EEC's Solid-State Ranger X-Band Weather Radar: Synergy, Analytical Diagnosis and Technology Advancement via the CASA Dallas-Fort Worth X-Band Radar Innovations Testbed

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Overview

The Collaborative Adaptive Sensing of the Atmosphere (CASA) partnership, along with the North Central Texas Council of Governments have embarked on a five-year, $10 million project to create the Dallas/Fort Worth (DFW) Urban Demonstration Network. This project is centered on the deployment of a network of 8 dual-pol, X-band radars to demonstrate improved hazardous weather forecasts, warnings and response in a densely populated urban environment. These radars provide weather hazard information at spatial and temporal scales that are relevant to urban decision-making and human response. To date, the DFW innovations network has provided both CASA researchers and commercial partners with the perfect environment to develop technologies, while also understanding market value. Enterprise Electronics Corporation (EEC), via a partnership with the University of Oklahoma (OU), was one of the first suppliers of solid-state X-band weather radar technologies to the DFW test bed. EEC realized numerous innovations in it's Ranger® product line thanks in large part to the true "plug-and-play" environment provided by the CASA DFW proving ground.

About Ranger®

Developed in cooperation with OU, EEC's Ranger® radar system is a new generation, X-band, lightweight, low power Adaptive Polarization Doppler Weather Surveillance Radar that fills the gap between high-cost, high-power traditional C and S-Band radar systems and passive ground station weather sensors. The system uses relatively low power (100W or 500W) solid-state transmitters and pulse compression technology to attain nearly the same performance capabilities of much more expensive traditional radar systems. Ranger® employs Adaptive Dual Polarization techniques to allow Alternating or Simultaneous Dual Polarization capability with total control over the transmission polarization state using dual independent coherent transmitters.

Ranger-X1® System (100W, 1.0m Antenna)

Ranger-X5® System (500W, 1.0m Antenna)

Ranger® and CASA

EEC, in cooperation with OU and the University of Massachusetts, delivered a Ranger®-X1 system to the CASA DFW X-Band Radar Innovations Testbed in late 2013. This deployment into Addison, TX, represented the first operational installation of the Ranger® product line, as well as the first commercial solid-state X-Band system added to the CASA network.

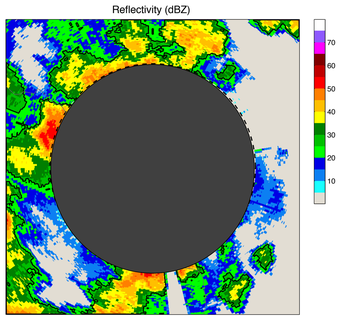
CASA Ranger®-X1 (100W, 1.0m antenna, no radome) System in Addison, TX

Inherent with any initial operational deployment were challenges focused on specific functional aspects of the Ranger® system. Some items included:

- Pulse compression techniques and the blind region
- Polarimetric data quality concerns

Ranger® Challenges

One fundamental challenge with using low power transmitters is the need to implement pulse compression techniques, combined with frequency modulation (FM) in order to achieve usable range resolution and higher sensitivity. However, such techniques also lead to a blind region (from 0-~15km) due to the radar not being able to receive a signal during the first pulse. This blind region is a critical area near the radar that users need to view in order to make life-saving decisions.

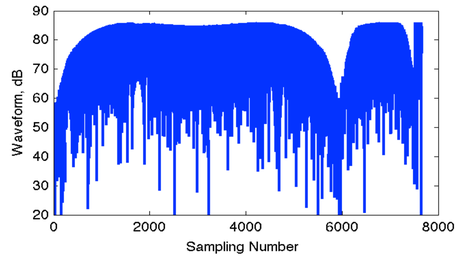


Blind Region due to Transmitting Long Pulse for Pulse Compression

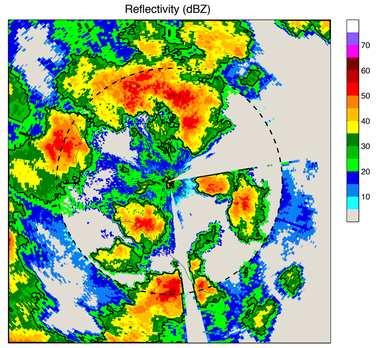
Another focus area regarding the newly deployed Ranger® system in Addison was the quality of polarimetric data sets. Although initial products were accurate, issues with signal-to-noise ratio (SNR) and φ_{dp} lead to less-than-ideal data displays. Such displays were challenging for the non-scientific end users to understand and base their emergency management and asset protection decisions.

Diagnostic Advantages of the CASA Testbed

Thanks to the numerous analytical and diagnostic advantage provided via the CASA testbed, the joint CASA + EEC team was able to remedy the two major challenges discussed previously. With specific regards to the blind region, the CASA testbed afforded the perfect setting to test and implement a first-of-its-kind 3-pulse, Time-Frequency Multiplexed (TFM) waveform design. By using 3 pulses (78µs, 20µs, 2µs; NLFM, NLFM, sinusoid wave), EEC was able to reduce the sensitivity difference in the blind region close to the 15km boundary. The result was accurate detection (by the 20µs pulse) of weak echoes inside the 0-15km blind region.

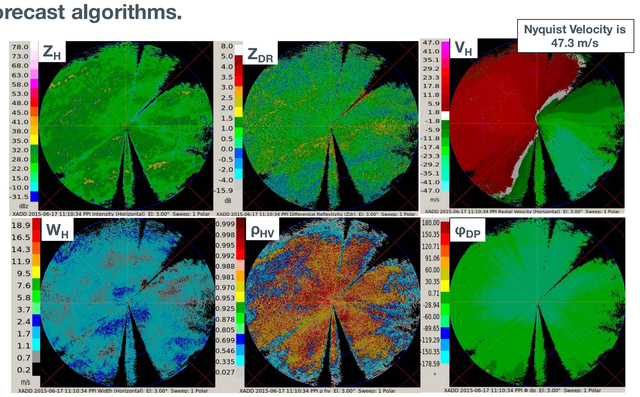


Ranger® 3-Pulse TFM Waveform



Blind Region Echo Detection via the 3-Pulse TFM Waveform Design

Additionally, use of the CASA testbed provided for quick resolution to polarimetric data output concerns. As shown below, the CASA + EEC team was able to address SNR issues, as well as general product cleanliness items, resulting in data sets that were integrated into the CASA advanced rainfall estimation and forecast algorithms.



CASA Ranger®-X1 Polarimetric Data (Beam Blockage Along Numerous Radials due to Trees)

Summary

The synergy and diagnostic advantages provided by the CASA testbed were vital in advancing the Ranger® technologies. Specifically, the two primary challenges faced during initial deployment were seamlessly addressed in large part due to the environment afforded by the testbed. These improvements, along with subsequent developments, have all been rolled back into the commercial Ranger® product line, benefiting all customers operating a Ranger® system. Special thanks and acknowledgment to the entire CASA team, including Apoorva Bajaj, Eric Lyons, and Brenda Philips. Also thanks to our CASA partners at OU, Dr. Jerry Brotzge and Dr. Keith Brewster. Ranger® diagnostic analyses and subsequent corrections performed by EEC's Dr. Qing Cao.