

# UPDATE ON NOVEL APPLICATION OF AGC AT REDSTONE ARSENAL MSFC- 003 – ACHIEVING SUCCESS WHEN THINGS DON'T GO AS PLANNED



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US Army Corps  
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# SITE OVERVIEW

Redstone Arsenal, Huntsville, AL  
NASA's Marshall Space Flight Center (MSFC)-003  
MRS-2: ~30 acres

Cooling tanks and test stand just off MRS built for Saturn Rocket development (moon missions).

Current use- Blue Origin test stand just offsite and NASA occupied building; significant infrastructure/utilities and coordination required, including intrusive ops at night

Prior to NASA- WW2 era waste disposal area, including conventional MEC and Chemical Warfare Materiel (CWM)





# SITE OVERVIEW

Interim Measures AGC removal of MEC (conventional and CWM)  
Objective: Reduce time and cost by minimizing digs requiring full chemical agent (CA) protocols.

In previous investigations, non-standard MEC items –random length/shape detonation cord channel –were identified.

*Phase I- dig all potential CWM single point anomalies (SPAs) with full CA protocols*

*Phase II- dig the rest with CA Contingency protocols (reclassify site as low probability CWM, CWM dig ~25x cost of contingency)*



4.2" mortar  
Z=48 cm  
+ 55 gal drum



M70 bomb, Z=110 cm  
+ metal bar, sheet metal



Det chord channel  
Z=23 cm

Table 10.1  
Known and Expected MEC

Item	Encountered (SPAs) Maximum Depth (meters)	Encountered (Area Targets) Maximum Depth (meters)
Bomb burster tubes	0.27	1.14
75mm projectiles	N/A	0.48
105mm projectiles	N/A	0.91
M50 Incendiary Bomb Dispenser <sup>1</sup>	0.23	N/A
M16 Fire Bomb Igniters	0.09	N/A
M50 Incendiary Bombs <sup>1</sup>	N/A	0.76
M47 100lb Bomb parts <sup>1</sup>	N/A	1.14
M70 115lb bombs <sup>3</sup>	1.10	0.40
4.2-inch mortars <sup>3</sup>	0.48	0.91
Rifle grenades <sup>1</sup>	N/A	0.31
M69 Incendiary Bombs <sup>1</sup>	0.24	N/A
Detonation Cord <sup>2</sup>	0.23	N/A



<sup>1</sup> Based on MD recovered or historical analysis

<sup>2</sup> Non-standard MEC item

<sup>3</sup> Chemically configured



# DATA, INITIAL DIG LIST

- UltraTEM Classifier (One-pass system)
  - 25.6 acres
- UltraTEM Screener followed by MetalMapper 2x2 Cued (2-pass)
  - 1.7 acres

