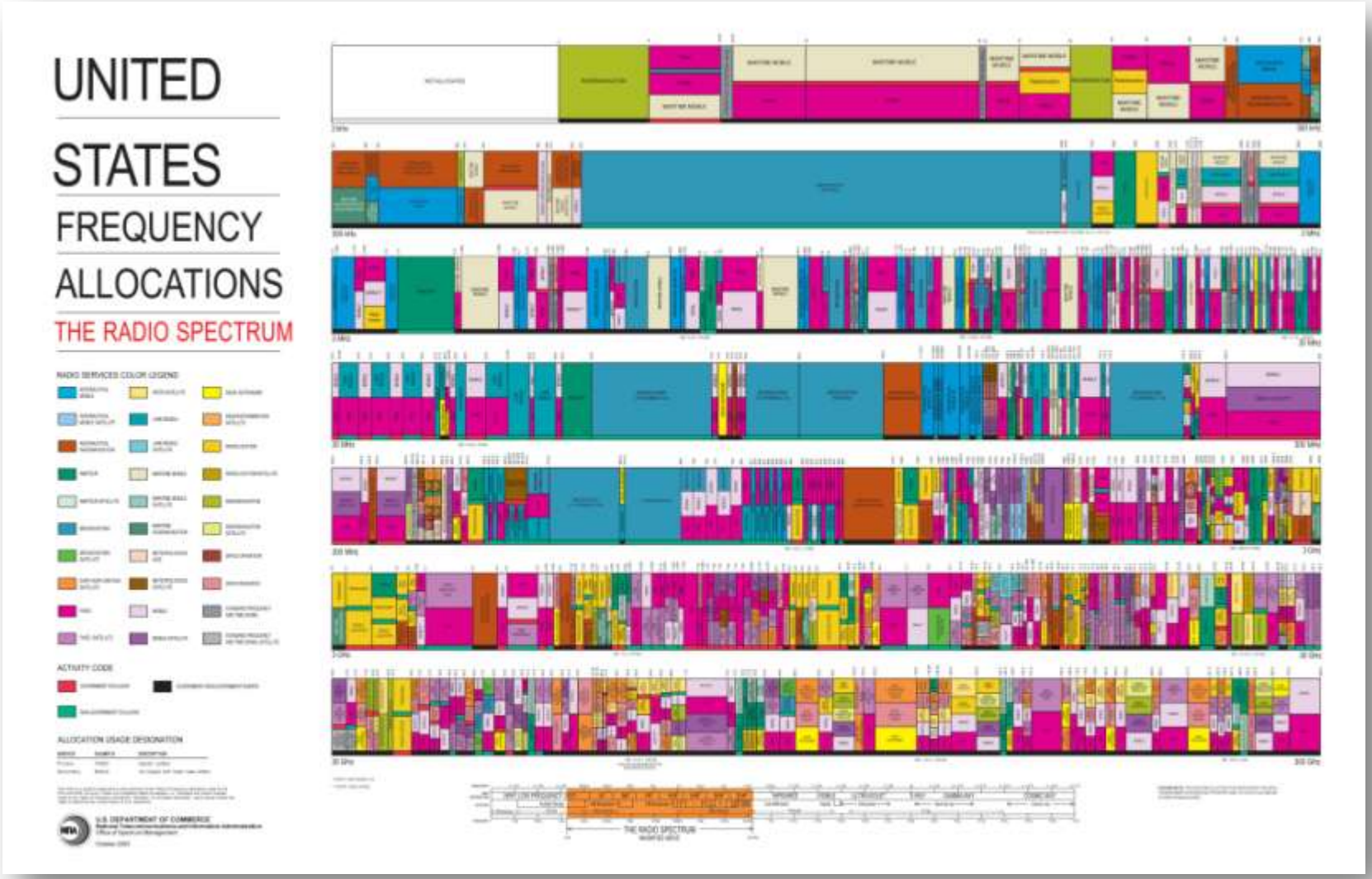
Enhancing Access to the Radio Spectrum (EARS)

Andrew Clegg
NSF Directorate for Mathematical & Physical Sciences

Radio Spectrum Allocations

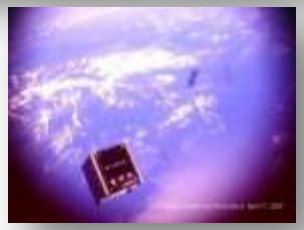


NSF as a Consumer of Radio Spectrum

- NSF grantees and facilities rely on access to the radio spectrum for a large variety of scientific research
  - Radio & radar astronomy
  - Remote sensing
  - Meteorology
  - Atmospheric science
  - Ionospheric & magnetospheric research
  - Space weather modeling and prediction
  - Oceanographic research
  - Arctic/Antarctic science and logistics
  - Cyber-networking
  - Picosats
- Major spectrum-reliant NSF centers:
  - National Center for Atmospheric Research (NCAR)
  - National Radio Astronomy Observatory (NRAO)
  - National Astronomy and Ionosphere Center (NAIC/Arecibo)
  - National Ecological Observatory Network (NEON)







