WIDE AREA ASSESSMENT – DEVELOPMENT AND CASE STUDY

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1. INTRODUCTION

Munitions response is a high priority issue for the Department of Defense (DOD). Over 3,600 munitions response sites (MRS) are in DOD's inventory of sites with potential military munitions and explosives of concern (MEC) contamination, including unexploded ordnance (UXO) and discarded military munitions (DMM) [1]. Because many of these sites are large in size (greater than 10,000 acres), the investigation and remediation of these sites could cost billions of dollars [2]. To address this issue, a wide area assessment (WAA) process was developed to quickly and cost effectively assess 100% of a site to reduce the footprint to only those areas with known MEC contamination (i.e. MRS). In this paper, we present a discussion of the origins of the WAA concept, a case study of its first large scale application, and descriptions of the component technologies.

2. BACKGROUND

The first large-scale WAA program was implemented at the Former Lowry Bombing and Gunnery Range (FLBGR), CO from 1999 through 2002, in response to a legal Settlement Agreement between the State of Colorado and the Department of Justice. The concept was initially developed in 1998 by the U.S. Army Corps of Engineers (USACE), Omaha District together with the Colorado Department of Public Health and Environment and Sky Research, Inc. (SKY), with the objective being to reduce the footprint of the 59,000-acre site [3]. The following remote sensors were used: 1) synthetic aperture radar (SAR); 2) hyperspectral imagery (HSI) 3) Light Detection and Ranging (LiDAR); and 4) high-resolution color orthophotography. Extensive collaboration and field verification efforts were performed by the entire project team throughout the WAA development process. Upon completion of the WAA efforts at FLBGR, it was determined that the combined use of orthophotography and LiDAR, both off-the-shelf technologies, was the most cost-efficient for widespread use [4].

From 2002 through 2005, the USACE, Omaha District and SKY collected orthophotography and LiDAR data over 362,000 acres at six sites of varying terrain, size, and locations for WAA analysis. In 2005, the USACE, Omaha District began implementing WAA across the country under the Air Force Military Munitions Response Program (AF MMRP) with its contractor SKY, with orthophotography and LiDAR data collected to date on nearly 600,000 acres nationwide on 13 sites. The WAA efforts have been ground-truthed at a number of installations, including heavily-vegetated mountainous areas, heavy pine forests and open high desert environments.

The WAA process that emerged from this initial development was a practical, reliable and cost-effective method of facility assessment with respect to MEC contamination that supports defensible site definition. Equally important, the WAA process also defines regions of the affected facility which are “presumptively clean”, a term that denotes the absence of substantial MEC and which expedites the transition of resources to safe re-use. This site delineation process and related footprint reduction is a critical aspect of WAA and used to support the optimized clearance of a site and makes possible defensible prioritization of cleanup objectives and financial management of long-term cleanup activities.

3. TECHNOLOGY IMPLEMENTATION

WAA utilizes multiple technologies used in a logical progression to complete a “fence-to-fence” characterization of a facility. Deployed via a fixed-wing aircraft, WAA employs remote sensing techniques to detect and identify munitions-related surface features that indicate the presence of MEC / UXO or direct physical evidence of prior munitions-related military activities such as training or disposal. Identified munitions related features are field verified and, along with historical records review data, used to establish an accurate conceptual site model (CSM).

3.1 Wide Area Assessment Technology Components

WAA uses remote sensing techniques including LiDAR, orthophotography, SAR, and HSI for detection of various classes of munitions related features (Table 1). Geographic information systems (GIS) technology is used for historical information review, data management, data integration and communicating results / reporting.

Table 1. WAA Technology Components

Sensor Application	Sensor
Identify topographic features (i.e. craters/berms and target delineation features)	LiDAR
Identify man-made features – military munitions related (i.e. access range roads, berms, remnants of bombing targets, and other target delineation features)	Orthophotography
Discriminate LiDAR features and identify manmade features - unrelated to military munitions activity (i.e. roads, furrows, tree blow down, and structures)	Orthophotography
Detect surface metal debris	SAR
Discriminate surface non-metallic objects	HSI

3.1.1. LiDAR

The LiDAR data collection system – comprised of an Optech ALTM 3100 laser scanner, global positioning system (GPS), and inertial measurement unit (IMU) – produces precise high-resolution topographic data. Collected at a nominal altitude of 1000 m above ground level (AGL), the LiDAR sensor produces spot spacings between 20 – 75 cm with a vertical accuracy of better than 15 cm and horizontal accuracy of 33 cm. Data from this multi-return, 100 KHz laser-scanning sensor are processed to generate digital models of the ground and vegetation surfaces. For this WAA application bare earth models are used to identify munitions related features.

Figure 1 shows LiDAR data and identified craters from heavily-vegetated New Boston Air Force Station, New Hampshire.

