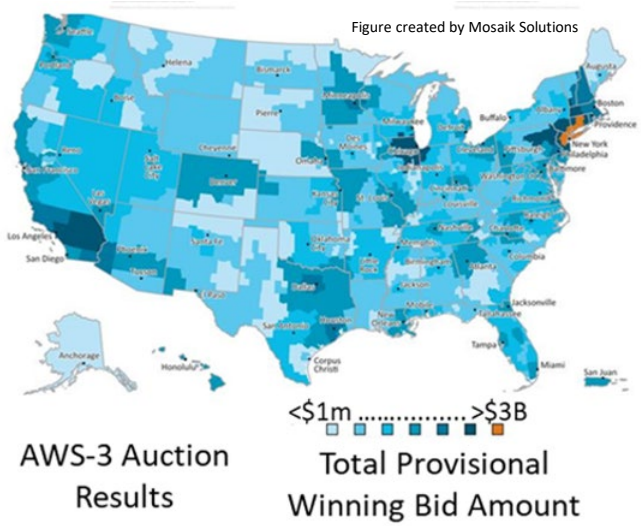
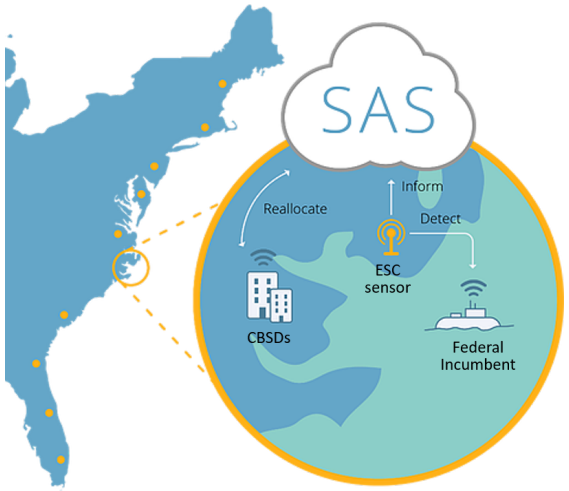
Spectrum Sharing: Implications for the Testbed Community

Growing Need for Spectrum Testing

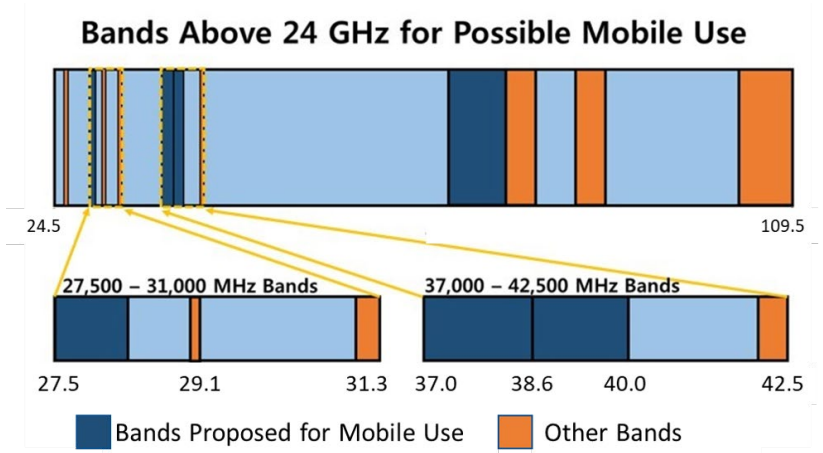
Through spectrum auctions, reassignment, or other methods, wireless communications and incumbent systems must operate in compressed or shared spectrum. While these create new opportunities for spectrum usage, risks for potential impact between systems also increases.



Advanced Wireless Services
AWS-3 (LTE)
Outdoor Test ranges



Citizens Broadband Radio Service
CBRS (3.5GHz)
Military Radars



Spectrum Frontiers (24&28GHz)
Weather and
remote sensing

Spectrum Testing – multiple approaches, needs

The U.S. Government has a distributed approach to communications research, development, testing, and evaluation (RDT&E)

The Advanced Wireless Test Platforms (AWTP) Interagency Team was formed in 2020 to help the USG address research challenges and opportunities for improving access and coordination of nationwide wireless test platforms.

- 5G Joint Workshop (AWTP and FMG)
- Report on Federal testbeds
- Workshop on Shared Spectrum implications for testbeds

https://www.nitrd.gov/coordination-areas/wsrd/awtp/

What do we mean by spectrum sharing testbeds?

