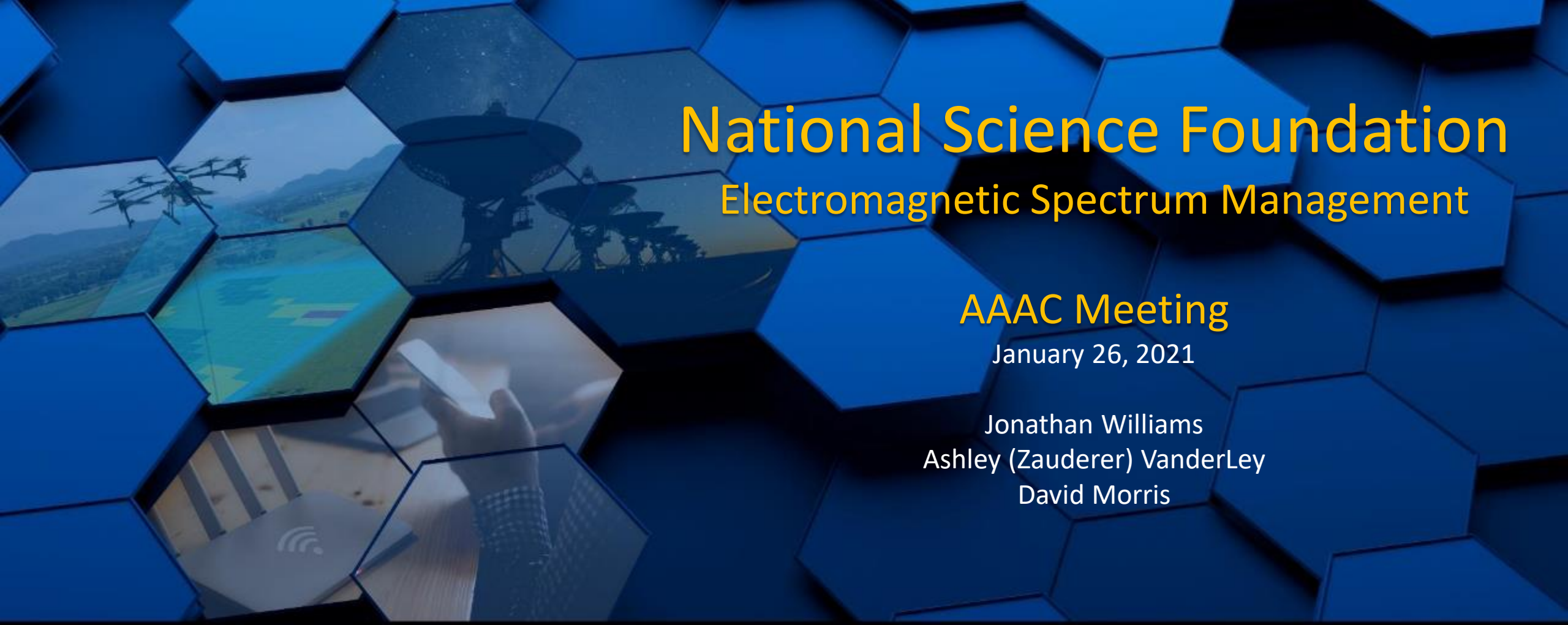


# National Science Foundation

## Electromagnetic Spectrum Management

### AAAC Meeting

January 26, 2021

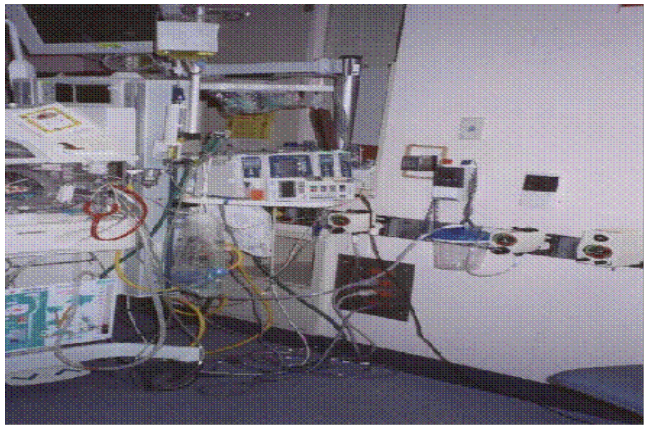
Jonathan Williams
Ashley (Zauderer) VanderLey
David Morris