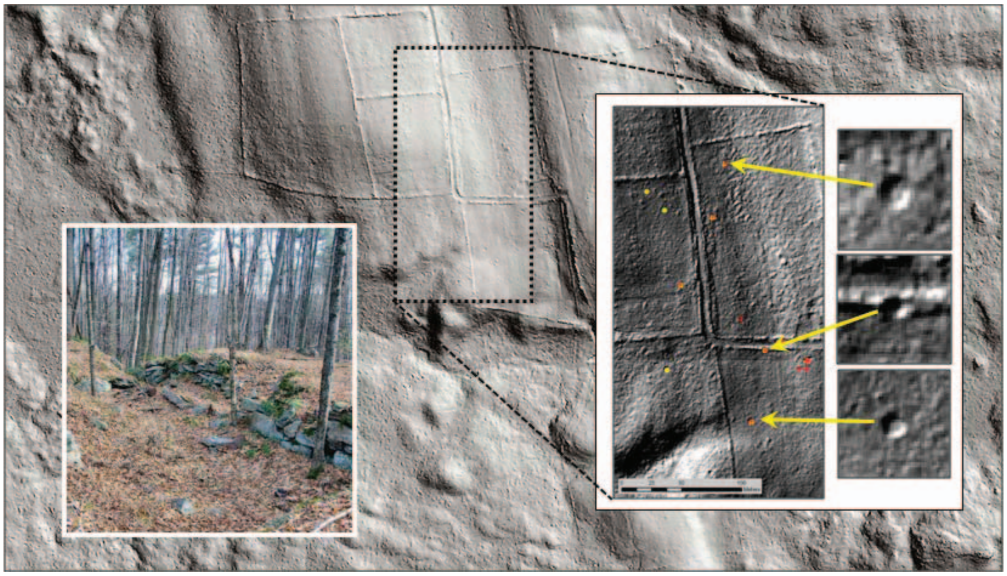

Figure 1. LiDAR is used to produce vegetation and bare earth terrain models to identify munitions related features. Inset-right shows verified craters from prior military training activity.

3.1.2.Orthophotography

High-resolution digital photographs are co-collected with the LIDAR data using an Optech ALTM 4K02 digital metric camera with high-resolution Charged Couple Device (CCD) backing mounted in the aircraft. This system works as follows: the CCD converts light into electrons, which are enumerated and converted into a digital value. The ability of a CCD to accurately measure and convert the value of electrons into digital format is the measure of quality. As a small format system, the ALTM4K02 camera used for data collection offers a 36° field of view minimizing layback distortion at the edges of images which allows for minimal image distortion during the orthorectification phase of processing. Collected at 1000 m AGL, the resolution (ground sample distance) of Sky Research orthophotography is better than 17 cm. From this altitude, horizontal accuracy of photo data is between 5 and 30 cm root mean square error (RMSE). Figure 2 shows orthophotography data with munitions related man-made features.

Figure 2. Digital orthophotography supports WAA through direct identification of munitions related features and verification of LiDAR features.

3.1.3. Other Sensors Used in WAA

SAR and HSI technologies are also useful in the execution of WAA projects. While these methods are still under development for munitions characterization applications, both have been tested by USACE, Omaha District and shown to be effective [3, 4]. SKY operates a UHF 220-470 MHz band SAR which allows foliage penetration and modest (~10 cm) ground penetration. Tested extensively for both UXO and improvised explosive device (IED) detection, this technology can reliably detect surface and shallow-buried UXO and related MEC with long-axis dimension greater than 30 cm [5]. The HSI system used for WAA was the HyVista HyMap which offered the best available combination of spectral and spatial resolution, signal to noise ratio (SNR), and geospatial accuracy necessary to achieve initial objectives [6]. The HyMap is an airborne hyperspectral sensor that measures the electromagnetic spectrum from 0.45 micrometer (µm) to 2.5 µm in 126 separate but contiguous bands that have variable widths (from 15 nanometers [nm] in the visible wavelengths to 17 nm in the short-wave infrared [SWIR] wavelengths).

4. CONCLUSIONS

Through a government collaboration with industry a robust and reliable WAA process has been developed, thoroughly tested and transitioned into wide use to support the assessment of DOD military facilities affected by military munitions. The WAA process provides defensible fence-to-fence characterization across many geographic site conditions utilizing an integrated suite of remote sensing tools. The WAA process is cost effective and supports several subsequent steps in the MEC clean-up process to optimize the use of geophysical techniques deployed via helicopter or ground based UXO detection systems. Based on the success at FLBGR and through the extensive subsequent refinement by USACE, Omaha District, WAA is now a robust, flexible and reliable model for assessment of large military munitions response sites.

5. REFERENCES

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