Live Site Demonstration Results Tobyhanna Army Depot (TOAR) Formerly Used Defense Site (FUDS), Pennsylvania %

Military Munitions Support Services (M2S2) Webinar

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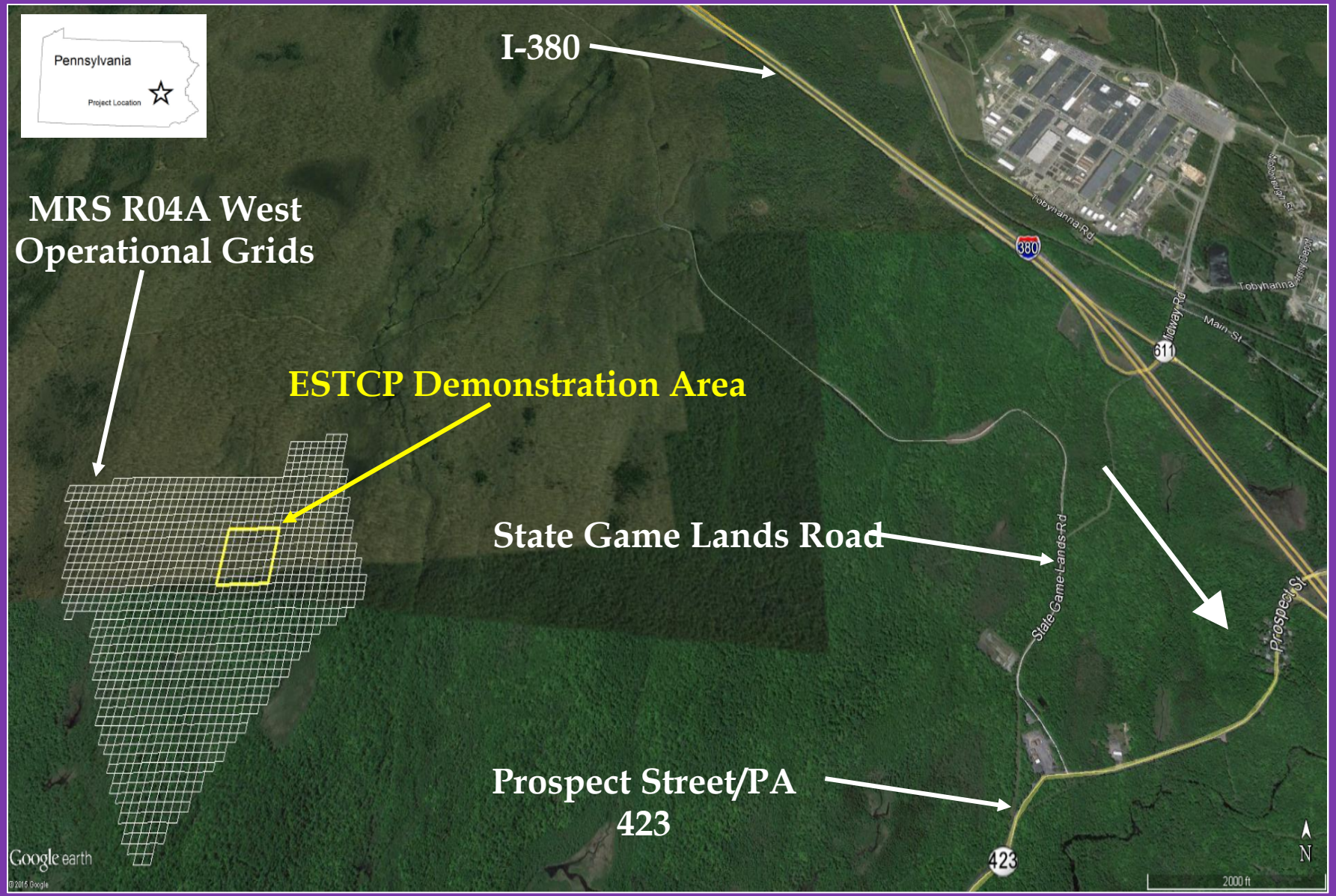
Investigation purpose

To demonstrate performance of advanced EMI sensor in detection of subsurface metal and classification of derived targets as TOI under challenging field conditions.

- Dynamic Survey – performed to identify locations of subsurface metal and derive targets for follow-up cued interrogation

- Cued Interrogation – performed to gather data at target locations, which will be used to derive extrinsic and intrinsic properties of metal objects

General site location %

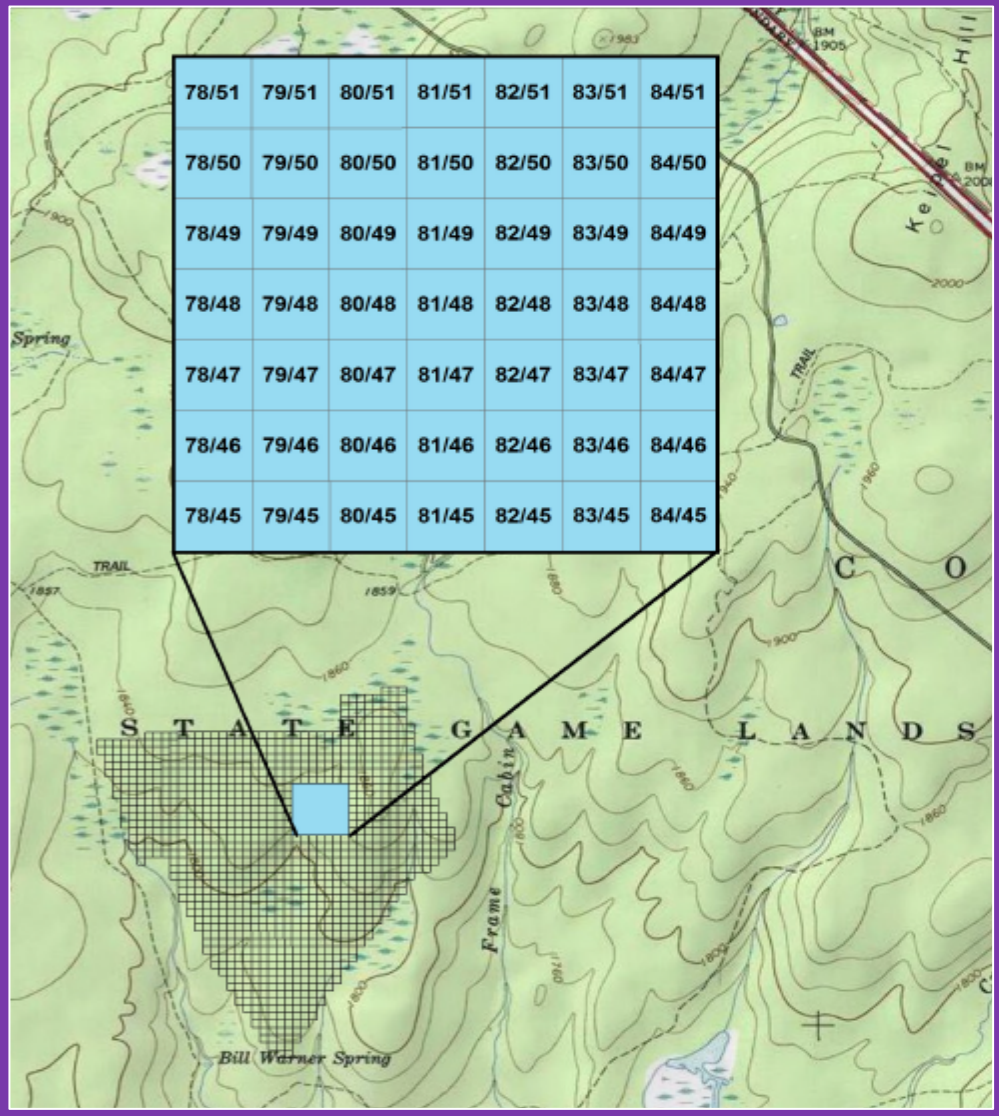


Demonstration area %

- ~11 acres
- 100’ x 100’ Grids
- Suspected impact area west of Grids 78/49 and 78/48

