# Mobile Broadband and Spectrum Sharing

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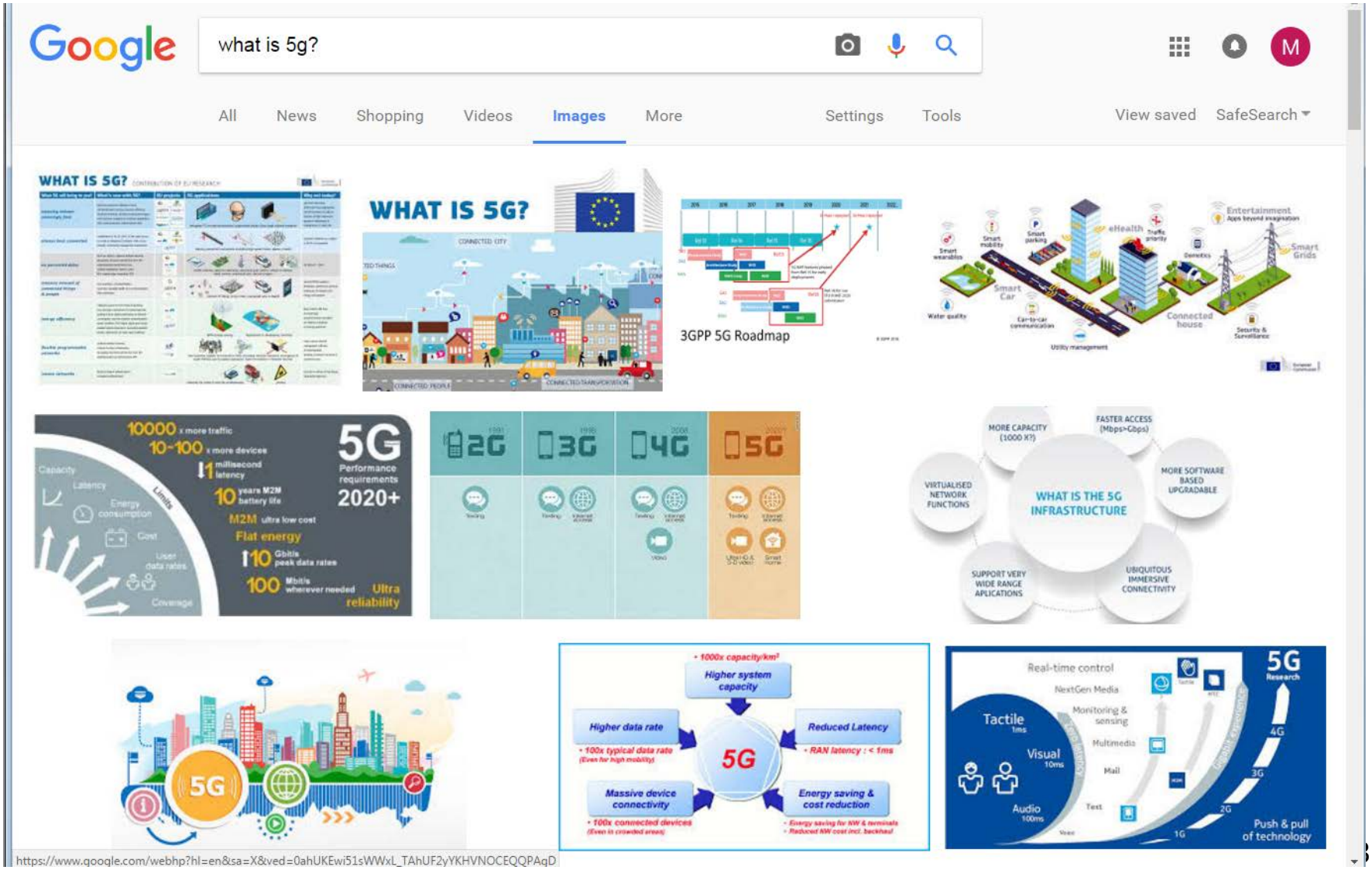
Note: The views expressed in this presentation are those of the author and may not necessarily represent the views of the Federal Communications Commission

