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Satellite and terrestrial hybrid networks

In this month's Technology Topic we analyze how the dynamics of the satellite business are changing and what this means for the global cellular operator and terrestrial broadcasting community.

In particular we study the impact of hybrid satellite terrestrial systems on present cellular and terrestrial broadcast business models.

Dual mode networks that combine satellite and GSM cellular services already exist. Thuraya, a network operator servicing the United Arab Emirates and ACeS servicing Asia are two present examples.

Hybrid satellite/terrestrial systems are different in that they use terrestrial repeaters to combine the wide area coverage capabilities of satellites with the urban coverage and in building capabilities provided from terrestrial networks. These may or may not be associated with existing cellular or terrestrial broadcast networks.

The terrestrial repeaters are described in the US as Ancillary Terrestrial Components (ATC) and in Europe and Asia as Ground Based Components.

In China the networks are described as Satellite and Terrestrial Interactive Multi Service Infrastructure (STiMI).

Hybrid networks are already used in the US to deliver audio broadcasting for in car and more recently in flight entertainment. Widespread deployments of these systems are planned both for audio and TV broadcasting and for two way cellular service provision.

These deployments exploit already allocated L Band and S Band spectrum in US and rest of the world markets. Some of this spectrum has been gifted to the operators. Typically these allocations are not owned by traditional terrestrial cellular or terrestrial broadcast service providers.

As such they represent a competitive threat and by implication a collaborative opportunity for the cellular network operator and traditional terrestrial broadcast community.

Hybrid networks are an integral part of the convergence presently taking place between satellite and terrestrial cellular, TV broadcast and broadband and narrow band data delivery systems.

This convergence offers positive cross over value opportunities but these opportunities need to be qualified within the present overall context of the satellite industry.

Satellite spectrum and orbit options

The satellite systems of interest to us are deployed either into L Band between 1518 and 1675 MHz or S Band between 1.97 and 2.69 GHz and are either in geostationary geosynchronous (GSO) orbits at 35000km, in Medium Earth (MEO) Orbits between 10,000 and 20,000 km or in low earth (LEO) orbits or 'high' low earth orbits (HLEO) between 700 and 1400 km. For the sake of comparison, the US Space

Shuttle orbits at 350km.

Some highly elliptical orbits such as the Molniya or low polar orbits provide optimized coverage for countries at extremely northern or extremely Southern latitudes. 'Seeing' geostationary satellites from these latitudes can be problematic.

The choice of orbit determines the number of satellites needed to provide a particular coverage footprint, the size and position of the satellites determines their functionality.

The spectrum into which the satellites are deployed and the proximity of this spectrum to other users also determines their functionality particularly in terms of system interoperability with other terrestrial or satellite networks.

LEOS have the advantage of low round trip latency, about 20 milliseconds compared with 133 milliseconds for a MEO and 500 milliseconds for a GSO satellite.

Geostationary satellites have the advantage that they stay in the same place when viewed from the earth. This simplifies handover and radio planning algorithms when servicing mobile users.

The size of the satellite determines the size of the antenna array, sometimes upwards of 20 meters in large geostationary satellites. The size of the array determines the uplink and downlink gain available particularly if adaptive spot beam forming techniques are used.

Similarly the size of the solar panel array, sometimes upwards of 40 meters in large geostationary satellites dictates the amount of power that can be generated which determines both the coverage and capacity.

Advances in launch technologies have made it possible to launch satellites weighing over 5000kgs into geostationary orbit. Advances in RF and baseband hardware deliver a steady year on year increase in functionality per kg of orbital weight.

Conversely micro miniaturization techniques have made possible new generations of super small satellites though these tend to be used for more specialist low orbit or deep space exploration applications.

Improvements in station keeping fuel efficiency and hardware reliability have helped to increase the life span of satellites. An operational life of 15 years is now a realistic expectation.

A reasonably broad choice of launch options and some innovative mission insurance solutions have helped trim launch costs. All these factors together contribute positively to the overall economics of providing satellite based services.

However terrestrial network hardware costs have also reduced over the past twenty years by roughly 15% year by year and functionality has greatly increased.

In particular the rapid growth in subscriber numbers served by terrestrial cellular networks and terrestrial broadcast networks has attracted engineering investment which in turn has improved the delivery cost efficiency of these networks. Present upgrading of the DAB terrestrial networks in the UK to provide improved coverage and higher data rates provides an example.

In terms of user devices, the economies of scale available to the cellular industry effectively dictate the radio functionality included in mobile handsets.

