COMPLEX SEED SCENARIOS – DOES AGC WORK AS ASSUMED IN MULTISOURCE SETTINGS?

Case Study from Former Fort Huachuca

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Agenda

1. Overview of Fort Huachuca project
2. Summary of complex seeds
3. Complex seed classification challenges
4. Investigation and analysis
5. In-depth analysis of single seed pair
6. Conclusions, implications, USACE perspectives and final thoughts

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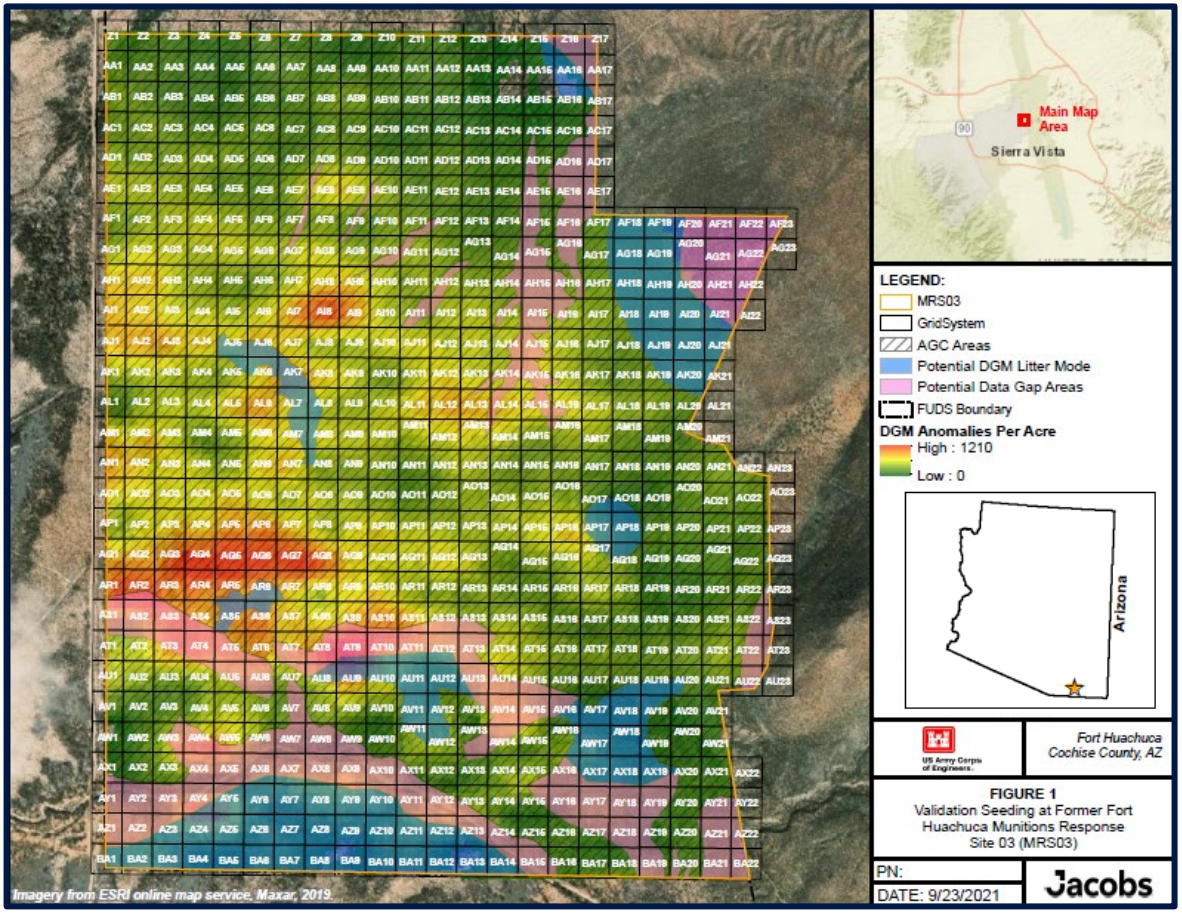
Overview of Former Fort Huachuca Project



- RA over 548-acre MRS
- Jacobs contracted to perform third-party validation seeding, included:
  1. Placing over 1,000 seeds
     - Small ISO80s
     - Horizontal orientation
     - Two depths: 0.15 m (6 in) or 0.08 m (3 in) bgs
  2. Cued survey with MM 2x2 to ensure seeds detectable and classifiable
     - Measurements had to achieve standard cued metrics
     - Achieve decision statistic of ≥ 0.9000

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Complex Seed Summary

- 100 seeds (50 pairs) emplaced in a “complex” scenario
  - Complex = two ISOs placed as a pair near each other
- Goal - provide USACE data to monitor RA contractor’s performance in multi-source scenarios
- Constraints from Seed Plan and QAPP:
  - Seeds not placed one on top of other
  - Distances allowed: touching - 0.5 m (~20 in) apart
  - Cued measurement over each seed in the pair
- Ground truth details:
  - Actual seed distances: 0.10 m (3.9 in) - 0.41 m (16.1 in)
  - Orientation
    - 1 pair perpendicular
    - 22 pairs parallel side-by-side
    - 27 pairs parallel in-line
  - All complex seeds initially buried at 0.15 m (6 in) bgs