# Spectrum Frontiers / 5G

# 5G Offers Something for Everyone



# Themes from 2016 CORF Annual Meeting

- Proven formula:
  - Make spectrum available
  - Encourage and protect innovation-driving competition
  - Stay out of the way of technological development and details of implementation
- Spectrum:
  - Flexibility:  FCC will not designate the 5G band or bands
  - Trifecta: Importance of low, mid and high band spectrum

# Opening of High Band Spectrum

*Spectrum Frontiers*

*Report and Order and Further Notice of Proposed Rule Making*
*Adopted by the Commission July 14, 2016*

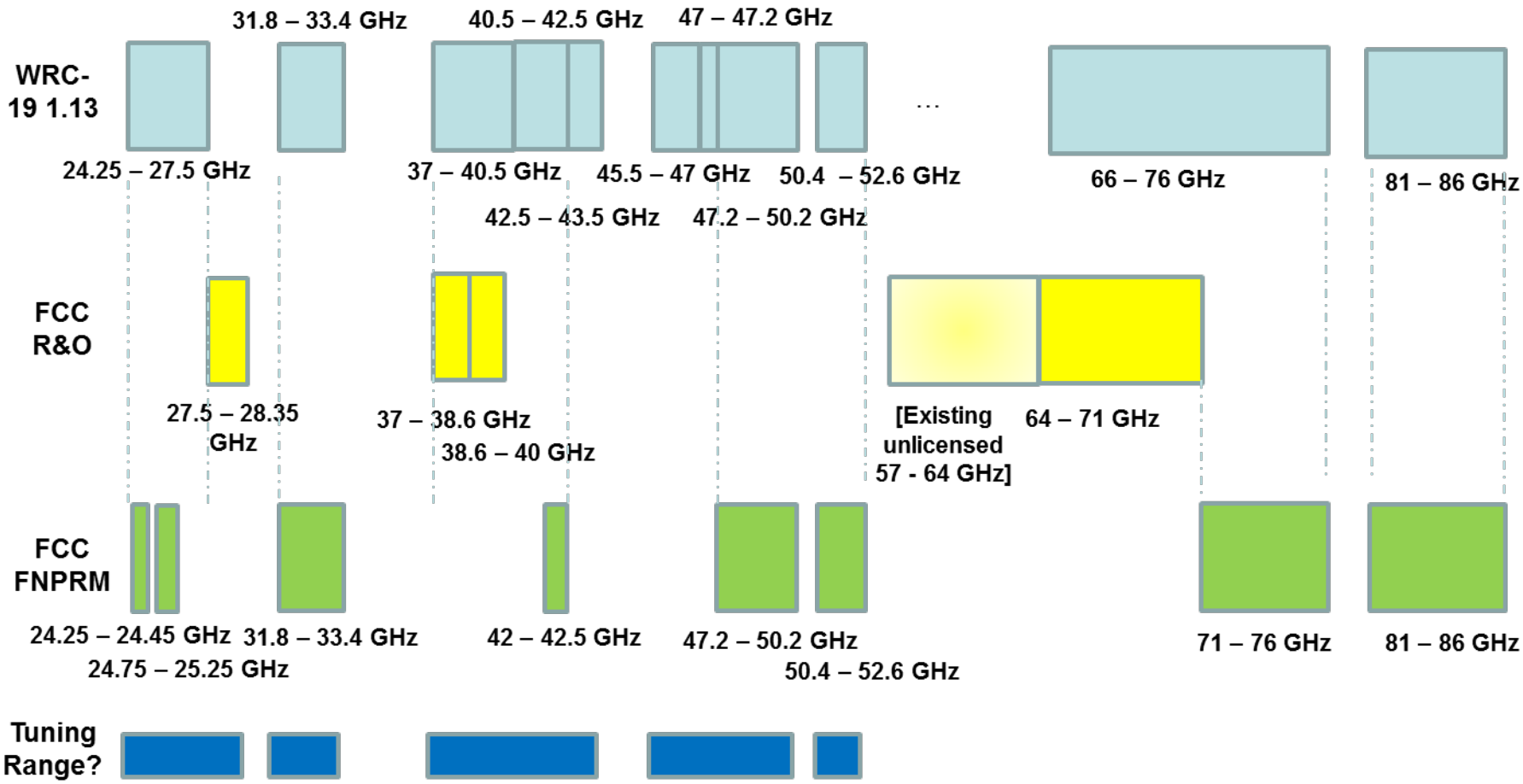
## Spectrum Allocations

- 10.85GHz of Spectrum added for mobile
  - Licensed Bands (3.85GHz): 27.5-28.35 GHz; 37-38.6 GHz; 38.6-40 GHz;
  - Unlicensed Bands (7GHz): 64-71 GHz

## Service Rules

- Part 30: Upper Microwave Flexible Use Service (UMFUS)
- Geographic Area Licensing, Area Size, Band Plan, License Term, Overlay Auctions
- Technical rules
- Performance Requirements
- Ensure cyber protections considered from the start

# Opportunities for International Harmonization



# Further Developments

- Petitions for Reconsideration:
  - Generally strong support for FCC actions
  - Revisions requested for:
    - 28 GHz: Greater flexibility for earth station deployments
    - 37 GHz: Sharing with federal systems
    - 39 GHz:  Adjust sharing criteria regarding terrestrial power limits and satellite pfd limits
    - Many other details

- Much industry activity: market transactions
- Continued industry testing, R&D, standardization, trial deployments

# Next Steps

- Address petitions for reconsideration later this year
- Determine which additional bands to make available among 24.25-24.45 GHz; 24.75-25.25 GHz; 31.8-33.4 GHz; 42-42.5 GHz; 47.2-50.2 GHz; 71-76 GHz; 81-86 GHz;
  and, bands above 95 GHz
- Continue support for R&D through new experimental program licenses
- Continue work looking towards WRC-19

# NGSO Systems

# NGSO Systems

- NGSO satellite systems intended to provide fixed and mobile-satellite service (MSS) to earth stations are subject to a processing round
  - After a “leading NGSO application” is accepted for filing a cut-off date is established for the submission of competing applications using overlapping frequency bands
  - NGSO FSS NPRM for Parts 2 & 25: on-going
- Ku-/Ka-band: Processing Round for NGSO systems closed November 15
  - Triggered by OneWeb Petition for Declaratory Ruling for market access for 720 satellite system in the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz bands
  - 11 Additional NGSO applications filed
- V-band: Processing Round for NGSO systems closed on March 1, 2017
  - Triggered by Boeing application to operate an NGSO system consisting of 2956 satellites in the 37.5-40GHz, 40-42GHz, 47.2-50.2GHz and 50.4-51.4GHz bands
  - 6 Additional NGSO applications filed

# Ku/Ka Processing Round Applications

| Satellite System | Number of Satellites | Frequency Bands |
|---|---|---|
| **OneWeb** | 720 | • Ku- and Ka-bands |
| **O3b/SES** | 20 + 40 additional | • Ka-band |
| **SpaceX** | 4425 | • Ku- and Ka-bands |
| **Boeing** | 60 | • Ka-band |
| **Telesat Canada** | 117 | • Ka-band |
| **LeoSat** | 78 | • Ka-band |
| **Audacy Corporation** | 3 | • Ka- and V-bands |
| **Theia Holdings A Inc.** | 112 | • Ka-band |
| **Kepler Communications Inc.** | 140 | • Ku-band |
| **ViaSat, Inc.** | 24 | • Ka- and V-bands |
| **Karousel LLC** | 12 | • Ku- and Ka-bands |
| **Space Norway AS** | 2 | • Ku- and Ka-bands |

# V-Band Processing Round Applications

| Satellite System | Number of Satellites |
|---|---|
| Boeing | 2956 |
| Theia | 112 (previously filed) |
| SpaceX | Some of the 4425 (previously filed) + 7518 |
| Boeing 2 | 147 |
| Telesat | 117 (follow-on to the 117 Ku/Ka) |
| OneWeb | 720 (previously filed) + 1280 |
| O3b | 24 (previously filed) |

