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# Considerations for Advanced Geophysical Classification Integration on Guam

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ESTCP Project Number MR-201231

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Nashville, Tennessee

# Acknowledgements

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## **ESTCP Munitions Response Live Site Demonstration**

Andersen Air Force Base, Guam

ESTCP Project Number MR-201231



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# OVERVIEW

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- Site History
- AGC and DGM Equipment
- Survey Design
- Implementation Challenges
- Survey Results

# INTRODUCTION



- Andersen Air Force Base (20,000 acres)
- Located in Yigo (Gee-Go) on the norther end of Guam
- Primarily used as B-29 staging base during WWII
- Continues to support strategic operations in the region and serves as a staging base for activities in ASIA and the South Pacific.
- Guam is a strategic military stronghold known as the “tip of the spear”



# Guam Military History



- US territory after the Spanish-American War
- Invaded by Japanese military on December 10, 1941
- Japanese occupation of Guam lasted from 1941 to 1944
- The Battle of Guam began on July 21, 1944
- Japanese forces officially surrendered on August 10, 1944
- Heavy military activities resulted in a variety of American and Japanese war time remnants, including MEC, to be distributed throughout the island.



# Munitions Types



- MK II Hand Grenade
- 20mm Mortar
- 60mm Mortar
- 81mm Mortar
- 105mm Projectile
- 155mm Projectile
- 5-inch Projectile
- 6-inch Projectile
- 100lb bomb



# Regulatory Drivers



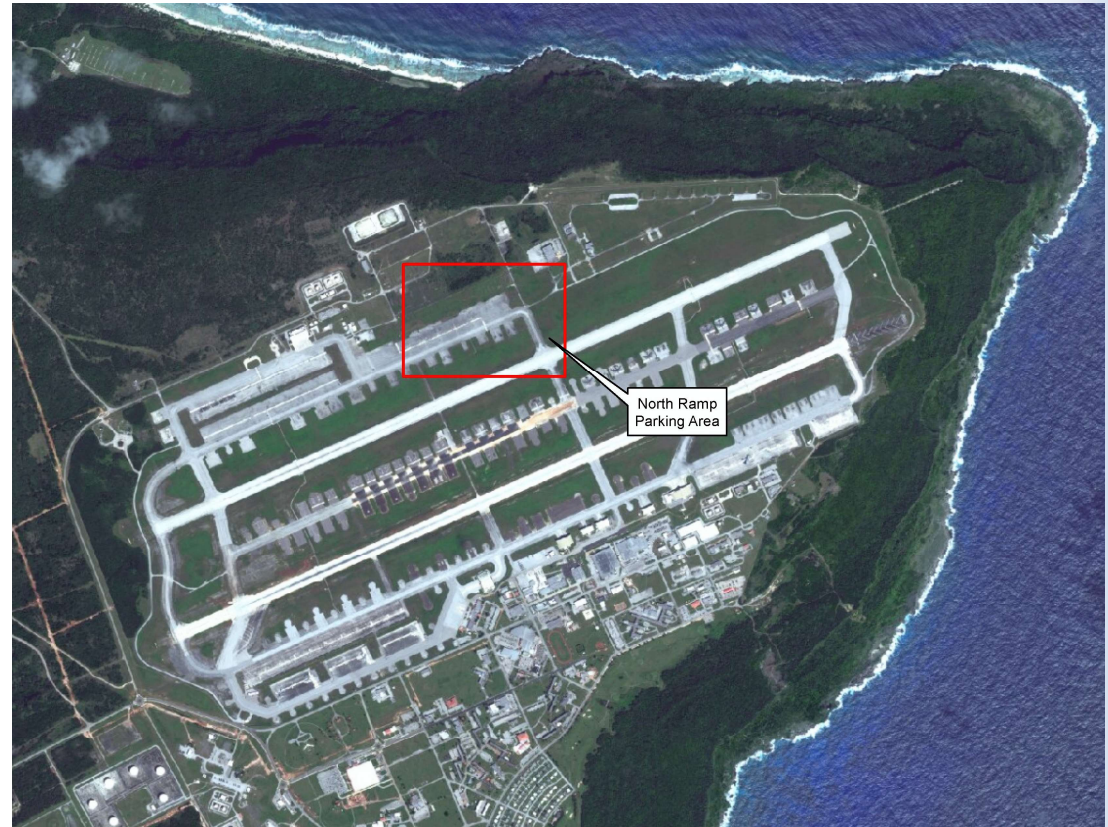
- Environmental Security Technology Certification Program (ESTCP)
- The Military Munitions Response Program (MMRP)
- Military Construction (MILCON) Program
- \$9B of future Military Construction Planned on Guam
- All items require careful excavation by trained unexploded ordnance (UXO) technicians
- Often 90% of excavated objects are non-hazardous metallic objects or geologic features
- Excavation includes expensive and disruptive safety measures (e.g. barriers, exclusion zones)
- If items could be determined with high confidence to be non-hazardous some of these expensive measures could be eliminated or non-hazardous items could be left unexcavated