In the past these factors have invalidated a number of apparently promising satellite based business models.

New satellite ventures therefore have to be approached with some caution and the relative merits and demerits of each option need to be carefully considered.

This is particularly true when significant amounts of spectrum are being allocated by regulators either for satellite based services or for new hybrid satellite terrestrial network propositions.

Satellites have delivered telecommunications, TV and data for over 50 years, the original triple play proposition. This interdependency has determined the economics of the industry.

Over the past twenty years improved power output (downlink capability) and sensitivity (uplink capability) has allowed satellites to play an increasing role in delivering communications to mobile devices including mobile handheld devices.

Hybrid satellite terrestrial networks are a logical next step but have to be qualified in terms of the additional value that they deliver to existing terrestrial networks.

Terrestrial Broadcast and satellite co existence in L Band
Table 1 shows the present allocations to terrestrial broadcast, satellite broadcast and satellite two way services in L Band.

Table 1 Terrestrial Broadcast and satellite co existence in L Band

L Band Terrestrial Broadcast									
		MHz	MHz	MHz	MHz	MHz	MHz	MHz	MHz
DAB	Broadcast audio	1452.96 1478.64							
			25 MHz						
DVB	Broadcast video							1670 1675	
								5 MHz	
L Band Satellite broadcast									
S DAB	Broadcast audio		1480.352 1490.624						
			10 MHz						
World Space	Broadcast audio	1453.384 1490.644							
		35 MHz							
L Band Satellite Two Way Mobile									
Inmarsat Thuraya ACES				1525 1559			1626.5 1660.5		
				34 MHz			34 MHz		
Mobile Satellite Ventures				1525 1559			1625.6 1660.6		
				34 MHz			34 MHz		
Iridium						1610			

						1626.25			
						16 MHz			
L Band /S Band Two Way Mobile									
Globalstar						1615.15 1626.15			2483.5 2500
						10 MHz			15MHz
L Band GPS Satellite Positioning									
GPS					1575				
Galileo					1575				
Glonass						1602 1615			

Terrestrial DAB Satellite DAB and DVB H
The L Band allocations for DAB and DVB H are identified although these allocations are not universally available in all countries. DAB is intended primarily for radio but can carry a TV multiplex of up to 7 video channels on a 1.7 MHz OFDM channel.

DVB H has been implemented as a trial in New York delivering 75 TV and music stations transmitted from 74 terrestrial sites covering 475 square miles. The network uses a 5 MHz channel rather than the standard 8 MHz used for DVB H at UHF or S band.

Provided regulatory approval is obtained, DVB H could be implemented in L band as a DVB SH network with terrestrial repeaters

World Space Satellite Broadcast L Band GSO plus proposed ATC
World space provides radio services to Africa and Asia from two geostationary satellites, Afristar launched in 1998 and Asia star launched in 2000. These satellites use the same air interface as XM radio.

Plans to launch a third satellite Ameristar to serve South America were not implemented as these L band frequencies are used by the US air force.

This satellite is now intended to be repurposed to provide European coverage with a particular emphasis on Italy. The satellite would transmit and receive with an air interface theoretically compliant with the ETSI satellite digital radio standard which is presently being extended to include S UMTS and DVB SH and a legacy set of standard documents known as GMR, the geostationary mobile radio standard.

World Space has terrestrial repeater licenses for Bahrain and the United Arab Emirates and could be expected to lobby for similar license concessions in its other addressable L band markets.

Inmarsat - L Band GSO Two way mobile communications
Inmarsat have traditionally provided mobile and fixed communication services to the maritime, aeronautical, land mobile and remote area markets. Recent investments have focused on increasing data rates as part of their Broadband Global Access (B GAN) network.

Space to earth links are at 1525 to 1559 MHz and earth to space are at 1626.5 to 1660.5 MHz. The network supports user data rates up to 256 kbps. Terminals are typically 1.3 kg or above and power consumption is in the region of 14 watts. There are ten satellites in a geostationary (GSO) orbit. The latest satellites launched have a planned 13 year operational life and a 9 meter antenna array. There are no stated plans for a hybrid ATC network.

Thuraya 2 L Band GSO plus Tri Band GSM and GPS

Thuraya provides satellite service to mobile hand held devices that also support tri band GSM and GPS with coverage optimized for the United Arab Emirates and the Middle East. The original geostationary satellite was launched in 2000 with a second in 2003 and a third in 2004. Uplinks and downlinks are the same as Inmarsat. The Thoraya 2 satellite has a 12 meter antenna array. The GPS frequency at 1575.42 sits reasonably conveniently between the L band uplink and downlink frequencies used in the handset. There are no stated plans for a hybrid ATC network.

