Comparisons of Solid-State C-Band vs. Klystron S-Band Weather Radar Observations over the Southeastern United States

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Introduction

Enterprise Electronics Corporation (EEC) recently launched a new, fully-solid-state C-band Doppler weather radar system. Branded Endurance C, this next generation of weather radar systems is driven by lower powered solid-state C-Band amplifiers versus legacy magnetron or klystron tubes. Endurance C systems provide for ultra-wideband performance and low life-cycle costs thanks to advanced solid-state power amplifiers operating in the widest C-band frequency range available. EEC recently tested the performance of their in-house Endurance C system, utilizing pulse compression technologies, against a nearby S-band NEXRAD system and found many positive results, further justifying solid-state transmitter and pulse-compression technologies as a viable, operational solution for weather radar users around the globe.

Systems Overview – Endurance C

The Endurance C solid-state, dual-polarization C-band Doppler weather radars features include:

- Polarimetric system: full suite of single-pol and dual-pol moments
- Solid-state transmitters: 4 x 10 kW solid-state, fully redundant amplifiers
- Advanced pulse compression configuration: ~350 kW of Equivalent Transmitter Power (ETP)
- C-Band frequency: high-sensitivity, minimal attenuation
- Advanced super-high resolution 16-bit digital receiver (IQ2)
- Reliable antenna and pedestal system

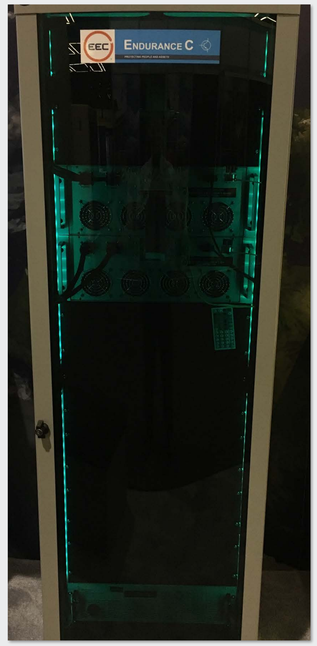
Technical Specifications:

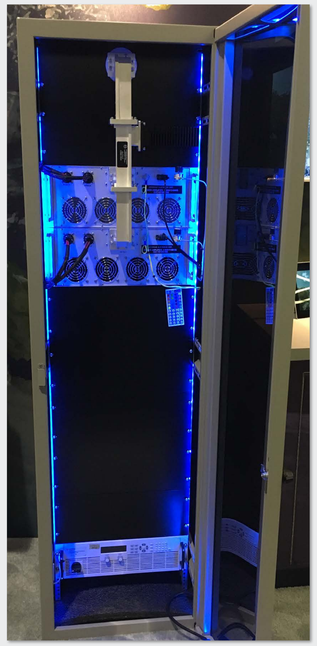
Endurance C	
Operating Frequency	5200 – 5900 MHz
Pulse Width	0.2 – 100 µsec
Pulse Repetition Frequency	200 – 2400 Hz, User Selectable
Dual-Polarization	Simultaneous H/V (CDR)
Transmitter Peak Power	10 kW
Equivalent Transmitter Power (ETP) when using Pulse Compression	~350 kW
Antenna Size	4.2 meters
3-dB Beam Width	0.95°
Sensitivity - Reflectivity	-18 dBZ @ 30 km

Endurance C Antenna + Pedestal Assembly

Endurance C System Advantages

EEC's Endurance C radar uses modern solid-state technologies to provide users with decreased life-cycle maintenance costs, a smaller hardware footprint, and increased operational up-time.





Endurance C Transmitter Cabinet (shown here with only two of the final four operational 2.5 kW amplifiers bays)

Klystron and magnetron tubes are considered consumables within a radar system. This means they require replacement every few years at a significant cost. EEC's Endurance systems come standard with fully solid-state power amplifiers. These amplifiers last far longer than klystron and magnetron tubes, rarely requiring replacement. This results in an immediate life-cycle maintenance cost savings over klystron and magnetron tube-based systems.