NSF as a Supplier of Spectrum Technology

- NSF funds a wide variety of research directly related to wireless technology and policies
  - Wireless networks, RF hardware, propagation, auction and market theory, antennas, security & encryption, public policy, interference mitigation, software-defined radios, dynamic spectrum access, cognitive radio systems...
- Approximate direct NSF investment in wireless research is $700 million over the past 11 years (~$65M per year)
  - Investments are across MPS, ENG, CISE, & SBE
- The results of NSF-funded research have been incorporated in a large number of highly successful applications
  - Wi-Fi, 911 cell phone location technology, explosives and biohazard detection, ground-penetrating radar, GPS, digital TV, adaptive antennas, body scanners, ultrawideband communications and imaging systems, WiMAX, the Internet...

Value of the Radio Spectrum

- FCC auctions for slices of bandwidth have raised $78 billion in net bids since 1994
  - Only a small fraction of the radio spectrum (about 4%) has been auctioned
- 2009 domestic wireless revenue was $151.2 billion, larger than the gross domestic product of Kuwait
  - 1992 – 2007 growth rate of U.S. wireless industry exceeded 16% per year, compared to 3% for the general economy
  - The domestic wireless sector presently exceeds the agriculture industry in economic size, and is predicted to exceed the auto industry within five years
- Some industry experts estimate that the indirect impact of wireless is ~10% of U.S. economy, or about $1.4 trillion annually

Economic Recovery and the Radio Spectrum

- Based on the value of the radio spectrum, it is clear that even small improvements in the efficiency in which we use this limited (but renewable) natural resource can have tremendous impact on the national economy
- Improving access to wireless goods and services, especially through improved access to broadband Internet service among traditionally underserved populations and geographic areas, can also have significant economic impact by enabling and expanding national and global commerce
- These two areas are the fundamental research targets of the EARS program

EARS Program Concept

- Fund research that will lead to increased efficiency with which radio spectrum is used and/or lead to enhanced access to wireless services for all Americans
- Emphasis is on meeting the challenges through *interdisciplinary* research
  - Particular interest in collaborative research that transcends traditional disciplinary boundaries (will be an additional merit review criterion)
- Several broad areas of investment interest include:
  - New interdisciplinary technology solutions that enable spectrum efficiency and enhanced spectrum access including hardware and materials innovations, new spectrum access methods and protocols, spectrum security, and interference mitigation.
  - Green spectrum technologies that enable energy efficient communications and radio systems with low environmental impact in fabrication and disposal.
  - Innovative technologies that expand the use of the radio spectrum including millimeter-wave communication systems and free-space optical communication networks.
  - Interdisciplinary research on spectrum allocation and assignment including market- and nonmarket-based methods for spectrum access and usage, economics of radio spectrum access including auctions and secondary markets.
  - Research on the social, behavioral and economic impact of wireless, including new (and potentially disruptive) technologies; physical and social networks; the adoption and use of wireless and related technologies; implications for access to educational, health and other resources; the impact of wireless and continuous monitoring on social and economic interactions of individuals, groups and organizations; the creation and impact of public policies and regulations around wireless allocation and use.
- EARS will give full consideration to all cross-cutting proposals with viable innovative ideas for increasing radio spectrum efficiency and access.

EARS Workshop




- Held in August 2010
  - 40 invited experts across science, engineering, networking, economics, and commercial/government/military sectors
  - Presentations by Secretary of Commerce Gary Locke, FCC Commissioner Meredith Attwell-Baker, and acting NSF Director Dr. Cora Marrett
  - Additional participants and observers included representatives of the White House (OSTP and NEC), Congress, and the World Bank
- Workshop charge
  - Identify interdisciplinary research opportunities that will
    - Lead to future enhancements in the efficiency by which the radio spectrum is used
    - Enhance the ability of all Americans to access broadband wireless services and realize other benefits derived from efficient spectrum use
- Results from three days of interdisciplinary breakout sessions
  - List of research priorities – ~150 cross-cutting topics to help address present and future spectrum challenges and meet national goals
  - Attendees strongly endorsed the EARS program concept
  - Workshop report available on NSF Web site (EARS program page, tinyurl.com/nsfears)

