RTT TECHNOLOGY TOPIC
October 2019

5G for Free

Earlier this year the US Federal Communications Commission (FCC) concluded the country's second auction of high band *'5G-suitable'* frequencies yielding $2.02 billion from the 24 GHz band adding to the $700 million realised from the earlier 28 GHz auction.

In South Korea, the 28 GHz auction coupled to 100+100 MHz of C band (centred on 3.5 GHz) raised $3.3.billion.

In the UK £1.356 billion was realised from the auction of 40 MHz of the 2.3 GHz band for 4G and 150 MHz of 5 G spectrum at 3.4 GHz divided between O2, EE and Vodafone with O2 paying a premium price of £5.147 million per MHz for the 2.3 GHz spectrum and £7.943 million per MHz for its 3.4 MHz. spectrum, a mere drop in the ocean when compared to the 3G auction in 2000 which realised an eye watering and economically insane £30 billion.

The 5G service offer is being developed with additional 700 MHz spectrum being made available to provide coverage. Similar low band 5G in the US is being positioned to address coverage issues.

In China, 5G spectrum between 3.5 and 3.6 GHz was allocated to China Unicom and 3.4-3.5 GHz was allocated to China Telecom, China Mobile was allocated TDD spectrum at 2515 to 2675 MHz and 100 MHz at 4800-4900 MHz.

In Australia, $616 million was raised from the 3.6 GHz band.

It could be argued that the auctions represent good value for the bidding operators compared to the heady prices paid for 3G spectrum however 5G has significant cost multipliers which are a direct consequence of the headline data rates and added value service offers, in particular Ultra-Reliable Low Latency Connectivity where the residual bit error rate requirement will require significant over provisioning of capacity and coverage to meet service level guarantees and expectations.

The assumption is that beam forming gain in any FR2 bands (above 6 GHz) will deliver sufficient flux density to make these service economic assuming the service offer is combined with the 5G coverage available from sub 1 GHz 5G and other FR1 bands up to 6 GHz. The caveat is whether these bands can be supported in user and IOT devices without a significant loss of RF efficiency.

In the US for example, devices will need to support a mix of bands from 600 MHz to 28 GHz. Although device form factors have increased over the past ten years, devices remain space constrained and it is still not uncommon to come across non optimum antenna designs producing a negative gain of 10 dB or more in lower band spectrum. In the FR2 bands, the generic approach is to place beam forming antenna modules around the edge of the device but inevitably hand capacitance effects will make performance highly variable.

On the network side, there is limited opportunity to achieve economic gain from beam forming in any sub 3 GHz bands and only marginal gains to be realised at 3.5 GHz once additional antenna costs and size are factored into capex and opex costs.

And devices and network hardware will be required to support a bewildering mix of FR1 and FR2 pass bands which will make it frustratingly hard to achieve economy of scale. Add in additional insertion loss and the vulnerability to interference that multiple pass bands, often over wide pass bands imply and it is difficult to see how an economic link budget and economic hardware supply chain will ever be realised.

It could therefore be argued that 5G spectrum could be regarded as a liability rather than an asset.

This partly explains the alternative regulatory approach of gifting spectrum to operators in return for roll out and service obligations.

The China example referenced above is an example and would appear to be a generous offer to the operators until you factor in the requirement that all operators must use China Tower as their tower provider.

There are good technical reasons for having a single tower operator particularly when multiple TDD networks need to co-exist (multiple TDD networks work much better when clocked together and supported from the same cell sites). However China Tower is wholly owned by the Chinese government with complete control of tower rental and access costs.

The Japanese model is more interesting.

In April 2019, the Ministry of Internal Affairs and Communications (MIC) assigned spectrum in the 3.7 GHz, 4.5 GHz and 28 GHz bands through a beauty contest to three mobile operators and a new market entrant

NTT DoCoMo was assigned spectrum at 3.6 to 3.7 GHz, 4.5 to 4.6 GHz and 27.4 to 27.7 GHz.

KDDI has spectrum at 3.7 to 3.8 GHz, 4.0 to 4.1 GHz and 27.8 to 28.2 GHz

Softbank has spectrum at 3.9 to 4.0 GHz and 29.1 to 29.5 GHz

The fourth operator, Rakuten has spectrum at 3.8 to 3.9 GHz and 27 to 27.4 GHz.

The operators are committed to providing coverage of the population five years after license issue of 90% (NTT DoCoMo and KDDI), 64% (Softbank) and 56% (Rakuten) equating to an investment commitment of $7 billion (NTT DoCoMo), $4.8 billion (KDDI), $1.8 billion (Softbank) and $1.7 billion (Rakuten).

