Lessons-Learned from Design / Application / Approval for Exclusion Zone Reductions

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SAGEEP 2025/3rd MRM Denver, Colorado USA

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Presentation Topics

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- Basic Definitions, Options, & Tasks
- Relevant Background
- Things to Evaluate (Upfront)
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  - MSD Bin Inconsistencies (Draft Phases)
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- Things to Re-evaluate (Feedback)
  - Wall-Thickness Considerations
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  - Classification Depth Considerations
  - Feedback Summary (Findings vs Solutions)
- Recommendations
- End of Presentation

Preliminary Statement

"For the project example presented, the maximum EZs/MSDs were implemented through the entire digging process to date, however, all AGC data and field preparations were made with results tracked, as if reduced MSDs were implemented."

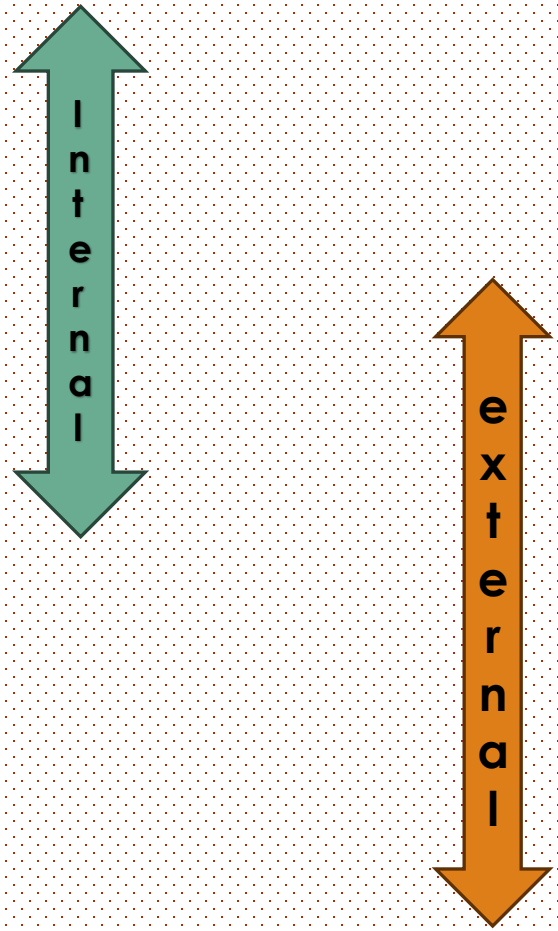
In other words, no persons (UXO Techs, Recreational Visitors, Installation Workers) were in danger.

MSD 1 digs remain, the group with the smallest-size, so leveraging AGC to reduce MSD is still of great interest.

We did receive all AGC / other approvals to date for the MSD process, simply hadn't reached DDESB yet.

Personnel Involved & Communications (1 of 2)

- **PREPARATION & INTERNAL FEEDBACK**
  - Prime Contractor (GSI)
    - Senior Scientist & Coordinator
    - UXO SMEs
    - GIS SME
    - Project/Program Manager
  - Geophysical Contractor (TPMC-WRT JV)
    - Project Geophysicist
    - QC Geophysicist
    - DAGCAP Quality Manager
- **REVIEW & EXTERNAL FEEDBACK**
  - Government Oversight / Management
    - QA Project Geophysicist / AGC SME
    - DAGCAP / EMCX / AGC SME
    - UXO SMEs
    - Explosive Safety Document Reviewers
    - Project/Program Management



Personnel Involved & Communications (2 of 2)

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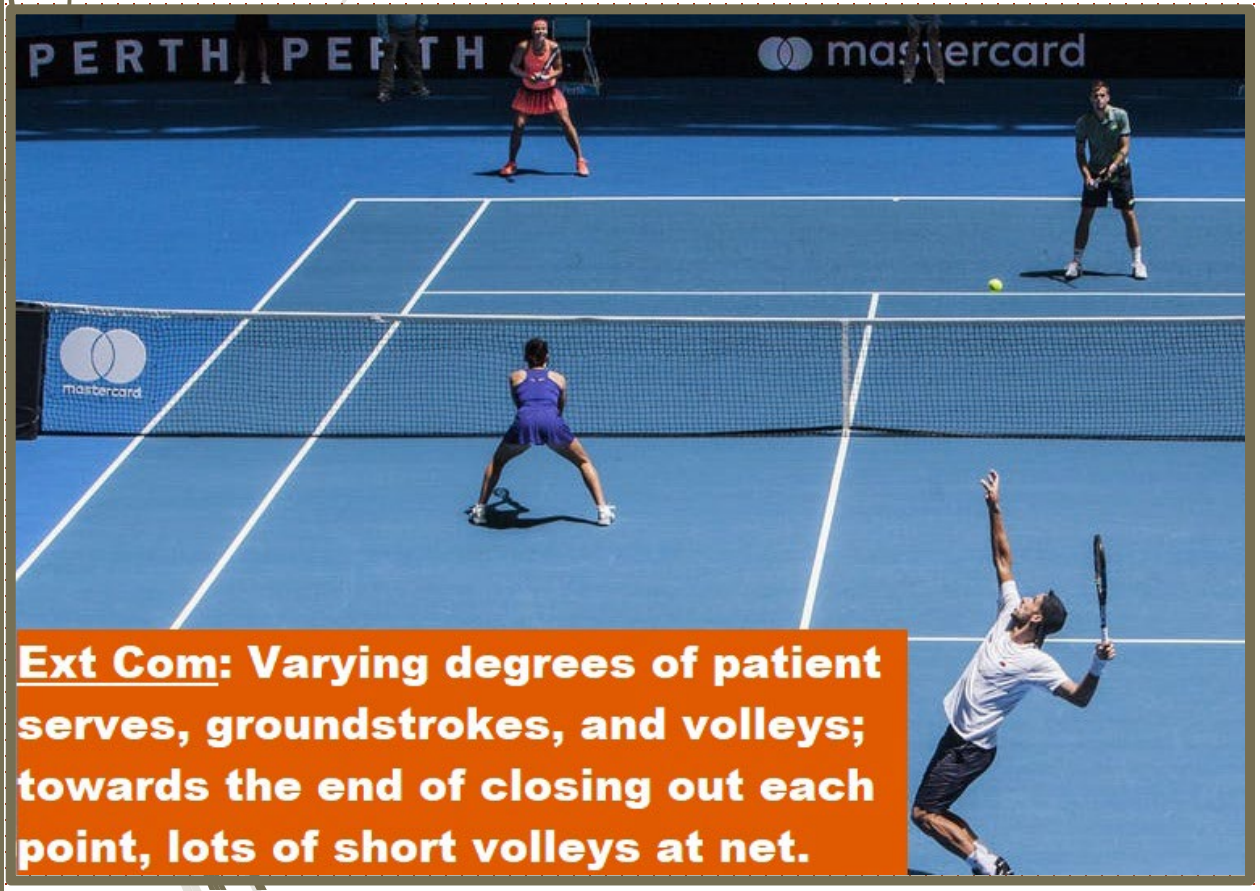
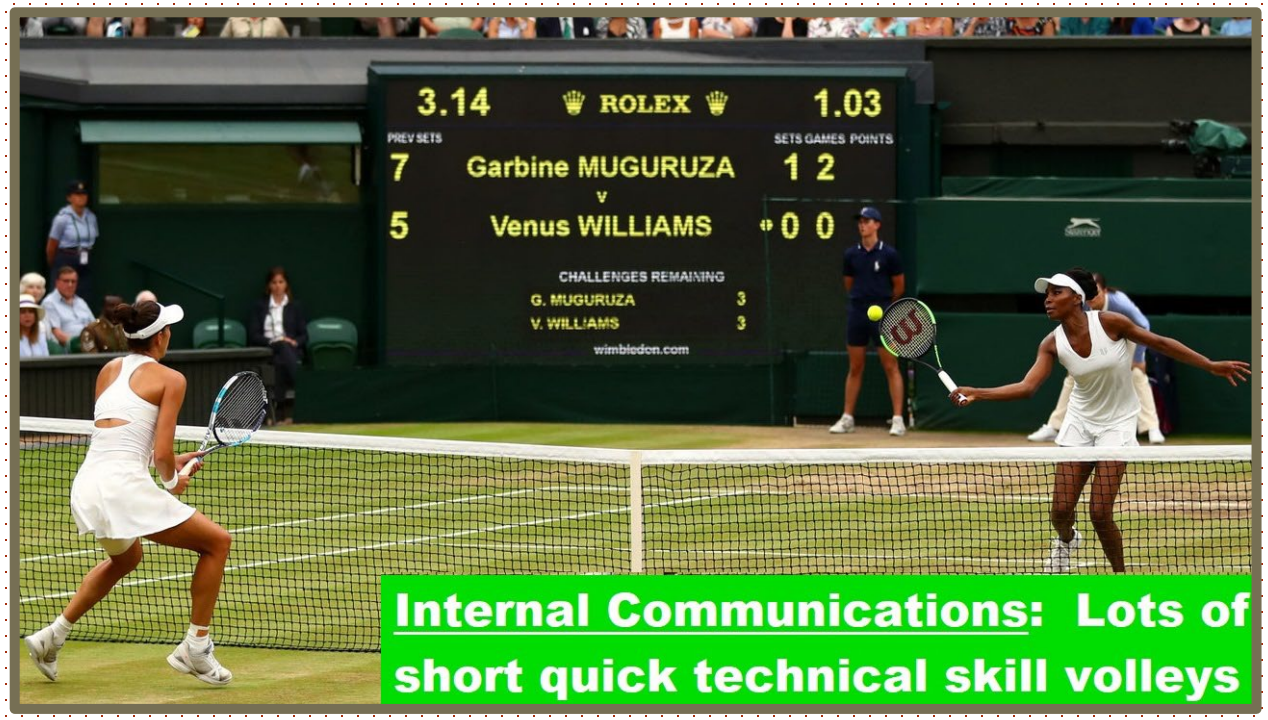




