C-band Interference due to Aircraft and How to Mitigate its Impact Sep 2016

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Introduction

Terrestrial Interference like WiMAX, BWA and IMT has caught a lot of attention from the users and satellite operators because of the widespread deployment of these wireless networks and their persistent impact on C-band Fixed Satellite Service (FSS). Among other interfering sources, aircraft altimeter is also a common source of interference for C-band satellite reception. Even though it is not generally known to users, its impact on C-band satellite service can be significant. This article will examine the causes of interference due to aircraft and how to mitigate its impact.

Satellite C-band is heavily used for satellite communications throughout the world for a multitude of service. Due to its ubiquitous coverage, high availability and instant connectivity, C-band FSS plays a key role in the socio-economic development of many countries to provide vital services and is also crucial for disaster relief operations. This band is also used by governments in conjunction with international commitments.

Despite the ubiquitous coverage, high availability and the instant connectivity nature of satellite, satellite receivers are designed for reception of very low incoming satellite signals which are transmitted from roughly 38 000 km away and the dynamic range of the satellite receiver is set accordingly. Typically, a satellite receiver LNA/LNB will reach the 1 dB compression point with a total incoming power of around -50 dBm and the LNA/LNB would start to show a non-linear behavior, creating undesirable intermodulation products and even suppression of carrier when the total incoming power is above -60 dBm (i.e. 10dB below the 1 dB compression point). Signals from terrestrial transmitters can, because of the much shorter distance, generate much higher incoming signal levels (>> -60 dBm) at the satellite receiver. Those incoming terrestrial signals can severely affect the operating point of the LNA/LNB and drive it out of its dynamic range to where it exhibits a non-linear behavior that may result in serious distortion or even suppression of the satellite signal.

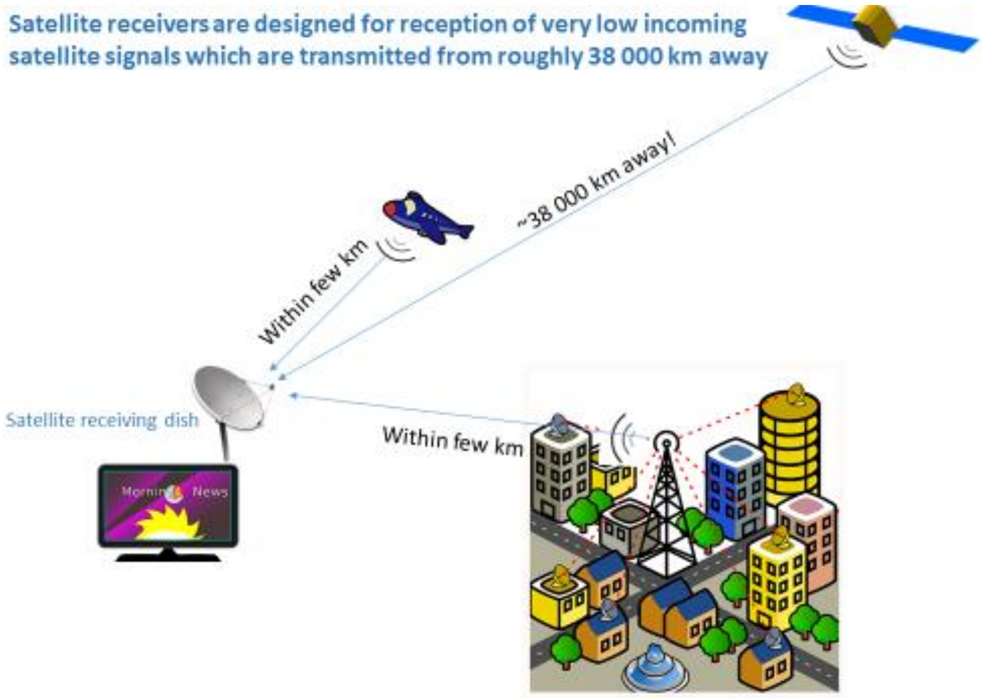

Figure 1: Satellite receivers are designed for reception of very low incoming satellite signals which are transmitted from roughly 38 000 km away

Operating frequencies of aircraft altimeter

Aircraft altimeters operate within the 4 200 – 4 400 MHz band. There are two types of radio altimeters in use today; one type utilizes Frequency Modulated Continuous Wave (FMCW) modulation, the second type utilizes pulsed modulation. According to Recommendation ITU-R M.2059, altimeters operate at a centre frequency of approximately 4 300 MHz and the 40 dB emission bandwidth is less than 200MHz. With C-band satellites operating in the 3 400 – 4 200 MHz band, direct in-band interference (where the terrestrial signals fall within the 3 400 – 4 200 MHz range) is avoided as designed by policy for co-existence. However, equipment vendors cannot manufacture hardware as precise as mathematical equations with infinite rejections with zero guard band.

