Characterisation of Dismounted Combatants Radar Signature from Airborne Platforms

Michael McDonald [1], Anthony Damini [2]

Defence R&D Canada,
3701 Carling Avenue,
Ottawa, ON K1A 0Z4
[1]mike.mcdonald@drdc-rddc.gc.ca
[2]anthony.damini@drdc-rddc.gc.ca

***Abstract*—The radar signature of dismounted combatants as observed from a moving airborne radar platform was examined and quantified. The dismounted target presented a characteristic amplitude and frequency modulated signature which proves useful in distinguishing true targets from those due to uncancelled clutter discretes.**

I. Introduction

The detection of dismounted combatants (hereafter simply referred to as dismounts) via airborne radar surveillance is a challenging problem due to the small radar cross sections of human targets and their low target velocities. It is well known that the operation of radars from moving platforms introduces a significant Doppler spread into the ground clutter spectrum due to the width of the antenna azimuth beam pattern. This ground clutter spectrum will typically overlap with the Doppler signature of the slow moving dismount making it necessary to employ Space Time Adaptive Processing (STAP) techniques to suppress the clutter. The following paper examines a typical dismount target signature as observed in real data collected using an airborne radar.

II. Data Collection

The real data used in this study was collected near the Defence Research and Development Canada Ottawa (DRDC Ottawa) research lab using the DRDC Ottawa X-band Wideband Experimental Airborne Radar (XWEAR) [1]. The aircraft flew a grid pattern composed of both broadside and forward looking antenna pointing directions, corresponding to maximum and minimum Doppler broadening, respectively. During each run, data was collected in a spotlight mode in which the radar antenna remained pointed at the same location on the ground, i.e., as the plane moved the antenna pointing direction was adjusted to stay centred on the same ground location. Two legs of the collected data were chosen for examination corresponding to a forward looking and broadside collection geometry, respectively. The broadside data set contains a group of three walkers at a range of approximately 30 km from the radar. The forward looking data set contains one walker; in this case the range varies from 30 to 15 km as the aircraft is flying towards the targets during the collection period. The radar employed a 2 phase centre antenna with 30 cm separation and a radar resolution less than 1m.

III. Examination of Data

A. Forward Looking Data Collection

As briefly discussed above, the forward looking collection configuration produces the least amount of Doppler spreading of the clutter spectrum due to the aircraft motion. For the data set in question, the aircraft was flying at a speed of approximately 100 m/s producing a Doppler spread of only a couple of Hz at the 6dB two way azimuth gain pattern point. Given typical walking speeds of 3-5 km/h (0.8-1.4 m/s), we can expect a target Doppler on the order of tens of Hz which is comfortably outside the clutter spectrum.

To characterize the target signature, it is convenient to examine the spectral and amplitude characteristics of the target separately. The range-Doppler signature of the dismount is expected to be spread in Doppler due to a combination of the finite length of the coherent processing interval (CPI) and the micro-Doppler of the target. The micro-Doppler signature of a walking human is quite complex due to the interaction of multiple moving parts, such as the arms, legs and main body. Figure 1 presents the spectrogram of a walking person measured using a simple ground based CW setup in which the complex frequency behaviour is apparent. The structure of the micro-Doppler spectrum has been modelled [2] and examined in other studies using ground based radar measurements [3]. Due to practical considerations, such as range walk of the target through resolution cells, it was not possible to observe the fine micro-Doppler behaviour in the airborne data and we are mainly restricted to observation of the dominant component represented by the red band in figure 1. We restrict our analysis below to an understanding of the dominant components.

We first examine the frequency modulation of the signal by extracting the peak Doppler component for contiguous time windowed data samples. The corresponding temporal variation of the target spectrum for a CPI of 128 pulses is illustrated in figure 2 and corresponds to a frequency modulated (FM) Doppler target signal. The average Doppler frequency of about 90 Hz corresponds to a radial target velocity of 1.4 m/s. The corresponding spectrum of the frequency modulation is