# Other Satellite Proceedings/Topics

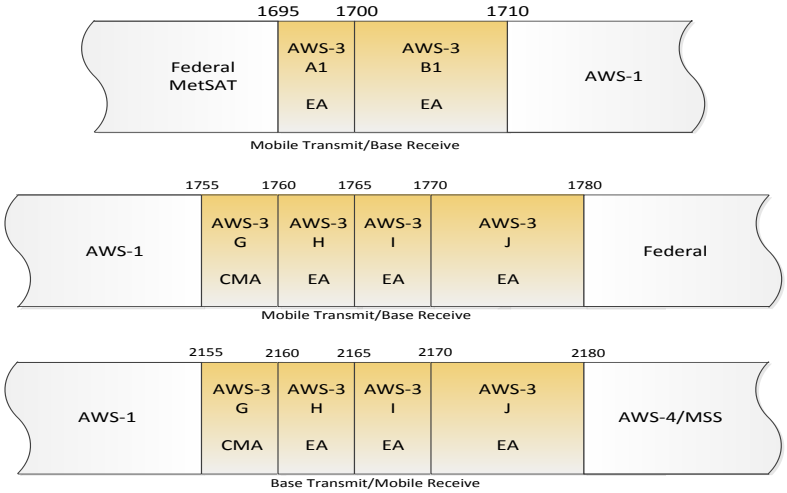
- FSS NGSO NPRM
- ESIMs NPRM
- NGSO Applications

- Spire Global & HISPASAT Coordination

# Other Bands

# Advanced Wireless Service-3 (AWS-3)

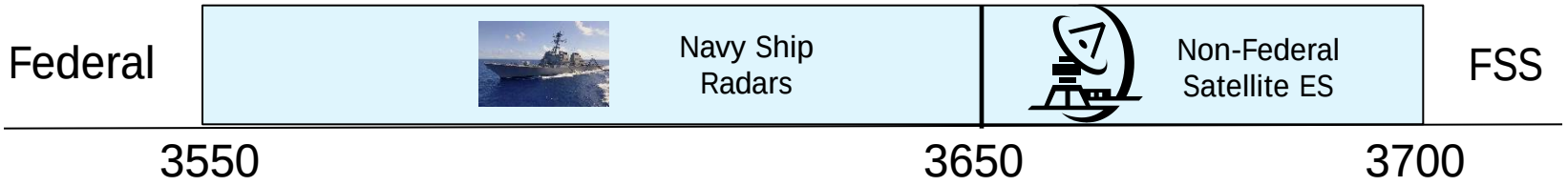
- Paired 2155 MHz - 2180 MHz with 1755 - 1780 MHz;
- Unpaired 1695 – 1710 MHz
- Band Class 66 (AWS-3) is already implemented in several LTE phones
- Limited testing is on-going as it takes time for DOD systems to relocate
- Supplemental downlink is available as needed

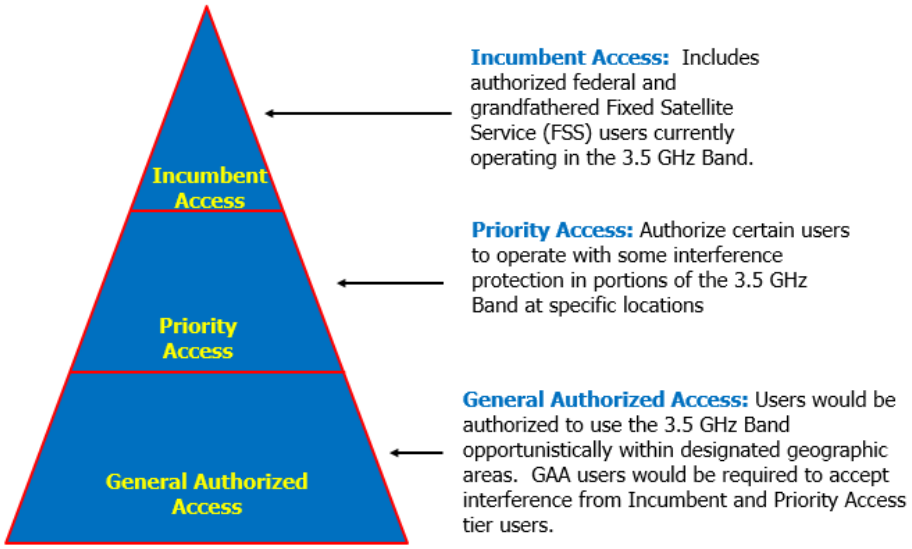



## Federal Incumbent Systems:

- 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

# 3.5GHz Citizens Broadband Radio Service




- In process of testing and approval of SAS Database Administrator
- Working with ITS (Institute for Telecommunication Sciences) in conjunction with NIST and WinnForum to develop and verify the test codes and execution
- Next step is be certification of SAS and ESC