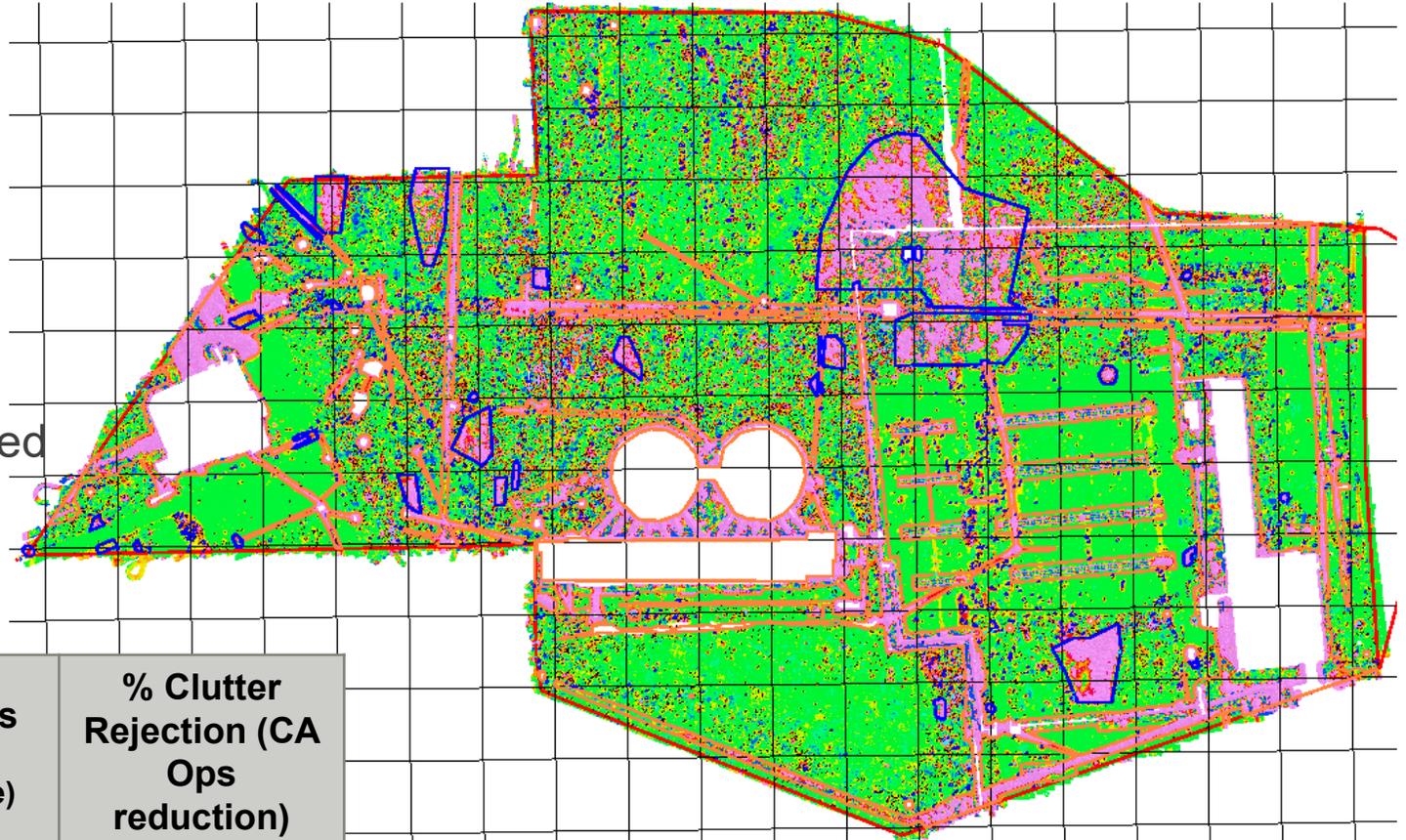




# DATA, INITIAL DIG LIST



- Presence of magnetic soil increases background noise signal
- Lower noise in paved areas (e.g. parking lots)
- Unknown Saturated Response Areas (SRAs)- to be dug as CA
- Utility/Infrastructure polygons delineated - will remain as gaps
- SPA CWM dig list based on library match