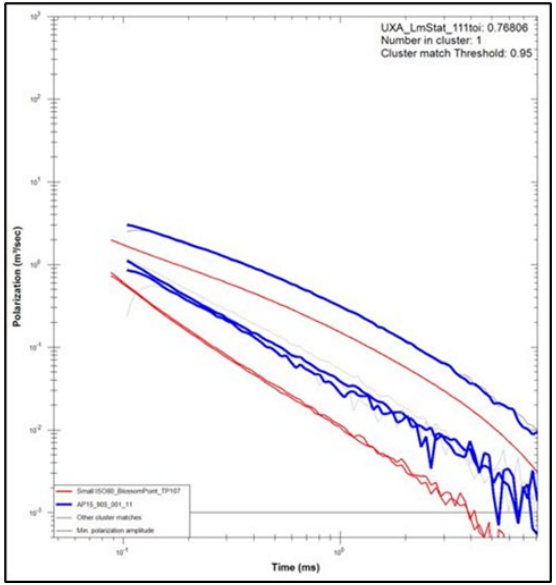

1 Perpendicular Seed Pair


22 Side-by-Side Seed Pairs


27 In-line Seed Pairs

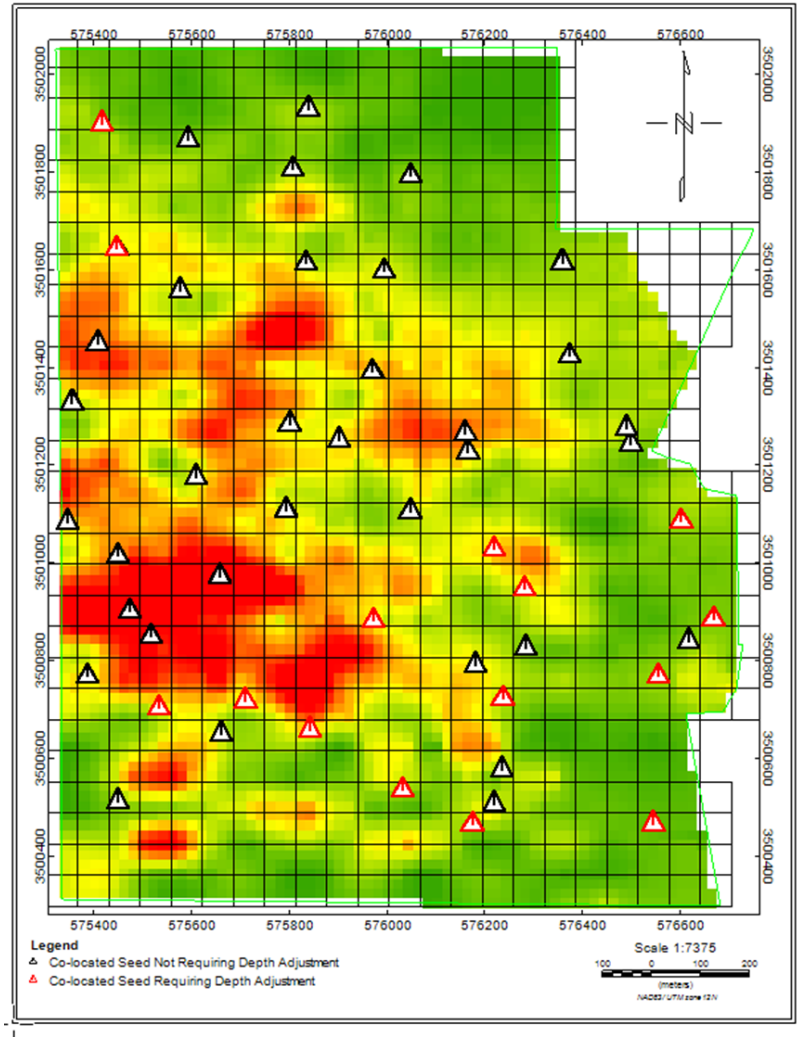
Complex Seed Classification Challenges

- 33% of complex seeds failed 0.9000 decision stat (significantly higher than single source seed failure rate)
- Following a second round of cued measurements, fail rate dropped to 19%, which was still considered high
- Failing decision statistics had an average 0.7839 and similar classification results
- Distance ranged between complex seed pairs that failed:
  - Minimum - 10.7 cm (4.2 in)
  - Maximum - 39.6 cm (15.6 in)
  - Average - 26.1 cm (10.3 in)
- In accordance with QAPP, all 19 failing seeds adjusted from 6 to 3 inches bgs and passed at shallower depth