# Site Selection



- North Ramp Parking (NRP) area – 3 acres
- Chosen as the first AGC demonstration in Guam
- High probability of encountering MEC
- Demonstration was integrated with previously scheduled MILCON removal action
- 80.2 inches of annual rainfall
- Average 226 days of precipitation





# Project Objectives



- Overall Objective; Validate classification technology over the NRP area at Andersen AFB
- Install Instrument Verification Strip (IVS)
- Install 36 blind seeds to support the Geophysical System Verification (GSV) plan
- Perform Dynamic detection survey using NRL TEMTADS 2X2
- Select TEMTADs targets and integrate with previously selected EM61 targets
- Perform cued target interrogation using TEMTADS 2X2 on selected targets
- Process cued geophysical data to correctly classify TOIs on site

## Performance Objectives

Performance Objective	Metric	Success Criteria
Repeatability of Instrument Verification Strip (IVS) measurements	Amplitude of EM anomaly	Down-track location $\pm 25$ cm
	Measured target locations	Library match $\geq 90\%$ using 3-criterion metric with equal weighting to the three criteria using first day's IVS inversion as the library item.
Complete coverage of the demonstration site	Footprint coverage calculated using UX-Process Footprint Coverage Quality Control (QC) tool; excludes inaccessible areas.	$\geq 85\%$ coverage at 0.50-m line spacing; and $\geq 98\%$ coverage at 0.60-m line spacing
Along-line measurement spacing	Point-to-point spacing from data set	$98\% < 25$ -cm along-line spacing
Detection of all TOI	Percent detected of TOI	100% of TOI detected within 40-cm halo of the surveyed location
Cued interrogation of anomalies	Instrument position	100% of anomalies where the center of the instrument is positioned within 40 cm of actual target location
Correctly classify QC seeds and correctly classify native and population seed items	Percent classified as TOI	100% classified as TOI
Correctly identify group	Percent of TOI and excavated non-TOI grouped correctly	85% correctly grouped in the small, medium, and large groups
Correct estimation of extrinsic target parameters	Measured location and depth to center of mass of recovered items	X, Y $< 15$ cm ( $1\sigma$ ) Z $< 10$ cm ( $1\sigma$ )
Maximize correct classification of non-TOI	Number of false alarms eliminated	Reduction of clutter digs by $> 50\%$ while meeting all other demonstration objectives
Minimize number of anomalies that cannot be analyzed	Number of anomalies that must be classified as "Unable to Analyze"	Reliable target parameters can be estimated for $> 95\%$ of anomalies on each sensor anomaly list.