## NSF's Spectrum Innovation Initiative

*… enabling Industries of the Future*

# Then…

***25 years ago***



# …and now

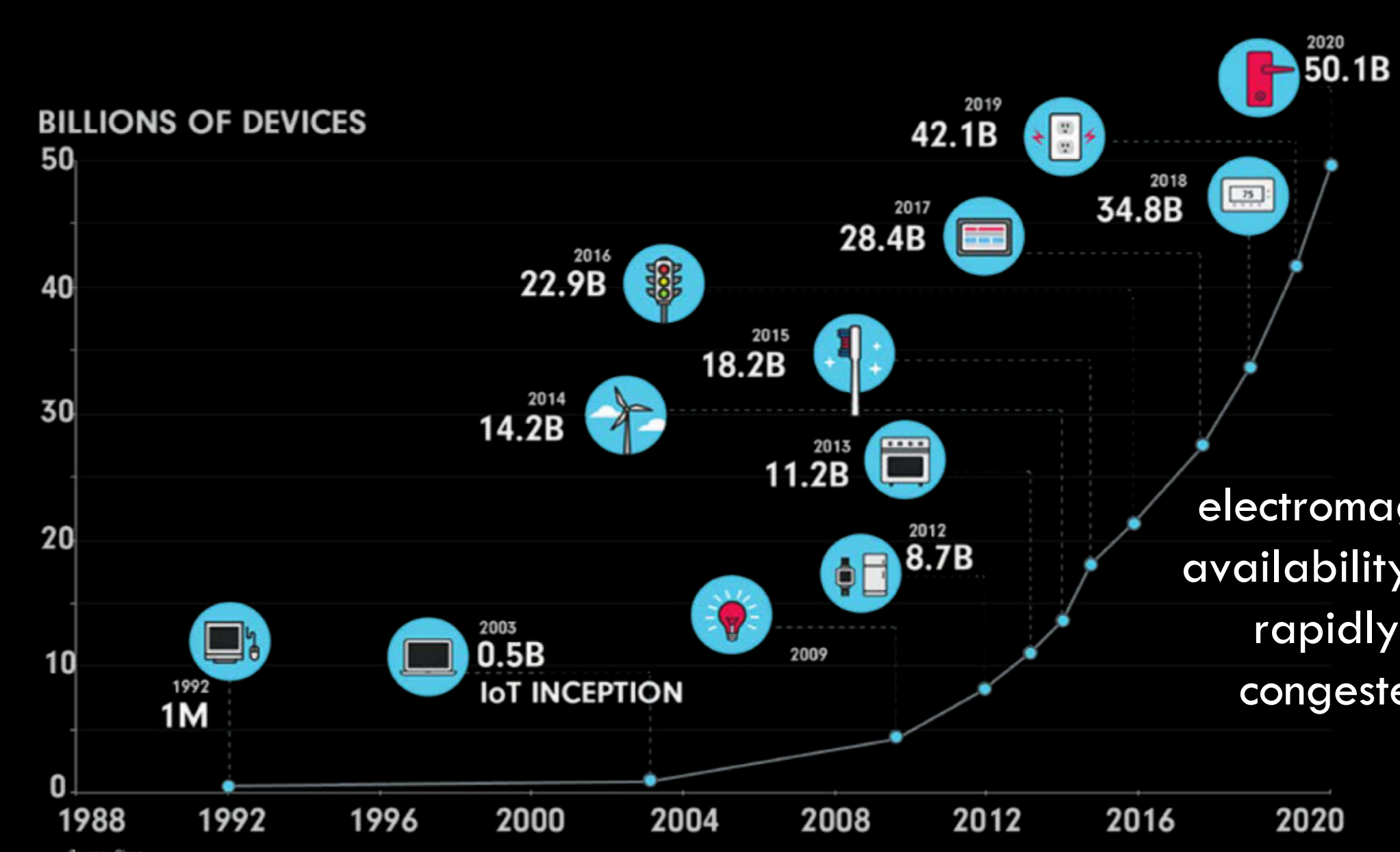
## *Advanced Wireless networks are the enabler*

- WiFi, Bluetooth
- 3G → 4G → and (upcoming) 5G

## *Rapid growth in connected devices**

- 1 million in 1992 → 5 billion in 2008
- <u>50 billion in 2020</u>

*Cisco Annual Internet Report, 2020




Demands for electromagnetic spectrum availability are increasing rapidly in an already-congested environment

