

# EEC's Next Generation X-band Polarimetric Weather Radar: Solid-State Ranger Series

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## Introduction

New, innovative X-band weather radar systems have recently attracted interest in both the research and commercial market spaces. This is primarily due to the inherently lower cost of these systems, as well as the ability to construct networks providing improved detection of the lower region of the atmosphere over conventionally spaced C- or S-band radars. As global leader in commercial weather radar innovation and manufacturing, Enterprise Electronics Corporation (EEC) has developed their next generation X-band weather radar, which capitalizes on a low power, low cost, and high reliability solid-state transmitter design. Recently, EEC has successfully launched the novel X-band solid-state polarimetric weather radar system dubbed Ranger®. Currently, numerous Ranger®-X1 (dual-100W transmitters) and X5 (dual-500W transmitters) systems have been delivered to various research and commercial agencies around the world.

## System Overview

Major features:

- Polarimetric system: Dual-transmitter design — flexible & redundant
- Solid-state transmitters: low cost, low power, high reliability
- X-Band frequency: compact size, high sensitivity
- Advanced super-high resolution 16-bit digital receiver (IQ2)
- Reliable antenna and pedestal system
- Remote operation, maintenance, and troubleshooting



	Ranger®-X1 or X5
Operating Frequency	9200-9700 MHz
Pulse Width	0.4-100.0 μsec
Pulse Repetition Frequency	100-2500Hz
Dual-Polarization	Simultaneous H/V
Transmitter Peak Power	100W or 500W per channel
Antenna Gain	≥ 37.3 dBi / 40 dBi / 45 dBi
Antenna Size	1m / 1.8m / 2.44m
3-dB Beam Width	≤ 2.3° / 1.3° / 0.95°
Sensitivity @ Typical Range	18 dBZ @ 50km or 120km
3-dB Range Resolution	60-125 m
Minimum Gate Width	15.625 m / 31.25 m
Pulse Compression Waveform	TFM, NLFM

## Ranger® series design—joint effort between industry and research institute

Working with world-renowned experts at the University of Oklahoma's (OU) Advanced Radar Research Center (ARRC), EEC developed proprietary hardware schema and signal processing algorithms for the Ranger® system. EEC has also worked with scientists from the Center for Collaborative Adaptive Sensing of the Atmosphere (CASA) to improve the Ranger® performance and data output quality.

## Operational Ranger® systems delivered worldwide

Operational Systems:

- One X1 units (Radome-free) for CASA (USA)
- One X5 unit for KLTV-TV (USA)
- One X5 unit (Mobile) for Indonesian Air Force
- One X5 units for BMKG (Indonesia)

In Production:

- Two X5 units to BMKG
- One X1 unit (Radome-free) to CASA
- One X1 unit (Radome-free) to C. America
- Six X5 units to TV Stations (USA)



Work status

Transportation

Indonesian air force mobile Ranger®-X5 system



CASA radome-free Ranger®-X1 system (#1) (Addison, TX)

