

# Bridging the Gap: Translating Academic Spectrum Research into National Impact

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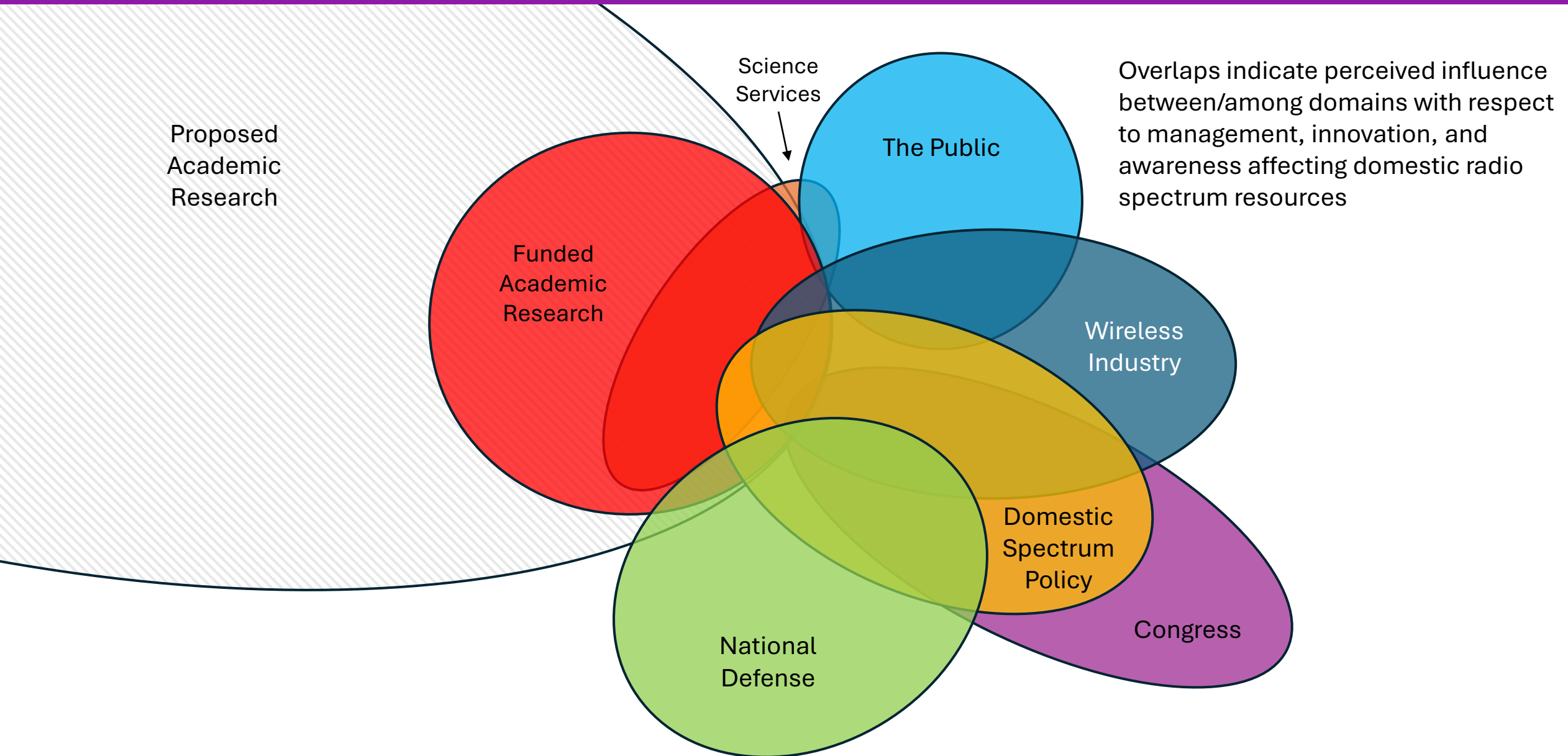
# The Nation's Interest in Spectrum

- Estimated \$3,000,000,000,000 annual impact on U.S. economy
- A critical component of national defense
  - “Nearly every modern military system — from airplanes to satellites, tanks, ships and radios — depends on spectrum to function.”
    - ADM Mike Rogers, USN (ret) and LTG Bruce Crawford, USA (ret)
- Topic of Executive Memoranda by every U.S. president since Clinton
- Addressed in major Congressional bills (IIJA and OB3 recently)
- Focus of Congressional hearings
- Topic of federal court cases
- Articles, editorials, and opinions in major U.S. newspapers
- TV commercials
- Spectrum is relied upon every day by everyone

