Changes & Challenges

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Changes & Challenges

Introduction

Philip Marnick
Group Director
Spectrum Policy Group
Ofcom

Changes & Challenges

Agenda – Day 1

13:35 – 14:30	Turning Strategy into Reality & Spectrum Information
14:30 – 14:50	Keynote: Julius Knapp, Federal Communications Commission
14:50 – 15:10	*Coffee Break and technical demonstrations*
15:10 – 16:20	Dynamic Spectrum Sharing
16:20 – 17:25	Big ears, loud voices: Coexistence and RF technology
17:25 – 17:30	Day 1 close including outline of Day 2

Technical demonstrations

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Agenda – Day 2

09:30 – 10:00	Full Duplex Radios: From impossibility to practice
10:00 – 11:00	Coverage and Capacity – The mobile data challenge
11:00 – 11:15	Coffee break & technical demonstrations
11:15 – 12:30	The future of content delivery
12:30 – 13:30	Networking lunch and technical demonstrations
13:30 – 14:00	Keynote: World Radio Conference 2015
14:00 – 15:15	Internet of Things
15:15 – 15:30	Coffee break and technical demonstrations
15:30 – 16:45	Public Sector Spectrum Release
16:45 – 17:00	Conclusion and close

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TURNING STRATEGY INTO REALITY

Charles Jenne, Spectrum Policy Director, Ofcom

Changes & Challenges

Our Strategy

Objective	**Our key objective is to secure optimal use of spectrum in the UK i.e. the use that delivers the greatest value to UK citizens and consumers**				
The context of future spectrum management	Requirements for wireless service are likely to increase for many spectrum uses. This will lead to **growing competing demands** for key spectrum resources	Adopting **technologies that enable more efficient use** of spectrum will be crucial, There will still be **increased pressures on spectrum,** especially in concentrated geographical locations	Competing demands will need to be addressed by a mix of **spectrum re-purposing** to higher value uses and greater use of **spectrum sharing**		
Strategy in action	We will continue to combine the use of market mechanisms possible and effective and regulatory action where necessary. We will place a growing emphasis on four aspects of how we manage spectrum: Exploring **new forms of spectrum sharing** and extending **sharing across new bands** / Maintaining our increased focus on understanding the **coexistence challenges** associated with changes in spectrum use / Promoting **improvements in radio performance standards** to reduce future coexistence issues / Increasing the quantity and quality of **information on spectrum use** we make available When we do take action we seek to retain flexibility in order to create options, rather than dictate solutions. We will also **continue to play a leading role in international spectrum debates** where this is most relevant to good outcomes in the UK				
Priorities	Addressing future mobile data demands, the importance of mobile coverage and the availability of new mobile services	Implementing our strategy for the 700 MHz band and considering the evolution of Free-to-View TV	Supporting the Government's Public Sector Spectrum Release (PSSR) Programme	Addressing the challenges around future PMSE spectrum use	Enabling growth and innovation in M2M/IoT applications	Supporting Government in its consideration of the future wireless communication needs of Emergency Services

Spectrum trading

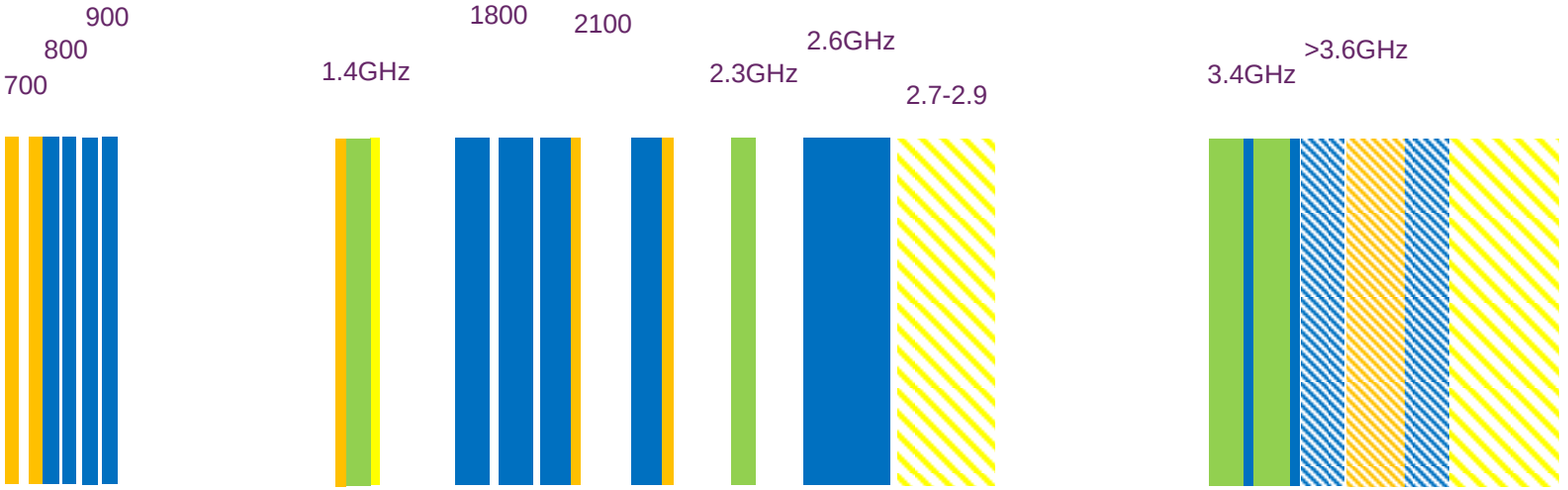
Sector	Traded licences (2008 – 14)	Total tradable licences (2014)	% turnover of licences over 2008-14
Business Radio	3684	47,168	8 %
Fixed Links	7596	31,782	24 %
Maritime	14	1,994	1 %
Satellite	15	418	4 %
Block Assigned	55	59	93 %
Total	**11,364**	**81,421**	**14%**

Our priority areas

- Mobile data demand
- 700MHz band and future of free to view TV
- Public Sector Spectrum Release

- PMSE (wireless cameras and mics)
- M2M/IoT
- Emergency services

Mobile Data Strategy – May 2014 statement



Mobile data - on going work

- International engagement (including WRC-15)
- Studies on candidate bands for future mobile data use (1.4GHz, 3GHz+)
- Keeping our priorities under review
  - Implications future technology developments (eg. 5G)
  - Maintaining a long term UK perspective on changing demand and supply option

  Development of tools to analyse mobile data spectrum access
- Mobile coverage

Changes & Challenges

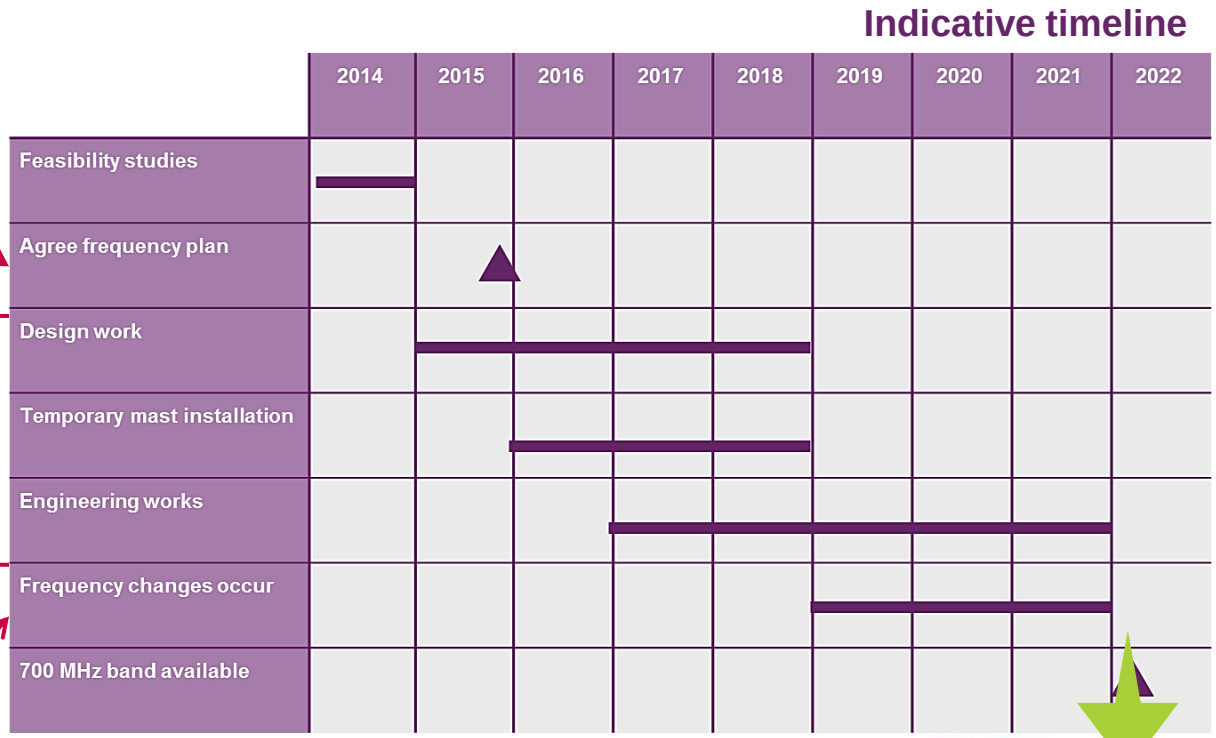
700 MHz and Free to view TV

May 2014 consultations on 700 MHz Cost Benefit Analysis and Future of Free to View TV

Detailed negotiations with neighbouring administrations and agreement on revised frequency plans will be required

Design and engineering work would take several years to carry out

Consumers would need to retune their receivers



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Public Sector Spectrum Release

- Work on 2.3 / 3.4 GHz spectrum release of MOD spectrum on-going. The work is split into two main areas:
  - Technical co-existence studies: Consultation ran Feb-May; main responses on Wi-Fi impact; testing ongoing; further consultation planned on Wi-Fi this winter.
  - Auction design due to consult in the autumn. This will also cover our competition assessment, technical and non technical licence conditions.
- Auction planned for FY 2015/16
- Work on sharing of MOD spectrum bands continues.

Changes & Challenges

PMSE

Wireless camera challenge

Reduced access in core bands around 2GHz and above

What we've done

- Independent study into technology evolution and future demand
- Completed analysis and stakeholder engagement to assure future spectrum needs are accommodated (major and national events)

Emerging solution

- security of tenure for remaining bands at 2GHz, additional channels at 7GHz and migration of some applications to 7GHz
- Licensing changes to support greater access

Policy statement later this year

Wireless microphone challenge

Reduced access to sub 1GHz spectrum

What we're doing

- Extensive demand analysis to identify impact of potential loss of access to 700MHz band
- Evaluating long tern sharing options in alternative bands through coexistence studies and stakeholder engagement
- Exploring scope for improvements in planning spectrum use for peak events and developments in microphone technology
- Close involvement of PMSE stakeholders in TV White Spaces

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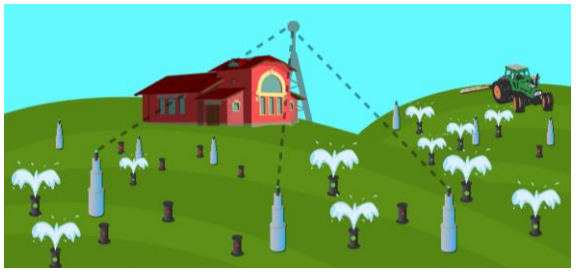
Internet of Things

- July 2014 Call for Inputs on IoT: wider than spectrum issues alone

- Existing spectrum options
  - Existing licenced services (GPRS etc)
  - Other licence exempt bands (eg. 868-870 MHz)

- 870 – 876 MHz band:
  - opened for licence exempt (M2M) use in June 2014
  - September 2014 consultation on allowing Network Relay Points

- Other possibilities:
  - New GSM standard (900 MHz) / LTE cat 0
  - 2 x 3MHz around 700 MHz and 800 MHz band plans
  - 55-68 MHz, VHF for backhaul
  - TVWS



Emergency Services

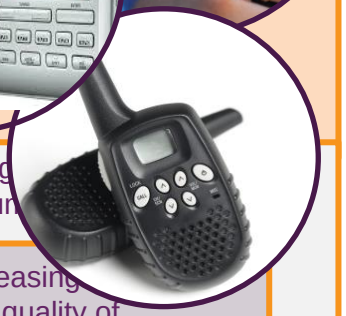
- Government procurement exercise under way for the next generation communications platform

- **Ofcom's role**
  - Advising users/HMG/Industry on related spectrum matters
  - International regulatory engagement within Europe and WRC-15

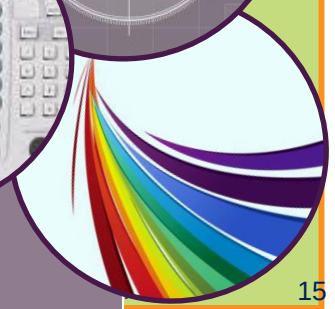
- **Key objectives**
  - realise benefits for both Emergency Services and public mobile data services in the 700MHz spectrum space whilst protecting DTT services
  - maximum flexibility in terms of spectrum access (primarily European context)
  - ongoing work to identify spectrum for supporting applications (core network requirements now deemed stable)

spectrum sharing

RF performance



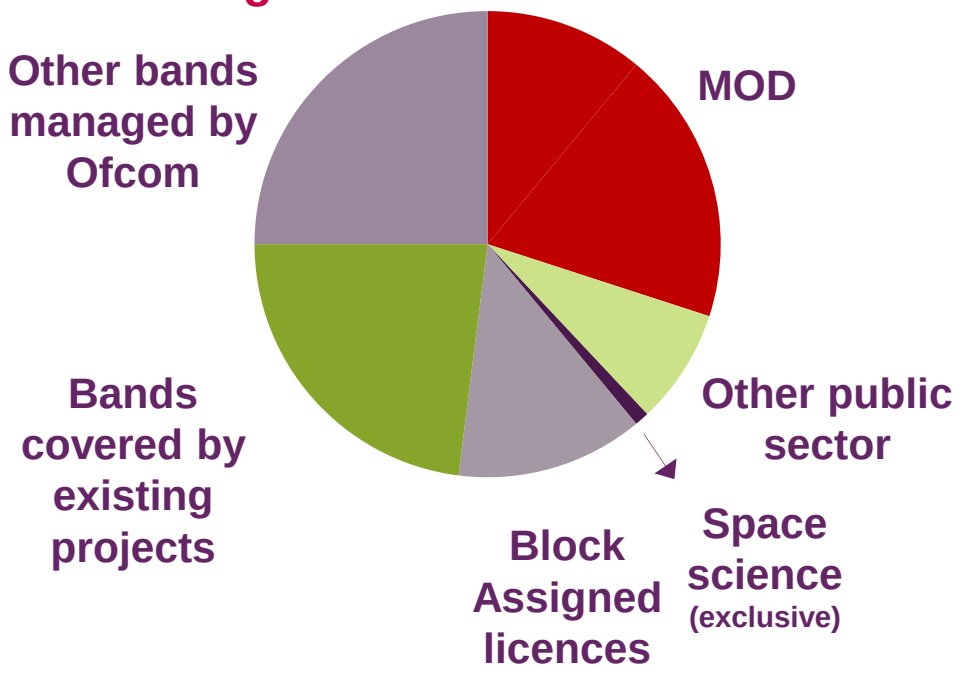
Managing Coexistence



Spectrum Information

Spectrum Sharing

Searching for candidate bands for new sharing



Development of sharing tools

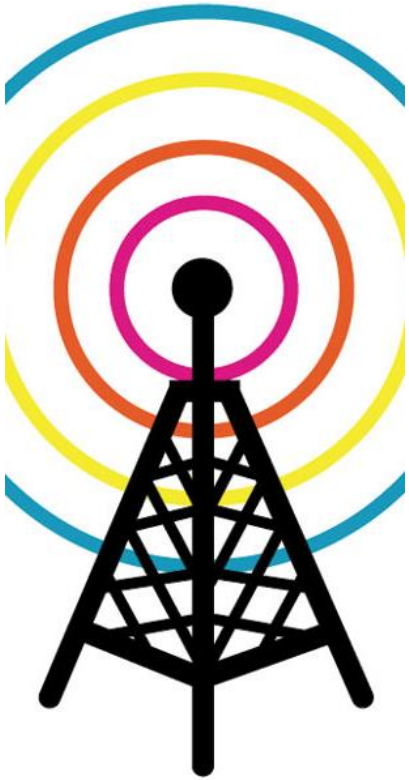
- Evolution of database managed sharing
- Ofcom coordinated sharing (e.g. 3.6 GHz, E- band, 1.4 GHz)

Regulatory initiatives

- UK leading work in CEPT on TVWS database sharing
- Legislation to facilitate database managed regulation?