HISTORY:

- Originally established as Camp Sumerall in 1909
- Machine gun & artillery training in 1913
- Field artillery practice from 1913 to 1949
- Live cannon fire 1919 to 1932
- Explosives storage depot ~10 months in 1919



Recovered* munitions-related items at MRS 04A West

- 75mm shrapnel projectile
- 75mm HE projectile
- 155mm shrapnel projectile
- 155mm HE projectile
- PD fuze

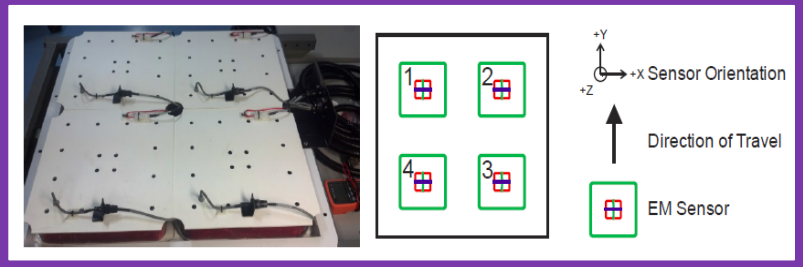
Note: 37mm projectile use reported onsite but at different part of TOAR FUDS

*Previously recovered by USACE contractor performing site investigations

Site conditions %

- Densely wooded
- Variable underbrush thickness
- Impact craters
- Large boulders
- Variable relief
- Hunting area
- Remote location (Access by UTV)
- Poison plants, ticks, bees

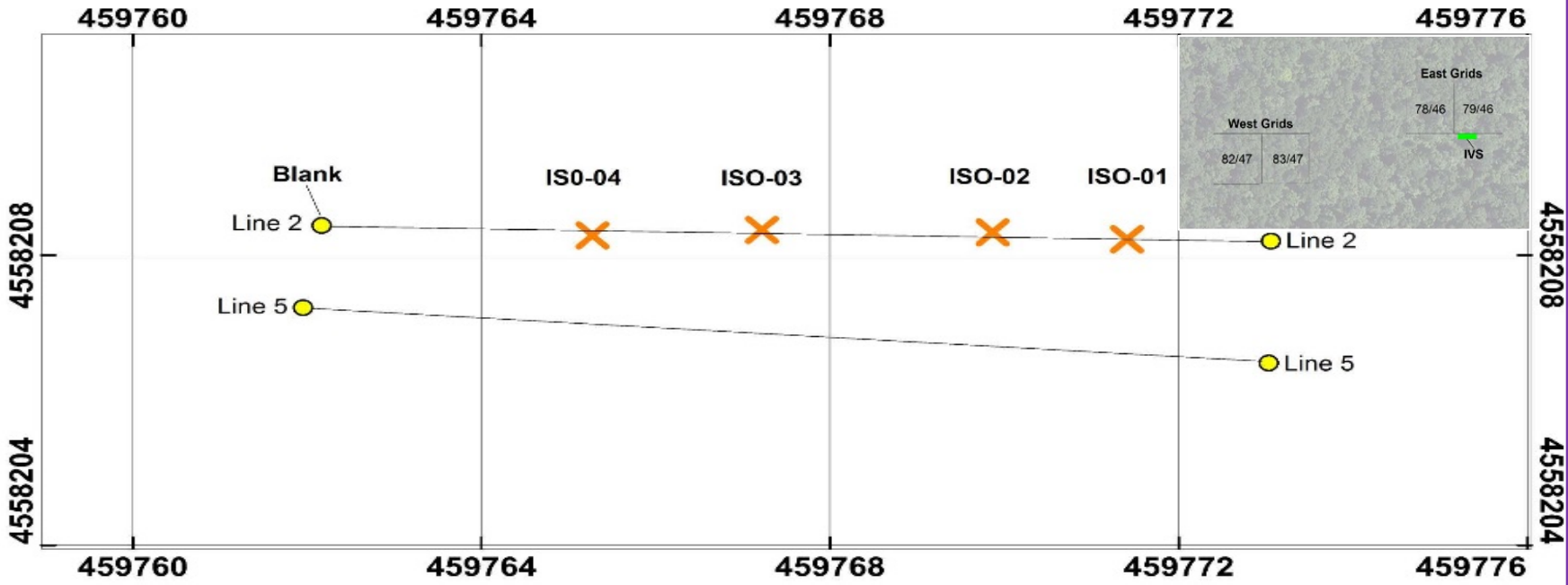
Technology



Approach

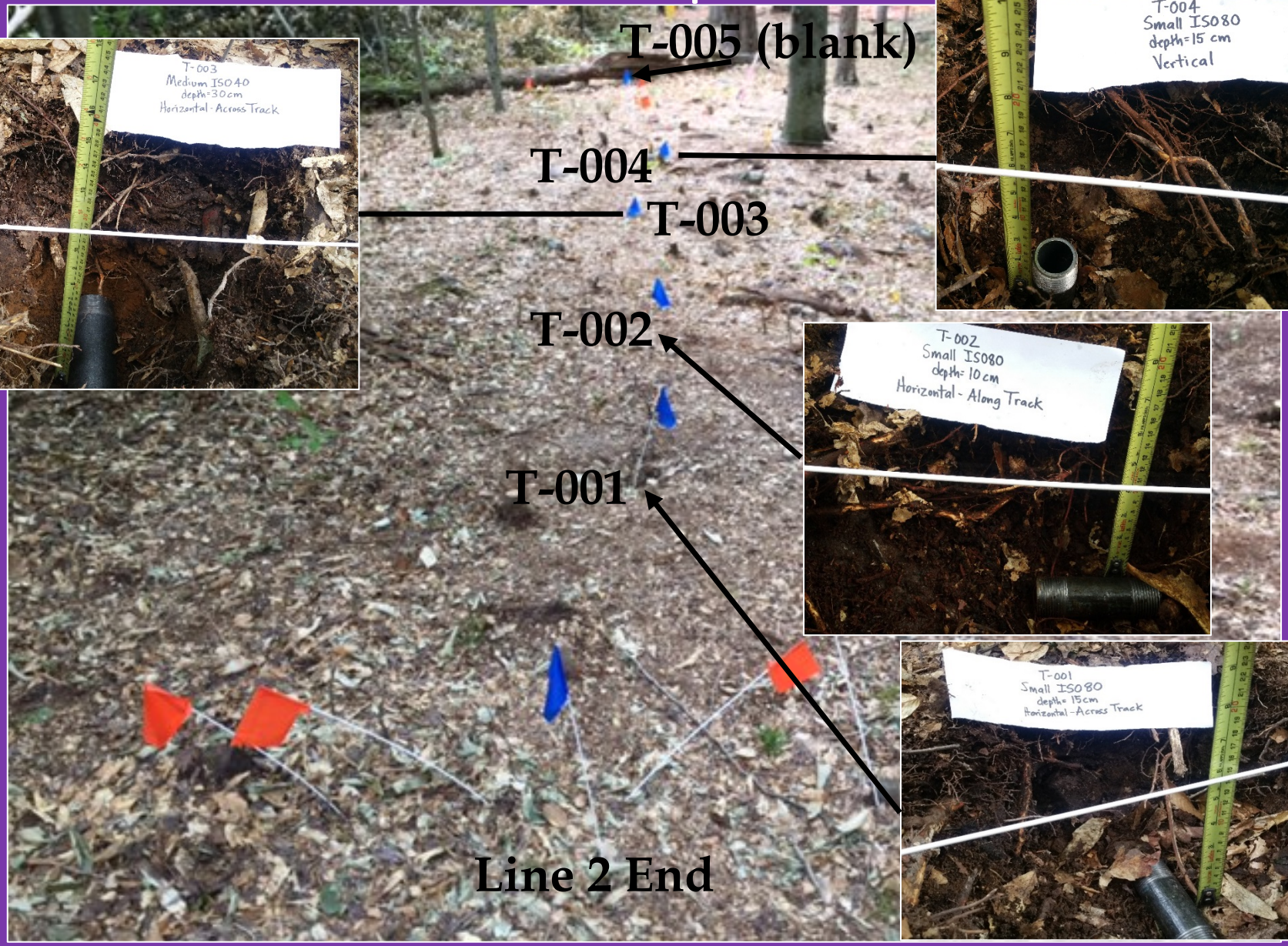
- Conduct G-858 transect survey to select ~2 acres of grids
- Prepare the site
- Conduct dynamic TEMTADS survey (0.5 m lane spacing)
- Process data / select target locations
- Flag target locations / conduct cued interrogation
- Analyze data /derive prioritized dig list
- Intrusively investigate all target locations

