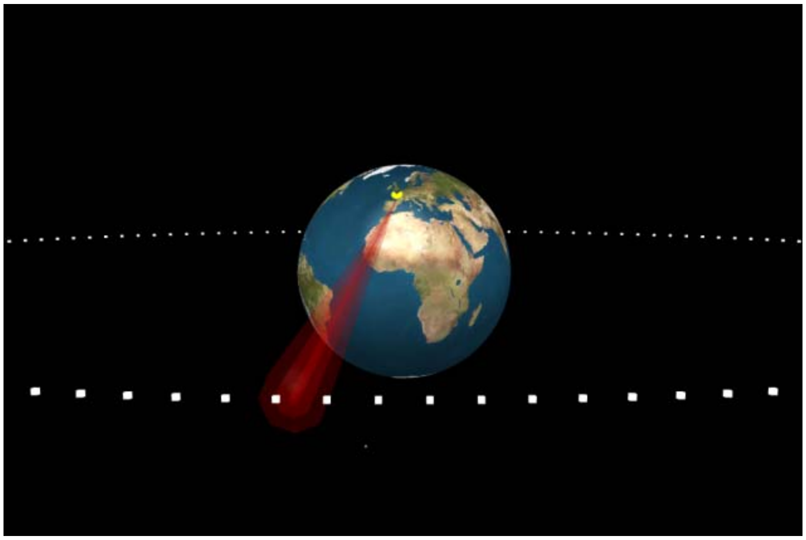

Figure 5 Geostationary arc, satellite slots, and ground station beamwidth

Conclusions

Unintended interference can cause serious service disruptions, capacity reduction, and mission compromise. Field technicians and network operations center staff have critical roles in the prevention of interference. To prevent interference, these personnel must be trained not only in installing specific hardware but in several critical, fundamental skills:

1. Accurate antenna pointing
2. Accurate polarization adjustment
3. Proper transmit power adjustment
4. Correct modem signal settings
5. Correct selection of cable and attachment of connectors

About the authors

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