ACeS L Band GSO plus Tri Band GSM and GPS
More or less equivalent to Thuraya combining service from one geostationary satellite launched in 2000 and positioned to provide optimal coverage over Asia rather than the Middle East. Inmarsat and ACeS are proposing to combine their present network proposition to provide global coverage. There are no stated plans for a hybrid ATC network.

Mobile Satellite Ventures L Band GSO plus ATC
Mobile Satellite Ventures plan to launch two geostationary satellites in 2009/2010. These are large satellites weighing 5500 kgs with a 22 meter antenna array and 500 spot beams. Coverage is to be optimized for the US, Southern Canada and Latin America.

The company has a license to deploy a 30 MHz paired band with the lower duplex between 1525 and 1559 paired with the upper duplex between 1625.5 and 1660.6 MHz based on proposals first tabled to the FCC in 2001.

The mobile uplink will be processed by both satellites with the signal being diversity combined, a technique also used by Globalstar.

Terrestrial transmitters will be added to existing cellular sites to provide additional coverage and capacity

Essentially this is an extension of the terrestrial repeater principle to two way communication based on a combination of terrestrial cells with a radius of between one and five kilometers nesting within a satellite cell with a radius of about 100 km.

This brings Mobile Satellite Ventures into direct competition not only with terrestrial broadcasters but also with cellular service providers.

Mobile Satellite Ventures claim to have substantial patent based intellectual property regarding space/terrestrial frequency re use, beam forming with larger arrays and handover algorithms. There is some cross over of patent value and personnel with XM radio.

Iridium - L band LEO
The Iridium satellite network is based on 66 satellites in six equally spaced orbits at 700 km. The satellites weigh 700 kg and are rated at 530 watts with 48 spot beams per satellite and orbit at 26931 kph (100 minute orbits). The constellation is still operational after ten years and is expected to continue to provide service until 2010.

The uplink and downlink are between 1610 and 1626.25 MHz and provide voice and low bit rate data service to mobile terminals. The satellites can inter satellite switch at Ka band at 23 GHz and have a 19.4-19.6 GHz downlink and 29.1-29.3 GHz uplink.

Motorola invested substantial orbit specific engineering resources developing handover and inter satellite switching algorithms for Iridium. The air interface is broadly similar though not identical to GSM. There are presently no publicly stated plans to implement a hybrid satellite/ATC network.

Globalstar L Band/S Band Two Way Mobile with proposed ATC
Launched ten years ago as a competitor to Iridium, the Globalstar network is based on 48 satellites in a high LEO Walker orbit at 1410 km. The satellites weigh 350 kg and are rated at 550 watts with 16 spot beams per satellite. The uplink is at 1615.15 to 1626.15 MHz and the downlink is at 2483.5 to 2500 MHz.

Some RF hardware failures are now occurring due to radiation damage but the network is still operational. Qualcomm supply a range of cellular handsets including devices with integrated GPS capability.

In common with Iridium, Globalstar went into Chapter 11 in 2000 but re emerged and refinanced.

The company plans to implement an ATC at some future stage.

Global Positioning MEOS at L Band GPS, Galileo and Glonass
Table 2 below summarizes the global positioning MEO's

Table 2 GPS satellite constellations

Name	Orbit	Number of satellites	L band spectrum MHz	Status
GPS	MEOat 20,200 km	24 operational satellites, six nearly circular orbits	1575.42	Fully operational since 1994,
Galileo	MEO at 23222km	30 satellites, in three Walker orbits	1575.42	Planned to be fully operational by 2012
Glonass	MEO at 19100 km	24 satellites	1602-1615 MHz	Fully operational

The US managed GPS satellites have a 7.5 year design life but satellites are lasting 12 years.

Galileo is a European initiative with coverage, positioning accuracy and satellite lock times optimized for Europe. The satellites will have a 12 to 15 year design life.

Galileo has the same downlink frequency as GPS and could be expected to be implemented as standard in future handset designs.

It is theoretically convenient to build an L band transceiver with GPS capability though care has to be taken to avoid desensitization of the GPS or Galileo signal within the handset.

