# Communications On The Move (COTM)

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Communications On The Move (COTM) has increased dramatically in the last years. The need for broadband connectivity on vessels, aircraft and ground vehicles has demanded new terminals that can provide this services. Along with these needs, there are physical and security considerations that need to be taken in account.

Military campaigns are specially prone to the use of COTM. Military personnel cannot afford to lose connectivity at any moment. Whether cruising on the seas, flying through the air or traveling across the battlefield, high speed, reliable, always-on connectivity is imperative to their success. Increasingly, the military is turning to satellite communications for these critical needs.[1] Current COTM terminals are using 18” antennas and there is a trend to reduce them even more to 12”. With this comes along the need of trade offs between complexity, capacity and availability.

Because of the limited space on a moving platform, most moving vehicles will require very small antennas, normally under 1 m. in diameter, these terminals have been defined as Ultra Small Satellite Terminals (USAT). Although the commercial industry has been working on the development of COTM terminals, there are limitations governed by the laws of physics that need to be contemplated. The size of the antenna limits the amount of energy collected, and determines the width of an angle where energy can be focused at a specific distance. With this in mind we can see that the smaller the

[1] MilsatMagazine, January 2008

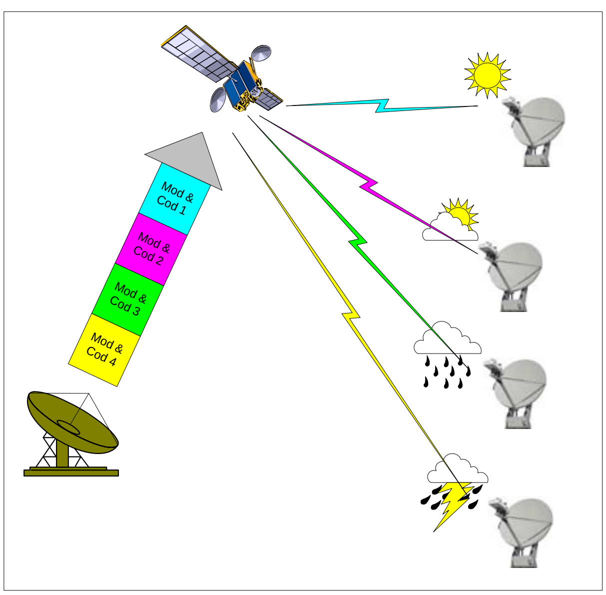
antenna the less energy that can be collected, therefore more susceptible to atmospheric changes, decreasing the availability of the service.

Because radiofrequency spectrum is a scarce resource, different satellite providers use the same frequency band and same polarization on satellites that are as close as 2 degrees apart from each other. This vicinity increases the probability of interference on a given frequency and polarization, and even more if the antenna used is a USAT.

**ACM**

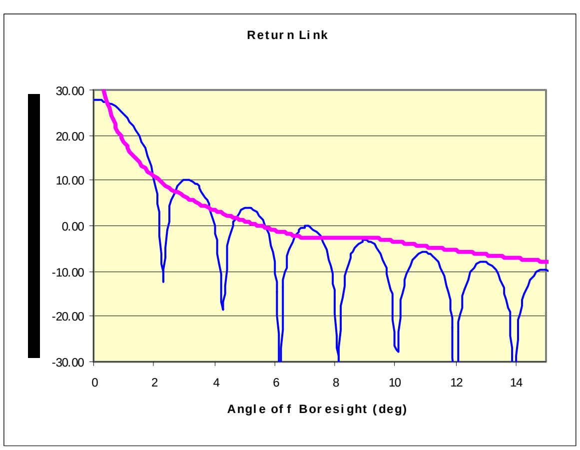
The use of the appropriate coding and modulation schemes can maximize the throughput and availability achieved while minimizing the antenna size and interference.

Current technology developments such as DVB-S2 and Adaptive Coding and Modulation (ACM) allow for stronger coding schemes and a dynamic selection of coding and modulation depending on link conditions such as atmospheric conditions, position in the footprint, interference and limited power on the satellite..

