RTT TECHNOLOGY TOPIC
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FLAT VSATS
5G and satellite spectrum sharing

In our October Technology Topic, **Circular Arguments,** we reviewed the tension points between the NEWLEO satellite companies, OneWeb, Space X and LEOSAT and incumbent MEO and GSO operators.

NEWLEO business models are predicated on the assumption that 12 GHz and 28 GHz High Throughput Satellite (HTS) duplex pass bands can be co shared with MEO and GSO incumbents by using space based progressive pitch angular power separation combined with handover and power control.

The NEWLEO interference models associated with this approach are contested by satellite TV incumbents and adjacent military users at 12 GHz and HTS GSO and MEO satellite operators at 28 GHz. While understandable, this is a process that weakens rather than strengthens the satellite industry advocacy position at WRC 2019. The argument essentially revolves around protection ratios. If the incumbents insist on high protection ratios then the NEWLEO operators are forced to use low inclination angles which introduce additional path loss and latency. Excessive power control reduces flux density to uneconomic levels.

The problem is similar to the arguments between terrestrial TV and terrestrial mobile operators in the 800, 700 and 600 MHz digital dividend bands. This 'battle for broadcasting bandwidth' lasted ten years, cost millions of dollars and resulted in a commercially and technically inefficient sub 1 GHz band plan. The 'race for space spectrum' is a carbon copy of this earlier battle that no one won.

Flat VSATS as the answer

The terrestrial broadcast and 4G interference issue was resolved by improving TV receiver resilience to interference. There is a similar answer for the satellite and 5G industry. The answer is not in space but on earth and comes in the shape of the Flat VSAT. VSATS (Very Small Aperture Terminals) have been the work horse of the satellite industry for the past 15 years. As the name implies, VSATS utilize the shorter wavelengths of Ku and Ka-band to provide gain from a compact dish and have enabled the satellite industry to provide cost effective business to business connectivity. They work best when pointed at one fixed point in space which is generally a geostationary satellite floating over the equator.

Variants of VSATS have been developed that are capable of tracking moving satellites in low earth orbit, medium earth orbit or geosynchronous Quazi zenith orbits. This is realized either by mechanical pointing (used in radar systems for the past seventy five years) or by electronically steering the multiple elements of a phased array antenna. These AESA (active **e**lectronically **s**teerable **a**rray) antennas are the precursor of a new generation of antenna which for the lack of a better term we describe as Flat VSATS.

Material and Manufacturing Innovation

Flat VSATS exploit two complementary material innovations, metamaterials and electronic band gap materials. Metamaterials are materials that have properties that are not found in nature, arranged in repeated patterns at scales that are shorter than the wavelengths of the medium with which they are intended to interact. It is the structure and its shape and orientation and arrangement as much as the base material that influences the performance and behaviour of the device. It could be argued that PIFA antennas are a precursor to metamaterials and are one example of size efficient shapes and structures in conventional antennas coupled with innovative ground planes. However, metamaterials are more complex and elaborate. As with electrically steerable conventional antennas, metamaterial based antennas are becoming widely used in military radio and radar systems including wide band radio systems scaling from UHF to K- band. They can enhance and block and absorb and bend electromagnetic waves.

A second class of material known as electromagnetic band gap (EBG) material can be combined with metamaterials to mitigate the distance separation issue of antennas at lower frequencies. Developed by the US Army Research Laboratory at the University of Michigan, these materials are claimed to realize an antenna in S band at 2.72 GHz with a 3-centimetre physical separation but with over 40 dB isolation between the antennas, more than 20 dB more than can be achieved with conventional antenna materials. Put another way, to realize a three-centimetre separation distance using EBG material is equivalent to a metre separation using conventional materials.

VHF to E band Beam Forming – Directly Upwards Satellite Connectivity for Smart Phones

Putting these two materials together makes it possible to produce antenna arrays that can scale from VHF to E band. This is useful but even more useful when combined with either passive or active beam forming.

In passive beam forming, the phase off sets between antennas elements are pre-set to produce a directly upwards cone of visibility, the higher the element count, the narrower the cone. These antennas look directly upward at the sky. They provide visibility to whatever happens to be directly above them. At the equator this could be a GSO, MEO or LEO, at higher latitudes it will be a LEO or MEO.

A 5G satellite smart phone placed on its back on a horizontal surface will look directly upwards through a 32, 64 or 128 element passive antenna built in to the display and be able to transmit and receive to the nearest GSO, MEO or LEO satellite. It will also null out all unwanted signal energy outside the cone of visibility including 5G and 5G in band backhaul horizontal signal energy.