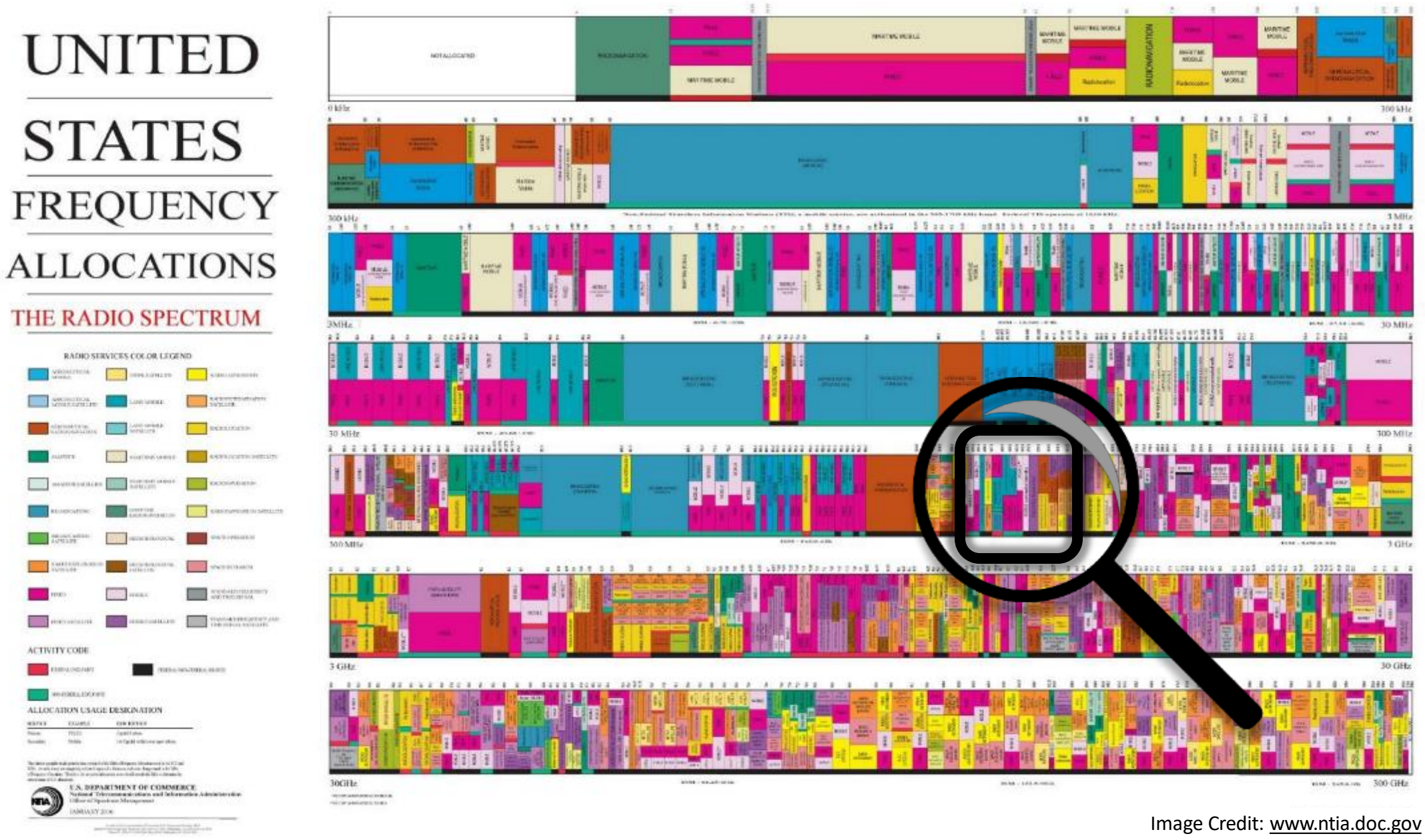



Image Credit: www.ntia.doc.gov

# Science applications share the spectrum with many other users

GPS

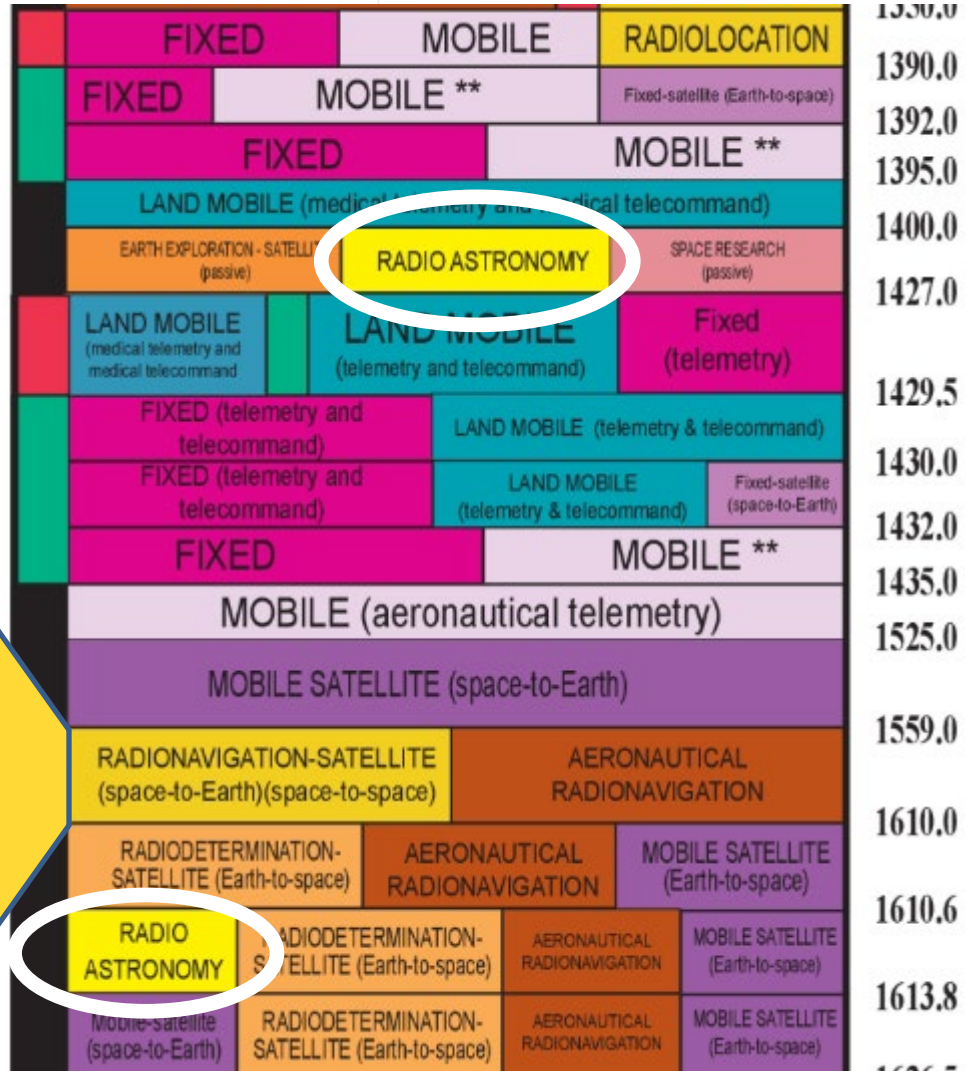



Figure Credit: https://techcrunch.com/2016/02/05/new-air-force-satellites-launched-to-improve-gps/

**Frequency Allocations: 1390 – 1614 MHz**

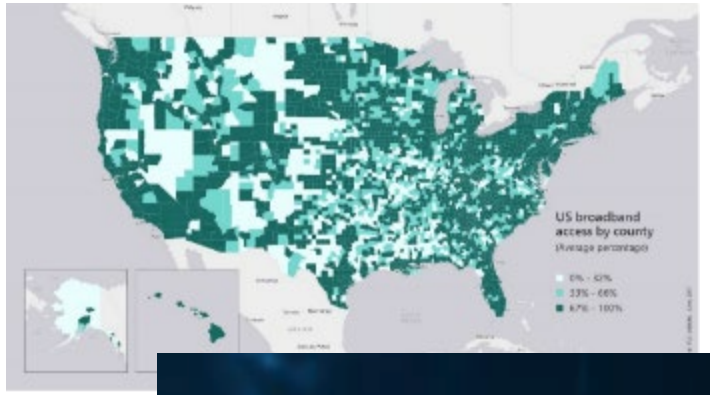
# Challenges include:

**Commercial -** Providing cellular and broadband internet coverage in rural areas

**Public Safety -** Interference to communications for emergency first responders

**National Security -** Congested usage for the DoD (e.g., 5G, radars) requiring flexibility

**Science -** Many scientific uses of the spectrum are passive (listen only) and extremely sensitive to interference





# NSF-supported research relies on access to the electromagnetic spectrum *and* catalyzes its efficient usage

## *Passive – "listen only"*

- GPS Radio Occultation
- Radio Astronomy
- Geodesy

## *Active – "transmit"*


- Wi-Fi, Bluetooth, Television Whitespaces, Millimeter Wave/ TeraHertz Bands
- Research Drones, Cubesats
- Radar