Instrument Verification Strip



ID	Easting	Northing	Seed Type	Depth (cm)	Orientation
ISO-01	459771.4	4558208.224	Small ISO80	15	Horizontal; cross track
ISO-02	459769.9	4558208.317	Small ISO80	10	Horizontal; along track
ISO-03	459767.2	4558208.351	Medium ISO40	30	Horizontal; cross track
ISO-04	459765.3	4558208.276	Small ISO80	15	Vertical

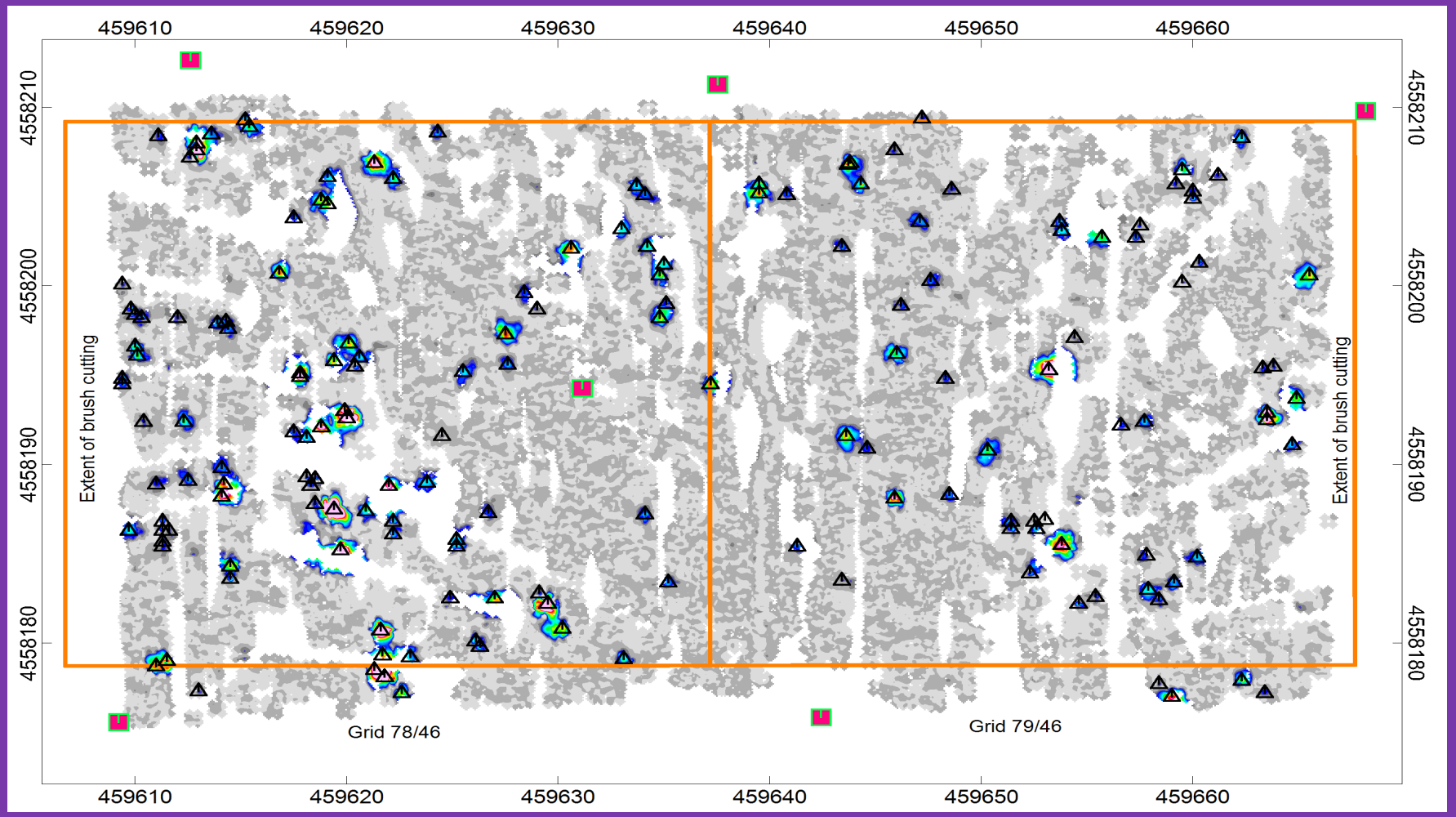
Instrument Verification Strip %



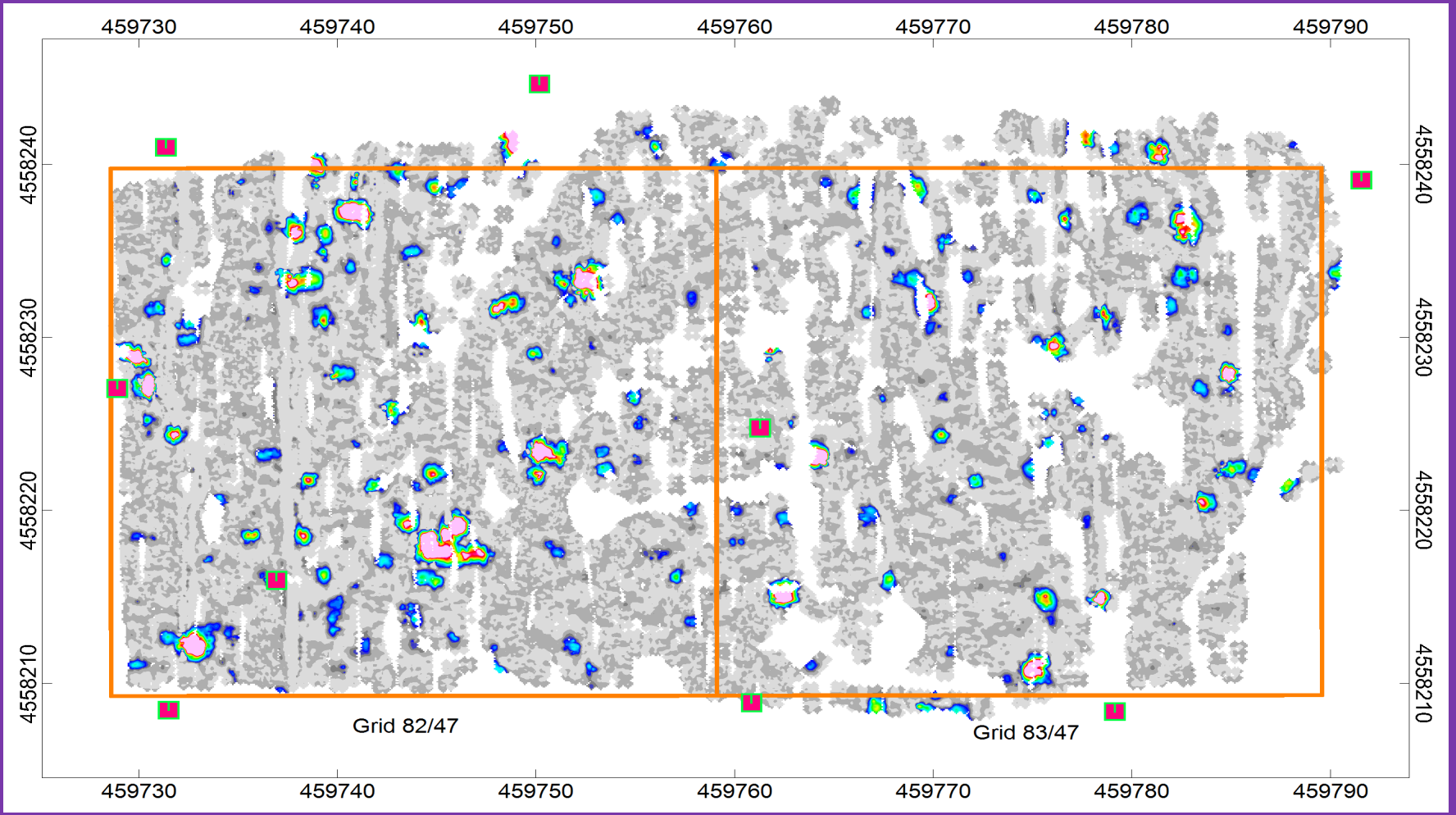
Dynamic TEMTADS 2x2 survey

- 8 days to collect 4 grids (~1 acre total)
- 3 days for gap-fill (attempt to get 100% coverage in one grid)