Maintaining increased focus on coexistence

- Coexistence assessments integral to our work on changes in use, e.g.:
  - 800 MHz and DTT
  - TVWS and PMSE, DTT
  - 2.3 GHz release and Wifi
  - 1.4 SDL repurposing and adjacent fixed link assignments
- Is there scope for moving to less conservative approaches where risks are limited and credible mitigation approach is available in event of interference?



RF Performance

- Interventions driven by major changes in use:
  - Social alarm SRD ETSI standard
  - LTE device OOB limits in 700MHz
  - WiFi router selectivity in 2.4 GHz

Identify situations where case for regulatory engagement:

- Applications with greater risks
- Prospective change in RF environment

Understand effectiveness of different levers:

- Standards bodies / mandates to ETSI
- Direct engagement with industry players
- Information provision

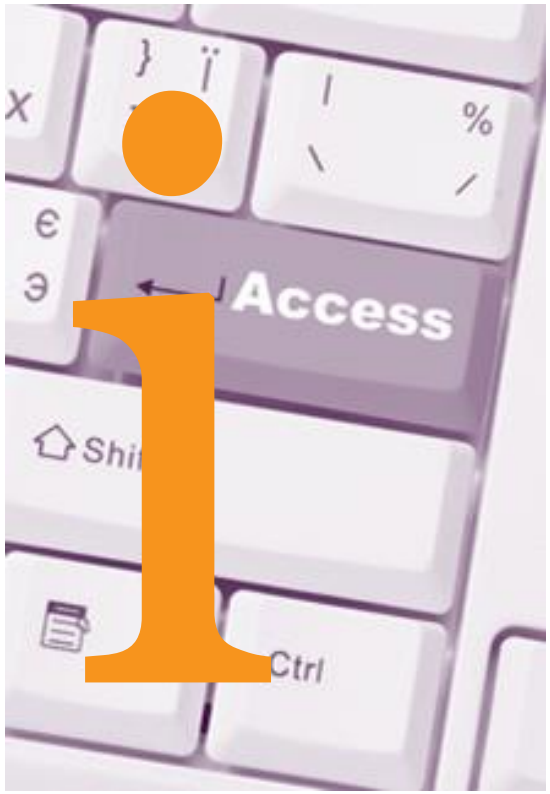
SPECTRUM INFORMATION

Cristina Data, Principal Policy Advisor, Ofcom

Changes & Challenges

Increasing focus on spectrum information

- Using information more intelligently
- Ensuring accessibility and usability
- Combining a variety of datasets to support the analysis
- Enabling wider access to data



Why?

- Spectrum information is essential to:
  - Enable spectrum management functions
  - Support stakeholders spectrum decision making process
  - Enable innovation

Available spectrum information tools

- UK Plan for Frequency Authorisation (UKPFA) provides information on spectrum managed by Ofcom
- Wireless Telegraphy Register (WTR) provides details on all tradable licences issued by Ofcom (and we are working on its extension to include all licence classes)

More recently Ofcom has:

- Published an Interactive Spectrum Map showing how spectrum is used in the UK.
- Published a online searchable version of the UK Frequency Allocation Table.

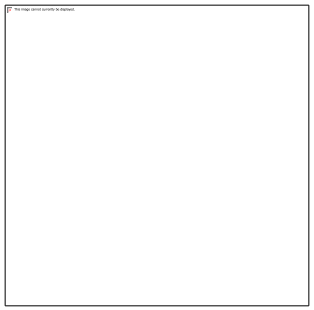
What else?
More?
Different?

KEYNOTE: JULIUS KNAPP

Julius Knapp, Chief of the Office of Engineering Technology
Federal Communications Commission

Changes & Challenges

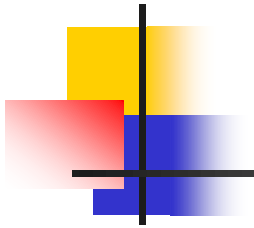
Spectrum Management Strategy in the USA



Julius Knapp, Chief
Office of Engineering and Technology

Ofcom Spectrum Event:
Changes and Challenges
October 1 - 2, 2014

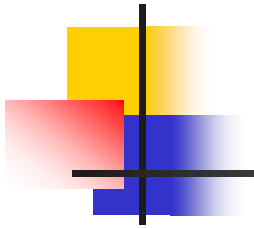
Note: The views expressed in this presentation are those of the author and may not necessarily represent the views of the Federal Communications Commission



Overview of Spectrum Strategy

Spectrum Strategy

- Driver: Growth of mobile & other services
- Key Milestones:
  - Jobs Act
  - National Broadband Plan
  - Presidential Memos
  - NTIA ten year plan
  - Department of Defense Spectrum Strategy
  - FCC spectrum speeches
- Strategy:
  - Consider potential reallocations, but becoming more difficult
  - Spectrum sharing
  - Continue to advance efficient use of the spectrum



Spectrum Reallocations: Advanced Wireless Service-3

AWS-3 et al / 1755 – 1850 MHz

- Spectrum Act calls for FCC to issue licenses for various spectrum bands by Feb. 2015
- 2155 – 2180 MHz band pairs ideally paired with 1755- 1780 MHz federal spectrum
- NTIA released report on potential for reallocation of federal spectrum at 1755 – 1850 MHz for wireless broadband
  - Challenges - - cost, complexity, time
  - Strong support for increased sharing
- NTIA convened work groups under Commerce Spectrum Management Advisory Committee (CSMAC):
- Department of Defense submitted proposal to share 1755 – 1780 MHz

Jobs Act - Section 6401 - Auction:

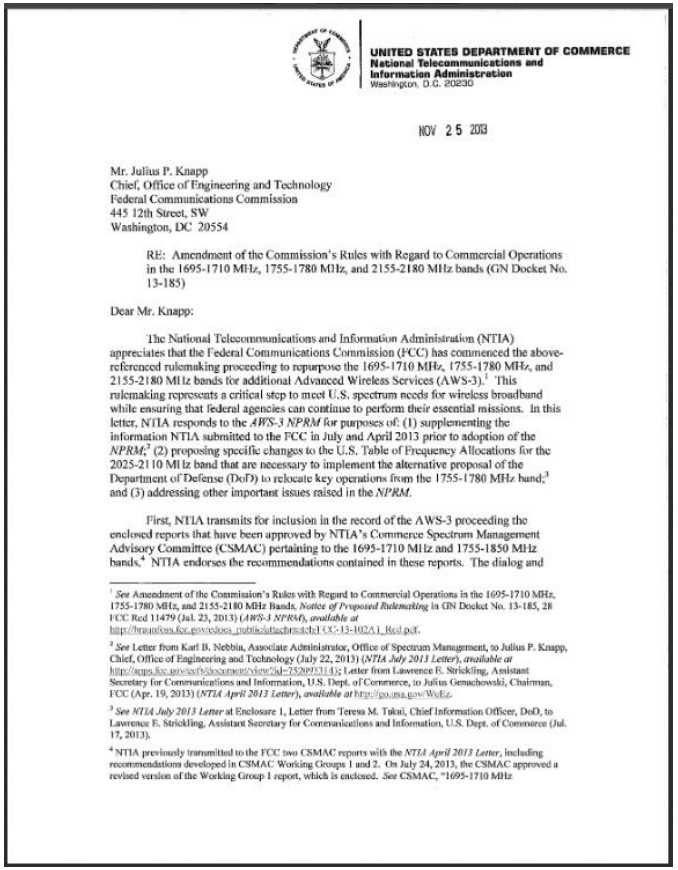
1915- 1920 MHz; 1995 – 2000 MHz;
15 MHz between 1675 & 1710 MHz;
2155 – 2180 MHz; 15 MHz to be identified by the Commission

Federal Incumbent Systems:

- Fixed Point-to Point Microwave
- Military Tactical Radio relay
- Air Combat Training System
- Precision Guided Munitions
- Tracking, Telemetry & Commanding
- Aeronautical Mobile Telemetry
- Video Surveillance
- Unmanned Aerial Systems
- Other Systems

Progress on AWS-3

- NTIA Nov. 25, 2013 letter supports DoD proposal
- Relocate most federal operations from 1755-1780 MHz
- DoD will maintain capabilities by sharing with broadcast auxiliary at 2025 – 2110 MHz
- FCC Adopted Report and Order 3/31/2014 (Gen Docket 13-185)
- DoD transition plans completed
- Auction to begin Nov. 13, 2014



UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, D.C. 20230

NOV 25 2013

Mr. Julius P. Knapp
Chief, Office of Engineering and Technology
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

RE: Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz bands (GN Docket No. 13-185)

Dear Mr. Knapp:

The National Telecommunications and Information Administration (NTIA) appreciates that the Federal Communications Commission (FCC) has commenced the above-referenced rulemaking proceeding to repurpose the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz bands for additional Advanced Wireless Services (AWS-3).[1] This rulemaking represents a critical step to meet U.S. spectrum needs for wireless broadband while ensuring that federal agencies can continue to perform their essential missions. In this letter, NTIA responds to the *AWS-3 NPRM* for purposes of: (1) supplementing the information NTIA submitted to the FCC in July and April 2013 prior to adoption of the *NPRM*;[2] (2) proposing specific changes to the U.S. Table of Frequency Allocations for the 2025-2110 MHz band that are necessary to implement the alternative proposal of the Department of Defense (DoD) to relocate key operations from the 1755-1780 MHz band;[3] and (3) addressing other important issues raised in the *NPRM*.

First, NTIA transmits for inclusion in the record of the AWS-3 proceeding the enclosed reports that have been approved by NTIA's Commerce Spectrum Management Advisory Committee (CSMAC) pertaining to the 1695-1710 MHz and 1755-1850 MHz bands.[4] NTIA endorses the recommendations contained in these reports. The dialog and

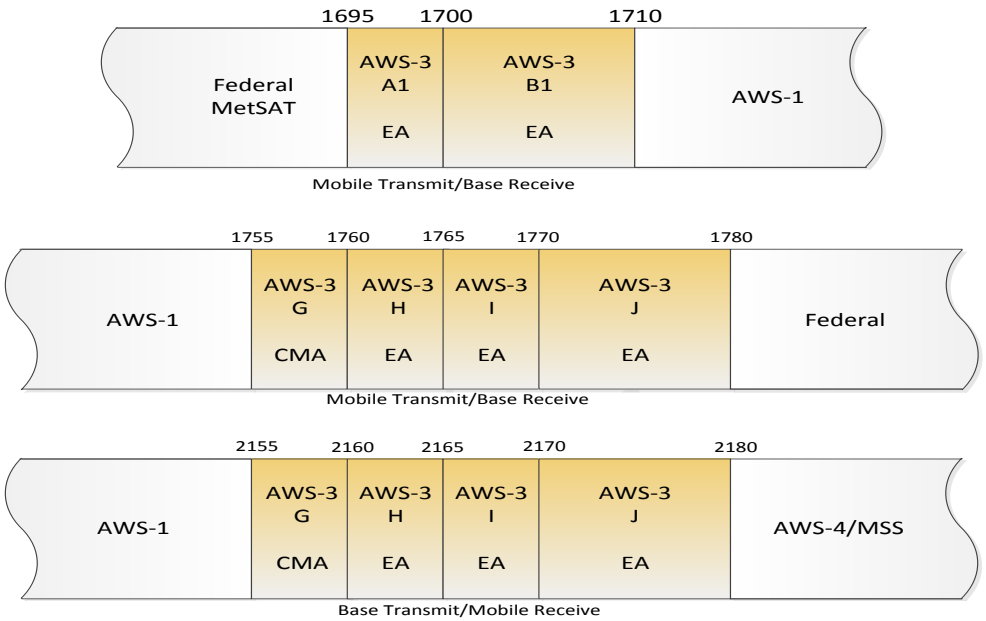
[1] *See* Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands, *Notice of Proposed Rulemaking* in GN Docket No. 13-185, 28 FCC Rcd 11479 (Jul. 23, 2013) (*AWS-3 NPRM*), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-13-102A1_Rcd.pdf.

[2] *See* Letter from Karl B. Nebbia, Associate Administrator, Office of Spectrum Management, to Julius P. Knapp, Chief, Office of Engineering and Technology (July 22, 2013) (*NTIA July 2013 Letter*), *available at* http://apps.fcc.gov/ecfs/document/view?id=7520955314; Letter from Lawrence E. Strickling, Assistant Secretary for Communications and Information, U.S. Dept. of Commerce, to Julius Genachowski, Chairman, FCC (Apr. 19, 2013) (*NTIA April 2013 Letter*), *available at* http://go.usa.gov/WsEz.

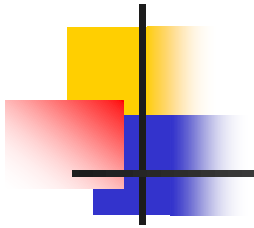
[3] *See NTIA July 2013 Letter* at Enclosure 1, Letter from Teresa M. Takai, Chief Information Officer, DoD, to Lawrence E. Strickling, Assistant Secretary for Communications and Information, U.S. Dept. of Commerce (Jul. 17, 2013).