Testbeds for Spectrum Sharing - Evolve new spectrum sharing solutions

- Performance-based evaluations of systems that use spectrum sharing
- Characterize, analyze, and understand new spectrum sharing approaches and technologies
- Evolve new spectrum sharing management practices

Spectrum Sharing for Testing – Using spectrum sharing to enhance testing

- Augment access to testbeds, data
- Increase number and type of items in testbed, reduce delays

Large variety of Testbeds – Outdoor, Labs, Modeling

UAV/Drones, collaborative sensing

https://wrc-nc.org/aerpaw/

mmWave, propagation

https://www.cosmos-lab.org/

SDN, Massive MIMO, Spectrum mgmt

https://powderwireless.net/

Radio Quiet Zone CRAIN

https://its.ntia.gov/research-topics/table-mountain/tm-home/

Metrology and standards

https://www.nist.gov/ctl/national-broadband-interoperability-test-bed-nbit

COLOSSEUM

https://www.northeastern.edu/colosseum/

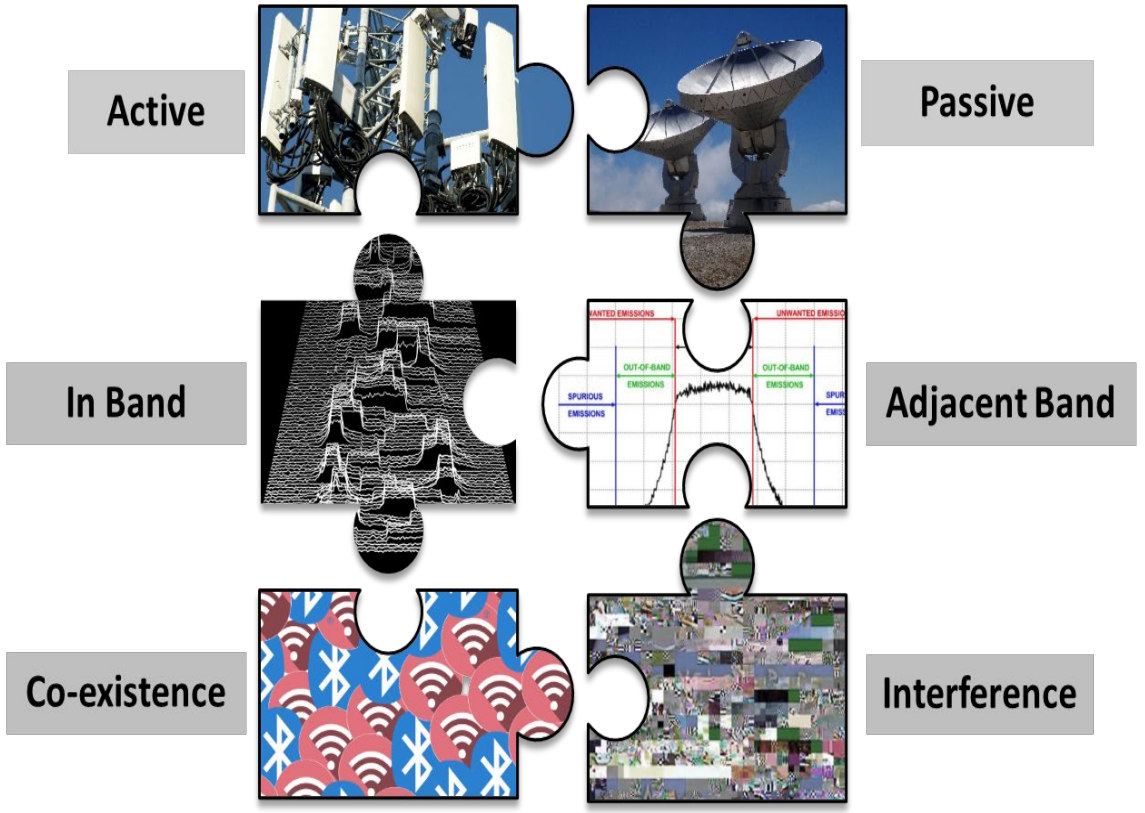
NextG Channel Model Alliance

https://www.nist.gov/ctl/nextg-channel-model-alliance

Many considerations must be taken into account

Testing Considerations/Approaches:

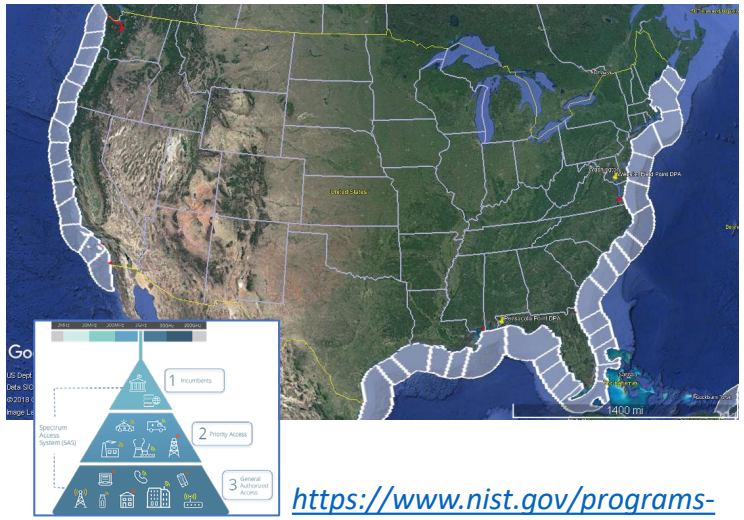
- Active, Passive, In-Band, Adjacent-Band, Co-Existence, Interference
- Centralized sense/response vs localized sense/response
- Characterizing Testbeds (and stability and Adaptable systems)
- Specialized vs Generalized (access)
- Leverage Existing vs New testbeds



Additional information: https://www.cio.gov/assets/files/Framework-to-Conduct-5G-Testing-508.pdf

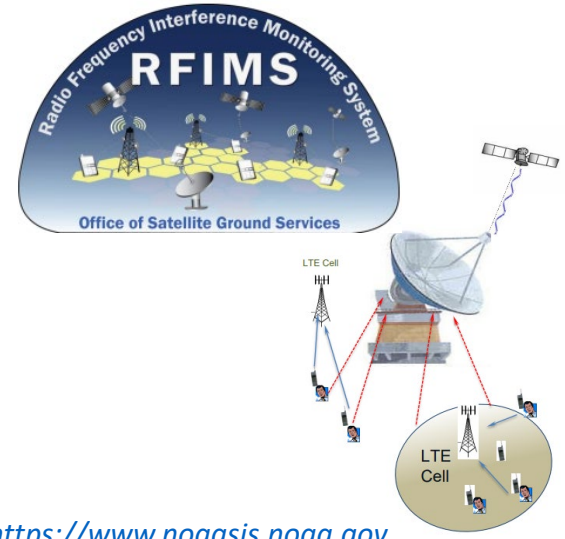
Different approaches of sharing

Example: Centralized sense/response vs localized sense/response



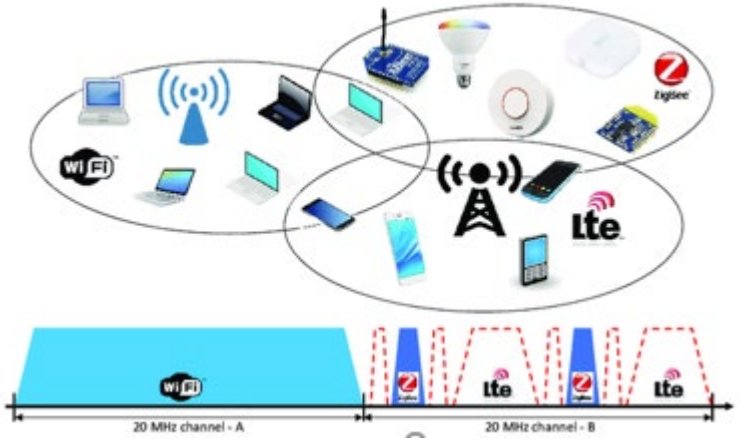
https://www.nist.gov/programs-projects/citizens-broadband-radio-service

Large area, centralized response (timescales on minutes/day)



https://www.noaasis.noaa.gov

Regional area, timescales on seconds/minutes



Figueiredo, A Baseband Wireless Spectrum Hypervisor for Multiplexing Concurrent OFDM Signals