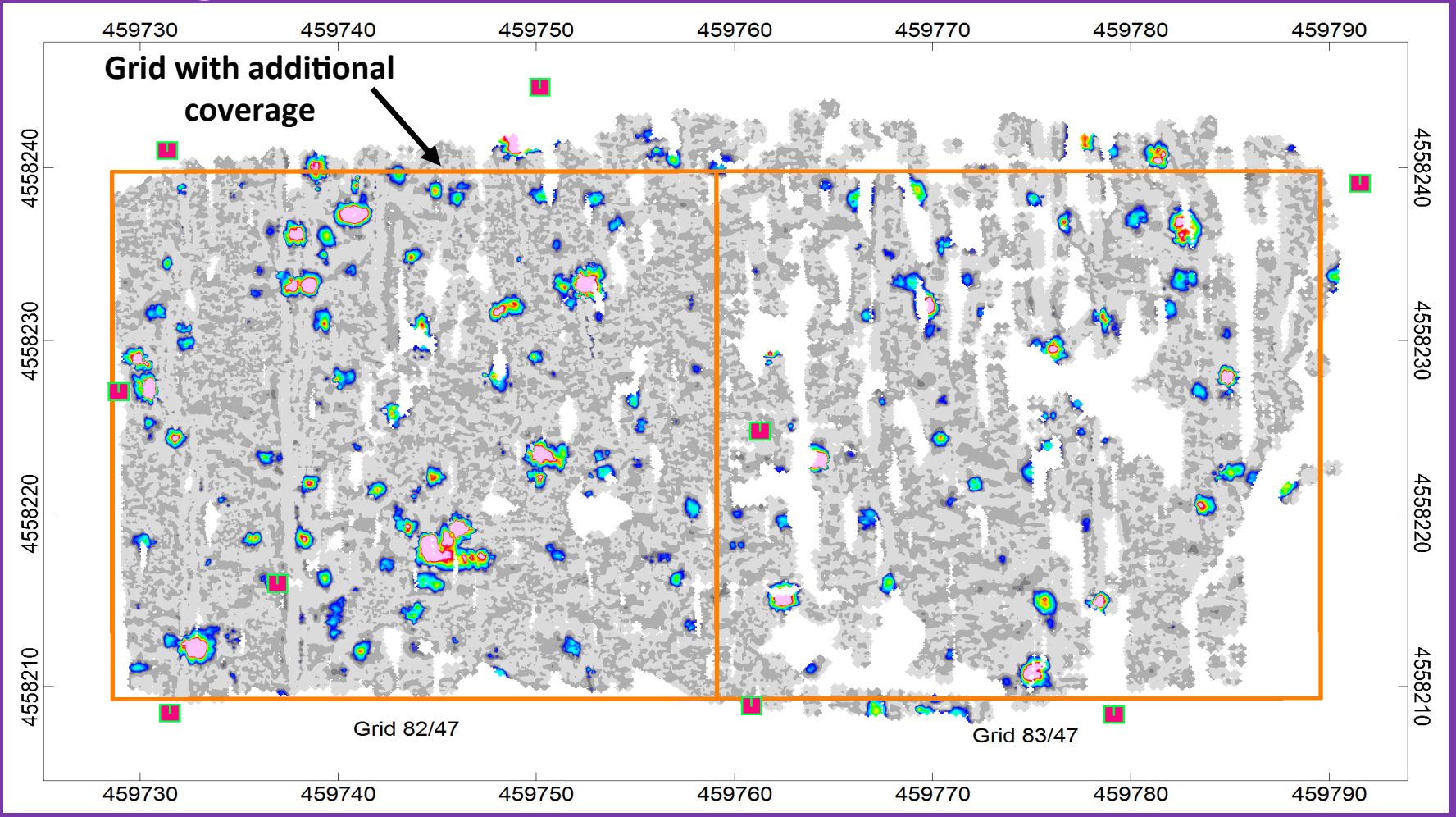
Dynamic survey results – west grids



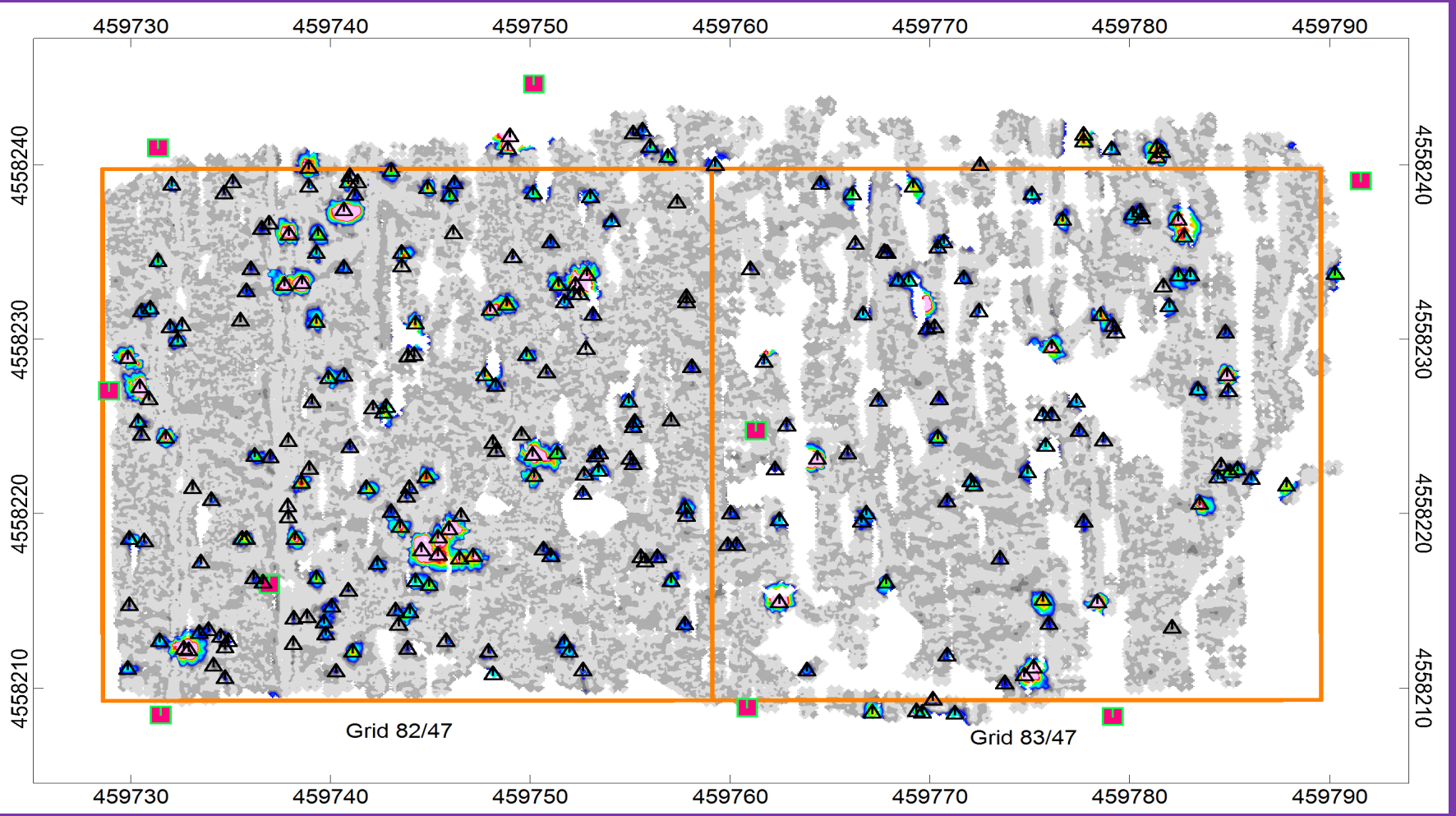
Dynamic survey results – east grids (initial coverage)



Dynamic survey results – east grids (additional coverage)



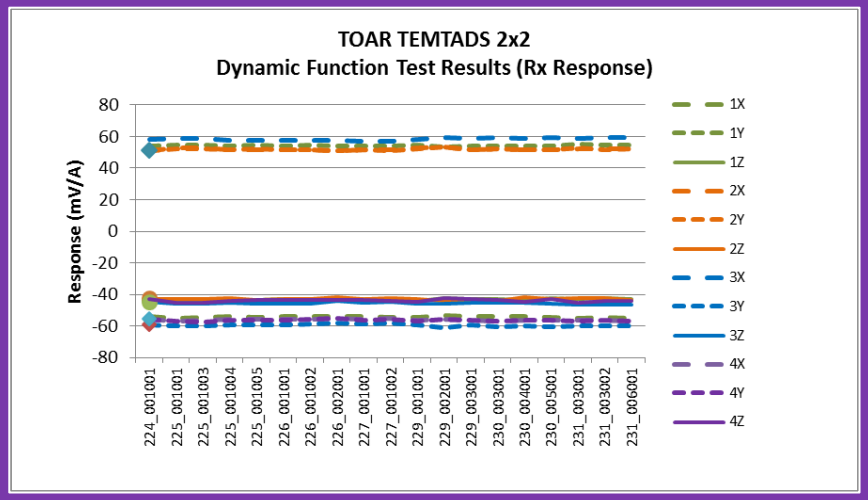
Dynamic survey results – east grids (target

