RTT TECHNOLOGY TOPIC
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L band LTE ATC

L Band LTE ATC networks – pie in the sky or new delivery model?

Auxiliary **T**errestrial **C**omponent (ATC) Networks are hybrid satellite terrestrial systems that use terrestrial repeaters to combine the wide area coverage capabilities of geostationary or low earth orbit satellites with urban coverage and in building penetration provided from terrestrial networks. In Europe and Asia the networks are described as satellite networks with a ground based component. In China the networks are described as Satellite and Terrestrial Interactive Multi Service Infrastructure.

ATC networks have been covered previously in our July 2007 Technology Topic, **Satellite and Terrestrial Hybrid Networks** and February 2008 Technology Topic **Satellites for Emergency Service Provision.** In both documents we stated that ATC networks were potentially a competitive threat or collaborative opportunity for the global cellular operator community. In particular there was an obvious opportunity for L band and possibly S band spectrum to be repurposed for terrestrial use at a fraction of the cost of acquiring spectrum by auction.

Meanwhile the US cellular community became focussed on bidding for the 700 MHz spectrum in the belief that this would provide a low cost mechanism for delivering rural broadband and urban fixed and mobile coverage to consumer, business and government users. In the rest of the world a similar focus is now being applied to the 800 MHz bid process with similar assumptions.

Hybrid terrestrial cellular/satellite networks can also claim to provide a cost effective way of providing rural broadband and urban fixed and mobile broadband coverage. The satellite sector delivers fixed and mobile rural broadband connectivity albeit with some additional latency. The terrestrial network delivers urban connectivity and in building penetration. The combination can be regarded as more resilient than a terrestrial only network. Can it also be more cost effective?

To date it might seem doubtful. With the exception of high added value regional networks in the Middle East it has proved difficult to date to realize hybrid cellular/satellite investment models that make economic sense. The right to build a terrestrial network using satellite spectrum has been contingent on delivering a mandated service level from the satellite segment of the network. This has not always been achieved with the result that the sector is soured by litigation, policy reappraisal and bankruptcy. **Terrestar** for example has just filed for Chapter 11 protection with $1.6 billion dollars of debt having just launched a dual mode phone with **AT and T.**

One of the problems has been that nationally focused network initiatives have failed to achieve global scale either in terms of harmonised band allocations or technology. Apart from the network economics, there just wasn't enough pull through to get a broad enough range of performance competitive cost competitive user equipment into the market and insufficient market volume to amortise user equipment R and D and manufacturing investment.

In this month's technology topic we explore whether there is a global rather than national opportunity to deliver L band and/or S band hybrid terrestrial /mobile satellite network and user equipment solutions. We take a look at C band as well. We discuss whether LTE could provide a family of standards around which the sector could coalesce albeit recognising that previous attempts to achieve this with S-UMTS have never progressed. But mainly we explore whether a new delivery model has emerged. If it has then what does this mean for the US and ROW cellular operator community?

A new investment and delivery model?
On October 4th **Harbinger,** a US based private investment firm, sold half its stake in **Inmarsat**, the London based operator of geostationary based mobile satellite services. The sale raised $649 million, the proceeds of which will go towards financing a US LTE terrestrial mobile broadband network to be operated by **LightSquared,** a company owned by Harbinger. The LTE network is to be deployed in L

band using part of the L band spectrum used for mobile satellite service provision. LightSquared will pay Inmarsat $337.5 million to cover re banding costs and $115 million per year for the right to use Inmarsat's L band spectrum. Harbinger still holds just over 14% of Inmarsat's share capital.

Nokia Siemens Networks have signed an eight year agreement with LightSquared to build an outsourced network of 40,000 base stations to cover 92% of the US population by 2015. The agreement is claimed to be worth $7 billion dollars though quite how much of this is vendor financed is presently unclear.

LightSquared also announced that Qualcomm would be adding L band LTE to its mainstream chip set road map together with an advanced satellite air interface technology called EGAL (Enhanced Geostationary Air Link) about which little is known but whose stated purpose is to enable the LTE mobiles to be used in satellite mode. It is claimed that the devices will be similar in terms of size, capability and build cost to present mobile broadband user equipment. The network will be operated as a **wholesale operation.**

On the 16th September the FCC announced that **Globalstar,** the L band and S band mobile satellite services provider that uses Qualcomm chip sets and a repurposed Qualcomm CDMA air interface were told by the FCC that they would not be allowed to continue with a secondary leasing agreement made with **Open Range Communications.** Open Range secured $100 million of private equity finance in January 2009. This allowed the company to draw down a $267 million broadband access loan from the **US Department of Agriculture's Rural Development Utilities Programme.** The plan was and is to provide rural communities with WiMax wireless broadband fixed and or mobile terrestrial broadband connectivity using Globalstar's spectrum repurposed for terrestrial use.

The reason given for permission withdrawal was Globalstar's failure to provide satellite coverage. This was due to a number of RF hardware failures in space. The Globalstar constellation is presently being renewed and it could be expected that the permission withdrawal will be rescinded when coverage is restored but it illustrates that replacing base stations in the sky takes a while and incurs direct and indirect cost.

Open Range has an addressable rural market of at most six million people not all of whom will want or need broadband connectivity. Meeting cost targets without scale economy is inherently difficult. Public subsidies help but can be assumed to be relatively temporary. It would be better to find a technology solution that made financial sense without the subsidy. The implication is that an L band or S band solution is needed which has global customer scale, spectral scale, technology scale and multi vendor and multi operator support.

L band then and now

In 1997 there were two established regionally based dual mode networks that combined satellite and cellular services, **Thuraya,** a network operator servicing the United Arab Emirates and **ACes** servicing Asia.

In parallel **Inmarsat** developed a multi regional business providing customers with mobile terminals and a **mobile broadband service offering.** Coverage is presently provided from three Inmarsat 2 satellites, five Inmarsat 3 satellites and three Inmarsat 4 satellites, repositioned in February 2009 to cover the Americas, EMEA and Asia Pacific. The Inmarsat 4 satellites have large antennas with spot beams provide sufficient link budget to support hand held use for line of sight applications. This summer the company introduced its first **hand held device.**

L band spectrum is allocated internationally by the **ITU** with national regulators determining how the spectrum is used on a local basis. Inmarsat and Thuraya have access to up to 34 MHz of duplex spaced spectrum between 1525 and 1559 MHz and 1626 to 1660 MHz. Through a rather complex process of acquisition, (buying Sky Terra), share ownership and negotiation (Inmarsat's rebanding)and lobbying (persuading the FCC to waiver existing ATC rules), Harbinger have acquired access to 30 MHz of spectrum in L band by 2013 at a fraction of the cost of more traditionally acquired cellular spectrum. Harbinger's investment in 2008 in Sky Terra and Mobile Satellite Ventures provided access to two geostationary satellite build programmes. These satellites and their orbital slots will be optimised for US, Southern Canada and Latin American coverage. The satellites sourced from Hughes are huge and need to be to deliver an acceptable link budget for hand held terrestrial use. Presently it is assumed these satellites will use the EGAL air interface from Qualcomm rather than the already established Hughes physical layer.

Technically it would be possible for Inmarsat to provide coverage. However the present Inmarsat 4 satellites are less powerful than the ones to be supplied by Hughes which means the user terminals have to be bigger. However Inmarsat has the advantage of having a global customer base. This potentially unlocks the global scale needed to support an adequate supply of cost competitive and performance competitive user equipment. Actually it is better than that. This is not a new band but an existing band being repurposed for dual use. RF components are already available for L band hand held terminals. Japanese RF component and user equipment vendors have also been producing devices for the 1.5 GHz cellular networks in Japan for many years albeit at slightly different frequencies (1427 to 1452 and 1475 to 1500 MHz).

However there is no inherent incentive in place to encourage handset manufacturers and the RF component supply chain to add L band to present cellular handsets or mobile broadband devices particularly if this adds cost and compromises performance. There is even less incentive to add dual mode terrestrial and satellite functionality. Getting good performance out of a hand held device accessing a geostationary satellite 35000 kilometres away even with a new generation of more powerful satellites will be far from easy.

