Spectrum: The next decade
exploring wireless innovation

Ofcom
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30 – 10:45</td>
<td>Dynamic spectrum access: Beyond TV white spaces</td>
</tr>
<tr>
<td>10:45 – 11:00</td>
<td>Coffee break</td>
</tr>
<tr>
<td>11:00 – 12:15</td>
<td>Machine-to-Machine (M2M)</td>
</tr>
<tr>
<td>12:15 – 13:15</td>
<td>Networking lunch and technical demonstrations</td>
</tr>
<tr>
<td>13:15 – 13:45</td>
<td>A view from Google</td>
</tr>
<tr>
<td>13:45 – 15:00</td>
<td>Content, production and transmission</td>
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<tr>
<td>15:00 – 15:15</td>
<td>Coffee break</td>
</tr>
<tr>
<td>15:15 – 16:30</td>
<td>Wireless broadband communications: 5G and beyond</td>
</tr>
<tr>
<td>16:30 – 17:30</td>
<td>Technical demonstrations</td>
</tr>
</tbody>
</table>
DYNAMIC SPECTRUM ACCESS: BEYOND TV WHITE SPACES

David Harrison, Technology Strategy Director, Ofcom
Spectrum sharing
From licence exempt to dynamic spectrum access
Consumer demand for mobile data is increasing

Use of connected devices is rising and M2M is also emerging...

...with increasing amounts of data being consumed

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
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<tbody>
<tr>
<td>Mobile connections</td>
<td>81.7m</td>
<td>84.2m</td>
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<tr>
<td>Total mobile data</td>
<td>19.7m GB</td>
<td>26.3m GB</td>
</tr>
<tr>
<td>Data per connection</td>
<td>0.24 GB</td>
<td>0.34 GB</td>
</tr>
</tbody>
</table>

Take-up (%)

- Smartphone:
  - 2011: 27%
  - 2012: 39%
  - 2013: 51%
- Tablet:
  - 2011: 2%
  - 2012: 11%
  - 2013: 24%
From a spectrum perspective, we have three approaches to meet demand

1. **Low frequency**: More cleared low frequency licensed spectrum to deliver good coverage

2. **High frequency**: Increasing the total amount of mobile broadband spectrum available for use in smaller cells

3. **Sharing**: Sharing frequency bands to further increase supply and reduce barriers to access
Spectrum sharing in the Wi-Fi bands has become an integral part of the UK communications infrastructure.

**Wi-Fi today**
- 89% Wi-Fi router take-up
- Manual connection to indoor Wi-Fi network

**Wi-Fi in the future**
- Increasing proportion of outdoor mobile traffic
- Seamless connection and roaming between Wi-Fi and LTE networks

**Home / enterprise Wi-Fi**
- Manual connection to indoor Wi-Fi network

**Current outdoor Wi-Fi**
- 7.4% of all mobile traffic offloaded through Wi-Fi
- Manual connection and roaming between Wi-Fi hotspot networks

**Future outdoor Wi-Fi**
Advances in technology are allowing more intelligent approaches to sharing

- **“Dumb” devices**: Listen before talk
- **Dynamic frequency selection**: Use geolocation to avoid interference with primary user
- **White Space Devices**
  - Use geolocation to avoid interference with all users
  - Check other users using geo-location database and cognitive sensing

**Other bands?**
**TV White spaces**
**Wi-Fi**

Increasing access to spectrum

Improving spectrum sharing between users
We have published a consultation and would welcome views on our long-term approach

- Initial consultation on the role spectrum sharing could play in opening up access to spectrum and supporting innovation

- Focus on three key areas:
  - Need for more Wi-Fi spectrum
  - Geographic sharing
  - Dynamic Spectrum Access

- Closing on 9 November
Dynamic Spectrum Access – Reflections and challenges

Simon Mason Senior Technologist Digital Platforms
3rd October 2013
Areas that need to be considered for Dynamic Spectrum Access (DSA) services

- For DSA to work there has to be co-existence between:
  - Incumbent service(s) and new DSA service
  - DSA to DSA service

- Data bases are key to DSA services
  - Data bases require accurate field strength predictions from mathematical models for all the services sharing the band
  - The models need:
    - Knowledge of the incumbent service
    - The New DSA service
    - The possible geometry between devices
    - The time and location statistics
    - The allowed interaction between the services in terms of impact
Areas that need to be considered for Dynamic Spectrum Access (DSA) services

- Dynamic Spectrum Access (DSA) into cleared spectrum is easier to achieve than into interleaved spectrum.
  - Compare 800 MHz co-existence with DTT with a new DSA service interleaved in spectrum with DTT
    - Filters can be fitted to protect DTT from 4G service in 800 MHz
    - Down link adjacent to DTT in 800 MHz, 4G base stations locations known so impact easier to model and consumers can be warned
    - Experience so far shows overload of TV distribution amplifiers is the main mechanism of loss of DTT service.
Challenge to Industry

- How can we improve the models that calculate the impact of one service into another to ensure the best input into the data bases?
- Clever modulation schemes which improve protection ratios.
- Low cost transceivers which carry services tolerant to noise and overload and give the consumer some understanding of the source of the interference.
- How does the consumer manage their wireless devices and home networks when there is a co-existence problem? When the band of operation is licence exempt there is no one to call.
Panel discussion

- **Microsoft**
  Andrew Stirling, Senior Policy Adviser UK/EU

- **Arqiva**
  Simon Mason, CTO, Digital Platforms

- **Qualcomm**
  Wassim Chourbaji, Senior Director of Government Affairs EMEA
MACHINE-TO-MACHINE

Steve Unger, Chief Technology Officer, Ofcom
the 50Bn connected device opportunity
about TTP Group

a leading independent technology & product development organisation
based near Cambridge, UK
active in a wide range of markets, worldwide
major centre of wireless communications expertise
proprietary & standard wireless technology
connected device innovation: energy

energy efficiency improvements through connected services
868MHz/GPRS M2M

mass market smart metering, energy display smart home
868MHz/broadband
Green Energy Options
connected device innovation: medical devices

- artificial pancreas for diabetes management
  2.4GHz Bluetooth LE

- mHealth technologies for diagnosis, disease monitoring and medication management

- connected medical devices
  consumer health & fitness
  many wireless technologies

- wireless audio for hearing aids
  spectrum?
connected device innovation: other markets

retail displays using e-paper & ultra-low-power wireless
868/915MHz
TTP/ZBD Solutions

novel connectivity solutions for industrial & professional markets
915MHz (USA)

heads-up wearable display technology
2.4GHz ISM
ecosystems to deliver connected services

- business-critical IT and user experience
- systems integrators
- network operator/MVNO
- module/silicon vendor
- specialist terminal design/manufacture
Invitation to register:

2020 – Visions of a Connected World

7 November 2013
Cambridge Wireless Connected Devices SIG
The Talking Point, Melbourn Science Park, Melbourn, Cambridgeshire
www.cambridgewireless.co.uk/sigs/connecteddevices/

Network • Collaborate • Innovate
Building IoT Networks Using Weightless™

October 3, 2013
Who is Neul?

Startup based in Cambridge, UK
- Founded in 2010
- Core engineering team founders of CSR plc

Building low-cost Weightless™ technology for the Internet-of-Things
- Developing (and supplying) low-cost endpoints and basestations
- Developing and delivering NeulNET™ Connected Device Platform (CDP) as a service

Key contributions to Weightless™
- Major contributions to Weightless™ PHY-layer and MAC-layer
- First implementation of Weightless™ in silicon
- First Weightless™ IoT networks in Q1 2014 and used by developers in Q2 2014
Internet of Things is both exciting and confusing

Gartner Hype Cycle
Internet of Things – what is it?

Dramatically better QoS
Dramatically lower costs
Totally new services
Totally new information

Data
Data analytics

Smart Waste
Water management
Vending
Parking
Washroom
Meters
Pest control
Smart Grid
Traffic management
Adaptive lighting
Here’s where we fit in.....

