NRDZ Partnership and Workshop Series Kickoff Meeting Summary Notes

November 10, 2020

Keynote Talks

Speakers were asked to provide perspectives from the three key constituencies impacted by NRDZ's, in addition to regulatory/policy issues that researchers should be mindful of as part of their technical academic research.

Opening remarks from *Dr. Ashley Zauderer*, NSF, Division of Astronomical Sciences

- The current spectrum challenges are well-established, and the US faces a need for spectrum to support science, the economy, and national security. The country needs both increased access to spectrum as well as increased efficiency in how spectrum is utilized.
- It is also well-established that spectrum has been divided up into very complex and overlapping frequency assignments. Allocating spectrum in this manner has resulted in coexistence conflicts between users that have overlapping spectrum assignments but different requirements.
- All spectrum users (scientific, government, and commercial) are in need of wider bandwidths and higher sensitivities to meet their ever-increasing performance needs.
- NSF has several broad goals with respect to NRDZ’s:
    - Designate limited geographic areas to pilot innovative uses and testbeds.
    - Develop techniques and technologies to perform RFI/Sensing/Waveform analysis at frequencies up to 115 GHz.
    - Explore cognitive and machine-to-machine coordination for dynamic allocation of spectrum.
    - Develop true win-win solutions for active/passive user coexistence.
    - Focus on ways to improve the efficient use of spectrum.
- The long-term objective (thinking 40-50 years out) is to enhance the useability of spectrum for both active and passive users and promote future deployment of innovative systems.
- An NRDZ could perform as a “virtual Faraday cage” using some sort of active management infrastructure. The same infrastructure that manages active users could also be used in an inverse manner -- to protect passive users inside the NRDZ from active signals originating from outside the NRDZ.
- It’s also important to recognize the 3D nature of the spectrum environment. Communication systems are increasingly airbore and represent a significant interference potential to passive users.

Dr. Monisha Ghosh, CTO, FCC and Research Professor, University of Chicago

- The primary metric of choice for harmful interference is Received Signal Strength (RSS). This is based on a legacy approach where interference power in a band was directly correlated with performance degradation.
- Modern digital communication systems are more resilient to interference power than their legacy, or analog, counterparts. Perhaps there should be other metrics that could describe performance degradation in the presence of a co-band interfering signal.
- Interference analysis is based on legacy propagation measurements, models, and the aforementioned RSS metric. It would be valuable to have a designated area to conduct controlled experiments and measurements to refine these approaches.
- In most communication systems, beamforming has focused only on improving performance. Interference avoidance has not been brought into the network or system design, although it could be a valuable tool.

***Mr. Peter Tenhula*, Director of NTIA Office of Spectrum Management**

- An NRDZ would be extremely valuable as a "sandbox" that could be used for experimentation where the spectrum rules were significantly relaxed.
- Both NTIA and FCC encourage experimentation and would like the experimental license process to be easy and flexible.
- An NRDZ could be modeled after NTIA Red Book Section 7.11 which designates specific geographic areas and frequencies with minimal regulatory barriers to experimentation.
- The challenge to an NRDZ would be figuring out how to make it work across all frequency bands. [Editors Note: including those that are sensitive to interference, e.g., GPS].
- Another challenge is to figure out how an NRDZ impacts the larger wireless ecosystem---the ideal would be to transition away from specific frequency allocations that are heavily sought after towards something more flexible and dynamic.

***Dr. Tony Beasley*, Director, National Radio Astronomy Observatory**

- Passive users are building the next generation of systems -- such as the Next Generation Very Large Wavelength Array -- that are an order of magnitude more sensitive than current systems.
- These next generation systems will be susceptible to new forms of interference as well as weaker levels of interference.
- Radio Astronomy has a large number of specific frequency allocations from 3 -- 30 GHz, in the prime frequency range for most terrestrial communication systems.
- Satellite communication systems and IoT devices are increasingly generating an aggregate level of interference that is worrisome to passive users.
- Management of an NRDZ requires measurements, particularly above 20 GHz. It is imperative that the community improve and enhance measurement techniques.

Summary of the general discussion following the Keynotes

- As a community, we need to define what exactly an NRDZ is and what it entails.
- We need to consider what makes an NRDZ different from a testbed or innovation zone.
- To create an NRDZ, we need to consider several different aspects:
  - Facilities - How users can access the NRDZ
  - Technology - What techniques for monitoring or infrastructure is available for users.
  - Policy - What frequency bands, emission limits, and enforcement are available.
- NSF needs a conceptual design that can be used to solicit further work by the community.
- What are the requirements of a sensing system, particularly when considering the need to protect passive users that could experience interference from extremely weak signals.
- What are the frequency and geographic interests? For example, at 100 GHz, we don’t need an NRDZ that can support 10’s of kilometers of range.
- What coordination needs to happen (real-time or a prioi) between disparate users of the NRDZ site?

Lightning talks delivered by NRDZ supplement award recipients.

Speakers were asked to discuss their vision of NRDZ, their research activities and outstanding challenges towards the realization of NRDZs.

1. ***Dr. Josep Jornet***, Electrical and Computer Engineering, Northeastern university. Wireless communications, THz communications, wireless nano-communications, electronics design, channel modeling, PHY/MAC design.