[4] NTIA previously transmitted to the FCC two CSMAC reports with the *NTIA April 2013 Letter*, including recommendations developed in CSMAC Working Groups 1 and 2. On July 24, 2013, the CSMAC approved a revised version of the Working Group 1 report, which is enclosed. *See* CSMAC, "1695-1710 MHz

AWS-3 Report and Order



Block	Frequencis	Pairig	Bandwidh	Area	Licenss
G	1755-1760 and 2155-2160 MHz	2 x 5 MHz	10 MHz	CMA	734
H	1760-1765 and 2160-2165 MHz	2 x 5 MHz	10 MHz	EA	176
I	1765-1770 and 2165-2170 MHz	2 x 5 MHz	10 MHz	EA	176
J	1770-1780 and 2170-2180 MHz	2 x10 MHz	20 MHz	EA	176
A1	1695-1700 MHz	1 x 5 MHz	5 MHz	EA	176
B1	1700-1710 MHz	1 x10 MHz	10 MHz	EA	176



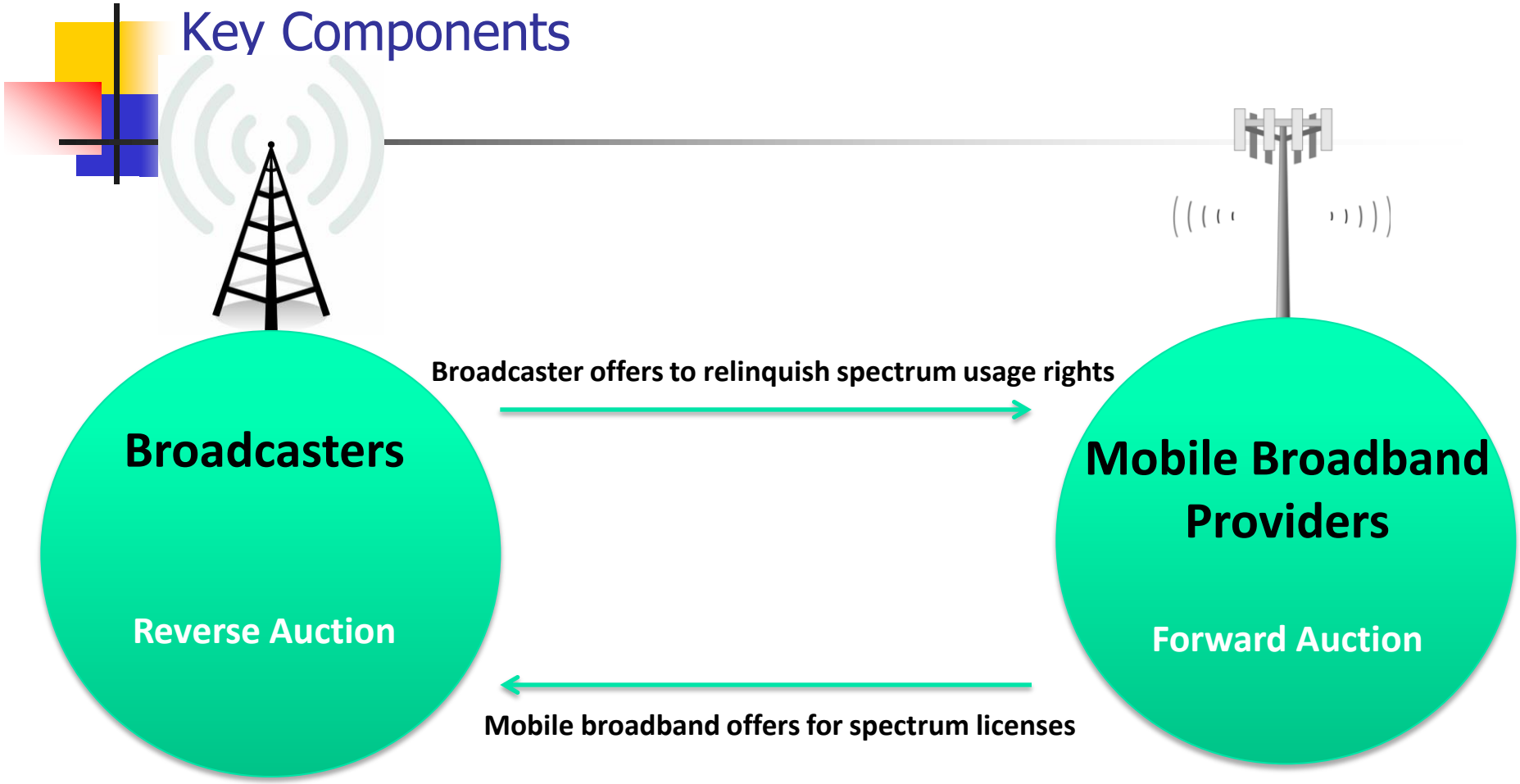
Spectrum Reallocations: Incentive Auction in TV Band

Background

"Seldom have I seen such a risk-free opportunity as that represented to broadcasters by the incentive auction." – Chairman Tom Wheeler

- The Incentive Auction is an innovative new tool authorized by Congress to help the Commission meet the Nation's accelerating spectrum needs.
- Incentive auctions are a voluntary, market-based means of repurposing spectrum by encouraging licensees to voluntarily relinquish spectrum usage rights in exchange for a share of the proceeds from an auction of new licenses to use the repurposed spectrum.
- In June 2014, the FCC released rules to implement the Broadcast Television Incentive Auction. Based on these rules, the FCC will develop and seek additional public input on detailed, final auction procedures in the pre-auction process.

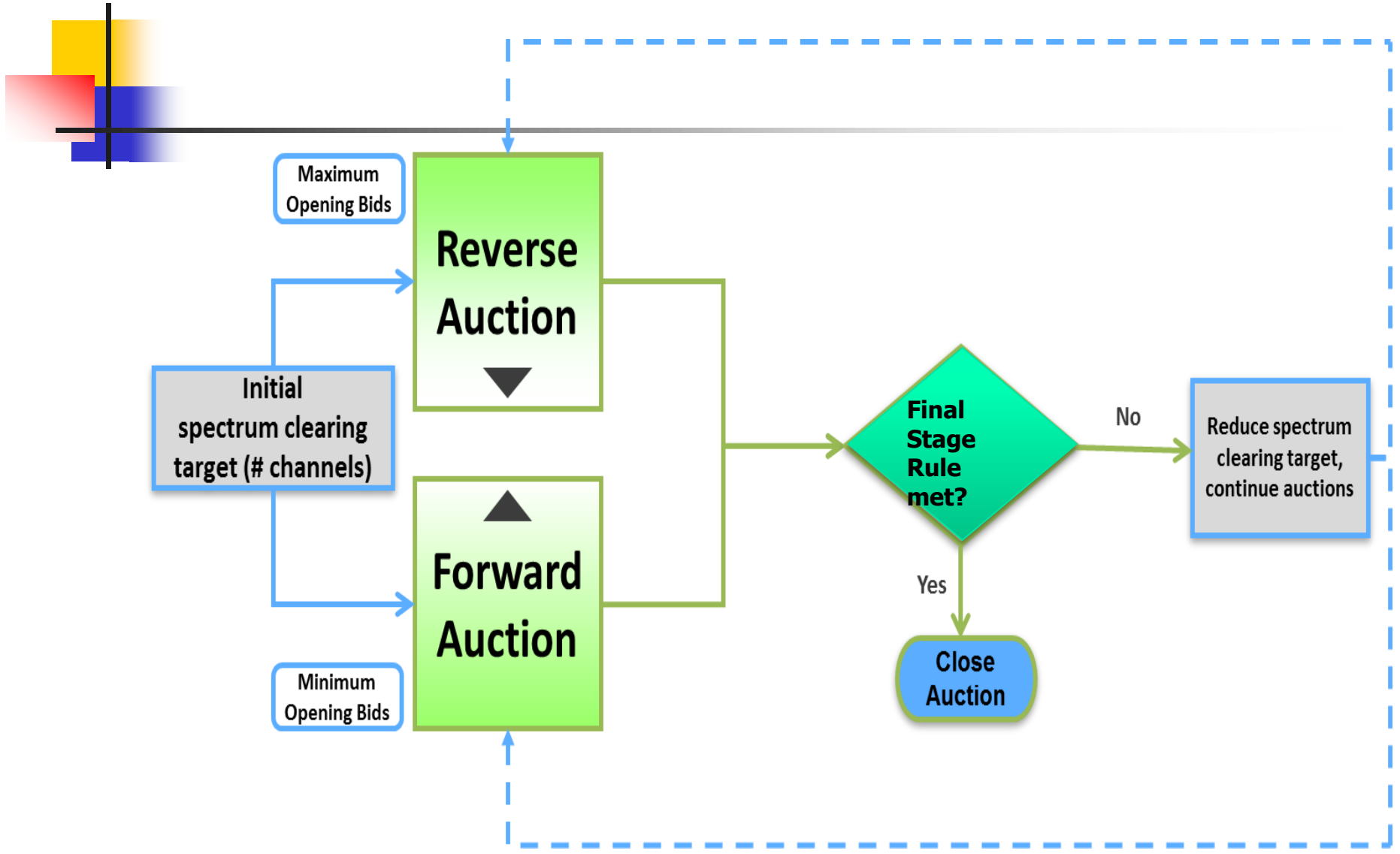
How the Auction Works—Broadcast Incentive Auction: Key Components



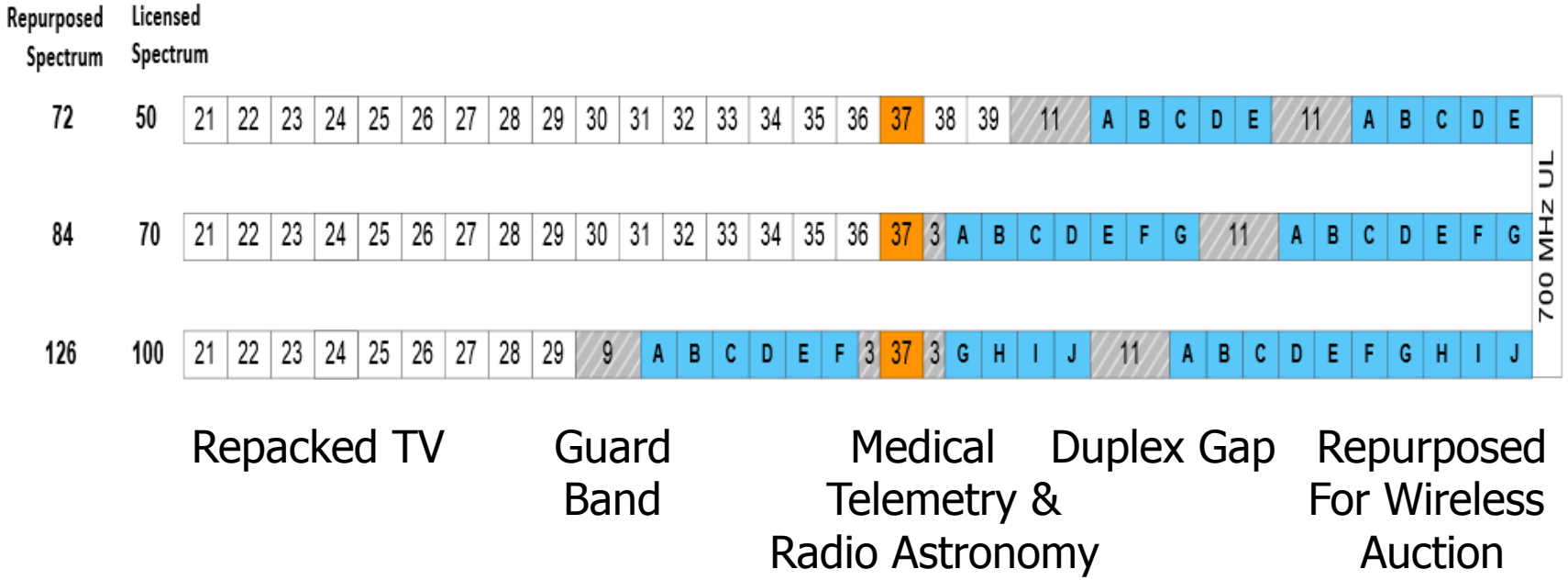
Broadcaster Bid Options

- ***Go Off Air***: Bid to relinquish license, receive payment, and go off air.
- ***Channel Share***: Bid to relinquish current channel, receive payment, and share a channel with another broadcaster after the auction.
  - Two channels in LA have already had great success sharing a channel in a pilot channel sharing program.
- ***U to V***: Bid to relinquish a UHF channel, receive payment, and move to either a high VHF (7 to 13) or low VHF (2 to 6) channel.
- ***High V to Low V***: Bid to relinquish a high VHF channel, receive payment, and move to a low VHF channel.