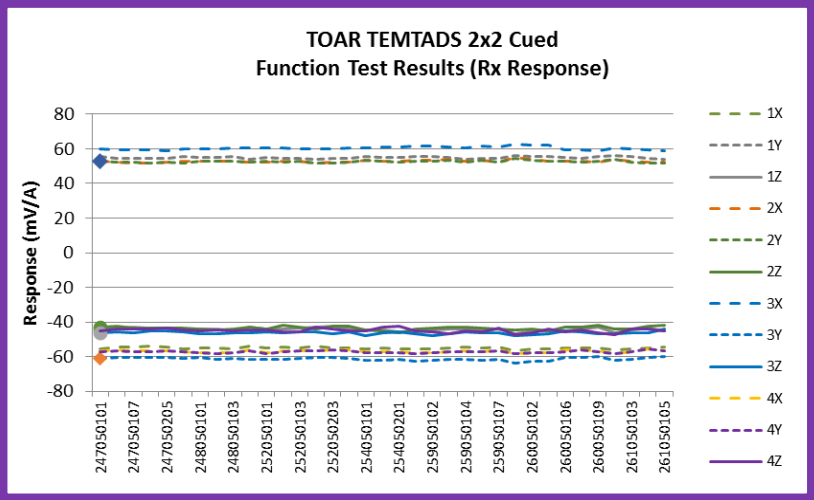


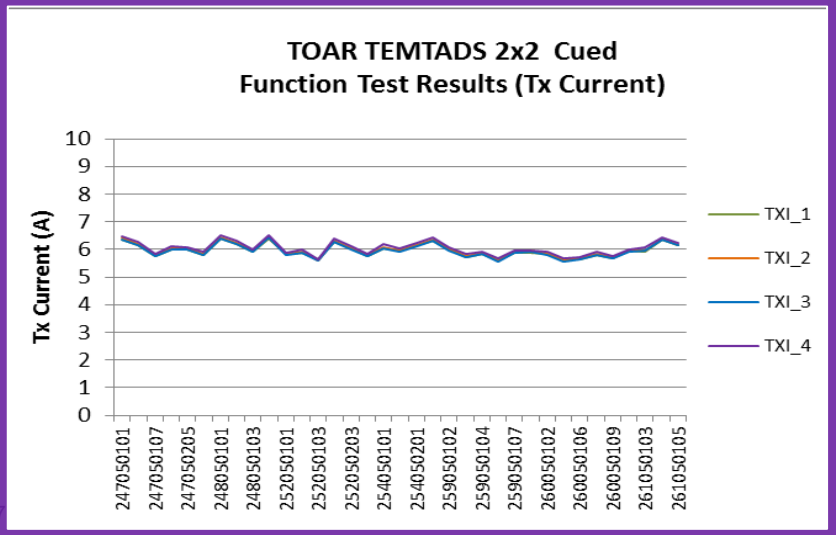
Cued TEMTADS 2x2 survey %

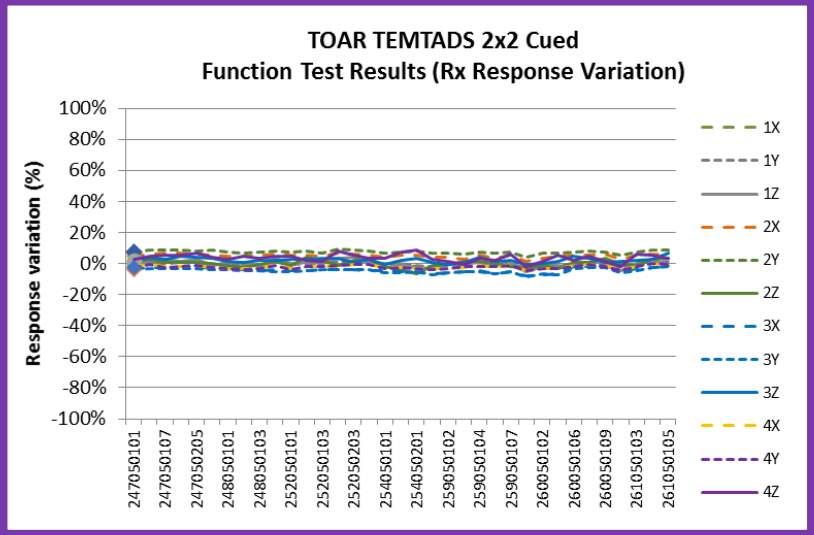
- 264 targets in east grid pair
- 165 targets in west grid pair
- Targets flagged by surveyor
- 7 days data collection

Function tests



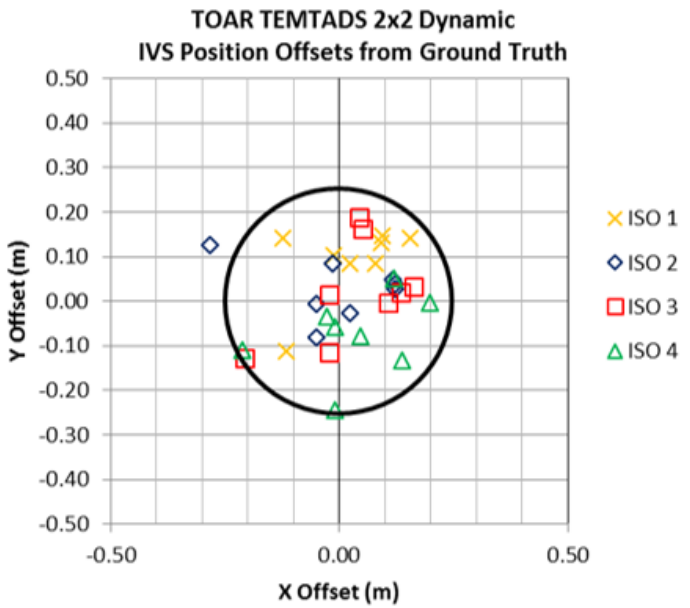