Installation of CASA Ranger®-X1

Installation of BMKG Ranger®-X5

Compact antenna Ranger®-X5

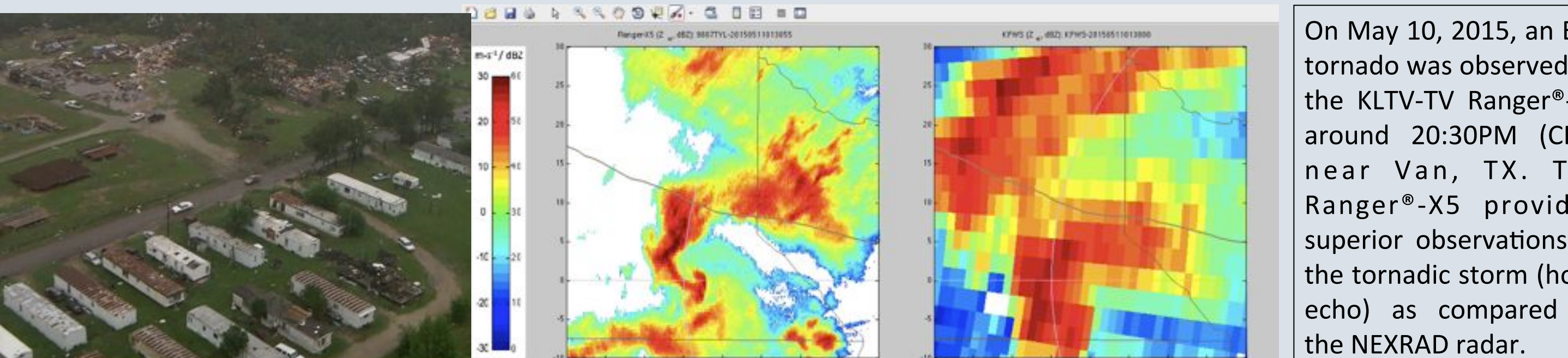
KLTV Ranger®-X5 testing

Ranger® system can opt to use a larger size antenna to improve radar performance.

