Utah State University High Frequency Radio Propagation Research Group

Annual Synopsis for IARU – Use of the NCDXF Beacon Network

Prepared for Peter Jennings, VE3SUN, Curator of the NCDXF Beacon Project

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Introduction

At Utah State University (USU), the High Frequency Radio Propagation (HFRP) Research Group has relied on the NCDXF/IARU International Beacon Network (IBN) as a cornerstone tool for both teaching and research. Under the direction of Dr. David A. Smith, the group uses beacon signals to investigate the variability of high-frequency (HF) radio propagation across the globe.

The beacons provide not only a reliable, time-sequenced set of transmissions across multiple bands, but also a uniquely standardized dataset: one that can be observed from virtually any receiving location. For a university group without access to the resources of a national lab, the beacon network provides an indispensable infrastructure. Its global footprint allows us to connect theoretical modeling of ionospheric behavior with the practical experience of radio reception.

The beacon network also creates a powerful pedagogical opportunity. Over the past several years, physics undergraduates at USU have engaged in senior capstone projects (PHYS 4900: Senior Research Experience) that rely heavily on beacon reception and analysis. These projects have not only trained students in experimental physics and data analysis, but also produced findings that are directly relevant to the amateur and professional radio communities.

How We Use the NCDXF Beacons

The beacon network forms the backbone of our experimental design in multiple ways:

1. **Long-Term Propagation Monitoring**
   Using a GAP Eagle vertical antenna paired with an Icom IC-718 transceiver and computer-automated logging, our group records beacon transmissions on 14 MHz and 18 MHz. These logs provide evidence of diurnal and seasonal variations in HF propagation, enabling students to see ionospheric dynamics unfold in real time.
2. **Correlation with Geospace Models**
   The standardized signals from the beacons allow us to align reception reports with outputs from empirical geomagnetic models such as Tsyganenko's T96 and Tsyganenko–

Sitnov's storm-time fields. This gives students direct exposure to comparing *theory versus measurement*, a skill central to physics training.

3. **Event Studies**
   Beacon data have been used in focused studies of particular geophysical events, such as geomagnetic storms or the ionospheric effects of the 2022 Hunga Tonga volcanic eruption. The time-sequenced beacon signals, especially their global distribution, make them ideal markers of propagation anomalies.
4. **Educational Applications**
   For physics majors, the NCDXF beacons provide a tangible way to connect Maxwell's equations, wave propagation, and magnetospheric physics with observable radio phenomena. The presence (or absence) of a beacon signal is a direct, measurable reflection of physical principles they learn in class.

Student Research Contributions

Several PHYS 4900 research students have produced senior reports or symposium posters using the NCDXF beacon network as their foundation. These include:

- **Jayson Wiggins (2024)**
  "Solar Factors Influence HF Radio Propagation"
  Wiggins examined how solar indices such as F10.7 and Ap correlate with daily beacon reception logs at 14 MHz and 18 MHz. His project demonstrated a clear relationship between geomagnetic disturbances and mid-latitude propagation variability, tying beacon reception directly to space weather drivers.
- **Spence Brothers (2024)**
  "The 2022 Hunga Tonga Volcanic Eruption's Impact on Radio Communications"
  Brothers investigated whether beacon reception anomalies following the eruption could be linked to ionospheric disturbances from volcanic atmospheric waves. His work showed notable disruptions in the days immediately following the eruption, reinforcing the beacon network's role as a global sensor system for both geophysical and ionospheric events.
- **Stuart Barney (2023)**
  "The Effect of Geomagnetic Storms on Radio Wave Propagation on the 14 MHz and 18 MHz Frequencies"
  Barney focused on specific geomagnetic storm intervals, using beacon reception data to illustrate the loss and recovery of HF paths. His results, presented at the USU Undergraduate Research Symposium, showed how HF operators can anticipate degraded conditions during storms.
- **Cameron D. Eggleston (2022)**
  "Automatic Aurora Detection"
  Eggleston's project aimed to use beacon reception patterns, combined with automated sky camera observations, to build a low-cost auroral detection system. His integration of beacon logging into a broader space weather monitoring concept highlighted the flexibility of the beacon system as a research tool.

- **Tyler Larsen (2021)**
  "High Frequency Radio Communication"
  Larsen's project laid the groundwork for the group's use of the beacon network by developing automated beacon logging and analysis routines. His early work provided the tools later students have built upon.

Each of these projects has culminated in poster presentations at the annual Undergraduate Research Symposium, where students interact with faculty, peers, and the broader university community. Importantly, these projects are not only exercises in physics education; they also contribute to the collective understanding of radio propagation, bridging amateur practice and academic research.

Broader Impact on Physics Students

Physics students at Utah State University have directly benefited from the existence of the NCDXF beacon network in several key ways:

- **Hands-On Application**
  The beacon network provides a real-world laboratory without walls. Students gain experience setting up and maintaining receiving equipment, automating data collection, and analyzing signals using computational methods.
- **Interdisciplinary Training**
  Projects bridge physics, atmospheric science, and electrical engineering. Students learn about ionospheric plasma, HF propagation, and the engineering of receiving systems, broadening their perspective beyond standard coursework.
- **Connection to a Global Community**
  By working with beacon signals, students become part of a worldwide collaborative project that includes amateur operators, researchers, and space weather professionals. This builds a sense of community and purpose.
- **Professional Preparation**
  Alumni of these projects have moved on to graduate study and careers where data analysis, modeling, and communication skills are critical. The beacon projects serve as an early proving ground for these abilities.

Acknowledgment and Appreciation

On behalf of the HFRP Research Group at Utah State University, I extend deep appreciation to Peter Jennings (VE3SUN) and the NCDXF/IARU community for their continued stewardship of the beacon network.

For our students, the network represents more than just a series of signals. It is a gateway into experimental physics, a bridge between classroom concepts and global geospace phenomena, and a tangible demonstration of how collaborative international infrastructure can support both amateur radio and academic research.

The network's operation depends on funding, coordination, and volunteer effort. We want to affirm that these investments have produced direct educational dividends for physics undergraduates at Utah State University. Without the beacons, our students would lack a standardized, global-scale tool for probing HF propagation. With them, they gain not only scientific insight but also a sense of participation in a worldwide enterprise.

Conclusion

The NCDXF/IARU beacon network has been and continues to be an invaluable resource for the High Frequency Radio Propagation Research Group at Utah State University. Through its use, our students have produced senior theses, symposium posters, and research reports that deepen understanding of solar–terrestrial interactions, HF communication, and space weather impacts.

The beacon network's standardized, global signals have provided the rare combination of accessibility, reliability, and scientific utility. These qualities make it uniquely suited for student research and training.

We respectfully submit this synopsis in recognition of the beacon network's impact at Utah State University and in gratitude for the ongoing work of those who support and maintain it.

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https://artsci.usu.edu/physics/hfrp/