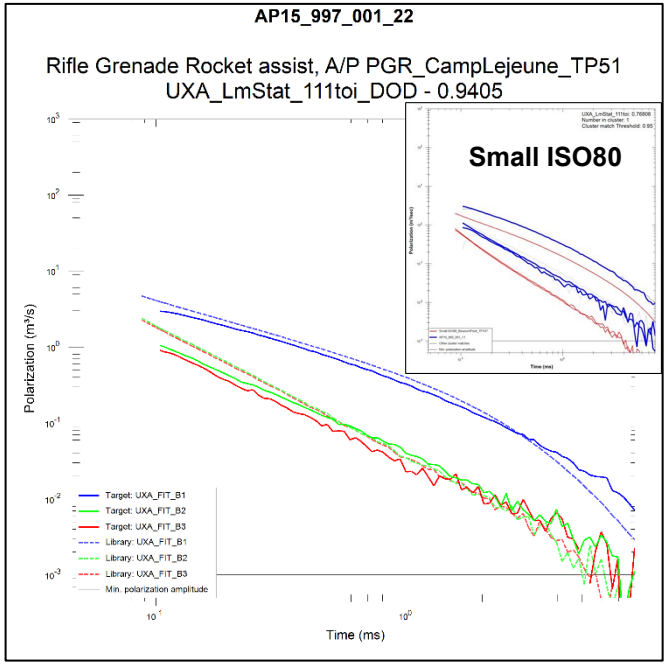
Investigation Findings

- Attempt to determine the root cause of the complex seed failures
- Map shows location of all complex seed pairs; red triangles required depth adjustment to pass
- Complex seed failures occur mostly in low - mid anomaly densities and are geographically distributed across site
- Seed pair orientation of failures:
  - 17 parallel and in-line
  - 1 parallel side-by-side
  - 1 perpendicular
- SBGs reviewed, all passed quantitative and qualitative analysis, no indication of drift issues



Investigation: What do the failed seeds match to?

- Ran failed complex seeds against entire DoD TOI library
- Failed seeds matched well to rifle grenade rocket
- Comparison made of size/decay for small ISO vs. rifle grenade vs. seed results
  - Equivalent wall thicknesses for all three
  - Rifle grenade ~63% larger than small ISO
  - Seed results ~53% larger than small ISO



TOI	Size	Decay
Small ISO	0.24	0.03
Rifle grenade	0.65	0.03
Seed results	0.51	0.04

Analysis of Single Complex Pair

-Seeds AP15_905 and AP15_997

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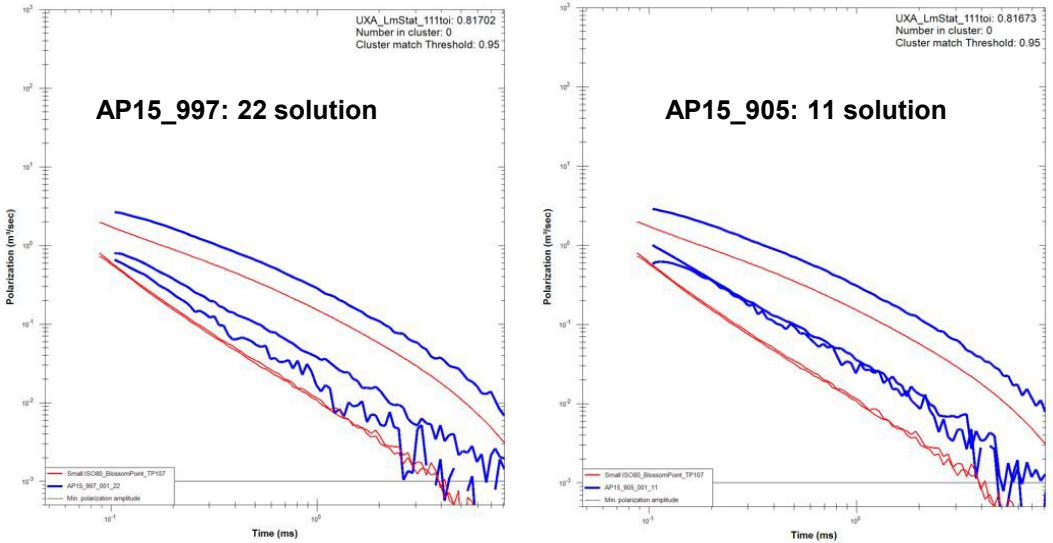
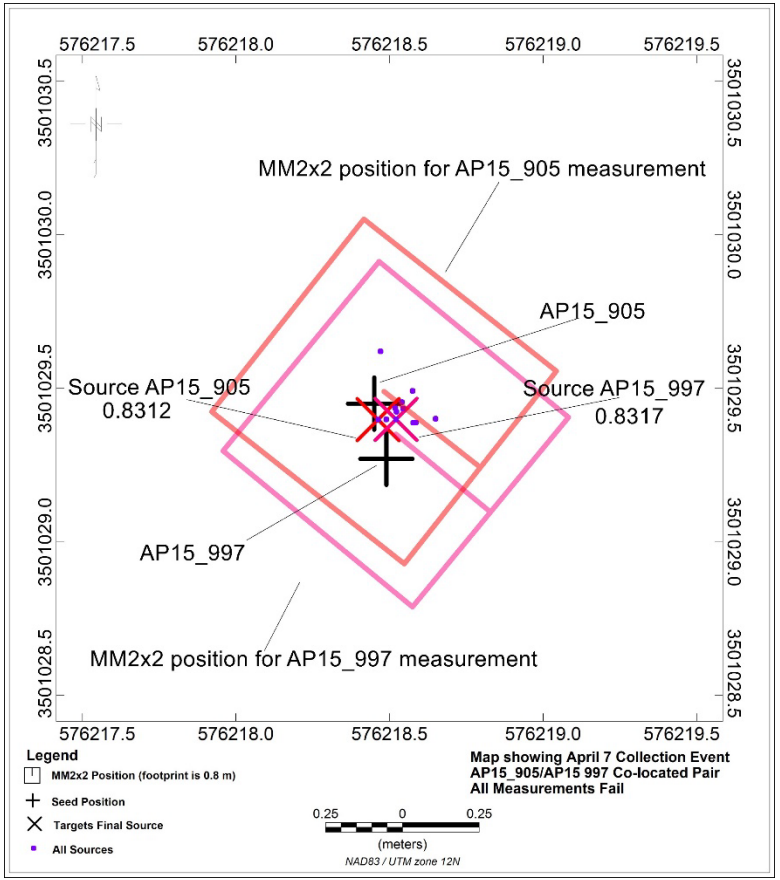
AP15_905/AP15_997 Seed Pair Collection Summary

