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5G TV

In our February 2007 Technology Topic, the Battle for Broadcast Bandwidth, we argued the case for constructive technical and commercial engagement between the mobile broadband industry and terrestrial broadcasting.

Vendors and industry analysts were predicting a stellar future for mobile TV and a parallel decline in terrestrial broadcasting.

Twelve years on, terrestrial broadcasting remains remarkably resilient and is still the lowest cost delivery option both in terms of capex and opex. It is hard to beat the economics of TV towers built on decades of capital amortisation. 3G by comparison was an eye wateringly expensive way to deliver video content both in terms of bandwidth occupancy and user device power consumption. It was never going to work or at least would never be truly commercially successful.

Terrestrial broadcasters built their business model on extravagant amounts of bandwidth and power.

For the first fifty years, this included low band VHF (44-87.5 MHz supporting seven 6 MHz channels in the US, 47-87.75 MHz supporting five 7 MHz channels in Europe), high band VHF (in the US, seven 6 MHz channels between 174 and 216 MHz, in Europe, eight 7 MHz channels between 174 and 216 MHz) and a UHF band from 470 to 890 MHz deployed as a multiple frequency network planned on conservative reuse ratios.

The analogue to digital transition in TV broadcasting through the 1990's delivered an order of magnitude improvement in spectral efficiency so it was always going to be hard for the broadcasters to argue the case for holding on to 40% of sub 1GHz spectrum.

Cable and then fibre also became viable delivery options in some markets as well as C-band and Ku-band satellite.

The end result is that terrestrial TV has become (literally) compressed into the lower end of the UHF band. This includes the recent allocation of Band 71 at 663-698 MHz/617-652MHz promoted as a 'pioneer 5G band'. The reverse auction process has made this transition profitable for the US broadcasting community.

The open question is whether satellite broadcast spectrum will follow a similar route.
This includes the C Band TV satellite band from 3.7 to 4.2 GHz, the Ku satellite band from 11.7 to 12.7 GHz and Ka band (18.3-18.8 GHz/19.7 to 20.2 GHz).

Typically these are deployed as 250 MHz channels divided into 40 MHz sub-channels each supporting a 36 MHz transponder. Each 36 MHz transponder can support 15 HDTV channels. The underlying debate is whether the economic value of this bandwidth will be increased by making the bandwidth bi-directional.

To come to a reasoned view on this requires some questions to be answered.

Firstly, will 4G and 5G services implemented in 600, 700 and 800 MHz terrestrial TV spectrum deliver more long term value than the broadcast services that they are replacing?

The answer is probably yes though not in all markets.

Will 5G services implemented in C band, Ku and Ka-band satellite TV spectrum deliver more long term value than the broadcast services that they aim to replace?

This depends on the future economic value realisable from TV broadcasting. Rather bizarrely this is a function of screen size.

For the past twenty years the average size of TV screens has been growing at the rate of one inch per year.

In parallel, TV transmissions have transitioned from 2K (two thousand OFDM sub carriers) to 4K. 4K TV's were introduced in 2013 supporting 3840 by 2160 pixel resolution, more than adequate for 55 inch screens.

The 8K broadcasting standard was agreed in 2014 and test broadcasts started in 2016. The 2020 Olympics will be broadcast as an 8K transmission supporting 7680 by 4320 pixels delivered to 65 inch screens.

The bandwidth implications of this transition are profound. A standard definition TV broadcast can be encoded at a channel rate of 2.5 MBPS. 4K increases this to 25 MBPS and 8K increases this to 72 MBPS. There is an optional 120 KHz frame rate and a 10 or 12 bit depth (compared to 60 KHz and 8 bit for 2K).

Encoder/decoder efficiency could continue to improve but higher compression levels require higher flux densities so bandwidth occupancy is traded against power.

If you happen to be connected to fibre then this is not a problem but fibre is far from ubiquitous and although fibre costs have reduced, the cost of digging a hole has remained largely constant.

In many cases, satellites are therefore the most technically and commercially efficient delivery option.

It might be theoretically possible to support some band sharing between satellite TV broadcast and 5G but a number of factors make this presently unlikely.

In terms of satellite TV to 5G interference, higher flux densities will make coexistence harder. If implemented as TDD, 5G to satellite TV interference will be problematic.

Additionally, LEO and MEO operators are also deploying networks into the same bands, for example the OneWeb LEO Ku-band downlink between 10.7 and 12.7 GHz and the SES/O3b MEO Ka-band downlink between 17.70 and 20.2 GHz.

The FCC has also been petitioned to allow 12.2-12.7 GHz to be used for 5G by the MVDDS (Multi Channel Video Distribution Service) Coalition. Dish Networks as an active member of this advocacy group, supplies satellite TV in all three TV bands (C-band, Ku-band, Ka-Band) and has access rights to three terrestrial cellular bands, unpaired AWS-3 uplink spectrum (1695 MHz to 1710 MHz), H Block downlink spectrum (1995 to 2000 MHz)and AWS-4 spectrum (2000 MHz to 2020 MHz). In June 2016, 3GPP formally approved Band 70 which aggregates these terrestrial bands together.

The other pioneering bands identified within 3GPP for 5G are all in Ka-band, N257 at 26.5-29.5 GHz, N258 at 24.75-27.5 GHz, N259 at 31.8-33.4 GHz and N260 from 37-40 GHz. These are not satellite TV bands but are widely used by satellite operators for data delivery deployed typically as 250 MHz FDD duplex pass bands. These companies are understandingly less than enthusiastic about co sharing spectrum with 5G TDD terrestrial networks.

But in all the above there are ways in which some carefully managed co sharing could be implemented with potential commercial benefits for all parties. The coexistence issues of terrestrial TV and mobile broadband in the 700 and 800 MHz bands proved easier to manage than anticipated and it is reasonable to assume that angular separation in Ku-band and Ka-band could be used to minimize and mitigate inter and intra system interference.

In the longer term, this latest Battle for Broadcast Bandwidth may prove to have been a pointless exercise. Trials are ongoing to explore the options of delivering super and ultra-high definition TV over 5G networks and it could be argued that high power high tower 5G is not so different from traditional terrestrial TV broadcast topologies.

As we have stated before, rural terrestrial connectivity and street level urban connectivity is delivered typically at elevation angles of 30 degrees or less which means that in band signals could also potentially be received simultaneously from any source more directly overhead.

This opens up the possibility of supporting satellite connectivity in sub 3 GHz terrestrial mobile broadband spectrum and 5G connectivity in satellite spectrum including broadcast TV spectrum, a reciprocal arrangement which would deliver additional coverage, additional capacity and better cost recovery.

5G and Satellite Spectrum, Standards and Scale

Our latest book, **5G and Satellite Spectrum, Standards and Scale** is available from Artech House. You can order a copy on line using the code VAR25 to give you a 25% discount.

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