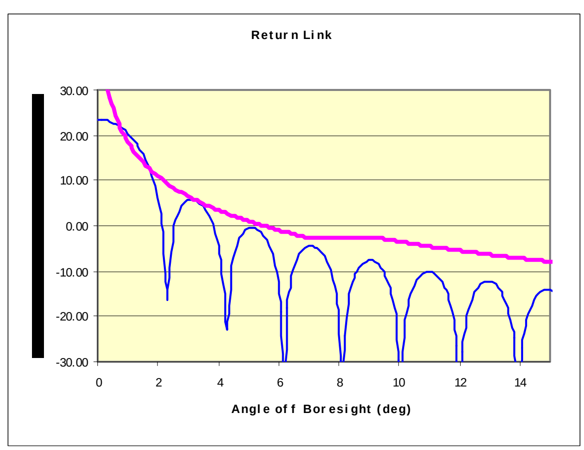


As mentioned before, a particular aspect of an antenna is its capability to focus energy on a region of interest forming a beam. The physics of radiation creates a spillover of energy beyond the area of interest causing some times interference in adjacent satellites. The smaller the antenna the wider the beam and more prone to interfere. This interference is measured in dBW/Hz and is defined as spectral density. The spectral density is specified by the ITU and FCC, meaning that a given terminal shall not transmit energy to a non-intended satellite beyond a certain spectral density (dBW/Hz) threshold. Therefore the challenge is to provide broadband connectivity to a terminal on a moving platform that is moving across possible different link and atmospheric conditions, where power will be dynamically increasing and decreasing but without interfering with adjacent satellites.

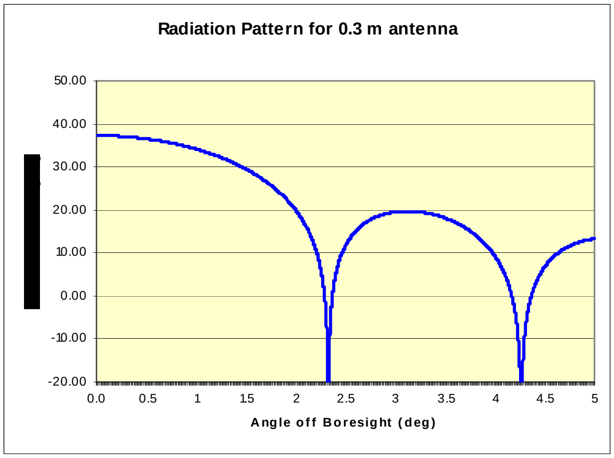
There are techniques that allow to overcome the interference with adjacent satellites where a given power from a terminal has exceeded the spectral density limitation. The most common used and proven technique is known as Spread Spectrum, where the same amount of spectral density (Y) is distributed or spread over a larger bandwidth or spectrum by a factor Z, therefore the original bandwidth (B) is now (Z x B Mhz), and the spectral density is (Y/Z dBW/Hz), reducing the spectral density by a factor of Z.