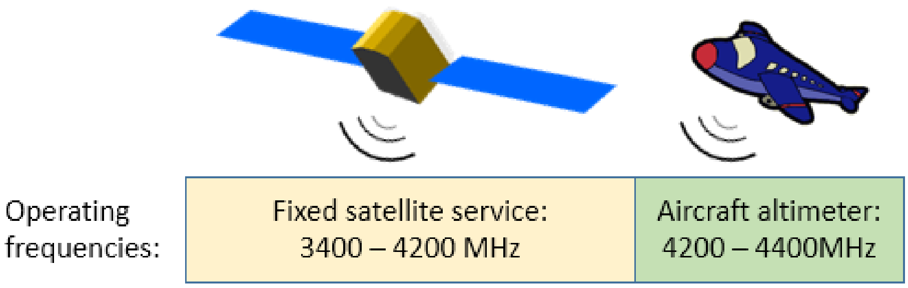

Figure 2: Operating frequencies for fixed satellite service and aircraft altimeter

Reason for interference even when there is no frequency overlap

Although there is no frequency overlapping between the band used by aircraft altimeters and fixed satellite service, satellite reception could still be affected by the aircraft altimeter, especially when the satellite receiving earth stations are located close to airport or directly under heavily used air traffic routes. There are two dominant mechanisms for adjacent band interference:

- Unwanted emissions of the terrestrial transmitter;
- LNA/LNB overdrive.

<u>Unwanted emissions of the terrestrial transmitter</u>

According to Recommendation ITU-R M.2059, altimeter signals will be at least 40 dB down at +/- 100 MHz from 4 300 MHz. However, there is a huge difference in distance to the geostationary satellite and the terrestrial transmitter. For example, if the distance to the terrestrial transmitter, the aircraft altimeter in this case, is 1 km while the distance to the geostationary satellite is 38 000 km, this would give rise to a difference in spreading loss of about 91.5 dB. To give a satisfactory C/I (e.g. 20dB), if the EIRP of the aircraft altimeter and the satellite is the same, the altimeter emissions in the band of the satellite signal would need to be 111.5 dB lower than that of the altimeter in-band power level, achieving such large out-of-band discriminations is not trivial. Depending on the power level, emission bandwidth, roll off of the altimeter emission and the distance between the aircraft altimeter and the satellite dish, unwanted emissions of the aircraft altimeter falling in the 3 400 – 4 200 MHz range cannot be ruled out.

<u>LNA/LNB overdrive</u>

Traditional satellite LNAs and LNBs receive the entire 3 400 – 4 200 MHz band. To achieve a low noise figure, LNAs and LNBs are seen to have a wide band pass in the 2 900 – 4 500 MHz with very flat frequency response in the 3 400 – 4 200 MHz, any roll-off will be outside the 3 400 – 4 200 MHz (or even 3 200 – 4 400 MHz), Figure 3 shows the frequency response of a typical C-band satellite receiver. Terrestrial signals in any part of the receiving bandwidth of the LNA and LNB will affect the operating point of the LNA or LNB even if the signals are not overlapping. Due to the order of magnitude differences in power levels between the nearby terrestrial signals and the far away (~ 38 000 km away) satellite signals, noting the dynamic range of the LNAs/LNBs which is set to match that of the very low power incoming satellite signal levels, terrestrial signals can overdrive satellite earth station LNA and LNB or bring them into non-linear operation. This will block reception of satellite signals anywhere in the entire 3 400 - 4 200 MHz band, even if the terrestrial signal is not overlapping with the satellite signal. Figure 4 shows a spectrum plot where the satellite signal is not affected by aircraft altimeter, whereas Figures 5 and 6 show two spectrum plots that the signal signals are affected by the aircraft altimeter.