Basic Definitions, Options, & Tasks

- **Definitions:**
  - Exclusion Zone (EZ): Area in which non-essential personnel (i.e., personnel without safety training and technical skills/knowledge) are not allowed within during specific operations (i.e., in our case, intrusive work during ordnance-related investigation); and
  - Minimum Safe Distance (MSD): linear distance to which non-essential personnel must remain outside of in all directions; EZs can be made from drawing arcs from MSDs and, in the case of multiple dig teams or multiple active sites, multiple arcs must be drawn.
- **Commonly-Used EZ Options:**
  - Administrative[1]: communicate to installation that workers must avoid building access or other mission critical operations must stop during intrusive operations. For some project sites this requires evacuation of off-base residents and/or on-base workers;
  - Physical[1]: checkpoints, barriers, locked gates, etc., at set distances; and
  - Engineering Control[1]: structures which eliminate/reduce EZs by reducing potential harmful effects (e.g., fragmentation, pressure) from unintentional detonation.

[1]*Can be disruptive and/or logistically unfeasible pending types/sizes/EZs of munitions, relative to the installation mission and other active land use requirements on various sites.*

- **AGC-to-MSD Preparation Tasks:**
  - ESS Portion: summarize the basics of tasks involved and personnel assigned;
  - AGC Portion: understand HOW targets will be grouped into similar size/shape related 'bins' (e.g., small-med-large, 1-2-3), WHAT parameters will be leveraged for the size/shape/quality assessment, and LIST the assigned maximum MSD for each 'bin';
  - Dig Portion: logistically plan investigations based on the MSD assignments; and
  - SOPs/Memos: Document procedures to implement and evaluate (see slides 11-13).

Relevant Background

- **Backdrop:**
  - **Purpose**: Complete TCRA with minimal impacts to installation mission;
  - **Site Info**: ~ 25-acre property with beach, camping, and overarching recreational mission, across a site known/suspected to contain munitions from fuzes to bombs;
  - **Target of Interest (TOI) List Properties**: included both ferrous/non-ferrous, thick / thin-walled items, and multiple make/mod numbers from the same munitions' type; and
  - **Potential TOI List Complications**: list of items may have complications discerning between electromagnetic size[1] and physical size[2], lending itself to the potential for two items of different physical size having the same electromagnetic size or vice-versa.

[1]*Electromagnetic size is the estimated size based on the AGC response properties.*
[2]*Physical size is the measured size in the field with calipers and/or rulers.*

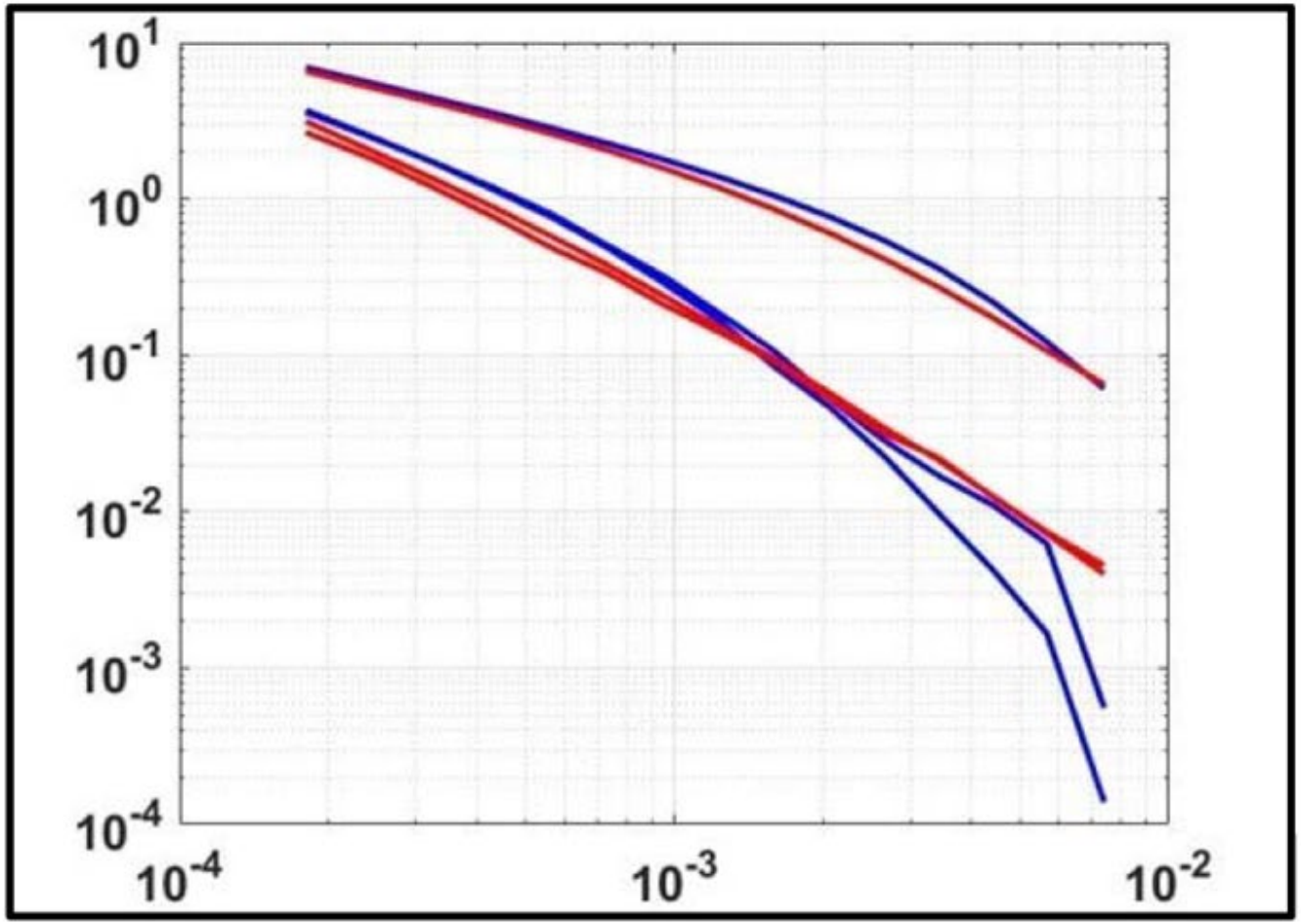
- **Project Groundrules:**
  - **SOPs**: Reviewed/approved through multiple rounds of internal discussions (*GSI* & *WRT*), external discussions (*USACE* & *EMCX*), and programmatic discussions (*AF* & *USACE*).
  - **MSDs**: Intrusive investigation results will be monitored for what MSD should have been chosen. There are no active safety concerns (only prepping for later) as the revised ESS with multiple MSDs was not approved (in time) prior to intrusive investigations; and
  - **Revisions**: Surprises would imply SOP revisions after Technical Memorandum approval.

- **Parameters to Evaluate:**
  - **Size**: Polarizability Amplitude(s), single value or range of values, pending # examples;
  - **Quality Factors Evaluated**: Polarizability Noise Level (Size Estimation Confidence), Polarizability Noise Suitability (Size Estimation Usability); and
  - **Quality Factors Finalized**: Weighted Factor Source Size (based on the # of Sources).

Things to Evaluate (Upfront)?

As part of the SOP preparation process.

Polarizability Curve Overlap



Polarizability (Shape) Curves for Cooper Bomb (red) and 3.5-inch Rocket (blue)

Physical Size

C. Bomb > 3.5 Rocket

Electromagnetic Size

C. Bomb ~ = 3.5 Rocket

MSD Distance

C. Bomb < 3.5 Rocket

Thus, physical size not always equal to EM size; other common examples include different materials and/or thicknesses of same physical size doesn't equate

So whats the problem? The two MSDs are ~100-ft different, so they must be grouped together with the larger value because the curves are indistinguishable

MSD Bin Inconsistencies (Draft Phases)

Library Item	Size	MSD Bin (Initial)	MSD New Bin (FINAL)
'HJ_1000lbs'	113.03	3	3
'250-lb GP Bomb_Mk81_HPt1_85'	89.11	3	3
'100lb-M38A2'	87.55	2	3
'HJ_500lbs'	80.64	3	3
'100-lb GP Bomb_AN-M30A1_HPt1_6'	64.96	2	3
'250-lb GP Bomb_AN-M57_VND_83'	50.1	3	3
'250-lb GP Bomb_AN-M57_VNU_82'	40.74	3	3
'100-lb GP Bomb_AN-M30A1_VU_4'	32.07	2	3
'100-lb GP Bomb_AN-M30A1_VD_5'	29.33	2	3
'250-lb GP Bomb_Mk81_VU_84'	29.25	3	3
'100-lb GP Bomb_AN-M30A1_VD_7'	22.66	2	3

Can't allow two MSD bins (2, 3) to be consistently interwoven when sorted by size --> chose higher bins (3) and MSD allocation

Library Item	Size	MSD New Bin (Rev 1)	MSD New Bin (FINAL)
'37mm Projectile_M74 AP-T_HN1_108'	0.38	1	1
'37mm Projectile_M59_VNU_114'	0.34	1	1
'37mm Projectile_M74 AP-T_VNU_109'	0.29	1	1
'37mm Projectile_M74 AP-T_V-D_344'	0.28	1	1
'MK2 grenade Short'	0.27	1	1
'37mm Projectile woFuze_Mk2 HE_HN1_112'	0.24	1	1
'37mm Projectile wFuze_Mk2 HE_VND_111'	0.22	1	1
'MK2 grenade Length= 11 cm'	0.22	1	1
'37mm Projectile_Mk1 LE_Hpt1_113'	0.18	0	1
'MK2 grenade Length= 8 cm'	0.15	0	1

Cannot have the same type of rounds (grenade, 37mm projectile) and, in turn, MSD, in two different bins --> chose higher bin (1) and MSD assignment

Library Item	Size	MSD New Bin (Rev 2)	MSD New Bin (FINAL)
'M6-Fuze'	0.1	0	1
'M6-Fuze'	0.1	0	1
'M42A1-Flare'	0.05	0	1
'M42A1-Flare'	0.05	0	1
'FiringDevice'	0.02	0	1

Eventually reach a point where discerning an extra bin, particularly at the point wherby the smallest size becomes difficult to discern from small. Also, the MSD benefit diminishes rapidly, given min team separation.

Submittals/Reviews of SOPs (1 of 2) – summary

- SOP 1 (Generic) More of an introductory SOP which includes summary details
  - Guidance on MSDs and summarize complexities (e.g., electromagnetic size overlaps);
  - Table of Simplified MSD Decisions (i.e., TOI list grouped into MSD bins after sorted by MSD and electromagnetic size); and
  - Listing the SME reviewers from internal and external to the contractor for individual deliverable (i.e., dig-lists with assigned MSD annotations) approvals prior to digging.
- SOP 2 (AGC-centric) More detailed DAGCAP SOP focused on analyst methods
  - Re-iterate additional complexities, with solutions (e.g., round up one MSD level);
  - Review analyst steps for how to handle inconclusive or lesser quality solutions (e.g., round to maximum MSD) and manual review (e.g., relative to other TOI positions): and
  - Discuss independent QC reviews, etc.
- SOP 3 (Assessing 'Success') Imbedded in SOP or Memorandum outside ESS but
  - Tied to principles and methods introduced in the ESS SOPs;
  - Account for condition[1] and construction[2] , particularly thin-walled or non-ferrous;
  - Define how success is measured (e.g., MSD[1] only, physical/EM size[1,2] + MSD[1]) and what types of items (e.g., MEC/MD, MEC/MD/seeds, all) the standards apply; and
  - Generate Field Evaluation Chart for dig teams of MSD versus physical properties.

[1]condition (e.g., crushed, compromised, separated) may have an effect.
[2]construction (e.g., materials, thicknesses) effects ability for condition deteriorations

Submittals/Reviews of SOPs (2 of 2) – 'defining success' (e.g., field evaluation chart) project-specific for dig team

Size Bin	Type of Find	Evaluation / Communication / Documentation Details
MSD 3 (638 feet)	Intact Munitions	Only of concern if item is munitions-related, size > measured dimensions (X3" x Y3"), and MSD 3. Communication/Consequences of decision is BLANK. List docs to backup decision or modify process.
MSD 2 (390 feet)	Intact Munitions	Only of concern if item is munitions-related and size ≥ measured dimensions (X2" x Y2"). Communications / Consequences of decision is BLANK. List docs to backup decision or modify process.
	Axisymmetric Item	Only of concern if axisymmetric w/ 2 smaller dimensions > X2" x X2" and size ≥ X2" x Y2". Communication / Consequences of decision is BLANK. List docs to backup decision or modify process.
	Non munitions shape, non-ferrous, geology, or no find	No concern to invoke MSD. Automatic pass as no safety issues associated with MSDs. No change.
MSD 1 (144 feet)	Intact Munitions	Only concern if item is Large ISO (4" x 12") or munitions-related and size > X1" x Y1". Communications / Consequences of decision is BLANK. List docs to backup decision or modify process.
	Axisymmetric Item	Only of concern if axisymmetric w/ 2 smaller dimensions > X1" x X1" and size ≥ X1" x Y1". Communications / Consequences of decision is BLANK. List docs to backup decision or modify process.
	Non munitions shape, non-ferrous, geology, or no find	No concern to invoke MSD. Automatic pass as no safety issues associated with MSDs. No change.