- 11 cued measurements taken over pair
  - 7 over AP15_905
  - 4 over AP15_997
- Data collected over ~40 days
- Three different background locations
  - SAM/SBG Distance: 303 m - 118 m
  - SAM/SBG Time: 20 mins - 7.5 mins
- Seeds in-line, 19 cm (7.5 in) apart

UXA Target ID	Collection Date	Collection Time	Background	SBG/SAM Dist (m)	SBG/SAM Time Offset	Seed to Array Dist (m)	Decision Stat	Pass/Fail	Seed Depth (in)
Seed AP15_905									
AP15_905_001_11	3/31/2022	18:40:48	AN15_2034	118.40	12:16	0.07	0.7783	Fail	6
AP15_905_001_11	4/7/2022	15:37:11	AN15_2065	118.49	08:48	0.05	0.8312	Fail	6
AP15_905_001_11	4/18/2022	17:44:23	AN15_2065	118.53	11:59	0.04	0.8376	Fail	6
AP15_905_002_32	**4/22/2022**	15:10:03	AR13_2043	195.76	19:57	0.14	0.8269	Fail	6
AP15_905_001_21	5/3/2022	18:01:21	AP20_2039	303.21	07:39	0.04	**0.9057**	**Pass**	**3**
AP15_905_001_21	5/10/2022	14:48:20	AR13_2043	195.74	07:58	0.01	**0.9655**	**Pass**	**3**
AP15_905_002_22	5/10/2022	14:48:54	AR13_2043	195.74	08:31	0.02	**0.9859**	**Pass**	**3**
Seed AP15_997									
AP15_997_001_33	3/31/2022	18:42:01	AN15_2034	118.57	13:29	0.04	0.8025	Fail	6
AP15_997_001_22	4/7/2022	15:38:22	AN15_2065	118.63	09:59	0.09	0.8317	Fail	6
AP15_997_002_22	4/18/2022	17:46:34	AN15_2065	118.61	10:41	0.02	0.8318	Fail	6
AP15_997_001_21	**4/22/2022**	15:29:31	AR13_2043	195.65	15:33	0.02	**0.9224**	**Pass**	**3**

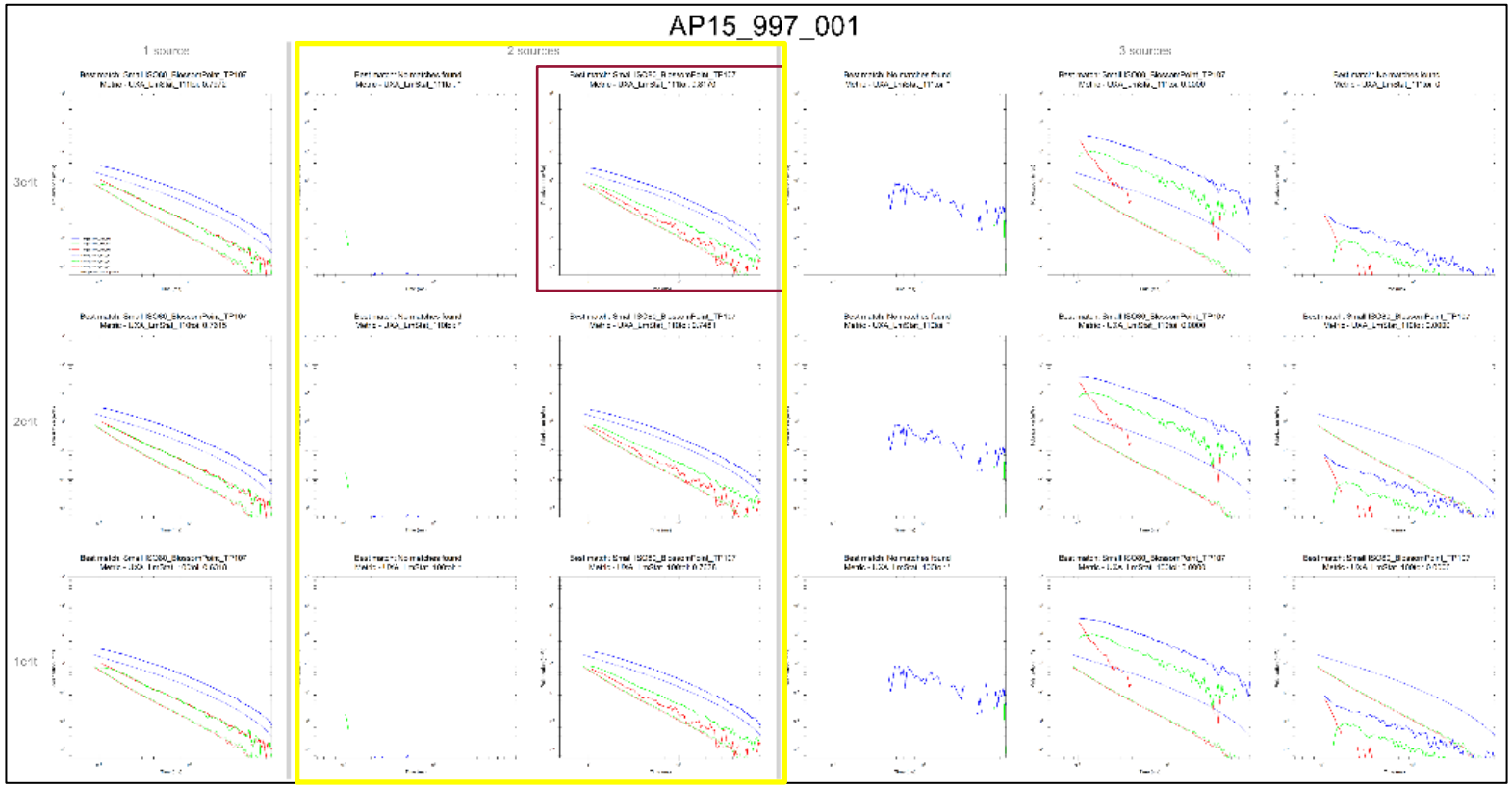
AP15_905/AP15_997, April 7 Classification Results



