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High Power High Tower

High power high tower cell sites implemented at 700 MHz are being promoted as the economic answer for deploying 4G networks into the emergency services sector but will the same approach work for 5G?

4G networks for the emergency service and public protection and disaster relief (PPDR) agencies are required to cover 95% of the population and match or exceed the geographic coverage available from existing narrow band VHF and UHF private radio networks.

This is achieved by deploying additional 4G rural radio sites (high power high tower sites) in the 700 MHz band with the addition of truck mounted mobile cell sites with satellite connectivity to provide coverage and capacity for special events or localised emergency response. Rural LTE coverage from lighter than air balloons is an additional option together with LTE base stations on light aircraft, drones and helicopters for on demand air to ground and ground to air communication.

In parallel, vendors are pushing capex investment for rural cell site hardware down towards $20,000 with a two to three year investment payback with user communities of 500 or less.

Chinese vendors are in the vanguard of this cost reduction though whether this will offset security considerations in some developed markets remains open to question and payback on low ARPU areas remains problematic.

Cost reduction is also made harder by technically and commercially inefficient band plans, the product of auction policy geared towards realizing short term returns for national treasuries rather than long term economic sustainability.

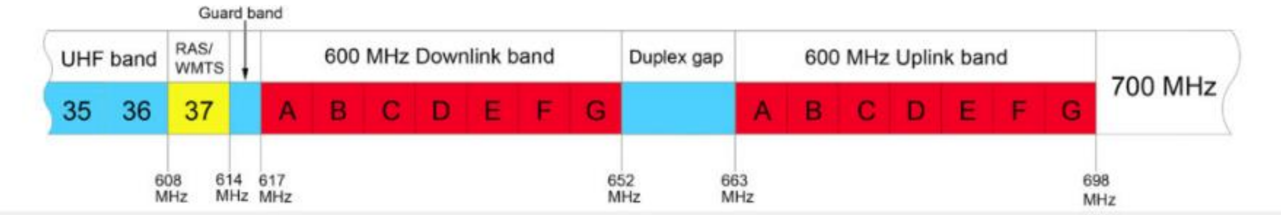
The First Net network in the US deployed by AT& T in Band 14 for example is a reverse duplex band with an uplink at 788 to 798 MHz and a downlink at 758 to 768 MHz immediately adjacent to Band 13 (777-787 MHz and 746 to 756 MHz) predominantly used by Verizon.

Technically it would have been more sensible to deploy these spectral assets as a combined band with sufficient bandwidth to provide a migration path to 5G. Commercially this would have required an unrealistically close collaboration between AT&T and Verizon.

An alternative option would be to aggregate other 700 MHz bands. Band 17, a band widely used by AT&T (704-716 MHz, 734-746 MHz) is a candidate and could potentially be coupled to Band 12 to provide a wider pass band (15+15 MHz with 2 MHz of guard band rather than 10+10 MHz).

The legacy issue with Band 12 is its proximity to high power TV broadcasting. However, as TV shifts towards internet delivery there are more opportunities to manage TV and mobile coexistence technically and commercially. The reverse auction of 600 MHz spectrum for example has provided an incentive for the US TV industry to realise value from a duplex band between 617 and 652 MHz and 663 to 698 MHz (the lower boundary of Band 12). The band is now described within the 4G/5G New radio specification documents as Band 71.

Band 71



http://www.spectrumgateway.com/600-mhz-spectrum

T-Mobile bid and won a slice of this spectrum and are implementing high power high power sites to provide enhanced rural coverage in the US and Latin America. Existing T Mobile deployments in Band 12 create the opportunity to aggregate their 600 and 700 MHz spectral assets to provide 'nationwide 5G' by 2020.

While this is an admirable ambition, there are particular technical and commercial constraints that limit the potential capability of 5G deployed into these lower bands.

Technically it should be remembered that the underlying principle of 5G is to use beam forming to increase the amount of wanted RF energy sent in the right direction (delivering coverage gain) and to reduce the amount of unwanted RF energy sent in the wrong direction (delivering inter system and intra system capacity gain).

While this is relatively easy to achieve at 28 GHz with a one centimetre wavelength, it is significantly hard to achieve at 600 MHz with a fifty centimetre wavelength without either having enormous antennas structures on towers with a related weight and wind loading cost or without introducing real estate and RF efficiency costs into space and power constrained IOT and user devices.

There is also the issue of bandwidth ratio.

A 500 MHz pass band at 28 GHz typically used in high throughput (terabit) satellites has a realisable band width ratio of 5.6%

Self-evidently it is not possible to implement a 500 MHz pass band at a 600 MHz centre frequency. An equivalent bandwidth ratio realizes a 33 MHz pass band which represents the practical performance limit of a SAW or FBAR filter.

While a 33 MHz pass band is adequate in its own right to support a relatively wide band 5G (relative to a 5 or 10 MHz LTE channel) it can only be realized if operators' co-share the available bandwidth which has as yet to be accommodated within the auction and regulatory process.

Additionally although T-Mobile are able to range list smart phones and IOT devices with 600 MHz support there will be reluctance to include multiple 5G bands at 600 and 700 MHz due to the cost, real estate and efficiency loss (power drain) implications.

This reluctance will be compounded by a failure to harmonize available bands on a global scale, an existing issue in the 700 MHz band.

The alternative of carrier aggregation provides a possible solution but still introduces front end design challenges including intermodulation and associated linearity requirements which are addressable in a base station form factor but problematic in user and IOT devices.

The alternative would be to provide in band direct access to satellites.

The rationale is that signal energy from a terrestrial high power high tower will usually be arriving at an inclination angle of around 30 degrees.

Signal energy from a mixed constellation of high count LEOS, MEO and GSO satellites will be arriving at an inclination angle of close to 90 degrees and could potentially be at a similar or higher flux density.

If this is combined with smart beam forming on the satellites to provide a fractional beam width uplink and downlink then it is at least theoretically possible to design screen embedded passive antennas in smart phones and IOT devices which are low cost and relatively efficient. The spectrum is also effectively reused in the spatial domain theoretically doubling the financial return from the auctioned spectrum.

While this may take a while to happen it should be born in mind that planning time scales in the emergency services radio sector are longer than commercial market planning. Public safety networks in general are expected to be future proofed for twenty and preferably thirty years.

Given that over this time scale we are likely to see major reductions in satellite delivery cost and major increases in available power and bandwidth and given that terrestrial costs are likely to increase rather than decrease over the same time scale then it would seem that direct access in band satellite in the emergency services sector in any band below 1 GHz and particularly in the 600 and 700 MHz bands should be considered as an essential part of the delivery mix.

Coincidentally or perhaps not coincidentally, the high power high tower terrestrial infrastructure for the AT&T First Net roll out is being built by a consortium led by a former Ligado executive.

Having some of those towers in space equates to 25 years of zero rental cost and free energy and inter-satellite switched fast efficient low cost long distance backhaul.

What's not to like?

Post Script
It has taken many years to get to the point at which LTE can be considered to be commercially and technically suitable for emergency service networks.

A posting from October 2010, Blue L(i)TE set out the challenges that had to be overcome and helps to explain the long and problematic adoption process.
https://www.rttonline.com/tt/TT2010_010.pdf

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.

http://uk.artechhouse.com/5G-and-Satellite-Spectrum-Standards-and-Scale-P1935.aspx

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