- Connectivity plays
  - LAN/PAN
  - Cellular
  - Low power WAN

- Edge plays
  - Aggregation

- Vertical mkt plays

- Applic Enablement Platform plays

- Visualization/toolkit plays

- Connected Device Platform plays
  - LAN
  - Cellular
  - LPWAN

- Metering play

- ‘Big Data’ analytics plays

- THINKBig Analytics
- IBM
- Electric Imp
- Intel
- Qualcomm
- Neul
- Redwood Systems
- Streetline
- Deteq
- Unfarm
- ThingWorx
- Xively
- Jasper Wireless
- Neul
- Sensus
- SilverSpring Networks
Low Power WAN is better than LAN

1. **Cheaper endpoints.** Yes, it really will be cheaper than LAN
2. **More reliable.** Clearly under control, with QoS
3. **Long battery life.** Multiple years in the field on a single small cell
4. **Ubiquitous.** ~96% pop coverage with seamless service

Why not cellular WAN?

1. **Too heavyweight.** Complexity, messaging overhead, qualification
2. **No obvious air interface.** GPRS re-farming, 3G & LTE unsuitability
3. **Short battery life.** Days or weeks
4. **Fragmented.** Each use is a mini-system integration project
Weightless™ Endpoint Roadmap
Driving lower cost through chip integration

$12
2014

$7
2015

$4
2016

TV White Space and narrowband operation
Weightless™ Basestation
NeulNET™ 2510 street furniture

**Physical**
- Ethernet connection to backhaul
- Power over Ethernet supply
- Panel Omni / Sectorised Antenna’s (similar to cellular)

**Initial Spectrum support**
- TVWS downlink (in 470-790MHz range)
- Narrowband uplink (in 410-790MHz range)

**Software**
- Implementation of Weightless™ BSC in Java
- Running on Linux

Sampling in Q1 2014, pre-commercial in Q2 2014
**Spectrum Challenges for IoT LPWAN**

### TODAY

- **License-exempt**
  - TV White Space (2º or 3º use)
  - ISM
  - SRD

  - Easy to get going
  - ISM/SRD for WAN risks poor QoS for all
  - TVWS tuning range adds endpoint costs

- **Licensed**
  - Specific licenses
  - Cellular

  - QoS assurances feasible
  - High hurdle to repurpose from cellular
  - Allocated known spectrum cuts endpoint costs

### FUTURE?

- **Agile IoT spectrum**
  - Hard allocation of TV channel(s)? (1º use)
  - Channelized into license-exempt & licensed or License Shared Access (LSA)
  - <1GHz Flexibly chargeable LSA to deliver QoS over WAN (price/database determines throttling & channel adjacency)
  - More spectrum >1GHz
Thank you
Panel discussion

- **Joint Radio Company**
  Adrian Grilli, Managing Director

- **The Technology Partnership**
  Antony Rix, Senior Consultant, Wireless Communications

- **Neul**
  Stan Boland, CEO

- **Toumaz Healthcare**
  Dr Alison Burdett, VP of Silicon Engineering
CONTENT, PRODUCTION AND TRANSMISSION

Peter Bury, Spectrum Policy Director, Ofcom
Session 5: Content, Production and Transmission
October 03, 2013
Richard Lindsay-Davies, Director General, Digital TV Group
Spectrum – the next decade

- Not only are existing transmissions here to stay, new service innovations are data hungry
  - **SD MPEG2** = 4 Mbps
  - **HD H.264** = 8 Mbps
  - **UHD HEVC** = 20 Mbps

- DTT is forecast to remain the most popular TV platform

- HDTV is now mainstream; is UHD on the way?
  - Major operators introduced HD after 5% penetration
  - All popular TV channels will be broadcast in HD
  - All Samsung TVs >32” are HD

- Technical efficiency innovations help but spectrum availability still ≠ mobile + broadcast demand

- Transition to new technologies and frameworks must balance both – COLLABORATE!

Sources: 3 Reasons LLP, Spring iteration (c) 2013
UHF band technology roadmap

Shaping the future of digital TV

2013
- 4G: LTE and TV services: co-existence in UHF
- Dynamic Spectrum: TV white space applications

2014
- UHD Defined: More pixels, better colour, motion and audio
- DTT Receiver Performance: Improved reception in crowded spectrum
- WRC-15: 700 MHz mobile and TV: More co-primary mobile and TV use
- 4k Production: Highest quality for premium content

2016
- Mobile Video: Content available via more devices
- UHD Realised: Step change in quality for the home
- 700 MHz Clearance: Potential spectrum clearance for mobile

2018
- Radio DSO?: Future of radio listening
- 5G: More than just faster data
The future of spectrum management is about collaboration

Helping to bring innovation to life through world-class collaboration

THANK YOU

rdavies@dtg.org.uk
www.dtg.org.uk
@DigitalTVGroup
Spectrum - The Next Decade
2nd-3rd October 2013 - Ofcom UK - Riverside House

Alan March - Sennheiser UK
What Is PMSE?