# Two Sides to the Spectrum Coin

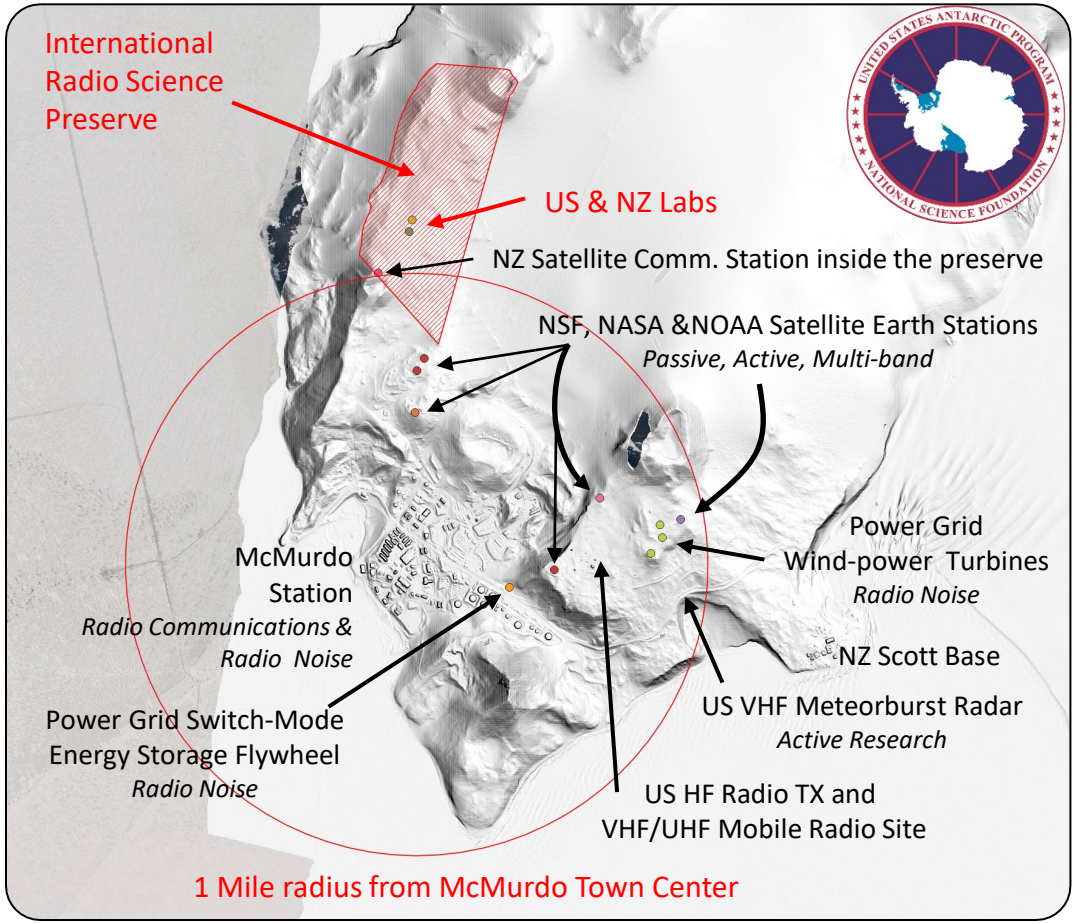
***Spectrum for basic research***

Radio quiet environment is critical for scientific observations, such as Cosmic Microwave Background experiments at the South Pole.


***Spectrum for communications and operations***

Access to the spectrum for communications is essential for many operations, both for logistical purposes and for relaying data.

# GEO US Antarctic Program McMurdo Station Case Study




- **Tension between general rise of industrial noise/spectrum use and the active/passive radio sciences**
- **Requires new methods of harmonization, coordination, and resiliency**

# NSF's response to ***new*** spectrum challenges

1-2 full-time spectrum managers (1970s)

***Focus on radio astronomy -> broaden to consider all NSF interests and optical/IR impacts***

Spectrum research: "Advanced Wireless" (1997)

**Individual research programs -> platforms -> external partnerships**

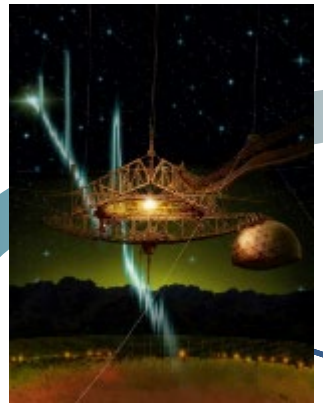
NSF-wide ESM Coordination Group formed (2018)

***NSF-wide collaboration***

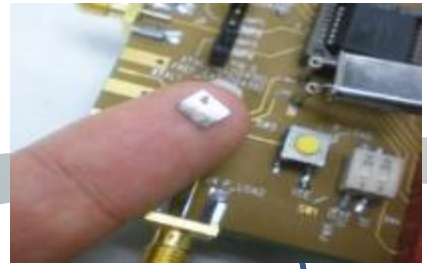
Spectrum Innovation Initiative (2020)


**Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future**

# Spectrum Connections Across NSF



**MPS**
Astronomy



**ENG**
Wireless Devices/ Circuits

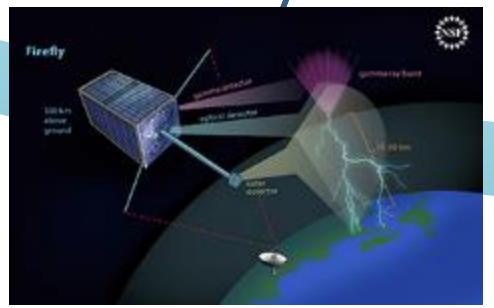
**SBE**
Spectrum Auctions/ Game Theory

**BIO**
NEON/ Biosphere Monitoring

NSF-wide ESM Coordination Group

**EHR**
Workforce Development

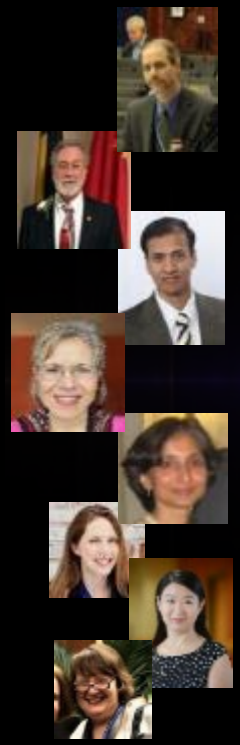
**GEO**
Cubesats/ Earth Sensing




**CISE**
Wireless Technology/ Networking/Theory/Algorithms/Software

# NSF ESM Coordination Group

- *Formed March 2018*
- *Includes NSF input across all Directorates*



| | |
|---|---|
| **Jonathan Williams** | *Chair, MPS/AST, ESM Unit* |
| **Patrick Smith** | *GEO/OPP* |
| **Thyaga Nandagopal** | *CISE/CCF* |
| **Carmiña Londoño** | *ENG/ECCS* |
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| **Ashley Vanderley** | *MPS/AST, ESM Unit* |
| **Li Yang** | *EHR* |
| **Nancy Lutz** | *SBE* |