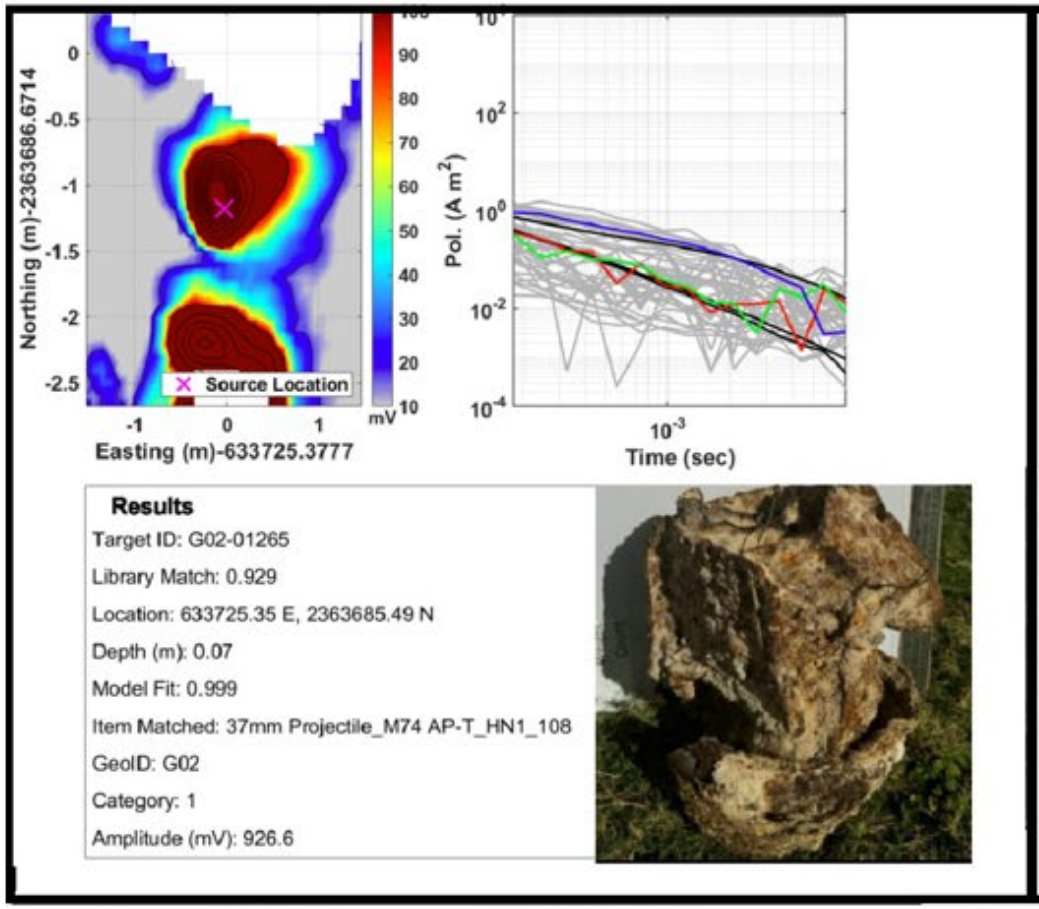
Application of ESS-Related AGC SOPs

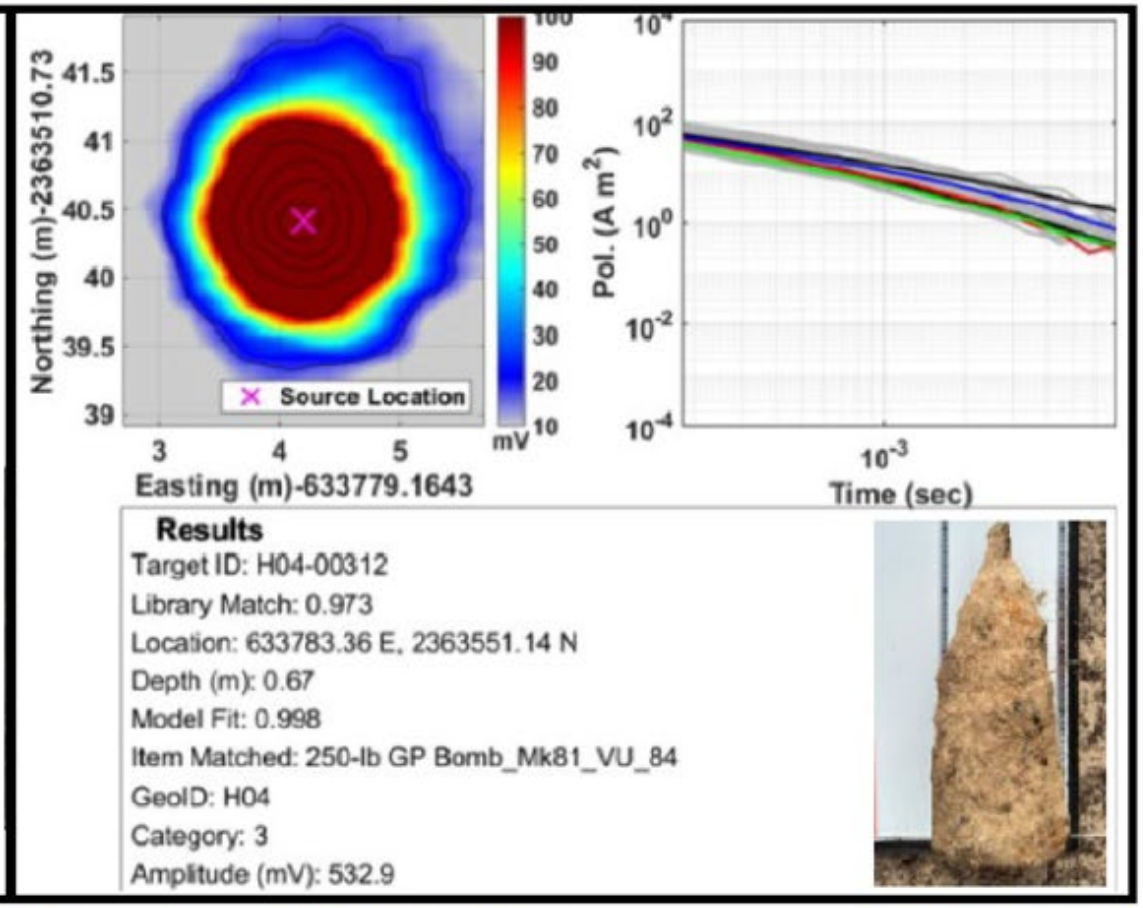
- Example Below is from Case Study, will vary from site to site. As a general rule, desiring useful 'MSD jumps' between size bins and abundance in smaller bins.
- MSD Bin 1 (Small)
  - Examples include fuzes through 60mm mortars, landmines, and 2.36 rockets;
  - Physical size diameters from 0.5 to 2.5 in., with variable lengths from 3.0 to 24.5 in.;
  - Electromagnetic size Pol-Amplitudes from 0.05 to 3.14 Amperes^2; and
  - MSD ranges from 0 to 144 feet, with MSD of 144 feet chosen for the group.
- MSD Bin 2 (Medium-Large)
  - Examples include 75mm projectiles, 3.5 rockets, and 25-lb bombs;
  - Physical size diameters from 3.0 to 5.2 in., with variable lengths from 14.5 to 26.5 in.;
  - Electromagnetic size Pol-Amplitudes from 1.73 to 7.19 Amperes^2; and
  - MSD ranges from 239 to 390 feet, with MSD of 390 feet chosen for the group.
- MSD Bin 3 (Huge)
  - Examples include 100-lb practice bombs (thin & thick walled) and 500-lb bomb;
  - Physical size diameters from 8.1 to 14.0 in., with variable lengths from 40 to 57 in.;
  - Electromagnetic size Pol-Amplitudes from 22.65 to 113.03 Amperes^2; and
  - MSD ranges from 440 to 638 feet, with MSD of 638 feet chosen for the group.
- Results w/ 50% SF are ≤ 0.865 (bin 1), 0.866 – 11.33 (bin 2), and > 11.33 (bin 3)

Things to Re-Evaluate (Feedback)?

As part of the intrusive investigation process.

Wall-Thickness Considerations (1 of 2)

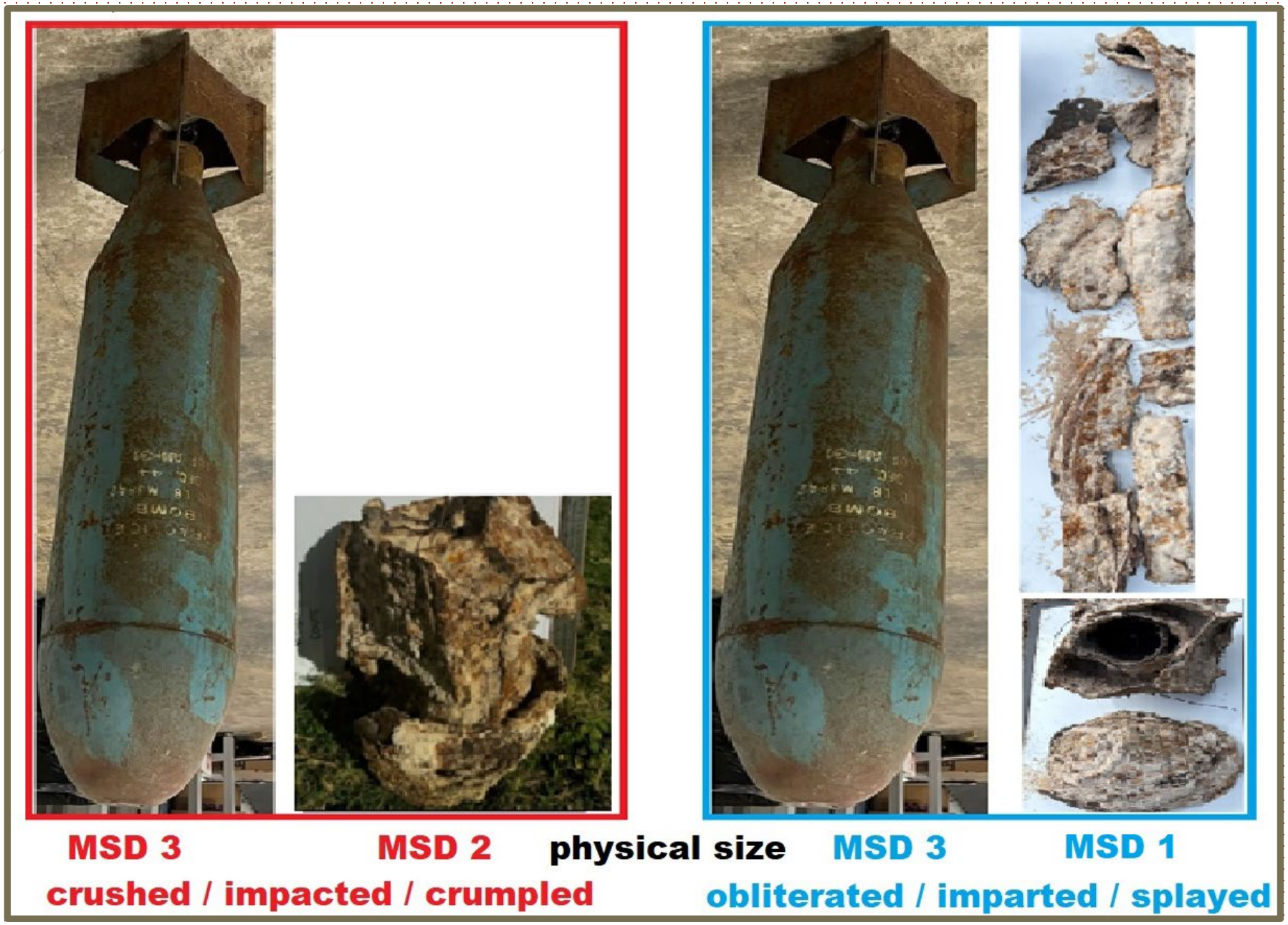




splayed pieces (MSD 1) < crumpled/crushed (MSD 2) < preserved (MSD 3)

AGC Results for Crushed thin-walled 100-lb bomb munition (left) and thick-walled 100-lb munition variant (right). The thick-walled muntion size, shape, etc., were preserved adequately to emplace into MSD Bin 3, while thin-walled was not preserved to which AGC appears to have classified near to surface (smaller) broken off pieces as to the reason for the incorrect MSD assignment.

Wall-Thickness Considerations (2 of 2)

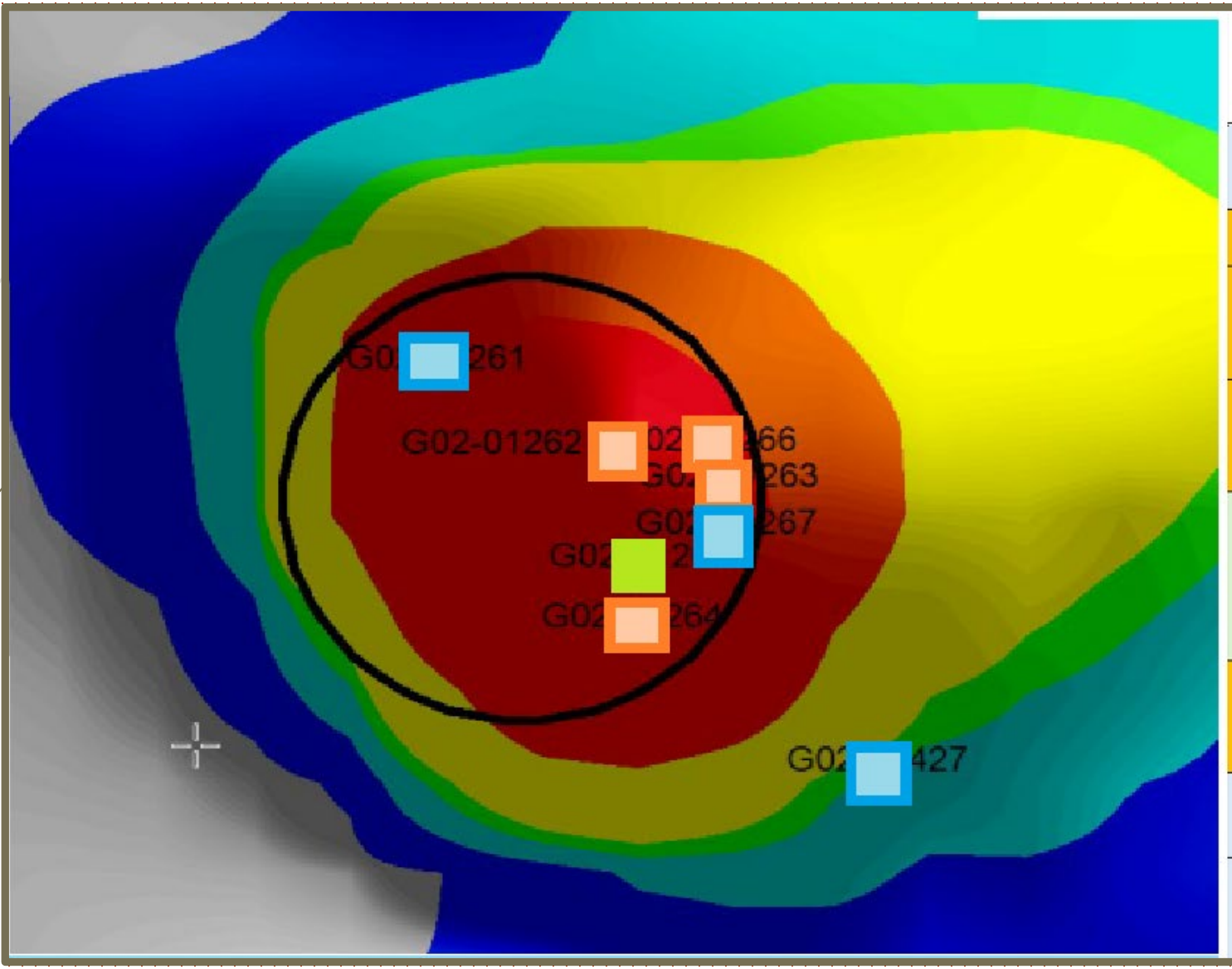


Horizontal Offset Considerations (1 of 3)

Source ID	Target ID	Category	Library Confidence	Best Matching Item	Number of Samples	Source Depth (m)	Size	Maximum Source Cluster Size	MSD Bin	Status
G02-01261	N/A	3	0.8652	37mm Projectile_ M59	5	0,02	0.34	0.38	1	Below confidence threshold
G02-01262	N/A	3	0.9506	Rocket Motor	77	0.10	1.84	2.63	2	Converted to a duplicate pick
G02-01263	N/A	3	0.8984	Amour Piering Landmine_ M2A1	14	0.41	2.55	3.31	2	Converted to a duplicate pick
G02-01264	N/A	3	0.8916	60mm Illumination Mortar M8 3A1	43	0.16	1.99	1.99	2	Converted to a duplicate pick
G02-01265	G02-041	1	0.9293	37mm Projectile_ M74 Amour Piercing Tracer	113	0.07	0.52	0.89	1	Selected for intrusive investigation
G02-01266	N/A	3	0.8911	60mm Illumination Mortar M8 3A1	4	0.52	2.43	2.43	2	Converted to a duplicate pick
G02-01267	N/A	3	0.8002	3.5-inch Rocket_M3 0A1	1	0.64	4.41	4.41	2	Below confidence threshold
G02-01427	N/A	3	0.7426	2.36-inch Bazooka Warhead_ M6	2	0.04	0.96	0.96	2	Below confidence threshold