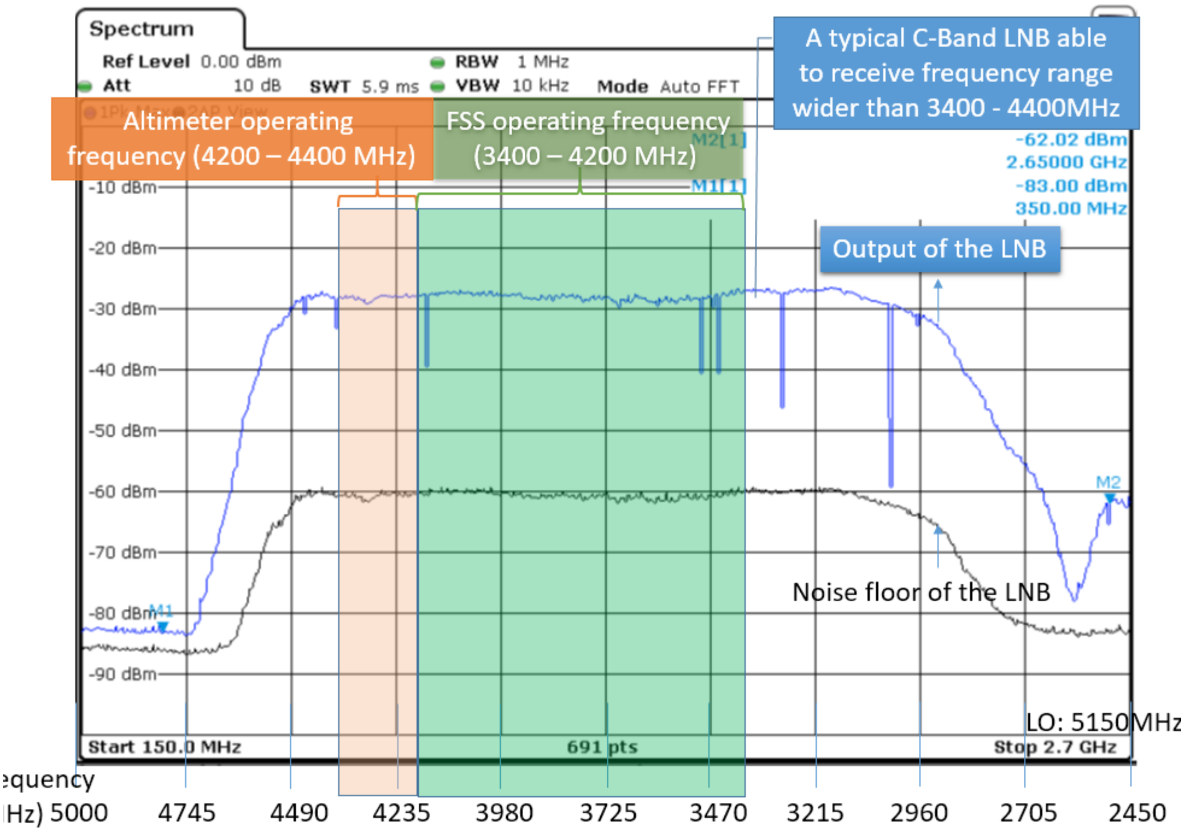

Figure 3: Frequency response of a typical C-band satellite receiver

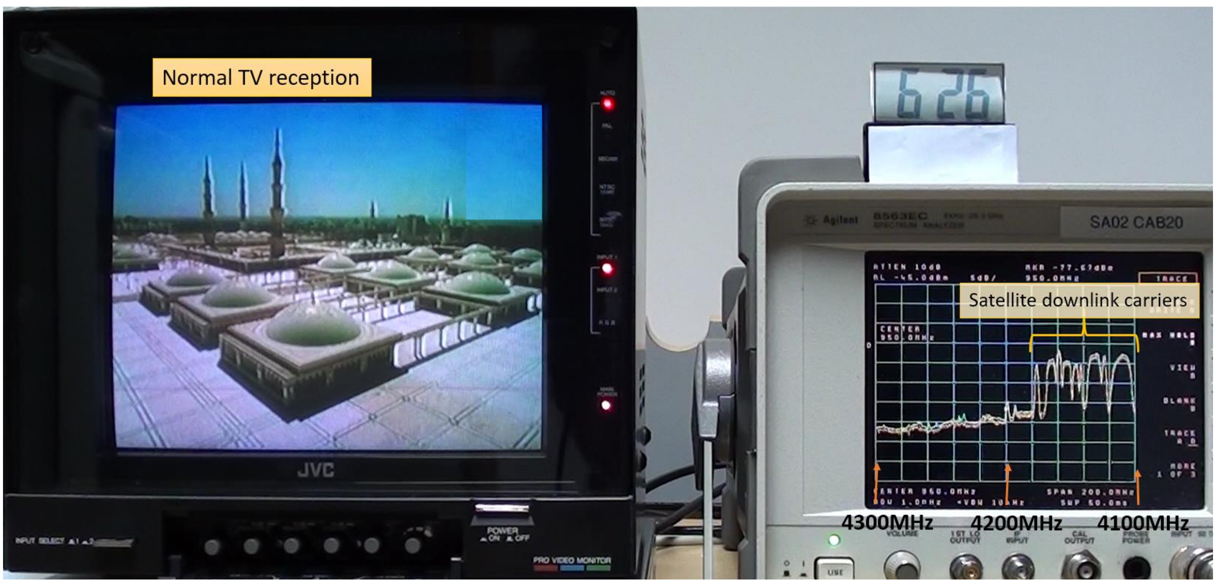

Figure 4: Spectrum plot where a C-band