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# Equipment



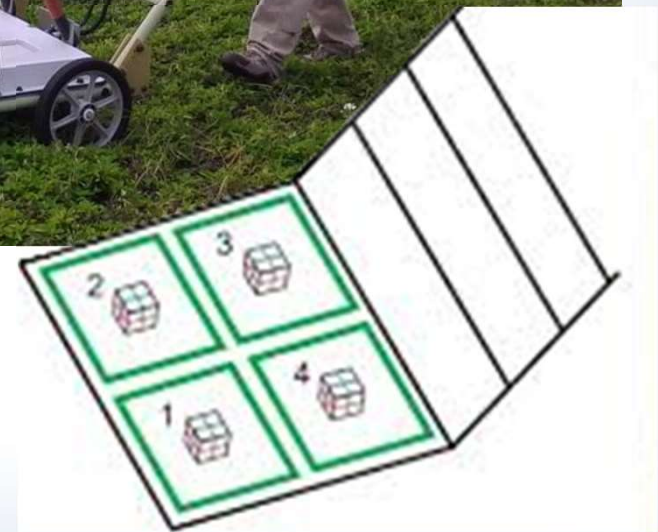
- NRL Time-Domain Electromagnetic Multi-Sensor Towed Array Detection System (TEMTADS 2X2)
- Geonics EM61-MK2 – single axis sensor
- Trimble R8 Real Time Kinematic (RTK) GPS
- Internal Measurement Unit (IMU)
- Geosoft Oasis Montaj with UX-Analyze



# TEMTADS 2X2



- Developed by the Naval Research Lab
- Four 35cm transmit coils with four 8cm tri-axial receiver cubes
- Center to center distance between transmit coils is 40cm creating an 80cm by 80cm array
- Traditionally deployed as a man-portable wheeled cart with a sensor height of approximately 18cm
- One operator navigates equipment and second operator controls acquisition software using a field tablet
- Advantages; man-portable, provides ability to classify anomalies as being TOI or non-TOI
- Limitations; Sensor is not ruggedized to withstand inclement weather.



# TEMTADS 2X2

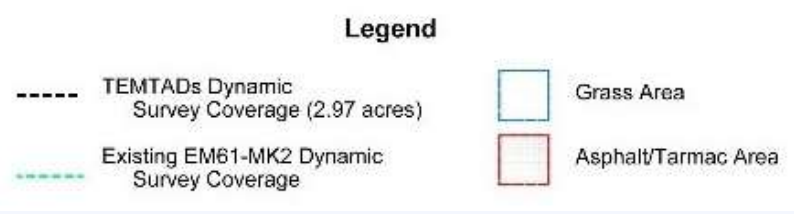
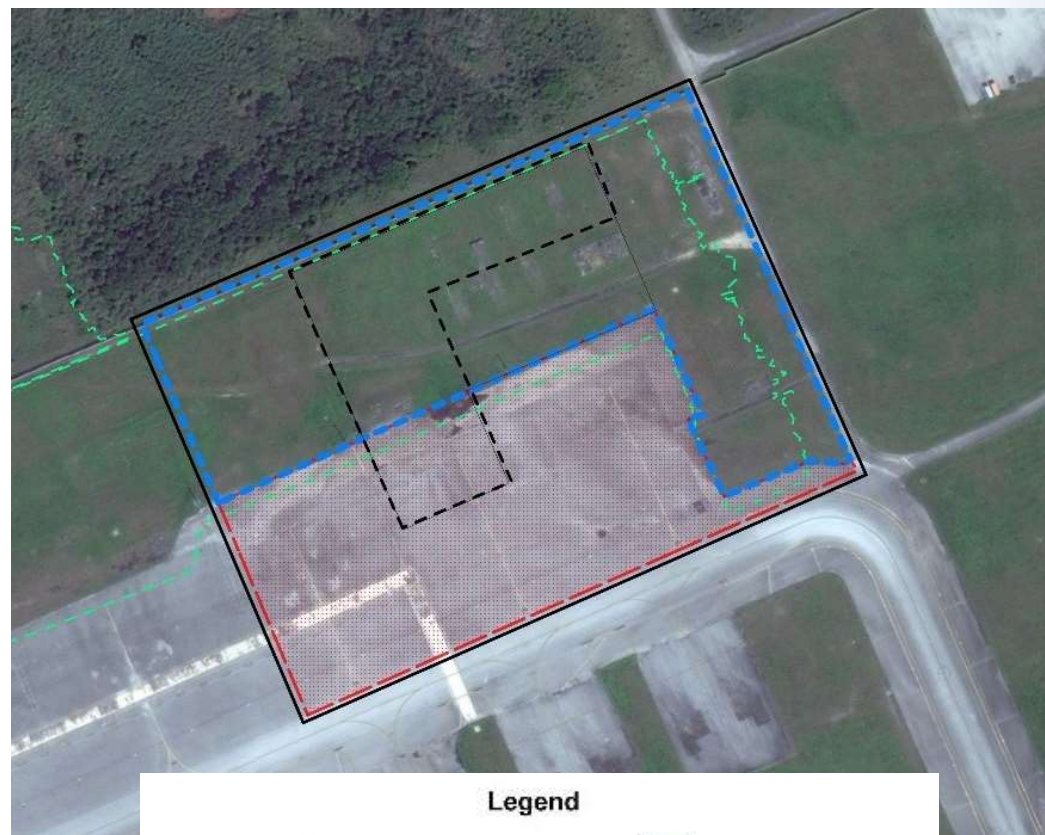