Additionally most incumbent operators are hoping that 700 or 800 MHz network investment will address most of the rural coverage and or public safety broadband access requirement. Adding 700 and 800 MHz and 2600 MHz functionality is going to be hard enough without adding L band into the mix. In this context the announcement by LightSquared that Qualcomm will be able to produce L band multi band dual mode terrestrial and satellite transceivers that have the same form factor and cost and price point and RF performance as core market devices must be treated with caution. As an example the Inmarsat **IsatPhone,** a single mode device, weighs close to 300g (ten ounces). These are not mass market consumer devices.

From a user perspective, if satellite access is essential there are also other single mode L band network and user equipment alternatives that work perfectly well today and will work even better in the future, **Iridium** being presently an obvious example. Iridium has not applied for an ATC license probably because it is more spectrally constrained than Globalstar and Inmarsat and probably because its customer base is happy with what it is has already. Iridium as a low LEO has the lowest latency of any of the present satellite access options. Both Iridium and Globalstar can cover high latitudes that are poorly served from geostationary satellites.

L Band and S Band LEO based satellite/terrestrial hybrids

An additional alternative would be to implement a hybrid L band and S band network. Globalstar has 11.35 MHz of uplink spectrum between 1610 and 1621 MHz and 16.5 MHz of downlink spectrum between 2483.5 and 2500 MHz. It has been licensed to use 5.5 MHz of spectrum in each direction for ATC and has applied to use the whole allocation for ATC. The first replacement satellites are presently being launched to refresh the existing satellites in high LEO/MEO orbit. Technically this should provide the basis for a robust dual network and the satellite access would support the ATC terrestrial license conditions. There are some technical and commercial challenges. The S band downlink is not close enough to other global S band terrestrial allocations to allow for RF component commonality. Re-establishing relationships with Open Range and other potential wholesale partners will also need to be carefully handled. However Globalstar could provide ATC coverage in the USA and in multiple terrestrial markets outside of the US with high latitude coverage opening up a wider satellite segment geographic application base. The lower latency is also better suited to interactive or conversational traffic for rural broadband fixed or mobile access.

S Band Hybrids?

Yet another alternative would be to implement S band only ATC networks. In the US there is a 20 MHz duplex band at 2000 to 2020 and 2180 to 2200 MHz. The lower duplex band is immediately proximate to the Sprint Nextel PCS terrestrial downlink and the upper band is immediately proximate to the AWS downlink. The ownership and implementation rights attached to these allocations have been and are still in dispute and even if these are resolved it would be problematic from a user equipment cost and performance perspective to aggregate this additional bandwidth with existing terrestrial network band plans. The same problems exist with the S band satellite allocations in Europe with a two by thirty MHz duplex allocation at 1980 to 2010 and 2170 to 2200 MHz. Adding this bandwidth to the existing band plan would incur substantial performance loss unless separate TX/RX paths were implemented in the front end of user devices. Band 1 operators might be motivated to get vendors to look at this if the revenues from the additional spectrum came in their direction but not otherwise.

C band

C band was the first frequency band allocated for commercial telecommunications via satellite and is still widely deployed and effective, particularly in regions with high rainfall. Nearly all C band communication satellites use frequencies between 3.6 and 4.4 GHz for their downlinks and 5.9 to 6.4 GHz for the uplink.

The implementation of broadband fixed wireless networks between 3.5 and 3.7 GHz was fiercely opposed by satellite operators on the basis of potential interference and similar objections are being raised to proposals for advanced LTE network band allocations in the same band.

Technically this might well be the best band for implementing ATC satellite/terrestrial networks as it will be expensive to provide rural terrestrial mobile broadband coverage. However the industry cooperation needed to realize these networks commercially will almost certainly be frustrated by an allocation and auction process designed to be adversarial.

Private sector/Public sector hybrids

Companies with exposure to ATC opportunities make the political case that hybrid networks are well suited to providing rural broadband coverage via satellite access, though with rather high latency (at least with GEO based networks). They also provide the extended coverage and resilience needed for **p**ublic **p**rotection and **d**isaster **r**elief (PPDR), and for emergency service and homeland and national security both in remote rural areas via satellite and urban areas via the terrestrial network.