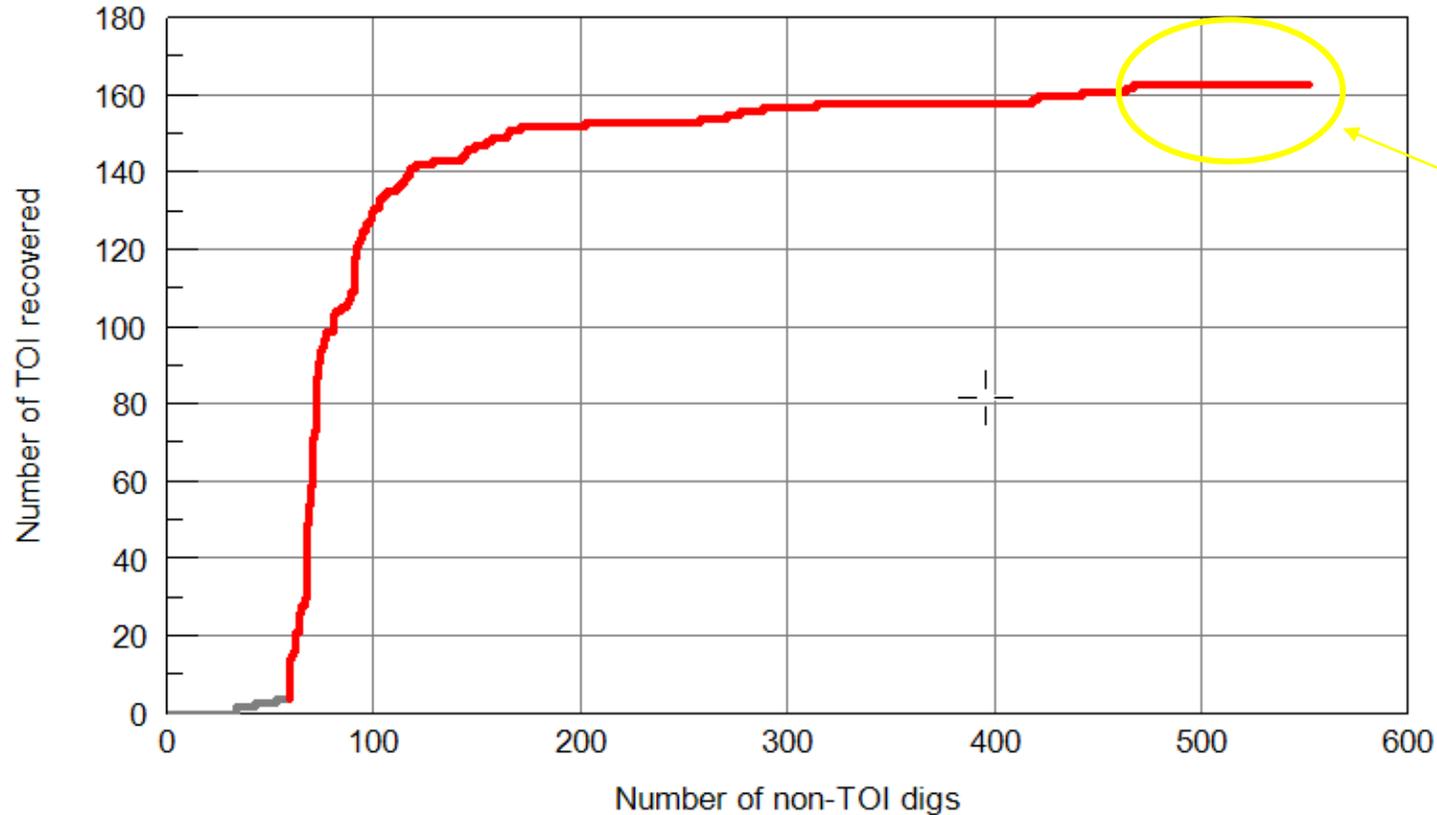
— SRA  
— Utility/Infrastructure

Raw Targets Picked to Analyze	Unique Sources (in MRS, outside polygons)	PCWM Digs (including inconclusive)	% Clutter Rejection (CA Ops reduction)
39,254	17,514	642	96%



# INITIAL DIG RESULTS – GOOD NEWS

- 642 CWM TOI digs: 114 recovered items of concern (IOC)- (110) 4.2” mortars and (4) M70 115lb bombs; all expended/empty
- ROC curve- good news- lots of high ranked 4.2” mortars (also includes seeds removed from ‘642’ CWM list as known items)



Lots of digs past last IOC

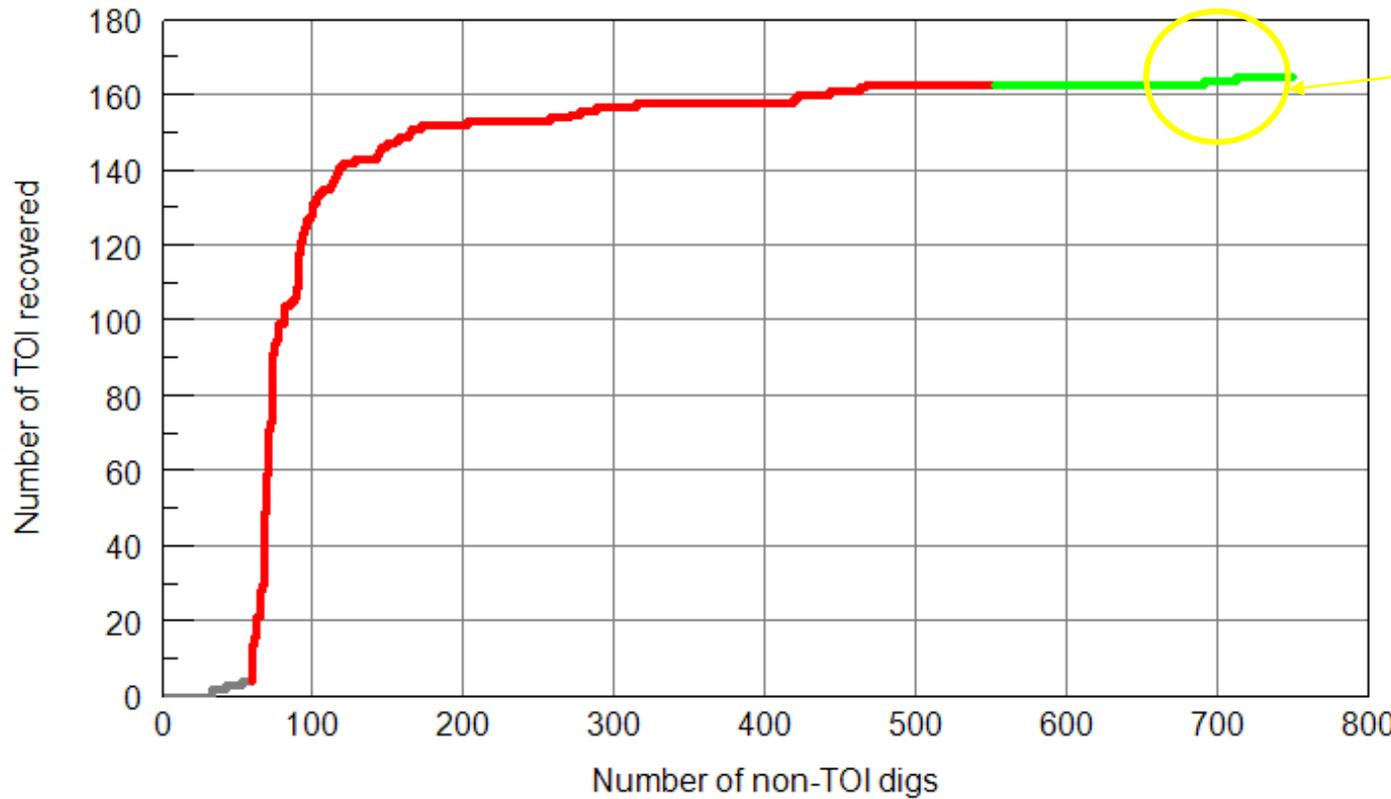


# INITIAL DIG RESULTS – BAD NEWS

## THRESHOLD VERIFICATION DIGS – ROUND 1



The next 200 targets that exceeded the TOI/non-TOI threshold were dug using CWM dig protocols



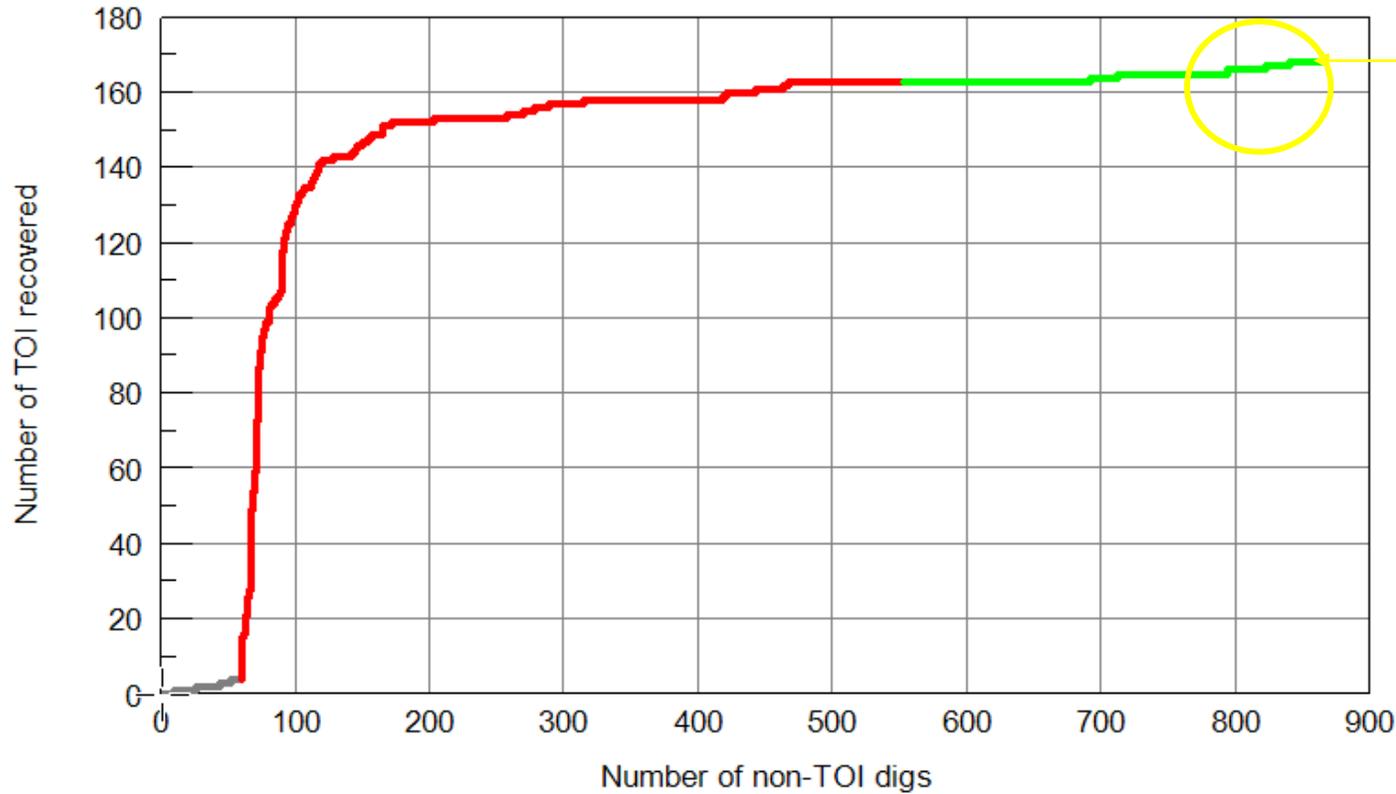
4.2" mortars  
(empty) at  
76 & 63 cm deep



