RTT TECHNOLOGY TOPIC
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Terrestrial TV - The notion of positive cross over value

In this month's Technology Topic we review the technology and engineering dynamics that are presently changing the terrestrial TV service proposition and the impact these changes will have on broadband fixed, portable and mobile devices.

As analogue TV transmissions are switched off, digital terrestrial broadcast transmissions will be increased to power levels which potentially enable **portable** devices, including devices with internal antennas, to receive standard and in the longer term high definition TV.

In parallel, sub sets of the DVB standard have been developed to optimize **mobile** handheld receiver performance. DVB H reduces power drain in cellular phones by time slicing and uses time slicing to support cell to cell handover algorithms.

Proprietary solutions such as Media FLO are based on similar principals. In parallel, DVB SH based technologies are being introduced to support the delivery of satellite downlinks to mobile devices.

The purpose of this Technology Topic is to explore the complementary positioning of digital terrestrial TV when compared to the whole range of alternative delivery options including fiber, cable and copper and the complementary positioning of digital terrestrial TV when compared with other forms of fixed, portable and mobile wireless access including satellite and cellular service provision.

In particular we set out to discuss the role that digital terrestrial TV will play in realizing value from broadcast, broadband and cellular service integration.

The Future of Fibre
To do this, we need to study the present and potential future performance potential of other broadcast and broadband delivery options, starting with fibre.

Fibre began as single wavelength then progressed to multiple wavelengths and more recently has progressed to multi mode, three generations of optical technology evolution.

Essentially fibre comes in two flavours, multi mode and single mode.

Single mode is used for backhaul and can support data rates of 40 g/bits or above. It has a loss of about .37 dB per km at 1310 nanometres. It is expensive when compared with multi mode fibre and requires expensive connectors and exotic laser diodes.

Multi mode is used in final mile applications. In a multi mode fibre, if the angle of the light entering the fibre is changed then that light 'channel' will follow a certain reflective path. This means it will have travelled a different distance to other light channels introduced at a different angle and will therefore arrive at a different time at the receiver.

This is the basis for time division multiplexing and allows for up to 64 'channels' to be supported. Multi mode fibre is relatively low cost when compared to single mode fibre and does not require expensive high precision connectors. However it has a relatively high propagation loss, about .8dB per km at 1310 nanometres and relatively low bandwidth when compared with single mode.

Newer multi mode fibre also supports shorter wavelength transmission at 1510 nanometres. Attenuation losses reduce to about .23 dB per km but chromatic dispersion is worse.

Multi mode fibre is used extensively in passive optical networks. The ITU-T G983 specification defines the downstream at 1490 nm at 622 M/bits/s, a 155 M/bits upstream at 1310 nanometres and an RF video overlay at 1550 nanometres.

The 18 billion dollar FioS Optical network being deployed by Verizon in the US is an example of a passive optical network based on a combination of multi mode and single mode fibre transport.

Even allowing for multiplexing on the multi mode drop, these networks offer super fast downloads of recorded content including high definition video, multiple (200 or more) standard TV channels and high definition TV. Peak rates are capped per user but can be 45 M/bit/s and could theoretically be much higher.

Both multi mode and single mode fibre have substantial untapped bandwidth potential which will be realized as optical components improve over time.

The only problem with fibre is the installation cost given that competitive access options have either been fully amortized (copper) or written down (cable).

The 3G Cable Proposition
Cable data rates are lower than fibre but in common with fibre are increasing over time. The increase in data rate has primarily been delivered through the adoption of higher order modulation schemes.

The downstream frequencies used in cable are typically from 42 to 850 MHz with an upstream between 5 and 42 MHz in the US and between 5 and 65 MHz in Europe.

The table below shows how data rates have increased over the past ten years over three generations of DOCSIS (data over cable service interface specification).

Table 1, **Three generations of DOCSIS cable specification**

DOCSIS	DOWNSTREAM	UPSTREAM
DOCSIS 1.0	38 M/bit/s	9 M/bit/s
DOCSIS 2	38 M/bit/s	27 M/bit/s
EURODOCSIS 2/DVB C	51 M/bits	9 M/bit/s

DOCSIS 3.0	160 M/bit/s	120 M/bit/s

DOCSIS 3.0/Eurodocsis will be needed to support a credible offering of high definition TV and is designed to be IPV6 compatible. The higher data rates are achieved partly by higher order modulation schemes and partly by channel bonding.

Eurodocsis is essentially a redistribution of the uplink/downlink budget to support the 8 MHz digital TV channel bandwidths and data rates needed to meet European DVB-C broadcast requirements.

Table 2 shows DVB-C modulation options and data rates. Present standardization efforts are being directed towards producing a new iteration of DVB-C known as DVB-C2.