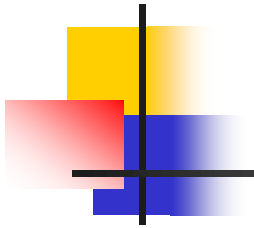
How the Auction Works—Auction Design Overview



TV Incentive Auction 600 MHz Band Plan



http://wireless.fcc.gov/incentiveauctions/learn-program/Broadcast_Incentive_Auction_101_slides.pdf



Spectrum Sharing: Unlicensed @ 5 GHz

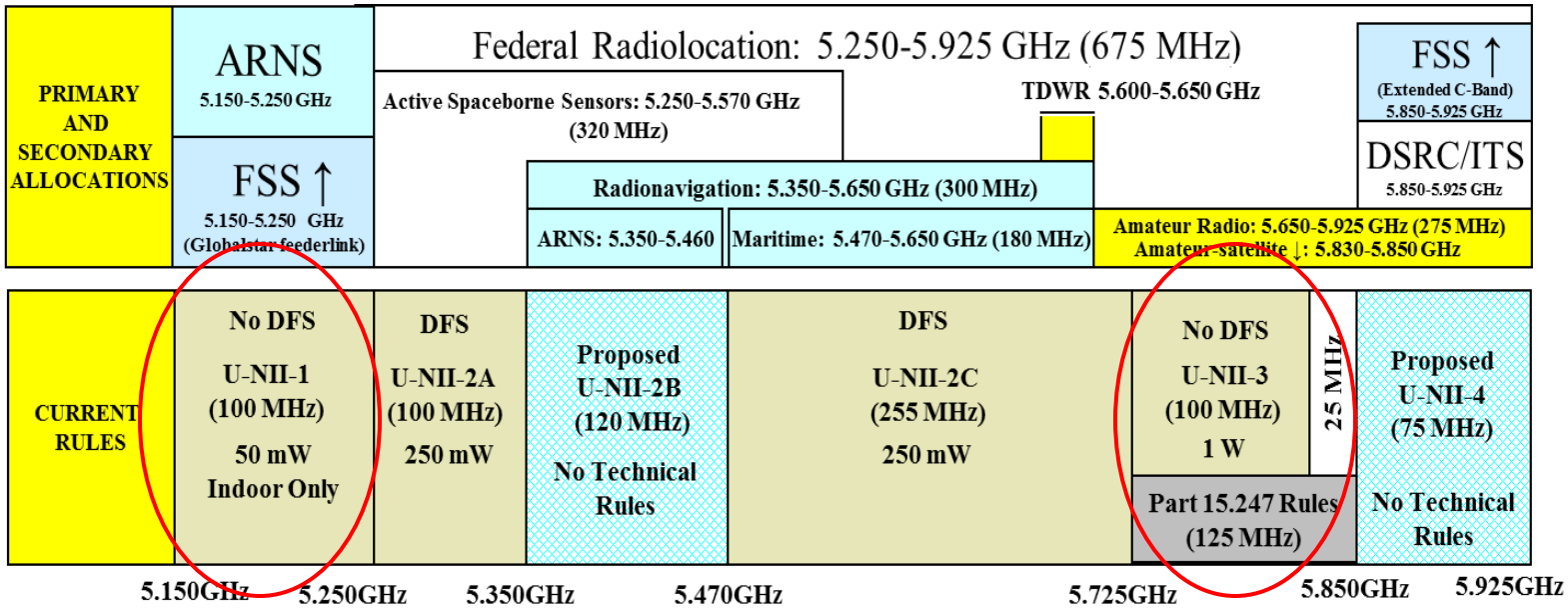
Proposal for Additional Spectrum for Unlicensed at 5 GHz **(ET Docket 13-49)**

- Existing Part 15 rules provide access to 555 MHz of spectrum for unlicensed use in the 5 GHz region
- U-NII-2A and U-NII-2C sharing with federal radars based on Dynamic Frequency Selection (DFS)
- Devices "listen" and perform processing to detect radars
- Jobs Act called for NTIA studies of access to add'l 195 MHz without interference to federal systems. First report Jan. 2013
- FCC issued proposal on 2/20/13 proposing to add 195 MHz of spectrum predicated on outcome of studies

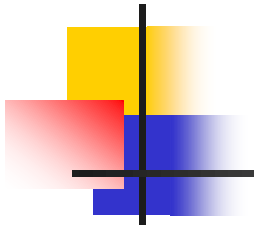
First Report & Order

Adopted 3/31/2014 ET Docket No. 13-49

Previous Rules



- For U-NII-1: Removed indoor-only restriction and increased permitted power: Increases utility of spectrum and accommodates next generation of Wi-Fi technology.
- Extended upper edge of the 5.725-5.825 GHz band to 5.85 GHz and consolidated
- Required all U-NII device software be secured to prevent its modification
- Modified rules to protect Terminal Doppler Weather Radar (TDWR) systems and other radars



Spectrum Sharing: TV White Space

Overview of TV White Space Rules

- Both fixed and personal/portable devices may operate in the TV white spaces on an unlicensed basis
- Devices must:
  - 1) include a geolocation capability and
  - 2) access a database of protected radio services at that location to obtain a list of available channels
- Database(s) established by third parties

Progress on White Space in the TV Bands (Unlicensed)

- Adopted final rules in 2012
- Nine devices approved:
  - Adaptrum, Koos Technical Services, Meld, Carlson, Redline and 6harmonix
  - All fixed devices, designed for professional installation - location entered manually
  - All are generic boxes with an input for a digital signal (voice, video, data).
  - About 450 devices deployed
- Data bases approved:
  - Spectrum Bridge, iconectiv (formerly Telcordia), Google and Key Bridge Global
- IEEE developing "af" standard
- Strong international interest

Meld Carlson Adaptrum

Spectrum Bridge iconectiv

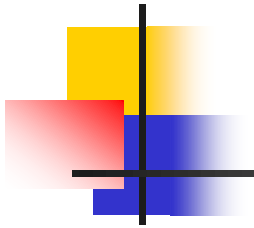
Wireless Cameras Cover Park in Wilmington NC

Data Base Administrator Approval Process

- File application
- Workshops
- Submit data base
- FCC Review
- Public beta test
- Final report
- Public comment
- Final approval
- Maintenance: Q&A's

White Space Database Administrators

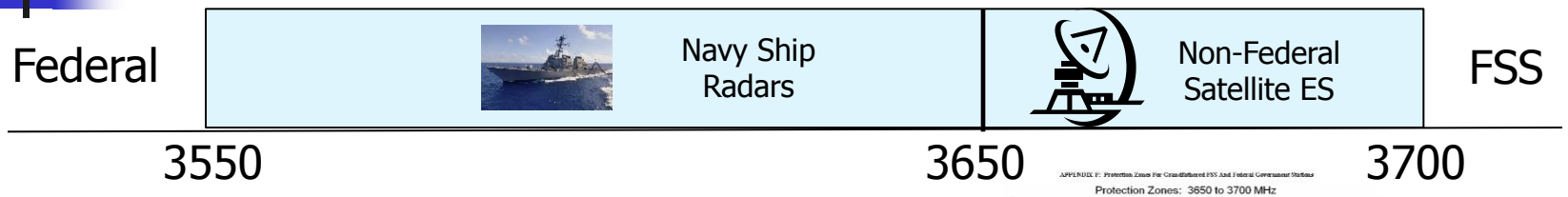
Administrator Name	Contact Information	Approval Status
Airity, Inc. (formerly WSdb LLC)		Pending
Comsearch	H. Mark Gibson, 19700 Janelia Farm Boulevard, Ashburn, VA 20147 mgibson@comsearch.com	Pending
Frequency Finder, Inc.	Peter Moncure, 8910 Dick's Hill Parkway, Toccoa, GA 30557 pmoncure@radiosoft.com	Pending
Google Inc.	Alan.Norman, 1600 Amphitheatre Parkway, Mountain View, CA 94043 alannorman@google.com	Approved
KB Enterprises LLC and LS Telcom	Dr. Georg Schöne, Im Gewerbegebiet 31-33, D-77839 Lichtenau, Deutschland GSchoene@LStelcom.com	Pending
Key Bridge Global LLC	Jesse Caulfield, 1600 Tysons Blvd., Suite 1100, McLean, VA 22102 jesse.caulfield@keybridgeglobal.com	Approved
NeuStar, Inc.	Brian Rosen, 1775 Pennsylvania Ave., NW, Washington, DC 20006brian.rosen@neustar.biz	Pending
Spectrum Bridge, Inc.	Peter Stanforth, 1064 Greenwood Blvd, Lake Mary, FL 32746 peter@spectrumbridge.com	Approved
iconectiv	John P. Malyar, 1 Telcordia Dr., Piscataway, NJ 08854 jmalyar@iconectiv.com	Approved
Microsoft Corporation	Ian Ferrell, One Microsoft Way, Redmond, WA 98052, ianf@microsoft.com	Pending



Spectrum Sharing: Small Cells @ 3.5 GHz

3.5 GHz Proposal (GN Docket No. 12-354)

December 2012



Analysis based on full power ubiquitous LTE network

Large exclusion zones Along the U.S. coasts

Figure 4-8. Terrain Dependent Exclusion Zone Distances for Shipborne Radar – 1

Federal fast-track spectrum at 3550 – 3650 MHz

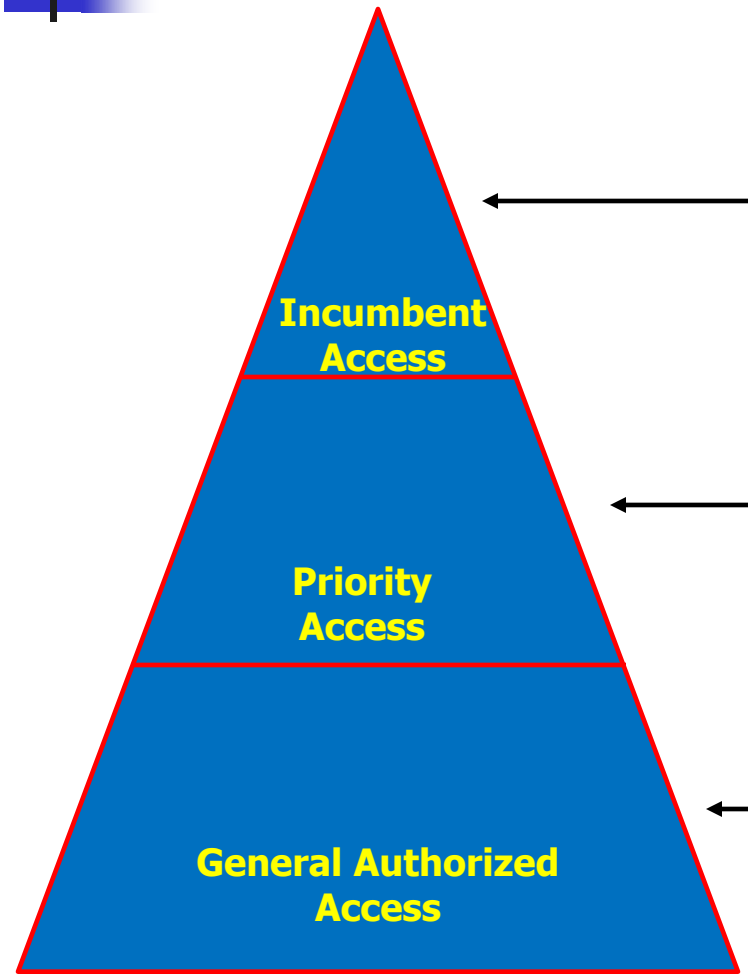
Formerly Federal Transfer Band at 3650 – 3700 MHz

Nationwide non-exclusive Licensing - - fixed broadband

Satellite Protection Zones

- FCC NPRM would provide for small cells and other uses through data base access / dynamic spectrum access - - reduce exclusion zones
- A small cell is a low power access point that operates in licensed spectrum
- A spectrum access system, incorporating a geo-location enabled dynamic database, would govern access to the 3.5 GHz Band
- Proposal considers including 3650 – 3700 MHz

3.5 GHz Spectrum Access Tiers



Incumbent Access: Includes authorized federal and grandfathered Fixed Satellite Service (FSS) users currently operating in the 3.5 GHz Band.

Priority Access: Authorize certain users to operate with some interference protection in portions of the 3.5 GHz Band at specific locations

General Authorized Access: Users would be authorized to use the 3.5 GHz Band opportunistically within designated geographic areas. GAA users would be required to accept interference from Incumbent and Priority Access tier users.

Spectrum Access System

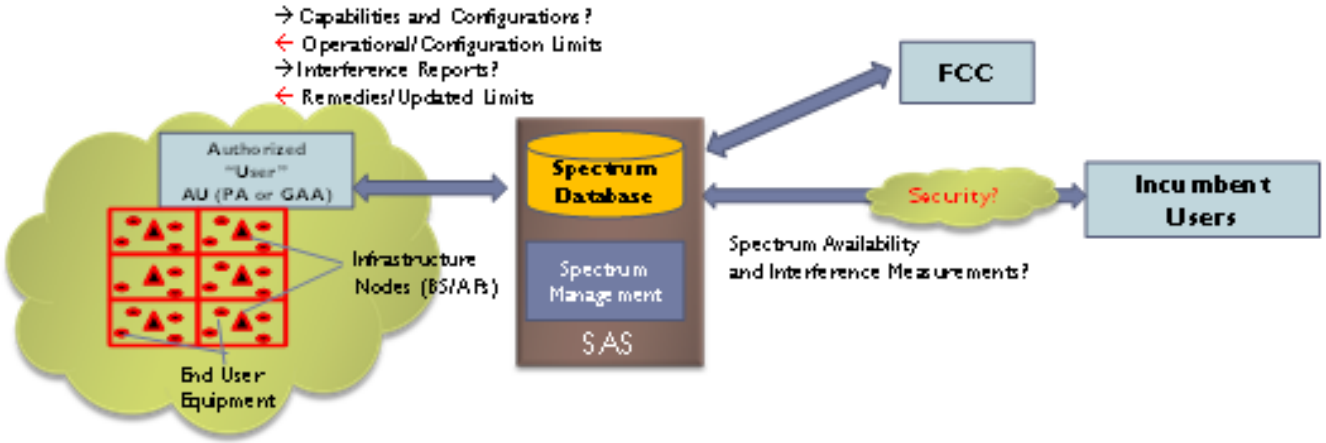
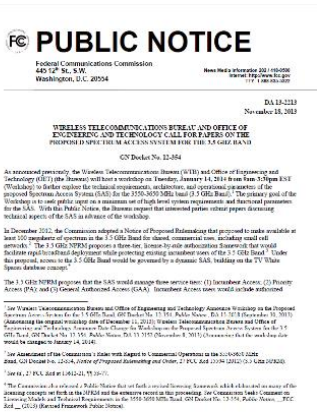


Figure 1: Spectrum Access System



PUBLIC NOTICE

Federal Communications Commission
445 12th St., S.W.
Washington, D.C. 20554

WIRELESS TELECOMMUNICATIONS BUREAU AND OFFICE OF ENGINEERING AND TECHNOLOGY CALL FOR PAPERS ON THE PROPOSED SPECTRUM ACCESS SYSTEM FOR THE 3.5 GHZ BAND

GN Docket No. 12-354

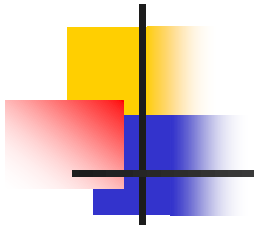
Public Notice Nov. 18, 2013: Call for Papers - Focus Areas:

- General Responsibilities and Composition of SAS
- Key SAS Functional Requirements
- SAS Monitoring and Management of Spectrum Use
- Issues Related to Initial Launch and Evolution of SAS and Band Planning

FCC Workshop was held on January 14, 2014

Further Notice of Proposed Rule Making - April 23, 2014

- Proposed text of rules
- Citizens Broadband Radio Service – Part 96
- Specific proposals:
  - Implement the three tier model
  - Exclusion Zones for incumbent federal operations
  - Create an open eligibility authorization system
  - Establish rights for the Priority Access tier
  - Set a defined "floor" for GAA spectrum availability,
  - Provisions for "Contained Access" Users
  - Baseline technical rules for fixed or nomadic base stations
  - Guidelines for operation and certification of SASs



Why Spectrum Sharing?

Why Spectrum Sharing?