# Recent Developments

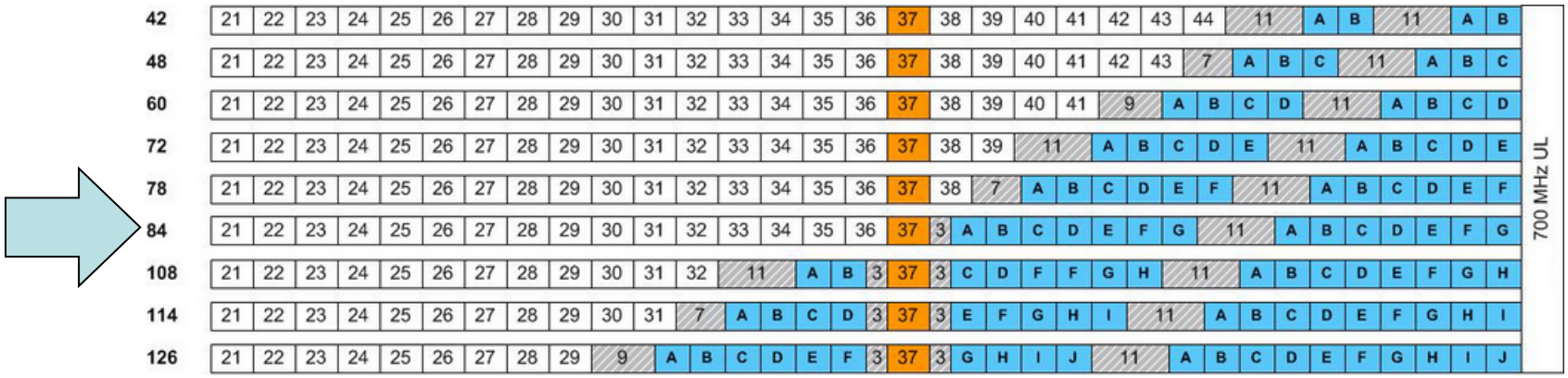
- Second Report & Order & Order on Reconsideration - April 28, 2016
  - Affirms regulatory approach
  - Allows increase in the power level for non-rural Category B CBSDs
  - Allow a single PAL to be issued in License Areas located in Rural Areas in the absence of mutually exclusive applications
  - Establishes Engineering-based approach for determining when Priority Access License area in use
  - Adopts a robust, flexible secondary market for Priority Access Licenses
  - Balances the expanded access for wireless broadband operators with the need to protect fixed satellite service operations
- Certification of SAS Administrators and ESC
  - Public Notice December 2015 established procedures for submission and review of proposals from prospective SAS Administrators and ESC operators
  - February 2016 meeting of prospective SAS Administrator sand ESC operators
  - “First Wave” Proposals filed in May 2016
  - April 2017 - PN announces how 3650-3700 MHz incumbents file for grandfathered, protected status
  - Separate PN announces a second-wave deadline to apply for approval to serve as SAS and ESC administrators

# SAS & ESC Approval Process

- Similar to TVWS
- Overseen by WTB/OET; close consultation with NTIA and DoD
- Applications to include all information in PN
- Evaluate all of the “first wave” proposals
- Release list of those conditionally approved
- Assess and test each conditionally approved SAS and ESC
- Public testing period, including incumbent protection capabilities

# TV Incentive Auction
# 600 MHz Band Plan

First time the Commission has needed to develop band plans without knowing how much spectrum will be available!