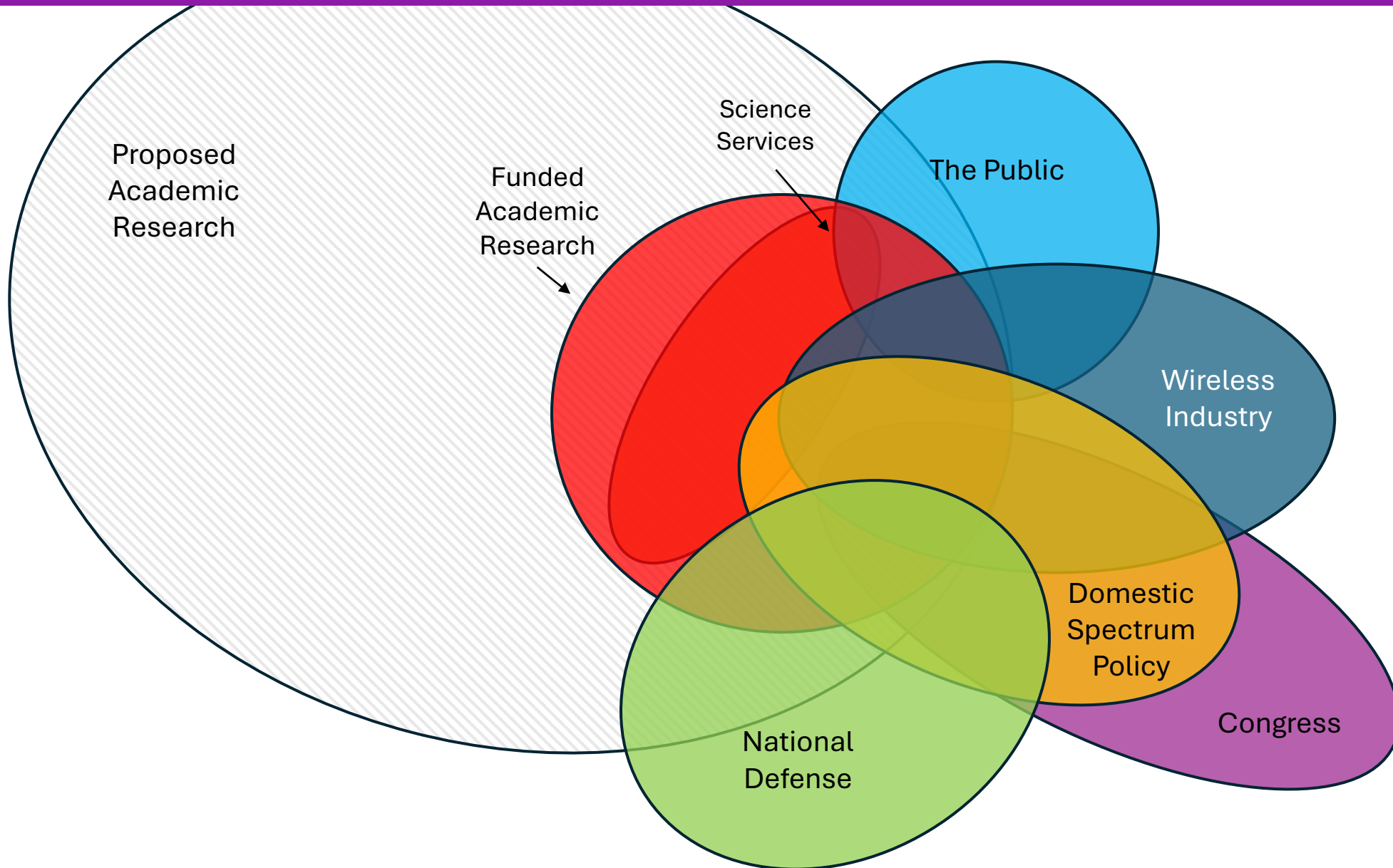
# Why Does Impact Matter?

- Aligning your research with national spectrum needs and priorities:
  - Increases its value to society
  - Improves chances for funding
  - Exposes opportunities for new ventures
  - Positions your students for future success
  - Appeals to a greater variety of alternative funding sources

# Suboptimal Coupling in the Spectrum Domain



# Improved Coupling in the Spectrum Domain



# SpectrumX

57 team members/30 member institutions

External Advisory Board

Collaboration Board



## Advanced Spectrum Sensing & Coexistence Experimentation Platforms

Extremes of Software-Defined Radios (SDRs)

Scalable Data Management

AI/ML Acceleration



## Congressional Hearing Testimony on Spectrum Issues



## Funded Agency Collaborations

NTIA Liaison Projects

DoD Spectrum Taxonomy Project

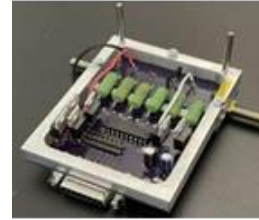
National Spectrum Strategy Listening Session



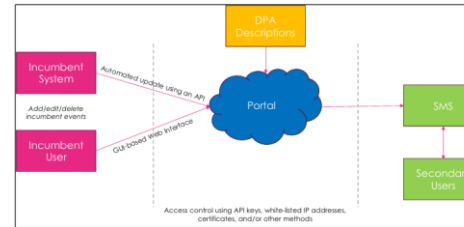
Hub for Spectrum Management through Adaptive and Reconfigurable Technology  
15 universities/25 researchers



Congressional Testimony



Switched-network plasma tuner  
20-70 W power handling  
300 us switch time



Incumbent protection using  
closed-loop interference feedback

Technology Development and Transfer



Workforce Development



Feb 2025 Technology Demo to Stakeholders

# Research Opportunities Based on Recent Experiences

- Lessons learned from recent large-scale spectrum sharing implementations can be used to identify promising areas for impactful research
- Lessons learned from CBRS have been addressed in three significant releases:
  - Wireless Innovation Forum [\*Lessons Learned from CBRS\*](#) (WINNF RC-1017)
  - FCC Technological Advisory Council [\*Recommendations to the FCC on CBRS Lessons Learned\*](#)
  - Commerce Spectrum Management Advisory Committee [\*Report of Subcommittee on CBRS\*](#)



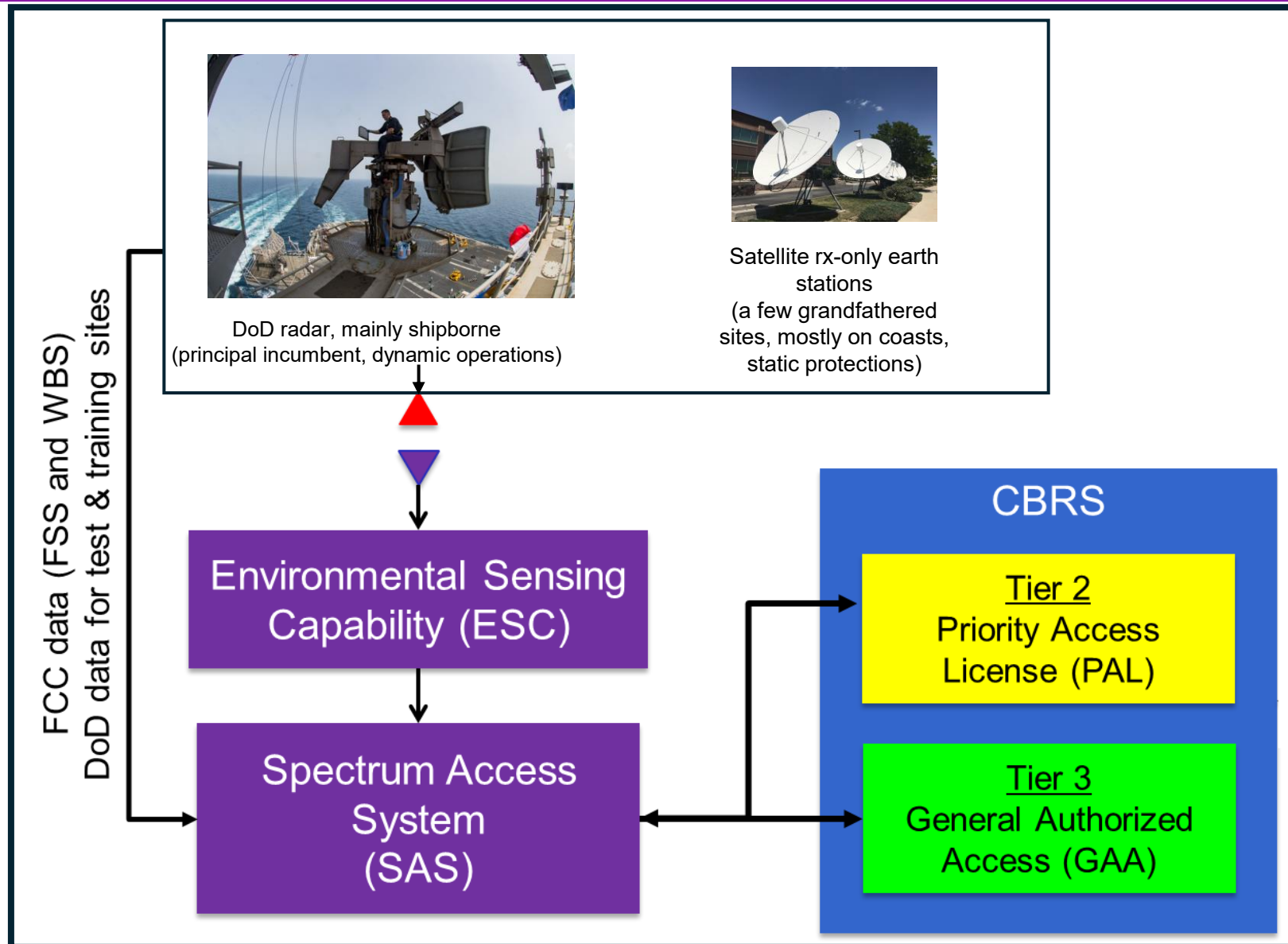
# Citizens Broadband Radio Service (CBRS)

- Broadband services in a band shared with federal and non-federal incumbents
- CBRS is an underlay service that must not interfere with incumbents
- Three-tier sharing architecture: incumbents + two tiers of CBRS:
  - CBRS Priority Access License (**PAL**)
    - Licensed
    - Protection from interference from lower tier (GAA)
  - CBRS General Authorized Access (**GAA**)
    - No intrinsic interference protections
    - Can use spectrum not used by PALs or incumbents
    - Lightly-licensed (generally like license-exempt or unlicensed)
- CBRS devices (**CBSDs**) are controlled by a centralized Spectrum Access System (**SAS**)
  - Category A CBSD: max 1W/10 MHz EIRP
  - Category B CBSD: max 50 W/10 MHz EIRP, outdoors only
- As of August 2025, approximately 420,000 CBSDs are deployed
- There has never been a reported instance of interference into incumbents in the 5 ½ years of CBRS operation

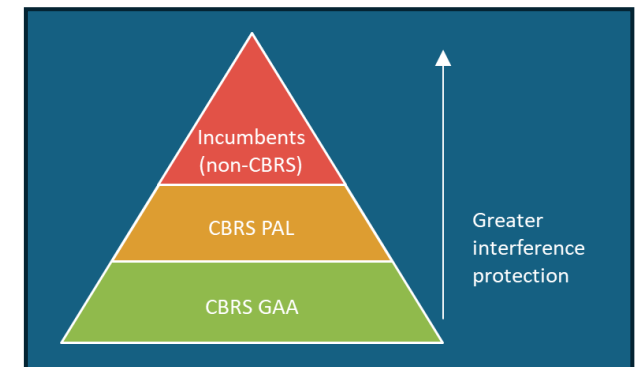
# Incumbent Activity Awareness

- Military radar activity is sporadic in time, frequency, and location
  - The Navy does not inform CBRS users when and where they will operate
  - Radar activity is on varying frequencies but typically one activation stays on the same frequency, is on for minutes to hours, and overlaps only at most two CBRS channels
  - Sensing systems called Environmental Sensing Capability (**ESC**) must be established along the U.S. coasts to monitor for military radar activity and inform the SAS when activity is detected
  - The SAS reconfigures CBSDs during the incumbent activation to avoid interference
  - Activity at a few inland DoD radar sites is booked through an online portal (TARDyS3) which the SAS connects to regularly and uses the information to protect those radar operations when and where scheduled
- Receive-only satellite earth stations are stationary and generally unchanging, and information is available through a specialized (but public) FCC API
- **By far the greatest incumbent protection complexity is with regard to Navy radar. If there was no dynamic military radar to protect, CBRS would be much simpler.**