Many of the present LEO and GEO networks already carry substantial traffic from these specialist user communities, generating high value income and amortizing space sector investment. The newer constellations such as **Iridium Next** will also carry other payloads such as earth and environmental monitoring that help to cover capital and operational costs.

Similar amortization opportunities exist for the 700 and 800 MHz bands. In the US, parts of the 700 MHz band have been allocated for PPDR **(see last month’s technology topic)** In theory these networks could be optimized for rural coverage with commercial networks providing urban connectivity. Conversely commercial operators struggle to make any kind of business case out of proving rural broadband connectivity. The PPDR networks could make rural spectrum available via secondary leasing arrangements as and when needed with pre emption to ensure PPDR or emergency access when required. At least costs will then be more broadly amortized.

Either way these networks require capital investment that needs to come from public funding or from private sources in which case operational costs will be high.

Essentially irrespective of whether rural wireless broadband or specialist user broadband service is delivered over terrestrial networks or over a mix of terrestrial and satellite networks, costs will be substantial.

A Multi User Multi Use Multi Operator Multi Market Money Making Model?

However it is possible that Harbinger and Globalstar may have both come up with a genuinely new investment and delivery model in which L band and possibly S band satellite spectrum is repurposed to provide terrestrial coverage.

The terrestrial and satellite connectivity can either be supplied directly (the Globalstar model) or wholesaled (the Harbinger model) to small, medium and large scale market intermediaries. National governments will also be able to buy bandwidth from these networks to provide mobile broadband connectivity for public protection and disaster relief and emergency service users.

It is possible that enough L band spectrum could be made available in enough markets to confer sufficient scale economy incentive to support the development and manufacture of single and dual mode user equipment which met user form factor, functionality and cost and performance expectations. RF components are already produced for L band mobile satellite products and Japanese vendors could repurpose 1.5 GHz PDC components and devices. This is not a new band but an existing band repurposed for terrestrial use so the normal caveats of RF component availability do not apply.

It is possible that satellite physical layer standards could be converged with terrestrial fixed and mobile broadband standards to achieve additional scale economy. However there is already a mix of LTE and WiMax being used for terrestrial connectivity so the prospects for a single global ground based standard seem slim. For the satellite uplink and downlink there is still uncertainty as to whether LightSquared will use Qualcomm's EGAL air interface and or whether EGAL would or could be harmonized with LTE and what the position of Hughes is likely to be on this. The Inmarsat satellites use their own physical layer. The large and often safety critical BGAN device population that Inmarsat support would make it hard for them to change so any global standardization for the satellite access segment is also unlikely. This looks like a potentially costly muddle at the moment.

With or without a harmonized technology standard, the economics only add up if spectral and network and user equipment R and D and manufacturing investment can be amortized over multiple geographic markets and multiple demographic markets within those geographic markets. The US market on its own will not be large enough unless government subsidies continue to be available.

Multiple geographic and demographic markets require a degree of cross regional cross industry co operation that has not been historically achieved within the ITU regulatory structure and is unlikely to emerge from pure market based cooperation. However the existing MSS satellite spectrum used by Inmarsat has a more or less global footprint with the exception of higher latitudes better covered by LEO and MEO constellations. Inmarsat and Globalstar could both play the role of honest broker for global L band LTE ATC network deployment and Globalstar could play a brokerage role for S band redeployment.

However the regulation of satellite service provision has always been politically sensitive and this is unlikely to change in the present international political climate. The relationship between the satellite industry and terrestrial cellular community has been historically adversarial and competition for C band spectrum is likely to intensify this. The honest broker role will therefore be politically challenging. The standards issue needs sorting out as well.

There is also a risk of litigation. AT and T and Verizon have invested $20 billion dollars in 700 MHz spectrum. The band has arduous RF implementation challenges and no matching band plan in other regions. This compromises scale economy.

Harbinger have acquired rights to a significantly larger amount of cleaner spectrum with a matching band plan in most other markets presently served by Inmarsat and or Thuraya which could potentially deliver global scale economy and global market reach. An established RF component supply chain already exists for mobile satellite devices in the band with a potentially large eco system of Japanese user equipment vendors leveraging commonalities with existing 1.5 GHz cellular devices. All this for a rebanding cost of just over $300 Million dollars and a rental fee of $115 million per year, no wonder Harbinger are happy with the outcome.

