Design Considerations for Developing Airborne Dual-Polarization Dual-Doppler Radar

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I. Introduction

An airborne radar has only a limited amount of time to collect measurements over a specified sample volume, the e-scan will significantly enhance temporal and spatial resolutions of airborne radar observations (Bluestein et al. 2003). At present, airborne weather radars, such as NCAR's Electra Doppler radar (ELDORA), use mechanical scan and they are not compatible for collecting dual-polarization radar measurements (Hildebrand et al. 1996) . This poster presents the concept, and preliminary design of a C-band, airborne, dual-polarization, dual-Doppler precipitation radar. EOL proposes to develop a novel airborne phased array radar (APAR) to be operational on NSF/NCAR C-130 aircraft with improved spatial resolution and polarimetric measurement capability (Loew et al. 2007). Preliminary design specification of the APAR that may replace the ELDORA are described in this poster.

II. Rationale for Next Generation Airborne Radar

The NWRT (The National Weather Radar Testbed) phased array radar (PAR) has demonstrated the estimation of accurate Doppler velocity and reflectivity in ground-based configuration in a single polarization mode (Foresythe et al. 2006; Weber et al. 2007; Zrnic et al. 2007). Recent NWRT measurements showed the phased array radar's ability to reduce scan time at least by a factor of two by rapidly steering the beam to a set of spatially diverse pointing angles using beam multiplexing (Yu et al. 2007).

The atmospheric science community has enthusiastically endorsed the development of a phased array radar to replace the aging ELDORA. This next generation radar can be mounted on the fuselage of the NSF/NCAR C-130 aircraft as described in the next section. Technical specifications and configuration of an airborne phased array radar capable of providing dual-Doppler wind fields and dual-polarization measurements are discussed in the following sections.

III. APAR Instrumentation and Technical Background

Figure 1. Proposed configuration of C-band active electronically scanned array (AESA) radars on C-130. Four AESA radars are strategically mounted on the fuselage of the NSF/NCAR C-130 turboprop aircraft

The "composite" scanning of all four AESAs yields a full 360° dual Doppler coverage, as in the current ELDORA. An important advantage of the AESAs over ELDORA is the ability to scan in azimuth as well. This feature, used in conjunction with data from the C-130 weather avoidance radar, will be exploited to produce a composite PPI "surveillance."