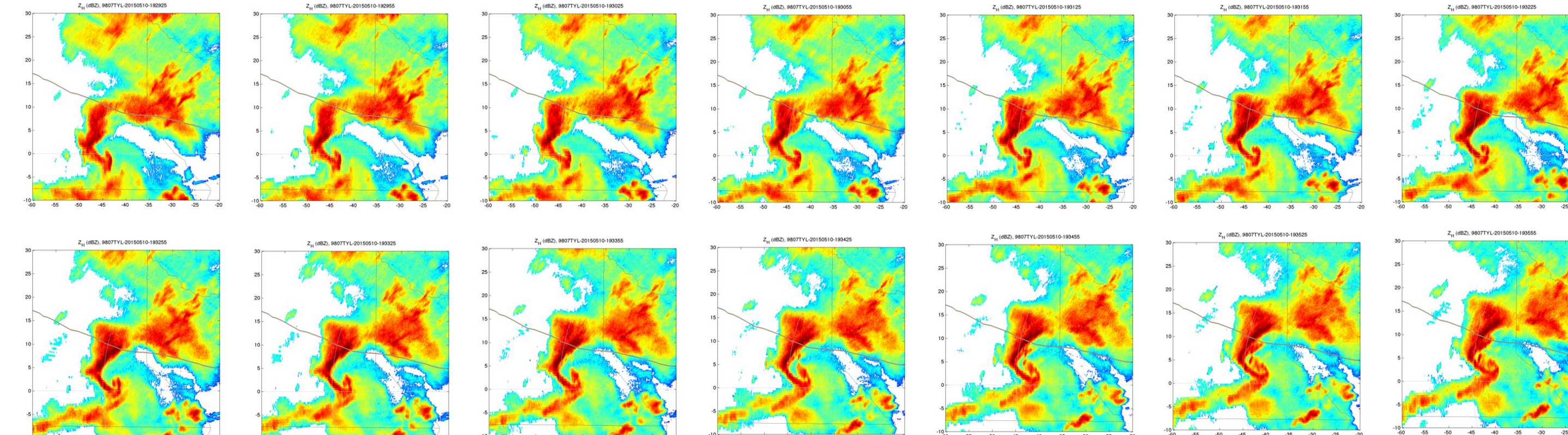
CASA #2 Ranger®-X1

## Ranger® Series Radar Observations

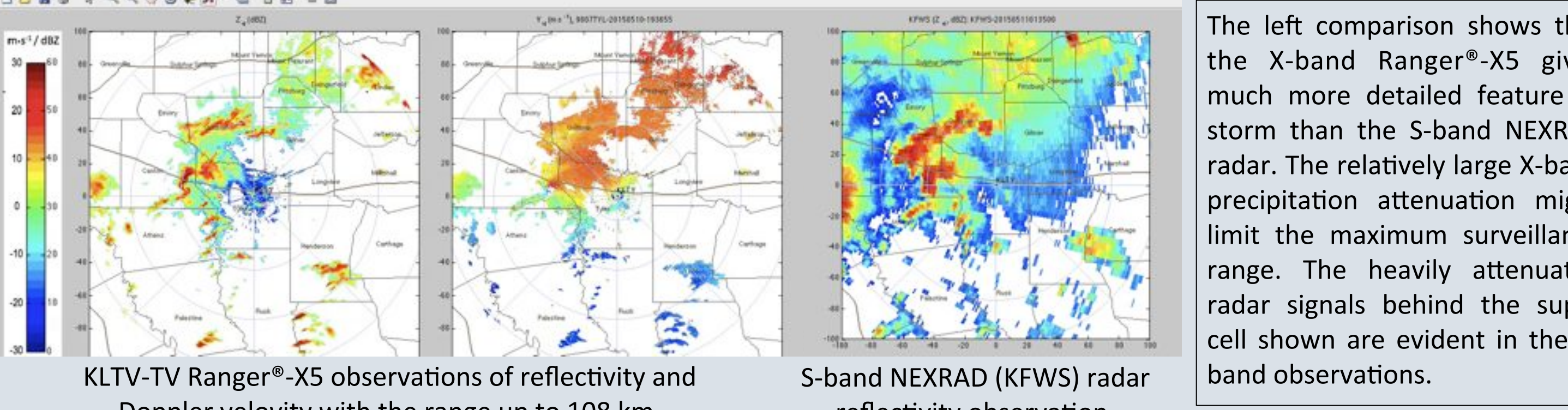
Examples of Ranger® radar observations are from the KLTV-TV (TV station) Ranger®-X5 unit deployed in Tyler, TX, and the CASA Ranger®-X1 unit deployed in the Dallas/Fort Worth (DFW) area.