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# Survey Design



- Dynamic data was collected over 2.97 acres of NRP MRS
- Anomalies were selected from TEMTADS 2X2 dynamic survey
- Anomalies were combined with existing EM61-MK2 datasets
- All anomalies were selected for cued interrogation using the TEMTADS 2X2
- A total of 1,195 anomalies were selected for cued interrogation
- Cued datasets were processed using UX-Analyze Advanced to extract target parameters
- Parameters were passed to classification routines that were used to produce ranked anomaly lists
- Intrusive investigation of these anomalies was handled by the contractor performing the removal action



# Data Collection



- Data collected using a 0.5m line spacing
- Lane control was established prior to survey using ropes and wooden stakes or beanbags
- Coverage was ensured using beanbags to mark instrument path during data collection
- Dynamic anomalies were marked in the field using non-metallic pin-flags prior to cued investigation
- Dynamic survey took 5 days to complete (.6 acres/day)
- Cued collection took 10 days to complete (120 locations/day)

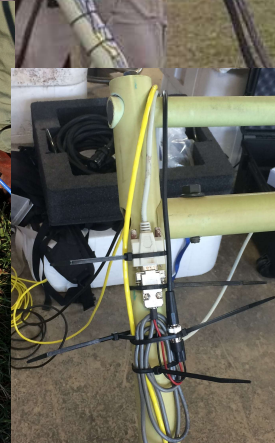


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# Implementation Challenges



- Equipment is not weatherproof – approximately 10 field days were lost due to inclement weather. 40% of field effort.
- Equipment is not rugged – Wheels are held on by zip ties rather than non-metallic bolts or cotter pins
- No real-time status to monitor production during collection – Track Paths
- No option to import target lists into system – increases chances of operator error during collection due to manual entry
- Terrain limitations – vegetation and slope



# Data Processing



- Data Import and initial QC
- Static function tests
- Background removal
- Data Positioning
- Anomaly selection (dynamic)
- Library Validation (cued)
- Classify and Rank (cued)