# CBRS Architecture



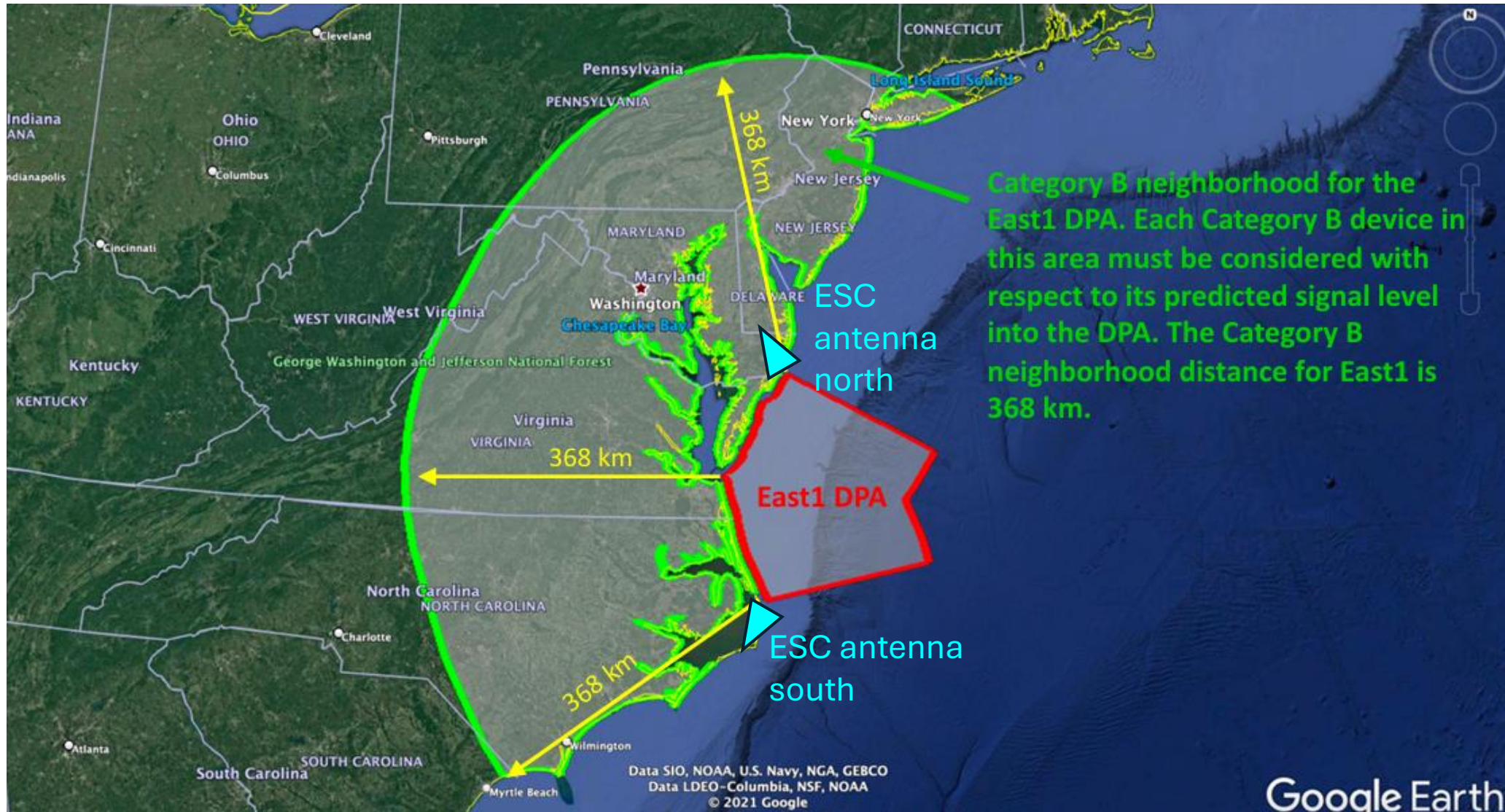
Three-Tier Sharing



SAS is required to manage interference protections:

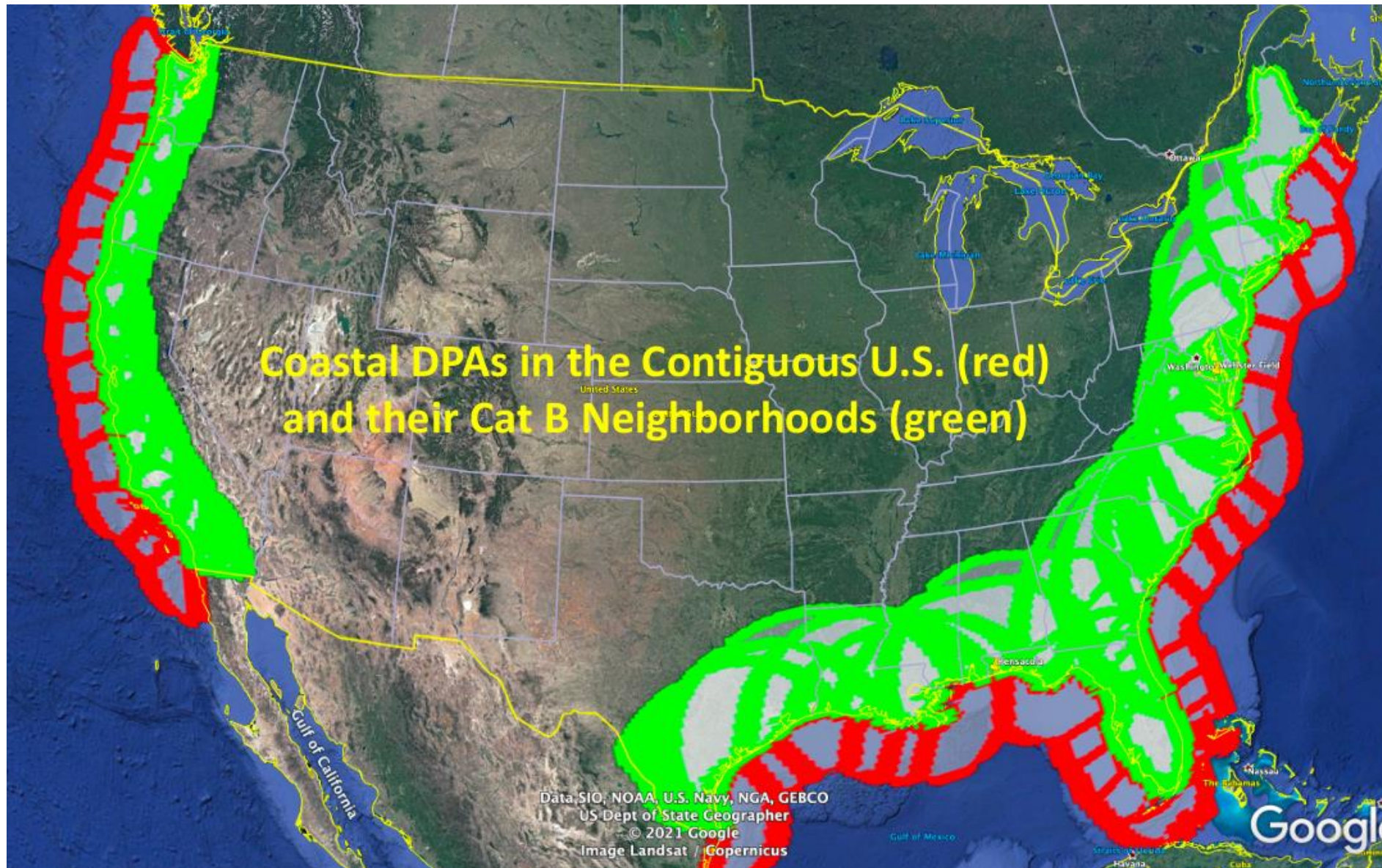
- From Tiers 2 & 3 into Tier 1
- Within Tier 2
- From Tier 3 into Tier 2