**Jim Ulvestad** — *Chief Officer for Research Facilities, Office of the Director*

**<u>SII Working Group Members:</u>**

**Lisa Winter (GEO)**

**Jenshan Lin (ENG)**

**Alex Sprintson (CISE)**

**Mohammod Ali (ENG)**

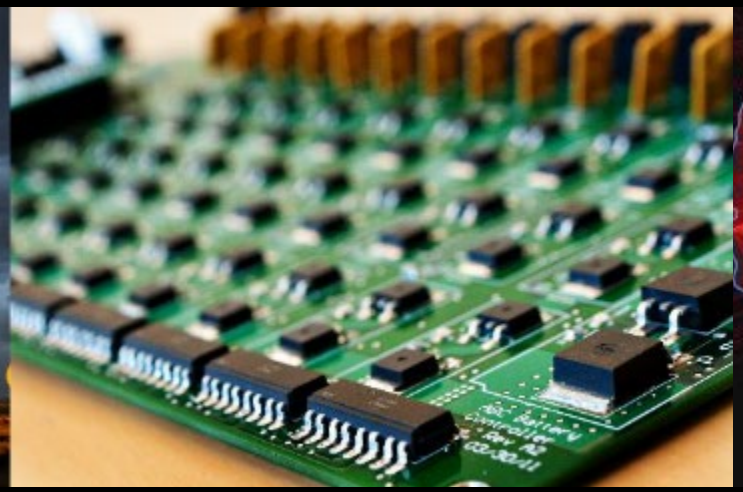
**Larry Goldberg (ENG)**

## NSF Spectrum Goals:

# *Innovate* and *Secure*

# NSF's Spectrum Innovation Initiative

***Cross-Directorate, housed in MPS Office of Multidisciplinary Affairs (OMA)***
***(via a stewardship model similar to NSF Big Ideas)***

I. National Radio Dynamic Zone

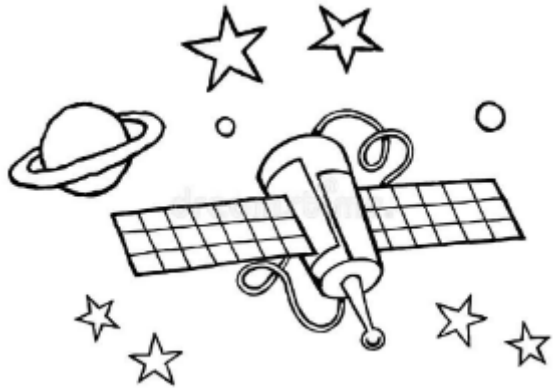
II. National Center for Wireless Spectrum Research

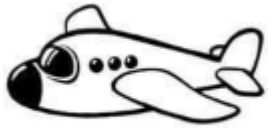
III. Spectrum Research Integrative Activities