There is a contingent liability to fund and operate two geostationary satellites but these could carry complementary pay loads and or provide high added value government user connectivity to help amortize the investment.

To rub salt into the wound LightSquared will be wholesaling on demand low cost fixed and mobile broadband rural and urban connectivity to AT and T and Verizon's existing competition and enabling a new generation of local and national and possibly demographic service providers. If smaller competitors can lease bandwidth on demand then the need to over dimension broadband wireless networks to maintain QOS with bursty traffic loading will largely disappear. It might even make sense for AT and T and Verizon to buy top up bandwidth when required.

Even the terrestrial build out might be a fraction of the $7 billion dollars stated. It would be logistically daft to set up 40,000 new sites. It would be completely sensible to upgrade existing 1900 MHz and/or AWS base station sites with L band transceivers. NSN would be well positioned to implement this though would need to be careful not to alienate their existing customer base.

In this context it would be surprising if AT and T and Verizon decided to sit back and do nothing in response to Harbinger's (and Globalstar's) ongoing ATC initiatives. The same will likely apply for other operators in other markets. In fact it can be safely predicted that L band and S band ATC spectrum will be a gold mine for lawyers and lobbyists for some years to come. For this reason L band LTE and L band and or S band LTE ATC might take a few years to take off but it is probably too compelling a proposition to be suppressed in the longer term. Dual use spectrum is here to stay and terrestrial cellular and fixed and mobile broadband business plans need to factor this in as a risk or opportunity. It could and should have a major impact on 800 MHz and 2600 MHz bid valuation and could devalue existing 700 MHz spectral investment.

The cellular industry tends to forget that the mobile satellite industry not only exists but is doing rather well, despite and sometimes because of the occasional excursion into Chapter 11.

As with the broadcast community, cellular operators will probably be better off finding ways of cooperating with satellite partners rather than fighting them in the courts over spectral access rights.

A regulatory environment that encouraged this would be helpful.

Networks and the New Economy – November Workshop in the UK
The political, economic and technical challenges and opportunities for integrating terrestrial networks with geo stationary ATC satellite and low earth and medium earth orbit satellite systems and other networks (energy, environmental and transport) will be addressed in a one day workshop, 'Networks and the New Economy' being held in Cambridge on the 9th November.

Speakers include Dan Mercer from **Iridium,** Andrew Bell from **Huawei**, Paul Wallace from **Oracle**, Paul Green from **Arkessa**, Olivier Andre from **Alcatel Lucent**, Franck Chevalier from **Analysys Mason** and Tim Summers from **Freescale Semiconductor.**

This workshop is free to Cambridge Wireless members or DCKTN members (and the DCKTN is free to join).

More information and registration details are available **HERE**

LTE Study from RTT

RTT have produced a major 70 page study on LTE user equipment and LTE network economics. The study is written by RTT with statistics and economic modelling from **The Mobile World** and is sponsored by **Peregrine Semiconductor** and **Ethertronics.**

The study, 'LTE User Equipment, network efficiency and value' is available free of charge from the linked web site.

www.makingtelecomswork.com

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An additional level of detail on this topic and related topics can be accessed via the **Resources section** of our linked web site **www.makingtelecomswork.com** www.makingtelecomswork.com provides a cost and time efficient way in which telecommunication engineers, product managers and policy makers can access **technical information and advice not readily available elsewhere in the public domain.**

The web site also provides information on RTT workshops, **Making Telecoms Work Europe**, **Making Telecoms Work Asia** and **Making Telecoms Work in the US.**

The workshops demonstrate how engineering issues can be practically resolved and how performance gains and cost savings can be achieved.

European work shops are held at the Science Museum in Kensington West London**. Information on the next workshop is available here.**

A number of sponsorship opportunities are available linked to the web site and related Science Museum telecom industry educational initiatives.

If you would like more information on these opportunities please e-mail **geoff@rttonline.com** or phone **00 44 208 744 3163**

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