# Protecting Incumbents with Dynamic Protection Areas (DPAs)





# Protecting Incumbents with Dynamic Protection Areas (DPAs)



# CBRS Lessons Learned

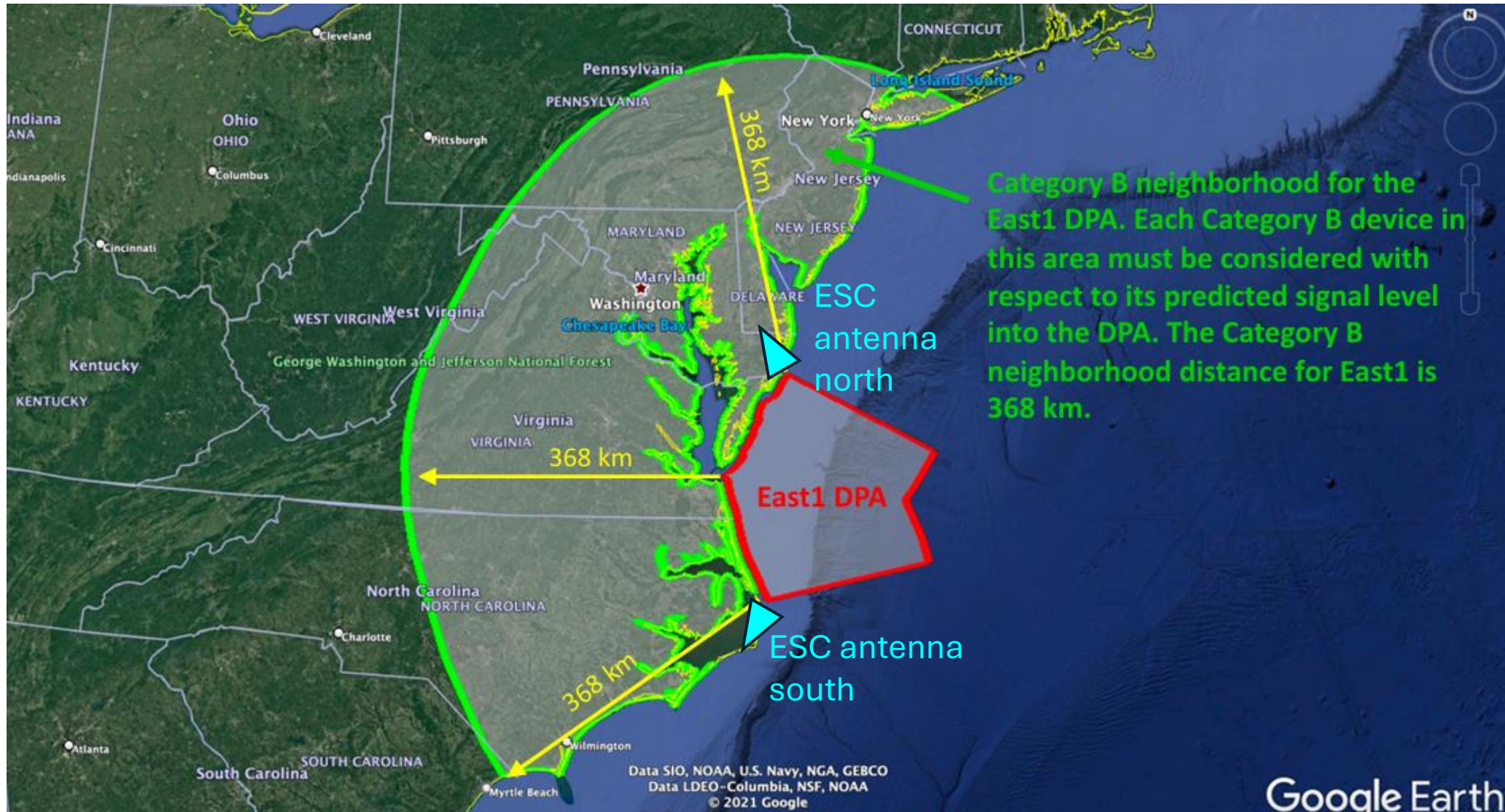
- The CBRS Framework is a Success
  - The CBRS framework has successfully demonstrated that centralized, tiered spectrum sharing is a viable model. It has enabled commercial operations without causing harmful interference to federal incumbents. The model is seen as a blueprint for future shared spectrum initiatives.
- The Model is Not Perfect and Needs Improvement
  - Overly Conservative Protections:
    - The initial federal incumbent protection requirements were intentionally conservative, and this has led to a number of negative impacts.
    - Overly conservative propagation models, large Dynamic Protection Area (DPA) neighborhood sizes, and unnecessarily long DPA activation times reduce the amount of spectrum available for commercial use.
  - Outdated Databases:
    - The FCC's licensing databases (ULS) are often incomplete, inaccurate, or lack the necessary information for accurate interference analysis.



# CBRS Lessons Learned

- **Lack of Clear Coexistence Rules:**
  - The absence of defined coexistence rules for the lowest-tier (GAA) users has resulted in interference issues between commercial users.
- **Reduced Economic Value:**
  - The CBRS PAL auction generated significantly less revenue per MHz-pop than the adjacent, less-restricted C-band, suggesting the sharing model has a tangible economic cost.
- **Operational Challenges:**
  - Dynamic frequency assignments make spectrum planning and network management complicated.
  - The reliance on Environmental Sensing Capability (ESC) sensors has created "Whisper Zones" that reduce commercial spectrum availability, particularly along the coasts.
  - The use of aggregate interference creates computational and competitive challenges

# Protecting Incumbents with Dynamic Protection Areas (DPAs)



# DPA Neighborhoods

- Why are the DPA neighborhoods so big?
  - The propagation model (NTIA/ITS Irregular Terrain Model, ITM)
    - Based on measurement data from the 1950s and 1960s
    - FORTRAN code developed in the 1960s