UKA	UKA DECAY	UKA SIZE	UKA Target ID	Identification	Length	Dip angle	Depth	% GAFFCENTR
SP_49_003_11			105mm Projectile M1	105mm Projectile M1	0.47	-90.00	0.41	105mm Proj
SP_47_005_11			105mm Projectile M1	105mm Projectile M1	0.47	-90.00	0.41	105mm Proj
SP_47_005_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	-90.00	0.40	105mm Proj
SP_48_003_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	90.00	0.40	105mm Proj
SP_49_004_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	0.00	0.38	105mm Proj
SP_55_005_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	-90.00	0.40	105mm Proj
SP_56_003_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	90.00	0.40	105mm Proj
SP_57_003_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	0.00	0.38	105mm Proj
SP_43_003_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	-90.00	0.26	105mm Proj
SP_44_003_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	90.00	0.26	105mm Proj
SP_45_003_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	0.00	0.26	105mm Proj
SP_47_003_11			105mm Projectile SABOT	105mm Projectile SABOT	0.47	-90.00	0.26	105mm Proj
CL_95_003_11			17mm German ERST	17mm German ERST	0.28	-90.00	0.28	17mm Garr
CL_92_002_11			17mm German ERST	17mm German ERST	0.28	0.00	0.22	17mm Garr
CL_102_001_11			17mm Projectile HE	17mm Projectile HE	0.09	-90.00	0.18	17mm Proj
SP_90_003_11			17mm Projectile M541	17mm Projectile M541	0.11	0.00	0.18	17mm Proj
SP_38_003_11			17mm Projectile M59 w/o Band (blue)	17mm Projectile M59 w/o Band (blue)	0.10	0.00	0.18	17mm Proj
SP_53_005_11			17mm Projectile M59	17mm Projectile M59	0.11	90.00	0.17	17mm Proj
SP_54_005_11			17mm Projectile M59	17mm Projectile M59	0.11	90.00	0.17	17mm Proj
SP_43_005_11			17mm Projectile M74 AT TP	17mm Projectile M74 AT TP	0.12	-90.00	0.18	17mm Proj
SP_45_005_11			17mm Projectile M74 AT TP	17mm Projectile M74 AT TP	0.12	0.00	0.17	17mm Proj
SP_48_005_11			17mm Projectile M74 AT TP	17mm Projectile M74 AT TP	0.12	-90.00	0.26	17mm Proj
SP_35_005_11			17mm Projectile M74 HETP	17mm Projectile M74 HETP	0.12	90.00	0.18	17mm Proj

