THE ALLTEM SYSTEM

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The ALLTEM system is an advanced multi-axis time-domain electromagnetic (TEM) induction system for detection and discrimination of unexploded ordnance (UXO). Design, construction and testing of the ALLTEM prototype have been supported by SERDP under Project MM-1328. ALLTEM has three orthogonal transmitting coils and an array of receiving induction coils as do some other TEM systems. ALLTEM differs from other multi-axis TEM systems in that it uses a continuous triangle-wave excitation. Mathematically, this is equivalent to measuring target step response rather than the more common impulse response. There are two resulting practical advantages. First, responses from ferrous and non-ferrous metal objects are of opposite polarities, providing a distinctive visual cue in the real-time waveform display that is clear to even an untrained operator. Second, at late times, the response for ferrous objects approaches a non-zero constant, rather than decaying toward zero. This improves late-time signal-to-noise ratio (SNR) -- an advantage for both detection and data inversion for target-identifying orthogonal polarizabilities. In May 2006, the U.S. Geological Survey operated ALLTEM with a Leica 1200 GPS over the Army’s UXO Calibration Grid and Blind Test Grid at the Yuma Proving Ground (YPG), Arizona. ALLTEM multiplexes through all three orthogonal (Hx, Hy, and Hz axes) transmitting loops and records a total of 19 different transmitting and receiving loop combinations while in motion. Data are recorded at a constant 100 kilosamples/s rate with 24-bit precision. Filtering and processing remove almost all ground response and system drift effects from the data. The SNR improvements enhance detection of small or deep targets and inversion for target parameters. Our physics-based inversion algorithm was applied to YPG data with good results. Position errors from GPS and cart roll, pitch, and yaw were usually small enough that inversions provided good estimates of target position, depth, and orientation, and reproducible values for dipole polarizability moments of these targets, even though the system was moving. Thus it appears possible to obtain good multi-axis system target inversions and identifications from moving platform data even with some position “noise.” A test stand with an automated positioning system has been developed and used to obtain high spatial density data over a number of UXO and clutter items. These new data have allowed us to further assess effects of spatial data density, position error, and sensor noise on target parameter calculations produced by the inversion algorithm.

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