Table 2, **Example Modulation options and data rates for an 8 MHz digital TV channel**

Modulation	16QAM	32 QAM	64 QAM	128 QAM	256 QAM
Data rate Mbit/s	25.64	32.05	38.47	44.88	51.29

These higher order modulation schemes are noise sensitive. This suggests that present cable networks may need substantial additional investment to ensure that sufficient bandwidth is available to support a competitive high definition TV proposition and acceptable down load times for high definition content. This of course strengthens the business case for competitive or preferably complementary fiber investment but also implies a substantial engineering common interest between cable and fiber in final mile access platforms.

The copper alternative

The copper alternatives are shown in Table 3. In common with cable modems, ADSL modems use higher order modulation schemes, typically 16 level QAM. ADSL2+ sacrifices uplink bandwidth to deliver a 24 M/bit downstream which can be increased theoretically to 48 M/bit/s using channel bonding.

These higher order modulation schemes combined with adaptive channel coding schemes deliver data rates that are presently competitive for internet access but marginal for high definition TV.

VDSL modems add in an OFDM multiplex to deliver some additional bandwidth gain but are severely distance limited. The 100 M/bit high profile service for example needs to be within 350 meters of a fiber node.

As with cable this suggests that present copper networks may need substantial additional investment to ensure that sufficient bandwidth is available to support a competitive high definition TV proposition and acceptable down load times for high definition content.

This strengthens the business case for competitive or preferably complementary fibre investment but also implies a substantial engineering common interest between copper and fiber in final mile access platforms.

Table 3, **ADSL and VDSL Modem options and data rates**

ADSL	Downstream	Upstream	VDSL2		
ADSL2	12 M/bit/s	3.5 M/bit/s	Low profile	Medium Profile	High Profile
ADSL2 +	24/48 M/bit/s	1 M/bit/s	25 M/bit/s	30 M/bit/s	100 M/bit/s

The DVB-S satellite alternative
Satellites are power budget limited. For this reason, DVB S satellites use QPSK or 8 PSK modulation. These modulation schemes have less amplitude modulation than QAM schemes and therefore support more power efficient RF power amplifiers.

Present standardization efforts are being directed towards producing a new iteration of DVB-S known as DVB-S2 based on using 16 PSK and 32 PSK modulation combined with adaptive variable source coding (AVC).

Table 4 shows the data rates needed for present SDTV and HDTV transmission and the possible data rates achievable using AVC coding. High definition TV occupies over four times the bandwidth of a standard definition transmission.

Compression schemes such as AVC provide a partial solution to this but increase error and jitter sensitivity. Similar constraints apply to MPEG4 based coding schemes. A 36 MHz satellite transponder capable of supporting 25 standard definition TV Programmes will be hard pressed to support more than 5 or 6 HDTV channels.

Table 4, **DVB-S Data rates**

Definition	Data rate	Data rate with AVC coding
SDTV	4.4 M/bit/s	2.2 M/bit/s
HDTV	18 M/bit/s	9 M/bit/s

Terrestrial TV
We have covered terrestrial TV technologies in various prior Hot Topics/Technology Topics.

August 1999 '3GTV', May 2005 'Adaptive Systems' and June 2005 'Broadcast Over Cellular' all provide useful reference.

Terrestrial TV has a significant advantage over satellite in that it is potentially neither power nor bandwidth limited. The need to co share spectrum with analogue transmissions has required digital TV to transmit at sub optimum power levels but this constraint disappears once analogue transmissions are switched off.

There are obvious opportunities to increase signal strengths over and above present analogue TV transmissions by increasing the number of DVB transmission sites. Cellular operators are a natural partner in this process.

This opens up the possibility of supporting a wider range of portable and mobile devices including the use of these devices within buildings.

It could of course be argued that in building portable and mobile device applications can also be serviced by a combination of fiber, cable or copper access combined with WiFi.

However it would be economically hard for any alternative delivery options (including cellular and/or possible future combined WiFi/WiMax networks) to match the ability of terrestrial TV to deliver a 20 M/bit or 30 M/bit downlink to devices irrespective of where or how they are being used.

Discussions are ongoing as to how much of the UHF bandwidth terrestrial broadcasters retain after the analogue to digital switchover is complete. Even if the cellular industry took 100 MHz of digital dividend spectrum there would still be 300 MHz available to support a broad range of national and local standard and high definition TV multiplex options.

Terrestrial TV therefore has a significant role to play in the standard and high definition TV delivery process including the delivery of these services to portable and mobile devices.

The developing interdependency of all delivery options. Differentiating positive and negative cross over value opportunities.

However terrestrial TV should be regarded as complementary rather than competitive to other delivery options. In practice all delivery options across both fixed and mobile access domains have a developing interdependency.

As this interdependency increases over time, the opportunity to release positive cross over value increases in parallel.

Positive cross over value is the value realized from exploiting technology and engineering, market and business synergies across apparently competitive access platforms. For example it is quite possible and in fact probable that most households and corporate premises will be served by a combination of fibre, cable, copper and wireless access.

There are capability overlaps across all four access domains and these overlaps create apparent competitive advantage opportunities. However if one of the access domains is used to cannibalize the revenues of other access domains then **negative cross over value** occurs.