The term PMSE is a generic one - it stands for Program Making and Special Events - older attendees might know it as SAP or SAB - Services Ancillary to Program Making or Services Ancillary to Broadcasting. We are talking about wireless microphones, in-ear monitor systems, some wireless talkback and wireless audio links. And there are currently many, many thousands of these devices in use daily across the UK and millions across the EU and beyond.
Where Is PMSE?

Simply put - everywhere. PMSE touches the lives of almost every citizen and consumer in the UK. Film, Television, Sports Events, Churches, Musical Theatre, schools, colleges - it’s in this room this afternoon - I trust you are correctly licenced? Opening and closing ceremonies of large globally broadcast events - I believe we had a small example of that here in the UK last year - Peter might be aware of that one... The bottom line is that PMSE is inextricably linked, woven into the fabric if you like, of contemporary content production. And content production in the UK is big business...
PMSE - How Much?

Some Numbers?
PMSE - How Much?

Concert Managers Association - £3964.45 Million GBP  
Society Of London Theatres - £2411.10 Million GBP  
Theatre Manager’s Association - £1880 Million GBP

Figures from the Concert Manager’s Association suggest that UK PLC benefits to the tune of £3964.45 million pounds per annum. Figures compiled for the Society of London Theatres £2411.1 million pounds per annum - and this is just from a few square miles in London. A third set of figures from the Theatre Managers Assn., which represents regions outside of London suggests a further value of £1880 million pounds. Not inconsiderable sums, I’m sure you’ll agree. Yet current spectrum policy puts all of this, and a lot more, at risk.
PMSE - HM Govt. Recognition

“The great TV we produce and consume continues to define us as a nation, and is increasingly in demand around the world. The revenue generated from international sales of TV and associated activities grew by 9% between 2010 and 2011 to £1.4 billion. This is supporting jobs and growth across the UK’s creative industries as well as those moments when we gather together around the TV to watch great sporting achievements or the latest instalment of our favourite soap.”

Source - Connectivity, Content and Consumers
DCMS - July 2013

While only concentrating on TV in this statement, it is clear that DCMS, at least, recognise the importance of the UK’s creative sector and the value that it brings to the UK economy and the cultural lives of UK citizens and consumers. PMSE has been integral in driving up production standards over the years. The spectacular West End shows, Saturday night TV (X-Factor, Strictly etc), medium to large music concerts - the list goes on and on - none could be produced to the globally recognised high standards that they are, without PMSE. So why is current spectrum policy allowed to discriminate against an existing valuable service, that is critical to a significant portion of our economic and cultural wellbeing...
Discrimination?

A Strong Word?

A strong word yes, but from where we are sitting, that’s what it feels like...why?
We all know that the 800 MHz auction is done and dusted. However, what many of you may not realise is just how disruptive and costly this was for the PMSE sector. Even those that qualified for the hard won channel 69 funding scheme (compensation deal) still faced significant costs associated with equipment replacement in the field. These costs were not covered by the funding scheme, and if you were operating on frequencies in 800 MHz, but not in Channel 69, then your equipment did not qualify for inclusion in the scheme. Additionally, as at the time TV31 to 37 (550-606 MHz) was still being mooted as a band to be sold off, many professional multi-channel PMSE users and operators chose to replace their 800 MHz equipment with 700 MHz equipment...oh dear...
700 MHz - Going, going….gone?

Agenda Item 1.1 - more mobile broadband in general
Agenda Item 1.2 - mobile broadband using 700 MHz
WRC 15

The loss of the 800 MHz band was a serious set back for the professional PMSE sector. The loss of access to a further 96 MHz of spectrum - without alternative frequencies being identified outside of the UHF band - will be catastrophic for our sector - and so, as all of us consume PMSE derived content, by definition, everybody. The costs associated with moving the PMSE sector out of the 700 MHz band, I believe will lead to serious market failure. Businesses and owner operators will be forced out of business due to the costs associated with having to replace their PMSE equipment all over again.
Channel 70 (863-865 MHz)  
A questionable future?

