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National Spectrum Strategy (NSS): Its Impact on the DOE Spectrum Allocations

July 2024

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Changing the World's Energy Future

Idaho National Laboratory

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2024 CYBERSECURITY AND TECHNOLOGY INNOVATION CONFERENCE

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Mission Spotlights

National Spectrum Strategy (NSS): Its Impact on the DOE Spectrum Allocations

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INL Wireless Security Institute (WSI)

VISION: National Leadership on Wireless Security for Secure Adoption of Advanced Technologies including 5G, Next G/6G, Wi-Fi 6E and related Spectrum

MISSION: Provide best in class security research, assessments, evaluations, engineering support, and technology development to enable government and industry harvest the benefits of advanced wireless technologies

Innovative Research

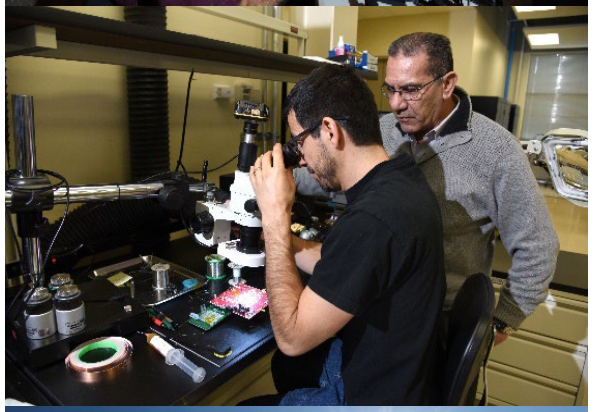
- Lab directed research on security of advanced technologies and secure spectrum use and sharing
- Externally funded research, analysis, and engineering studies to address national security gaps in secure use of 5G & Future G/6G technologies and spectrum
- Proof of Concept for development and deployment of secure real-world use cases with transformational technologies

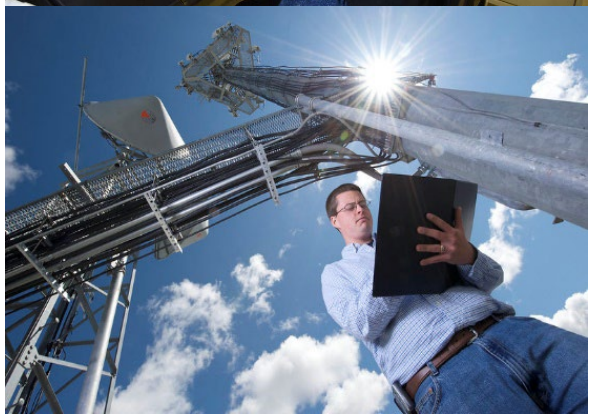
Evaluation & Validation

- Effective, accurate, responsive testing and verification
- Advanced Lab based systems for highly efficient and intrusive testing
- Unique Wireless Test Bed (WTB) in outdoor environment providing capability to test real world scenarios at scale
- WTB Spectrum flexibility with NTIA experimental station status

External Collaborations

- Academic and Industry Researchers in US
- Hosting of National Security workshops and Conference Tracks addressing key security topics with participation from US Government, Industry, and Academia
- International collaboration with wireless leaders in US Government partner countries





NOTABLE OUTCOMES: Diversely Funded RDD&D Portfolio supported by WSI as a National Authority on Wireless Security and utilizing resources across INL to exceed customer expectation

Unique National Security Infrastructure and Capabilities

Electric Grid Test Bed

Commercial Feeds,
Test Loops/Spurs

Water Security Test Bed

Municipal Water System

Radiological Ranges

First Responder Training

Specific Manufacturing

Quality Product

Wireless Test Bed

Agile Spectrum

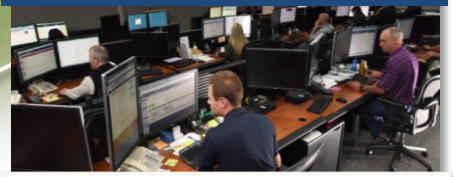
National Security Test Range

~20k TNT, VA Center

Nuclear Materials R&D

Electro-refining, SNM for Test/R&D

Research and Education Campus



Controls & Energy Security Labs

- ✓ **Full-scale real-world testing and deployment** *(designed, built and operated by INL)*
- ✓ **Integrated testing across multidisciplinary areas** *(radiological, physical security, explosive, power, controls, cyber)*
- ✓ **Rapid development through model, test, validate, and refine** *(high fidelity, effects-based modeling, rapid testing and measurement)*
- ✓ **Access to the full range of support services** *(lineman, engineers, rad techs, fire fighters and security forces)*
- ✓ **Ability to develop prototypes, manufacturing process and resolve uncertainty**