Radio Spectrum as a National Priority

- National Broadband Plan (March 2010)
  - Congressionally-mandated FCC plan to connect all Americans to broadband
  - NSF appears in five separate recommendations in the NBP
  - Recommendation 5.14:
    - The FCC should initiate proceedings to enhance research and development that will advance the science of spectrum access. A robust research and development pipeline is essential to ensuring that spectrum access technologies continue to evolve and improve. As described in Chapter 7, the FCC should start a rule-making proceeding to establish more flexible experimental licensing rules. Additionally, the National Science Foundation, in consultation with the FCC and NTIA, should fund wireless research and development that will advance the science of spectrum access.
  - Additional recommendations for NSF involvement in networking, testbeds, accessibility, and technology transfer
  - http://www.broadband.gov

Radio Spectrum as a National Priority

- Presidential Memorandum (June 2010)
  - "Unleashing the Wireless Broadband Revolution"
  - Calls on NSF to work with Commerce Department "to create and implement a plan to facilitate research, development, experimentation, and testing by researchers to explore innovative spectrum-sharing technologies"
    - NSF's EARS is a major component of this plan (EARS and NSF are specifically mentioned in White House fact sheet accompanying the Presidential Memorandum)
    - NSF and Commerce are co-chairing a NITRD sub-group to meet this directive

Radio Spectrum as a National Priority

- State of the Union (January 2011) (five-year wireless objective)
  - President announces Wireless Innovation and Infrastructure Initiative (Wi3)
  - "...This isn't just about faster Internet or fewer dropped calls. It's about connecting every part of America to the digital age..."
  - Wi3 includes substantial NSF funding for wireless research, including EARS

The President's Wireless Innovation & Infrastructure Initiative (Wi3)

- Goals:
  - Free up 500 MHz of spectrum for mobile broadband
  - Provide at least 98% of Americans with access to high-speed wireless
  - Catalyze innovation through a Wireless Innovation (WIN) Fund
  - Develop and deploy a nationwide, interoperable wireless network for public safety
  - Cut the deficit by $9.6B over the next decade

The President unveils Wi3 at a public event at Northern Michigan University in Marquette, MI February 10, 2011

Wireless Innovation Fund

- $3B over five years, to be funded by reinvesting ~10% of spectrum auction revenues
- WIN breakdown (five year run-out)
  - $1B for NSF
    - $500M for EARS and Cyber-Physical Systems (CPS)
    - $500M for the Global Environment for Network Innovations (GENI)
  - $500M for DARPA for "secure, reliable, and scalable networks"
  - $500M to NTIA for Spectrum Relocation Fund
  - $500M to NIST for Public Safety wireless technologies
  - $100M each to ARPA-Energy, ARPA-Education, Centers for Medicare & Medicaid, Research & Innovative Technology Administration, and Economic Development Administration

EARS in the FY12 Appropriated NSF Budget

- EARS is also a line item in the NSF budget, in addition to WIN investment
- Small amount that could be used to fund exploratory work while we await passage of Wi3 legislation
- Cross-disciplinary commitments:
  - MPS: $3M
  - ENG: $4M
  - CISE: $7M
  - SBE: $1M
- A corresponding solicitation is being drafted

EARS Small Business Technology Transfer (STTR) Competition

- We are working with ENG/IIP to develop a complementary single-topic EARS STTR solicitation that parallels the goals of the EARS initiative
  - STTR funds cutting-edge, high risk, high quality scientific, engineering, or science and engineering education research that would have a high potential economic payoff if the research is successful.
- Solicitation will be released in summer 2011, with proposal deadline in fall 2011
  - Phase I: Up to $150K for one year for provide evidence of a commercially viable product, process, device, or system
  - Phase II: Follow-on to Phase I, provides up to $500K for up to two years
- Additional investment of $12M (Phase 1 & 2) in addition to $15M FY12 appropriation and $300M WIN

EARS, Science Services, and Future Spectrum Access

- EARS goal is to fund innovation that will help transform spectrum access and efficiency
- Perhaps the greatest innovations that will be required is in the transition phase of getting from where we are now to where we want to be in the future
- There is a growing proliferation of NIMBY among entrenched & complacent spectrum users who aren't prepared to face the "new world order"
  - Some may argue that many science services are among them
  - It's important for ourselves and for the spectrum using community at large that we become part of the solution, not part of the problem
  - There are tremendous opportunities under EARS to fund transformative work on interference avoidance, mitigation, compatibility, and other innovations that will become increasing important to science services, and we already have significant contributions to contribute and grow

EARS Next Steps

- EARS solicitations (WIN and appropriated) are in the works and will be in "hot standby" mode awaiting passage of Wi3 and FY12 NSF budget
- EARS STTR solicitation is being drafted, including high-level consultation with stakeholders
- Continue to socialize EARS concept to remote corners of NSF that haven't been engaged
- Work with Congressional staff on understanding NSF's role in wireless research as specified in pending legislation (Wi3 and others)