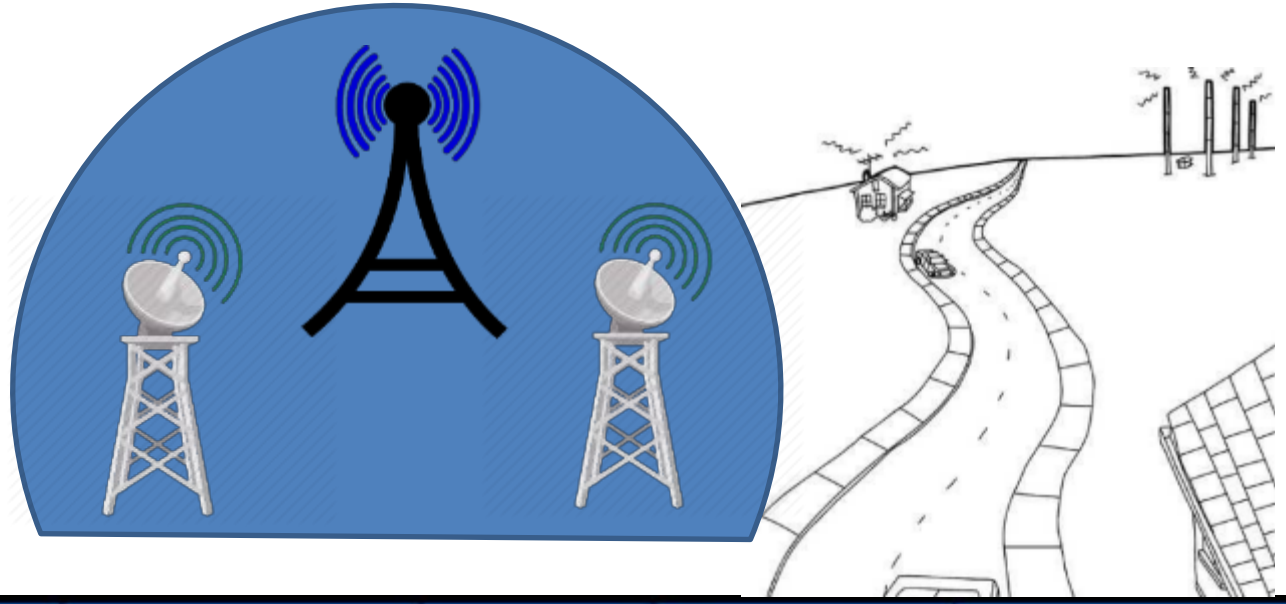
IV. Education and Workforce Development

National Radio Dynamic Zone

Wireless testing “in” the zone does not interfere with users of spectrum outside

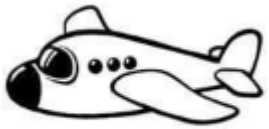


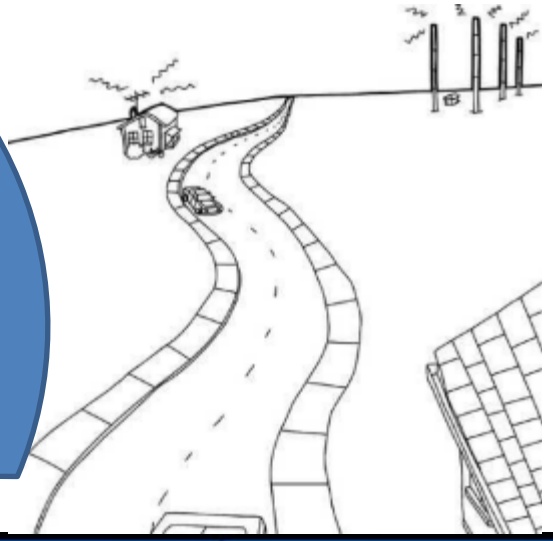




National Radio Dynamic Zone

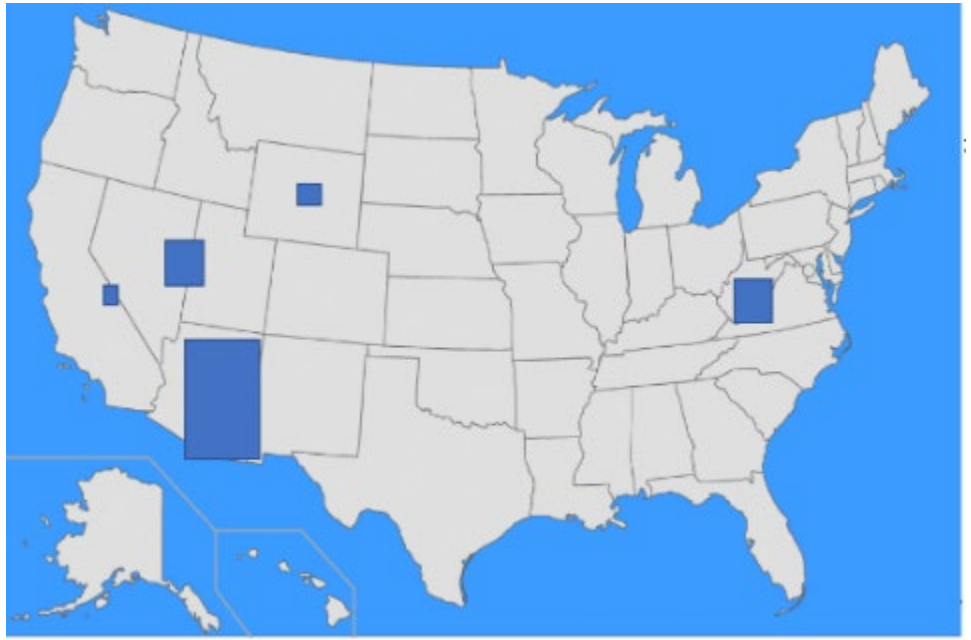
Spectrum users “outside” the zone do not interfere with passive users in the zone