demonstrations for

INL Wireless/Spectrum Security Programs

- **DOD OUSD**: Security Assessment for 5G Operate Through Program
- **NTIA/FCC/DOE**: National Spectrum Strategy (NSS) Implementation Plan (7/8 GHz Interference Study)
- **DOE-CIO**: 1) Spectrum Security for Advanced Wireless Technologies; 2) Spectrum Nuclear Power Plant Modernization with Advanced Wireless
- **DOE-CESER**: 1) Study of harmful interference in 6 GHz to incumbents; 2) Security Assessment of Automatic Frequency Coordination (AFC)
- **CISA/NRMC/NISAC:** Study of 5G small cell backup batteries
- **DOJ/DoD**: Spectrum agile video surveillance communications
- Multiple LDRD research projects for WSI call section 5.3. Secure Wireless Communications and Dynamic Spectrum Sharing

Spectrum Repurposing and the Need for Scientific Interference Study

- In 2020, FCC repurposed spectrum in the 6 GHz band allocated to DOE/US Government for commercial use of Wi-Fi 6E/7 & 5G-NR-U.
- The 2024 National Spectrum Strategy (NSS) implementation plan is now considering 7/8 GHz band for co-existence of commercial devices with federal incumbents such as DOE.
- A scientific study on any potentially harmful interference caused by the commercial devices in real-world scenarios is critical for future decisions to allow additional spectrum co-existence.

5G Spectrum – FCC Allocations

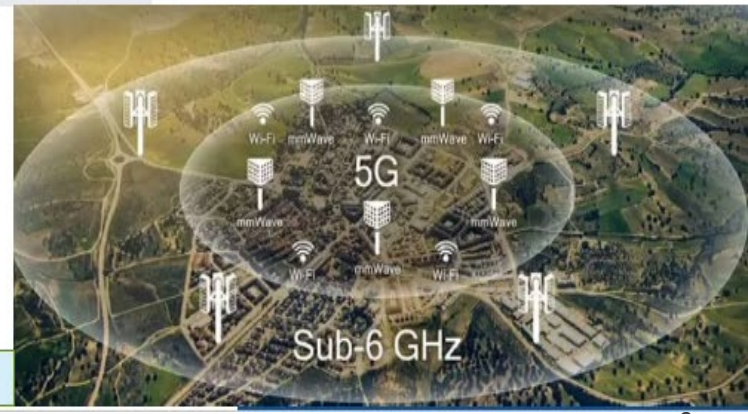
High-band (mmWave):

- ✓ 24 GHz, 28 GHz, upper 37 GHz (shared) , 39 GHz, and 47 GHz bands – total of about 5 GHz licensed
- ✓ **Unlicensed**: 64-71 GHz: 7 GHz of new unlicensed spectrum, doubles existing 47-64 GHz band

From 3GPP 5G Implementation Guidelines, GSMA

Medium-band: 2.5 GHz, 3.3-3.45 GHz (shared with airborne radar), 3.45-3.55 GHz, 3.55-3.65 GHz (shared by CBRS PAL and GAA users), and 3.7-3.98 GHz/C Band, 5.905-5.925 GHz (C-V2X)

- ✓ **Unlicensed**: 5.925-7.125 GHz, 1200 MHz at 6 GHz (Wi Fi 6E, 5G-NR-U).