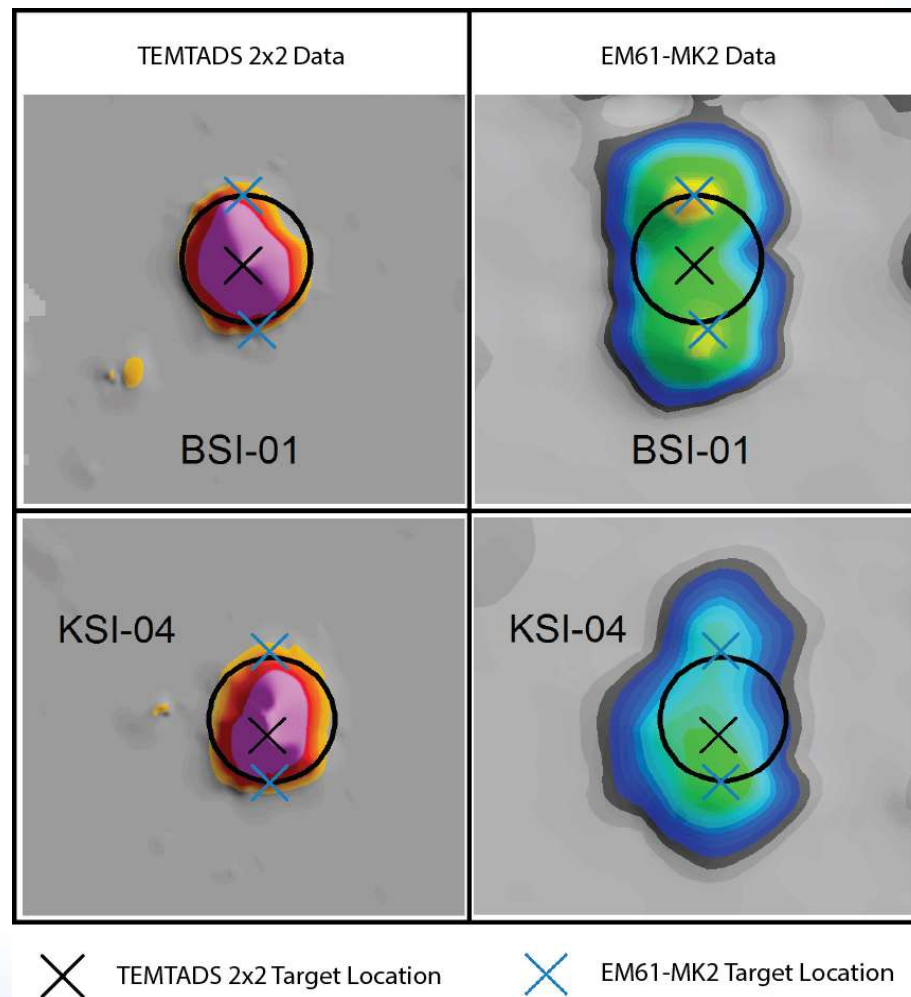
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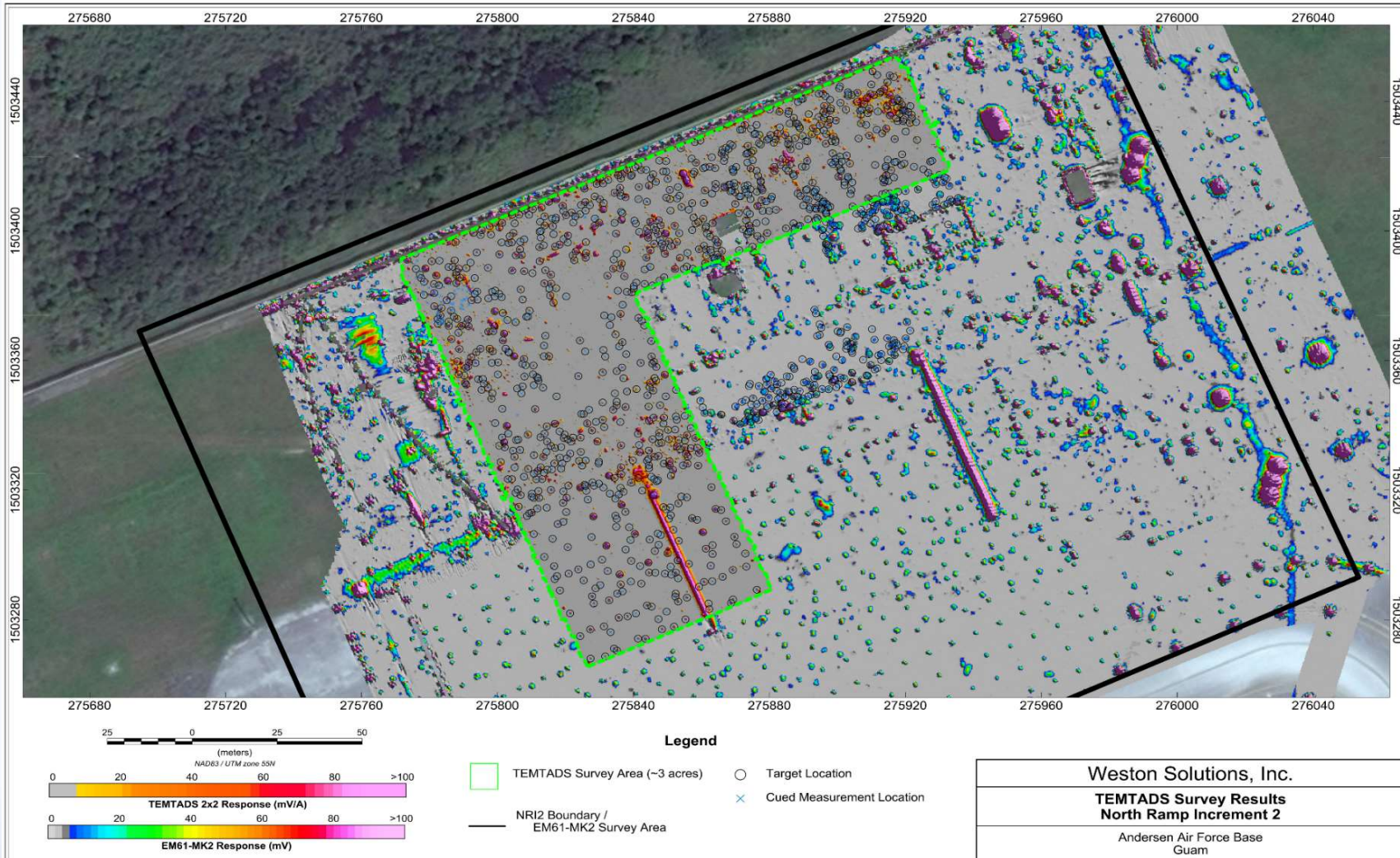
# Dynamic Detection