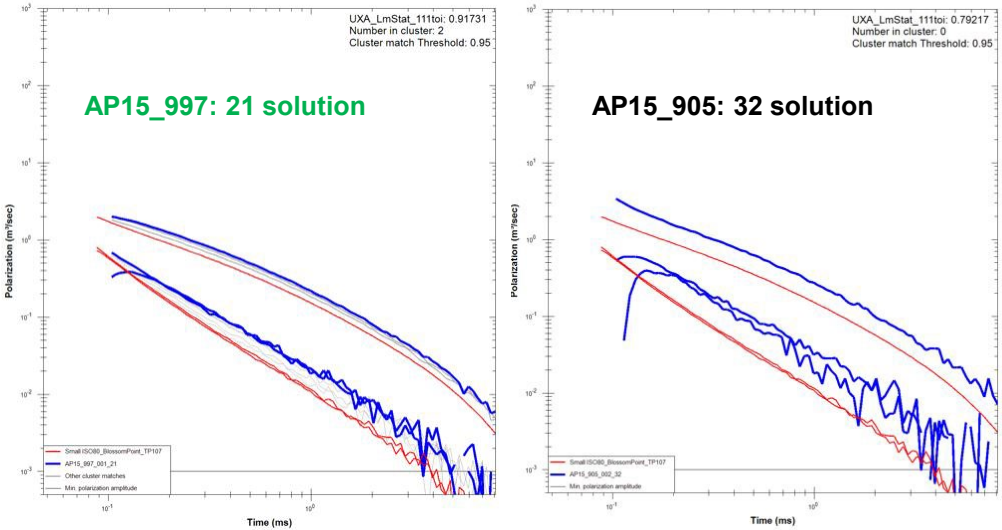


- SAMs taken less than 2 minutes apart
- Background: ~9 minutes and ~118 m between SAM/SBG
- Array to source offset and decision stat:
  - AP15_905: 5 cm (2.0 in); **0.8312**
  - AP15_997: 9 cm (13.5 in); **0.8317**

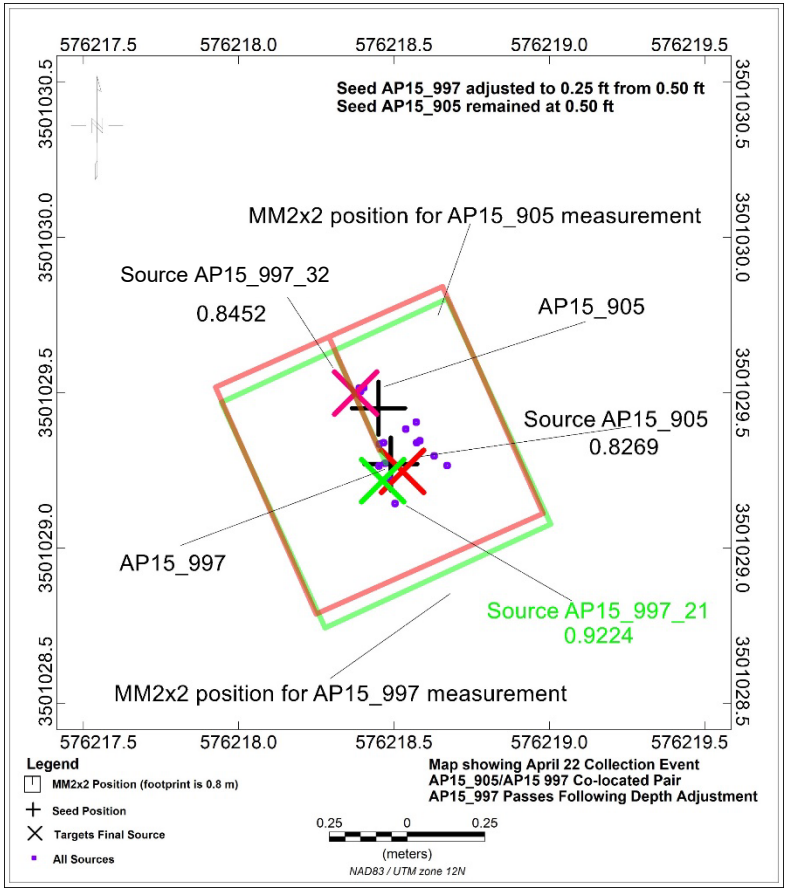
AP15_997, April 7 Multisource Polarizability Plot