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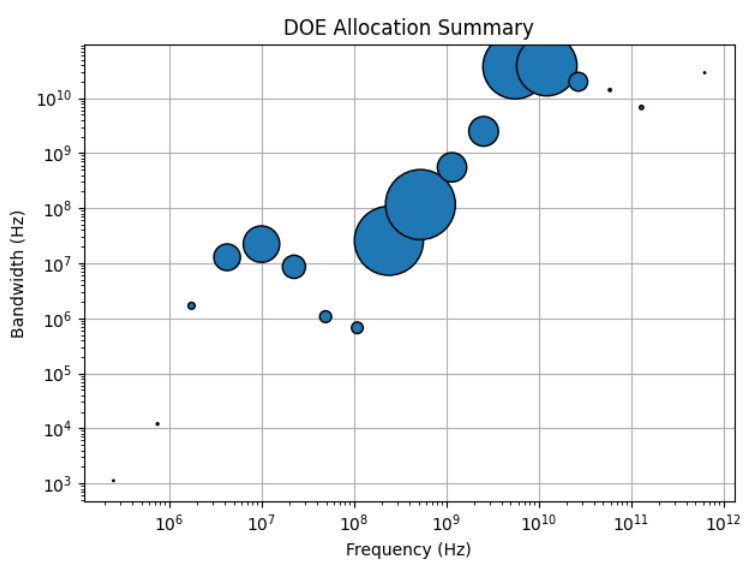
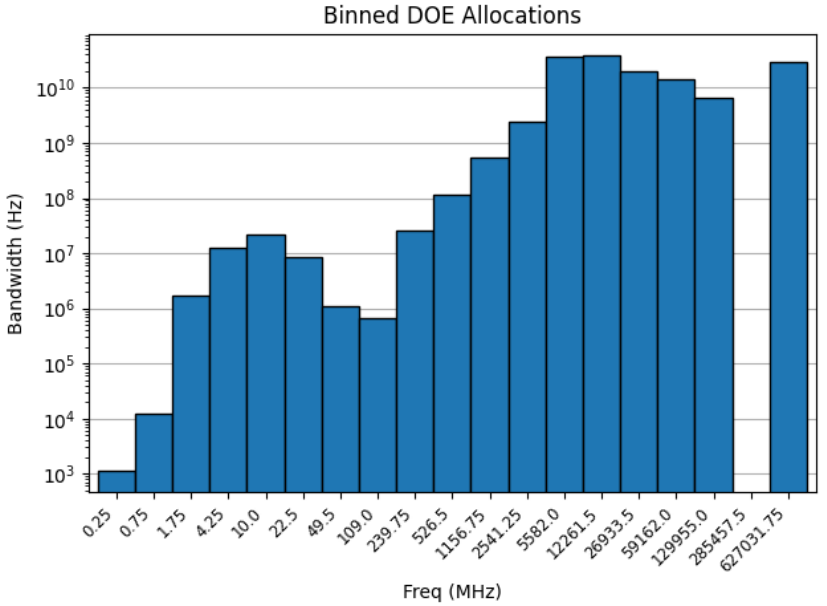
From https://www.androidauthority.com/what-is-5g-mmwave-933631/

INL Approach and Innovative Aspects

- Identify current DOE allocations and associated use cases.
- Analyze, detect and measure any harmful interference caused by commercial Wi-Fi 6E/7 devices in real-world scenarios to 6 GHz utility links.
- Develop methodology for scientific spectrum interference analysis for spectrum co-existence.
- Conduct security assessment of the Automatic Frequency Coordination (AFC) along with its functional effectiveness.
- Investigate autonomous spectrum sharing approach without centralized co-ordination.
- Identify DOE use cases that can benefit from spectrum co-existence.