For non-professional PMSE users the future for this small de-regulated slice of spectrum looks bleak. Interference from new LTE systems will almost certainly render the band unfit for use by PMSE equipment..
White Space Devices
A Brave New World?

Ofcom trials of new technology

And what of any interleaved spectrum that we might have left in UHF - after the loss of 168 MHz of spectrum and the shifting of DTV further down into the UHF band? It will have to be shared with an as yet, untested set of technologies that has the potential to interfere massively with PMSE operations. Especially as, with the release of the latest WSD Condoc, the work of 70 people over several months of the technical working group on WSD’s, seems largely to have been ignored.
We believe that any new technologies that come into the UHF band need to complement, not compromise existing services. New network providers run a real risk of shooting themselves in the foot as much of the content that they envisage being carried, highly profitably, across their networks, is derived using PMSE equipment. It’s an old adage, but it’s as true today as it was way back in analogue times...irrespective of your delivery platform, in the end, content is king!
PMSE - The Future - If Not UHF, Where To?

Investigate potential use of the bands 1200 to 1650 MHz?

Examine 174 - 216 MHz for semi-cognitive systems?

PMSE as primary user in 700 and 800 MHz duplex gaps based on cognitive use?

Consider what other bands could potentially be used by cognitive and semi-cognitive systems?

So, to finish this introduction, how might things change in the future? Continued use of the lower end of the UHF band is a preferred option, however it is critical that we start to examine NOW, other potential bands for PMSE use in the future. We, the PMSE community, are open to the future, but inadequate consideration for a user that generates and contributes so much, will make the lives of all citizens and consumers worse, not better. Better together is good...
Thanks for Listening.

Complement, Not Compromise
Content, Production and Transmission
Spectrum use now and in the future
Bo Olofsson, Director Product Research Group
Sky is a heavy spectrum user across a range of activities and frequencies

We use spectrum to create our content, deliver our services and connect our customers

*Sky content is also delivered by third parties across their own distribution networks which may use spectrum (e.g. use of Sky Go via LTE on mobile)*
There is undoubtedly a fast growing demand

- Demand for mobile data will increase exponentially in the short- to medium-term.

- Increased video traffic is a key driver in this growth.
  - Primarily driven by user consumption but also by more and increasingly complex production.

- Many different options needed to meet the increased demand for content.

- Wi-Fi is a fundamental component of serving this demand.
  - Wi-Fi networks already carry up to 20 times more internet data traffic than all cellular networks combined. Wi-Fi traffic growth is around 4-6 times that of cellular data growth. 4 out of 5 new wireless technologies using unlicensed spectrum.

Sources: Ofcom; RSPG; European Commission
Challenge is to enable different content delivery approaches to thrive and compete

- Approaches to spectrum allocation and access need to be revisited in light of expected demands.

- Existing uses of spectrum should be re-evaluated.

- Further licence exempt spectrum is crucial in meeting continued Wi-Fi growth.

- Dynamic spectrum access will enable innovative services to fulfil their potential.
Q&A

• **Digital TV Group**
  Richard Lindsay-Davies, Director General

• **BBC**
  Matthew Postgate, Controller, BBC Research & Development

• **BEIRG**
  Alan March, business development specialist at Sennheiser and an active member of BEIRG

• **BSkyB**
  Bo Olofssen, Director of Product Research Group
WIRELESS BROADBAND COMMUNICATIONS: 5G AND BEYOND

Graham Louth, Spectrum Policy Director, Ofcom
Spectrum Crunch

“Always Sufficient Rate” to give users the perception of “Infinite Capacity”

SPECTRUM:
The next decade
Exploring wireless innovation
5G and Beyond

Professor Rahim Tafazolli
Director, CCSR, 5GIC
University of Surrey
R.Tafazolli@surrey.ac.uk
Broadband Mobile Internet

- **Problems**
  - Mobile data traffic 1000x by 2020 compared with 2010
  - Mobile Data traffic is doubling every year
  - If trend holds –1000,000x by 2030
  - Capacity doubles every 10 years
    - Facing radio spectrum/Capacity crunch