OK, so dig some more verification targets to get 200 past last IOC...

# INITIAL DIG RESULTS – BAD NEWS

## THRESHOLD DIGS – ROUND 2



(2) 105mm UXO (same hole), d= 94 & 108 cm (same size as CWM)

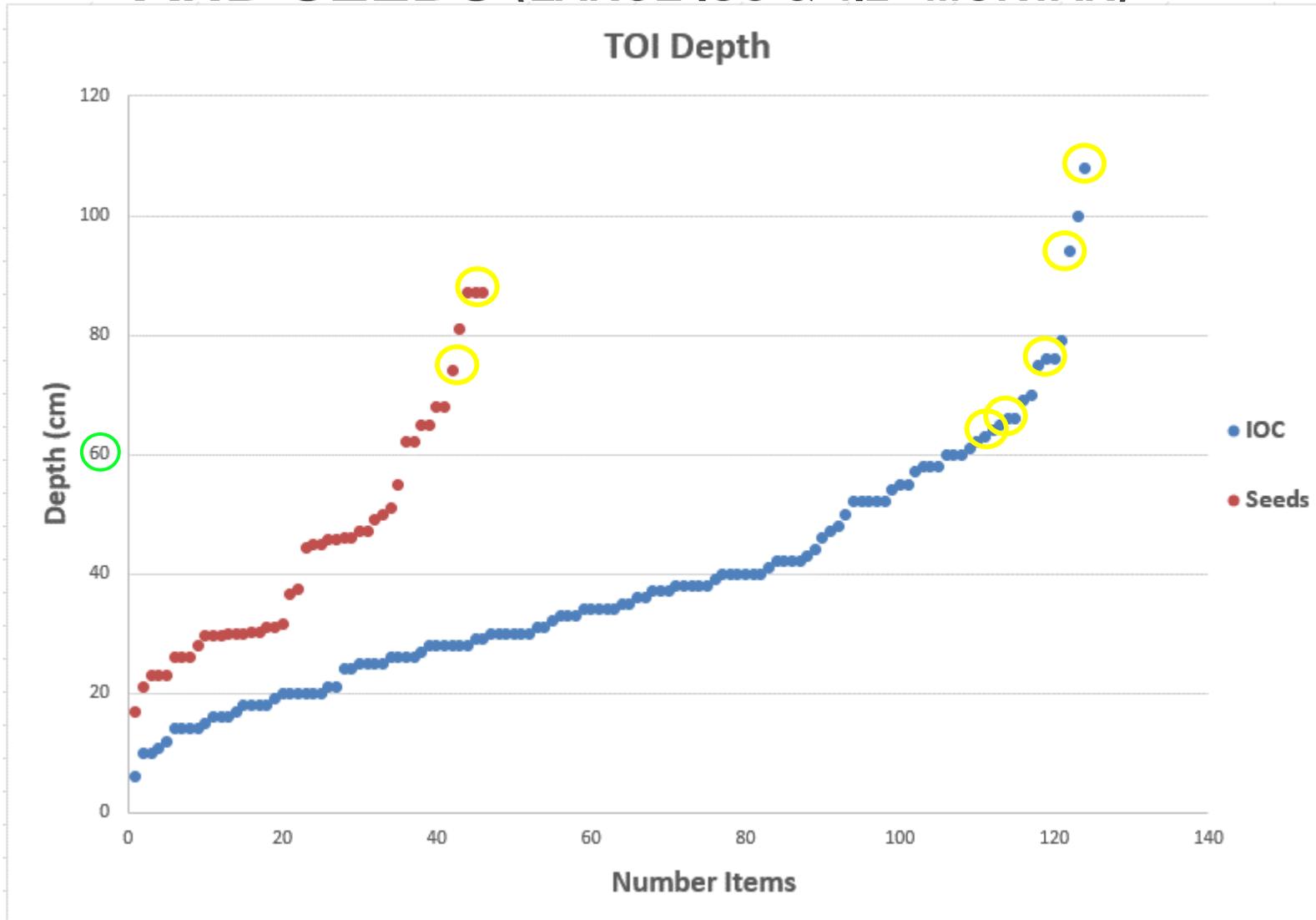
(2) 4.2" mortar (empty), d= 66 & 76 cm



Now what?



# DEPTH OF IOC (4.2" MORTAR, 105MM, M70 BOMB) AND SEEDS (LARGE ISO & 4.2" MORTAR)



● Misclassified Seeds: 74, 87 cm  
● Correctly Classified Seeds: 81, 87, 87

● Misclassified IOC: 63, 66, 76, 76, 94, 108  
● Correctly Classified IOC: 64, 65, 66, 69, 70, 75, 79, 100

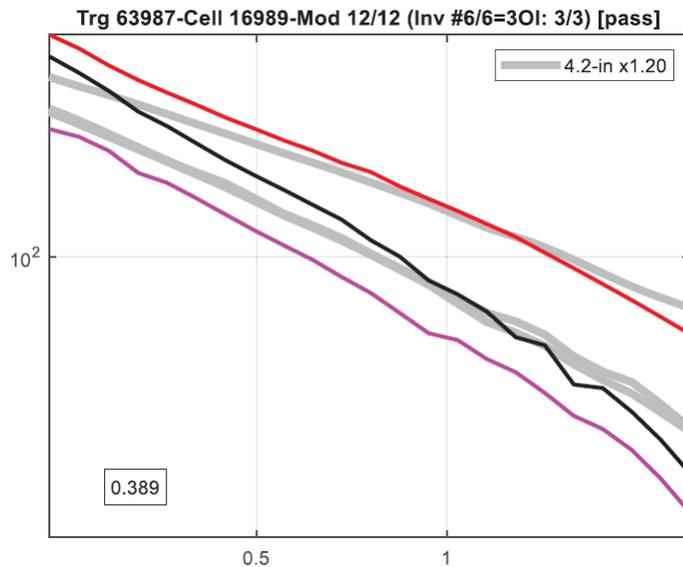
RCA for seeds- too deep to classify in local noise conditions, exceeds limits of technology.