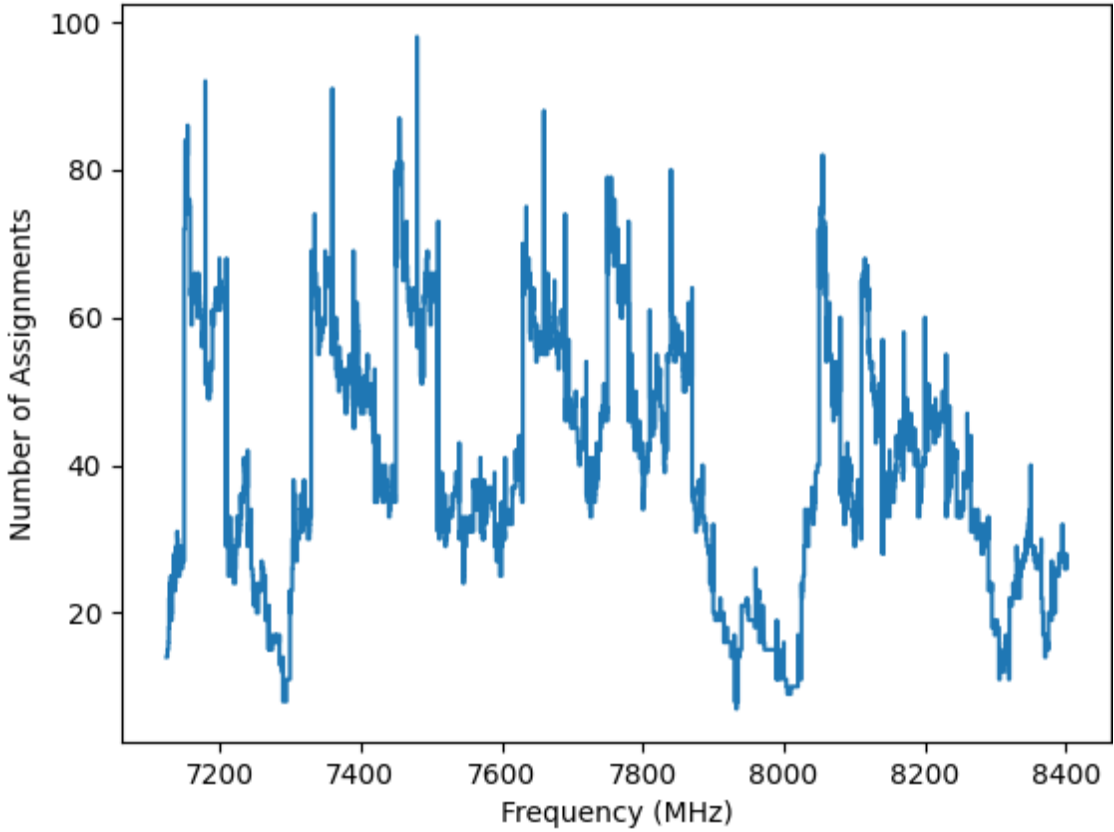
NSS Target Bands of Study

NSS Targeted Bands

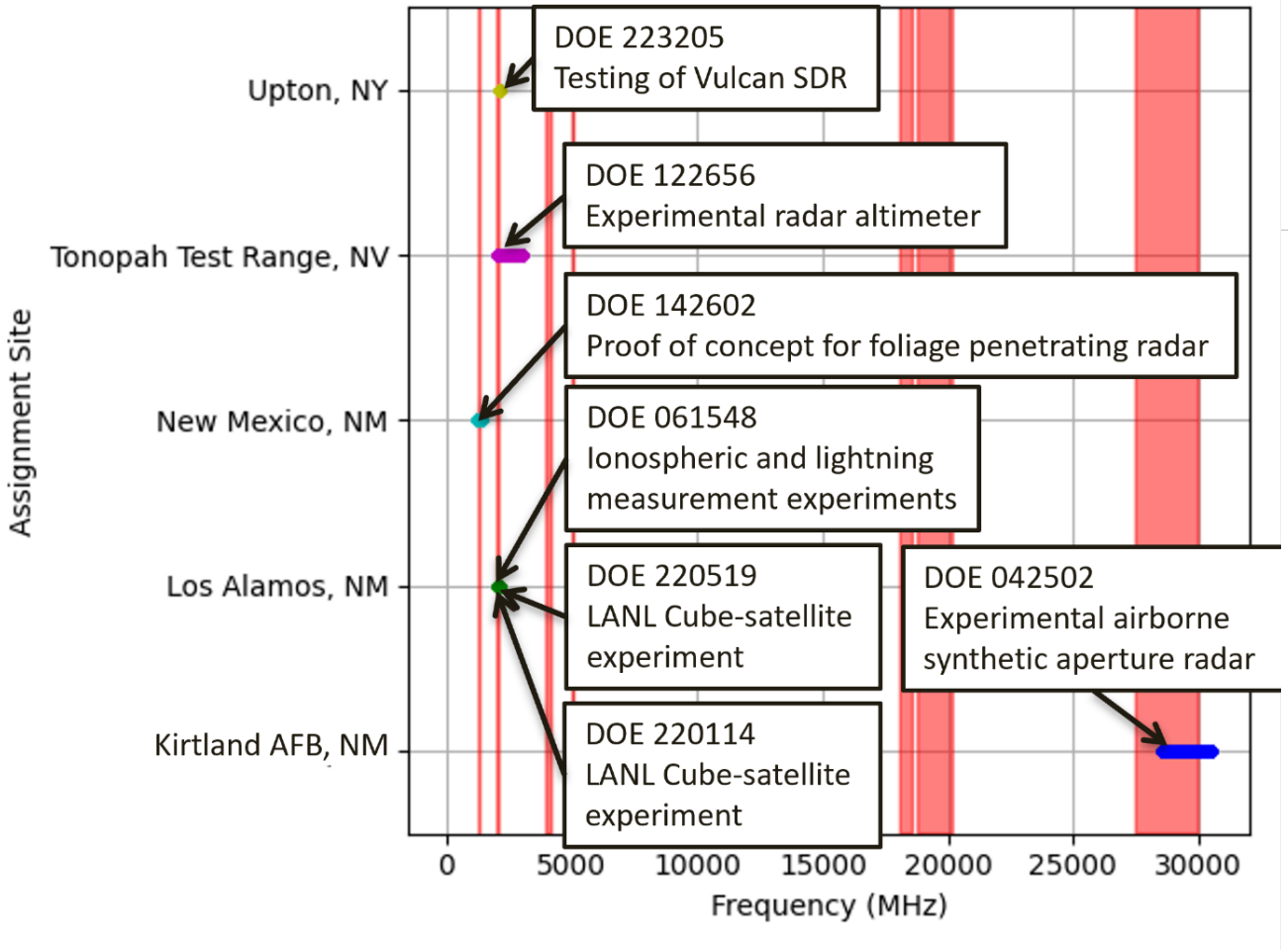
Lower Edge (MHz)	Upper Edge (MHz)	Width (MHz)	Center (MHz)
3100	3450	350	3275
5030	5091	61	5060.5
7125	**8400**	**1275**	**7762.5**
18100	18600	500	18350
37000	37600	600	37300

