RTT TECHNOLOGY TOPIC
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Cube SATS

In last month's technology topic we reviewed the potential economic benefits of high count low earth orbit satellite constellations. This could include any constellation deployed above the Karman line at 100 kilometres.
http://metro.co.uk/2017/08/29/how-high-is-space-and-what-is-the-karman-line-6886681/

More commonly, LEO constellations are deployed in orbits at altitudes between 700 and 1200 kilometres. The satellites can be anything from a few kilograms to hundreds of thousands of kilograms. The International Space Station for example weighs 400,000 kilograms, is the size of a football field and flies at an altitude of 400 kilometres at 28,000 kilometres per hour.

NASA defines small satellites to include mini satellites (100-180 kilograms), micro satellites (10-100 kilograms), nano satellites (1-10 kilograms), pico satellites (0.01 to 1 kilograms) and femto satellites (0.001-0.01 kilograms). It is not that different from the definitions of macro, micro, pico and femto terrestrial base stations.

Cube SATS, are nano satellites that are constructed using a standard size and form factor with one unit being a 10 by 10 by 10 centimetre cube but with the potential for multiple units to be bolted together or potentially docked together in space.

https://www.nasa.gov/content/what-are-smallsats-and-cubesats

They were originally developed at Stanford University in the late 1990's with an early focus on low cost platforms for university research but are now widely deployed for IOT connectivity and low cost earth observation.

In this month's technology topic, we explore the future scalability and viability of Cube SATS for low cost voice messaging, mobile and fixed narrow band and financial transactions and their potential complementary role and collaborative relationship with other satellite and terrestrial radio systems.

Cube SATS today

There are over 600 Cube SATS in orbit but the ability to load hundreds of satellites into a single re-usable rocket means this total could scale rapidly if the economics are sufficiently favourable to open up new markets including markets which are uneconomic for existing terrestrial providers.
http://www.nanosats.eu/

Myriota is one example of a young but fast growing company providing IOT connectivity in remote areas such as the Australian outback using sub GHz licensed spectrum and a 33 milliwatt uplink to gather 20 byte data packets from water tanks and agricultural sensors as the satellites pass 800 kilometres overhead on a ninety minute polar orbit. Farmers access the data via their cell phones from a centralized server.
http://myriota.com/

Adding imaging and sensing broadens the target markets. Deforestation monitoring is one example.
https://theredddesk.org/what-redd

Climate monitoring, energy and infrastructure, emergency response and insurance are also rapidly expanding. There are existing businesses making money out of Cube SAT connectivity combined with imaging and sensing capability consolidated into data sets that can be sold to third parties. Planet and Black Sky are two examples of companies successfully serving these markets.
https://www.planet.com/
https://www.blacksky.com/

The open question is how fast the Cube SAT market can grow over the next few years and what are the key adoption enablers and adoption barriers.

A recent investment note from an Australian Securities Research group on Sky and Space Global sets out some of the key risks and opportunities
https://www.skyandspace.global/wp-content/uploads/APP-Securities-SAS-Report.pdf

Sky and Space Global is an Israeli company based in London and listed on the Australian stock exchange. The company proposes to launch 200 Cube SATS into low earth orbit by 2020 to provide equatorial coverage to Latin America, Africa, Asia and Australia with an additional 800 satellites planned to provide longer term global coverage.

The total cost of the initial 200 satellite constellation is estimated as $700,000 dollars including construction and launch with the launch costs depreciated over four years. The intention is to deorbit 20% of the constellation every year to support a 5 year refresh cycle. The target markets are machine to machine, text, narrow band voice messaging and narrow band data including small farmer applications that are similar to the Myriota example above.
https://wefarm.org/

A recent commercial arrangement has also been made with a third party to provide secure low cost financial transaction services over the Social Finance Systems Humanity $1 dollar smart phone.
http://sdg.one/

The company has also signed an MOU with Virgin Galactic to provide connectivity to the Launcher One carrier craft. SAS claims to have proprietary network management software that allows the satellites to self-organise themselves in space, minimizing the need for telemetry links from earth stations and improving constellation phasing. The satellites can therefore potentially be deployed at a substantially reduced capital and operational cost on a per satellite basis.

It is harder to quantify the cost on a per bit basis when compared to other high count constellations such as OneWeb and Space X and LEOSAT and other established LEO constellations, principally Iridium.

The capital and operational costs of these constellations are several orders of magnitude higher than the projected costs for SAS but the satellites potentially last for twenty years and have hundreds of watts rather than milliwatts of power available from each individual satellite. OneWeb and Space X have also stated their ambition to scale their LEO constellations to several thousand satellites and have some interesting commercial innovation that could drive their market adoption rates. For OneWeb this includes the proposed connectivity initiative with Coca Cola for developing markets.
http://www.satellitetoday.com/telecom/2016/11/01/coke-oneweb-investment-good-business/

Both OneWeb and Space X have also stated their ambition to service the automotive connectivity market.

