RTT TECHNOLOGY TOPIC
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UHFMTS

Introducing this month's Technology Topic
Switching off analogue TV, a process now well underway and scheduled to finish by 2012, releases just over 100 MHz of UHF wireless spectrum between 470 and 862 MHz.

The assumption is that the TV broadcast community no longer has a need for this bandwidth and that other bidding entities with deeper pockets, specifically the cellular radio industry, will become significant investors - the process is known as 'the digital dividend.'

However there are opposing social, political and economic arguments in favour of the UHF spectrum being left with the Digital Broadcast community.

Additionally there are engineering arguments that suggest that co sharing the spectrum between broadcasters and cellular operators could be economically and spectrally problematic.

In this month's Technology Topic we explore some of the technology, engineering, market and business issues implicit in the repurposing of UHF.

The rationale for cellular in the UHF Band
The cellular industry has a legitimate interest in buying UHF spectrum. The present headway being made by a number of CDMA 450 operators underlines the potentially favourable cost economics of wireless infrastructure investment at these lower frequencies, particularly for rural coverage or to provide improved in building penetration in urban areas.

Operators without spectrum at 850 or 900 MHz would similarly benefit from access to the UHF band.

The cellular industry also sees itself as a delivery medium for broadcast content and can point at deployments of Media FLO and other proprietary broadcast technology solutions as proof of the viability of integrating TV with cellular service propositions.

Additionally the cellular industry has a potential complementary role in the HD and Super HDTV delivery process.

In the days of omnipresent analogue TV, a country the size of the UK could be covered from 50 large and high powered transmitter sites and 1100 lower power relay sites. This provided the statutory required coverage of 98% of the population including all communities with more than 200 people. Getting 90% coverage for a 3G network at 1900 MHz takes over 7000 base stations.

Major urban conurbations such as London were and still are covered substantially by one TV transmitter. For example Crystal Palace in London broadcasts to a 'local' population of 8 million people. The analogue transmitter delivers one megawatt, co sharing mast space with DVB, DAB, FM and medium wave transmissions. The station has a range of 60 miles for analogue TV and 30 miles for digital TV. HDTV broadcasts started from the site in May 2006.

Digital TV transmitters typically have effective radiated power outputs (the power that is delivered as a result of the transmitter power plus antenna gain) ranging from 2 to 50 kW. Crystal Palace is 20 kW. These output powers though relatively modest compared to analogue TV are still substantial when compared to cellular base stations.

This provides economic benefits in terms of rural coverage and urban in building penetration and a benefit to users in terms of reduced DC power drain when viewing digital TV content. However this in turn depends on network density.

There is a trend in digital TV broadcasting towards implementing an increasing number of lower power sites, particularly in urban areas. Many of these potential sites are owned by cellular operators or administered owned and/or managed by common third parties such as Crown Castle.

From the very beginnings of the cellular industry there has been a long tradition of site sharing with existing TV broadcast sites. More recently there has been a trend for cellular network operators to share mast space, Vodafone and Orange in the UK being a recent example.

A faster than expected transition to high definition TV including high definition TV and an earlier than expected transition to super high definition TV would strengthen the rationale for providing TV broadcast bandwidth from smaller sites previously optimised for cellular. The same principle could apply for local digital TV and digital radio broadcasts which could potentially be supported on interleaved spectrum.

Successful co sharing would however be dependent on a much closer integration of broadcast and cellular technologies (DVB, DVB-H and UTRAN LTE) and a careful analysis of any proposed shared spectrum options.

Can Digital Terrestrial TV and Cellular Share the UHF Band?
The World Radio Communication Conference to be held in October 2007 WRC 07 will be taking work items forward from the Regional Radio Communication Conference held in May/June 2006 RRC06 finalising details of the allocation and auctioning of spectrum presently being released for commercial terrestrial services as a result of the switchover to digital TV.

In the UK and Europe and some rest of the world markets, up to fourteen 8 MHz sub channels are becoming available for auction making a total of 112 MHz. In some markets, for example the UK, additional channels presently supporting aeronautical radar and Programme Making and Special Events (radio microphones and wireless SD and HD cameras) will also be available by 2012, the end of the switchover period,

politically coincident with the Olympic Games being hosted in London.

The US and Latin America (ITU Region 2) are substantially different. The digital broadcast spectrum is sub divided into 6 MHz rather than 8 MHz channels. The allocation available for re use for ITU Region 2 is in two bands. The lower 700 MHz band has 48 MHz of bandwidth consisting of eight 6 MHz channels between 698 and 746 MHz. These were formerly UHF broadcast channels 52 to 59.