DOE Assignments in 7/8 GHz

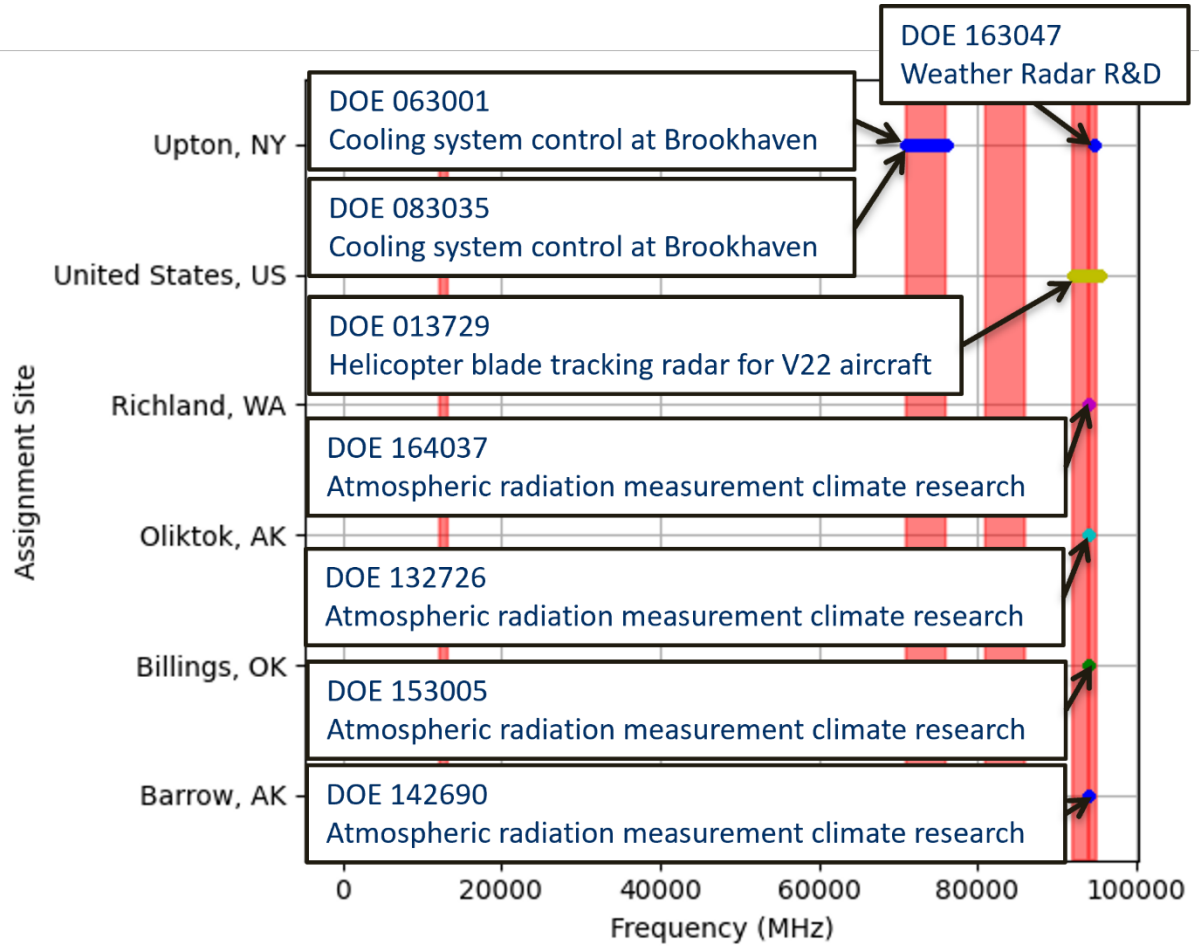
Comm Function	#	%	Width (MHz)	Total Spectrum %
Contingency	1222	15.84	36829.34	24.72
Microwave	889	11.52	23338.44	15.66
LMR	9	0.12	166.07	0.11
Telemetry	1	0.01	25.00	0.02