# ITM Does not Consider Clutter

Manhattan

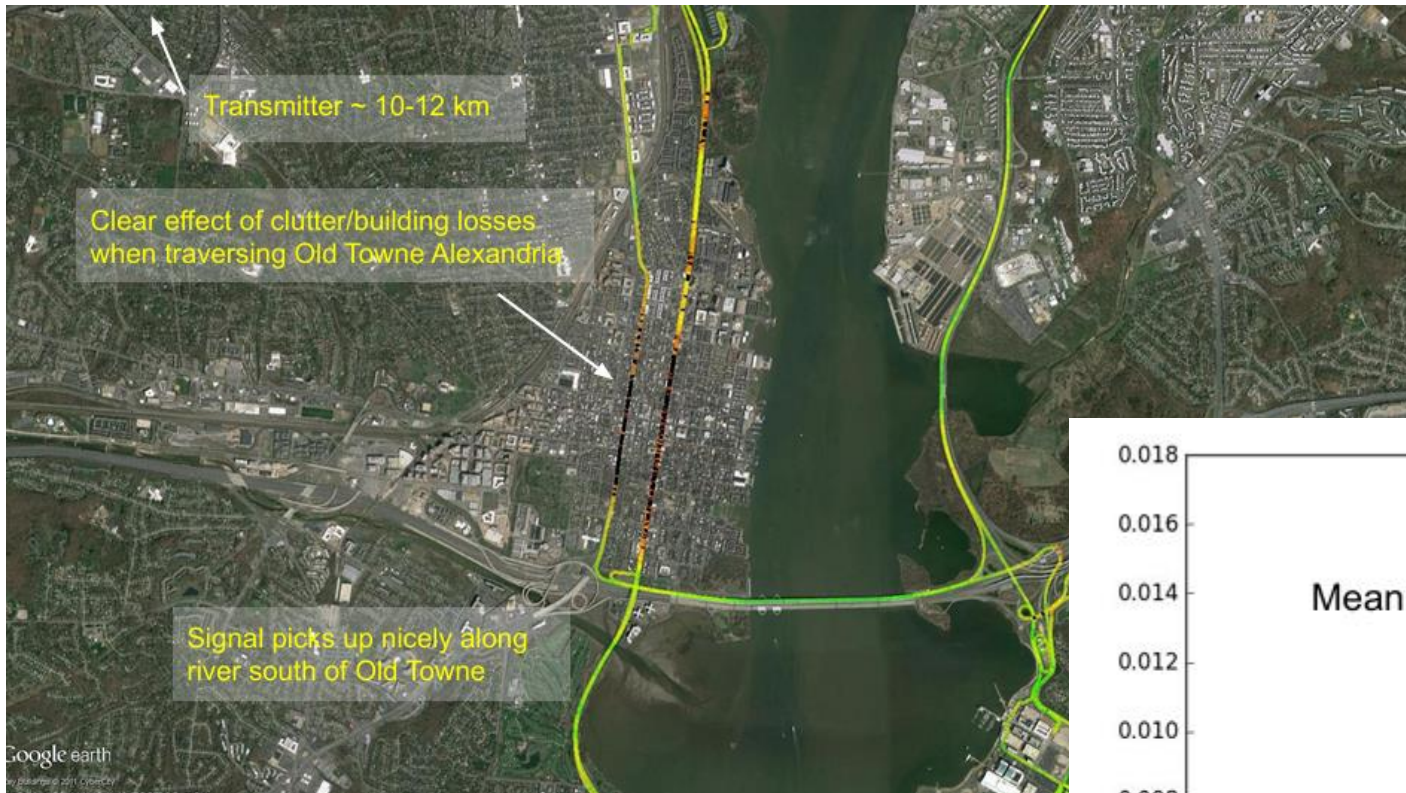


How ITM Sees  
Manhattan



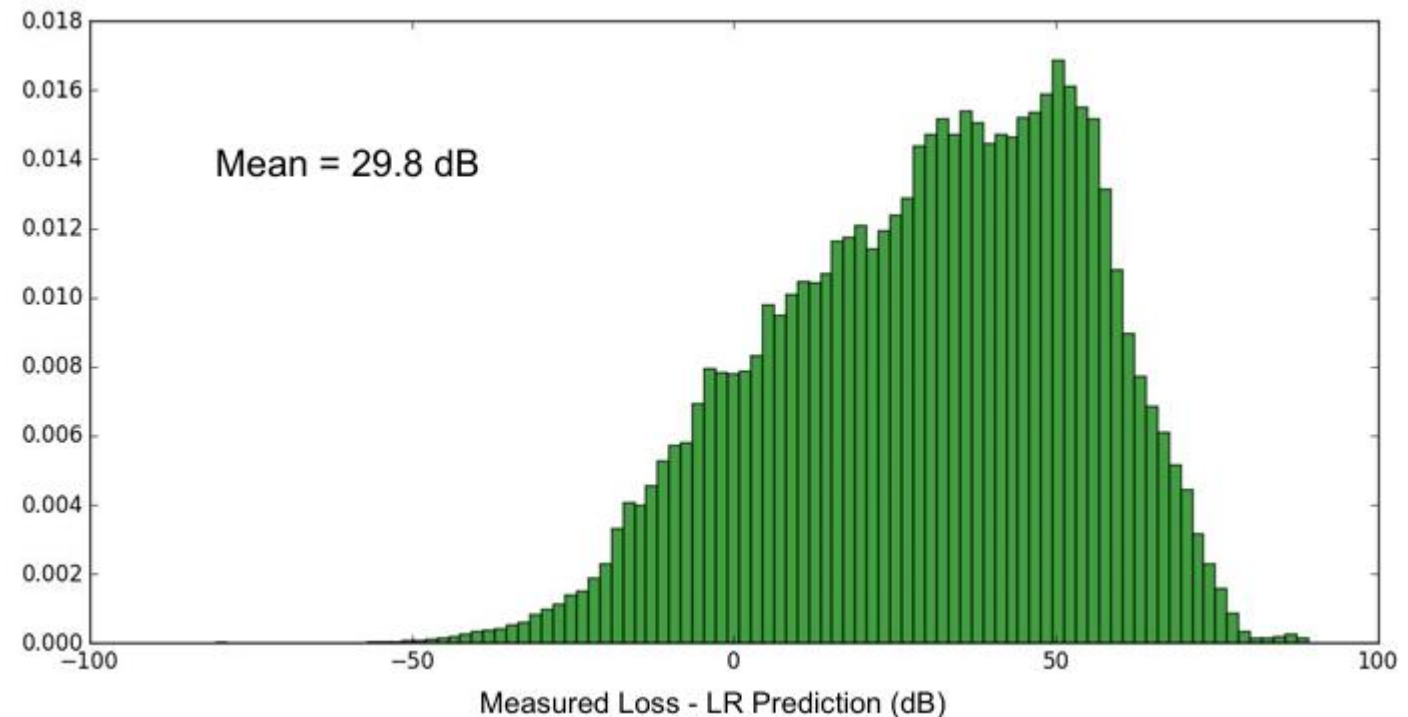


# Putting ITM to the Test



- ITM underpredicts propagation loss by an average of nearly 30 dB based on a propagation measurement campaign in the DC area
  - ~2 million measurements over ~1 year