Terrestrial Broadcast and satellite co existence in S Band
Table 3 summarizes present and proposed S band hybrid satellite and terrestrial broadcast and two way radio networks

Table 3 Present and proposed S band satellite and terrestrial (ATC) broadcast and two way radio networks

		MHz	MHz	MHz	MHz	MHz	MHz	MHz
XM Sirius	Broadcast 192 audio channels				2332.5 2345.00			
					12.5 MHz			

Mobaho Japan	Broadcast 11 video channels including HDTV 25 audio channels 3 data channels						2630 2635	
S- DMB Korea	Similar to Mobaho						2630 2635	
							25 MHz	
Terrestar and ICO US	Broadcast and two way		2000 2020	2180 2020				
			20 MHz	20 MHz				
ICO Europe	Broadcast and two way	1997.5 2010			2187.5 2200			
		12.5MHz			12.5 MHz			
Eutelsat SES Astra	Broadcast but potentially broadcast and two way	1980 2010			2170 2200			
		TBD			TBD			
WiFi	Potential integration with satellite receivers							2400- 2480
								80 MHz

XM and Sirius in the US - S Band GEO plus S Band ATC
XM and Sirius are two operators in the US providing MP3 quality audio radio for in car and more recently in flight entertainment. The two companies are presently in merger discussions

XM has four 15 kW geostationary satellites XM1 (Rock), XM2 (Roll), XM3 Rhythm and XM4 'Blues'. XM1 and XM2 have suffered some fogging on their solar panels.

The satellites work with 1500 terrestrial repeaters which are each technically capable of delivering an ERP of 25 kW. Sirius has an additional three satellites also in geostationary orbit.

The air interface is specified in a standard known as SDARS (Satellite Digital Audio Radio Service). The networks operate in a 12.5 MHz band between 2332.5 and 2345 MHz with four of the six radio carriers dedicated to the satellites and the other two channels dedicated to the terrestrial repeaters.

Satellites are QPSK to maximize power efficiency. The terrestrial repeaters use COFDM.

User terminals have two separate antennas, one for the satellite signals and one for terrestrial signals. The signals are combined in the receiver at baseband using maximal ratio combining. Alternatively simple voting is used to choose the strongest signal.

The receivers tend to be traditional superhets with a 75 MHz IF commonly also used in TV receivers.

ST Microelectronics for example supply an SDARS receiver module. The receiver IC is common both to SDARS at 2.3 GHZ and Wi Fi at 2.4 GHz suggesting a number of potentially integrated Wi Fi/satellite/terrestrial transceiver design opportunities. Maxim has a similar IC.

Antenna systems for these devices are complex though the design requirements for receiving satellite and terrestrial signals simultaneously are now well understood.

There is a present proposal to deliver more localized services from the terrestrial repeaters. The National Association of Broadcasters (NAB) in the US opposes this.

Mobaho in Japan and S DMB in South Korea - S Band GSO plus ATC
Mobaho in Japan and S DMB have a similar network configuration but implemented at 2.6 GHz. A single geostationary satellite covers Japan with a left polarized beam and S Korea with a right polarized beam. A 12.226 GHz transponder on the satellite provides a downlink to terrestrial transponders to provide services in subways and tunnels.

Terrestar S Band in the US- GSO with ATC
Terrestar have been granted access rights to two by 10 MHz allocations at 2000 to 2020 and 2180 to 2020 MHz. The band is shared with ICO. The launch of the initial Terrestar 500 spot beam geostationary satellite was originally planned for November 2007 but has been rescheduled for September 2008.

Terrestar have a joint venture with Orbcomm who have a legacy 30 satellite LEO constellation of micro 160 watt satellites with an uplink at 137-138 MHz and downlink at 400-401 MHz.

Orbcomm went into Chapter 11 with Iridium and Globalstar but re emerged and refinanced and presently provides services to M2M markets including telematics and asset tracking.

ICO S Band GSO with ATC
The FCC have granted ICO a license for the other two by 10 MHz allocations at S Band with a mobile uplink between 2000 and 2020 MHz and a downlink at 2180 to 2020 MHz. An initial satellite launch is planned for the end of 1997 optimized for US coverage.

The ground based components receive the satellite signal in K band, down convert to 2 GHz then transmit in synchronization with the satellite signal. Additional satellites would provide improved in building penetration.

The suggestion is that this network could provide up to 50 TV channels to mobile handsets and is therefore a potential competitor to Media FLO though the network would have other functionality including two way voice and data, interactive multi media and disaster relief capabilities.

ICO S Band MEO at S Band with ATC
ICO planned a MEO constellation of 12 satellites in two inclined orbits at 10,400km. The launch of the first satellite failed but the second satellite went into orbit in June 2001 and is operational and capable of providing services to Africa, Europe and Asia.