- **Current thinking**
  - 1000x traffic = 1000 x capacity
  - 10 (more cells) x10 (BW) x10 (spectral efficiency)
  - Advance radio access technologies (new waveforms, massive MIMO, etc..), WiFi-offloading, New Frequency bands –mm bands......
UK Situation in 2020

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Number of Devices/km²</th>
<th>Busy Hour System Utilization</th>
<th>Average Area Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>8396</td>
<td>1260 (15%)</td>
<td>2.8Gbp/s/km²</td>
</tr>
<tr>
<td>2020</td>
<td>8867</td>
<td>1773 (20%)</td>
<td>53Gbp/s/km²</td>
</tr>
</tbody>
</table>

- UK needs at least >19 x capacity

Ref: InterDigital-Surrey Vision beyond 2020
Traffic demand after WiFi offload of:

- ~6% (case A2) in 2020
- ~25% (case A3) in 2020
<table>
<thead>
<tr>
<th>Demand Scenario (UK)</th>
<th>2012</th>
<th>2014</th>
<th>2016</th>
<th>2018</th>
<th>2020</th>
</tr>
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<tbody>
<tr>
<td><strong>(Profile &quot;A&quot;) - Working pop. Inner London</strong></td>
<td></td>
<td></td>
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<tr>
<td>TOTAL Demand (Gb/s/km²)</td>
<td>2.10</td>
<td>6.89</td>
<td>14.88</td>
<td>31.55</td>
<td>67.72</td>
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<td>ISD = 1000m; cell rad. = 333m</td>
<td>98-215</td>
<td>323-633</td>
<td>700-1520</td>
<td>1480-2900</td>
<td>3175-6225</td>
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<tr>
<td>ISD = 500m; cell rad. = 167m</td>
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<td>88-180</td>
<td>190-395</td>
<td>400-840</td>
<td>860-1800</td>
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<tr>
<td>ISD = 200m; cell rad. = 100m</td>
<td>24-48</td>
<td>32-66</td>
<td>70-144</td>
<td>146-305</td>
<td>313-653</td>
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<tr>
<td><strong>(Profile &quot;D&quot;) - UK Peak</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL Demand (Gb/s/km²)</td>
<td>0.47</td>
<td>1.54</td>
<td>3.33</td>
<td>7.06</td>
<td>4.68</td>
</tr>
<tr>
<td>ISD = 1000m; cell rad. = 333m</td>
<td>22-48</td>
<td>118-158</td>
<td>156-306</td>
<td>330-720</td>
<td>710-1546</td>
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<tr>
<td>ISD = 500m; cell rad. = 167m</td>
<td>6-12.2</td>
<td>20-41</td>
<td>42-88</td>
<td>90-188</td>
<td>192-403</td>
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<td>ISD = 200m; cell rad. = 100m</td>
<td>2-4.5</td>
<td>7-15.2</td>
<td>15-32</td>
<td>32-68</td>
<td>70-146</td>
</tr>
<tr>
<td><strong>(Profile &quot;F&quot;) - UK Mean</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL Demand (Gb/s/km²)</td>
<td>0.04</td>
<td>0.14</td>
<td>0.31</td>
<td>0.65</td>
<td>1.40</td>
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<tr>
<td>ISD = 1000m; cell rad. = 333m</td>
<td>2-4.4</td>
<td>6.7-14.5</td>
<td>14.4-31.4</td>
<td>31-67</td>
<td>65-143</td>
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<tr>
<td>ISD = 500m; cell rad. = 167m</td>
<td>0.5-1</td>
<td>1.6-3.3</td>
<td>4-8.2</td>
<td>13-17.3</td>
<td>17.8-37</td>
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<tr>
<td>ISD = 200m; cell rad. = 100m</td>
<td>0.2-0.4</td>
<td>0.6-1.4</td>
<td>1.4-3</td>
<td>3-6.3</td>
<td>6.5-13.5</td>
</tr>
</tbody>
</table>
National Roaming

![Graph showing relative gain compared to no sharing in different scenarios of inter-network inter-site displacement. The graph compares sharing at CA stage, sharing at CA & TTI level, Power Efficiency, and Gain of Sharing at CA stage and CA & TTI level.](Image)
SAMSUNG
Howard Benn
Head of Standards and Industrial Relations
Samsung Electronics R&D Institute

