NSF’s Spectrum Innovation Initiative

... enabling Industries of the Future
Then...

25 years ago
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
• 50 billion in 2020

*Cisco Annual Internet Report, 2020
Demands for electromagnetic spectrum availability are increasing rapidly in an already-congested environment.
Science applications share the spectrum with many other users

Frequency Allocations: 1390 – 1614 MHz

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

Changes in the environment and activities around McMurdo Station are impacting radio science, communication, and environmental research operations. These changes include the expansion of the US & NZ Labs, US & NZ Satellite Comm. Station inside the preserve, and increased industrial activities such as Power Grid Switch-Mode Energy Storage Flywheel and Radio Noise from Wind-power Turbines.

The preserve area encompasses 1 Mile radius from McMurdo Town Center, protecting the scientific research and environmental monitoring. The map highlights critical areas such as the NSF, NASA & NOAA Satellite Earth Stations, US & NZ Satellite Comm. Station, US VHF Meteorburst Radar, US HF Radio TX and VHF/UHF Mobile Radio Site, and NZ Scott Base, all of which are active in radio communications and research.

The preservation efforts aim to maintain a balance between scientific research and environmental conservation, ensuring that the natural resources and scientific activities are not negatively impacted by the proliferation of industrial noise and spectrum use.
NSF’s response to **new** spectrum challenges

- **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)**

- **1-2 full-time spectrum managers (1970s)**
- **NSF’s response to new spectrum challenges**
Spectrum Connections Across NSF

- MPS: Astronomy
- ENG: Wireless Devices/Circuits
- SBE: Spectrum Auctions/Game Theory
- BIO: NEON/Biosphere Monitoring
- CISE: Wireless Technology/Networking/Theory/Algorithms/Software
- EHR: Workforce Development
- GEO: Cubesats/Earth Sensing

NSF-wide ESM Coordination Group
NSF ESM Coordination Group

- Formed March 2018
- Includes NSF input across all Directorates

Jonathan Williams  Chair, MPS/AST, ESM Unit
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SII Working Group Members:
- Lisa Winter (GEO)
- Jenshan Lin (ENG)
- Alex Sprintson (CISE)
- Mohammad 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
Wireless testing “in” the zone does not interfere with users of spectrum outside.
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
Multidisciplinary groups of scientists and engineers with a common vision to address nationwide challenges in wireless spectrum research
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:
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Spectrum Innovation Initiative Program Page:
https://nsf.gov/mps/oma/spectrum_innovation_initiative.jsp