The ITU/CEPT S Band allocation to ICO specified a 12.5 MHz mobile uplink between 1997.5 and 2010 MHz and a mobile downlink from the satellites between 2187.5 and 2200 MHz.

There has been regulatory discussion as the continuing validity of ICO's claim to this spectrum. ICO base their claim to continued access rights on the basis of their legacy investments and stated plans to repurpose present and future satellites to support a DVB SH ATC network as a joint venture with Alcatel Lucent.

Alcatel Lucent are leading a consortium with Sagem, Philips and DiBcom known as Television Mobile Sans Limite (Mobile Television without Limits) to promote wider adoption of the DVB SH standard.

China have several parallel standards initiatives including China Multi Media Broadcasting using Satellite and terrestrial Inter active infra structure and other localized re interpretations of the T DMB and DMB T standards.

Eutelsat and SES ASTRA GSO - 'free' S Band payloads
Eutelsat has twenty three geostationary satellites. SES Astra has 36 satellites in 25 orbital locations. Together they deliver over three thousand TV stations and over 2000 radio stations to 200 million cable and satellite homes.

The transition to HDTV represents a challenge and opportunity to these providers and implies a possible future need to work more closely with the terrestrial broadcasting community.

There are no stated plans by either entity to implement a hybrid ATC network **however an S Band payload will be included on the Eutelsat W2A satellite being launched in 2008/9** and the companies have a joint venture working on delivering additional S band capacity.

The technology, engineering and launch costs of these platforms are already very adequately amortized across a substantial and largely captive subscriber base. **S Band capacity can therefore be added at minimal incremental cost.**

It could be presumed that Intelsat would have similar economies of engineering, sourcing and subscriber scale that could be applied in a similar way

Other present and proposed S Band only providers need to consider the impact this could have on their future operational margins.

Intelsat C Band Ku Band and Ka Band GSO
Intelsat provides bi directional transponder services to corporate and national governmental markets predominantly at C Band (3.4 to 7.025 GHz), Ku Band (10.7 to 14.5 GHz and Ka band (17.3 to 30 GHz).

Intelsat has 51 geostationary satellites and uses spot beams to provide global, hemi, zone or spot beam coverage predominantly to fixed users. There are no stated plans for a hybrid ATC network.

In common with Eutelsat and SES Astra, Intelsat has the benefit of multiple satellite constellation economies of scale and a large corporate subscriber base over which to amortize future S band engineering investments.

Implications for Terrestrial Broadcasters
As can be seen from the above, a number of these hybrid satellite terrestrial networks represent new competition for traditional terrestrial broadcasters. The ability to deliver TV to mobile users either from terrestrial repeaters or a satellite and/or simultaneously from both provides a measure of additional flexibility not available to terrestrial only broadcasters. The addition of an uplink to support interactivity provides additional differentiation.

Conversely most of the hybrid satellite terrestrial operators require access to terrestrial sites and terrestrial subscribers many of which are largely under the control or influence of the incumbent traditional broadcast community.

This suggests that collaborative rather than competitive ventures would be likely to yield better shareholder returns for all parties.

Implications for Terrestrial Cellular Service Providers
A number of these hybrid satellite terrestrial networks represent new competition for traditional cellular service providers. The ability to deliver full duplex voice, video and broadband data services to mobile users either from terrestrial repeaters or a satellite and/or simultaneously from both provides a measure of additional flexibility not available to terrestrial cellular operators.

Conversely most of the hybrid satellite terrestrial operators require access to terrestrial sites and terrestrial subscribers many of which are largely under the control or influence of the incumbent traditional cellular community.

The impact of satellite terrestrial ATC hybrids on cellular spectral and corporate value
Table 4 shows the present US band allocations at S band
Table 4 US S Band cellular allocations including satellite/terrestrial hybrids

Band	Frequency MHz	Operational Bandwidth MHz
AWS	1710-1755	45
PCS 1900	1850-1910	60
Sprint/ Nextel	1910-1915	5
PCS1900	1930- 1990	60
Sprint/ Nextel	1990-1995	5
ICO/Terrestar	2000-2020	20
AWS	2110-2155	45
ICO/Terrestar	2180-2200	20
WCS(Sprint/Nextel)	2305-2320	15
SDARS (XM/Sirius)	2332.5-2345	12.5
WCS (Sprint/Nextel)	2345-2360	15
Wi Fi	2400-2480	80

The satellite spectrum was largely allocated in 1997 and was either gifted or acquired on advantageous terms particularly when compared with the sums subsequently spent by cellular operators on PCS, WCS and most recently AWS spectrum.

