ALLTEMP UXO DETECTION SENSITIVITY AND INVERSIONS FOR TARGET PARAMETERS FROM YUMA PROVING GROUND AND TEST STAND DATA

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An advanced multi-axis electromagnetic induction system, ALLTEMP, has been specifically designed for detection and discrimination of unexploded ordnance (UXO) with funding from SERDP Project MM-1328. ALLTEMP uses a continuous triangle-wave excitation that measures the target step response rather than the more common impulse response. An advantage of using a triangle-wave excitation is that the responses of ferrous and non-ferrous metal objects have opposite polarities. In May 2006, the U.S. Geological Survey operated ALLTEMP with a Leica 1200 GPS over the Army’s UXO Calibration Grid and Blind Test Grid at the Yuma Proving Ground, Arizona. The system multiplexes through all three orthogonal (H_x, H_y, and H_z axes) transmitting loops and records a total of 19 different transmitting (Tx) and receiving (Rx) loop combinations. The ALLTEM system was in continuous motion with a spatial data sampling interval of 15 cm to 20 cm. ALLTEM records data at a constant 100 kilosamples/s rate with 24-bit precision. The high-density time-series data are then digitally filtered. Using an early-time pick of 275 μs, late enough that the step response of an analog low-pass filter has settled, amplitude difference data and maps are produced. These data are almost free of ground response and system drift effects while retaining good sensitivity to UXO. The improvement in the signal-to-noise ratio greatly enhances the ability to detect small or deep targets. An inversion algorithm has been developed and applied to data from various sets of the available 19 Tx-Rx combinations over a number of targets. The algorithm is part of a processing and inversion package called GP Workbench and uses a physics-based non-linear inversion method. GPS position errors and additional errors from cart roll, pitch, and yaw were often small enough that the inversions provided good estimates of target position, depth, and orientation, and reasonable and reproducible values for dipole moments of these targets, even though the system was moving. This suggests that it is possible to obtain good multi-axis system target inversions 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 inert ordnance and clutter items. These data have allowed us to assess effects of spatial data density, position error, and sensor noise on target parameter estimates produced by the inversion algorithm.