Allocation Overlaps with Current Usage

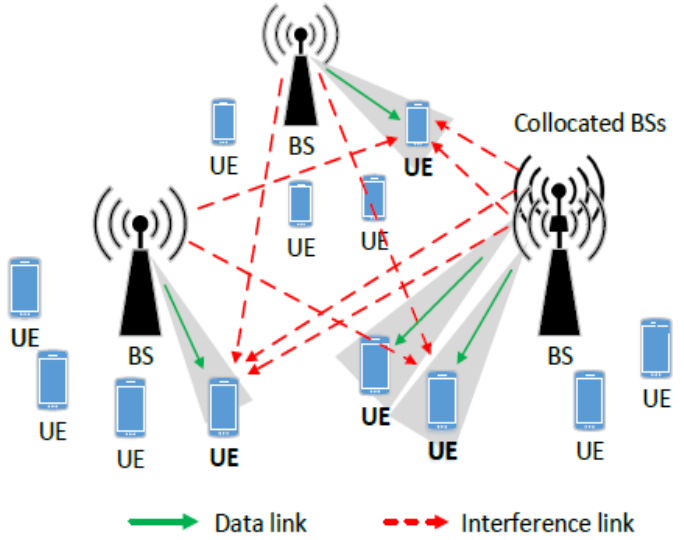


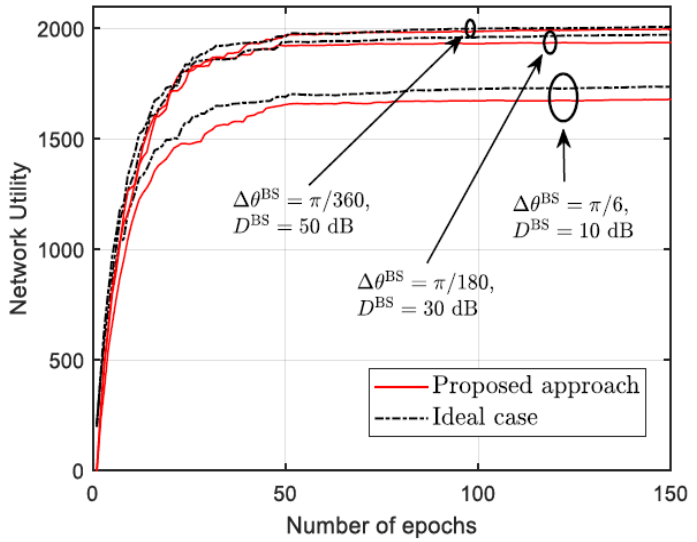
DOE Use cases in 7/8 GHz



Distributed Spectrum Sharing for 5G (and 6G)

- Lab Directed R&D (LDRD) with University of Utah: Secure mmWave Spectrum Sharing (SS) with Autonomous Beam Scheduling
- Each base station sharing spectrum uses sensing with its UEs for this scheduler
- Novel problem formulation based on the Lyapunov stochastic optimization framework
- Decomposed the network utility optimization problem into two sub-optimization problems
  - ✓ Convex optimization to determine auxiliary variables
  - ✓ Non-convex stochastic optimization problem for optimal power allocation for beam scheduling
- Q-Learning and Game Theoretic (GT) based approach to design the distributed scheduler
- Published 7 papers in IEEE Transactions on Wireless Communications, IEEE DySPAN conference and others
- Patent application filed





Conclusions and Path Ahead

- The NSS is actively trying to identify additional spectrum for coexistence of commercial service with currently allocated government entities such as DOE.
- An objective and science-based methodology to identify any harmful interference such coexistence can create is essential to identify suitable bands for coexistence.
- INL has created the foundation for this methodology by
  - ✓ Identifying currently allocated spectrum to DOE and associated use cases
  - ✓ Interference testing using real world scenarios with commercial Wi-Fi 6E and AFC
- NSS decisions will also affect future 5G and 6G deployments in US
- Spectrum coexistence can potentially be a win-win for government and commercial use and INL can help