Detection, geolocation and resolution of L-band radar rebroadcast interference

Interference is a growing problem for commercial and government communications users alike, amplified by the increasing number of satellites and terminals coming into operation. For government and military consumers, interference can be the difference between mission success and mission failure, and even life and death. Mike Felix, Network Operations Center Supervisor at Kratos, describes a recent interference event that was detected and resolved for one of Kratos' customers, and outlines how some interference can be avoided with good installation procedures.

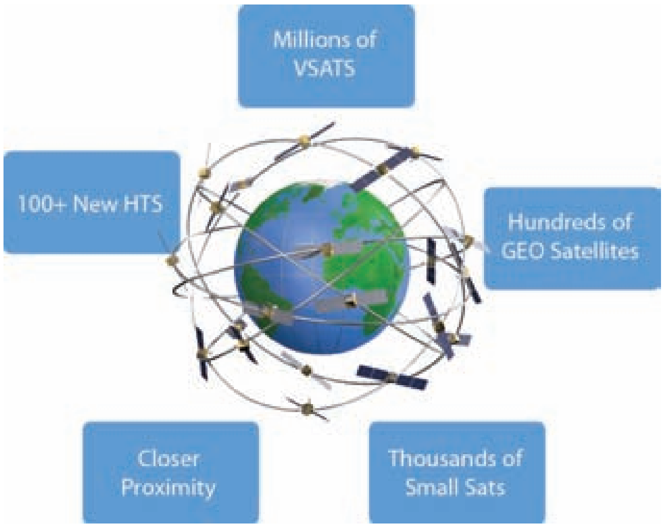

Figure 1: Space congestion

Radio Frequency Interference (RFI) has been steadily on the increase for a number of reasons. Millions of VSATS are now in service, two degree spacing between satellites in a geostationary arc is less common, industry estimates indicate more than 100 new HTS payloads and satellites are expected to launch over the next decade, and a proposed wave of low Earth orbit (LEO) communications satellite constellations could ultimately launch over a 1,000 small satellites.

The majority of interference is unintentional, due to a variety of factors. Operators may be using faulty equipment, systems may be incorrectly positioned, or operators may not be in compliance with regulations. Adjacent satellites can also be a problem due to their close proximity. Even though unintentional, RFI can have serious repercussions if not quickly detected and mitigated.

Fortunately, interference detection and geolocation capabilities have grown more precise and are helping to resolve the issue, even as it becomes more complex. Monics® and satID® from Satellite Interference Reduction Group (iRG) member Kratos, products for monitoring and detecting RFI and geolocating it, respectively, are two examples. Leading satellite and network operators have installed and rely on both Monics and satID. Kratos also provides RF interference monitoring and geolocation as a managed service for commercial and government clients.

Solving L-band radar interference

Mike Felix, Network Operations Center Supervisor at Kratos, describes a typical incident detected and resolved in a managed services scenario. "While the Kratos Network Operations Center (NOC) was monitoring bandwidth for one of our customers, we detected an interfering signal operating in two planned frequency slots," explained Felix.

The NOC had configured Monics with the particulars of all customer signals in the monitored transponder. A Monics monitoring plan was then configured to continuously scan both the planned and leased-but-unplanned portions of the transponder. In this case, Monics detected signals that did not match two different carrier slots and generated specific alarms, one at the transponder summary level and one for each carrier slot, indicating an unplanned carrier was present.

The interference experienced by the customer was caused by an L-band radar type signal being rebroadcast to the satellite (figure 2). This customer operates an L-band radar system that is commonly deployed to their facilities, which also feature SATCOM terminals. The radar system can operate in the same L-band frequency range as the SATCOM terminal's block up-converter (BUC) input. As in this case, if the cable between the user's modulator and BUC input is damaged or improperly terminated, the high-power radar signal will enter the BUC's input. At this point, the RADAR is up-converted, amplified, and transmitted to the satellite just like any L-band signal from the user's modulator.

Kratos' first step was to advise the customer of the issue and recommend they move the affected users while resolution efforts took place. Given the severity of this interference, it was likely that at least one of the two affected users would have been significantly impacted through either reduced link throughput or even the inability to maintain any kind of usable SATCOM link. By proactively detecting the interference and relocating the affected users to alternate spectrum, the user's throughput and link stability were ensured. This is an example of maintaining the customer's Service Level Agreement (SLA) while working the root cause of an interference problem.