- TEMTADS 2X2 is able to collect significantly more data than traditional EM61-MK2 surveys
- Multiple transmitters and receivers increase target resolution capabilities
- Average seed item offset with EM61-MK2 was 32cm
- Average seed item offset with TEMTADS 2X2 was 10.2cm
- Use of AGC equipment during dynamic collection can improve data results and reduce the number of necessary cued investigations
- Modern Dynamic AGC processing routines also have the ability to identify high-confidence non-TOI reducing the number of cued investigations

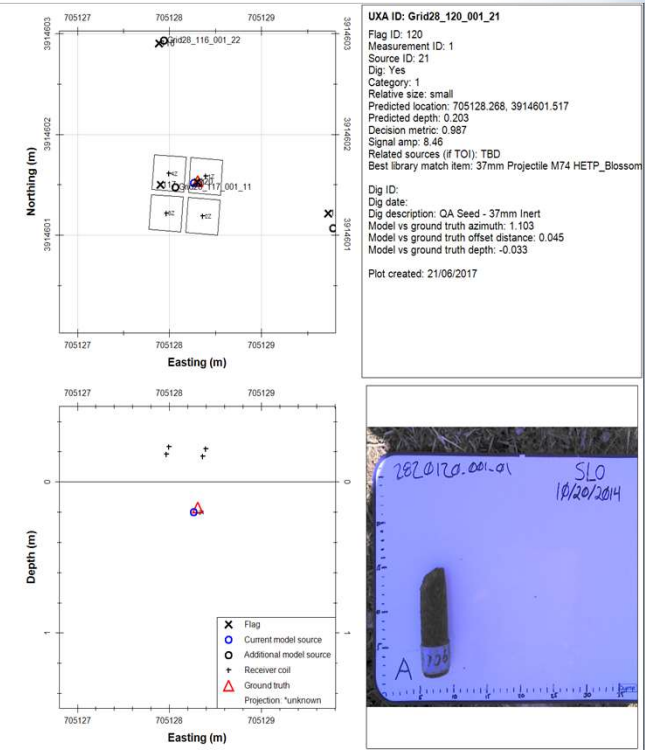
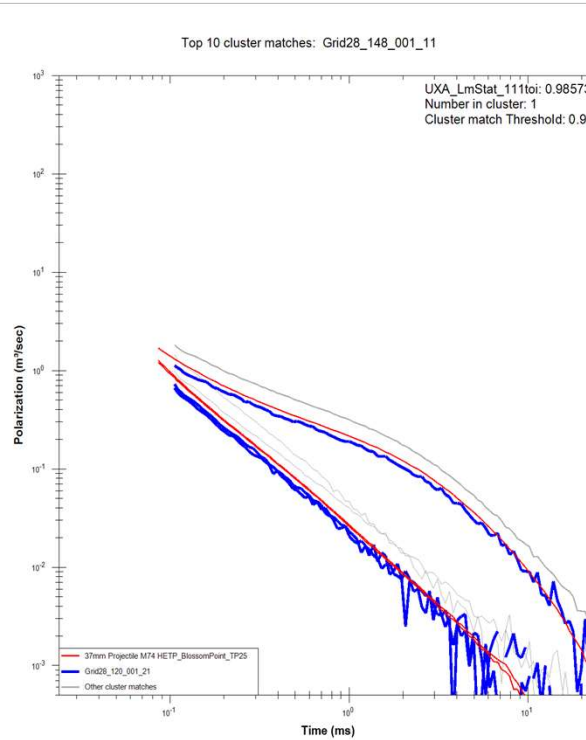
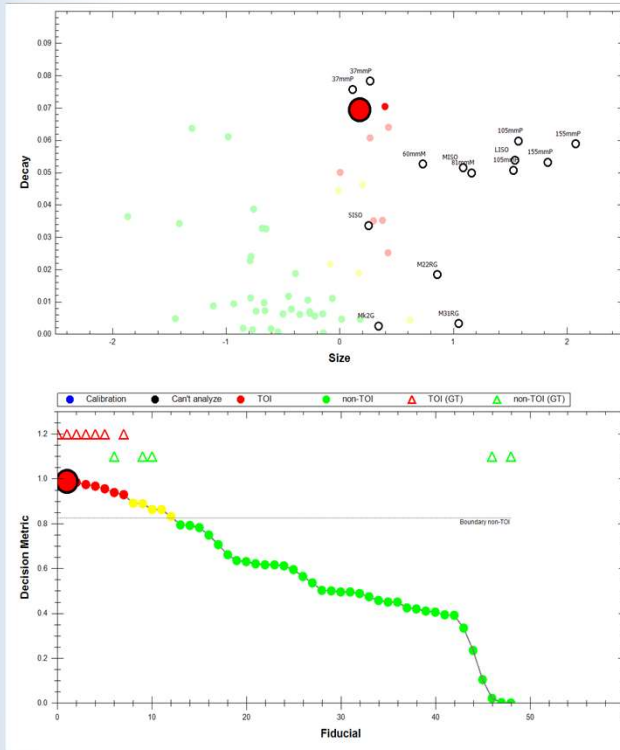