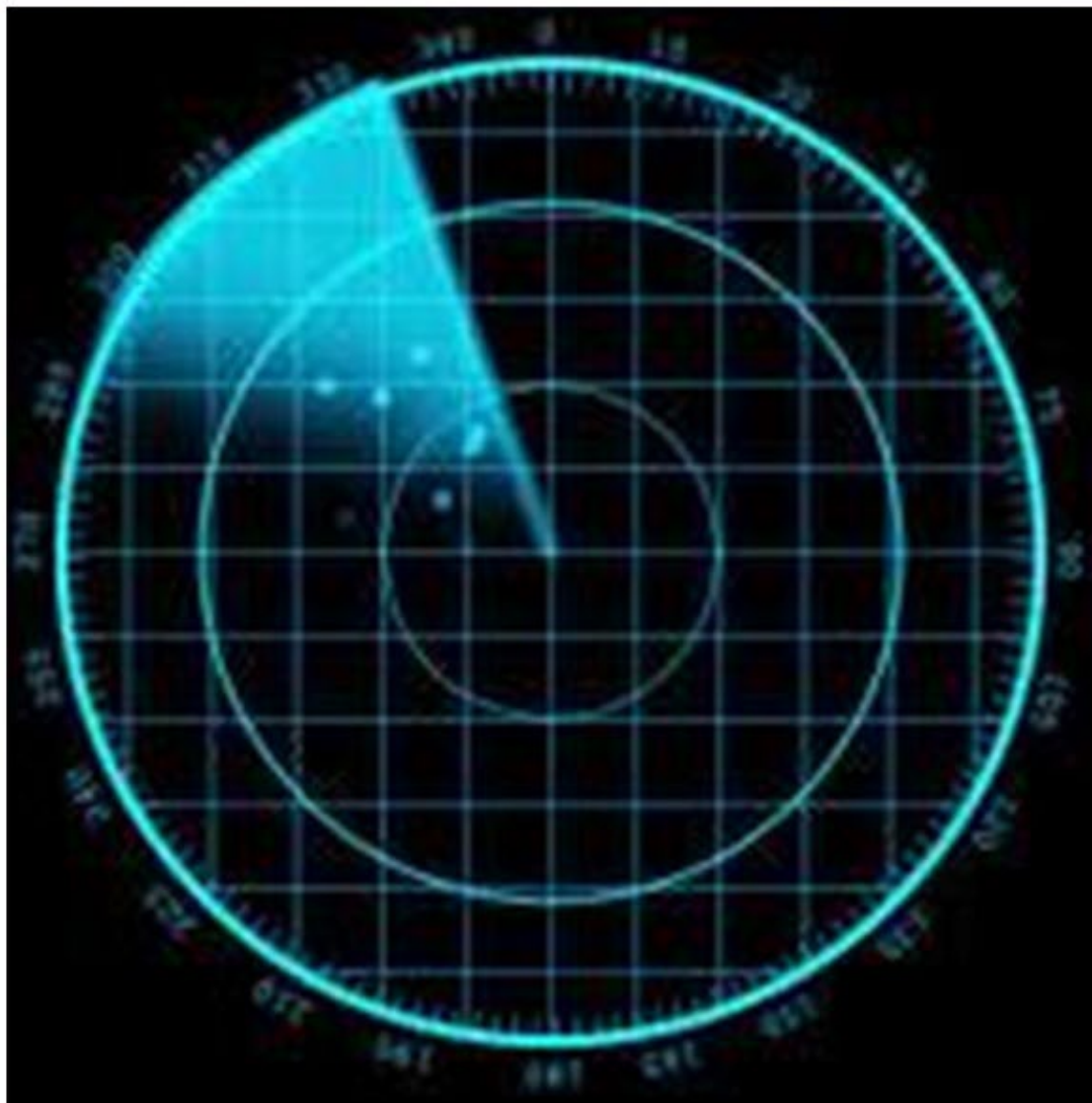
SAME CRUSHED MUNITION

Horizontal Offset Considerations (2 of 3)



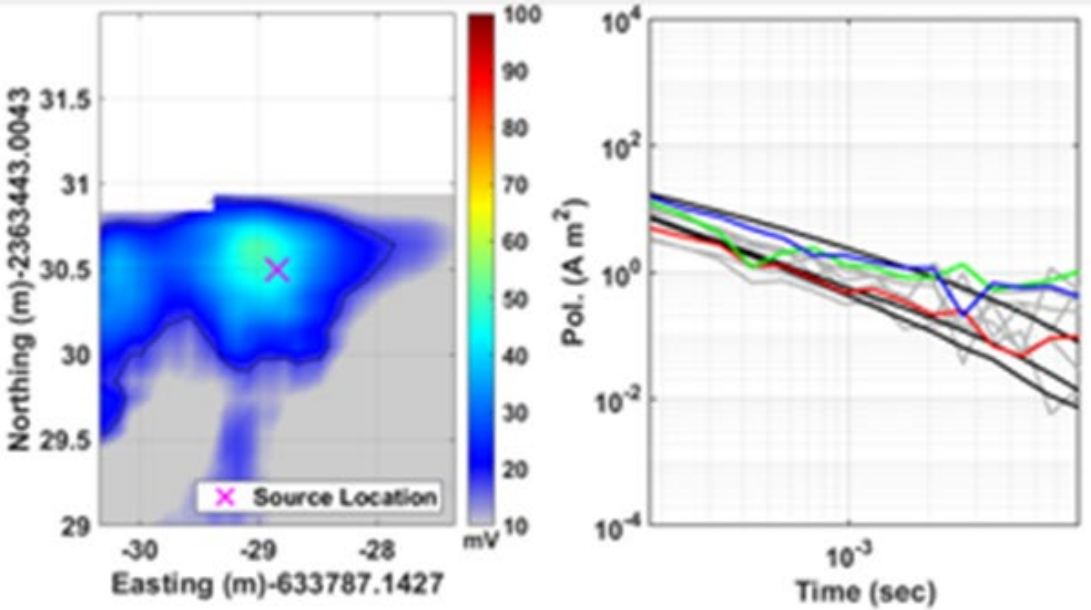
Number of Samples	Source Depth (m)	Size	Maximum Source Cluster Size	MSD Bin
5	0,02	0.34	0.38	1
77	0.10	1.84	2.63	2
14	0.41	2.55	3.31	2
43	0.16	1.99	1.99	2
113	0.07	0.52	0.89	1
4	0.52	2.43	2.43	2
1	0.64	4.41	4.41	2
2	0.04	0.96	0.96	2

Horizontal Offset Considerations (3 of 3)



Once the selected target location (x, y) is marked, a (25cm?) digital search for other sources (lesser threshold, duplicate) with variable (larger) MSDs due to larger predicted size characteristics. If this occurs than a manual override is recommended