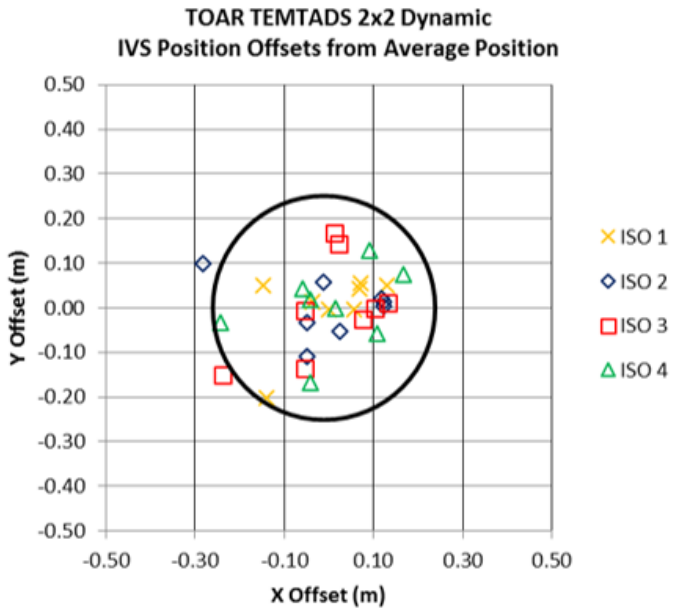


Dynamic IVS survey performance

- Horizontal targets are more difficult to position using amplitude response peak detection.

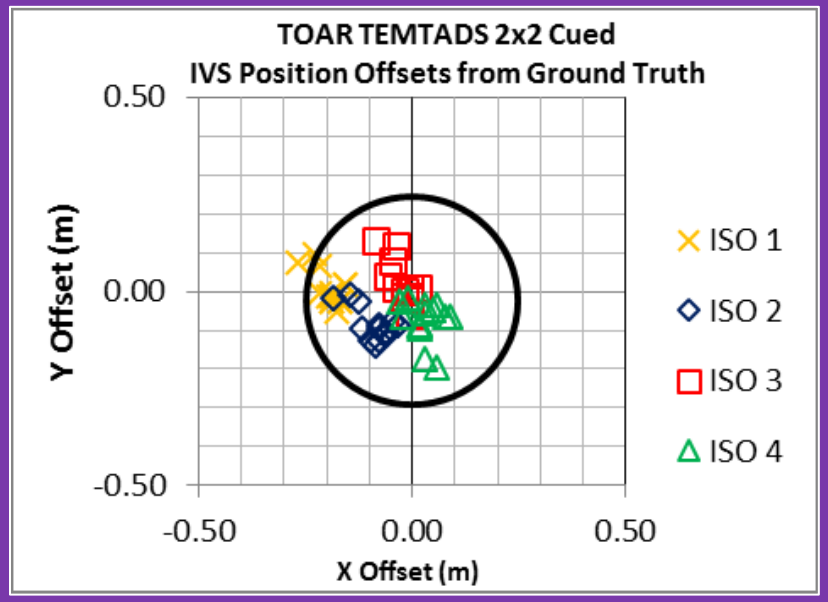


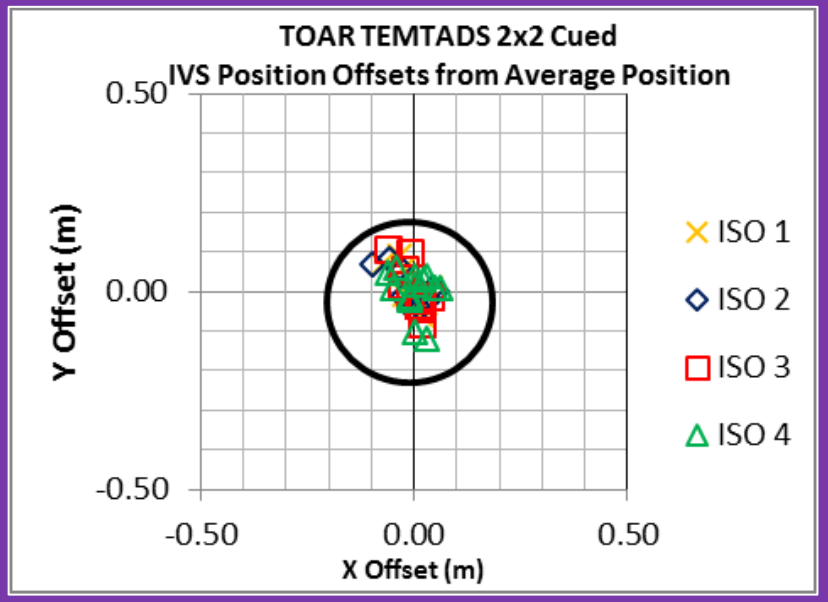
	Maximum Error (m)	Average Error (m)
ISO 1	0.21	0.15
ISO 2	0.31	0.12
ISO 3	0.24	0.15
ISO 4	0.25	0.15