Repacked TV

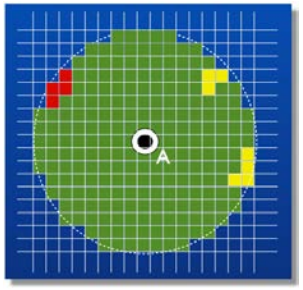
Guard Band

Medical Telemetry & Radio Astronomy

Duplex Gap

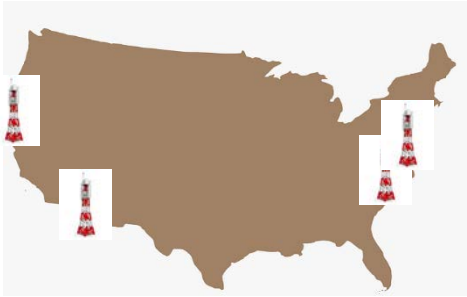
Repurposed For Wireless Auction

# Technical Pillars of TV Incentive Auction



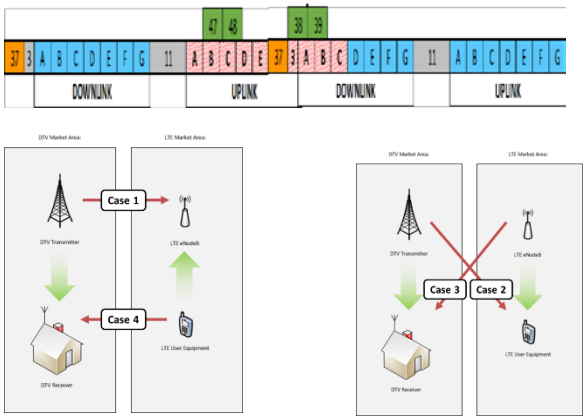
TV Study Software Used to predict Coverage & Population Served

OK to assign same channel – far apart

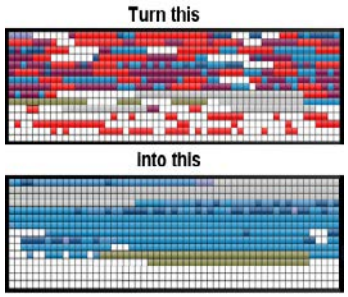


Can't assign same channel – too close

Constraints on Repacking Stations




Controlling Inter-service Interference




Reorganize remaining stations in most efficient way that recovers the most spectrum at the least cost - - akin to defragmenting a hard drive