Rakuten is effectively the Amazon of Japan, delivering anything and everything to the Japanese consumer regardless of whether they want it or need it.

Their entry into the 5G market could be a precursor of companies like Rakuten such as Google, Facebook, Ali Baba, Ten Cent and Amazon becoming more active in 5G investment.

However to date there has been absolutely no need for any of these companies to spend money on terrestrial connectivity which is effectively delivered to them for free. Instead they are investing in space connectivity.

This might seem perverse given that it still costs $3,000 dollars per kilo to send hardware into orbit but this will halve within the next 18 months. As with the aviation industry we can expect costs to decline at a rapid rate particularly given the investments being made by Messrs. Bezos and Musk on reusable rockets and other combined launch platforms (Mr Branson et al).

It could even be conceivable that costs reduce to the point at which delivery of an operational base station by road would take longer and cost more than by rocket. And as we have pointed out many times, the space based base station has free electricity costs and no site rent to pay.

Earlier this year, Amazon’s FCC filing for Project Kuiper began to reveal what their plans are for space based connectivity.

Just as a reminder, any entity, Space X, One Web or Google or Facebook or Ali Baba or Ten Cent with space ambitions must file with their local regulator who then forwards the filing request to the ITU which is required to sign off the proposed orbits, constellation count and coexistence requirements though local regulators retain sovereign jurisdiction over terrestrial interference.

The filing from Amazon is for 3,236 satellites in low earth orbit including 784 satellites at an altitude of 367 miles (590 kilometres), 1296 satellites at a height of 379 miles (610 kilometres) and 1156 satellites at 391 miles (630 kilometres) providing connectivity from 56 degrees north to 56 degrees south, an area occupied by 95% of the world's population.

In common with the Space X and OneWeb filings there is also reference to potentially millions of earth stations which includes Earth Stations in Motion (ESIM's) which are almost certainly Wi-Fi enabled though could be 5G enabled.

There are many economic analysts who question the viability of high count LEO constellations and it is fair to say that their viability is crucially dependent on the rate of cost reduction that can be achieved and the income realisable from space based connectivity.

The filings from all of the new LEO market players reference their 'mission to connect the unconnected'. This has been a standard part of almost all submissions over the past twenty years including Teledesic, Skybridge and O3b (an acronym for 'The Other Three Billion')

O3b however ended up servicing the luxury cruise market (Only Three Boats) which is as far from rural Africa as you could possibly get. Given that the founder of O3b, Greg Wyler then went on to found OneWeb suggests that market reposition will remain as a standard tactic.

However there are reasons to believe that the value realisable from space could be higher than many of us might think particularly when you consider that most space payloads are multi-purpose, combining connectivity with imaging and sensing.

Amazon has talked about this value in public briefings, discussing the value that can be realised from bringing information down from space, adding value to that information and reselling to third parties via an Amazon owned network of ground stations and terrestrial fibre, a new era of Space IOT.

https://aws.amazon.com/ground-station/

This adds to the value gain from universal geographic coverage including deep rural and deep maritime connectivity. More importantly, those of us with an Amazon phone will be providing Amazon with all it needs to know in order to sell us things that we didn't know we needed.

The connectivity part of this offer could of course be free.

The impact of this on the 5G mobile community and traditional incumbent satellite operator community would be catastrophic and would leave them vulnerable to bids from third parties. As we have pointed out many times, Facebook, Amazon, Google, Ten Cent, Ali Baba (and Rakuten in Japan) have enough cash to buy the existing satellite industry even at present value and enough borrowing capacity to buy most of the terrestrial telecommunications industry suggesting that the regulators have interesting challenges ahead.

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

About RTT Technology Topics

RTT Technology Topics reflect areas of research that we are presently working on. We aim to introduce new terminology and new ideas to help inform present and future technology, engineering, market and business decisions.

The first technology topic (on GPRS design) was produced in August 1998. 20 years on there are over 240 technology topics **archived on the RTT web site.**

Do pass these Technology Topics and related links on to your colleagues, encourage them to join our **Subscriber List** and respond with comments.

Contact RTT

RTT, and **The Mobile World** are presently working on research and forecasting projects in the mobile broadband, public safety radio, satellite and broadcasting industry and related copper, cable and fibre delivery options.

If you would like more information on this work then please contact **geoff@rttonline.com**
00 44 7710 020 040