AP15_905/AP15_997, April 22 Classification Results

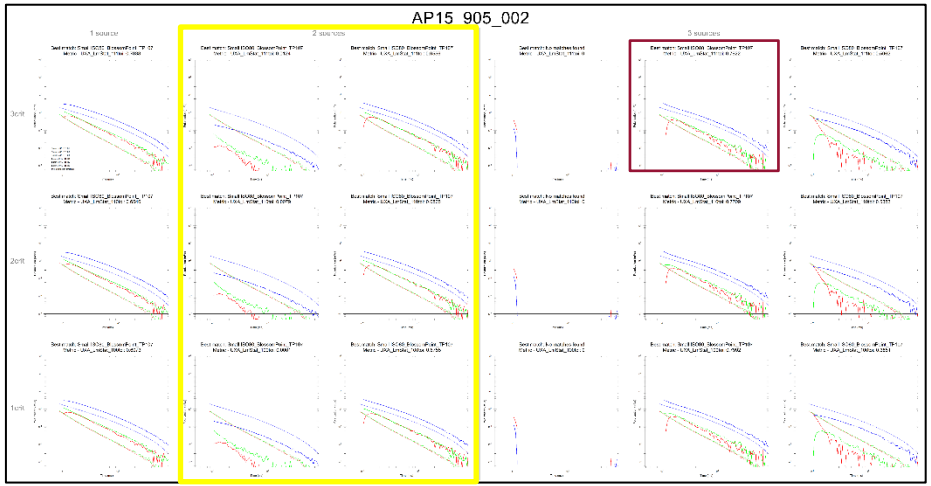


- SAMs taken ~6 minutes apart
- AP15_997 depth adjusted to 0.08 m (3 in) bgs, AP15_905 remained at 0.15 m (6 in) bgs
- Background: ~17 minutes and ~195 m between SAM/SBG
- Array to source offset and decision stat:
  - AP15_905: 14 cm (5.5 in); **0.8269**
  - AP15_997: 2 cm (0.8 in); **0.9224**

