The views expressed in this presentation are those of the author and may not necessarily represent the views of the Federal Communications Commission.
Finite spectrum
Exponentially increasing demand
Increasing efficiency is key to meeting our spectrum needs
Data Applications

E-Learning

M2M Segments
- Automotive
- Security
- Payment
- Consumer Electronics
- Metering
- Remote Maintenance and Control

E-Commerce

Online Entertainment
Looking for New Spectrum: Choices

- Exclusive Use
- Unlicensed/Shared Use
- Incumbent Rights/Protection
- New Entrant Flexibility

Spectrum Sharing to the Rescue
Dynamic Spectrum Sharing describes a set of technologies and techniques that enable radio communications devices to opportunistically transmit on available radio spectrum.

http://dynamicspectrumalliance.org/faq/
Finding Proper Incentives
Bi-directional Sharing
Predictability
Flexibility
Trust / Enforcement Mechanisms
Dynamic Spectrum Sharing: A Short History
White space devices may continue to operate until mobile licensee commences service in an area

Potential of 78 fewer megahertz available in any given area

White space devices continue to operate
- Low VHF channels 2-6
- High VHF channels 7-13
- UHF channels 14-36

Rules adopted to permit white space devices to share spectrum with wireless medical telemetry devices and Radio Astronomy Service (Subject of Petitions for Reconsideration)

Channel 37 acts as guard band between mobile systems and broadcast stations
- No additional guard band for use by white space devices

Commission sought comment on setting aside a vacant channel in any area for white space devices
- Not yet acted on by Commission
Sliding scale co-channel separation distance based on power / HAAT

Limited to less congested areas

Permit low power fixed device operation within adjacent channel contour
- Consistent with personal/portable device rules

Fixed white space device on channel 25
- 40 mW maximum EIRP
- 10 M maximum AGL
Fixed white space devices may operate on contiguous vacant TV channels:
- Maximum 100 mW EIRP
- Maximum antenna height 10 m AGL
- At least 3 megahertz guard band

Channel Bonding / Channel Aggregation

<table>
<thead>
<tr>
<th>White Space</th>
<th>TV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel 24</td>
<td>Channel 28</td>
</tr>
<tr>
<td>Channel 25</td>
<td>Channel 29</td>
</tr>
<tr>
<td>Channel 26</td>
<td>Channel 27</td>
</tr>
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<td>Channel 27</td>
<td>Channel 26</td>
</tr>
<tr>
<td>Channel 28</td>
<td>Channel 25</td>
</tr>
<tr>
<td>Channel 29</td>
<td>Channel 24</td>
</tr>
</tbody>
</table>
Citizens Broadband Radio Service

Federal spectrum allocations

- 3550 MHz
- 3600 MHz
- 3650 MHz
- 3700 MHz

- Navy Ship Radars
- Non-Federal FSS ES
- Federal Ground-Based Radar

Spectrum sharing across three tiers

- Incumbent Access
- Priority Access
- General Authorized Access

U.S. Census Tracts
Spectrum Access System (SAS) manages access to spectrum

SAS Functions

- Determine available frequencies at a location and assign them to CBSDs
- Determine maximum permissible power level for CBSDs at a location
- Register and authenticate CBSDs
- Enforce Exclusion and Protection Zones
- Protect PALs from IX from other users
- Facilitate coordination between GAAs
- Ensure secure and reliable transmission of information between the SAS, ESC, and CBSDs
- Protect Grandfathered Wireless Broadband Licensees
- Facilitate coordination and information exchange between SASs

Conditional approval to 7 SAS Administrators
6 ESC Proposals - pending

Multi-stakeholder group through Winnforum developing standards
### Spectrum for 5G

<table>
<thead>
<tr>
<th>Frequency</th>
<th>28 GHz</th>
<th>37 GHz</th>
<th>39 GHz</th>
<th>64-71 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bandwidth</strong></td>
<td>850 MHz</td>
<td>1600 MHz</td>
<td>1400 MHz</td>
<td>7000 MHz</td>
</tr>
<tr>
<td><strong>Terrestrial Allocation</strong></td>
<td>Licensed for fixed operations, with about 75% of the population covered by existing licenses; remaining licenses in inventory</td>
<td>Yes (no current use)</td>
<td>Licensed for fixed operations, with about 50% of the population covered by existing licenses; the remaining licenses are in inventory.</td>
<td>Yes (no current use)</td>
</tr>
<tr>
<td><strong>Federal Allocation</strong></td>
<td>No</td>
<td>Radio Astronomy / Space Research in 37-38 GHz @ 3 sites; Federal Fixed/Mobile in 37-38.6 GHz @ 14 locations</td>
<td>Fixed Satellite Service / Mobile Satellite Service in 39.5-40 (military use only)</td>
<td>Earth Exploration Satellite Fixed/Mobile/Satellite</td>
</tr>
<tr>
<td><strong>Satellite Allocation</strong></td>
<td>Yes Earth-to-Space</td>
<td>Yes (no current use) Space-to-Earth</td>
<td>Yes (no current use) Space-to-Earth</td>
<td>Yes (no current use) EESS, ISS</td>
</tr>
<tr>
<td><strong>Licensing Scheme</strong></td>
<td>Licensed</td>
<td>Licensed</td>
<td>Licensed</td>
<td>Unlicensed</td>
</tr>
</tbody>
</table>

- **Report and Order and Further Notice of Proposed Rulemaking adopted July 14, 2016**
- **Added 10.85 GHz of for mobile service**
- **Considering additional 15.8 GHz & above 95 GHz**
  - 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
  - bands above 95 GHz
5 GHz Band

555 megahertz of spectrum currently available for unlicensed devices

- Potential sharing of DSRC and unlicensed devices
- Some of this spectrum relies on dynamic frequency selection to avoid interfere with radars

FCC Notice of Proposed Rule Making

- Proposed access to U-NII-2B and U-NII-4 for unlicensed devices
- No change to existing spectrum allocations - existing allocations/services are protected against harmful interference
Significant progress towards dynamic spectrum sharing has been made
• Keep and open mind to new ideas
• Government/Industry collaboration

New norm for sharing
• Automation
• Speed
• Intelligence

Enablers
• Proper incentives
• bi-directionality
• Predictably
• Flexibility
• trust

The future for dynamic spectrum sharing is bright!
Thank you!