# National Radio Dynamic Zones (NRDZ)

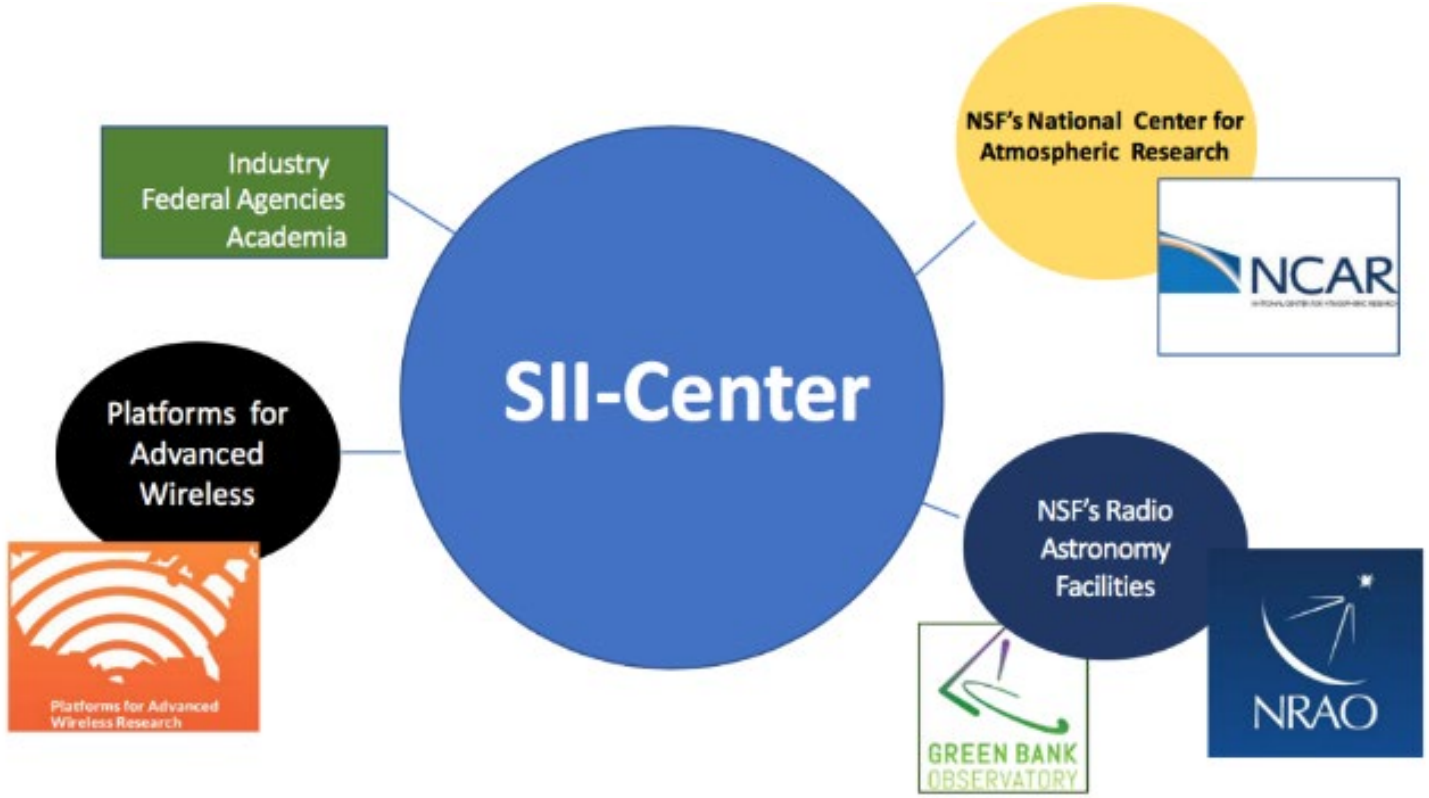
- Pilot innovative approaches for transmission/reception at various frequencies of interest
- Cognitive machine-to-machine frequency coordination  leading to dynamic allocation and improved efficiency



See Dear Colleague Letter NSF 20-079

# National Center for Wireless Spectrum Research (SII-Center)

- Multidisciplinary groups of scientists and engineers with a common vision to address nationwide challenges in wireless spectrum research





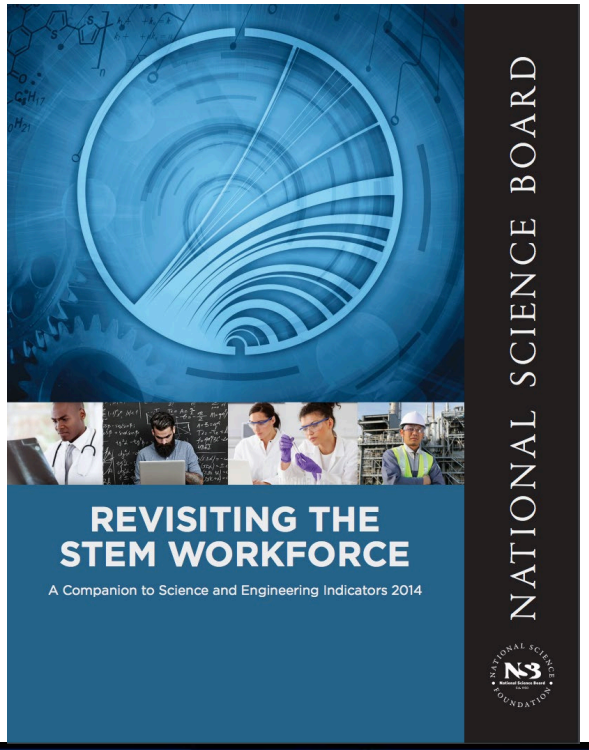

See Solicitation NSF 20-557

# National Center for Wireless Spectrum Research (SII-Center)

- **Grow the spectrum workforce in support of industries of the future**

The demands on the workforce in spectrum management and wireless technologies are challenging, ***requiring an interdisciplinary skill set.*** Along with research, innovation, and collaboration, a key goal of the SII-Center is the ***creation of education, training, and workforce development programs.***

- Expose trainees to open questions and challenges in wireless spectrum research in collaboration with national laboratories, industry and international partners
- Innovate in educational curricula and pedagogy reflecting the complexity of spectrum research and facilitate its replication by other institutions



Invest in R&D to contribute innovative solutions to the advanced wireless and spectrum challenges facing the Nation:


Innovate and Secure

# Contact information

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## Learn More

***Spectrum Innovation Initiative Program Page: https://nsf.gov/mps/oma/spectrum_innovation_initiative.jsp***