receiver is not affected by aircraft altimeter

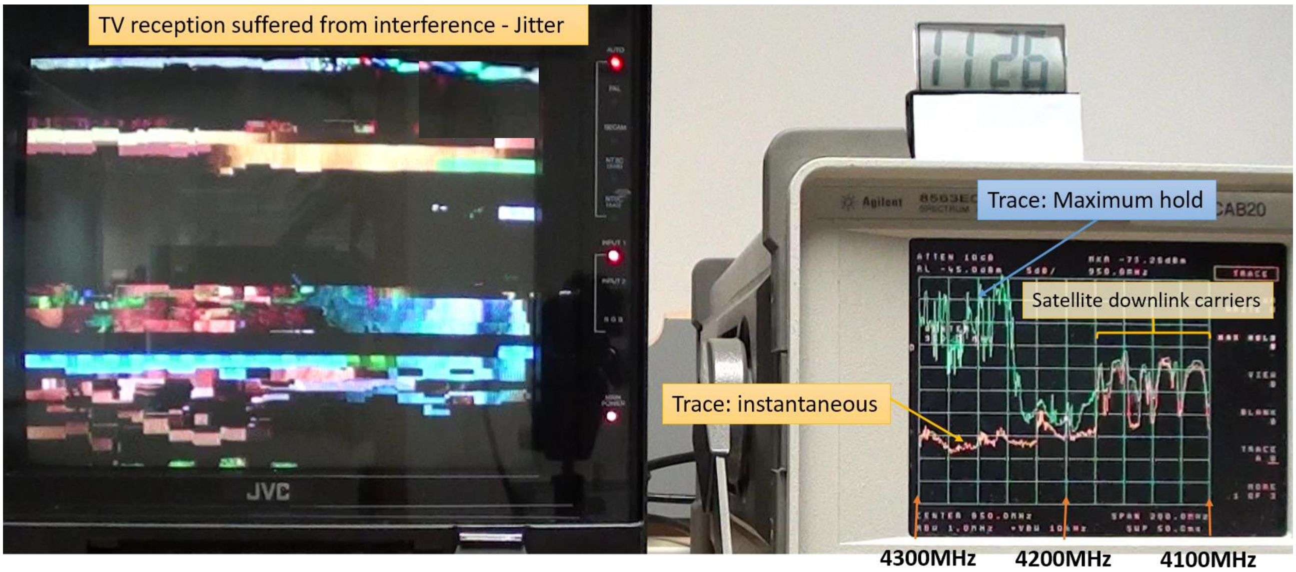

Figure 5: Spectrum plot where a C-band receiver is affected by aircraft altimeter - TV reception: jitter