With deep IOC recovered, not good enough.

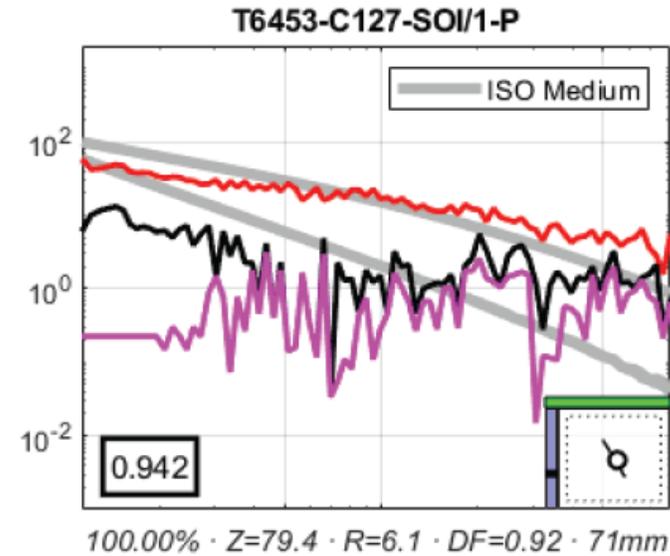


# WHAT NOW? RCA/CA

- Threshold IOC found both deeper and shallower than expected detection depth
- Polarizability curves for threshold IOC did not look great. Missed seeds were not close to last stop-dig point (far to the right on ROC curve)
  - lowering the library match threshold is not the way to go
- Depth of missed seeds and recovered IOC (up to 100cm) in initial digs should have clued us in that items were present deeper than could be reliably classified using library matching



Missed Classifier seed, LISO @ 74cm  
(no match, indicates large item)



Missed MM2x2 seed, LISO @ 87cm  
(no signal- 'empty')