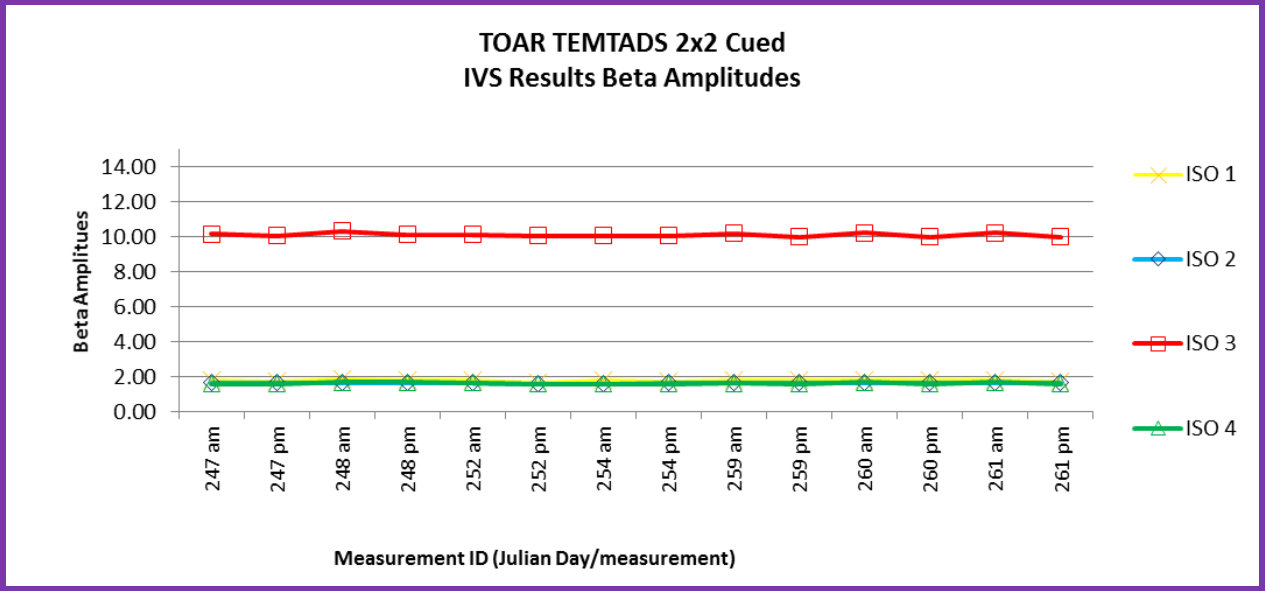


	Maximum Error (m)	Average Error (m)
ISO 1	0.25	0.10
ISO 2	0.30	0.12
ISO 3	0.28	0.14
ISO 4	0.24	0.13

Cued IVS survey performance

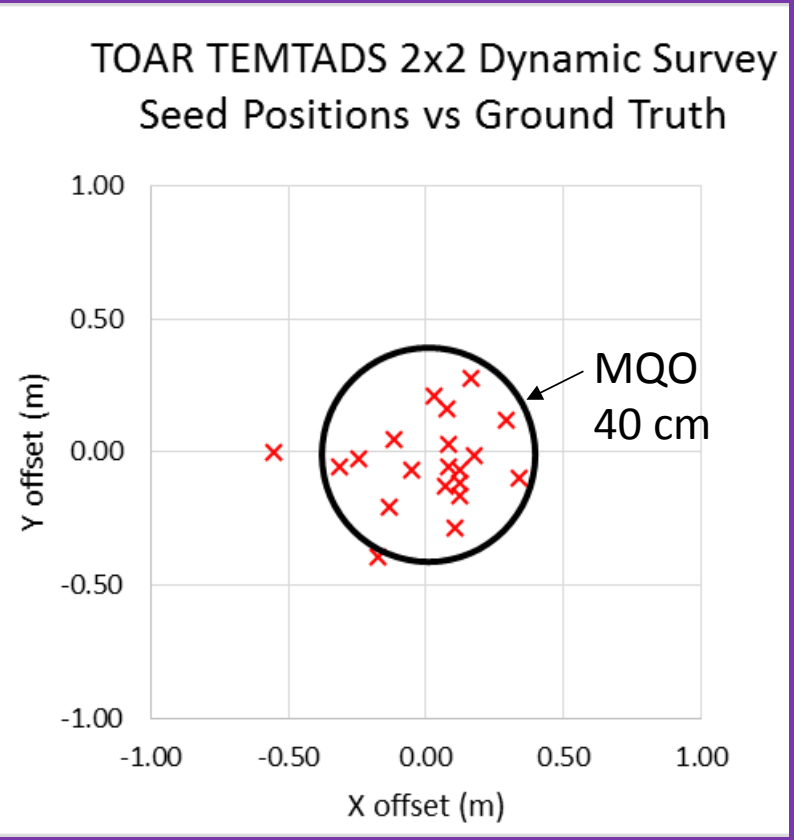


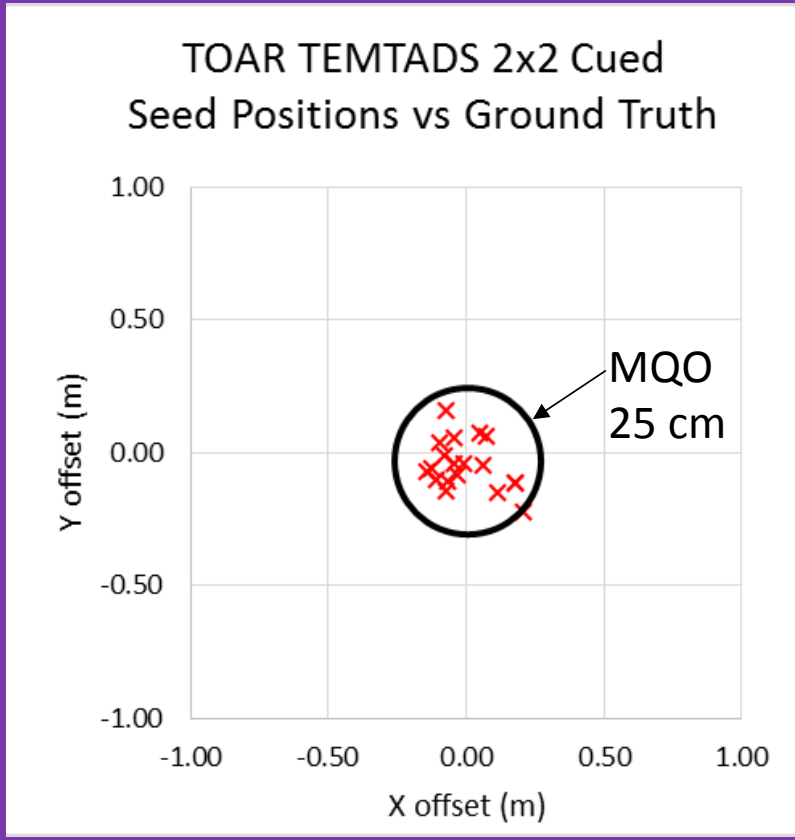




Dynamic IVS survey performance %

- Targets selected in dynamic survey using amplitude response peak detection have errors associated with coverage gaps
- Cued target positions are derived from dipole fit analyses