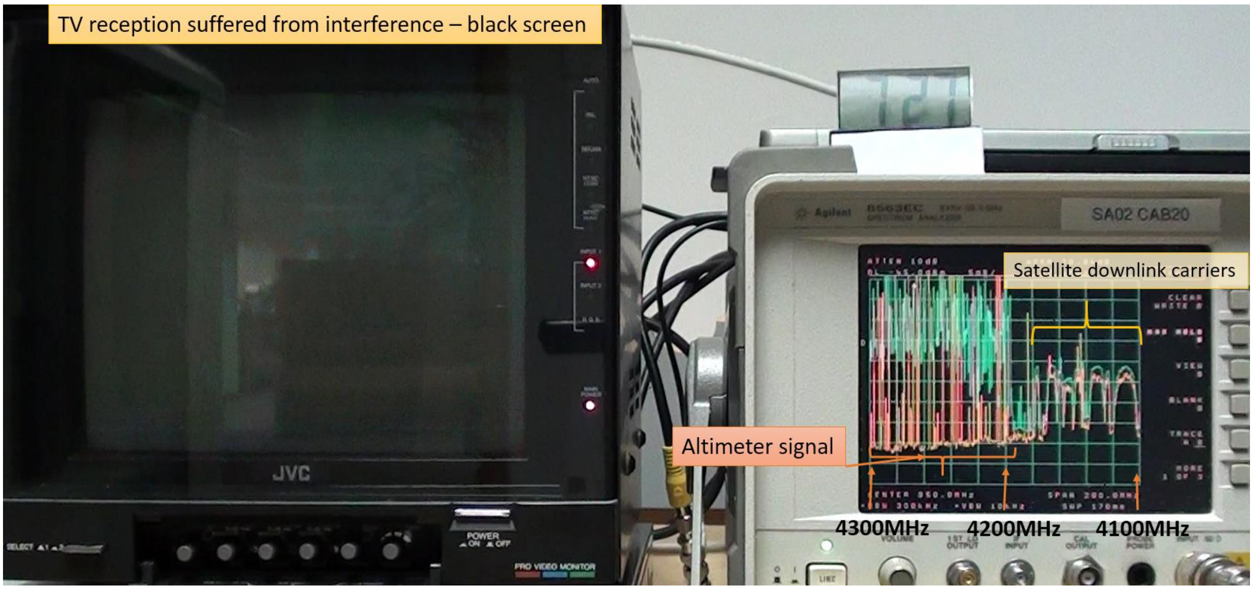

Figure 6: Spectrum plot where a C-band receiver is affected by aircraft altimeter – TV reception: black screen

Characteristic of the interference due to aircraft altimeter

Unlike other terrestrial interference (e.g. WiMAX), interference due to aircraft altimeter is usually brief, it may cause signal drop for a very short duration (e.g. 1 second of TV signal interruption in case of TV reception) for each aircraft passing by in the pointing direction of the antenna, the interruption may last longer and may be repetitive when the weather is bad or during heavy traffic periods. The interference occurrence pattern could be periodic or random depending on the flight schedules and flight route near the satellite receiving earth station. Therefore, if the interference is intermittent with short duration and the reception dish is in the proximity of the airport or flight path, the interference is likely to be from aircraft altimeter. Table 1 shows a comparison of C-band outage due to different sources.

Source:	WiMAX/BWA/IMT	Aircraft altimeter
Outage pattern	Prolong interference with long outage period	Intermittent with short duration typically in terms of seconds in irregular interval, season dependent
Source	Interference due to RF transmission in the lower portion of the C-band e.g. 3 400 – 3 600 MHz	Interference due to RF transmission in the band 4 200 – 4 400 MHz
Mitigation technique	Waveguide bandpass filter to be installed before the LNB, site shielding	Waveguide bandpass filter to be installed before the LNB
Reception dish location	Wide coverage	Close to airport or directly under air traffic route

Table 1: Comparison of C-band outage due to different sources

Methods to mitigate the interference due to aircraft altimeter

For reception dishes that are affected by altimeter's interference, e.g. at locations close to the airport or directly under heavily used air traffic route, it is recommended to install a pre-LNA/LNB waveguide filter to reduce the effect of LNA/LNB overdrive. For unwanted emissions of aircraft altimeters, such waveguide filters will not have any effect since the interfering signal component will be in-band to the satellite signal. In this case, the filtering would need to be on the side of the aircraft altimeter instead of on the satellite receiving side.

Installing a pre-LNA/LNB filter could also help to get rid of some other terrestrial interference like Broadband Wireless Access (BWA)/Fixed Wireless Access/WiMax in the C-band, see another article in our website for details.