When the customer contacted the service provider of this bandwidth to elevate the issue, the service provider initially claimed the interference was due to issues with a cross-pol (x-pol) user. Kratos was able to demonstrate that this was not a case of cross-pol interference by providing a cross-pol overlay spectrum plot. In the following Monics spectral plot (figure 3.), the affected (co-pol) frequencies are in green, while the light blue trace shows the active bandwidth on the cross-pol. Any differences in transponder local oscillators (LO, 'turnaround') frequencies are compensated for by the Monics Carrier Monitoring System (CMS). This also shows the benefit of ensuring that carrier management systems have the RF input of both the bandwidth to be monitored and the cross-pol

Figure 2. Interference Event – Monics Dwell Window

Figure 3. Monics Spectral Plot - Cross Pol

bandwidth on the same satellite.

The analysis showed that the interference source was not an improperly polarized terminal operating on the opposite uplink polarity. Kratos also provided additional time-based measurements of the interference using Monics' 'Spectrogram' feature (figure 4). In this mode, Monics measures the bandwidth over a user specified period of time, and we can see that while the two active user carriers are constantly accessed, the interference varies both in amplitude and frequency over time.

Given the unique spectral shape and behaviour of the interference, the Kratos NOC suspected this was likely an L-band radar rebroadcast, as it had dealt with previous instances of similar interference, all of which were traced to the same type of issue. Given this analysis, Kratos moved to geolocate the interference. A geolocation was deemed necessary as the initial spectral plots and interference characterization would likely not be enough to identify the terminal transmitting the interference. The geolocation results pointed to one of Kratos' customer's known sites, even though this site was not known to use this particular satellite's bandwidth at the time of the event (figure 5).

The customer reached out to the entity responsible for assigning bandwidth on this satellite/transponder to individual users. During this engagement, it was determined that a terminal at the suspected facility had recently been activated on the affected satellite, however, in a different transponder. As is the case with L-band radar rebroadcasts, the interference can insert itself anywhere in the BUC's L-band IF range. Depending on the uplink frequency band and manufacturer, this can be anywhere from 950 to 1750+ MHz. The terminal was contacted and during a brief turn-off test, it was determined to be the source of the interference. After making repairs, the terminal re-accessed without the interference present and, after a short monitoring period, the problem was solved.

"For some operators, a managed services approach is more efficient," said Felix. "At the NOC, we have professional operators who do this for a living. We have a global infrastructure that we maintain, and have developed the products that we deploy. So

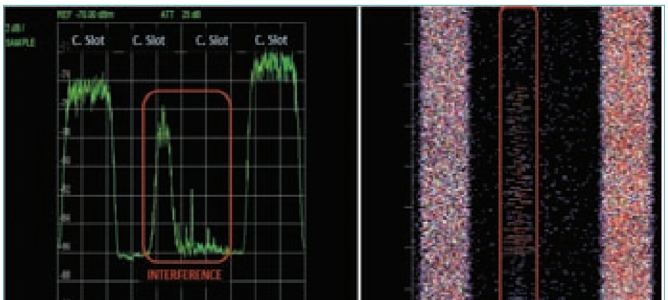

Figure 4. Spectrum Analyzer and Spectrogram views - The view on the left is a stand spectrum analyser type view with frequency on the X axis and amplitude on the Y axis. In the view on the right, the X-axis still represents frequency, but the Y axis represents time and the color differences represent amplitude

we can install new software or features that would benefit the customer, who doesn't have to worry about maintaining and operating the infrastructure." At the same time, he explained, many of the large satellite operators want to own and manage their own RFI monitoring, detection and geolocation systems; but for those customers whose operating environment is more conducive to a managed service approach, Kratos can offer them that as well.

Prevention is better than cure

Prevention is better than cure, and with that in mind installers and operators should use high quality, properly-terminated cables when dealing with any radio signal. More common cellular network issues can also cause these same issues with L-band based terminals. While this event was due to an L-band uplink chain issue, a legacy 70/140 MHz terminal could have easily succumbed to the same problem with an FM or other terrestrial signal. Installers and operators should ensure that any signal combiners and sample ports all have proper terminators installed. However, even with best practices, these types of issues will continue to occur in the real word. Over time, cables can be jostled by winds, vehicles can drive over cable runs, and animals can chew on cables. Terminal operators and maintainers must be aware of the entire path their cabling takes, from their modem to the BUC, as well as any test or combiner points in between.

Even in well run organizations, terminal installation and activation procedures can break down leaving people unaware that a new terminal had accessed a particular satellite. This can happen especially when service providers and installers are not required to coordinate with satellite operators to commission a new terminal. There will always be a need for someone to have a master list of all current, planned, and previous terminals on a satellite. In other cases, there might be requirement for a 'last kilometer' search via ground or helicopter to find the offending terminal. Having a list of known current, planned, and previously active terminals can help to expedite ground search efforts when looking for terminals with equipment issues. **GMC**

Figure 5. satID Geolocation map location

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