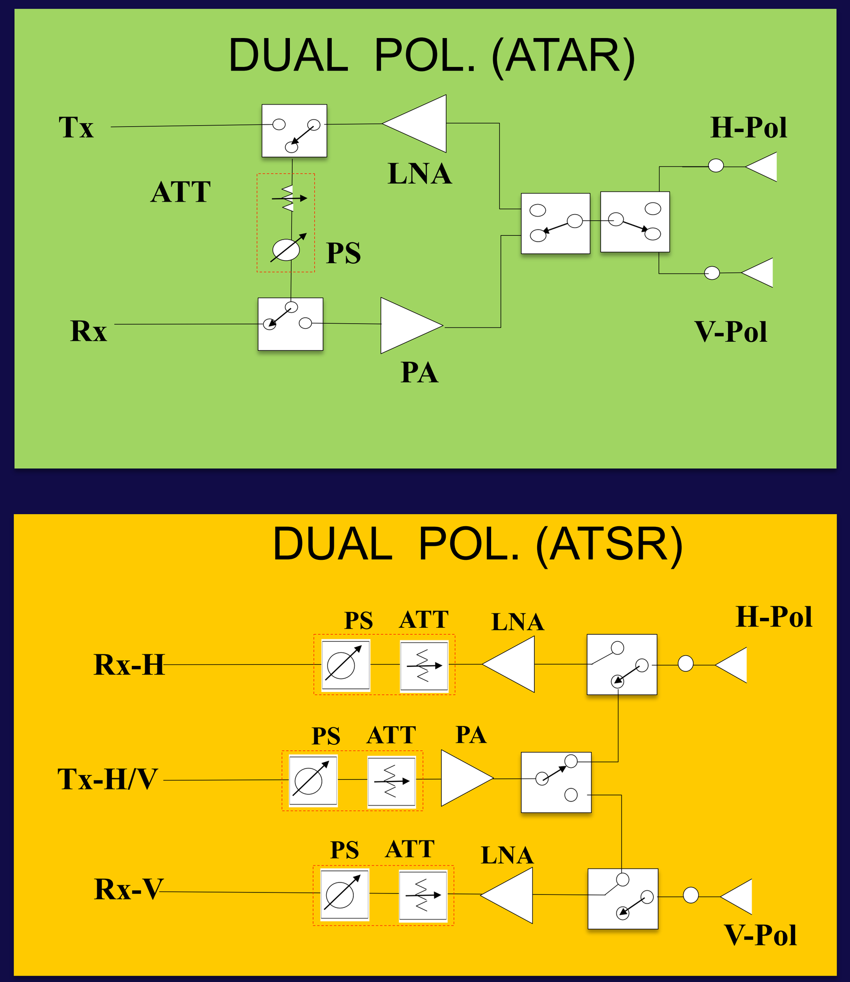

Figure 2. TR-Module architecture options for APAR:(a) dual-polarization for alternate transmit and alternate receive (ATAR) modes, and (b) dual-polarization alternate transmit and simultaneous receive (ATSR).

Technical Specifications of C-band APAR

Parameter	Specification
Frequency	5.4 GHZ
Element spacing along parallel and perpendicular to fuselage (0.5 lambda)	2.78 cm
Number of Elements along parallel and perpendicular to fuselage	56, 64 (3584)
Line Replacement Unit (LRU) Size	8X8 (64 elements)
Number of LRUs per PAR	7X8
Tx Beamwidth (Uniform)	θ_0: 1.8°, 1.6° θ_{45}: 2.1°, 1.8°
Rx Beamwidth (Taylor aperture illumination)	θ_0: 1.9°, 2.2° θ_{45}: 2.2°, 2.5°
Tx Gain	40dB
Rx Gain	39dB
Xpol isolation (ATSR)	<-25dB
Spatial Resolution at 10 km	~350m
Tx Power (4W per TR mod.)	14.3kW
Minimum detectable signal at 10 10km	-20 dBZ

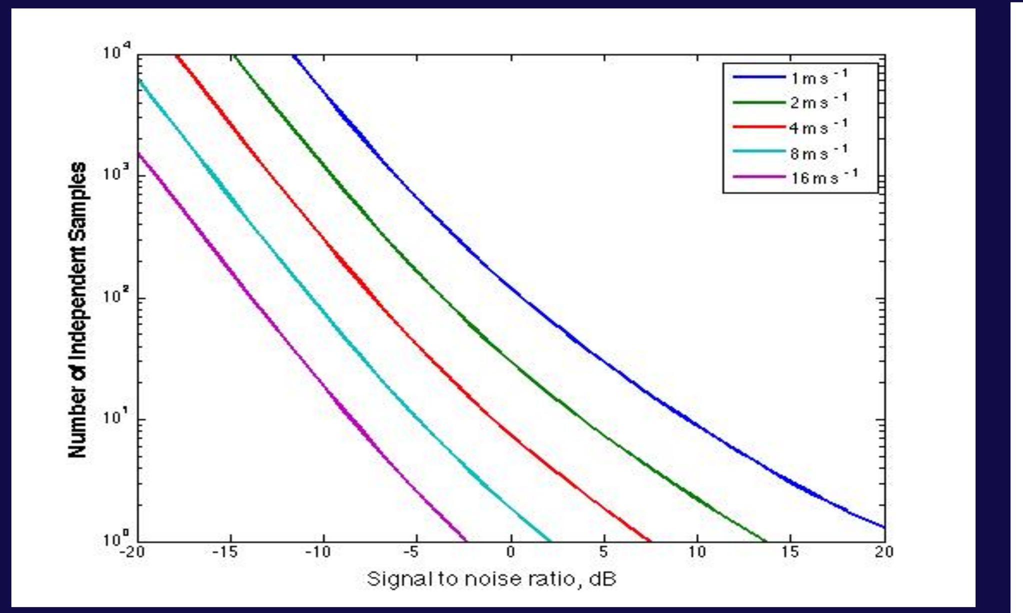

Figure 4. Number of independent samples verses along track resolution are shown for 35 and 60 % beam overlaps. The PRF is assumed 2000. Aircraft speed is assumed to be 125 m/s.