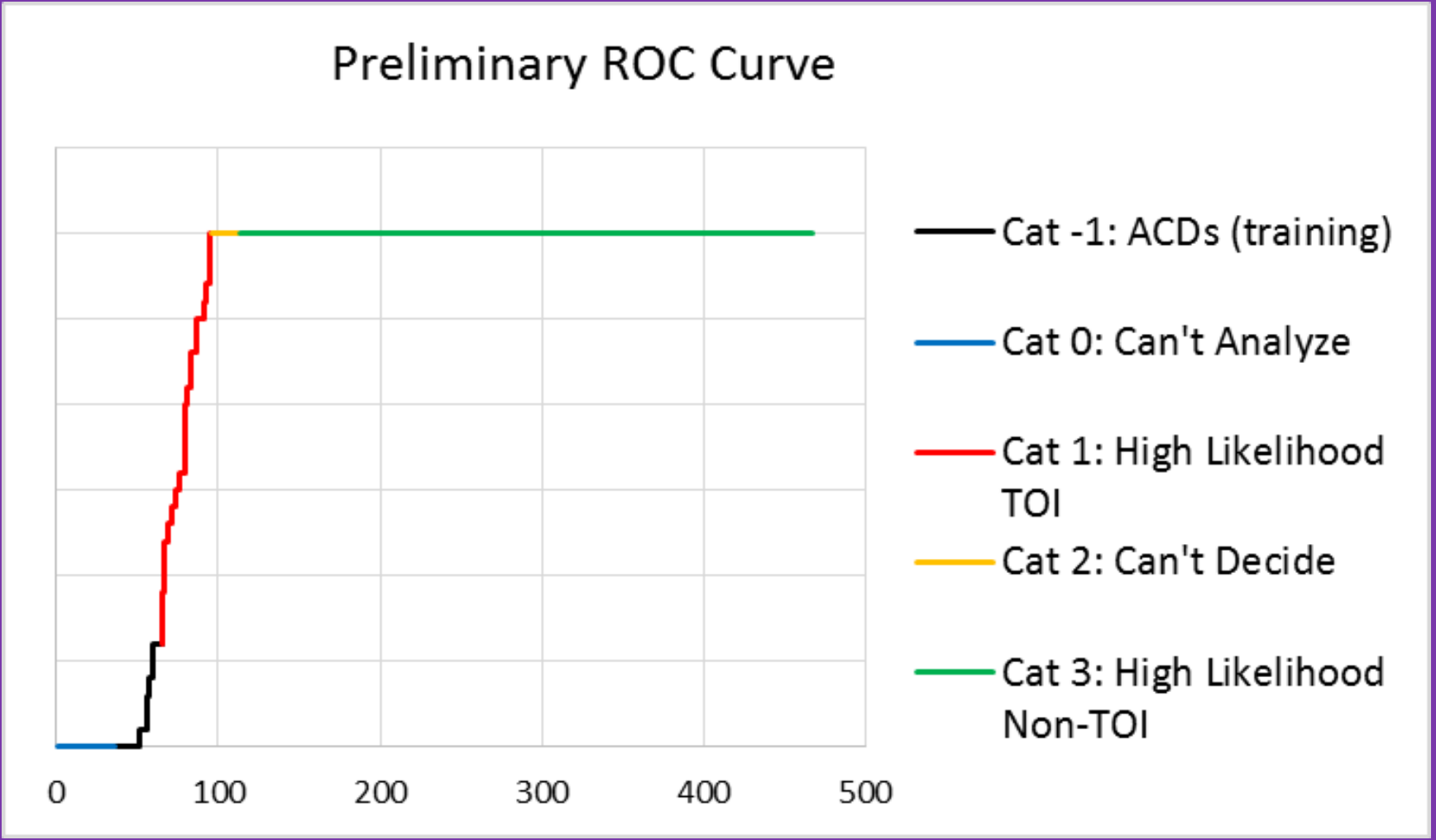
Performance objectives and results – dynamic survey

Performance Objective	Metric	Data Required	Minimum Acceptable Criteria	Result
Initial dynamic survey data positioning	Accuracy of derived target positions	Derived target positions from initial measurements at the instrument verification strip (IVS)	Derived positions within ± 25 cm of the ground truth	Fail (one outlier from horizontal targets – at 31 cm)
Ongoing dynamic survey data positioning	Precision of derived target positions	Derived target positions from daily measurements at the IVS	Derived positions within ±25 cm of the average positions during ongoing daily measurements	Fail (two outliers from horizontal targets – all within 30 cm)
Along line measurement spacing	Point to point sample distance	Mapped survey data	98% ≤ 25 cm; no gaps >40 cm unless obstruction or hazard is present	Fail, (Pass for 100% coverage area)
Dynamic survey spatial coverage	Effective footprint coverage	Mapped survey data	100% at ≤ 75 cm cross-track measurement spacing with intended spacing of 50 cm	Fail, (Pass for 100% coverage area)
Detection of TOI	Percent of seed items detected	Seed item locations Geo-referenced anomaly list	100% of seeded items within a 40 cm halo of ground truth	Fail (all detected, but coverage gaps resulted in 2 distance failures)

Performance objectives and results – cued survey % and classification %

Performance Objective	Metric	Data Required	Minimum Acceptable Criteria	Result
Initial cued survey data positioning	Accuracy of dipole-fit derived target positions	Target fit positions from initial measurements at the IVS	IVS item fit locations within ±25 cm of ground truth locations	Pass
Ongoing cued survey data positioning	Precision of dipole-fit derived target positions	Target fit positions from daily measurements at the IVS	IVS item fit locations within ±20 cm of average fit locations during ongoing daily measurements.	Pass
Initial cued sensor polarizability accuracy	Accuracy of dipole fit derived intrinsic target features	Dipole-fit derived polarizabilities from initial measurements at the IVS	Library Match metric ≥0.9 to initial polarizabilities for each set of inverted polarizabilities	Pass
Ongoing cued sensor polarizability precision	Precision of dipole fit derived intrinsic target features	Dip-ole-fit derived polarizabilities from daily measurements at the IVS	Match metric ≥0.95 to initial polarizabilities at the IVS for each set of inverted polarizabilities from daily measurements	Pass
Cued interrogation anomaly coverage	Instrument position	Cued data	100% of anomalies where the center of the array is positioned within 30 cm of anomaly location	Pass
Correct classification of TOI	Number of TOI correctly identified	Ranked anomaly lists	100% of all seeded targets	Pass
		Scoring reports from ESTCP Program Office	100% of all TOI categorized as "digs" or "Can't Analyze"	
Model results support classification decision	Number of anomalies classified as "Can't Analyze"	Modeling fit coherence results	≥90% of targets have fit coherence > 0.80	Pass

Preliminary ROC curve



Lessons learned

- Increased prism height was factor in lower positioning precision (more pronounced in detection survey)
- Use of RTS presents challenges with line-of-sight in wooded conditions:
  - Refresh rate of RTS after re-establishing lock with prism
  - Total loss of prism by RTS / need for it to search for prism
- Weight of sensor in tandem mode / personnel fatigue much greater than with system on its wheels
- Detection survey presented greater technical challenges, but classification still successful

This investigation was completed as ESTCP Project MR-201314 and under contract W912HQ-13-C-0039

Special thanks to:

ch2m SM