# Detection of Hard Targets Camouflaged Under Foliage Using Millimeter-wave Radars

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Over the past decade significant amount of effort have been devoted towards development of a reliable technique for detecting ground vehicles camouflaged under foliage. Because of foliage penetration capability of microwave signals, especially at low frequencies, ultra-wideband radar systems operating over the range of 50 MHz to about 500 MHz have been proposed for this purpose. Despite significant progress in system architecture, signal processing and automatic target recognition algorithms, the initial optimism in foliage-covered target detection has not yet led to the development of an operational system that satisfies the required false alarm rate and the probability of detection. These difficulties arise from the false alarms generated by tree trunk-ground interactions that may produce backscatter levels comparable to the hard targets in the scene. Besides, VHF-UHF ultra-wideband systems require large and non-dispersive antennas capable of operating over multi-octave frequency bands and there are always the issue of interference with TV, radio, and other wireless services that degrades the backscatter signal integrity.

Having recognized the aforementioned challenges and difficulties associated with the existing foliage penetrating side-looking radars, we reexamined the problem and considered millimeter-wave (MMW) radars for this application. It is noted that electromagentic signals at millimeter-wave (MMW) frequency can penetrate a few layers of foliage with some finite attenuation and the fact that there are considerable number of holes through most foliage covers. Furthermore, very high resolution and far more compact radar systems can be designed at millimeter-wave frequencies that can easily be mounted on a tactical UAV. Design of a nadir looking, wideband MMW, SAR with a 1-D phased-array antenna spanning the wings of the UAV and capable of scanning in cross-track direction is conceived. With such system a 3-D radar map of the terrain under the flight path can be produced. Isolating the radar returns of a hard targehut from those of vegetation, a 3-D high resolution height profile of the target can be obtained. To demonstrate the feasibility of this approach, extensive foliage penetration experiments at Ka- and W-band were conducted over two well-characterized sites. Backscatter measurements over rectangular regions with a spatial resolution of about 1 m were conducted with and without vehicles throughout the growing season using a boom truck. Foliage attenuation measurements were also carried out using an array of trihedrals. An algorithm is developed that classifies the radar return and isolates the radar return from hard targets. This algorithm is applied to the measured data and the feasibility of foliage-covered target detection and identification at millimeter-wave frequencies is demonstrated.