The Saga Continues: Advancements in the UnderstanDing of Complex Seed Scenarios

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## Abstract

 Complex seeds, and the real-world scenarios they represent, have captured the attention of the munitions response (MR) industry since 2022 when data were presented indicating advanced geophysical classification (AGC) sensors may not reliably resolve two separate sources in proximity to one another. Despite some gains in the understanding of AGC performance in complex source scenarios in the intervening time, the data usability implications are still not well understood. This has led to concern regarding the risks posed in situations where munition items may be located in close proximity to other sources at MR sites including the requirement in Interim Guidance Document (IGD) – Engineer Manual 200-1-15 (U.S. Army Corps of Engineers, 2024) to place “data usability seeds” to assess sensor performance in the presence of interference sources.

The challenge of understanding sensor performance for each possible complex scenario is daunting. Using only the 354 items currently in the U.S Department of Defense 8 millisecond target of interest (TOI) library, allowing only two combinations of items, and not accounting for parameters such as depth, item orientation, or sensor type results in more than 62,400 possible complex scenarios. This number also does not include the countless clutter items that may be encountered at an MR site. It is neither feasible nor practical to test each potential combination of items with each AGC sensor platform. However, testing can be designed to better understand and mitigate the limitations of AGC technology in complex item scenarios.

### Real-World Complex Seed Testing

In 2024, Jacobs performed real-world testing with White River Technologies’ APEX sensor at two project sites. The testing included placing, and then collecting, dynamic classification and dynamic-cued data with the APEX over nine complex item scenarios. Complex scenarios included industry standard object (ISO)/ISO combinations and ISO/clutter (in the form of spent small arms casings) combinations. Using standard processing procedures, the test results confirm the current understanding that there are limitations associated with the reliable discrimination of two separate sources for items of similar shape and size (ISO/ISO), with classification sometimes predicting a single, larger item and sometimes predicting two items. Interestingly, in ISO/ISO tests, analysis of the test data indicates that the library selection and the decision rules regarding duplicate source identification (i.e., two or more sources in proximity) have significant impacts on the ability to resolve two targets in these scenarios. The results from ISO/clutter combination tests always resulted in the classification of a single TOI from the site-specific library. The industry metrics for horizontal offset and model coherence were met in all test cases by at least one source. Interestingly, initial analysis indicates that for certain tests, the single source solution had higher library match statistics than those for the two source solutions.

### Synthetic Complex Seed Testing

In addition to real-world testing, complex seed scenarios were also analyzed at a range of depths and orientations using the forward modeling tool in UX-Analyze to help fill in knowledge gaps. Residual background responses were simulated by importing a low-noise static background file into the AGC library and adding it as an additional forward model input deeper than the synthetic seed locations. Each forward model produced a located database that was analyzed through gridding, target selection, and dynamic inversion. The first modeling scenario placed two small ISOs, oriented horizontally and in-line with one another, at incrementally increasing depths to determine the depth at which the two items no longer reliably resolved as discrete sources. The second modeling scenario placed two small ISOs at a moderately shallow depth with incrementally increasing horizontal separation to evaluate whether a 25-cm dig radius would always result in recovery of both ISOs. The third modeling scenario placed a small ISO in close proximity to a large ISO with varying horizontal separation distances to evaluate whether the response from the small ISO could potentially be masked and not recovered using a 25-cm dig radius.

## Conclusions

The results from the tests performed advance the understanding of AGC sensor performance in complex item scenarios. They also help inform the design of future tests, improve the current understanding of the data usability limitations associated with complex seeds, and shed light on the implications of project-specific factors including library selection and decision rules on the target selection outcome. In cases where a site-specific library may not include items that would match well to multiple similar items classified as a single source, self-matching cluster and feature space analyses may help identify complex item scenarios.

## References

U.S. Army Corps of Engineers, 2024. Interim Guidance Document – Engineer Manual 200-1-15. March.