Cube SATS and mixed constellations

In previous technology topics we have referenced SES and 03B as an early adopter example of a mixed GSO and MEO service offer. The proposed merger of Intelsat and OneWeb is on hold having been replaced with a joint 5G and satellite integration project between Inmarsat and Intel but mixed constellations of LEO, MEO and GSO satellites of various sizes and power is an obvious end aiming point for existing constellation engineering and marketing teams. The Inmarsat and Deutsche Telekom European Aviation Network may similarly mark the beginning of a wider adoption of hybrid terrestrial and satellite connectivity.

Having larger more powerful competition however does not mean there is not a viable space in space for Cube SATS as a useful, even critical part of this integrated delivery mix.

Regulatory Challenges and Insurance Costs

The challenge is potentially not technical or commercial but regulatory.

Regulatory barriers include the need to agree access to spectrum, orbital access rights and landing rights on a country by country basis. Incumbent operators such as Inmarsat and Intelsat and SAS have spent decades negotiating their way through the minefield of satellite regulation and have large expert technical, commercial and legal teams dedicated to the task. It is hard to replicate this expertise and effort from a standing start. Competition policy could also be a barrier to integration in some markets.

Last but not least there is the issue of insurance. Countries such as the UK insist that operators providing satellite services take out third party insurance. For the UK this was formalized in the Outer Space Act of 1986 and specified that indemnity had to be provided on an unlimited liability basis. This was amended in the Deregulation Act of 2015 with a provision to limit liability to $60 million Euros.

Even with this risk limit, insurance premiums for a low cost high count constellation can be higher than the cost of launching and operating the satellites. Launch insurance costs are dependent on reliability records over time. For example if Space X meets their stated target of reusing the same rocket 100 times with a low failure rate, this would have a dramatic impact on insurance cost. Once in space, insurance usually covers the first twelve months of operation and covers hardware failure and malfunction and debris damage (still rare). High count constellation satellites need to maintain an adequate distance from one another and from other satellites in other constellations with overlapping orbits, (see reference above to constellation phasing) but this is a well understood deterministic process so in orbit insurance costs could reduce or at least stay stable as satellite space becomes more densely populated.

Ideally near earth communication satellites would include additional power sources other than solar arrays (such as radio isotope heat sources) but this introduces additional regulatory complexity (more on this next month).

The satellite and space regulatory community therefore has some challenges heading its way as do regulatory bodies overseeing terrestrial network policy, spectrum allocation, interference mitigation and the arbitration of terrestrial and space competition but the challenges are not insurmountable. The space industry bill presently being passed by the UK parliament and the Space Renaissance Act in the USA are present examples of legislation catching up with the needs of the new space sector.
https://services.parliament.uk/bills/2017-19/spaceindustrybill.html
http://spacerenaissanceact.com/

Summary

The integration of satellite access with terrestrial networks could significantly improve the delivery economics of 5G. The economic benefit will be greater if the satellite industry grants the mobile

broadband industry access to their existing spectrum and the mobile industry grants reciprocal access to their VHF, L band and S band allocations. In some cases, for instance Band 1, this would yield usefully wider pass bands.

The concept of mobile broadband operators sharing their spectrum with the satellite industry is presently commercial anathema. But why should satellite operators agree to terrestrial access to their K band and V and W band and E band assets without reciprocal sub 4 GHz spectrum access rights?

Cube SATS are at the extreme end of the satellite sector both in terms of their physical scale (small and light), numeric scale (potentially thousands of satellites) and capability (imaging, sensing, data and voice messaging). Over the past twenty years the Cube SAT community has succeeding in confounding its sceptics to deliver new business models which against all the odds seem to work but the longer term sustainability of this small but feisty satellite sector is dependent on regulatory innovation and flexibility. This is one of many issues that will need to be debated in the 18 month run up to WRC 2019.

New Book - 5G and Satellite Spectrum, Standards and Scale

We are delighted to announce that our new book, **5G satellite spectrum, standards and scale** is now available for pre order from Artech House. Follow the link to take advantage of the pre-publication discount**.**
http://uk.artechhouse.com/5G-and-Satellite-Spectrum-Standards-and-Scale-P1935.aspx

If you apply promotional code VAR30, an additional discount applies which brings the price down to £88.90 (list price £127)

There is also a bundle discount promotional code VARRALL5G which allows you to order a copy of our previous book, 5G Spectrum and Standards. The two books together cost £177.80 including free shipping.

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 in April. For details, including the early bird registration booking offer, **follow the link.**

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