Local (Dynamic Spectrum Access), timescales on sub-seconds/ seconds

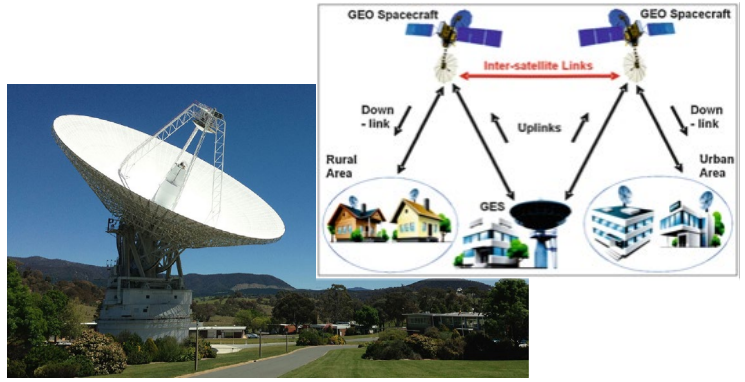
Pre-emptive sharing coordination → Multiple systems working pieces of the sharing → All systems contributing to sharing

Different approaches to Testbed access and design

Example: Specialized vs Generalized (access)

https://www.cosmos-lab.org/

https://www.aftc.af.mil/News/Article-Display/Article/3001369/hill-afb-supports-dod-5g-quick-reaction-tests/



www.nasa.gov

Community Access driven

- Academia (NSF)
- Industry (plug-in festivals)
- Remote access capability
- Access to data
- Flexibility, large and varied user base
- Customizable within bounds
- Standard interfaces

Mission Driven

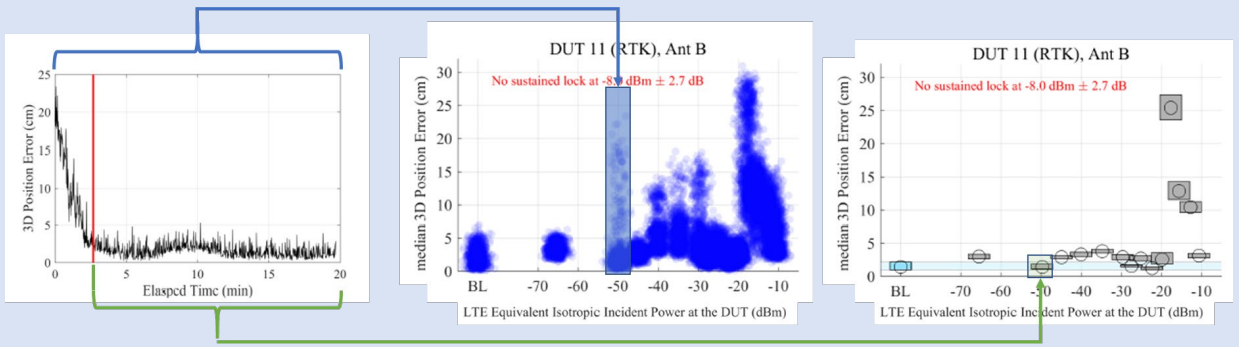
- Deep dive into specific problem or question
- Limited number of customers
- Highly customized testbed for each test

Operationally Driven

- No reserved frequencies (NASA, unlicensed)
- Spectrum sharing through necessity
- Opportunity-driven testing (during operations)

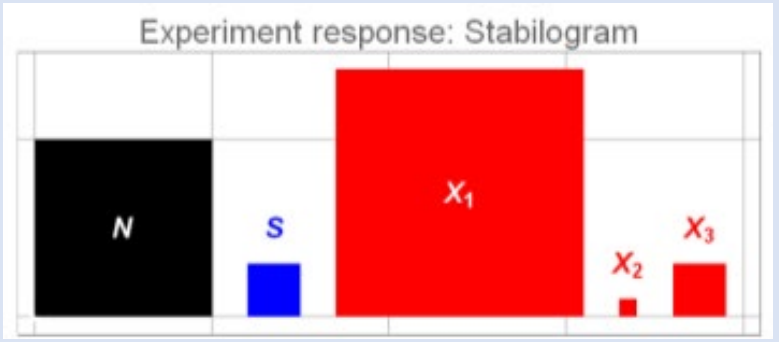
Characterization of Testbeds

Examples: Characterizing Testbeds (Stability)



Confidence regions for steady state conditions (settling/warm-up time) marry the variability in reported KPI's with testbed measurement uncertainty.

https://www.nist.gov/programs-projects/impact-lte-signals-gps-receivers



Anomalies hide within the natural stability (i.e. variations and patterns) of the communication infrastructure

New tool quantifies testbed stability into a visual representation leveraging statistical analysis methods (Anova, MS, RMS)

To be published 2022

Challenges - What's Next

A variety of challenges for current and future testing were raised during the workshop.