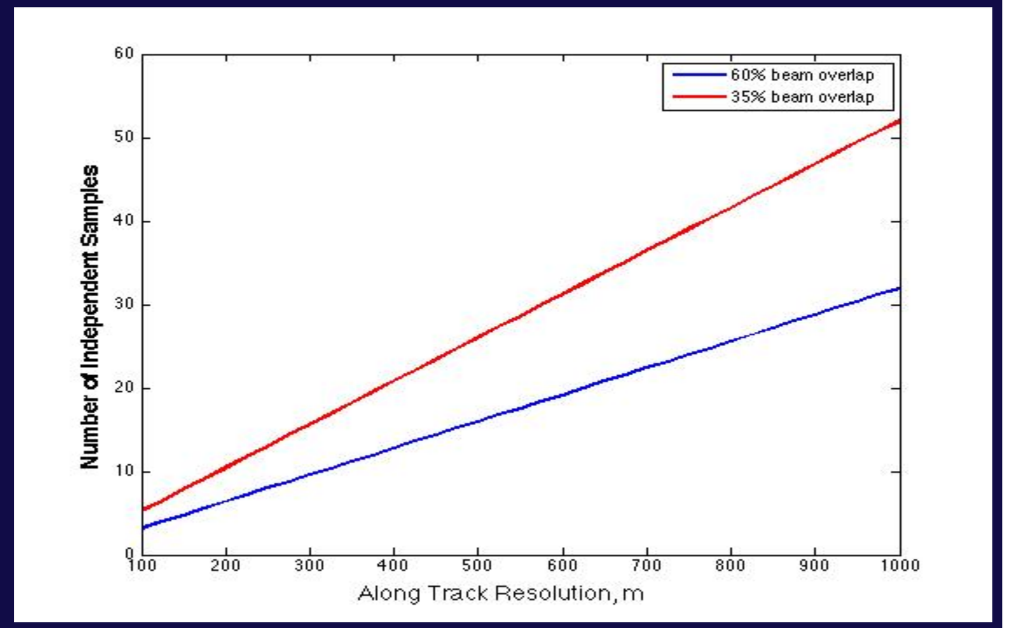

Figure 5. Requirement of number of independent samples as a function of signal-to-noise ratio for various mean velocity measurement accuracies are shown. Spectrum width is assumed 1 m/s and PRF is 2000 and transmit frequency is C-band.

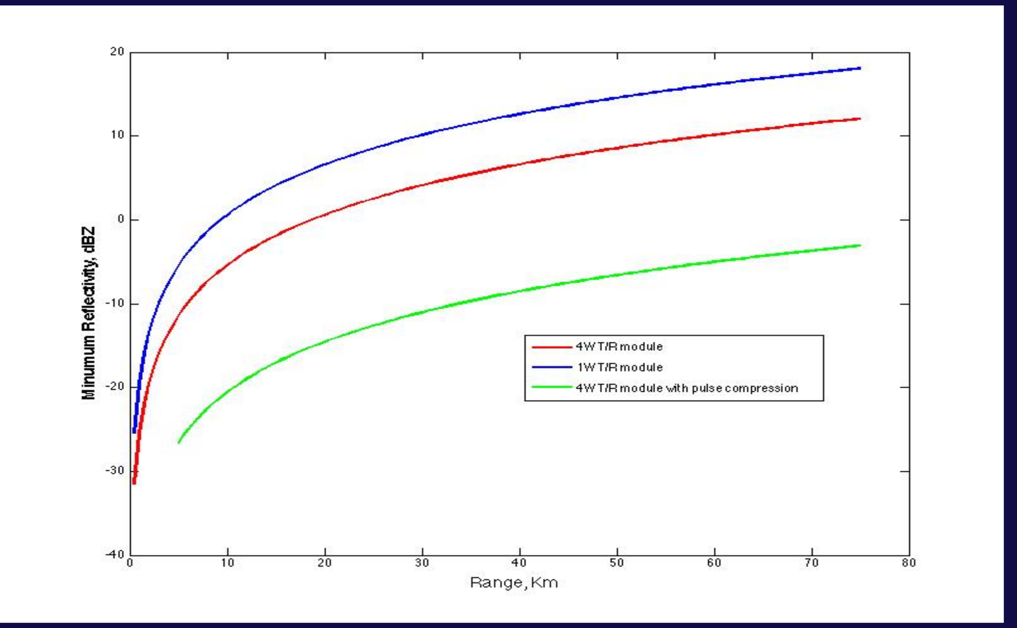

Figure 3. Sensitivities of the APAR for 4W and 1W transmit/receive (T/R) modules and 4W T/R modules with 33:0.3 pulse compression are shown as a function of range.

IV. Summary And Discussion

The APAR is being designed to be capable of collecting microphysical and dynamical scientific products. Design specifications of APAR are more stringent than a ground-based PAR. The airborne platform allows the measurement and collection of dual-Doppler and dual- polarimetric measurements to retrieve microphysical quantities of precipitation. Multiple AESA radars on the C-130 fuselage enhance spatial and temporal resolutions of measurements.

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