# WHAT NOW? RCA/CA



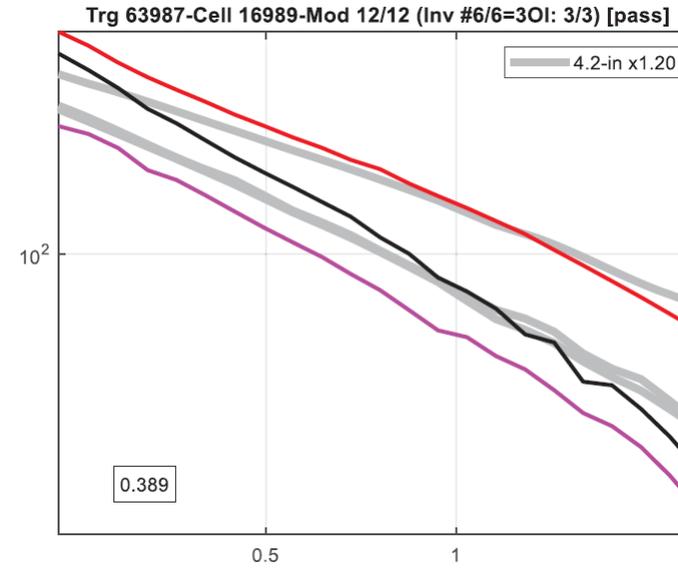
- Cannot consistently classify all IOC at depths they are present using library matching
- Are we going to have to scrap AGC altogether and dig remaining 16k+ as CWM?



# WHAT NOW? RCA/CA



- Data for missed IOC re-evaluated to identify other parameters indicative of deep mortars
- Missed IOC were all predicted to be big and deep, but shape/full polarizability curves not always well defined
- 'Potential Deep' CWM digs added based on these parameters (includes all missed IOC):
  - Predicted depths  $\geq 50\text{cm}$
  - Predicted size  $\geq 80\text{mm}$
  - L123 misfit  $\leq 1$  (omit noise sources)



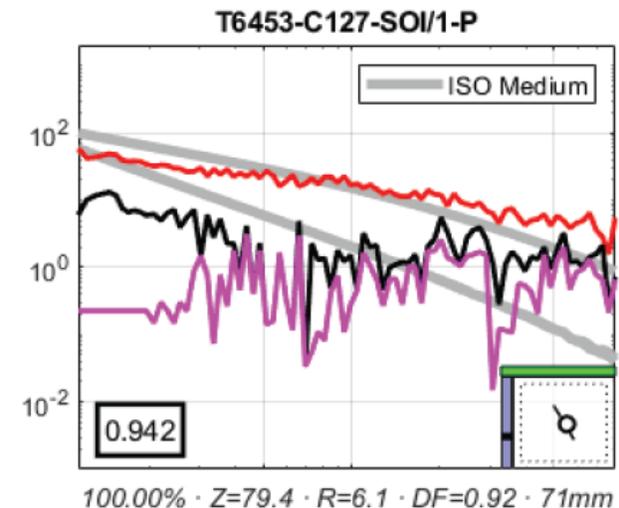


# WHAT NOW? RCA/CA



Oops...what about that seed missed by MM2x2?

- Not captured by the new 'potential deep' criteria, was called 'Empty'
- 'Empty'- sources that are judged (based on data and polarizability curves) to likely contain no significant metal (or potentially metal that is too deep to be characterized by the sensor). 419 empty MM2x2 targets. Originally planned to verify by digging 10%.
- High % of Screener targets resulted in 'Empty' MM designation.
  - More difficult area (steep slopes) leading to noisy Screener data?
  - Actual deep sources beyond MM capabilities?
- Now we know IOC beyond MM2x2 capability (not just seed)- May not look 'big/deep', may just look like background/no metallic source.
- Add all 'Empty' targets back to dig?
- Use Screener data parameters (size, depth)?