Passive versus active Flat VSATS

The advantage of passive Flat VSATS is that they are lower cost and more resilient to large temperature gradients.

Active beam forming Flat VSATS scan from horizon to horizon, selecting the '*best connect to space'* option from available satellites. For example, a heavy thunder cloud directly overhead may result in an alternative choice of beam pattern and lower elevation path. As with passive Flat VSATS, active Flat VSATS null out unwanted signal energy including 5G interference. An active Flat VSAT requires an RF power amplifier, low noise amplifier and filter path for each element. This adds cost particularly if extreme temperatures have to be accommodated, for example - 40 degrees centigrade to +125 degrees centigrade in a car roof or truck roof.

Low Cost Flat VSATS

Passive and active Flat VSATS can be produced on LCD production lines or solar panel production lines and can be embedded either in to a TV display or solar panel. These are simply devices that are capable of processing photons **and** electrons. The latest Apple 3 wireless watch is an early example of this trend towards putting antennas (LTE for the watch) into displays.

Low count versus high count antenna elements and target applications

FLAT VSATS scale from 4, 8 and 16 element arrays (for low cost IOT), 32, 64 and 128 element arrays (for smart phones) to 256, 512 and 1024 element arrays (cars and trains and boats and planes). Doubling the array count produces an additional 6dB of gain that can be realized as range gain, throughput gain or interference rejection or some combination of all of these.

The number of antenna elements is determined by the frequencies over which the antenna is expected to work. A 1024 element UHF antenna array is large and works well on an armoured tank but not on a smart phone. The higher count (256, 512,1026 element) passive arrays are well suited to car and truck (and tank) roof applications because they can be constructed as conformal antennas shaped to the profile of the roof and using the steel structure of the roof as a ground plane.

Flat VSATS and 5G and LEO, MEO and GSO Band Sharing

Passive and active Flat (and conformal) VSATS allow pass bands to be co shared between GSO, MEO, LEO and 5G and 5G backhaul. For example, a Ka-band smart phone at 28 GHz or Ku band smart phone at 12 GHz or extended C band smart phone at 3.8 to 4.7 GHz will use the same pass band for all five physical layers. Conversely all the 5G pass bands below 3.8 GHz, scaling down to Band 31 5G at 450 MHz, will be capable of processing any of the five physical layers through the same pass bands using the same channel rasters.

The commercial benefits of Flat VSATS

Flat VSATS deliver a number of commercial benefits.

Mobile operators supporting the Apple 3 wireless watch and its successors can provide connectivity anywhere in the world including at sea. The 5G business model becomes viable

The satellite industry becomes part of the consumer market value chain. The high count LEO constellation becomes viable and the EBITDA and enterprise value of the sector grows by two orders of magnitude.

Flat VSATS move the task of managing interference from space to earth. Managing interference from space using progressive pitch, power control and handover is expensive and results in disputed protection ratios. Managing interference at ground level using Flat VSATS is simple and effective and inexpensive.

Very large Flat VSATS with thousands of antenna elements will replace the mechanically pointed dish antennas presently used at ground stations to support feeder links to and from space. Flat VSAT ground stations combined with inter-satellite and inter-constellation switching (LEO, to MEO to GSO up before down routing) and autonomous station keeping reduces the number and cost of ground stations, another factor transforming the delivery economics of the satellite sector. Very large Flat VSATS also resolve feeder link interference issues, for example at 18 GHz.

The regulatory benefits of Flat VSATS

Flat VSATS remove the spectral tension points between the NEW LEO operators and MEO and GSO incumbents and provide a universal global harmonized band plan for 5G and satellite operators from UHF to E band. All other incumbents in all the other target 5G bands can relax. The 5G industry doesn’t need your spectrum any more.

All interference problems have a technology solution but the solution is not always available when needed. This particular solution has arrived at the right time.

A flat answer to a circular problem.

5G and Satellite Workshop in the Caribbean- April 23-25 2018

We are pleased to announce that our next 5G and Satellite workshop, presented in association with Niche Markets Asia will be held in the Caribbean next April. For details, including the early bird registration booking offer, **follow the link.**

New Book with Artech House - 5G and satellite spectrum, standards and scale

RTT, The Mobile World and Policy Tracker are working on a new book project on 5G and Satellite Spectrum and Standards and Scale and related regulatory and competition policy issues prior to WRC 2019. The book will be published by Artech House in July next year.

If you are interested in knowing more about this project or are developing products and services that you feel should be included or a regulatory and advocacy position that you feel should be reflected then please e-mail us for more information.

geoff@rttonline.com

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00 44 7710 020 040