This incongruity has allowed the satellite operators to refinance and revalue. The FCC ruling to allow ATC terrestrial repeaters has substantially helped in this revaluation process.

The regulatory intention is to encourage investment in satellite spectrum that has remained fallow for over ten years. Some US cellular operators might be minded to question whether this is in retrospect or prospect an equitable arrangement.

Table 5 shows the IMT S Band Cellular and satellite allocations in Europe

Table 5 IMT S Band Allocations

Standard	TDD	T-UMTS	S-UMTS	TDD	T-UMTS	S-UMTS
Frequency MHz	1900 1920	1920 1980	1980 2010	2010 2125	2110 2170	2170 2200
Operational bandwidthMHz	20	60	30	15	60	30
			ICO MEO			ICO MEO
Frequency MHz			1997.5 2010			2187.5 2200
Operational bandwidth MHz			12.5			12.5

The satellite spectrum was largely allocated in 1997 and was either gifted or acquired on advantageous terms particularly when compared with the sums subsequently spent by cellular operators on T-UMTS spectrum.

This incongruity has allowed the satellite operators to refinance and revalue. The CEPT/ITU ruling to allow ATC terrestrial repeaters (known as ground based components) has substantially helped in this revaluation process.

The regulatory intention is to encourage investment in satellite spectrum that has remained fallow for over ten years. Some European and Asian cellular operators might be minded to question whether this is in retrospect or prospect an equitable arrangement.

The same remarks could be made about L band spectrum.

L band, S Band, C Band, K band and V band hybrids

The available radio frequency spectrum carries on beyond Ka band into V band, the millimetric band between 30 and 300 GHz.

There are ambitious satellite based bi directional broadband communication projects currently under way in V band including an advanced global EHF satellite hybrid MEO GSO network providing broadband connectivity for US Stealth Bomber aircraft.

This network is being implemented between 36.1 and 51.4 GHz and is a dual constellation hybrid combining a MEO constellation for low latency exchanges with a constellation of geostationary satellites for less latency sensitive uploading/downloading.

Table 4 ITU frequency bands including V Band

UHF	S DAB	L Band	GPS and Galileo	S Band	C Band	Ku Band	Ka Band	V Band (Millimetric)
235 400 MHz	1452 1492 MHz	1518 1675 MHz	1575.42 MHz	1.97 to 2.69 GHz	3.4 to 7.025 GHz	10.7 to 14.5 GHz	17.3 to 30 GHz	30 to 300 GHz
Military mobile	TV and radio	Civilian mobile	Positioning	Cellular and broadcasting	TV, radio and data broadcast			Military mobile

Participation in these major military projects allows US vendors in particular to amortize engineering investments that can be translated to civilian applications.

The EHF project suggests that future commercial networks may combine terrestrial repeater coverage with hybrid MEO and GSO satellite coverage.

Summary

There have been rumblings of discontent in the cellular and terrestrial broadcast community that new generation hybrid satellite terrestrial networks are really terrestrial networks with an ancillary satellite component rather than satellite networks with an ancillary terrestrial component.

These networks are being deployed into spectrum that was acquired at a fraction of the cost of recent (past 7 year) cellular spectral investments. A number of the operators have also emerged from Chapter 11

This would seem to confer an unfair advantage to these companies.

This may of course be true but pragmatically there will be a high level of interdependency between satellite /terrestrial ATC networks, terrestrial broadcast and terrestrial cellular networks both at infrastructure and subscriber level.

Interdependency implies collaborative profit opportunity.

More tellingly, a number of the propositions outlined above will have to be closely coupled with already established terrestrial service providers in order to achieve long term financial viability.

In particular the significant economies of scale available to the cellular industry effectively dictate the radio functionality included in any handset. Satellite operators need to consider this factor with particular care.

The positioning of Eutelsat and SES Astra is potentially advantageous given their substantial existing satellite and subscriber assets and ability to amortize engineering and marketing investments over a large and secure existing revenue base. Intelsat has potentially similar advantages. S Band payloads on any of these satellites are essentially free.

This factor combined with other positive satellite technology and cost trends including lower launch costs, larger more efficient pay loads and improved uplink and downlink performance suggest that satellites will play an increasingly positive role in future terrestrial mobile broadband service provision.

At the very least satellites need to be more actively factored into present and future cellular and terrestrial broadcast business planning.

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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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