Qualcomm has implemented Media FLO in Channel 55 on a nation wide basis to service Verizon Wireless customers. The upper 700 MHz band has 60 MHz of bandwidth consisting of ten 6 MHz channels between 746 and 806 MHz. These were formerly UHF broadcast channels 60 to 69. The total bandwidth available across both bands is therefore 108 MHz.

The FCC started the spectrum repurposing process in 2001 with a (probably ambitious) shut off date for analogue services of 2009. The total auction proceeds are anticipated to exceed 50 billion dollars.

US digital TV standards are different to the DVB standard used in most of the rest of the world (excluding DVB T in Korea). The US digital TV standard does not support and is not optimised for mobile handset receiver applications. These requirements are being met by proprietary technologies such as QUALCOMM's Media FLO (forward link only) and possibly longer term variants of present US vendor centric Wi Max based solutions.

Rest of the World UHF TV Broadcast Spectrum Allocation
An agreement known as the GE 06 (Geneva 2006) agreement allocated the 'digital dividend' spectrum in 8 MHz channels across Europe for 'uses compatible with digital broadcasting'. This offers the prospect that a sufficient regional addressable market could be created to achieve adequate economies of scale.

The UK provides one example of how this spectrum is presently used.

Present UHF digital broadcast spectrum extends across forty eight 8 MHz channels numbered 21 to 69 divided into a lower band consisting of channels 21 to 44 from 470 to 662 MHz and an upper/higher band consisting of channels 45 to 69 from 662 to 862 MHz. The transmissions are downlink only though there are options within the standard to provide DVB uplink capabilities.

Digital terrestrial TV has pre allocated spectrum and or spectrum in present use on channels 21 through 30 and 41 through 44.

Channels 31 through 35 (550 to 590 MHz), Channel 37(598 to 606 MHz), and Channels 39 and 40 (614 to 630 MHz) are available for auction and are described as 'cleared spectrum'.

Channel 36 is presently used for aeronautical radar. In the UK, the present user of Channel 36, BAE Systems, has agreed a new band allocation with the Civil Aviation Authority. The channel is described as 'potentially cleared spectrum' and will be available for auction.

Channel 38 is used for radio astronomy. This channel is known as the ’quiet band’ and will remain with its present protection rights. This will almost certainly have implications for any potential new users of Channels 37 and 39.

Channels 63 through 69 (806-862 MHz) are available for auction and are described as cleared spectrum.

Channel 69 will also be available for use after 2012. It is therefore described as ‘potentially cleared spectrum’ and is to be included in the auction process. It is currently used for Programme Making and Special Events (PMSE), for example radio microphones and wireless cameras. These applications are managed independently in the UK by the Joint Frequency Management Group.

The inclusion of Channel 36 in the lower band and Channel 69 in the upper band means that a total of 128 MHz will be available.

Auctions for all available bands will start in 2008 in the UK and possibly earlier in other markets.

As only 6 digital terrestrial TV multiplexes are allowed at any one transmitter site, there are also interleaved bands available. These are generally considered to be unsuitable for use by cellular operators although could be used for local TV transmission. They are also useable for PMSE.

The channels designated by the European Broadcasting Union as preferred channels for an additional HD multiplex are channels 31 to 33 in the lower band and channels 63 to 65 in the upper band.

Cellular operator options for FDD (frequency division duplex) spacing
This therefore leaves a number of possible options for cellular FDD deployment, some of which overlap the preferred HDTV spectrum.

We have used unofficial but descriptive terms for these bands

Option 1 UMTS 550/800 (250 MHz duplex spacing) - combined lower and higher band.

Option 2 UMTS 550/625 (75 MHz duplex spacing) - lower band.

Option 3 UMTS 580/620 (40 MHz duplex spacing) - lower band.

Option 4 UMTS 810/850 (40 MHz duplex spacing) – higher band.

Actual duplex spacing will depend on the adopted channel raster. If UMTS, this will be at increment off sets of 200 KHz. This will probably also apply to UTRAN LTE.

Note that the traditional arrangement would be to have mobile transmit in the lower duplex paired band. It might however be tempting to have mobile transmit in the upper duplex band. This would mean UHF mobile transmit was closer to 900 MHz

mobile transmit and further away from digital TV receive channels. It would also mean that UHF cellular handsets could be designed to receive HD TV transmissions side by side with mobile cellular receive channels.

