Demonstration of Wide Area Assessment Technologies to Characterize Munitions Density

Closed Castner Firing Range
Fort Bliss, TX

Technical Project Planning Meeting 3
16 June 2010
Agenda

- Review project objectives
- Helicopter-borne Magnetometry Results
- Ground-based Geophysics Results
- Data Overlays
- Intrusive Investigation
- Explosives Site Plan
- Schedule Update & Questions
- Introduction to Incremental Sampling
- Questions & Wrap-Up
Project Objectives
• Millions of acres of closed ranges in MMRP site inventory
• Many acres do not contain UXO
• Need methods to cost effectively:
  – Focus characterization efforts on areas used for munitions related activities
  – Eliminate areas with no indication of munitions use
Full Coverage: “Mag and Flag”
Project Purpose

• Field test the WAA methods and conclusions included in the *Wide Area Assessment Cost-Benefit Analysis: Active Army Military Munitions Response Program* (USAEC 2009)

• Collect site characterization data using a variety of WAA methods in a manner to ensure usable data for subsequent MMRP investigations (i.e., RI/FS)
Objective

Demonstrate non-traditional technology applications for detecting munitions on Army property

• Determine areas with evidence of past military munitions use
• Determine relative density of anomalies across these areas
• Determine areas with minimal evidence of past military munitions use
What is not included…

- Remedial Investigation
- Decisions about future land use
- Decisions about transferring the property
- Decisions about developing the property
- Decisions about mapping individual ordnance items
- Decisions about cleaning-up all the munitions
What is included...

- Collecting data about the distribution and density of munitions on Closed Castner Range
- Demonstrating costs and benefits of applying proven technologies in innovative ways
Project Scope

- Site Reconnaissance
- Lidar & Orthophotography
- Site Prep
  - Survey
  - Run VSP
  - Mark Transects
  - Install IVS
- Helicopter-borne Magnetometry
- Ground-based Geophysics (towed array & man-portable EMI)
- Analog Data Collection
- Intrusive Investigation
- Project Reports
  - WAA Field Demonstration Report for Castner Range
  - Revised WAA Cost-Benefit Analysis: Active Army MMRP
  - WAA Cost Estimating Equations

Complete. Results discussed at TPP 2.

Complete. Results discussed today.

Yet to do.
Helicopter-borne Magnetometry
Helicopter-Borne Magnetometry

- Objective: Map relative densities of ferrous metals
- Fly 1-3m above ground surface
- 7 sensors spaced 1.5m apart; provide swath width of approx 9m
- Flight lines 7m apart provide for 2m overlap
- 100% coverage of survey area (approx 1,577 acres; < 5% slope)
- Approx 300 - 500 acres/day
- 11 - 14 January 2010
Helicopter-Borne Magnetometry: Preliminary Results

- Production rate higher than expected; flew 500-700 acres/day
- Site conditions limited utility of helicopter-borne magnetometry
  - Magnetic geology more extensive than expected (created noise)
  - Vegetation more problematic than terrain (high altitude, low pd)
- Data do not support conclusions about density and distribution of ferrous material at the site
Detection is a function of target size, altitude, and background noise.
Altitude Performance

Helimag Ft Bliss 2010 - Altitude Performance

Altitude (m agl)

Mean 2.9 m

Mean 3.1 m
What did we see?

Full Magnetic Field

Geology Filtered Magnetic Field

Analytical Magnetic Signal
Helicopter-Borne Mag Anomaly Density
What are we detecting?

Dipoles

- Not necessarily munitions
- Positive and negative magnetic fields associated with a ferrous object (like + and – poles of a magnet)
- Have distinguishing characteristics:
  - Size
  - Depth
  - Orientation
...but which are UXO?

Dipoles associated with MEC tend to be:

- Small (<5 Am²),
- Shallow (<1m depth), and/or
- Low magnetic remanence (dipole angle <60 degrees)
Anomaly Distribution: Depth, Size, and Orientation
Areas of Interest
Helicopter-Borne Mag Study Questions

• Can helicopter-borne magnetometry reliably detect each of the munitions types expected on the MRS (i.e., 37mm projectile, 2.36in rockets, 60mm mortar, 75mm projectile)?
• Can helicopter-borne magnetometry:
  – Reliably identify areas of concentrated munitions use?
  – Reliably identify areas with no indication of munitions use?
  – Improve the understanding of relative densities and distributions of MEC across the MRS?
• How confident are stakeholders in these conclusions?
• Does helicopter-borne magnetometry data make subsequent characterization steps (i.e., ground-based geophysics) more cost effective?
• Over what percentage of the MRS can we collect helicopter-borne magnetometry data?
• For what percentage of the MRS are we able to draw statistically valid conclusions based on helicopter-borne magnetometry data?
• What are the total cost, cost per characterized acre, and cost per surveyed acre associated with helicopter-borne magnetometry?