Classification Depth Considerations (1 of 5) – incidental finds



Results

Target ID: H06-00085

Library Match: 0.914

Location: 633758.30 E, 2363473.50 N

Depth (m): 0.70

Model Fit: 0.949

Item Matched: 3.5-in Rocket_M30A1_HPt1_96

GeoID: H06

Category: 1

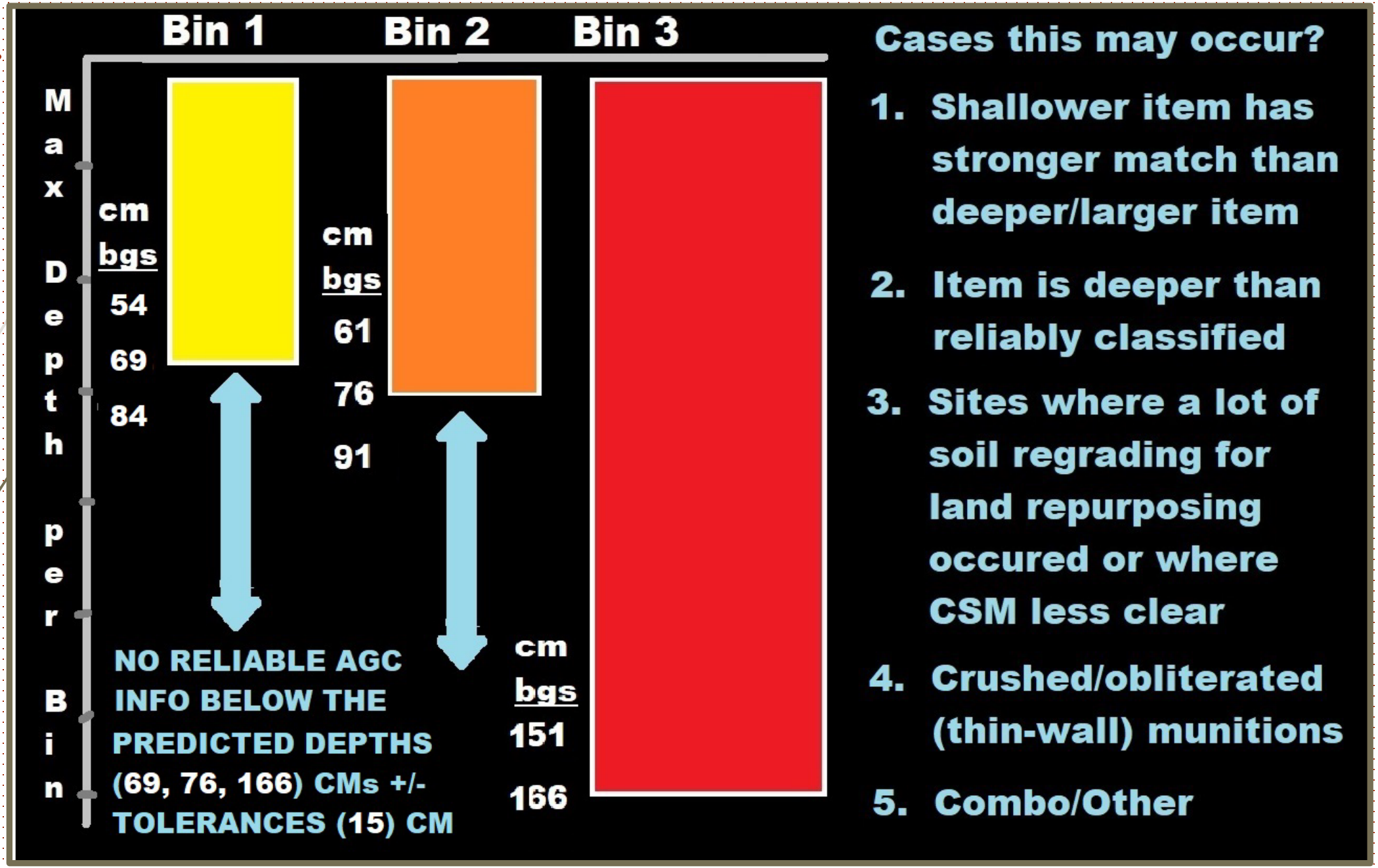
Amplitude (mV): 46.0

Top item is closer to estimated depth and representative of AGC..

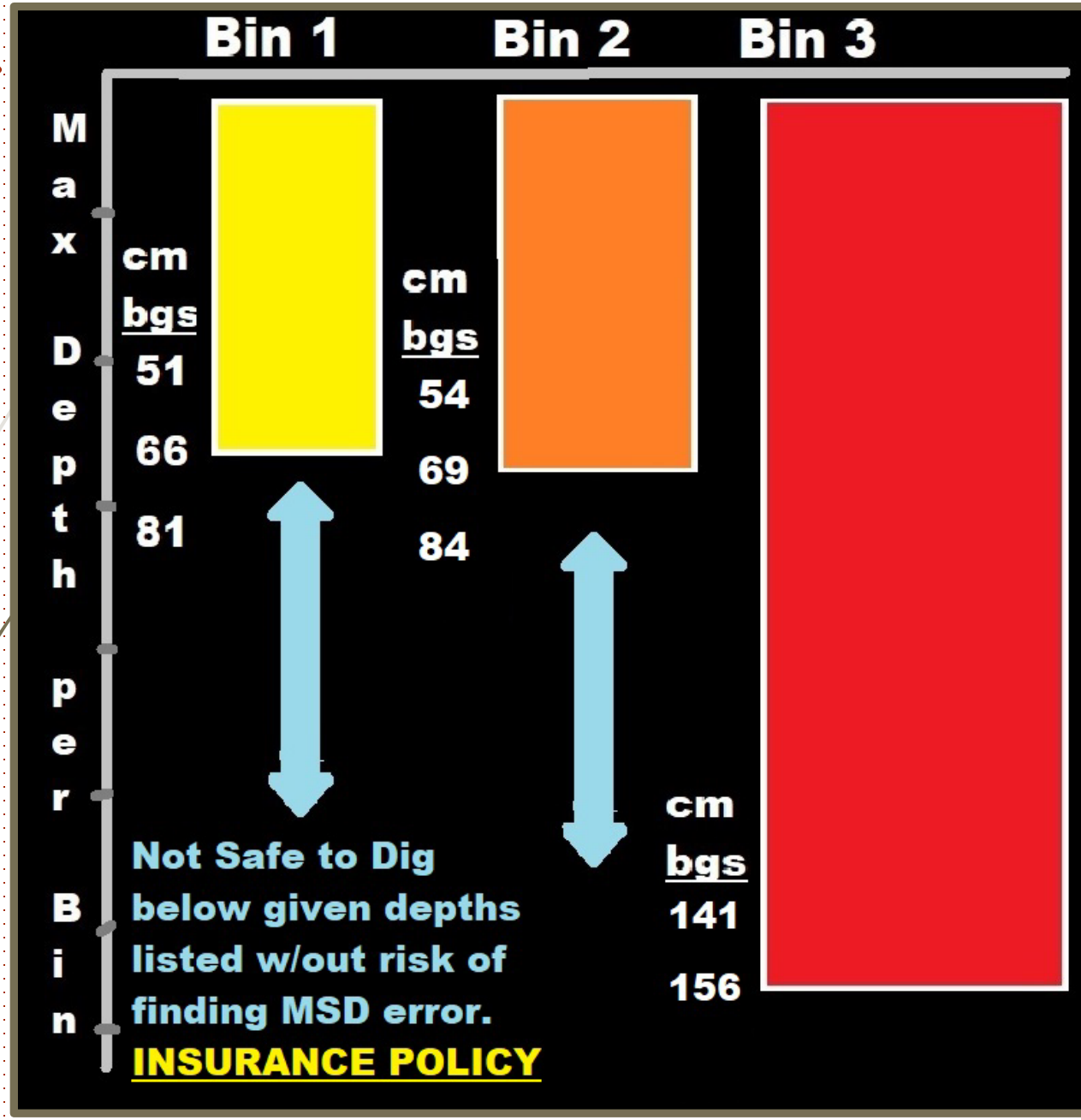
During the process a realized concern is digging below AGC classification depth (to clear the hole) for given size item should require an increased MSD or digging should stop.

37mm munitions item encountered coincident at a depth much deeper (95 cm) than maximum AGC depth for 37mm projectiles (38cm).

Classification Depth Considerations (2 of 5) – AGC limitations



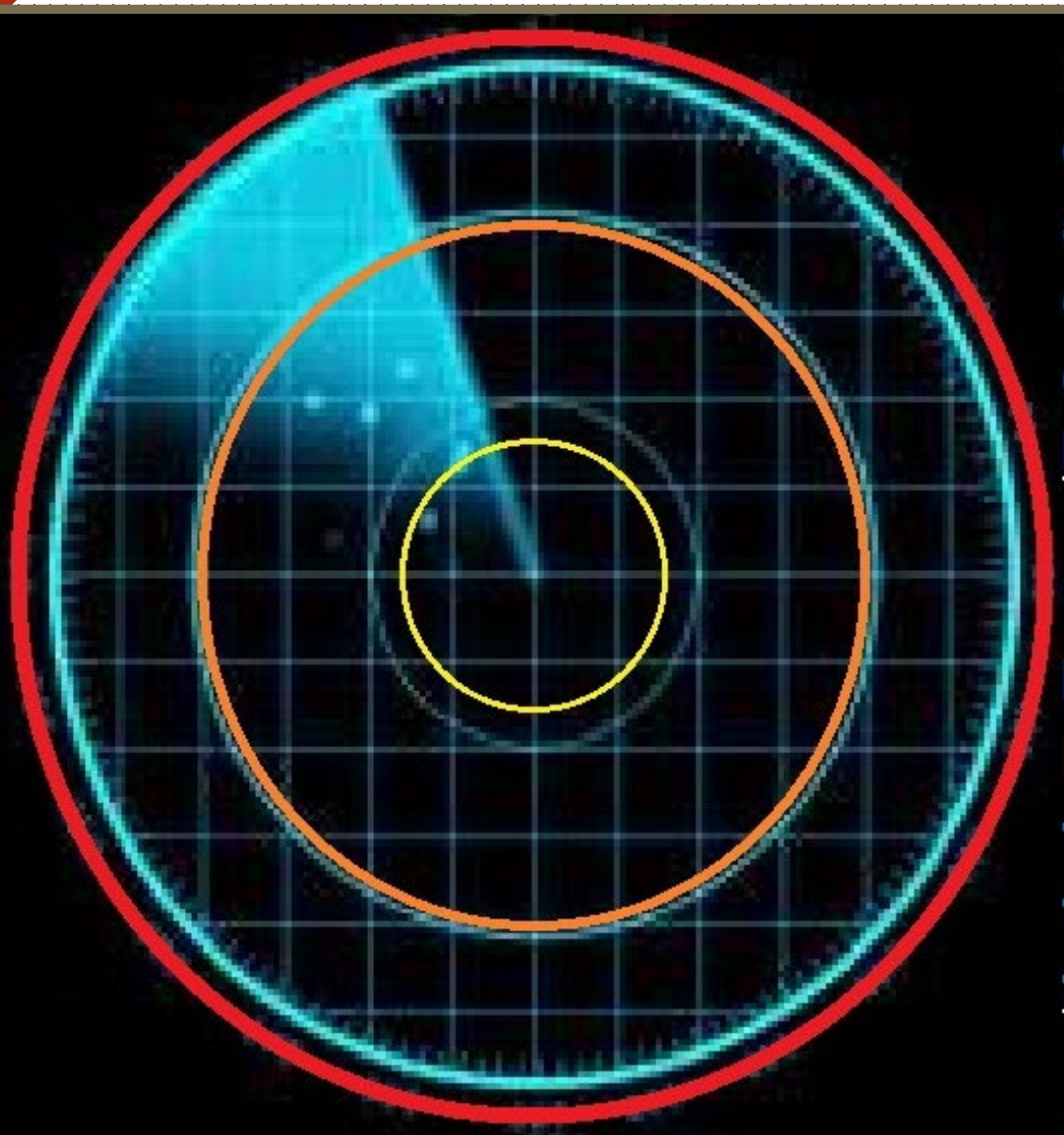
Classification Depth Considerations (3 of 5) – dig safe policy