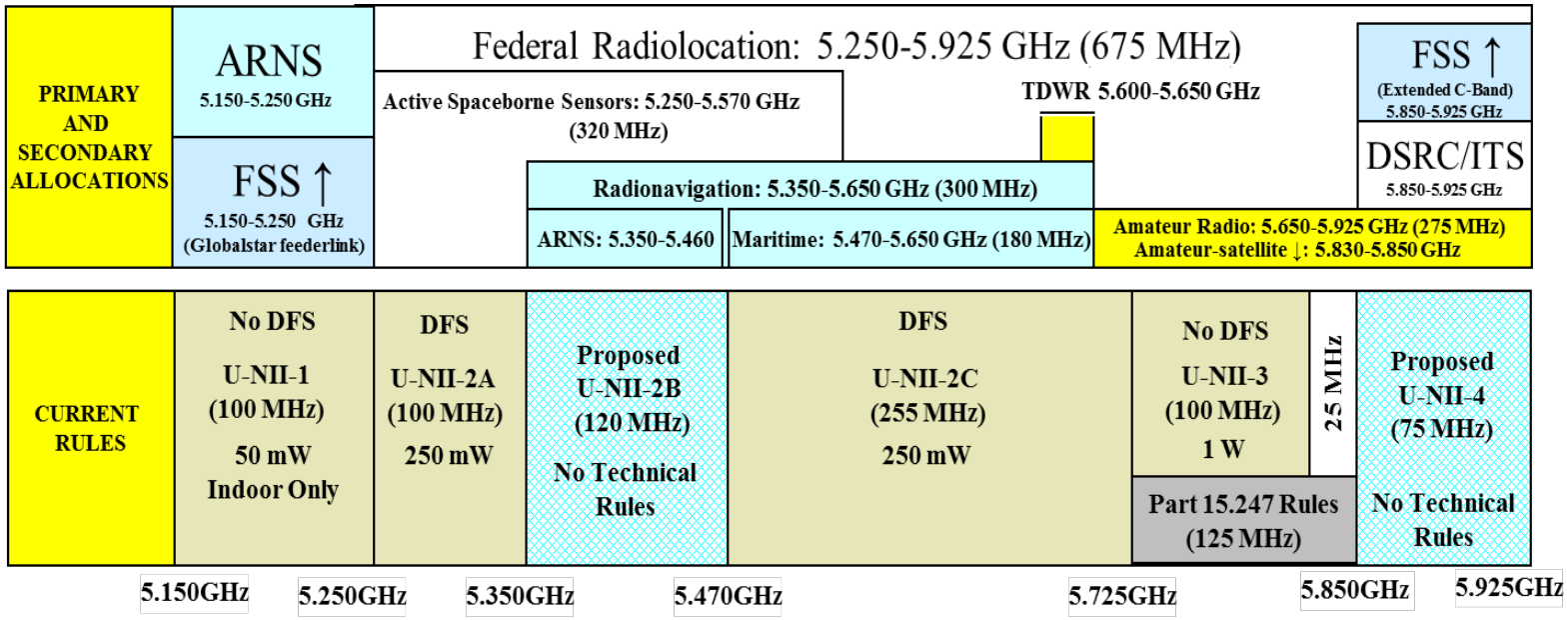
Repacking Optimization

# Incentive Auction Closed

- Bidding in the auction closed on March 30, 2017
  - preserves a robust broadcast TV industry while making valuable “low-band” airwaves available for wireless broadband
  - repurposes 84 megahertz of spectrum – 70 megahertz for licensed use and another 14 megahertz for wireless microphones and unlicensed use
  - yields $19.8 billion in revenue - including $10.05 billion for winning broadcast bidders, more than $7 billion to be deposited to the U.S. Treasury for deficit reduction

- April 13, 2017 Commission PN formally closes auction
  - Begins 39-month period for some TV stations transition to new channel assignments

# 5GHz Band

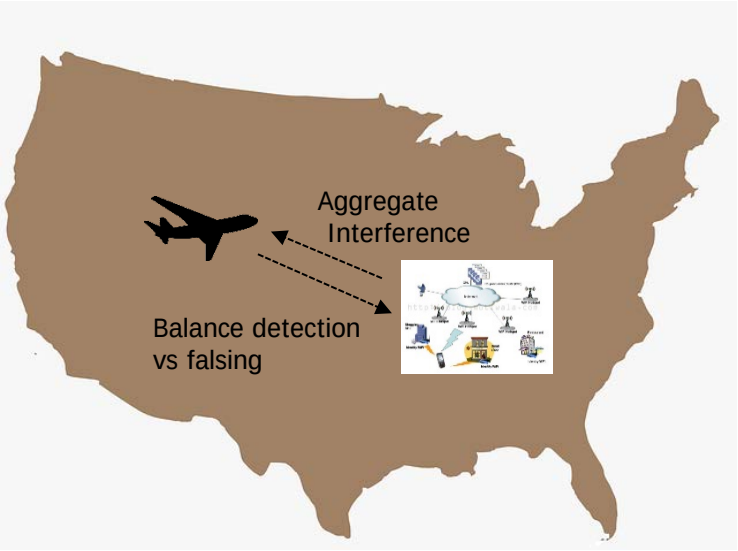



- WRC-12 R&O allocated 5030-5091MHz for UAS CNPC
- Note that AeroMACS allocation is at 5000~5030MHz and 5091~5150MHz
- DSRC/UNII-4 testing is on-going

# UNII-2B: 5350 – 5470 MHz

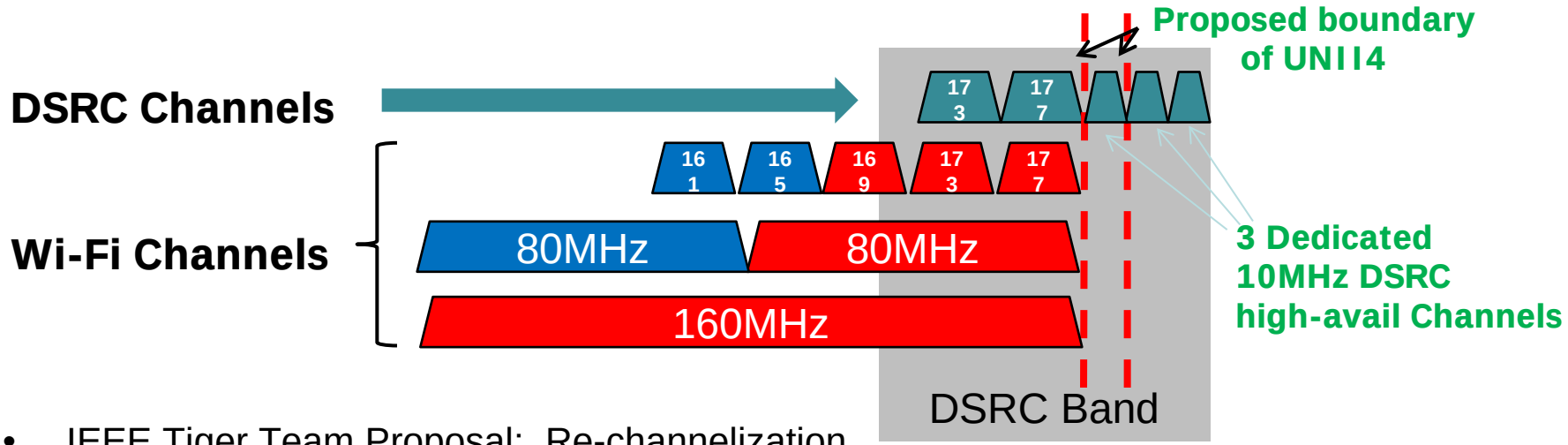
- Very difficult sharing scenarios
  - Includes federal plane/ship/terrestrial radars & earth exploration satellite
- US proposed to continue international work for WRC-19
- Work group established:
  - FCC/NTIA/DoD/NASA
  - Considered Ix protection studies & sharing approaches
- Have not been able to identify a way forward at this time

