

# The NRC W- and X-band Airborne Radar Systems: Calibration and Signal Processing

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The NRC W- and X-band airborne radars (NAWX) developed by the NRC Flight Research Laboratory and ProSensing Inc. are the primary remote sensing systems of the NRC Convair-580 research aircraft. These polarimetric Doppler cloud/precipitation radars are capable of sampling the three-dimensional structure and evolution of clouds or storms along the flight track. The NAWX antenna subsystems include three W-band and three X-band antennas and a two-axis motorized reflector plate for one of the W-band antennas. The NAWX radar's electronics and data system is rack mounted inside the aircraft cabin while the antenna subsystem is housed inside an un-pressurized blister radome. Over the years, hardware and software of the systems have been maintained and upgraded regularly to provide comprehensive and high quality data sets of cloud and precipitation.

In this paper, techniques for calibrating reflectivity and correcting Doppler velocity for the aircraft motion are presented. Due to the complex airborne installations, no single method of standard calibration methodologies can be applied for all of the antennas. However, the unique design of the NAWX's antenna system allows reflectivity cross-calibration between the antennas and frequencies. The calibration system includes internal calibration and end-to-end calibration. For the end-to-end calibration, water surface radar cross sections are used to calibrate the nadir-looking antennas and the W-band aft antenna with the reflector pointing down. Then the aft antenna is directed to other direction (zenith and side) to do cross-calibration with other antennas. Cross-calibration between the two frequencies are also done in drizzle or small ice crystal condition. This procedure provides a calibration accuracy of 1-1.5 dBZ for the W-band and 1-2 dBZ for the X-band.

For Doppler correction, the conventional ground surface method is used to estimate beam pointing vectors of the nadir and side-looking antennas. The zenith antennas beam pointing vectors are calibrated using drizzle and small ice crystals data with an assumption that in those conditions, the Doppler is constant at radar range gates close to the aircraft. The Doppler estimates have bias less than  $0.5 \text{ ms}^{-1}$  for the W-band and  $1 \text{ ms}^{-1}$  for the X-band.

In addition to the calibration, advance signal processing algorithms were developed to improve the NAWX data quality. Techniques described in this paper include algorithms for adaptive noise removal, ground clutter leakage mitigation, and cross-talks between different radar ports.

Keywords: Airborne Radar, Cloud Weather Radar, Radar Calibration, Radar Signal Processing