# METALMAPPER 2X2 CLASSIFICATION DEPTH

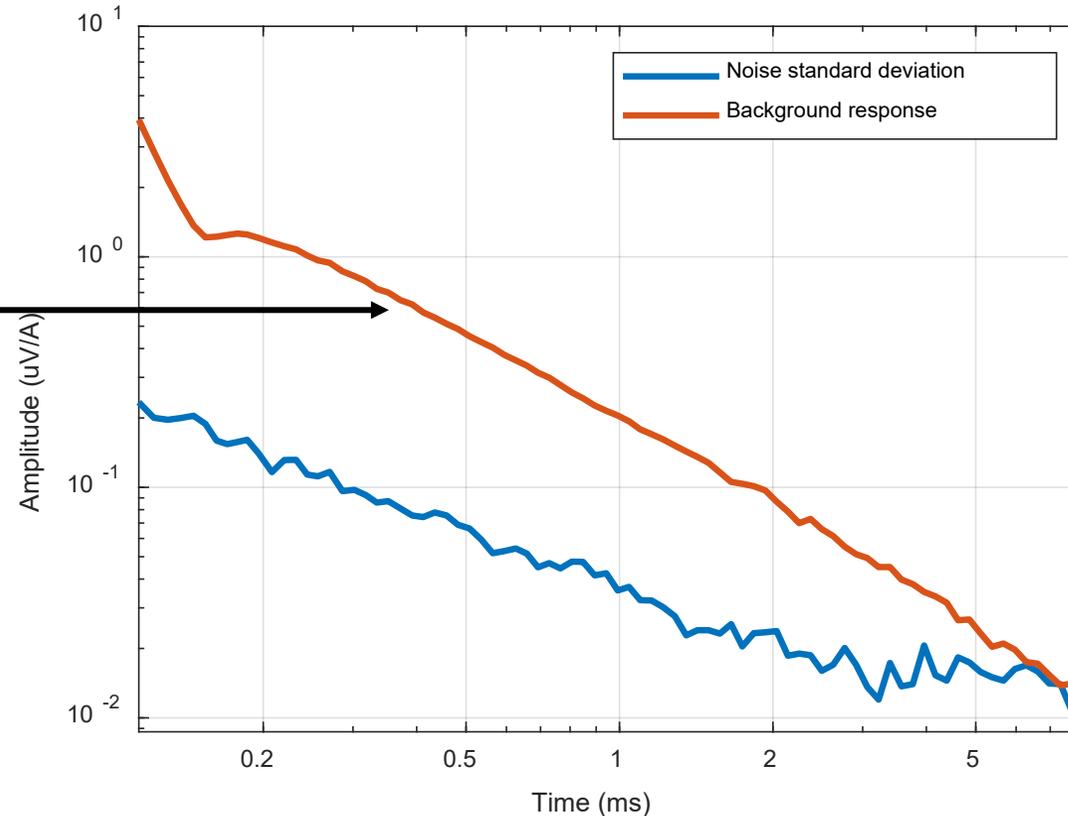


- Need to define the site-specific MM2x2 capabilities/limitations
- Polarizabilities for TOI and noise estimated from that “empty” MM sounding used to determine Classification Depth (sufficient signal above noise over multiple channels required for classification) – 0.8m
- Modelling indicates that a large ISO at 0.87 m should be easily detectable in MetalMapper data at early times (< 0.5 ms).
- This is clearly not the case as the missed QC seed is not detected at all- suggests that sensor/environmental noise is not the limiting factor for target detection and classification here.



# METALMAPPER 2X2 CLASSIFICATION DEPTH

- Background response also limits our ability to detect and classify
- Mean background response amplitude for background measurement used for missed QC seed (*high for z-components that are most strongly coupled with soil response*)
- Requiring the worst-case detection threshold to be 2x the background response gives results more consistent with site observations
- Maximum depth for reliable MM classification is **0.65 m**



Add Screener sources with predicted depth  $\geq 0.65\text{m}$



# UPDATED DIG LISTS, NEXT STEPS



- Re-evaluation of the data resulted in identifying an additional **2096** sources as potential deep TOI to be dug using full CWM protocols (1864 big/deep, 232 deep MetalMapper)
- Current dig list – went from **~94%** reduction in clutter digs to **~82%**, but still saving **>14k** CWM digs
- Next steps: dig potential deep targets, revise site to low probability CWM to dig remaining SPAs with CA Contingency protocols
- Big picture/reality check: Use other available information to make this determination- no CWM recovered from SPAs so far (all empty rounds, CWM only from SRAs/burial pits)
- CWM Digs >25x cost of Contingency (significant additional personnel- contractor and government- fully staffed personnel decontamination station, rescue team, mitigation team; air monitoring equipment; much slower dig rate)– estimated **dig savings >\$37M**



# LESSONS LEARNED



- Don't be so quick to accept 'too deep for classification' when seeds are missed
  - need vertical CSM re-analysis (recovered IOC) prior to RCA/CA close out
- Account for differences in depth capabilities when multiple systems
  - detection depth does not always equal classification depth
- Use all the data you have
  - full library match may not work, but there is still usable information





THANKS!



Thank you to co-authors and  
Laurens Beran

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