Aeronautical radar must pick up weak reflected signals from far away




Wireless networks must “hear” very weak signals from radar

# UNII-4: 5850 – 5925 MHz

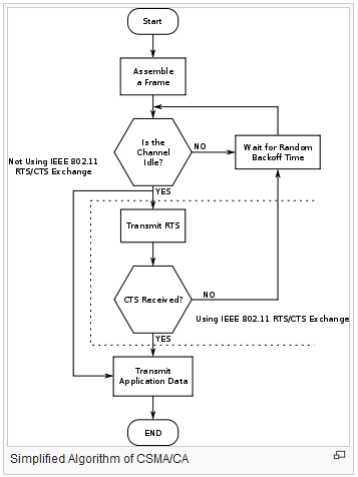



- IEEE Tiger Team Proposal: Re-channelization
- Dedicated DSRC spectrum
  - Open only the lower part of the spectrum to UNII devices
  - Leave 20MHz or 30MHz dedicated spectrum for DSRC high-avail channels
  - Share the Channel 173 and 177 between DSRC service channels and UNII devices
- For the shared spectrum
  - Encourage 20MHz DSRC service-channel operation
    - Would allow for more effective detection of the DSRC signals
  - Develop sharing solutions in IEEE
- Service channels can also use 802.11n/ac in any 5GHz band for service applications

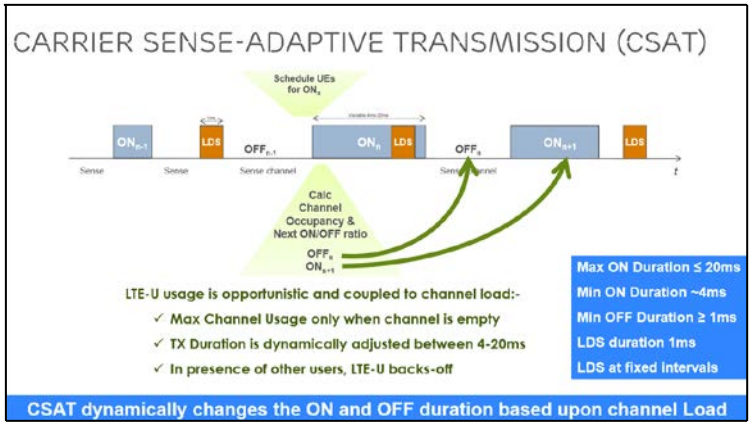
# LTE-U, LAA & Wi-Fi

- LTE – Long Term Evolution: Technology designed to operate in licensed spectrum
- LTE for unlicensed spectrum:
  - Focus on U-NII 1 & 3 (no DFS)
- OET/WTB sought to better understand technologies
- Wi-Fi Alliance Co-Existence Test Plan
- The FCC approved first LTE-U Devices
  - Tested to show they meet FCC rules
  - Though successful evaluation under co-existence plan, this is not an FCC requirement

Wi-Fi: Carrier sense multiple access with collision avoidance (CSMA/CA)



Simplified Algorithm of CSMA/CA



LTE-U

# 2016 TAC Discussion on HAPS/UAS

See https://www.fcc.gov/general/technological-advisory-council for 2016 TAC Recommendation Presentation