- Will continue to seek potential reallocations
- Relocations increasingly complex, time consuming & costly:
  - PCS – Relatively easy
  - AWS-1 – Complex federal relocations
  - AWS-3 – Much more complex
  - Broadcast auxiliary spectrum reduction took 15 years!
  - TV Incentive Auction – Many stakeholders
- Many systems can't be moved (satellites, radars)
- Technology is enabling new sharing techniques

Incumbent Concerns: "Garage Door Opener" Issue

- Myth: Military forced to stop deployment of mobile radios
- Reality: Consumer outreach & coordination of roll-out with garage door industry
- Fear: Consumer Complaints will trump spectrum rights
- Remedy: Robust technology

Ix → Reduced range or stopped functioning

Robust Technology

Traditional Paradigm

- Device receives interference
- Little ability to cope – one trick pony
- Performance seriously degrades
- Or worse, totally unusable

New Paradigm

- Device receives "interference"
- Strong ability to cope – big bag of tricks
- Performance degrades gradually
- Shifts to alternative spectrum resources

Examples

- LTE
- Wi-Fi
- Certain Medical

"Show Me"

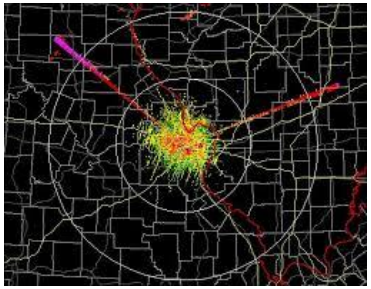
- Dialogue
- Tests

Security of Data Bases & Devices

- Need to prevent:
  - Outages via cyber attacks
  - Disclosure of classified or sensitive information
  - Modification of equipment
- Remedies:
  - Establish security provisions
  - Evaluate risks
  - Establish fallbacks
  - Enforce the rules

What occurs if data base is attacked?

How do we prevent changes?



How do we enforce to prevent interference?

Spectrum Rights & Controlling Interference

- Spectrum rights:
  - In the past, had your own lane
  - Now, lanes are shared

- Controlling interference
  - How to define harm?
  - Different expectations
  - Difficult when <u>everything</u> is flexible
  - Matters what you turn on

Turning on this . . .

or this?

Tackling the Issues

- Collaboration with NTIA, federal agencies & industry
- FCC & NTIA Notice of Inquiry: Creating a Model City
- FCC Technological Advisory Council
  - Interference harms claims threshold (receivers)
  - Probability in interference analyses
  - Sharing principles
  - Enforcement in dynamic sharing
- Investments in Sharing R&D:
  - Wireless Spectrum Research & Development (WSRD)
  - National Science Foundation (NSF)
  - Center for Advanced Communications (CAC)
  - Defense Advanced Research Projects Agency (DARPA)

DYNAMIC SPECTRUM SHARING

Charles Jenne, Spectrum Policy Director, Ofcom

Changes & Challenges

Panel

Peter Stanforth, Chief Technology Officer
Spectrum Bridge

Laurent Fournier, Senior Director, Business Development
Qualcomm

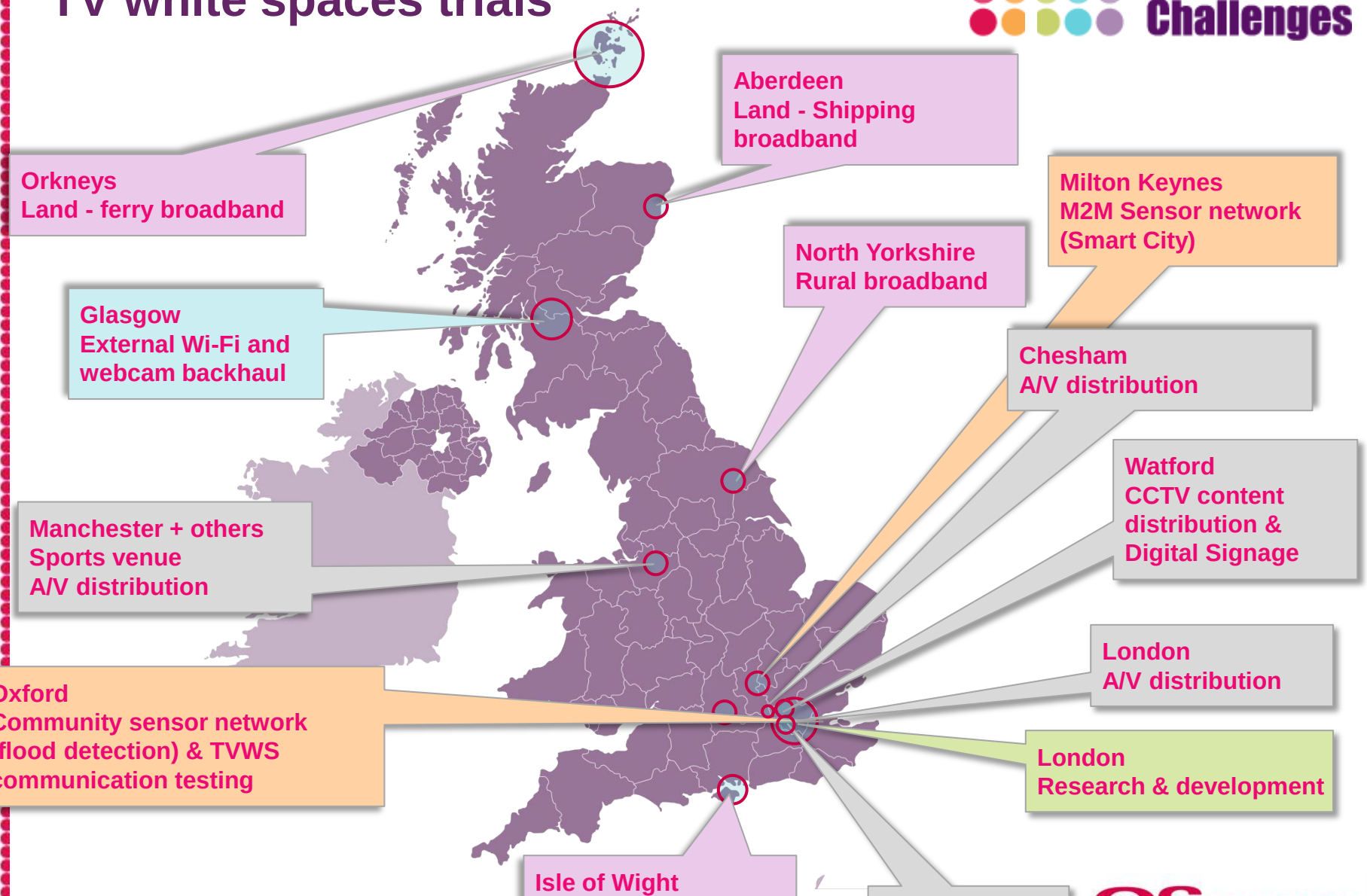
John Giusti, Head of Policy
GSMA

Kumar Singarajah, Director, Regulatory Affairs & Business Dev.
Avanti Communications Group plc

Julius Knapp, Chief of the Office of Engineering Technology
Federal Communications Commission

TV white spaces trials

Changes & Challenges



:map image ©iStock.com/rambo182

Ofcom

Peter Stanforth
Chief Technology Officer
Spectrum Bridge (US)

Laurent Fournier
Senior Director, Business Development
Qualcomm

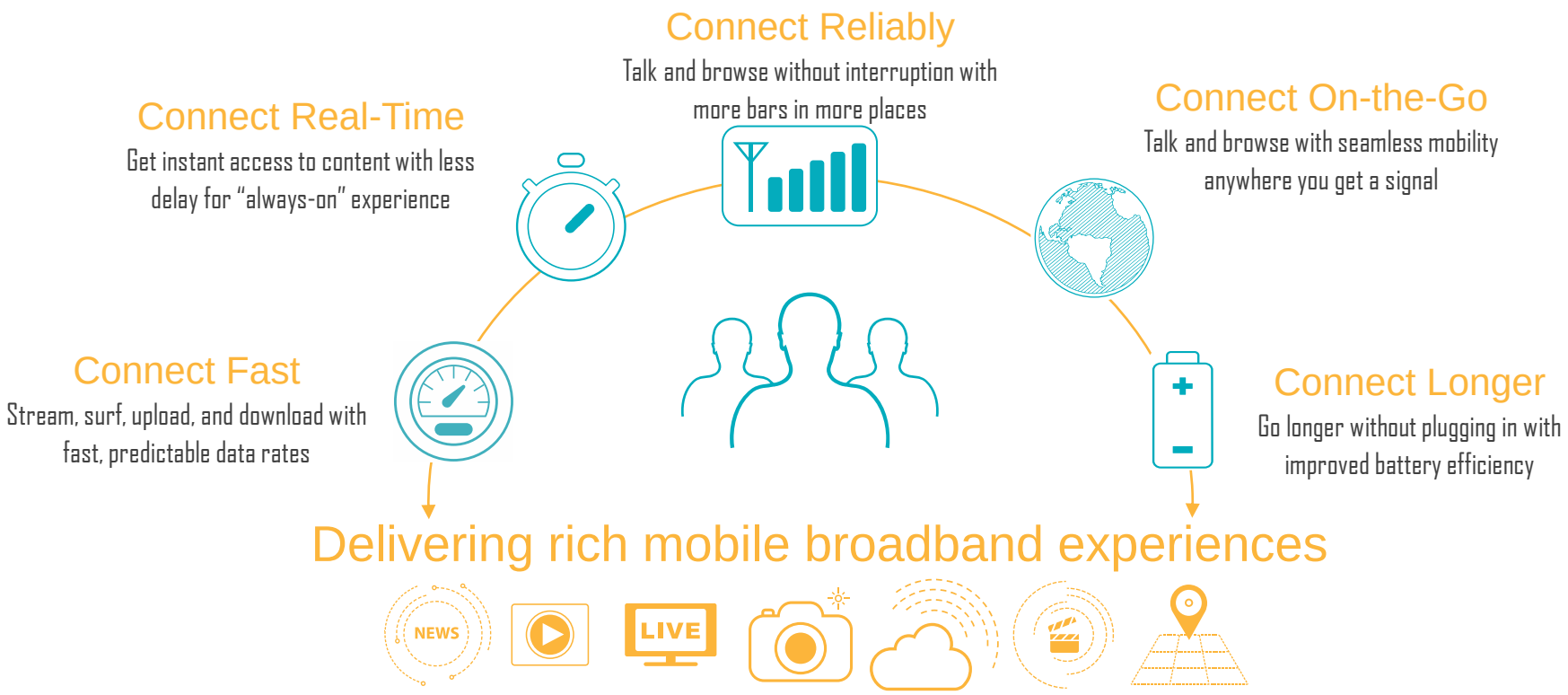
October 2014

Spectrum

The Lifeblood of Mobile Connectivity

QUALCOMM®

Connectivity is the foundation of a great mobile experience



Spectrum is the lifeblood of mobile connectivity

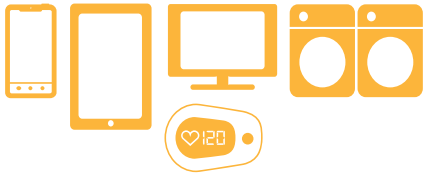
The airwaves that all wireless communications travel on

More
Spectrum
→ More
Capacity
→ Faster
Data
Rates

Richer content

Bestseller example (more video):

- 5.93 GB — Movie (High Definition)
- 2.49 GB — Movie (Standard Definition)
- 0.0014 GB — Homepage
- 1.8 GB — Game for Android
- 0.14 GB — Soundtrack



More connections

~25 Billion — Interconnected device forecast in 2020[1]

~7 Billion — Cumulative smartphone forecast between 2013-2017[2]

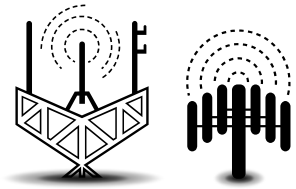
[1] Machina Research, Oct. '12; [2] Gartner, Sep. '13

We need to make best use of all available spectrum for 1000x

Use more spectrum (Hz) with more licensed spectrum as industry's top priority

Licensed Spectrum

Auctions of cleared spectrum for Mobile 3G/4G

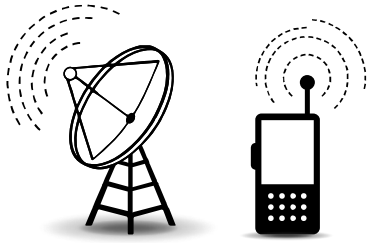


Exclusive use

Industry's top priority, ensures quality of service (QoS), mobility and control

Shared Licensed Spectrum

Complementary licensing for 3G/4G: Licensed Shared Access (LSA)

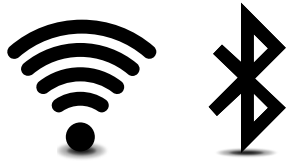


Shared exclusive use

LSA required when government spectrum cannot be cleared within a reasonable timeframe, or at all locations

Unlicensed Spectrum

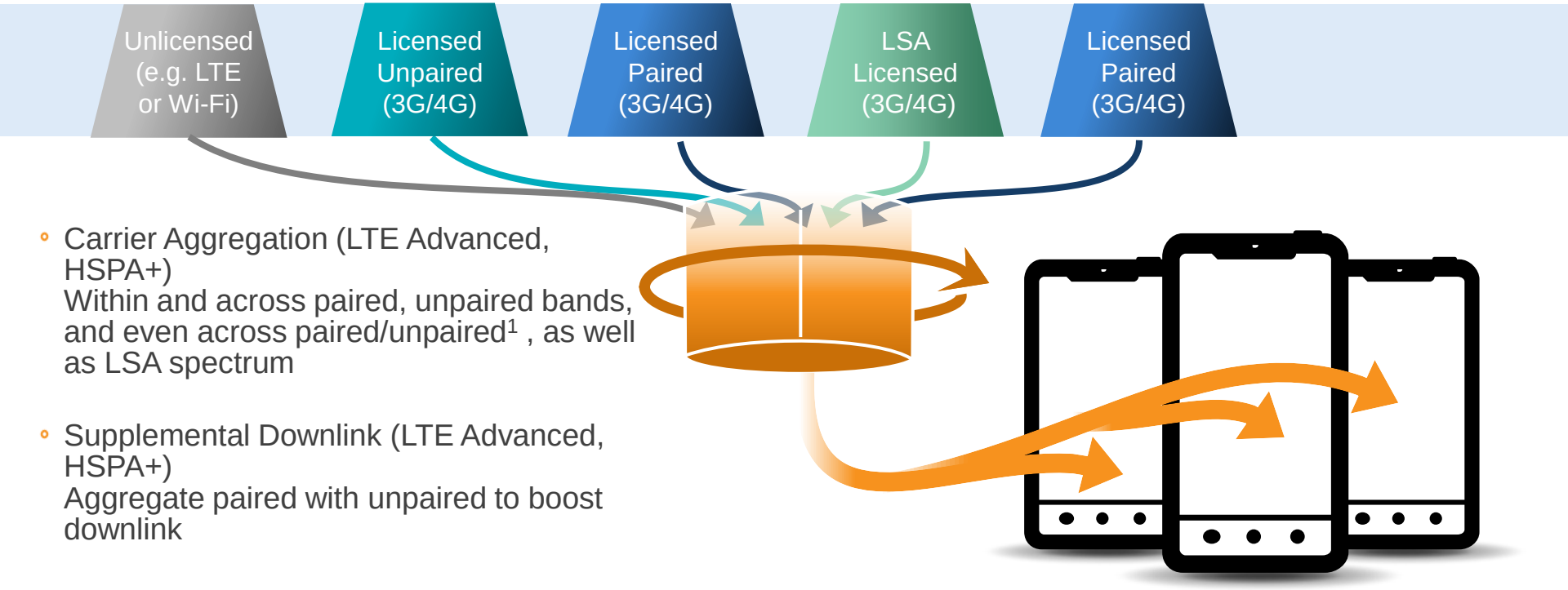
Multiple technologies (Wi-Fi, LTE, BT & others)