In some countries, for example France, Channels 68 and 69 are used for military purposes.

Time Division Duplexed (TDD) Options
An alternative option would be to consider TDD. The UMTS TD-CDMA-3GPP Multimedia Broadcast and Multicast Services standard, part of the Release 6 standards process, supports what is generically known as TDtv in the TDD1 band (1900 -1920MHz) and TDD2 band (2010 - 202 MHz) adjacent to 3G spectrum at 1900 and 2100 MHz.

Deployment is presently limited to trial systems but the addition of TDD at UHF would potentially broaden the application base and make economies of scale easier to achieve. MBMS in Release 6 is based on the existing UMTS radio layer but could be assumed to evolve to a TDD variant of LTE using OFDM at some later stage.

There is some loss of sensitivity in TDD deployment in terms of RX/TX separation on the base station receive path. However adaptive radio schemes including adaptive OFDM radio systems with or without smart antenna capabilities generally work better in TDD. In effect it is easier to characterise the channel in near real time if the uplink and downlink are on the same frequency. This is the basis for most present WiMax deployments and proposed future LTE options.

An OFDM multiplex has the benefit of slowing down the channel symbol rate which allows a longer guard band to protect against uplink/downlink inter symbol interference. This means that larger cells with higher user data rates can be supported in cellular networks and/or spectrally efficient single frequency networks can be supported in broadcast networks.

The disadvantage is that operators co sharing proximate or adjacent spectrum may need to support inter network symbol level synchronisation, though opinions presently differ on this.

Assuming these engineering issues can be resolved; TDD deployments could be made into any of the cleared or potentially cleared bands in UHF and could be used for UMTS TDD, UTRAN LTE TDD or WiMax TDD.

Note that the ability to scale occupied channel bandwidth from 1.25 MHz to 20 MHz as specified both in UTRAN LTE and WiMax provides additional flexibility in terms of spectral channel management. This applies equally to TDD or FDD allocations.

Note also that LTE has similar outer modulation options to digital broadcast (the OFDM multiplex), similar inner modulation options (QPSK to 64 level QAM) and similar adaptive channel coding schemes.

DTT Receiver Design and potential cellular to DTT interference
However all of the above options would be/are considered by digital broadcasters to

be potentially harmful to DTT reception. This includes fixed receivers but also portable digital TV receivers which would be considered to be particularly vulnerable to interference from mobile cellular handset transmit energy.

Digital broadcast receivers are not designed to be particularly selective or to have much front end dynamic range.

The receivers use a 72 MHz IF, a frequency well suited to low cost SAW filter implementation.

The 72 MHz IF means however that digital receivers are sensitive to image channel interference from channels on a 9 channel off set (nine times eight = 72 MHz) and local oscillator interference at a 5 channel off set (40 MHz).

This suggests that cellular mobile transmit energy in channels 31 to 37 and 39 in a conventional duplex deployment will be regarded by the broadcasting industry as being potentially harmful to DTT channels 22 to 30. These DTT channels include proposed DVB H receive channels.

DTT reception may also be disrupted by transmissions on adjacent channels including single channel and two channel offsets.

Any or all of these effects could result in ‘hole punching’, the term used by the broadcasting industry to describe the reduced coverage caused by interference. These are referred to as ‘viewer protection issues’.

However these effects are well understood and can be avoided through a combination of careful planning and good practice engineering though this will require a substantial amount of co operation between broadcast and cellular network optimisation engineers. The use of a reverse duplex could also help resolve potential co existence issues.

DVB-H/Cellular Handset Design Issues

Similarly the integration of DVB or DVB H receivers into cellular handsets is reasonably complex but achievable. The present trend is to support DVB-H, DVB-T, DAB, DAB-IP and T-DMB receive functionality. This implies a quad band receiver though could be extended to include DRM receive functionality at long wave, medium wave, short wave and VHF.

The receive performance therefore needs to be qualified in terms of its performance across all possible receive bands in the presence of cellular transmit energy that could be proximate or at least close to the receive frequencies particularly in the UHF band.

There are some present proposals that DVB-H could be used by the emergency services and PPDR (Public Protection and Disaster Relief) which would provide DVB-H with additional political leverage.

Regulatory Issues

This UHF spectrum has been ‘owned’ by the broadcasting industry for over 50 years.