    - **Vision:** NRDZs are a geographical area for wireless research, where the only limitations for experimentation are the laws of physics. "Whatever happens in an NRDZ, stays in the NRDZ". Such a capability will allow the testing of new technologies (hardware and software) for spectrum sharing, providing a joint opportunity for hardware and software researchers to work together. Long-term goal is to enable research at the coexistence of terrestrial active and passive communications.
    - **Activities:** NRDZ creates opportunities for research above 100GHz. The emphasis is on building from theory and experimentation over the past 10 years to propose rules to regulate emitted power to ensure that <100GHz communications would not depart the NRDZ boundaries.
    - **Challenges:**
        1. Understand the common needs of the active communications and the passive sensing communities: hardware (design transmitters/receivers), software (measure spectrum, make sense of the data, demodulate/decode signals) and more spectrum resources.
        2. Align the timescales between wireless communications and passive sensing. Future upgrades of ground-based and orbiting equipment can be challenging; design sensing techniques with long-term relevance in mind.
        3. Define dynamic ways to allocate and use the spectrum across both communities. Software-ize sensing.

2. ***Dr. Honggang Wang***, ECE, UMass Dartmouth. Sensing, communications and machine learning. Running the COMET tested -- 62 USRP nodes; multimedia applications and autonomous vehicles.

    - **Vision:** NRDZ should be an application-driven dynamic zone with an outlook towards scalability, multidimensionality, mobility, diversity.
        i. Scalability -- both large and small-scale network testing.
        ii. Multidimensional -- ground, space and underwater.
        iii. Mobility -- V2X, UAV, mobile users.
        iv. Diversity -- Enable education for students with different backgrounds.

    - **Activities:** Focusing on sensing requirements in support of cooperative perception for autonomous vehicles. Tests performed in the UMass Dartmouth area, with focus on wideband frequency switching.

    - **Challenges:**
        i. Support new and emerging technologies in the NRDZ testbed.
        ii. Enable experimentation and experimental devices.
        iii. Provision resources to allow for AI-based communication systems.
        iv. Collaborative use of the spectrum by different research groups and attracting partners beyond academia (industry and govt.).

3. ***Dr. Miguel Morales***. Physics, UW

    - **Activities:** Their focus is on gaining a practical understanding of the damaging effects of RFI on radio-astronomy applications. Passive sensing is being discussed in a broad sense; the concept of damaging RFI should be put in the perspective of remote sensing applications, particularly on the faint and rare tails of an RFI probability distribution that may be damaging to passive sensing applications.

    - **Challenges:**
        i. Many highly-sensitive radio telescopes are located in extremely remote RFI-quiet zones. These instruments can still experience interference originating from sources hundreds of kilometers away.
        ii. To ensure passive/active coexistence means understanding the tail of the RFI probability distribution, which may fall below the thermal noise floor; these emissions can still be detrimental to the performance of scientific instruments.
        iii. Ensure active users understand the unique RFI protection needs of passive scientific instrumentation.

4. ***Dr. Adam Cohen***, President and CEO Associated Universities, Inc (AUI). AUI is a non-for-profit established to manage two large NSF projects: the National Radio Astronomy Observatory and the Greenbank Observatory along with the National Radio Quiet Zone (NRQZ) and the West Virginia Quiet Zone.

    - **Vision:** To have a national facility or facilities that can be used for testing of methodologies for efficient use of the spectrum. Enable access for institutions and researchers so they can evaluate innovations on a large physical scale that is prototypical to the real environment but provides a controlled environment. Effectively an NRDZ would be a plug-and-play platform where researchers can come, plug their innovation on a unified framework, collect the necessary data and go on to analyze it.

    - **Activities:**
        i. Organize workshops and community outreach to understand the needs and capabilities of the research community.
        ii. Create an NRDZ concept definition in terms of construction and operation based on stakeholder input.
        iii. Identify spectrum metrology hardware that will be tested through existing Radio Quiet Zones.

    - **Challenges:** The grand challenge is how to create broadband monitoring capabilities over an appropriate physical scale to support optimal decision-making between active and passive users.

5. ***Dr. Tommaso Melodia***, ECE, Northeastern University. Wireless network systems, optimization, ML for wireless, spectrum sharing, PAWR (director of research for the PAWR project office).

    - **Vision:** An NRDZ should enable controllable and replicable experiments in large scale and controlled environments, without harming passive users. It should support experimentation with hardware-in-the-loop and with virtualized networking stacks.

    - **Activities:** Emulate the operation of NRDZs in Colosseum (the world's largest RF emulation environment developed as a part of DARPA's spectrum collaboration challenge). Colosseum provides the capability to emulate realistic RF conditions and realistic scenarios to investigate both the radio environment as well as operating protocols. Their effort is to emulate NRDZs in the Colosseum, open these up to the community and expand the datacenter's capabilities to emulate higher frequencies and larger geographic areas.

    - **Challenges:**
        i. Understand RFI at scale.
        ii. Understand effects of active users interference on passive applications by creating controlled complex scenarios, including with high-frequency directional communications.
        iii. Create capabilities for compatibility with PAWR platforms, so NRDZ experiments can be migrated onto PAWR testbeds.