# Data Results



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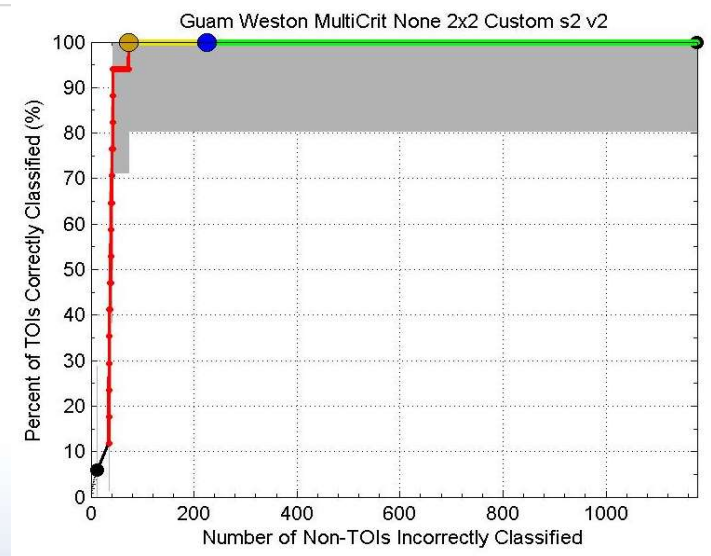
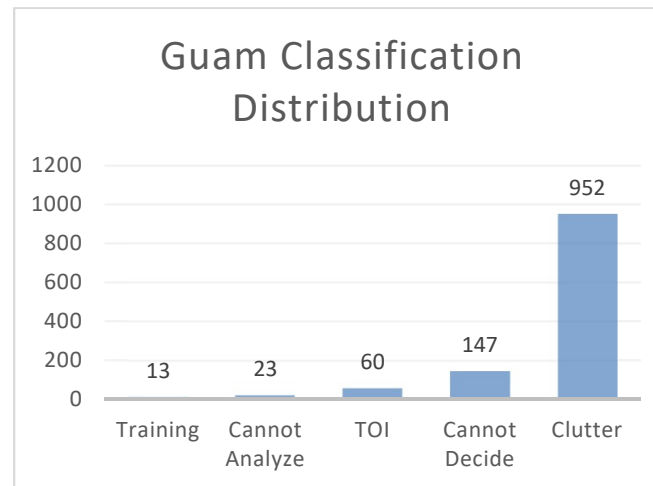


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# Data Results



- 970 anomalies identified in TEMTADS data
- 225 anomalies identified in EM61-Mk2 data
- 1,195 total cued locations
- 100% of TOI identified
- 81% in reduction



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# QUESTIONS?



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