OVERVIEW OF THE HDL IMPULSE SYNTHETIC APERTURE RADAR

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Historically, the relative bandwidth of radars has been sufficiently small that a target's echo is adequately modeled by a single number, σ, the Radar Cross Section (RCS) – usually given in square meters. As a corollary, historically, radar systems have not measured target ringing. In the ultra-wide bandwidth (UWB) case where $.5 < \Delta F/F_0 < 2$, however, a single number does not adequately describe a target's RCS. First, σ is a function of frequency. The well known plot of the RCS of a sphere showing Rayleigh, resonant, and optical regions is an example. Second, in addition to the magnitude characteristic plotted, there is also a phase characteristic. These two frequency-domain characteristics can also be represented as a time domain signature containing a ringing or resonant response. In either case – time domain or frequency domain – the plots can be referred to as the impulse response of the target.

The process of obtaining images of the reflectivity or density of target areas that are rotating and translating with respect to a sensor such as a monostatic or bistatic radar, a sonar, or an x-ray CAT scanner has been studied for the past 40 years. Dale A. Ausherman , Adam Kozma, Jack L. Walker, Harrison M. Jones, and Enrico C. Poggio ("Developments in Radar Imaging" IEEE Trans. Aerosp. Electron. Syst. AES-20, No.5, pp. 363-400: Jul. 1984) give an excellent review of the work done in this area. Until now, however, implementation and study of image formation processing has been limited to isotropic point scatterers. Most radar targets, however, are anisotropic, resonant, and dispersive scatterers. Treatment of these cases becomes important when the sensor spectrum covers the Rayleigh, resonant, and optical regions of a family of targets. For example, discrimination between scatterers can be based on the unique signature of each target - but only if the information in the signature is preserved in the image formation process. Inclusion of anisotropic features become even more important when the aperture covers large angles.

This paper describes an impulse radar built on a railroad track on top of the main building at the U. S. Army's Harry Diamond Laboratories facility in Adelphi Maryland. The radar operates over a Ultra-Wide Bandwidth (UWB) of 50-1000 MHz and is fully polarimetric. Coherence is maintained across the aperture by a coherent-on-receive system. The pulse repetition interval (PRI) is jittered by a code with a spike autocorrolation. A 384 foot railroad track is used to collect data over a synthetic aperture. The radar includes a 480 MFLOP array processor that is used to do pulse-to-pulse interference filtering followed by a backprojection focusing algorithm. Since the bandwidth of the radar is greater than that of real targets, both the range resolution and azimuthal resolution are a constrained by the target scattering characteristics rather than the radar. Azimuthal resolution is further degraded since the target RCS is not constant for all positions on the synthetic aperture. The backprojection algorithm works in the time domain. It is modified to preserve natural resonance energy reflected by targets. Measurements to be carried out by the radar include clutter backscatter, foliage penetration loss, foliage penetration group delay, signatures of dispersive targets in the presence of clutter, and signatures of anisotropic targets in clutter.