- There is no allowance for clutter loss in ITM
- Over longer paths, ITM resorts to troposcatter predictions, which have never been rigorously tested
  - Troposcatter predictions also don't include the effects of clutter on scattering angle and therefore predicted loss



# Aggregate Interference

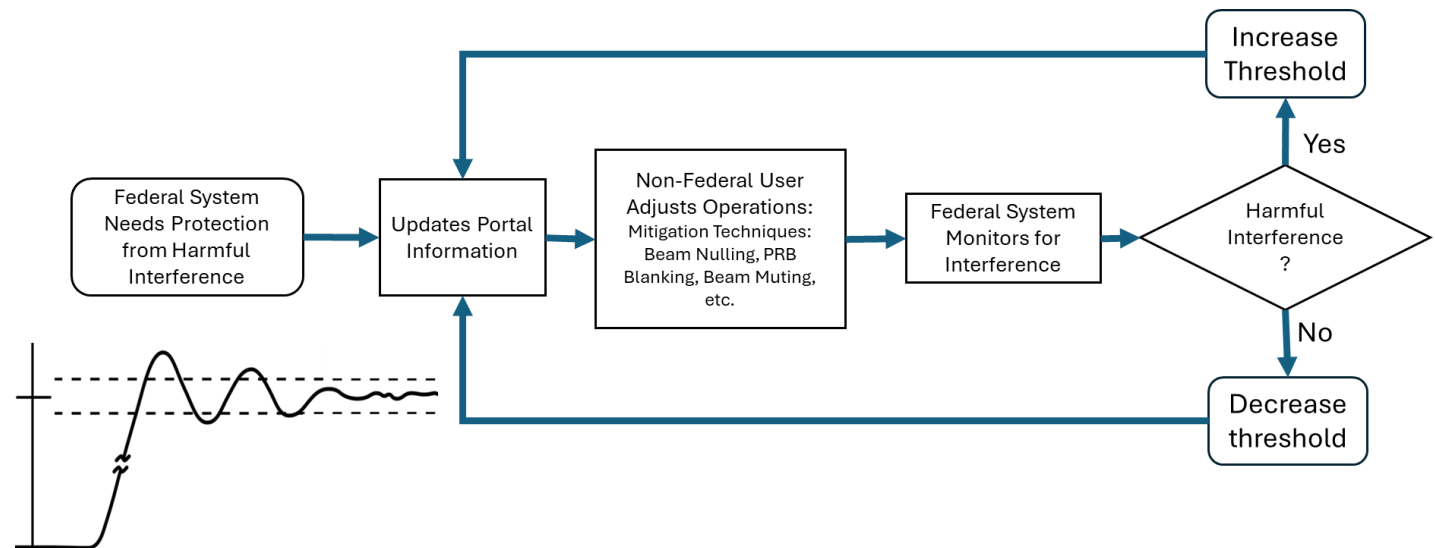
- Aggregate interference calculations are suboptimal
  - Computationally expensive
  - Requires every SAS Administrator to exchange commercially sensitive data with every other SAS Administrator every day
- CBRS aggregate interference calculations based on:
  - All CBSDs in each DPA neighborhood
  - Every 2 arc sec reference point in each DPA (in practice, representative points are used)
  - All DPAs (~100)
  - Every pointing direction of the DoD radar antenna (typically 3 deg beam)
  - Every CBRS channel
  - 2,000 Monte Carlo draws of ITM reliability factor for each set of aggregated co-channel CBSDs
  - Computations performed by each SAS every night; 2-3 hours of clock time each

# Rightsizing Interference Protections

- Based on extensive discussions among all stakeholders, standards were updated in 2024 to help “rightsize” interference predictions
  - Added a clutter term to propagation loss for CBSDs at or below 6 m
  - Included network activity and loading factors in CBSD EIRP
  - Switched to median reliability for ITM instead of 95%; Monte Carlo draws no longer necessary
- Resulted in an average of more than 80% reduction in DPA neighborhood sizes and a resulting substantial reduction in the number of CBSDs potentially impacted by DoD radar activity
- Even so, there remains no reported cases of interference to incumbents from CBRS
  - SASs are likely leaving spectrum “on the table”

# Can we (Mostly) do Away with Propagation Models Altogether?

- Real-time interference feedback could supplement, or possibly even obviate, propagation models
- Incumbent systems incorporate methods to measure received interference (if any) in real time, and report back to the SAS in real time through a portal such as TARDyS3
- SAS can make on-the-fly adjustments to CBSDs in the neighborhood to optimize spectrum utilization
- Incumbent is ensured of interference-free operation
- Hardly any need for a propagation model
- Promising avenue for investigation
  - Incumbent systems require modification
  - Interference measurement procedures and interpretation need significant study





Some Practical Suggestions for Keeping Your Eye on the  
“Bigger Picture” and Positioning Your Research for Impact

# FCC Technological Advisory Council

- Focuses on key issues affecting the development of emerging communications technologies
- Comprised of a diverse array of leading experts
- Provides technical advice and recommendations to help the FCC:
  - Identify important areas of innovation
  - Develop informed technology policies
- Recent working groups of the TAC included
  - 6G
  - AI
  - Advanced spectrum sharing
- TAC working groups often seek presentations from academic experts with research results that are relevant to the topic of the WG, and could help inform recommendations
- If you have relevant research results, please consider reaching out to the relevant TAC WG chairs to make them aware
- TAC is currently between sessions (the next session should begin early next year)
- If you are able to commit the time (typically 3-4 hours of online meetings per week and quarterly in-person meetings), please consider applying to join the TAC
  - See the TAC re-charter Public Notice ([DA 25-631](#)); deadline for applications is October 3rd

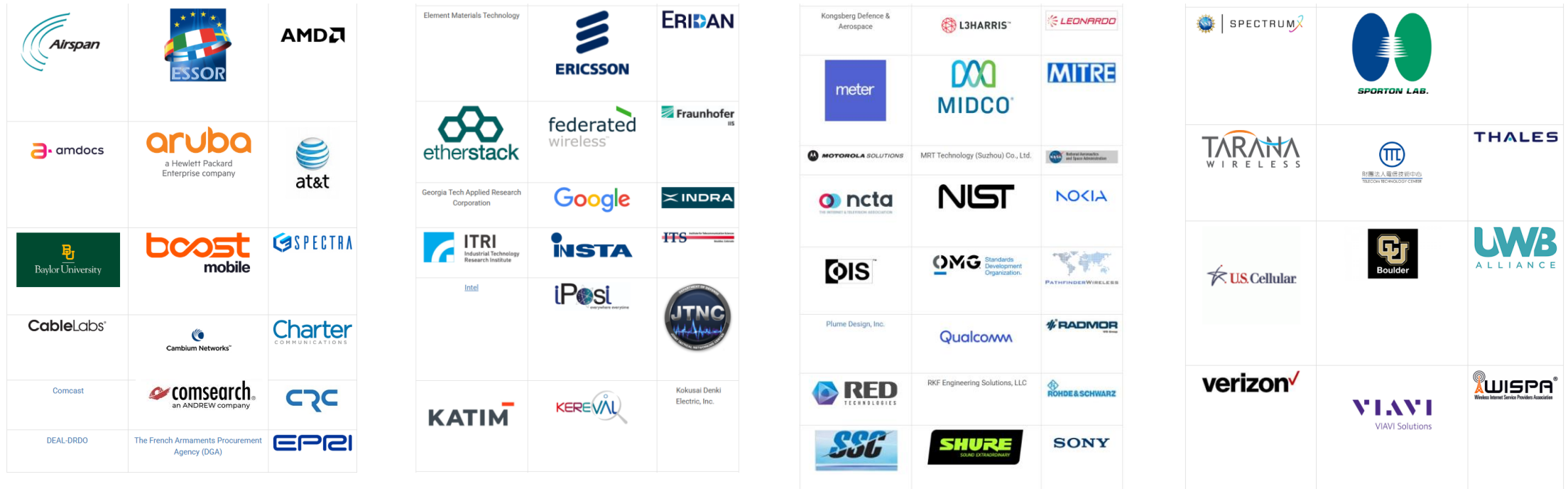
# Wireless Innovation Forum

- Not-for-profit 501(c)(6) organization established in 1996
- Registered in the U.S. as a Standards Development Organization under the Cooperative Research and Production Act
- Members share the common interests of:
  - Advancing technologies supporting the innovative use of the radio spectrum
  - Development of wireless communications systems and standards
- Members represent an international group of equipment vendors, software developers, service providers, research and engineering organizations, academic institutions, regulators, government agencies, and others
- Recent work of the WInnForum:
  - Created the complete standards and certification suite for CBRS
  - Collaborated with Wi-Fi Alliance to create the industry standards and certifications for the 6 GHz Automated Frequency Coordination (AFC) framework
  - Highly Dynamic Spectrum Sharing Technical Report to support ADSSD/NSC competition
  - Beyond the Radio Dial video podcast



# Wireless Innovation Forum

- WInnForum is an excellent venue for two-way information exchange
  - Provides regular opportunities to engage with industry and government on the latest wireless innovations
  - Opportunities to position your research for maximal impact
- Consider joining the Wireless Innovation Forum and/or offering to present particularly relevant research results to appropriate working groups





# Joint WInnForum/DySPAN/NSMA Meeting May 2026

- WInnForum, IEEE DySPAN, and the National Spectrum Management Association are currently planning a joint meeting (possibly including OnGo Alliance) in the DC area in May 2026
- Confirmation and details to be announced later



# Joint WInnForum/DySPAN/NSMA Meeting May 2026

- WInnForum will host WinnAI 2026 in conjunction with May 2026 joint meeting
  - AI/ML and Agentic AI in Advanced Wireless Communications and Spectrum Management
  - Invitation to the global wireless community to submit high-quality research papers, participate in workshop discussions, and engage in collaborative efforts to advance AI/ML applications in wireless systems
- Topic areas include
  - Spectrum Access System (SAS) Intelligence and Automation
  - Environmental Sensing Capability (ESC) Enhancement through AI
  - Multi-Agent Systems for CBSD Coordination
  - Intelligent Protection of Incumbent Users
  - Intelligent Resource Management and Optimization
  - Intelligent Automated Frequency Coordination (AFC) Systems
  - AI-Powered Spectrum Sensing and Database Management
  - Machine Learning for Propagation Modeling and Interference Analysis
  - Highly Dynamic Spectrum Sharing with Agentic AI
  - Advanced Spectrum Sharing Frameworks with AI Integration
- More details to be posted on the [Wireless Innovation Forum website](#) shortly

# Keeping Informed

- [One Big Beautiful Bill](#) (OB3)
  - Significant spectrum mandates, including band studies
- Keep your congressional delegation apprised of significant research results around spectrum
  - Focus on practical potential impacts, especially with respect to the economy or national defense
  - Simplify and simplify again, and then simplify some more
- [FCC Daily Digest](#)
  - Daily (weekday) list of FCC actions and issuances
- Follow FCC rulemaking proceedings
  - Current/recent examples:
    - [Modernizing Spectrum Sharing for Satellite Broadband](#)
    - [Satellite Spectrum Abundance](#)
    - [Lower 37 GHz Band, Use of Spectrum Bands Above 24 GHz for Mobile Radio Services](#)
    - [Facilitating Opportunities for Advanced Air Mobility](#)
    - [GPS Complements](#)
    - [Upper C-band](#)
  - Public comment and reply comments are required by law in almost all cases
  - Consider filing relevant comments on FCC proceedings in your area of expertise
    - Excellent exercise for graduate student participation

# Conclusions

- Help your research have more impact (and increase your chances of future funding!) by connecting your research to current national needs
- Monitor FCC proceedings, the FCC Technological Advisory Council, Congressional bills, and other activities to monitor the pulse of national spectrum challenges and priorities
- Consider joining and becoming active in associations such as the Wireless Innovation Forum to connect with industry and other academic researchers on the latest wireless innovations

Please feel free to contact me for further discussions. I'm all EARS!

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