The potential loss of over 100 MHz of spectrum to other commercial users some of whom will compete directly for a share of available consumer and corporate spending will motivate the broadcasting community to defend the interests of present incumbents and to raise legitimate technical concerns in relation to possible new service providers, particularly providers such as the cellular industry who would wish to provide uplink access in addition to the downlink only access traditionally supported in the band.

The European Broadcasting Union has been proactive in suggesting that it will likely be impractical, probably impossible to accommodate mobile uplinks, whether these are UMTS or WiMax or alternative two way access technologies.

The broadcasting industry is likely to have an expanding rather than contracting requirement for spectrum. The rapid uptake of large flat wide screen displays will inevitably increase consumer demand for high definition television and in the future, super high definition, SHDTV. These services when combined with enhanced audio (extended bandwidth five channel surround sound) are inherently bandwidth hungry and require substantial increases in transmitter power and/or network density'.

Presently proposed improvements in colour space colour fidelity described in the IEC61966-2-4 document(extended gamut luma chroma encoding) will add further loading to an already overloaded DTT digital multiplex and provide robust economic and technical reasons why the broadcasting community should be granted preferential access, essentially ‘reacquisition rights’ to digital dividend spectrum.

Other interest groups also have a potential interest in the spectrum including public safety agencies sometimes now described as Public Protection and Disaster Relief (PPDR). There are proposals for a common EU band for PPDR presently being discussed. Experience with the implementation of TETRA radio systems in the UK proximate to the Band III spectrum used for DAB and Specialised Mobile Radio implementation experience in the US in the 800 MHz band highlights the need for cautious spectral engineering when users with significantly different spectral requirements share proximate bandwidth.

Most regulatory agencies are also keen to encourage other bidding entities, for example mobile multi media service providers, whatever they may be, or fixed access service providers. This suggests the need for a reasonably complex and cautious spectral arbitration process.

Issues of spectral harmonisation for the cellular industry
None of the above options will be economically viable unless agreement can be reached on harmonised band allocations across a number of substantial markets.

Volumes have to be achieved in markets other than the US and Latin America (ITU Region 2). Additionally, any countries with existing networks based on the US AMPS band, which includes a number of countries in Asia, will have mobile transmit channels between 824 and 849 MHz. This will exclude use of digital TV broadcast channels 65 to 68 and the matching paired bandwidth in these target markets.

In common with ITU region 2, some markets also have politically sensitive specialised

mobile radio implemented in proximate spectrum. This suggests economies of scale have to be achieved across Europe and a limited number of Rest Of the World markets.

Other users who are close to the edges of the UHF band, for example RFID in the license exempt band from 865 to 868 MHz may also need to be considered.

Although some degree of harmonisation is being achieved across Europe, there are still country specific exceptions. Some of these may be localised within the country but still significant in terms of radio planning. For example in the UK, Channels 33 and 37 on the Crystal Palace transmitter are allowed to transmit at higher power and are granted additional protection rights in order to provide adequate coverage for London(including HD coverage).

WRC07 will also be deciding on CEPT proposals for 10 MHz within the 670 to 790 MHz band to be used for satellite digital TV. Satellite operators are not subject to national laws but paying for spectrum would provide them with protection rights.

Summary – Competition or cooperation
A number of industry groups have a particular interest in the repurposing of the UHF spectrum.

Digital broadcasters argue the case for an expansion of DTT bandwidth to support HD and longer term SHDTV multiplexes.

Although satellite and cable and standard telephone lines all offer alternative delivery options, all have disadvantages. Satellites are not under national jurisdiction, not all cable is capable of supporting DVB C transmission, standard telephone lines may be 50 years old and physically incapable of supporting required increases in data throughput particularly for high definition transmission.

Terrestrial broadcasters voice legitimate concerns about mobile cellular transmit channels interfering with DTT receivers, particularly portable DTT devices. Satellite broadcasters could potentially have similar concerns.

The cellular industry has an interest in UHF spectrum. It has favourable propagation characteristics particularly for rural areas where CDMA 450 is being presently successful and for urban coverage for improved in building penetration. 100 MHz of UHF spectrum would be a useful addition to present spectral asset balance sheets if it could be acquired at a reasonable cost.

However present incumbents have specific protection rights and expectations which have to be carefully considered and there may be competing entities for the spectrum, PPDR for example, who may be able to justify preferential access.

The sensible solution of course is for all these interest groups to work together amicably to resolve these issues. This is likely to create the maximum net gain to all parties involved.

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