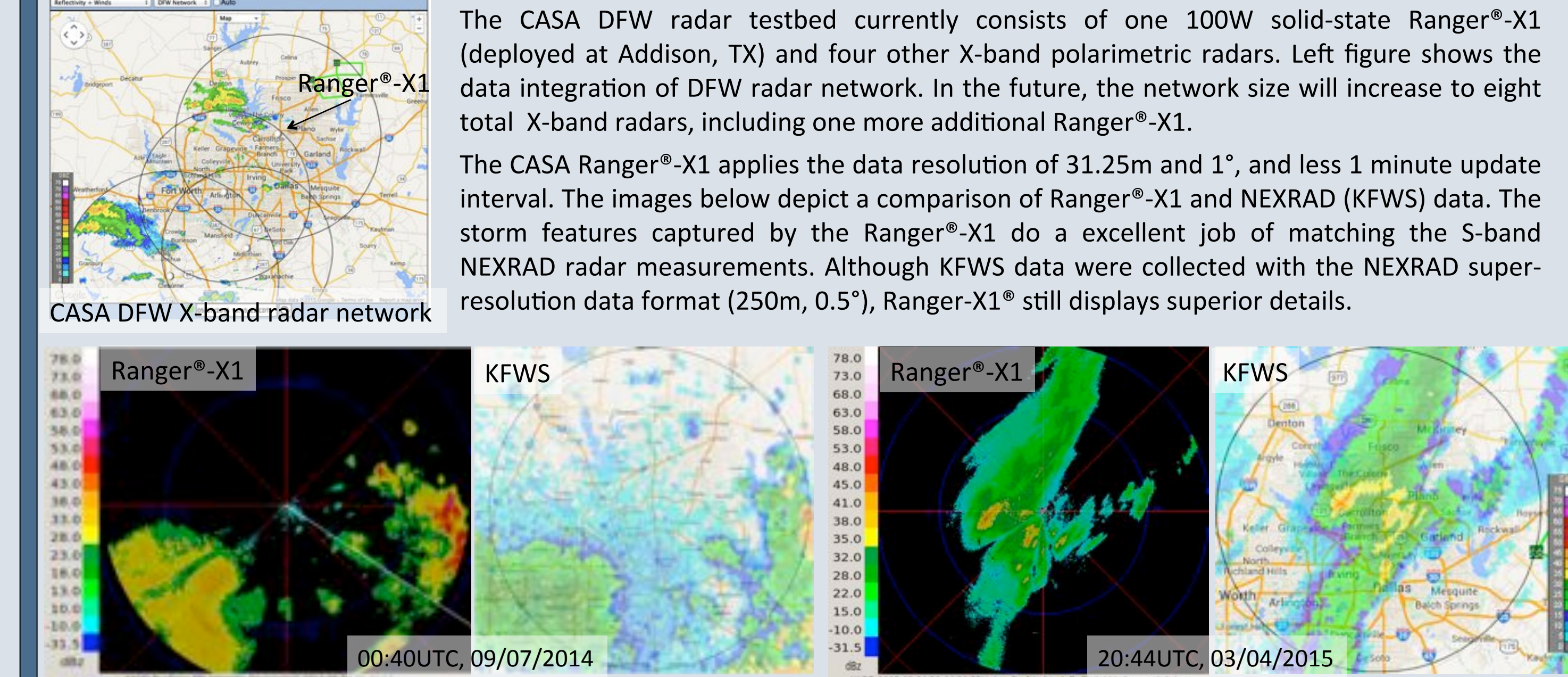
On May 10, 2015, an EF3 tornado was observed by the KLTV-TV Ranger®-X5 around 20:30PM (CDT) near Van, TX. The Ranger®-X5 provided superior observations of the tornadic storm (hook echo) as compared to the NEXRAD radar.