- Adaptable systems – testbed characterization and stability
- How do you measure Spectrum Management and policy?
  - Adding policy engines to their dynamic spectrum allocation
  - Measuring "Fairness"
- Testing and new management approaches for Passive systems
- Measuring Risk of Interference (vs measuring interference)
- 2 Way sharing
- Infrastructure/Logistics
  - Chicken-Egg: Spectrum sold before technology exists that utilizes it
  - Large number of systems and connections
  - Need for Operationally relevant environments
  - Doesn't fit into current processes/procedures

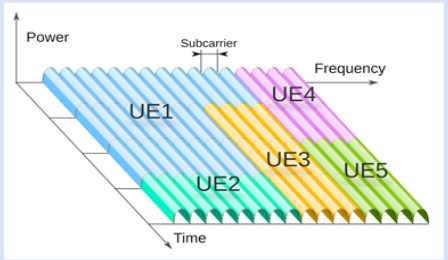
Challenges: Examples

Adaptable and Variable systems

- What does testbed “steady-state” mean?
- How does this affect EMC standards?

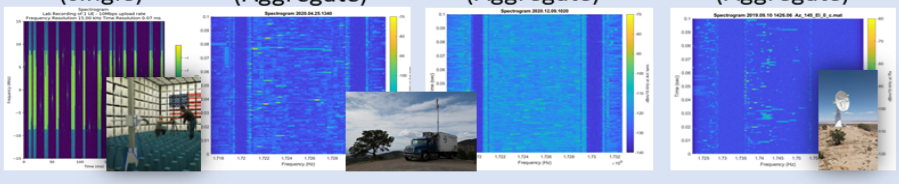
Characterizing cellular system interactions is complex

Adapts and varies in time, 1000’s of variations (local region scheduling, customized settings)



Cellular signals interleave (“schedule”) uplink broadcasts within their frequency allocation

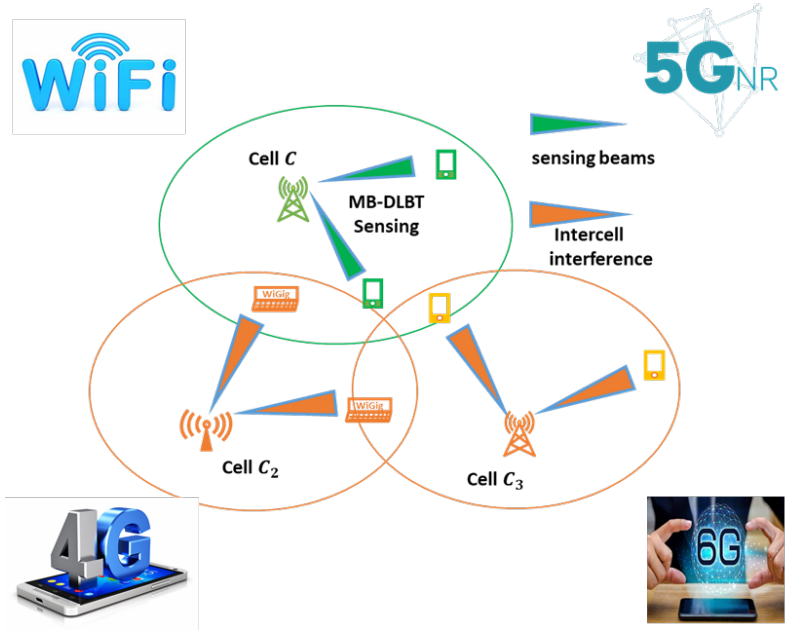
Lab (single) | Longmont (Aggregate) | Denver (Aggregate) | Edwards AFB (Aggregate)



https://www.nist.gov/programs-projects/aws-3-lte-impacts-amt

Wireless Co-existence (unlicensed/licensed)

- Network optimization (protocols, beamforming)
- How do you measure “fairness”?



https://www.nist.gov/news-events/news/2020/05/nist-formula-may-help-5g-wireless-networks-efficiently-share-communications

Summary

There is no one laboratory or outdoor range that can support the entire scope of research, development, and evaluation of wireless systems that is required by industry and Governments

- Multiple capabilities are required, each with varying levels of technical details based on intended use
- Significant trade-offs exist between operational response and flexibility when testbed equipment is tailored to a research area, application, or use case

Other Upcoming challenges

- AI and adaptable systems
- Data Driven spectrum policy and management
- Terrestrial to non-terrestrial