It is important to select a proper pre-LNA/LNB filter. The filter should have high rejection in the bands where the terrestrial signal is operating, low insertion loss (e.g. 0.5dB) in the intended receivable frequency range. Also, according to our experience, an integrated filter with the LNB cannot provide the same levels of rejection as an external filter. An external filter is therefore recommended.

Some typical filters:
http://www.microwavefilter.com/7893_chart.html
http://www.norsat.com/wp-content/uploads/bpf_c_mc.pdf
http://www.atci.com/filters.html
http://www.sotca.com/products/filters.aspx
http://www.dawnco.com/auto_links/pdf/C-BANDPASS-WIMAX4.pdf

Other possible interference due to aircraft

Apart from the potential interference from the altimeter, AsiaSat also observes cases where the uplink signal received from the satellite has dropped slightly and shortly (e.g. less than 0.5 second) due to uplink path blockage by an aircraft which may happen when the uplink path is physically intersected with an aircraft. However, it is observed that it has only negligible or even no impact on satellite reception. Therefore, it is believed that the impact due to uplink path blockage by an aircraft is insignificant. Nevertheless, we will continue our investigation and fully document the results. Figure 7 illustrates the situation when satellite uplink path is physically intersected with an aircraft.

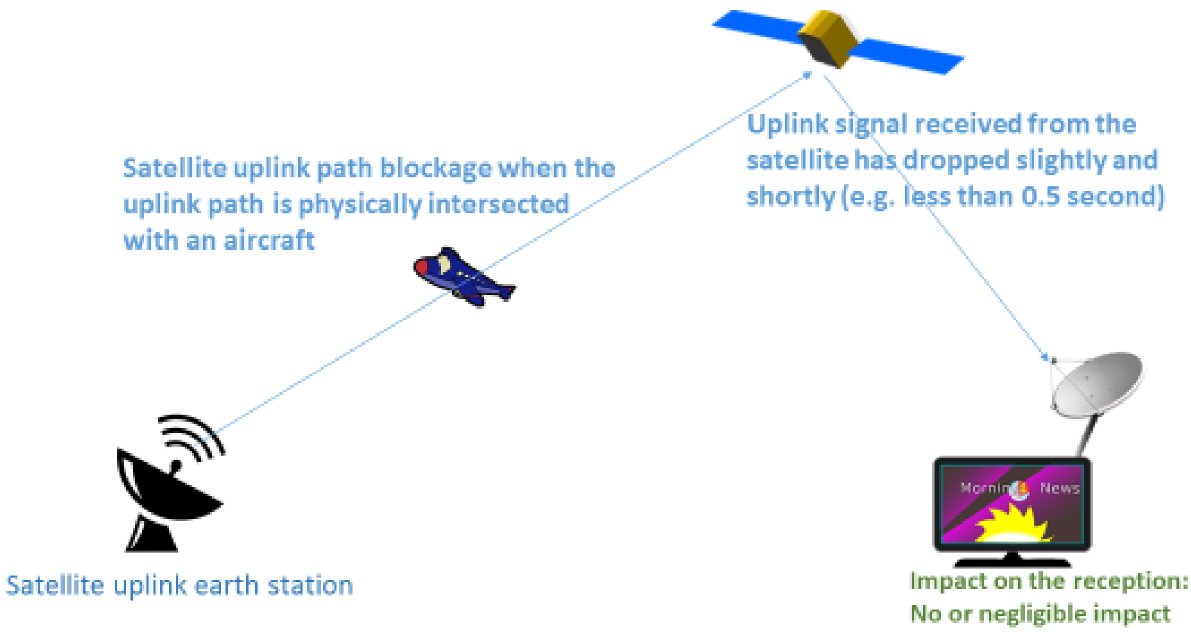

Figure 7: Situation when satellite uplink path is physically intersected with an aircraft

Conclusion

Aircraft altimeter is a common source of interference to satellite C-band reception. Although the impacts are of short duration in nature when compare to other terrestrial interference sources, satellite operators and users should pay attention to it and apply measures to eliminate or reduce the interference due to aircraft altimeter.

AsiaSat has conducted extensive monitoring and testing in this area and has developed the mitigation strategy necessary to minimize the impact of altimeter interference on satellite C-band reception to enable our customers and their clients to enjoy the best quality of services delivered by our satellites.