NEXT STEPS TO CONSIDER:

1. Calibrate predicted depth to anticipated dig depth to not impact top of item to ensure MSD field safety. (Remove thickness, aka half diameter of item)
2. Discuss whether you want to consider AGC prediction of depth tolerance (15) into the equation (51, 54, 141) after thickness (66, 69, 156) as a factor of safety.
3. In our case, the # of items to consider between 51cm and 66cm was miniscule.

Depth Considerations (4 of 5) – 'insurance policy' T's and C's

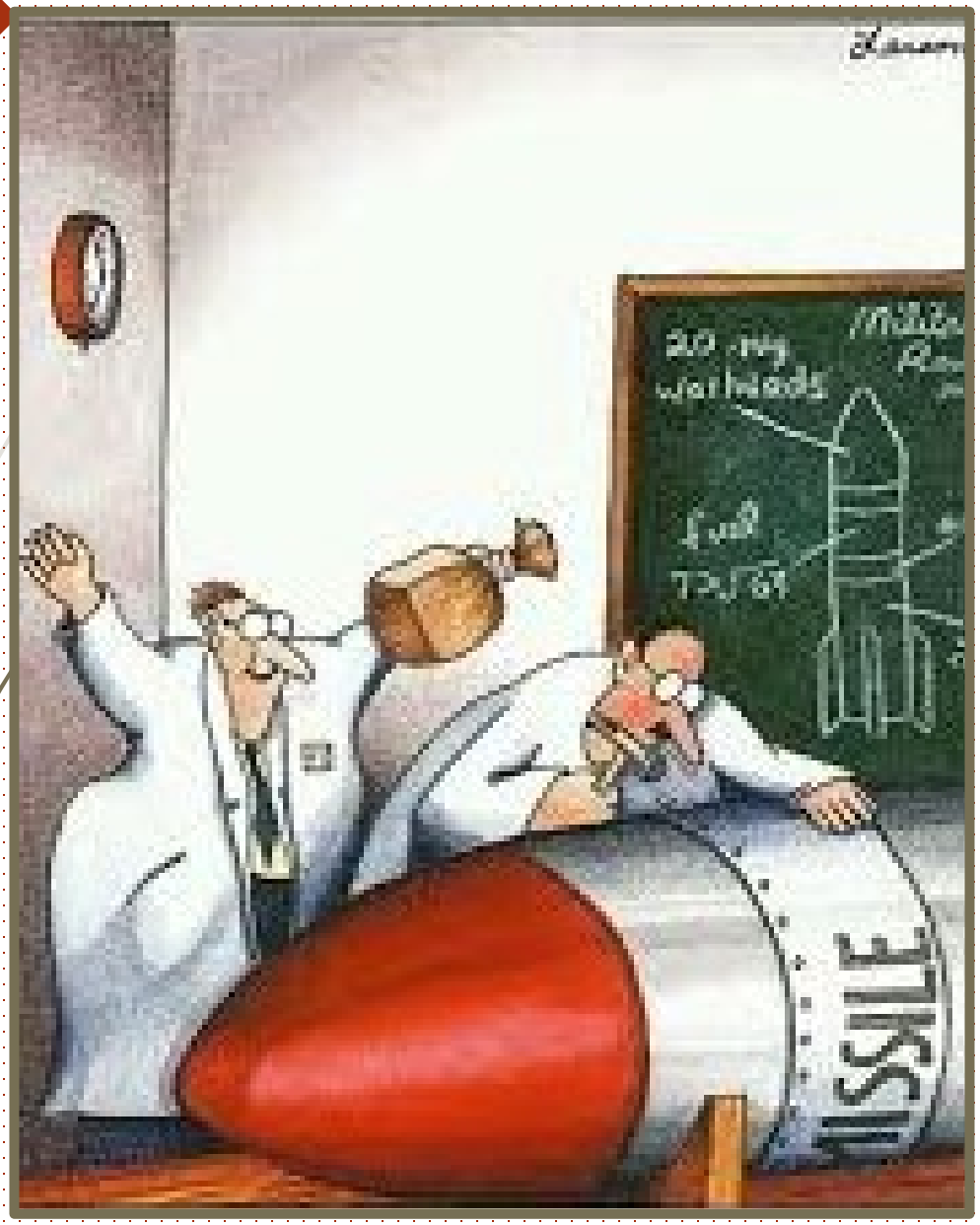


Digging > 51cm means MSD 1 (144 ft) changes to MSD 2 (390 ft) until > 54cm after which can either remain MSD 2 or increase to MSD 3, pending the AGC confidence and tolerance to the risk of losing the benefit of variable MSD use.

If you are on a project whereby the benefit between MSD 1 (144 ft) and MSD 2 (390 ft) isn't as great compared to MSD 3 or you expect more MSD 2 than MSD 1 items, then you may want to consider combining MSDs 1/2.

In our case, insurance $$ < 5% of digs.

Classification Depth Considerations (5 of 5) – gallows humor



Feedback Summary (Findings vs Solutions)

FINDINGS

- Varying degrees of thin-walled munitions do not preserve their physical or EM size. (For other sites compromised munitions may be similar but these weren't found). Thick-walled munitions preserved sizes.
- Multiple sources ('duplicates') tied to the same target location may (infrequently) arrive to a different MSD value
- Horizontal searches/extensions to clear holes may coincidentally encounter items of larger size/MSD than predicted
- Vertical searches/extensions to clear holes may coincidentally encounter items of larger size/MSD than predicted. (Following near surface breadcrumbs encounter deeper items never classified)
- Difficulty tracking field implementation for reasonable guardrails--ifs, ands, buts

SOLUTIONS

- Thin-walled munitions should be expected smaller during recovery and (at least for this site) lacked hazards due to severe deterioration and no residual explosive fillers/residues/powders observed.
- Analyst reviews search radii for largest MSD & either manually overrides the MSD from best solution or prioritize other source
- Intrusive investigation teams will stay within their radii during investigations of multiple MSD bins (different color flags)
- Intrusive investigations will stop at the maximum reliable classification depth after accounting for all factors (thickness, tolerances), or alternative solutions may involve changing MSD each step deeper.
- Color-code flags per MSD bin so there is control of horiz./vert. stop dig points

Recommendations

- Be very thorough and detailed when
  - Reviewing TOI list physical / EM sizes, MSD values, constructed materials, etc.;
  - Defining which MSD bin items belong with them and whether that is realistic;
  - Generating SOPs defining how to: complete analyses, QC/QA reviews, monitor and control intrusive investigations, and define 'success'; and
  - Determining which items do/don't have hazard when severely mis-shapen.

  In other words, take your time for complex sites with complex TOI lists.

- Considerations for minimizing field hazards imposed from MSD Bin errors
  - Color-code flags based on MSD Bins and investigate from high to low;
  - Choose highest MSD source or override preferred source with highest MSD #;
  - Limit investigations to a given horizontal offset (25cm). Do not reach to clear holes as the further anomaly was unlikely classified from this target; and
  - Similarly, limit investigations to a given depth for each MSD Bin (color-coded flag) and consider stop digging (LUCs ?) or enact larger MSD (insurance ?).

  In other words, use safety factors and control processes / procedures with SOPs

End of Presentation (Questions)

General Application Questions

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AGC-Specific Questions

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