Recommend greater efforts on site recon and selective application.
Ground-based Geophysics
Ground-Based Geophysics

- Man-portable (litter) EMI array with transect-based coverage
- Estimated characterized acreage is 4,020
- Approximately 1 million linear feet of transects
- Performers: NAEVA Geophysics and Sky Research
- 27 Jan – 18 Feb 2010
• Able to characterize nearly all terrain up to 18% slope
• Production rates higher than anticipated
• Litter mode increases levels of uncertainty/error in DGM data
• Reproducibility of transect data is surprisingly good
Summary Statistics

- Collected data over >1 million linear feet (>200 miles) of transects
- Transect spacing approximately 57m apart
- Identified and georeferenced approximately 21,000 anomalies
Sample Instrument Verification Strip (IVS) Results
Instrument Response and Anomalies
Sample Transect Repeatability Data
Anomaly Densities: Variable mV Threshold
Man-Portable EMI Study Questions

• Can man-portable EMI arrays reliably detect each of the munitions types expected on the MRS (i.e., 37mm projectile, 2.36in rockets, 60mm mortar, 75mm projectile)?

• Can man-portable EMI arrays:
  – Reliably identify areas of concentrated munitions use?
  – Reliably identify areas with no indication of munitions use?
  – Improve the understanding of relative densities and distributions of MEC across the MRS?

• How confident are stakeholders in these conclusions, particularly based on the transect survey approach?

• Over what percentage of the MRS can we collect man-portable EMI array data?

• For what percentage of the MRS are we able to draw statistically valid conclusions based on man-portable EMI array data?

• What are the total cost, cost per characterized acre, and cost per surveyed acre associated with man-portable EMI array?
Analog MEC Reconnaissance
Analog MEC Reconnaissance

• Based on USACE, Huntsville Center, Programmatic Work Plan for MEC Reconnaissance Surveys
• Use hand-held EMI sensors (MineLab 2) and GPS/PDAs to map anomalies
• Acquire data in areas inaccessible by DGM teams due to terrain:
  – In the arroyos, to test hypothesis that relative anomaly densities are higher inside the arroyos than across the remainder of the site
  – Along the unofficial hiking trails within the mountainous terrain of the site
  – Collected data along approx 22 miles of terrain
Course of Analog Data Collection
Surface and Subsurface Anomaly Densities
Data Overlays
Weight of Evidence

• Individually, data layers can be compelling
• Used together, multiple data layers corroborate, refute, expand on conclusions and increase level of confidence.

• Overlays:
  – Historical data
  – Recon/observational data
  – Optical sensor (lidar) data
  – Geophysical sensor data
Historical Range Fans and LIDAR Areas of Interest
Historical Range Fans and DGM Density Data
1994 Surface Investigation Areas and LIDAR AOI
1994 Surface Investigation Areas and DGM Density Data
2004 Surface and Subsurface Clearance and DGM Density Data

= munitions
Historical Range Fans, LIDAR AOI, and DGM Density Data
Proposed Target Area Delineation
Intrusive Investigation
(Future Work)
Intrusive Investigation

- Verify target and non-target areas:
  - Target areas:
    - Develop hypotheses about density of HE frag and MEC items per acre (e.g., \( \geq 50 \) pieces per acre)
    - Test hypotheses through intrusive investigation of detected anomalies on transects to confirm areas as targets (to 90% confidence level)
  - Non-target areas:
    - Develop hypotheses about MEC densities (e.g., less than or equal to 0.5 MEC items per acre)
    - Test hypotheses through intrusive investigation detected anomalies on transects to confirm non-target areas (90% confidence level)
- Characterize nature and extent of anomalies within target areas
  - Size
  - Nomenclature
  - Condition
  - Depth
  - Orientation
  - Coordinates
  - Photographs
Notional Sampling Areas for Intrusive Investigation
Coordination and Consultation

• Coordinate dig locations with Fort Bliss natural and cultural resources staff to minimize disturbance of sensitive areas
• Conduct Section 106 consultation through Fort Bliss programmatic agreement with continued consultation with the Tribes
Intrusive Procedures

- UXO Tech teams pinpoint anomaly locations using handheld EMI
- Use hand-tools to excavate all anomalies in sampling area
- Classify items
  - MEC
  - Munitions debris
  - Range related debris
  - Cultural debris
- Record data about each item
Explosives Site Plan (ESP)
Overview of ESP

• Prepared in accordance with:
  – DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards
  – EM 385-1-97, Explosives Safety and Health Requirements Manual

• Describes how explosives, including recovered MEC and MPPEH, will be safely managed during the project
  – Management of commercial explosives
  – Methods of MEC disposal/destruction

• Prescribes safety criteria including minimum separation distances and quantity distance arcs
Commercial Explosives

- Jet perforators. Total NEW = 4.4 lbs
- 50-grains/foot detonation cord. Total NEW = 10 lbs
- Electric blasting caps. (To ensure proper compatibility and separation, stored in integral cap box mounted on side of magazine.)
Options for explosives storage:

- Fort Bliss ASP
  - Very secure
  - 45 minutes away
  - Transport over public highways
  - Competing with military units for time

- Sited Type 2 BATF Magazine
  - On-site
  - Exclusive use
  - Safe and secure
Explosives Siting Requirements

• Quantity-distance arcs (separation based on NEW and HD) between storage and:
  – Operations
  – Buildings and roads
  – Other “exposed sites”
• Compatibility of storage
• Access control
  – Fencing
  – Locks
• Lightning protection / grounding
Quantity Distance Safety Arc Around Explosives Storage

601 feet
### Minimum Separation Distances

<table>
<thead>
<tr>
<th>Area</th>
<th>MEC²</th>
<th>MSDs (feet)¹</th>
<th>For Unintentional Detonations</th>
<th>For Intentional Detonations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Team Separation Distance (K40)</td>
<td>Without Engineering Controls (MFD-H)</td>
</tr>
<tr>
<td>Closed Castner Firing Range MRS (FTBLS-004-R-01)</td>
<td>155mm Mk I &amp; Mk III HE projectile</td>
<td>122 ³</td>
<td>447 ⁴</td>
<td>2842</td>
</tr>
</tbody>
</table>

¹ For Unintentional Detonations and For Intentional Detonations.
Maximum Fragmentation Distance and Hazardous Fragmentation Distance
Disposal Operations

• MEC will be detonated in place. Exceptions:
  – Movement necessary for the efficiency of operations or the protection of people, property, or critical assets
  – Risk associated with movement is acceptable
  – SUXOS and UXOSO must agree with the risk determination

• If occupied buildings or roadways are within the MFD-H, implement one of the following:
  – Implement engineering controls to reduce the MSD in accordance with HNC-ED-CS-S-98-7, August 1998, Use of Sandbags for Mitigation of Fragmentation and Blast Effects Due to Intentional Detonation of Munitions
  – If acceptable to move, relocate beyond the MFD-H from occupied buildings or roadways
  – Coordinate with Fort Bliss to evacuate any occupied buildings or block public roadways during MEC disposal operations

• Perforate MEC using commercial jet perforator charges in accordance with Explosive Site Plan (ESP)
Project Schedule
Project Schedule

• September 2010 – February 2011: Anomaly identification and intrusive investigation
• February – May 2011: WAA Report writing
Questions?
Introduction to Incremental Sampling
What are we doing?

• Field testing the U.S. Army Incremental Sampling Guidance

• Attempting to characterize nature and extent of MC on Castner Range
  – 7,007 acres
  – Variety of uses, terrains, potential for exposure
Munitions Constituents (MC)

In addition to UXO/MEC

- Energetics (examples):
  - Nitramines (RDX)
  - Nitroaromatics (TNT)
  - Nitrate Esters (NG)

- Metals (examples):
  - Lead
  - Chromium
  - Antimony
  - Zinc
  - Copper
The Problem: Heterogeneous Chunks (Chips)

- Heterogeneous:
  - Put 10 chips into a cookie recipe
  - Bake 100 cookies
  - Majority of cookies (samples) will have zero chips (underestimating chocolate concentration)

- Homogeneous:
  - Try it again but, this time, grind and blend the dough until the chocolate is evenly distributed throughout
  - Every cookie (sample) will have a representative amount of chocolate (makes really bad cookies though)
Heterogeneity of Explosives in Soils

14 Samples from a 4 ft circle:

- Range from 136 – 42,800 ug/kg
- Mean = 14,900 ug/kg
- Median = 1,220
- Relative Standard Deviation = 120%
- 1.2% of area sampled
Explosives/Propellant Residue Particles

- Fiber from 105-mm Howitzer: Fiber contained 24 μg 2,4-DNT
- 81-mm Low Order Detonation: Comp B (60% RDX / 39% TNT)
- 155-mm Howitzer Round: TNT
- M-16 Small Arms: NG

Courtesy of Alan Hewitt, USACE CRREL
Most of surface area uncontaminated (>95%)

Most contamination in chunks localized around “low order” (partial) detonations (distributional heterogeneity)

Most MC in top inch of soil on training ranges (deeper at demolition ranges)
Proposed Solution: Incremental Sampling Design

Discreet Sampling

VS.

Incremental Sampling

Sample collection point for 100 discrete samples

Path of travel

Increment collection point for two separate MI samples
Soil Sampling Methods

- Shallow surface soils
- Uniform sample depth
- Uniform sample size
- Quick and easy to take a lot of sample increments (remember 100 increments per sample)
EPA Method 8330

• High performance liquid chromatographic (HPLC)
• Detection of ppb levels of certain explosives residues in water, soil and sediment
• Prior to use, appropriate sample preparation techniques must be used.
Sample Processing (8330B)

1. Stratify range area
2. Incremental sampling design
3. Whole sample dried
4. Whole sample sieved
5. Whole sample pulverized
6. Subsampling
Proposed study questions:

• What is the effect of sampling unit size on IS concentrations?
• What is the effect of erosion vs. deposition on MC concentrations?
• What is the correlation between MEC and MD density on MC concentrations?
Potential Sampling Approach

- Establish multiple Areas of Interest (AOIs) based on WAA
- Characterize nature & extent in each AOI
- Distribute sampling units within each AOI
- Vary sampling unit size
- Bias locations to evaluate potential MC migration
- Assume approximately 200 sampling units dispersed across the site
- Take 60 discreet samples in AOIs and compare results to incremental samples
Discussion

• TPP members thoughts on:
  – Incremental sampling
  – Demonstration at Castner Range
  – Study questions
  – Approach
  – Levels and means of participation in process

• Further coordination with TCEQ to evaluate applicability under Texas Risk Reduction Program
Future TPP Meetings

- **October 2010**: Discuss target delineation and approach for intrusive investigation
- **February 2011**: Discuss findings from intrusive investigation
- **June 2011**: Discuss project results, stakeholder confidence in results, and WAA costs/benefits
Adjourn
Backup Slides: Lidar
Lidar & Orthophotography

- Lidar at 20 points/m²
- Analyzing two data sets
  - 20 points/m²
  - 5 points/m²
- Orthophotography at 10cm pixels
- Data acquired October 2009

Crater and Fighting Positions
Lidar Surface Model of the Site
Hole Groups 2
Hole Groups 3
Hole Groups 5
Lidar & Orthophotography

Study Questions

• To what degree do lidar/ortho detect surface features indicative of munitions related activities?
  – Craters/Crater Fields
  – Target Features
  – Berms
  – Demolition Pits
  – Burial Pits

• Do lidar/ortho images provide sufficient evidence to:
  – Reliably identify areas of concentrated munitions use?
  – Reliably identify areas with no indication of munitions use?
  – Improve the understanding of relative densities and distributions of MEC across the MRS?

• How confident are stakeholders in these conclusions?

• To what degree do lidar/ortho data make subsequent characterization steps (e.g., helicopter-borne magnetometry) more cost effective?

• What are the total cost, cost per characterized acre, and cost per surveyed acre associated with lidar/orthophotography?
Backup Slides: Site Prep
“Transect Spacing to Ensure High Confidence (95%) of Traversal and Detection of Target Areas”

Evaluated transect spacing for most likely munitions items:
- 37mm projectiles
- 60mm mortars
- 75mm projectiles
- 2.36-in rockets

Used combination of:
- Munitions firing table data (range and deflection probable errors) from Army field manuals
- Hazardous fragmentation distances from DDESB fragmentation database

2.36 inch rocket is the munitions item with the smallest estimated transect spacing at 57m
Establish Transects

- Used VSP output (57m) transect spacing
- Plotted on areas of <18% slope (safety/accessibility)
- Marking nearly 1 million linear feet of transect for ground-based geophysics
Geophysical System Verification

• **Purpose**
  – Demonstrate the geophysical system is meeting typical and acceptable detection performance
  – Evaluate the project team’s data collection and data transfer methods
  – Establish site-specific signal-to-noise ratios for selection criteria

• For ground-based and helicopter-borne systems

• Using specifications contained in “Geophysical System Verification (GSV): A Physics-Based Alternative to Geophysical Prove Outs” (ESTCP 2009)

• Includes:
  – Instrument verification strip (IVS)
  – Blind seed items in the production area
Instrument Verification Strip (IVS)

- A line of seed items of known size, shape, orientation, depth, and location
- Run geophysical equipment over the IVS before and after each data collection day to verify instrument performance
- Use “industry standard objects” (ISOs) with known signal responses for common instruments (e.g., EM61)
Industry Standard Objects (ISOs)