5G white paper
A brief introduction to Inmarsat

3rd October 2013
Business Overview

Market leader in MSS today moving into VSAT markets

Mobile Satellite Services (MSS)

‘Global Xpress’ Superbroadband Services

Today: MSS
- Market leader
- Global coverage in L-band
- Mission critical customer needs
- EBITDA margin 70%+

Tomorrow: MSS + VSAT
- Entering $2B established markets
- Global coverage in Ka-band
- Future-proof existing MSS business
- Fully-funded business plan

Strong core business and investment in new growth
Our global satellite network

- We operate 10 telecoms satellites in geostationary orbit
- 3 generations offering full global coverage for mobile broadband services
- Commercial life into the late 2020s
- Alphasat just launched – world’s most sophisticated telecoms satellite ever
- Nearly $2 billion invested since 2005
MSS markets

- Market leader in all sectors
- Mission-critical remote connectivity focus
- Unique safety services reliability & global coverage
- Extraordinary innovation record
- Strong subscriber growth
- EBITDA $643m
- 70% EBITDA margins
- Competition limited and facing financial challenges

<table>
<thead>
<tr>
<th>Maritime</th>
<th>56% of MSS revenue (^{(2)})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200,000 ships/3m crewmembers</td>
</tr>
<tr>
<td></td>
<td>Drivers: Ship management</td>
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<tr>
<td></td>
<td>Automation cost savings</td>
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<td></td>
<td>Crew welfare / access</td>
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<td></td>
<td>Smaller vessel adoption</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Land Mobile</th>
<th>18% of MSS revenue</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>200,000 users</td>
</tr>
<tr>
<td></td>
<td>~60% government business</td>
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<tr>
<td></td>
<td>Drivers: Military special ops</td>
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<td>International aid agencies</td>
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<td>Media: on-the-spot reporting</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Aviation</th>
<th>14% of MSS revenue</th>
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<tr>
<td></td>
<td>16,000 aircraft</td>
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<tr>
<td></td>
<td>~60% government business</td>
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<tr>
<td></td>
<td>Drivers: Military, VIP aircraft</td>
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<td>Business jets</td>
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<td>In-flight passenger connectivity</td>
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</table>
# High barriers to entry

## Multiple challenges for any new entrant

<table>
<thead>
<tr>
<th>Category</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital</strong></td>
<td>Scale needed to build a global network and fund replacement satellites</td>
</tr>
<tr>
<td><strong>Spectrum Rights</strong></td>
<td>Uniform global spectrum rights extremely challenging to secure and retain</td>
</tr>
<tr>
<td><strong>Orbital Slots</strong></td>
<td>Orbital locations can take years to secure and may not be available</td>
</tr>
<tr>
<td><strong>Licensing</strong></td>
<td>Inmarsat has established market access over 33 years of operations</td>
</tr>
<tr>
<td><strong>Distribution</strong></td>
<td>Distribution relationships with over 600 organisations, providing essential global reach</td>
</tr>
<tr>
<td><strong>Reputation</strong></td>
<td>33 years technical excellence and provision of global safety services</td>
</tr>
</tbody>
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**At least 6 years for a new competitor to enter the market**
The future

- Continued growth in core mobility services
- Successful launch of Global Xpress services
- Empower a rich solutions environment

Each strategic element reinforces the others
The Global Xpress revolution

Launching by year end

- A brand new global satellite network
- $1.4B move into Ka-band to deliver a huge step-change in data speeds
- 50 MB/sec anywhere, on the move
- Future-proofs our global mobility offering
- Expansion into $2B VSAT markets
- Revolution for air passenger connectivity
- Unique military Ka-band capability
- Service Enablement Platform investment
  - Provision of Global Xpress portal and test bed
  - Creates unique satellite application ecosystem
  - Fosters innovation across unique communities

World’s first global mobile superbroadband service
Panel discussion

- **University of Surrey**
  Professor Rahim Tafazolli

- **Samsung**
  Dr. Howard Benn, Head of Standard and Industry Affairs, Samsung R&D Institute

- **Inmarsat**
  Ruy Pinto, Chief Technology Officer

- **Ericsson**
  John Cunliffe, Chief Technology Officer, Western & Central Europe

- **EE**
  Kip Meek, Senior Advisor