Shared use

Unpredictable QoS, good for local area access and opportunistic use for mobile broadband

Spectrum aggregation makes best use of all spectrum assets



- Carrier Aggregation (LTE Advanced, HSPA+)
  Within and across paired, unpaired bands, and even across paired/unpaired[1] , as well as LSA spectrum
- Supplemental Downlink (LTE Advanced, HSPA+)
  Aggregate paired with unpaired to boost downlink
- Aggregate Unlicensed (LTE Advanced)
  Aggregate unlicensed and licensed spectrum
  with a unified LTE network

[1]LTE Advanced supports FDD or TDD aggregation, but FDD and TDD aggregation is a candidate for future revisions of the standard

Small cell hyper densification through all deployment scenarios

Bringing the benefits of more ’unplanned’, ad-hoc deployments to all scenarios

RESIDENTIAL/NSC

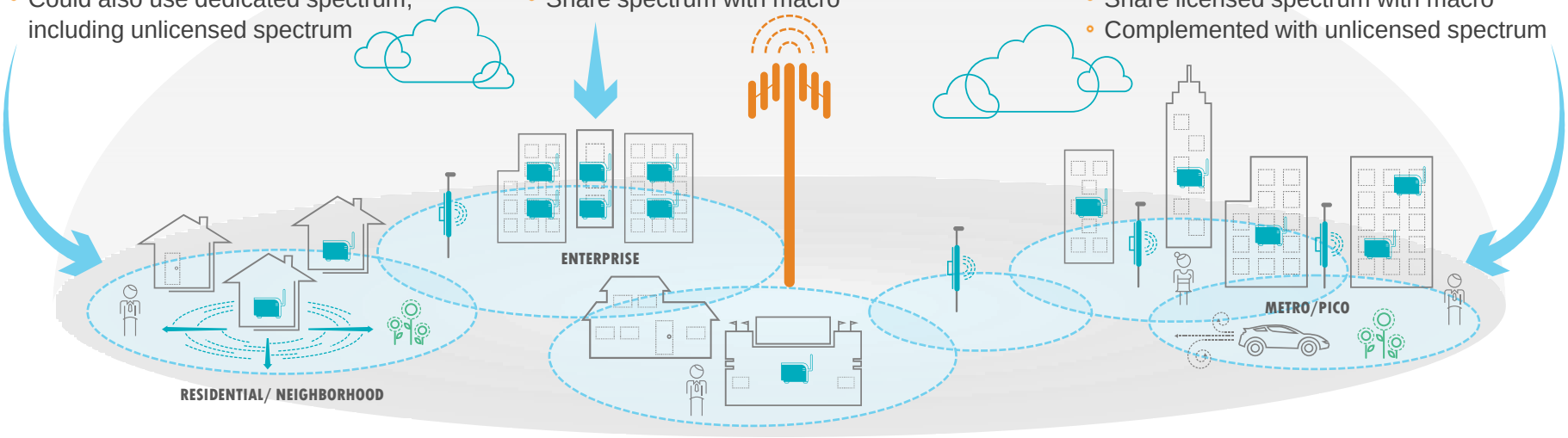
- Typically user deployed indoor small cells leveraging existing backhaul
- Open/hybrid access
- Also indoor to outdoor coverage (NSC)
- Could also use dedicated spectrum, including unlicensed spectrum

ENTERPRISE

- High density indoor cluster deployment by operator, IT department or third party
- Open/hybrid access
- Mainly indoor coverage
- Share spectrum with macro

METRO/PICO

- Mainly outdoor deployments by operator, or contractor/partner
- Open access
- Mainly outdoor coverage
- Share licensed spectrum with macro
- Complemented with unlicensed spectrum



Note: Unplanned from an RF perspective, there may still be other planning aspects (like permits) NSC=Neighborhood Small Cell

Key technology enablers to small cells everywhere

Self Organizing Networks (SON)	Interference Management	Backhaul—drives Small Cell Solution	Highly Compact, Low-cost Small Cells
Taking **plug and play** to the next level	So that **capacity scales** with small cells added	**Operator Provided:** fixed, wireless, relays	
Enables **hyper-dense** small cell deployments	Best with **device and network features** such as range expansion FeICIC/IC	**User Provided** enables user installed small cells	

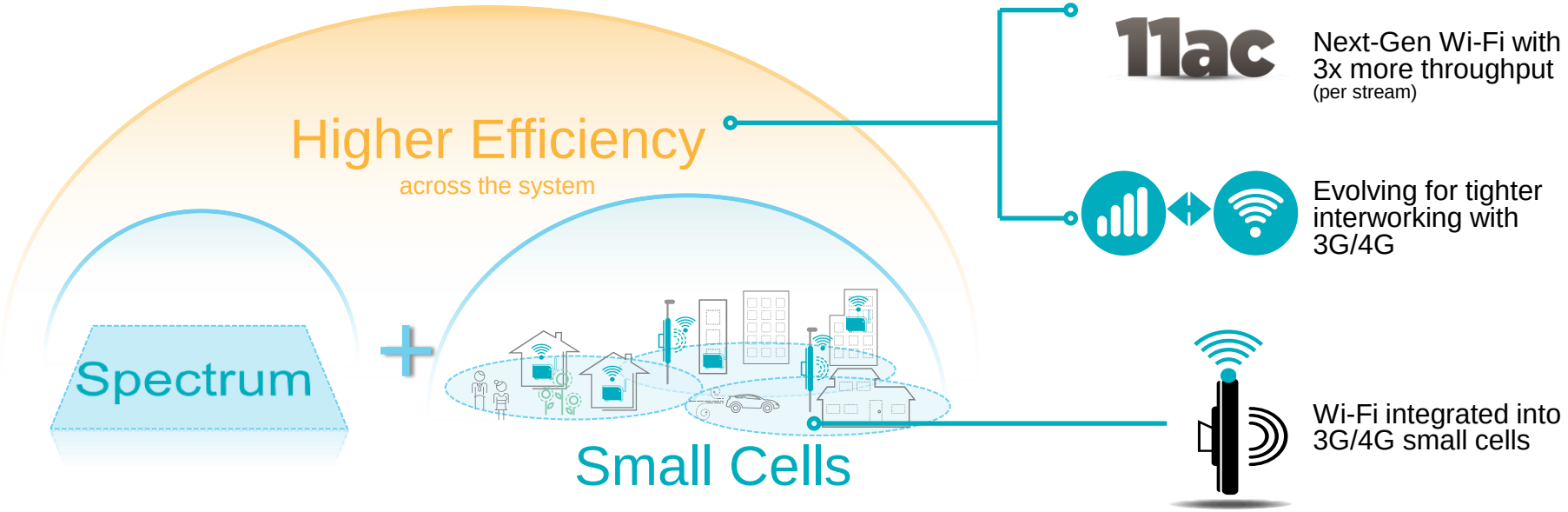
Qualcomm Technologies' UltraSON solves multiple challenges:

- SON for all small cell deployment scenarios
- Inter-small cell resource management (ICIC)[1]
- Backhaul prioritization/ management
- Tight integration with Qualcomm Technologies' FSM platform

[1] Using e.g. 3GPPs ICIC (Inter Cell Interference Coordination) between small cells primarily in the frequency domain. In addition, FeICIC interference management in the time-domain between small cell and macro with advanced receiver devices provides small cell range expansion and more capacity

UltraSON and FSM are products of Qualcomm Technologies, Inc.

Bringing 1000x closer to reality: Opportunistic use of Carrier Wi-Fi in small cells



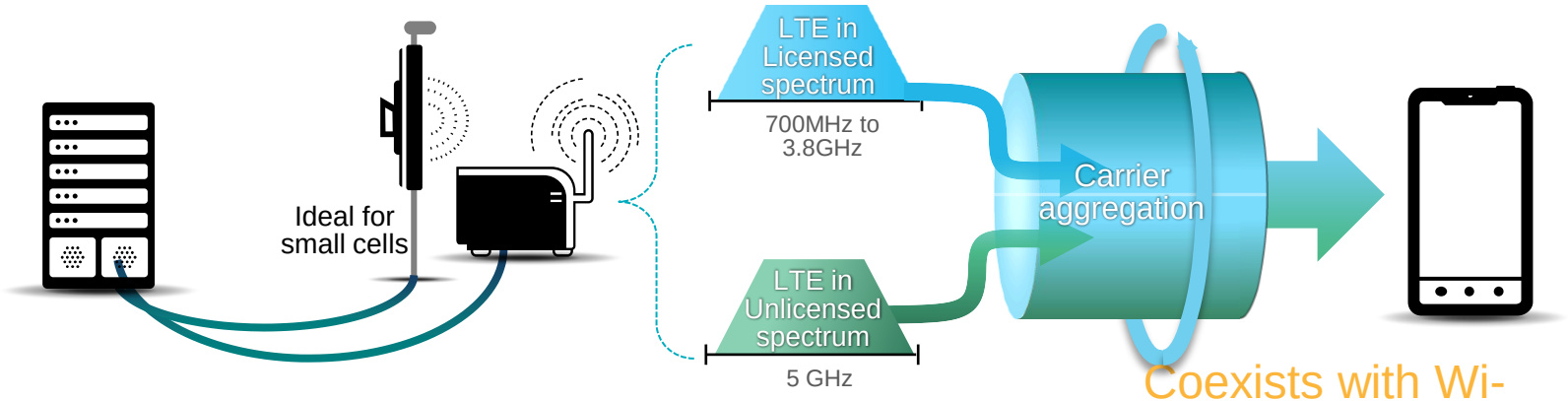
Bringing 1000x closer to reality: Extending the benefits of LTE Advanced to unlicensed spectrum

Better performance

Longer range and increased capacity

Enhanced user experience

Thanks to LTE Advanced anchor in licensed spectrum with robust mobility



Unified LTE Network

Common LTE network with common authentication, security and management.

Coexists with Wi-Fi

Features to protect Wi-Fi neighbors

Thank you

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www.qualcomm.com & www.qualcomm.com/blog

Changes & Challenges

John Giusti
Head of Policy
GSMA

Ofcom

THE IMPACT OF SPECTRUM MANAGEMENT ON MOBILE BROADBAND

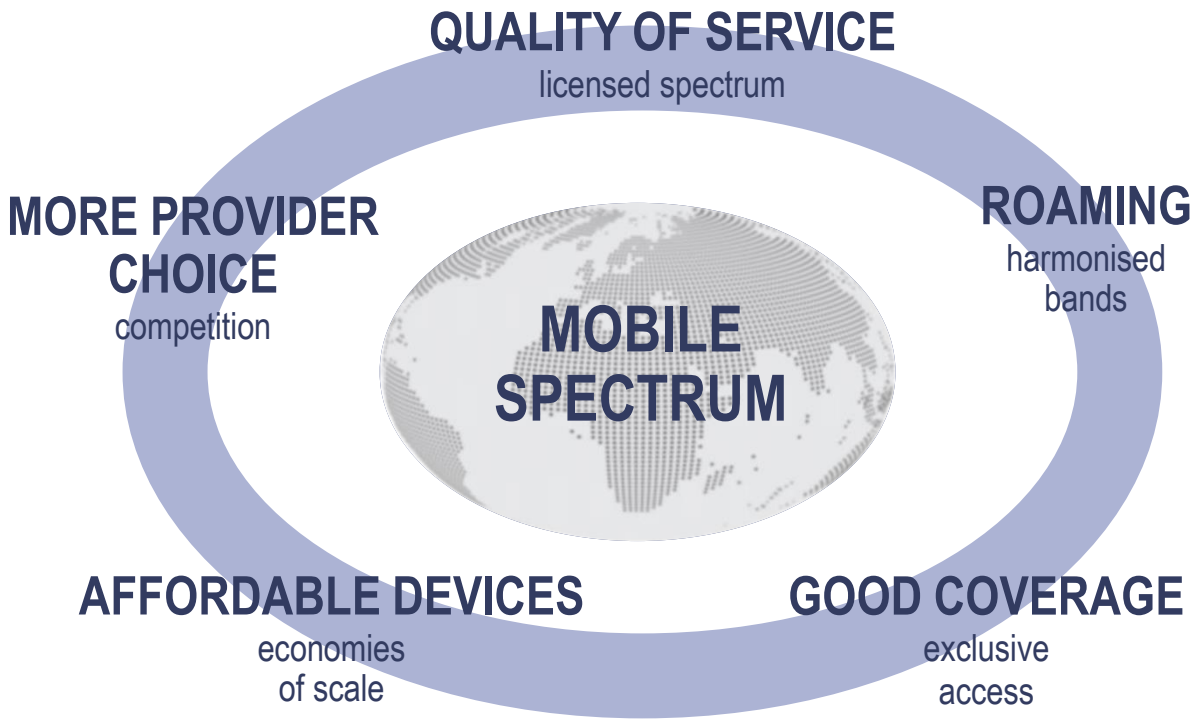
Recognising the unique role of licensed spectrum

John Giusti, Head of Policy, GSMA

1ST OCTOBER 2014

THE VIRTUES OF EXCLUSIVE LICENCES

GSMA BELIEVES EXCLUSIVE ACCESS SHOULD REMAIN THE MAIN REGULATORY PRIORITY DUE TO ITS UNIQUE ABILITY TO DELIVER:

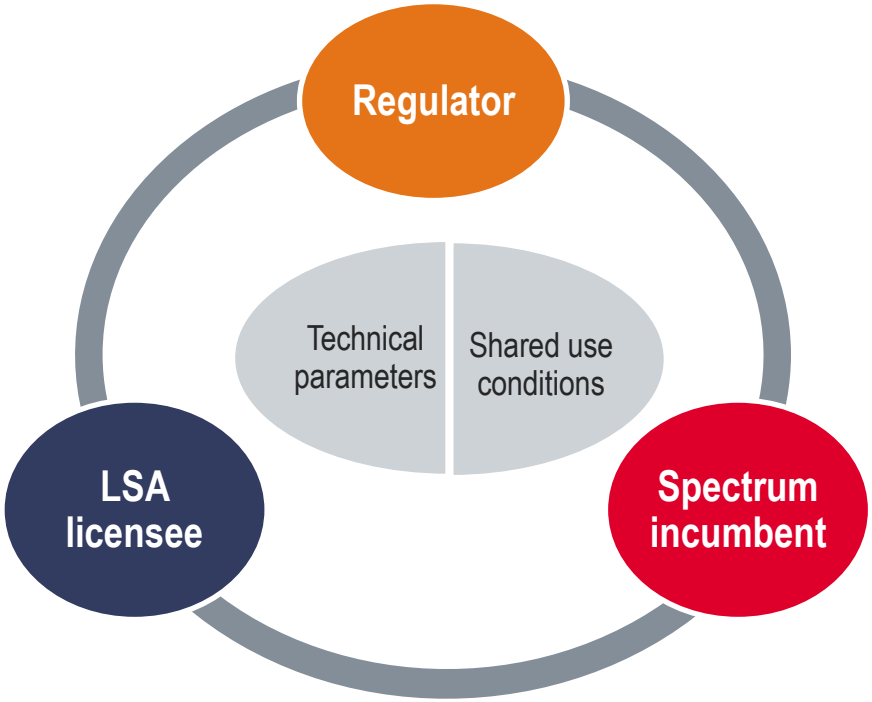


NOT ALL THESE BENEFITS CAN BE ACHIEVED WITH DYNAMIC SPECTRUM SHARING

LICENSED SHARED ACCESS

LICENSED SHARED ACCESS ALLOWS AN INCUMBENT'S UNUSED CAPACITY SPECTRUM TO BE SHARED WITH ANOTHER USER ON A LICENSED BASIS

- Guarantees access, assuring QoS
- Can support existing low cost devices
- Encourages spectrum efficiency



BUT THE TERMS MUST BE RIGHT:

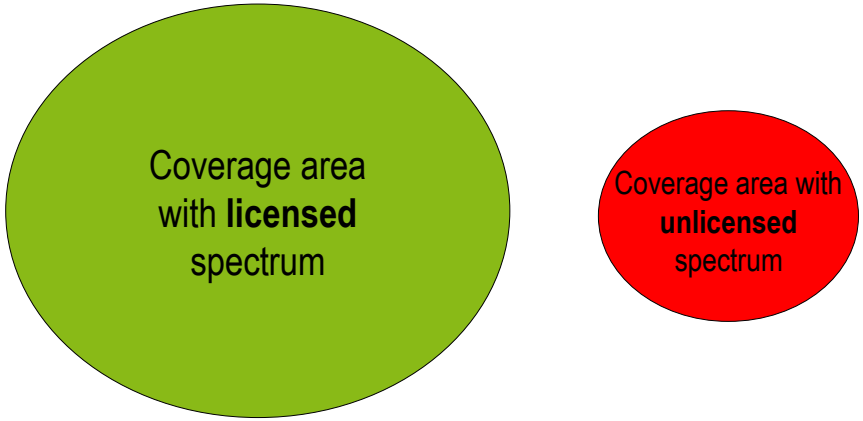
- Contract length must justify investment
- Spectrum must be available in right bands, at right times and places, for the right price

LSA CAN BE POSITIVE BUT SHOULD NOT DISTRACT FROM THE NEED FOR ADDITIONAL EXCLUSIVE MOBILE SPECTRUM

WHITE SPACE

THE WHITE SPACE APPROACH IS BEST EFFORT SO PROVIDES LESS RELIABLE QUALITY OF SERVICE AND LESS EFFECTIVE USE OF THE SPECTRUM

- Quality of service issues
- Patchy coverage
- Relatively small coverage area
- Fewer device options & higher cost
- Initially slower service evolution



MUST NOT JEOPARDISE REGULATORS POTENTIALLY LICENSING MORE SPECTRUM TO MOBILE SERVICES IN FUTURE IN THE DIGITAL DIVIDEND

- Otherwise it rewards broadcasters for inefficient spectrum use
- Squanders the propagation benefits of coverage bands
- Could negatively impact investment in mobile networks and spectrum

Kumar Singarajah
Director, Regulatory Affairs & Business Development
Avanti Communications Group plc

Dynamic Spectrum Access – A Satellite Perspective

Kumar Singarajah
Director Regulatory Affairs & Business Development

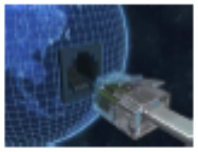
Ofcom Spectrum Conference / London
October 1, 2014

Trends In FSS Technology – Today & Tomorrow

Segment	Today (2014 - 2015)	Long Term (By 2030)
Satellite segment (typical) 	10 Gbit/s – 140 Gbit/s throughput Per satellite Narrow coverage spot beams (e.g Ka) or Wider coverage spots (e.g. Ku, C)	100 Gbit/sec – 1 Tbit / sec throughput Per satellite Narrow coverage spot beams at Ka or Ku with overlay of wider coverage spot beams at Ka, Ku or C.
User Terminals (typical) 	Consumer: 60- 74 cm / 1-3W Cost: < US$ 300 Single-band (Ku or Ka – unless dual feed) Other: 60 cm – 1.2m / 1 - 10 W Cost: Variable Tends to be single-band / dual-band	Consumer: 15 - 30 cm / up to 1W Cost: US$ 30 Single-band or Multi-band. Other: 30 cm – 1.2m / 1W - 10 W Cost: Variable Multi-band

Downstream FSS Customer Segments – Today & Tomorrow

Downstream Customers	Today (2014 - 2015)	Long Term (By 2030)
Enterprise Data Networks (High data rate users)	VSAT Networks (closed user group or open access–networks) (typical: 1 - 50 Mbits/sec)	Ditto (typical: 50 Mbits/sec – 1 Gbit/sec)
Consumers	Broadband Services in rural areas outside fibre / adsl coverage (typical: 10-20 Mbits/sec)	Nationwide coverage / service. Convergence via multi-band FSS / BSS systems of 2-way broadband / 1-way broadcast / mulicast services. (typical: 50 Mbit/sec – 1 Gbit/sec)
Mobile Network Operators RLAN Hot Spots Networks	Backhaul to 2G / 3G base stations (typical: 10 – 100 Mbits/sec) Backhaul	Backhaul to 2G / 3G / 4G / 5G base stations. Multi-cast / edge-cast of multi-media content (50 Mbit/sec – 10 Gbit/sec)
Civil Government	Schools, Post Offices, Police, Hospitals, Government departments (10 – 50 Mbits/sec)	Ditto (50 Mbit/sec – 5 Gbit/sec)
Non-civil Government	Defence / Homeland Security (10 – 100 Mbits/sec)	Ditto (50 Mbit/sec – 5 Gbit/sec)







avanticommunications

Facilitating Improved Access To Spectrum To Satellite Services In 17.7 – 19.7 GHz Band

- Strong interest from satellite operators etc in improving scope for spectrum access for FSS use – specifically for Ka-band VSAT use to provide ubiquitous high data rate broadband services.

Frequency Band	Co-Primary Services	Notes
17.7 – 19.7 GHz	Fixed Satellite Services (FSS)	Space-to-Earth Band
	Fixed Services (FS)	

- Topic under current study / consideration with CEPT WG FM (FM 44)
- Significant existing use of band by FS systems
- Key issue: How to "mitigate" effect of FS transmitter interference to FSS VSAT receivers, if a VSAT is located in "proximity" of a co-channel FS transmitter.

Idea - Dynamic Interference Avoidance

"Each FSS uncoordinated station would be capable to detect interference from sources located nearby, most likely FS. If the interference level is considered not acceptable, the FSS system assigns another channel to the user. This mechanism is known as DCA: Dynamic Channel Assignment."

Two types of DCA are identified:

- Permanent/Continuous DCA: From the commissioning and during the operations of an FSS terminal, an FSS system is able to assign and potentially modify the channel frequency allocated to the terminal, should that channel experience harmful interference, process which is repeated as many times as the evolving interference scenario requires;

- Protected DCA: At the commissioning of the FSS terminal, the FSS system is able to identify interference-free channels for that FSS terminal. From that point in time, that FSS earth station would receive regulatory protection from new FS links.

Authorisation / Licensing Methods

Individual authorisation (Individual rights of use)		General authorisation (No individual rights of use)	
Individual licence[1]	**Light-licensing**		**Licence-exempt**
Individual frequency planning / coordination Traditional procedure for issuing licences	Individual frequency planning / coordination Simplified procedure compared to traditional procedure for issuing licences With limitations in the number of users	No individual frequency planning / coordination Registration and/or notification No limitations in the number of users nor need for coordination	No individual frequency planning / coordination No registration nor notification

From ECC Report 132

Will DCA Work From Satellite Perspective

Method	Pros	Cons
Continuous DCA	Does not constrain future FS deployments.	Not possible to assure FSS customers a committed QoS or SLA. Risk of interference from future deployed / licensed FS links to VSAT. FSS / VSAT runs out of 'gaps'.
Protected DCA	Possible to assure FSS customers a committed QoS or SLA.	Poses constraints on future FS link deployments.

DCA – Will it be used in the 17.7 – 19.7 GHz band ?

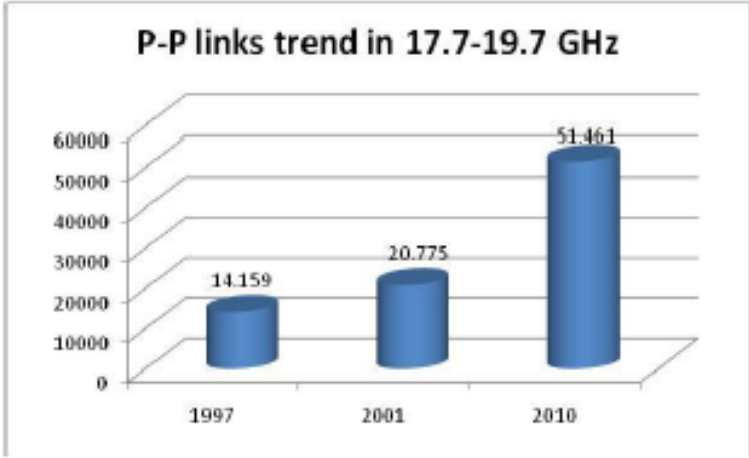
- Questionable satellite operators / VSAT vendors will invest in implementing Continuous DCA.

- Satellite operators / VSAT vendors will likely invest in implementing Protected DCA.

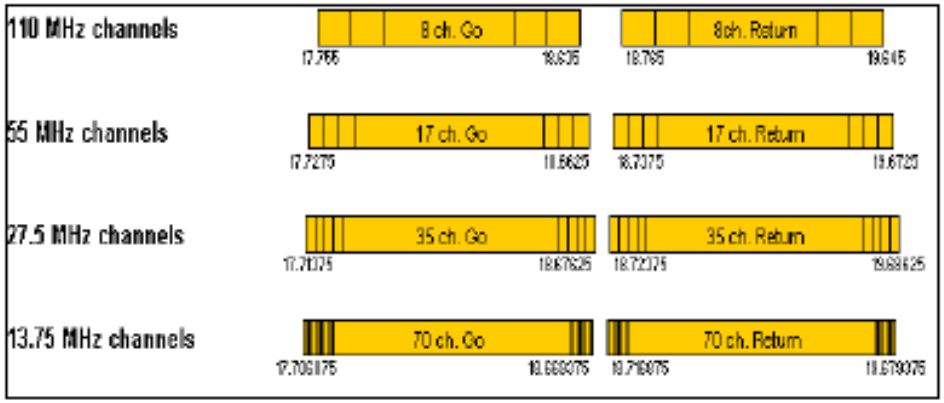
- CEPT Administrations invited to further study of 'Protected DCA' – perhaps under a *'Light Licensing Regime'*

- Satellite operators / VSAT will also continue to invest in improving spectrum efficiency *in other bands* (e.g. 29.5 – 30.0 / 19.7 – 20.2 GHz) currently identified by CEPT ECC Decisions for ubiquitous Ka-band VSATs in Europe and already used by the existing Ka-band satellite systems of Avanti, Eutelsat, SES et al.

FS Utilisation Context



P-P FS Links trend in 17.7-19.7 GHz



FS channeling arrangements of CEPT ERC/REC 12-03

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Julius Knapp
Chief of the Office of Engineering Technology
Federal Communications Commission (US)

Panel

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Avanti Communications Group plc

Julius Knapp, Chief of the Office of Engineering Technology
Federal Communications Commission

BIG EARS LOUD VOICES

Joe Butler, Spectrum Policy Director, Ofcom

Changes & Challenges

Panel

Julius Knapp, Chief of the Office of Engineering Technology
Federal Communications Commission

Richard Lindsay-Davies, Chief Executive Officer
Digital TV Group

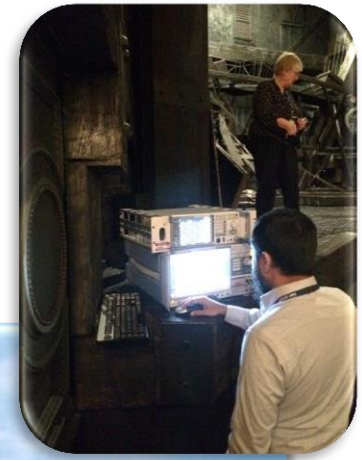
Rich Kennedy, Wi-Fi Alliance Spectrum & Regulatory Task Group Chair
Mediatek

Michele Franci, Chief Technology Officer
Inmarsat

Coexistence over the last decade
Not just loud voices

Changes & Challenges

- 4G / TV
- 4G / Radars
- 4G / Fire Services
- 4G / Social Alarms
- 4G / SRDs
- 4G / WiFi
- 4G / ALDs
- WSD / TV / PMSE



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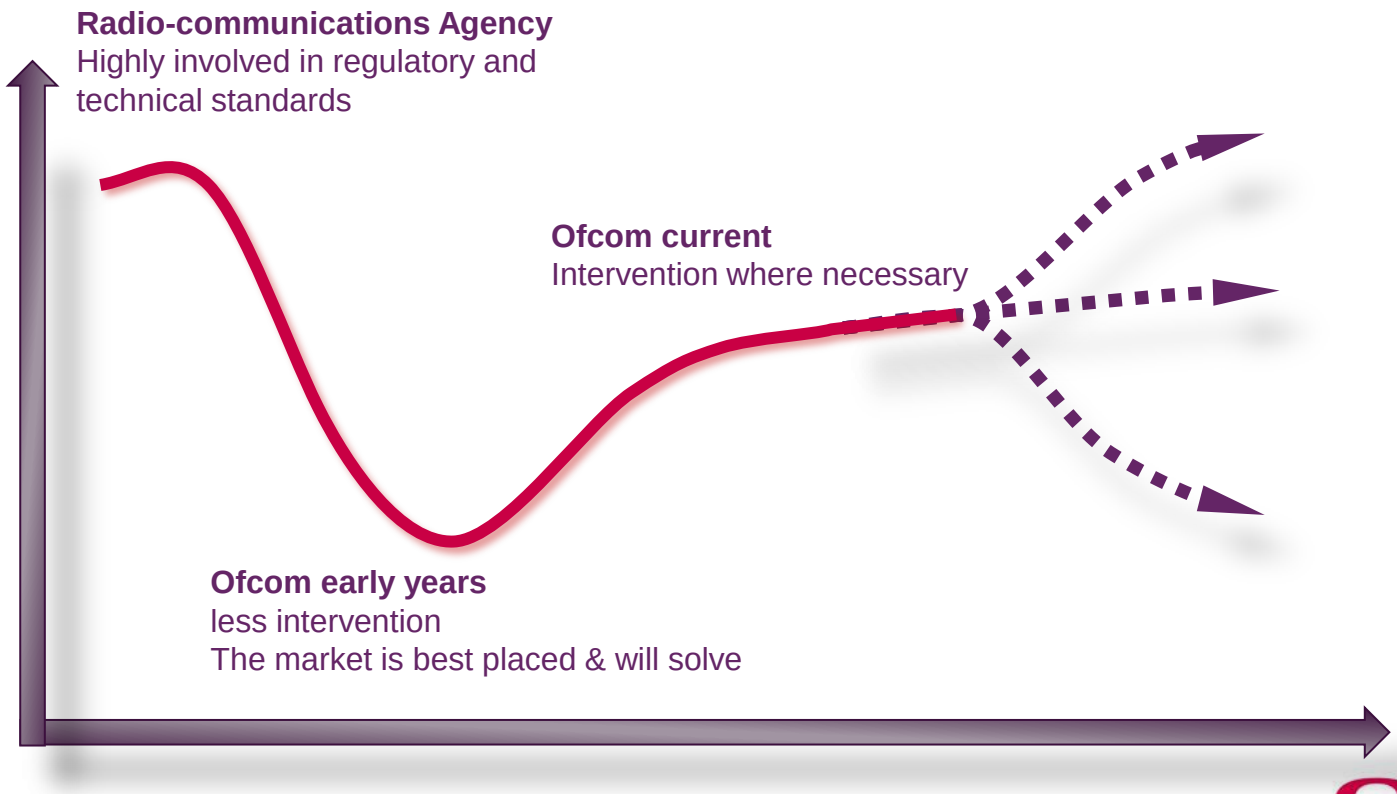
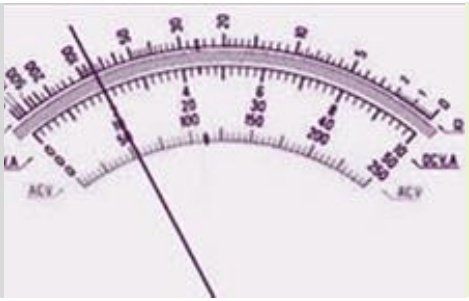
Coexistence over the last decade
In and out of fashion?



Why is coexistence important?

Enable efficient access to radio spectrum

Protect existing users & equipment



Enable access to new services & uses

What are we doing?

- **Greater focus on receivers and RF performance**
  - Radio Equipment Directive & more strategic engagement with key bodies
- **Ensure coexistence is well understood & conditions are well set**
  - Improving theoretical analysis where possible e.g. improving UK planning model for DTT
  - Much greater & earlier use of trials where possible e.g. Radars, White Space Devices, Wifi
  - Closer working with key stakeholders on technical issues & trials e.g. BBC, Arqiva, Sky, BT

Thinking about the longer term

What is the cost of underestimating vs overestimating the impact of coexistence?

How do we enable more robust receivers and better RF performance?

- What is reasonable to expect?

How do we balance the rights of incumbents and new entrants in the face of uncertainty about coexistence issues?

- In considering access should we assume better radios that can coexist or share?
- Should we reflect the pace and turnover of technology/devices in some areas is getting faster
- Are there areas of the spectrum where we should be more relaxed about interference – e.g. higher frequency spectrum?
- Should we move from an ex-ante based approach to an ex-post?

How should we do this in the future? What should Ofcom's role be?

- We are less present in standards organisations - is this right?

Panel

Julius Knapp, Chief of the Office of Engineering Technology
Federal Communications Commission

Richard Lindsay-Davies, Chief Executive Officer
Digital TV Group

Rich Kennedy, Wi-Fi Alliance Spectrum & Regulatory Task Group Chair
Mediatek

Michele Franci, Chief Technology Officer
Inmarsat

Julius Knapp
Chief of the Office of Engineering Technology
Federal Communications Commission (US)

Richard Lindsay-Davies
Chief Executive Officer
Digital TV Group

PREZI Presentation

Rich Kennedy
Wi-Fi Alliance Spectrum & Regulatory Task Group
Chair - Mediatek

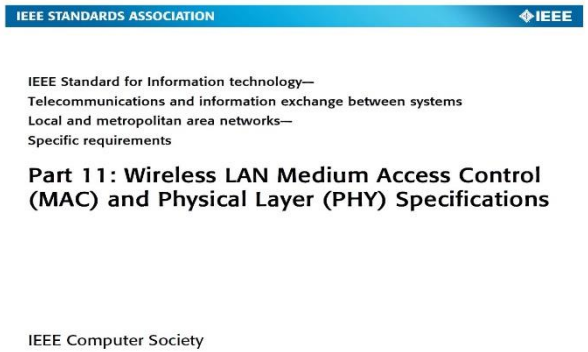
Spectrum - Changes and Challenges: Wi-Fi and the Future of Spectrum Sharing

Rich Kennedy

October 1, 2014

Disclaimer: Although I have been the Chair of the Wi-Fi Alliance Spectrum & Regulatory TG for the past eight years, the opinions expressed here are my own, i.e. have not been submitted to or approved by WFA Board of Directors.

Wi-Fi (IEEE 802.11) A Brief History



- FCC proposed unlicensed spectrum (ISM band) at a 1947 ITU meeting
  - Finally released in the US in 1985
- IEEE 802 published the basic 802.11 standard in 1997
  - First 1 and 2 Mbps products had vendor interoperability issues
  - Wireless Ethernet Compatibility Alliance (WECA, later Wi-Fi Alliance) developed interoperability test processes, resolving the issue and triggering huge industry growth
- IEEE 802.11a defined to take advantage of 5 GHz band availability
- Improvements continued to advance the technology
  - 802.11b – 11Mbps in 2.4 GHz band
  - 802.11g – 54 Mbps utilizing OFDM in 2.4 GHz band
  - 802.11n – Major rate improvement and MIMO in 2.4 and 5 GHz bands; 20/40 MHz
  - 802.11ac – capable of >1Gbps
  - 802.11ad – >1Gbps in the 60 GHz band
  - 802.11af – Operation in the white spaces of the TV bands
- With billions of devices sold, costs enable marketing to all economic groups – wireless broadband almost everyone can afford

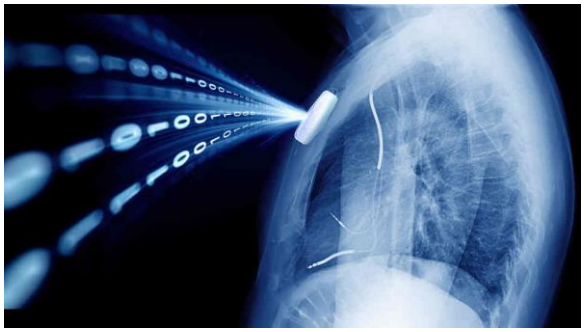
Spectrum Sharing Is In Our DNA

- The 83.5 MHz of spectrum in 2.4 GHz considered a “garbage band”
- FCC Part 15.5(b) devices must accept interference and not interfere with incumbents
- Listen-Before-Talk coupled with backoff mechanism enables sharing between Wi-Fi devices and interference avoidance with others
- Dynamic Frequency Selection (DFS) devised for detecting and avoiding interference with 5 GHz bands incumbents (in 5250-5350 and 5470-5725 MHz bands)
  - DFS tests have evolved over the years and 802.11 has kept pace
  - TDWR interference in 5600-5650 MHz not caused by legally operating Wi-Fi
- Wi-Fi operation in TV bands uses geo-location database for non-interference
- For over 15 years, Wi-Fi has met every sharing challenge and continued to support wireless broadband for the masses

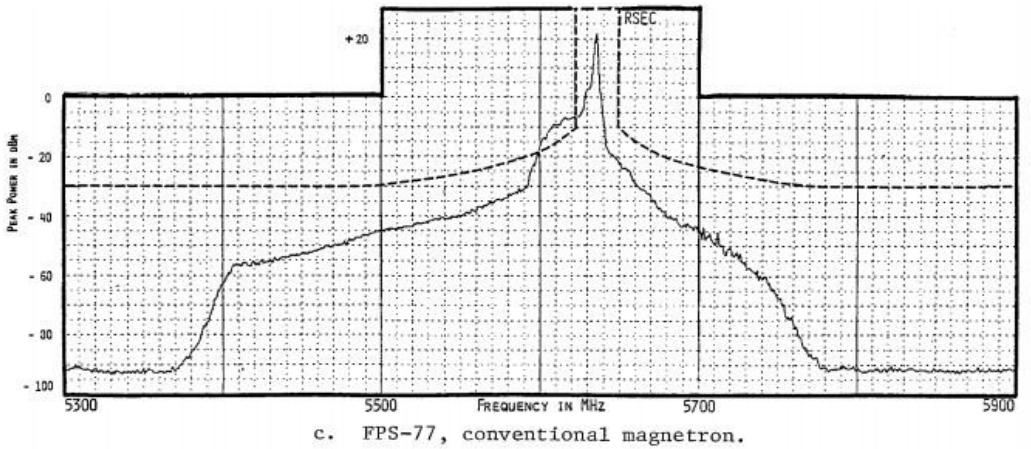
Receiver Improvements
The Wi-Fi Challenge

- The incredible success of Wi-Fi has its roots in the low equipment costs
  - Now in every laptop, tablet and smartphone with minimal impact on device cost
  - Access Points are affordable for home use and for small venue hotspots enabling free or almost free Internet access
- Major improvements in receiver selectivity can be expensive
- Current regulations do not include receiver requirements
  - Recent sampling has shown large variations between vendors
- Before we can consider how to improve receivers, we need to test susceptibility to interference
- Ofcom did test some TV receivers when planning TVWS regulations
  - Pulsed AWGN signals both in band and in adjacent bands at varying power levels
  - Generic approach as opposed to testing every possible interference source

Receiver Improvements Shortcomings



- Receiver improvement for new devices would not help the hundreds of millions of legacy devices
  - Some Wi-Fi devices, e.g. wireless medical, remain in the market for many years
  - Any spectrum sharing benefit would take many years to materialize
- Wi-Fi devices are often the victim of adjacent frequency devices with OOBE problems that receiver improvements could not help, e.g.
  - Older 5 GHz band radars
  - High power LTE in 2.3 and 2.5 GHz bands
- No amount of receiver improvement can protect against transmitters with excess OOBE

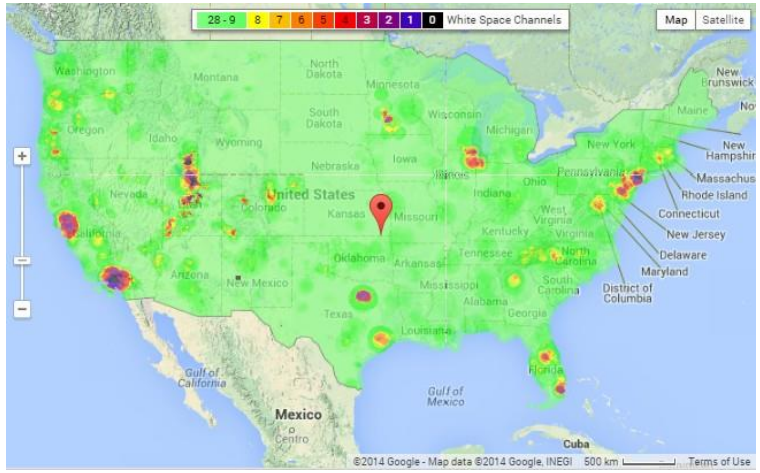


c. FPS-77, conventional magnetron.

MEDIATEK

Spectrum Sharing And the Future of Wi-Fi

- Sensing will always have a place
  - CSMA/CA for maximizing Wi-Fi channel usage
  - DFS for radars and satellites
  - Detect and Avoid in other spectrum, e.g. DSRC
- Geo-location databases in White Spaces
  - TV bands
  - Earth Exploration Satellites with fixed orbits
  - Licensed spectrum prior to build out



- Successes of the past show that the Wi-Fi Industry has the know-how
- Using all the tools developed over the past 15 years, and developing new tools as sharing challenges change, we will continue to provide low-cost wireless broadband to the masses as long as regulators do not shut us out in their pursuit of spectrum auction revenues

MEDIATEK

Michele Franci
Chief Technology Officer
Inmarsat

inmarsat
The mobile satellite company™

Co-existence and RF technology for satellite services

Michele Franci, Inmarsat

Satellite system basics

- Extremely long distances between satellites and earth stations – GSO satellites are approximately 36,000 km above the equator
- Both satellites and earth stations receive very weak signals and are therefore sensitive to interference
- GSO satellite field of view covers more than 1/3 of Earth's surface
- Even individual beams are very large, often covering several countries
- Satellite systems provide great benefits, in particular by providing instantaneous coverage of these large areas directly upon launch of a satellite. Such systems are essential for bringing connectivity to oceanic and remote areas

Basic requirements for satellite systems

- Harmonised spectrum allocations
  - To be commercially viable satellite systems need access to global, or regional markets
  - This implies internationally (preferably globally) harmonised spectrum allocations
- Internationally regulated sharing environment
  - Satellite beams can receive interference from terrestrial transmitters covering very large areas, spanning many countries; the aggregate levels of interference must be controlled to avoid interference
  - Local variations in spectrum use can result in interference to satellite services
  - Variable regimes, where the use of a frequency band is decided on a national or local basis, do not work well for satellite systems
- Generally auctions do not fit the satellite services model
  - The use of given frequencies is typically decided at international level, through ITU coordination
  - Through orbital separation, multiple networks may share the same frequencies in the same territory
  - Satellite systems cannot compete with terrestrial systems for spectrum access on a national basis – not financially viable and provides no guarantee of access throughout the coverage.

Frequency sharing for satellite services

- Some sharing regimes have proved feasible and efficient, such as sharing between fixed earth stations and terrestrial fixed links.
  - This works because there is a limited number of stations, all of which are in fixed locations
- In cases where either the terrestrial or the satellite service is deployed ubiquitously, sharing is less efficient or not feasible
  - A key example is the C-band spectrum which has already partially been identified for terrestrial use by either BWA or IMT. Sharing involves large interference zones making sharing impractical. Despite this, some administrations, especially in Europe, promote this band for IMT. Our concern is that this will force cause satellite systems out of the band.
  - Even though demand for IMT is not apparent, constraints on deployment of earth stations are being introduced.
- Some sharing techniques that may work well between terrestrial systems and services, such as "sense-and-avoid" do not work with satellite systems
  - This is due to the large distances between transmitters and receivers in satellite systems, and because terminals transmit and receive in different frequency bands.

Changes & Challenges

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Ofcom

Changes & Challenges

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