- Readily available, similar in size and shape to common munitions items
- Documented response curves
- Repeatable, consistent EM signals for calibration and performance validation

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal Pipe Size</th>
<th>Outside Diameter</th>
<th>Length</th>
<th>Part Number1</th>
<th>ASTM Specification</th>
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<td>1&quot;</td>
<td>1.315&quot; (33 mm)</td>
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<td>A53/A773</td>
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<td>8&quot;</td>
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<td>A53/A773</td>
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<tr>
<td>Large ISO</td>
<td>4&quot;</td>
<td>4.500&quot; (115 mm)</td>
<td>12&quot;</td>
<td>44615K137</td>
<td>A53/A773</td>
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1. Part number from the McMaster-Carr catalog.
Ground-based IVS

EM61 Signal Response for Seed Items in IVS

<table>
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<th>ISO Size</th>
<th>Position (m)</th>
<th>Depth (in.)</th>
<th>Orientation (relative to instrument path)</th>
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<tr>
<td>Small</td>
<td>2.5</td>
<td>3</td>
<td>Horizontal along path</td>
</tr>
<tr>
<td>Small</td>
<td>7.5</td>
<td>7</td>
<td>Horizontal along path</td>
</tr>
<tr>
<td>Small</td>
<td>12.5</td>
<td>3</td>
<td>Horizontal across path</td>
</tr>
<tr>
<td>Small</td>
<td>17.5</td>
<td>7</td>
<td>Horizontal across path</td>
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Airborne IVS

<table>
<thead>
<tr>
<th>Item/ Size</th>
<th>Orientation (relative to instrument path)</th>
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<tbody>
<tr>
<td>2.75-in. rocket (inert)</td>
<td>Horizontal along path</td>
</tr>
<tr>
<td>155mm projectile (inert)</td>
<td>Horizontal along path</td>
</tr>
<tr>
<td>155mm projectile (inert)</td>
<td>Horizontal across path</td>
</tr>
<tr>
<td>100-lb. bomb (inert)</td>
<td>Horizontal across path</td>
</tr>
<tr>
<td>ISO Large</td>
<td>Horizontal along path</td>
</tr>
<tr>
<td>ISO Medium</td>
<td>Horizontal along path</td>
</tr>
<tr>
<td>ISO Small</td>
<td>Horizontal along path</td>
</tr>
</tbody>
</table>
Blind Seeds

- Blind seeds evaluate adequacy of coverage, signal levels/instrument response, data processing, and positional accuracy
- 90 seed placements using 93 seed items:
  - 31 small ISO
  - 31 medium ISOs
  - 31 large ISOs
- 3 of the placements will contain two ISOs
Delineate Target Areas and Non-Target Areas

• Delineate boundaries of target areas through analysis of anomaly densities using VSP (90% confidence level)

• Target areas:
  – Develop hypotheses of MD densities (e.g., at least 100 pieces of MD/acre)
  – Test hypotheses through intrusive investigation of 20’x20’ grids to confirm munitions target areas (90% confidence level)

• Non-target areas:
  – Develop hypotheses of MEC densities (e.g., less than or equal to 0.25 MEC items per acre)
  – Test hypotheses through intrusive investigation of 20’x20’ grids to confirm non-target areas (90% confidence level)
Investigate the Nature of MEC in Target Areas

• Once the target areas have been confidently identified and delineated, reacquire and dig individual anomalies
• Focus on anomalies of high priority/high likelihood of being MEC
• Record:
  – MEC, munitions debris, range related debris, metal debris types
  – Size and type
  – Depth
  – Orientation
• Excavate anomalies
• Work scheduled September – December 2010
• Coordinate dig locations with Fort Bliss natural and cultural resources staff to minimize disturbance of sensitive areas

• Conduct Section 106 consultation through Fort Bliss programmatic agreement with continued consultation with the Tribes
Data Review & Analysis

• Review the ability of methods (i.e., lidar/ortho, helicopter-borne magnetometry, and ground-based geophysics) to answer study question
  – Did the method improve the understanding of relative densities and distributions of MEC across Castner Range?
  – Did the method reliably identify areas of past munitions use?
  – Did the method identify areas with no indication of munitions use?
  – How confident are stakeholders in the conclusions?

• Review the effectiveness of methods
  – Individually
  – In combinations (layered application)

Look for efficiencies: methods that give more bang for the buck, methods that make subsequent phases more effective, can we skip steps.
MC on Castner

- Extensive use of HE munitions
- Extensive demolition/disposal operations
- Relatively low precipitation rates
- Relatively low solubility of MC