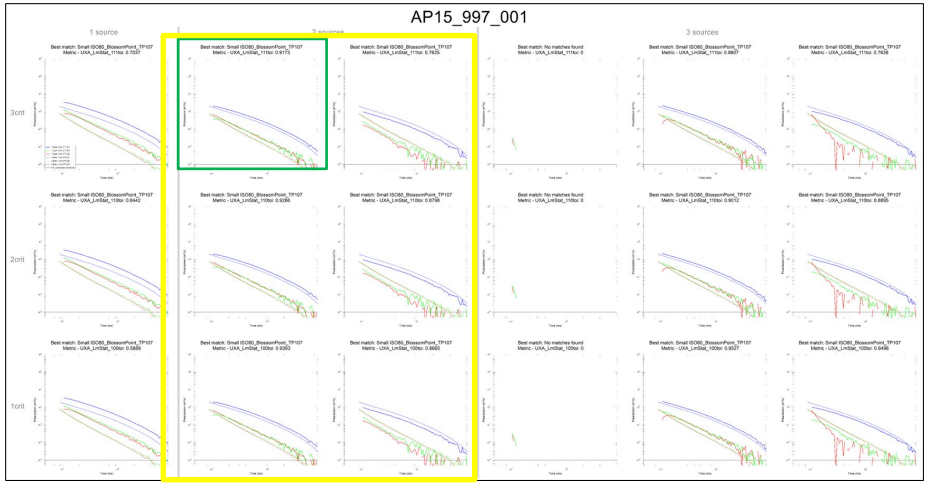


AP15_905/AP15_997, April 22 Multisource Polarizability Plots

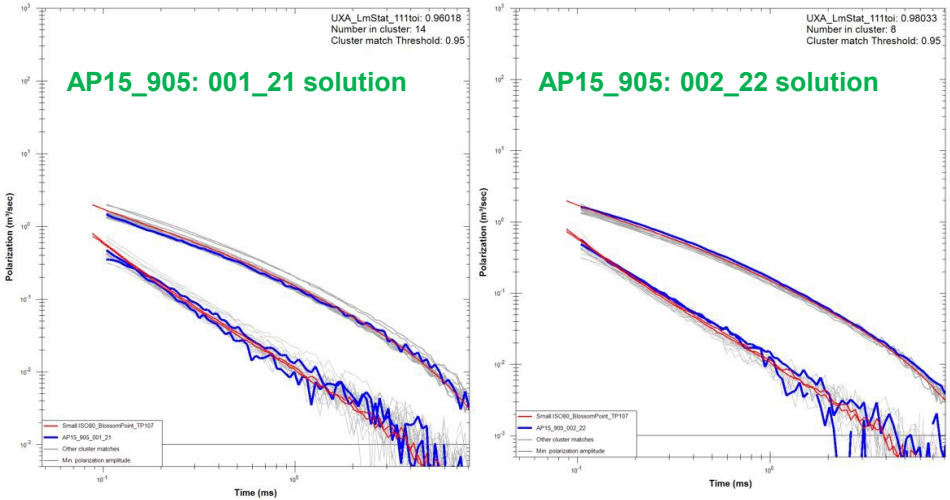
Seed AP15_905
Fails



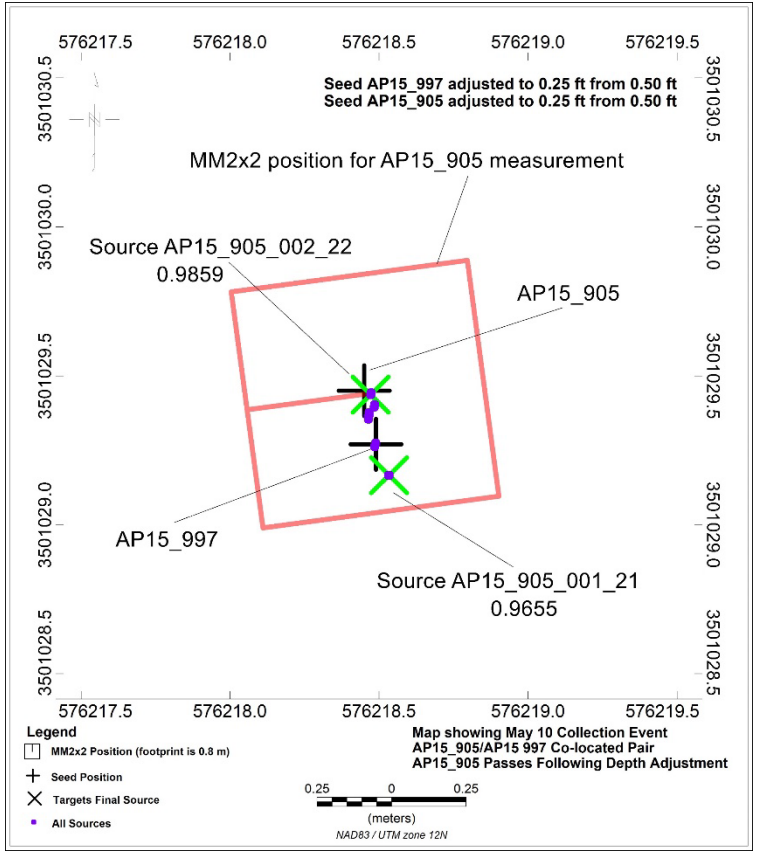
Seed AP15_997
Passes



AP15_905, May 10 Classification Results

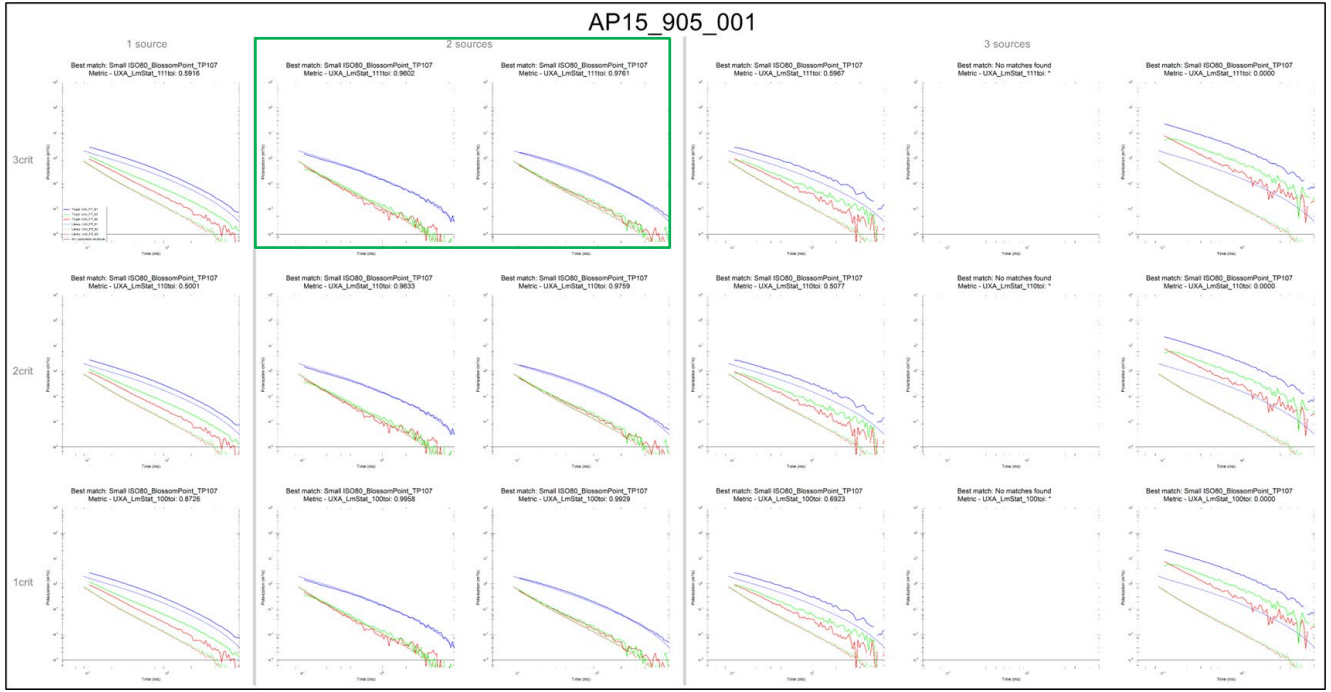


- Data collected over AP15_905 only (AP15_997 passed April 22)
- AP15_997 and AP15_905 adjusted to 0.08 m (3 in) bgs
- Background: ~8 minutes and ~195 m between SAM/SBG
- Array to source offset and decision stat:
  - AP15_905: 1 cm (0.4 in)
  - **Both seeds classified with decision stats above 0.9500**



AP15_905, May 5 Multisource Polarizability Plots

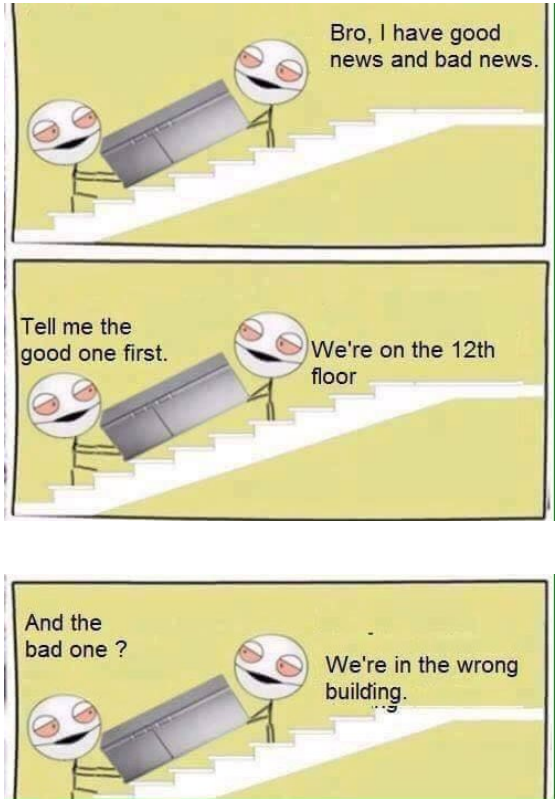
Seed AP15_905 Passes



Validation Seeding Complex Seed Analysis Conclusions

- Good news! All complex seeds passed at depths of either 6 in or 3 in bgs – complex sources the size of small ISO **can be reliably** classified at 0.08 m (3 in) bgs or shallower

- Bad news! Complex sources the size of small ISOs (37-mm) **cannot be reliably** classified at 0.15 m (6 in) bgs
  - Failure rate of ~20%
  - Failure occurs more often (~90%) when items are oriented parallel and in-line with each other
  - Two items in some cases resolve into a single, larger source



RA Complex Seed Results

- 6 pairs of complex seeds in non-AGC areas
- 44 pairs surveyed using APEX one-pass classification
  - **12 pairs (27%) pass:** two separate Category 1 sources met all MQOs
    - 7 pairs - both seeds at 15 cm (6 in)
    - 5 pairs - either one or both seeds at 8 cm (3 in)
  - **28 pairs (64%) pass/complicated :** single Category 1 source meets MQOs for both seeds
    - Most have second source that would pass, but was identified as a “duplicate” by the data analyst
  - **4 pairs (9%) fail:** single Category 1 source met MQOs, other seed failed horizontal offset MQO (25 cm)
    - 2 pairs - both seeds at 15 cm (6 in)
    - 1 pair - both seeds at 8 cm (3 in)
    - 1 pair - a seed at 15 cm (6 in) and 8 cm (3 in)
  - Almost all seeds (98%) are predicted as a larger, deeper item

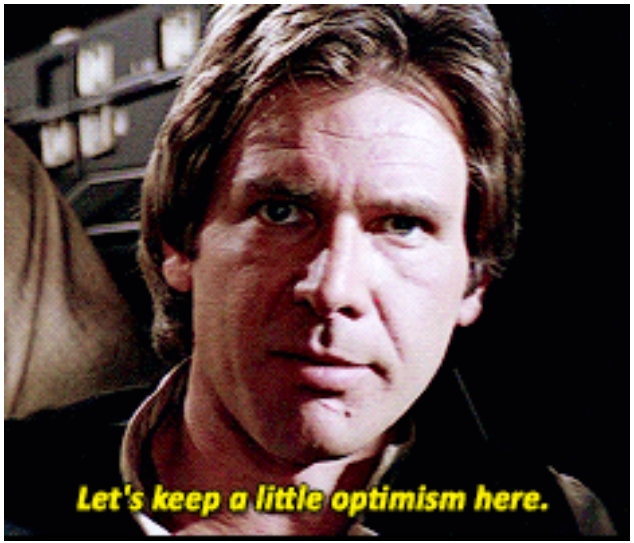
RA Summary Table and USACE Perspective

Classification Results	Number of Seed Pairs	Percent of Seed Pairs	Library Item Match	Number of Seeds
Pass – two sources	12	27%	Small ISO	2
			60mm Mortar	8
			2.36-inch Bazooka Warhead	14
Pass/Complicated – one source	28	64%	Small ISO	0
			60mm Mortar	20
			2.36-inch Bazooka Warhead	36
Fail – one seed ≥ 25 cm offset MQO	4	9%	Small ISO	0
			60mm Mortar	4
			2.36-inch Bazooka Warhead	4

- USACE will not be emplacing complex validation seeds
- Function should be QC, not QA, in accordance with upcoming 200-1-15 guidance revision

Final Thoughts

- These results challenge industry assumptions
  - Individual items cannot always be reliably classified in multi-source scenarios, even at depths not expected to challenge classification
  - Intrusive MQO “100% of recovered item positions ≤ 25 cm from predicted position” but complex seed failures occurred for seeds at a distance up to 39 cm and an average - 26.1 cm
- More research needed to
  1. Understand the implications of these findings
  2. Fully understand the failure in terms of depths, orientation of sources, and size of TOI
- Optimistic that the eventual industry-level solution will get us there!



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Thank you

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