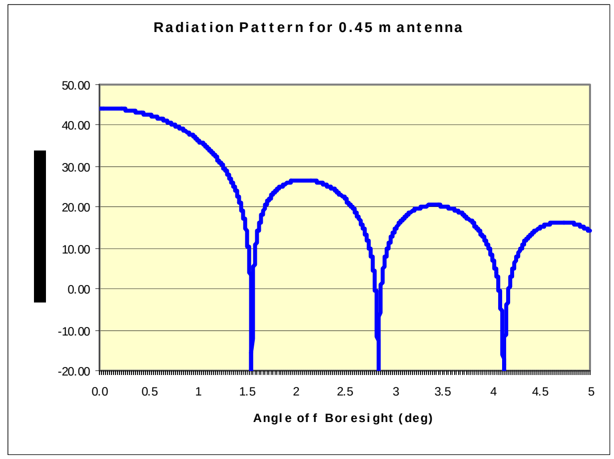



Signal exceeding FCC limitation, needing 4.3 dB spread




Signal exceeding after spreading

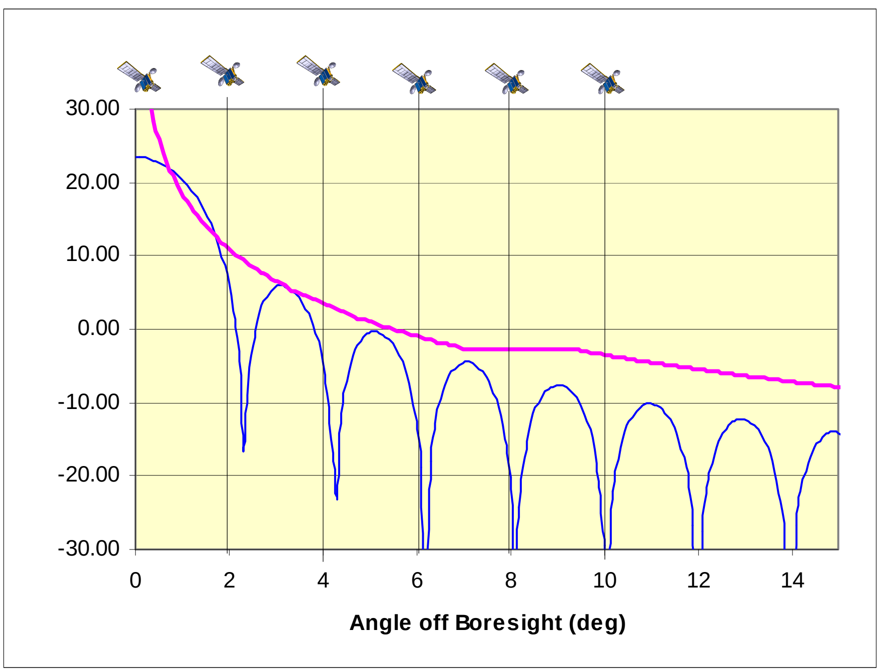



Another factor that needs to be considered is the Adjacent Satellite Interference (ASI). Unless an earth station is properly selected, installed and meets spectral density regulations, it will inadvertently leak an unwanted proportion of its energy to a satellite in an orbital position adjacent to the wanted satellite. The problem increases if more than one terminal is transmitting an interfering signal. The addition of these interferences reduces the carrier-to-noise ratio (C/N), degrading the signal of interest, creating the need of more power or larger antennas to overcome this interference. The same concept applies for a receiving antenna. While an antenna is especially sensitive to the signal coming from the wanted satellite, it is also sensitive to the signals coming from adjacent satellites. The sensitivity of an antenna increases as its diameter is reduced. Antenna manufacturers try to design their antennas so that they have physical characteristics that can suppress the side lobe radiation but to a certain limit.

The above considerations are critical when designing a network around a given satellite or constellation of satellites, since the engineering must be done around the parameters of the assigned satellite.  However when designing a service that includes a satellite in the offer, then there is more flexibility.  Specially when using selective frequency bands such as the ones for military applications, since these bands are less used on commercial satellites.

If a satellite or constellation of satellites were to be offered to the DoD, porting military frequency bands for broadband applications, then there would be more flexibility to accommodate such satellites at orbital positions where they do not interfere with other services, or separated apart from each other such that the spectral density created by a small antenna would not interfere with an adjacent satellite in this constellation.   Also a new satellite could be designed so its characteristics maximize the performance of the current terminals in the market, avoiding the redesign of terminals. Or even better, it can allow for the development of smaller terminals because the characteristics of this new satellite allow for it.



In this paper we have seen the inherent physical limitations of small antennas which are the most appropriate for moving platforms or COTM. We also have seen what are the trade-offs that need to be made in order to avoid interference affecting services in adjacent satellites, and what techniques can be used to mitigate the interference from terminals that may inadvertently leak energy into the wanted satellite.