A VHF RADAR FOR DEPLOYMENT ON A UAV FOR BASAL IMAGING OF POLAR ICE

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Understanding the response of the polar ice sheets to global climate change and their contribution to sea-level rise requires ice-sheet models that accurately predict their dynamic behavior. Three-dimensional characterization of the ice column and the basal conditions are needed for model development and validation. Parameters of interest available from radar measurements include ice thickness, bed topography and roughness, maps of internal layers and liquid water layers or channels. Land based platforms are slow and cannot safely be used in crevassed areas. Safety and resource issues limit the availability of manned airborne missions as well. An unmanned aerial vehicle (UAV) is being developed as a platform from which fine-resolution measurements can be made over vast areas. The VHF-band radar designed to operate from this UAV is the focus of this paper.

The Meridian UAV (see figure 1) is being developed specifically to support low-altitude polar remote sensing missions. The Meridian, composed of carbon composite materials, has a 26-ft wingspan, a range of over 1500 km, and is powered by a diesel engine [1].

Previous radar systems used to probe the ice sheets, have either been flown on a P-3 or Twin Otter aircraft which easily accommodate large, heavy systems; these have been on the order of 100 kg and more than a cubic meter [2]. The Meridian’s science payload compartment can accommodate a 20 cm x 20 cm x 10 cm radar chassis with an overall mass of 55 kg. This has lead to several new advancements in our radar system.

The radar will use a distributed architecture with transmit/receive (T/R) modules located out on the wings for signal conditioning prior to transmission or following reception. Eight wide bandwidth antennas will be suspended beneath the wings, each with an attached T/R module. As the T/R modules contain both analog and digital subsystems, to avoid producing electromagnetic interference requires that all digital signaling to and switching within the T/R modules be idled during receive periods. Each T/R module also contains an accelerometer to assist in the compensation of motion and wing flexure. Thus the radar equipment in the payload compartment provides analog-to-digital conversion, data logging, waveform generation, and signal timing whereas the T/R modules provide signal amplification, filtering, and switching. Each T/R module will transmit 20 W of power, so with 8 T/R modules on the wings there will be 160 W of total transmit power.

Depth sounding in the nadir direction provides useful information on the ice-sheet thickness; however side-looking synthetic-aperture radar (SAR) techniques to image swaths on either side of the flight path can provide topographic information over a larger area. To maintain a high signal-to-noise ratio (SNR) for off-nadir measurements a beam steering network will be used to steer the main transmit antenna beam ± 30° from nadir.

![Figure 1: UAV design with Vivaldi antennas [1]](image1)

![Figure 2: Previous generation multi-channel radar depth sounder [2]](image2)
Another new aspect to this radar is the use of ultra-wideband Vivaldi antennas. These antennas have a low aerodynamic profile and do not rely on reflections off the wing for beamshaping. These 3.2-lb. antennas operate from 162 MHz to 1.121 GHz and have radiation beamwidths of greater than 60° in both the E and H planes at 200 MHz [3].

The radar operates with a 195-MHz center frequency and a 30-MHz bandwidth. A 13-kHz PRF was selected to avoid Doppler ambiguities while accommodating 16 presums in each of the three transmit beam directions (left, right, and nadir) since the platform velocity could be greater than 70 m/s with a tailwind.

With these new features our UAV radar will allow us to collect data for side looking SAR imaging of swaths on either side of the plane as well as nadir depth sounding during a single pass.

References: