Current Findings from the NRDZ Initiative: Background for Workshop #2
(based on Meetings with Stakeholders from April 2021-October 2021)

There have been a number of recurrent themes that have come up in stakeholder discussions about a possible National Radio Dynamic Zone (NRDZ). These themes are organized below by topic, with the dominant feedback/discussion on each topic listed below. This input has been taken from four Lean Coffee Table events and a workshop held during 2021, all of which have involved stakeholders from the scientific community and government agencies. More about past activities can be found on our website: https://www.cs.albany.edu/nrdz-ra/.

I. NRDZ Use Cases, or "What is an NRDZ?": How might an NRDZ be used by various stakeholder communities? What are the reasons why a particular community/subcommunity might use an NRDZ?

- Unifying motivator: Increased spectrum access
- There are two very different models being discussed, referred to in some stakeholder discussions as a "Coordination Zone" (with various levels of management and enforcement), versus a "Wild West" (with little to no enforcement)
    - In general, the first model is more appealing to radio astronomy/earth sensing, the second more appealing to the active community
    - In all models – all potential users should be able to point to tangible benefits to their community. In the discussions thus far: active users get access to spectrum currently not allowed, passive users could get broad bandwidth observing
    - *Creative/Transformative Model: Could one concept for an NRDZ be that it is an automated National Radio Quiet Zone, NRQZ? Basically, software and coordination creates a framework for this new zone to be another NRQZ.*
- Topics of interest to a "Coordination Zone"
    - Time-based sharing seems to be a topic that rises to the top in many discussions of coordination schemes (see below)
    - Wide bandwidth, RFI-free observing for radio astronomy – this might be the "killer app" to interest radio astronomers in such a zone.
    - Broadband, Wide FOV radiometry in the 40-100 MHz range
    - "Rogue" Emitter Detection – best practices for detecting RFI and archiving data
- Topics of interest to a "Wild West"
    - The ability to test/experiment on larger physical scales (e.g. propagation)
    - Sharing between real users

II. Radio Frequency Interference (RFI): What is RFI, how should it be monitored, and what technical specifications are important for its monitoring? These are topics of interest to currently operating radio observatories, ESS systems and commercial operators

- In general, it is important to be able to characterize the RFI environment of potential NRDZ locations. Information required should include: location, direction, power level, duration, percent of time
- How will RFI information be used? The ways in which this information is used will drive the technical requirements of RFI monitoring
- Limitations of current systems
    - High frequencies (>40 GHz) not typically sampled
    - Nulling in the active community might still be well over (e.g. 120dB) over what the passive community considers RFI
    - Narrow band coverage is the norm in RFI monitoring
- Qualities of improved RFI detection and analysis
    - High frequency coverage (>115 GHz)
    - Large bandwidth
    - Ability to cover the entire monitored geographical region and spectrum quickly
- How best to monitor emissions?
    - Overview of current ongoing RFI measurements at observatories. What is the state of the art for existing systems to monitor transmissions in an NRDZ
    - Reporting excess emissions/RFI versus constant monitoring

    - What regions in the zone need to be covered (e.g. azimuth versus sky)?
    - Transmitters in NRDZ should tell you what they are doing - in addition to monitoring (e.g. self-reporting)
- Characteristics of RFI
    - Stakeholders want quantitative examples of RFI
    - How do we quantify "harmful" RFI
    - ESS – worst kind of RFI corrupts data, but you can't tell it is there (e.g., it is incorporated into models)

III. Spectrum Sharing Techniques: What are the most effective ways to share spectrum between users in an NRDZ? How would this compare to current practice?

- Spectral sharing by frequency allocation is the current norm. Not feasible long term, especially for RAS (with very narrow protected bands)
    - Coordination/Spectrum sharing is hard for ESS/RAS (certain physical lines are fixed in the spectrum)
- Time division/coordination seems the most feasible
    - Distributed versus centralized approach (see I. above)
    - An NRDZ could facilitate testing/refining temporal sharing techniques
        - E.g. reserve a fixed portion of every second. *Within an NRDZ – commercial users would only use specific portions of time*
    - For bi-directional spectrum sharing: what timescales should be explored?
        - Millisecond scales - useful to passive users, but interspersed on minute scales also workable/useful (e.g. first 10 ms of every s is reserved)
        - For RA, timescales of 1 hr are okay
        - What time scale of sharing is feasible for all?
    - Responding to transient RA sources
        - VLA could respond to transient in 8 min
        - Valuable to be able to clear out radio spectrum for a short time

IV. Geographical Location, Size and Spatial Boundaries: Where should an NRDZ be located, how large should it be, and how should it be bounded?

- Options
    - New location: "start from scratch"
    - Existing site with non-radio astronomy telescopes and infrastructure (e.g. former NSA site – Brevard, NC)
    - Existing site with radio astronomy telescopes (e.g. Hat Creek, Arecibo)
    - Existing NRAO/GBO site (e.g. GBO, VLA)
- Guiding principles:
    - NSF should support a diversified portfolio (handful of sites) that have different/complementary goals
    - NRDZs should make use of available infrastructure and address differing needs by population density: urban, suburban, rural