The present tension between the broadcasting community and the cellular industry over UHF spectrum allocation is based on an implicit assumption that the process will result in negative rather than positive cross over value.

This is a mistake. The broadcasting industry needs the cellular industry. The cellular industry needs the broadcasting industry. The fibre industry needs the cable industry, the cable industry needs the fibre industry and everyone needs access to copper.

Broadcast Broadband and Cellular Cross over Value

Cross over value can be realized either from technology and/or engineering, market or business common interest.

Technology cross over value comes from the developing commonalities in signal processing and signal conditioning which are being applied across all access domains. For example OFDM techniques are used in wireless access and copper access, higher order adaptive modulation techniques are used in wireless, copper and cable access, multi mode fiber uses TDMA techniques that are similar to many other access system solutions.

Engineering cross over value comes from exploiting engineering common interest, the co sharing of radio masts between the broadcasting and cellular community is one example, co sharing back haul is another, co sharing fiber, cable and copper cabinet space or conduit is another.

Market cross over value is the process by which markets are expanded as a consequence of broadening the user experience. Triple play and quad play go some way towards realizing market cross over value but a genuine multi play offering would span all four access domains with a more balanced and integrated user proposition.

Business cross over value is the process through which technology, engineering and market cross value is translated into corporate equity value, usually through merger and acquisition. Ericsson's acquisition of Marconi, strengthening their optical technology and engineering capability and their more recent acquisition of Tandberg TV, strengthening their TV technology and engineering capability is an exemplary example.

Differentiating internal and external cross over value
The realization of corporate equity cross over value is however usually hard to achieve. The reason for this is that businesses are structured internally to measure rewards on a business unit basis linked to investment.

For example if an operator has invested substantial sums of money in fiber then the focus is not surprisingly delivering a return on that investment. The fastest way to realize a return is probably to cannibalize revenues from another access domain. This can lead to destructive internal competition which translates into negative internal and negative external cross over value. It certainly makes it harder to foster a spirit of internal technology, engineering and market collaboration.

Confusing convergence with common interest
Fixed mobile convergence is an over used term in our industry. In practice the bit rate difference between each of the access domains is increasing rather than decreasing over time, a process of divergence rather than convergence.

This is not surprising given that all four access domains, fibre, cable, copper and wireless all benefit equally from improvements in signal conditioning and signal processing techniques.

However this process of divergence broadens the user experience. As the user experience broadens, integration value increases.

Integration value at a micro level implies the exploitation of common interest across traditionally separate disciplines.

Integration value at a macro level implies the exploitation of common interest across traditionally separate industries.

Sometimes these separate industries have substantial existing technology and engineering common interest which can be used as the basis for developing market and business common interest.

The repurposing of UHF spectrum provides a topical example of a potential common interest between the cellular industry and terrestrial TV. The objective has to be to deliver a net gain to all involved parties. This would be easier to achieve if standards bodies were less fragmented and if industry associations could come to terms with the need for collaboration and consolidation.

Terrestrial TV - the 'value' of free to air content. Differentiating aspirational and inspirational value.

We have focused on transmission related technology and engineering issues but there are of course directly related content production issues. The BBC has stated that all programme production will be in high definition by 2010, a decision that in itself implies substantial technology and engineering investment. Of course this does not mean all output will be transmitted in high definition but will certainly help to hasten the transition process.

It is a not uncommon notion to consider that public service broadcasting is in decline. However in practice in many countries, public service broadcasting is alive and well though increasingly sensitive to the need to develop new revenue opportunities. Lord Reith's original mission to Educate, Inform and Entertain free from political interference is arguably now needed more than ever before.

In this context it is worth reflecting that commercial broadcasting and public service broadcasting have different value models. Commercial broadcasting is dependent on advertising that is implicitly dependent on aspirational motivation - our willingness to buy things we did not know we needed.

Public service broadcasting is or should be inspirational. It should make us want to achieve things that we did not know we wanted to achieve. Typically the process of achieving something implies a complex process of collaboration within and outside existing peer group structures. This requires efficient and effective two way communication. This is the domain in which the cellular industry has unique expertise and capability.

This trigger process is often based on watching live rather than recorded events. Watching Wimbledon encourages us to play tennis with our friends, watching the Olympics may make us want to pole jump, watching a hurricane may make us want to save the world, the triumph of ambition over ability. In the world of public service broadcasting, live event based social networking is still a largely unexplored and under exploited phenomenon.

There is therefore a compelling content driven common interest that should in the future help to consolidate and integrate the cellular and broadcast industry user experience - the ultimate expression of positive cross over value.

About RTT Technology Topics

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We aim to introduce new terminology and new ideas to clarify present and future technology and business issues.

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Contact RTT

RTT, the Shosteck Group and The Mobile World are presently working on a number of research and forecasting projects in the cellular, two way radio, satellite and broadcasting industry.

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