Additionally, traditional weather radar systems utilize klystron or magnetron tubes as the core component of the transmitter. Although these tubes have a long track record of success and stability, they are older technologies, stemming back to the 1940's. In addition to older technology, klystron and magnetron tube systems also require large high-voltage power supply units housed in the transmitter cabinet. Utilizing low-power solid-state amplifiers, combined with pulse compression technology, Endurance radars do not require these large power supply components and cut the transmitter hardware footprint in half.

Finally, every Endurance solid-state weather radar comes with redundancy built into the transmitter. Each system includes 4 solid-state power amplifiers. In the rare case that an amplifier breaks down, all replacement activities are quick and easy, resulting virtually no operational system down-time.

Comparison Event - 19 December 2020

A 5kW Endurance C transmitter (only two of the four 2.5kW amplifiers were installed at time of testing) was configured at EEC's factory (Enterprise, AL) and the pulse compression technique was tested on Dec. 19, 2020. During this time, a large mesoscale convective system (MCS) passed through the region. Although the Endurance C radar was not tuned/calibrated to its final operating state (it was still in R&D/Test Mode), it performed very well and was comparable with the nearby high-power (850kW klystron) KEVX NEXRAD radar.

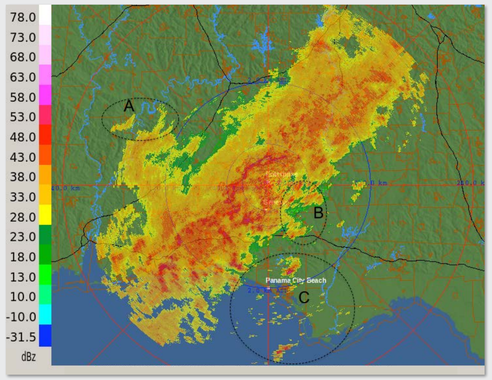


Fig. 1: Endurance C Z_H observations at 0.5 degree scan

Figure 1 (left) and Figure 2 (below) show the Z_H data at the 0.5° elevation scans level for the Endurance C radar and the KEVX S-band NEXRAD, respectively. The Endurance C, using only half (5kW) of the final operational configuration of 10kW (~350kW ETP when using pulse compression), provides an excellent observation of MCS features. For example, the storm features in regions A, B, and C are well presented in the Z_H data. Additionally, very little attenuation is observed, especially considering the lower ETP (~200-250 kW) used.

Please note that the KEVX NEXRAD is located to the south (in the FL panhandle) of the Endurance C radar. The observations might have some differences due to the radar sample volume in different altitudes, especially for the weak signals. The regions D and E in Fig. 2 show some weak echoes, while few weak echoes are seen in the same regions in Fig. 1. This difference is likely due to the difference in actual sample volumes of these two radars.

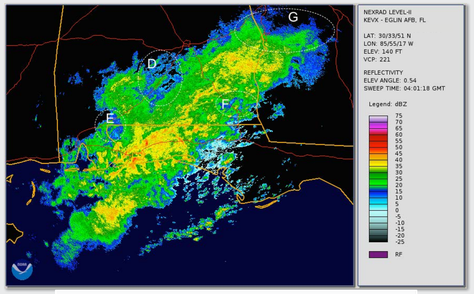


Fig. 2: KEVX Z_H observations at 0.54 degree scan

The evident effects of different sample volumes can be seen in regions F and G in Figure 2. The KEVX radar observed the higher portion of the storm cell, and the subfreezing region typically has lower radar echoes than the rain region. Therefore, lower Z_H values are shown in regions F and G.

Conclusions

The Endurance C solid-state transmitter radar provided very comparable performance with the KEVX NEXRAD without considering the minor differences in the absolute calibration. Keeping in mind that a) not only do these two system operate in different frequency ranges (C-band vs. S-band), b) some attenuation is expected in the C-band and c) the Endurance C was only operating with ½ of its final power amplifier configuration, the results are very encouraging. By performing further tests using the final 10kW configuration (which provides ~350kW ETP when using pulse compression), it is logical to deduce that any minor areas of attenuation and detection difference will be greatly reduced, proving Endurance C to be a highly-viable substitution for any magnetron or klystron-based radar system, especially in the C-band spectrum.