RTT TECHNOLOGY TOPIC
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New Radio and New Space
The RF Cost Economics of the Millimetre Band

The millimetre band opens up new opportunity to deliver high bandwidth high value products and services to new global markets.

However the RF challenge of supporting wider bandwidth at higher frequency needs to be factored into present and future business plans and spectrum policy.

For 5G, finalizing the standards is only the start of a long and hazardous economic journey. 5G New Radio in the millimetre band (5G NR FR2) has yet to prove that costs can be kept under control and that performance expectations can be met.

The satellite industry has successfully deployed radio networks in the millimetre band but not at consumer price points. For Starlink, Project Kuiper, OneWeb and fellow travellers, the challenge is not in space but on the ground.

In this month's technology topic (webinar) we analyse the RF implementation risks and rewards of millimetre band radio networks and network devices.

Read on

Forty years ago, RF designers were looking at ways of implementing cost economic frequency agile cellular phones working at 800 and 900 MHz. Radio phones up to that point had operated at VHF or UHF (450 MHz).

These new phones had to use expensive closely toleranced FR4 printed circuit board material and highly specified front end components and a superhet architecture integrated with a phase locked loop and frequency synthesiser capable of moving across hundreds of radio channels.

US AMPS phones needed to work across six hundred and sixty six 30 KHz channels between 825 and 890 MHz in a TX/RX pass band of 65MHz with 45 MHz duplex spacing.

TACS phones in the UK and other markets needed to work across one thousand 25 MHz channels in a 70 MHz TX/RX pass band between 890 and 960 MHz with 45 MHz duplex spacing.

The phones and their serving base stations needed to co-exist with other radio systems including military radio.

The phones took 8 hours to test and careful design and manufacturing control was required in order to ensure the phones were stable over temperature over time. These phones were seriously expensive. My first TACS transportable phone cost more per month than my company car.

Forty years on, designers of 5G New Radio and satellite companies developing low cost Ku and Ka band consumer devices are facing similar performance and cost challenges.

Three of the initial 5G terrestrial FR2 bands for deployment, Band n258 between 24.25 and 27.50 GHz, Band n257 between 26.5 and 29.5 GHz and Band n261 between 27.5 and 28.350 GHz are not technically in the millimetre band (> 30 GHz) but have the same performance and cost challenges. N259 is between 31.8 and 33.4 GHz and N260 is between 37 and 40 GHz.

The phones and radio networks are TDD with a carrier bandwidth of up to 400 MHz within pass bands of between 2 and 3 GHz and need to co-exist with earth station satellite uplinks at 27.5 GHz to 29.5 GHz and downlinks at 37.5 to 40 GHz with carrier bandwidths of typically 250 MHz, deployed as duplex spaced FDD.

TDD transmissions from 5GNR base stations and user devices will therefore be in band with FDD satellite receive pass bands and satellite transmit energy could potentially appear in the front end of 5G NR FR2 receivers. Radio astronomy will occasionally be an issue as well.

Co-existence can be managed by careful spatial separation but only if signals from satellites are being received at close to 90 degrees which is only possible with high count ((>20,000 satellite) LEO constellations or from GSO at the equator.

It also depends on careful management of 5G in band and out of band emissions which means that unwanted harmonics, harmonic distortion, intermodulation spurs and spectral regrowth (and for TDD, time domain dispersion) need to be measured and minimized. Those 8 hours of test time for a first generation 1980's cell phone may not be far off the mark for a 5G FR2 smart phone in 2021.

As with those first generation phones, 5G NR FR2 front end components need to be highly specified and modelled and managed for poor noise and gain matching across wide bandwidths and large temperature gradients.

Beam forming may help improve performance in some environments but requires additional expensive testing (see last month's technology topic) and will not mitigate losses from surface absorption and non-line of sight transmission (building blocking and foliage).

5G FR2 New Radio economics are therefore debatable and dependent on high value high bandwidth applications that are as yet unproven and which look unattractive when compared to other options including C band where deployments are ongoing.

The good news for the satellite industry is that most sensible terrestrial operators and their vendors have recognized the cost, performance and revenue risk of 5G NR FR2. This in turn dampens the appetite of the 5G terrestrial community for Ku and Ka band spectrum, an asset which the satellite industry have traditionally used as collateral for high levels of debt

For the satellite industry, specifically the NEW SPACE players such as Starlink, Project Kuiper and OneWeb, the problem is that they have similar cost and performance issues to 5G NR FR2 making it problematic to deliver consumer fixed and mobile broadband expectations at consumer price points.

Starlink claim to have invested $70 million dollars in their transceiver manufacturing facility but this does not guarantee that devices will work consistently once networks are fully loaded. The New Space device supply chain lacks the legacy manufacturing volume which helps 5G component and device vendors amortise R and D and manufacturing investment. Retailing first generation Starlink consumer premises equipment at $499 dollars is going to be an exercise in managing consumer expectations.

The NEW SPACE problem is compounded by the need to co-exist with OLD SPACE. The established MEO and GSO operators are understandably uneasy about thousands of satellites getting between them and their earth bound customers within the same pass band.

The solution to this conundrum first proposed twenty years ago by Teledesic and Skybridge (and later, O3b) is called progressive pitch angular separation.

The theory is sound but the practice is problematic because of non-line of sight and elevation loss. The bug bear of 5GNR FR2 therefore rears its ugly head as a problem for the NEW LEO operators compounded by long path lengths through clouds and low and variable gain from expensive phased array antennas working at angles of low elevation.

Note that this is a performance issue and market issue. Throughput will be slow at low elevation angles but it will also be variable. Smart antennas can be made to work effectively and efficiently but not at consumer price points and non-line of sight losses and elevation loss will still apply.

Experience also tells us that a poor but consistent level of service will produce a higher QOS score than occasionally good but inconsistent service.

The solution as stated above and in previous postings is to get 20,000 satellites into Low Earth Orbit all working within the same pass band with the same radio physical layer to give nearly always nearly overhead connectivity. This will mean that spatial separation with non GSO and GSO satellites can be delivered by simple switching rather than complex progressive pitch angular separation. It also means that low cost consumer friendly non GSO Wi-Fi enabled devices with simple dish antennas looking directly upwards can be delivered to those price sensitive markets which New Space New LEO operators claim they will be able to serve and need to serve to achieve long term financial viability.

Present regulatory and competition policy makes this impossible. Multiple satellite operators are encouraged to launch multiple networks that are incompatible with each other. The economic risk is compounded by collision risk.

One way out of this would be for all operators but one to go bankrupt but this a painful process with no guarantee that the last man standing will live to fight another day. Third parties would also have to take on the cost of deorbiting and collision damage limitation.

The better way would be for the United Nations and the ITU to legislate for one universal network in space, open and affordable to all - a United Nations Global Broadband Network (UN-GBN). Space has a good record for international cooperation, the International Space Station and radio astronomy being two notable examples.

A UN-GBN would give us the world’s most competent clock, the world’s most capable camera and the world’s most complete communications system with collision risk minimized to an acceptable level.

A UN-GBN could also facilitate the UN 2030 Sustainable Development Goals, surely a worthwhile objective?

Ends

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New Radio and New Space

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