KLTV-TV Ranger®-X5 observed the EF-3 tornado near Van, TX on May 10 2015. Ranger® provided super-high spatial (31.25 m) and temporal (0.5 minute) resolution data, which were far superior to both the nearby NEXRAD radar.

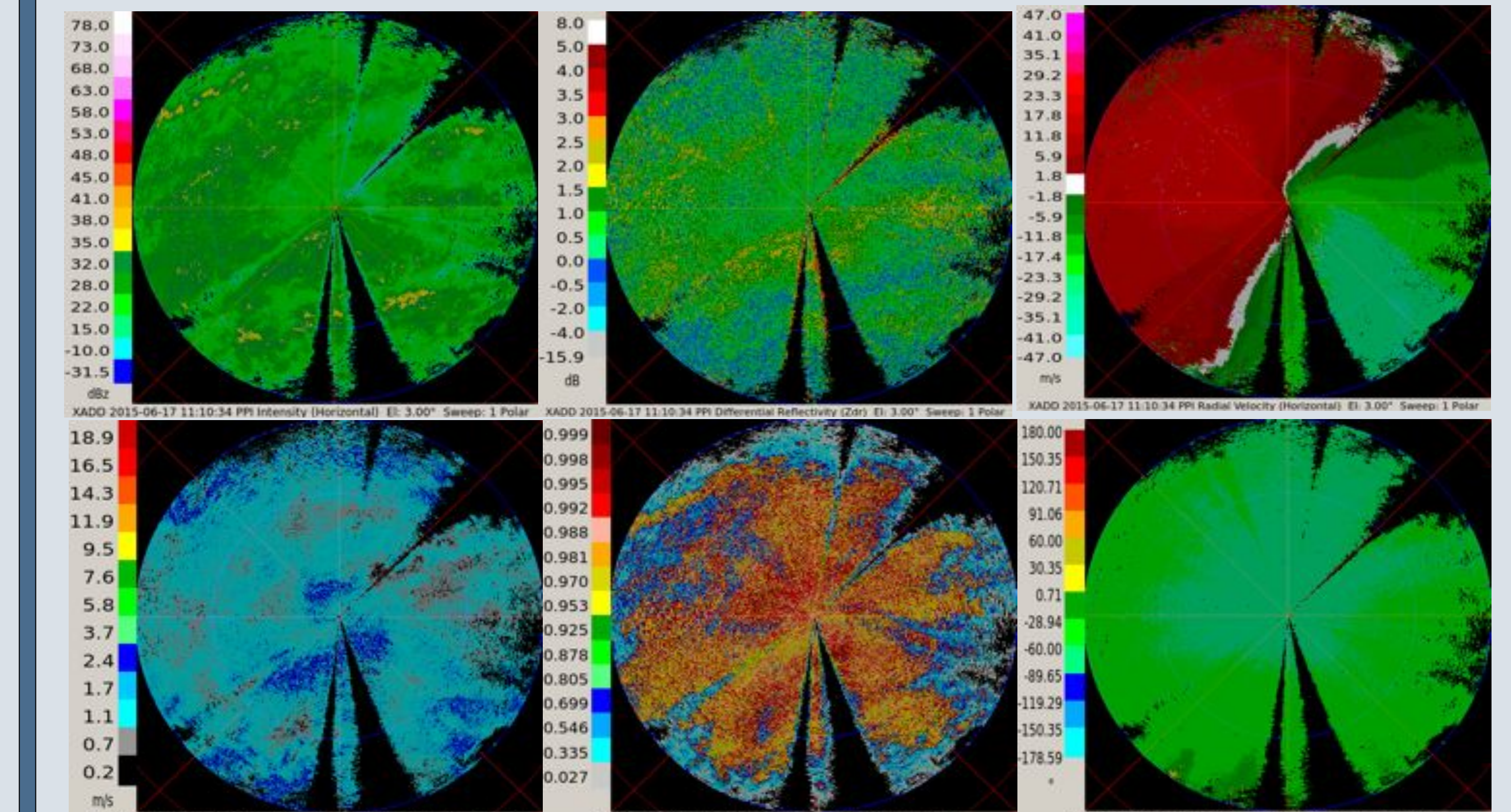


The left comparison shows that the X-band Ranger®-X5 gives much more detailed feature of storm than the S-band NEXRAD radar. The relatively large X-band precipitation attenuation might limit the maximum surveillance range. The heavily attenuated radar signals behind the super cell shown are evident in the X-band observations.



The CASA DFW radar testbed currently consists of one 100W solid-state Ranger®-X1 (deployed at Addison, TX) and four other X-band polarimetric radars. Left figure shows the data integration of DFW radar network. In the future, the network size will increase to eight total X-band radars, including one more additional Ranger®-X1.

The CASA Ranger®-X1 applies the data resolution of 31.25m and 1°, and less 1 minute update interval. The images below depict a comparison of Ranger®-X1 and NEXRAD (KFWS) data. The storm features captured by the Ranger®-X1 do a excellent job of matching the S-band NEXRAD radar measurements. Although KFWS data were collected with the NEXRAD super-resolution data format (250m, 0.5°), Ranger®-X1 still displays superior details.



The above six figures show the CASA Ranger®-X1 measurements (3° elevation angle, 11:10:34UTC, 17 June 2015): Z<sub>H</sub>, Z<sub>DR</sub>, V<sub>H</sub>, W<sub>H</sub>, ρ<sub>Hv</sub>, and Φ<sub>dp</sub> (from top to bottom, left to right). The radar observed precipitation is the stratiform portion of tropical storm Bill. The beam blockage at several directions (N, NNE, E, SSE, S, SW) due to nearby trees is evident in the images. As a 100W system, Ranger®-X1 applies the pulse compression (PC) technique. The data show that the blind region problem for traditional PC technique has been well resolved by the novel time-frequency multiplexing (TFM) waveform applied in Ranger series.

## Conclusion

EEC's Ranger® series radars apply the latest techniques of low-power, solid-state weather radar design and have demonstrated great potential for lower level atmosphere surveillance. Such polarimetric radar data from compact, solid-state X-band systems can improve the capability of weather detection, estimation, and forecast. For use by government agencies, research entities, and commercial organizations, the Ranger® system provides the ideal level of flexibility in system design, including the options of transmitter power, antenna size, mobile configurations, and radome-free deployments to meet ever-evolving and changing customer needs.

## ACKNOWLEDGMENT

The University of Oklahoma (OU) and the Collaborative Adaptive Sensing of Atmosphere (CASA) have provided invaluable support in the development and improvement of the Ranger® system. Special thanks is also given to the scientists from the OU ARRC and the Center for Analysis and Prediction of Storms (CAPS) at OU, as well as engineers and researchers from the University of Massachusetts-Amherst (Umass) and from EEC's Ranger® project team. All of these partners were influential in hardware design, signal processing, troubleshooting, software/hardware improvement, data collection and analysis for the Ranger® product line. We also appreciate the Town of Addison, which has provided endless support for the CASA Ranger®-X1 installation.