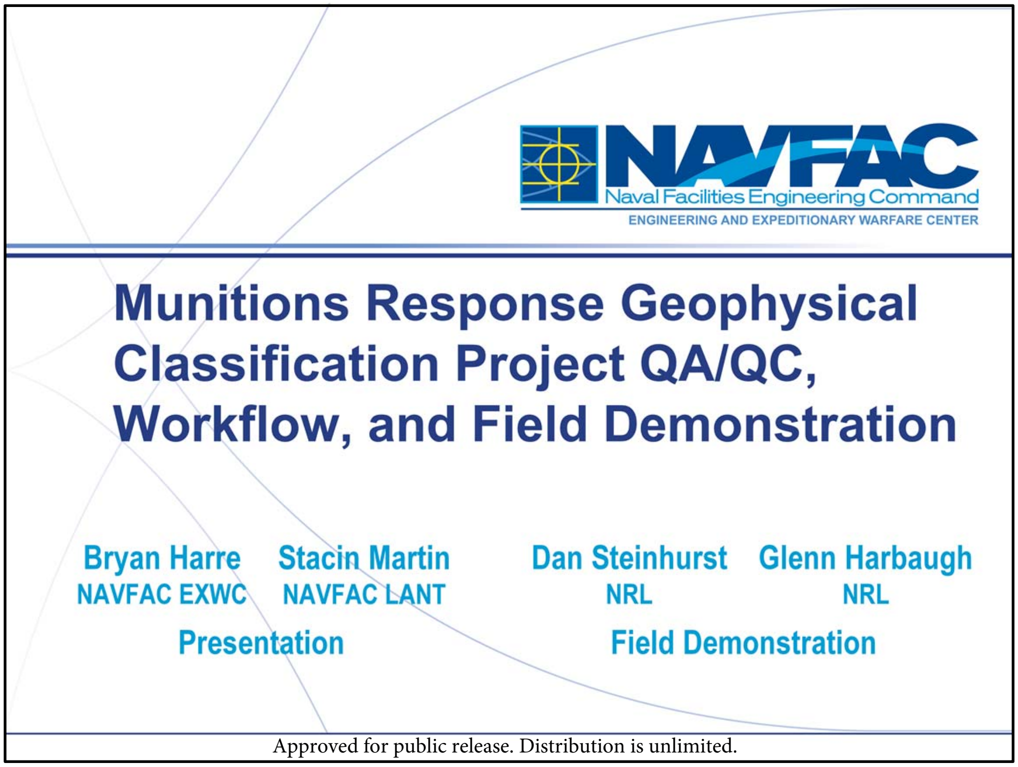
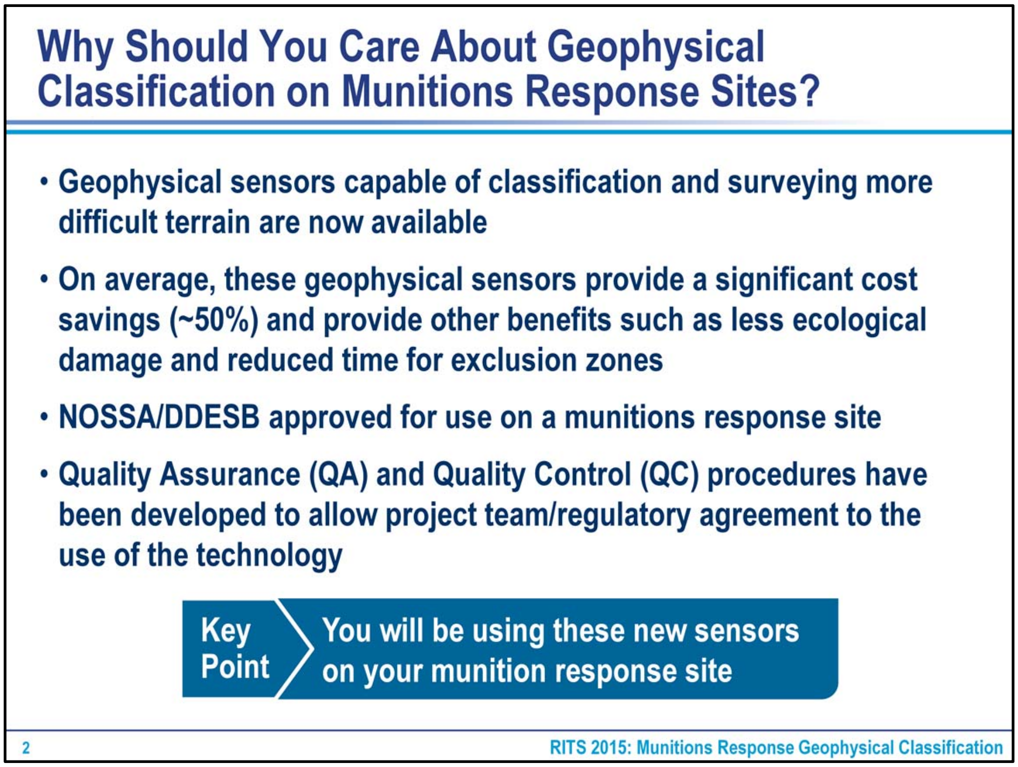
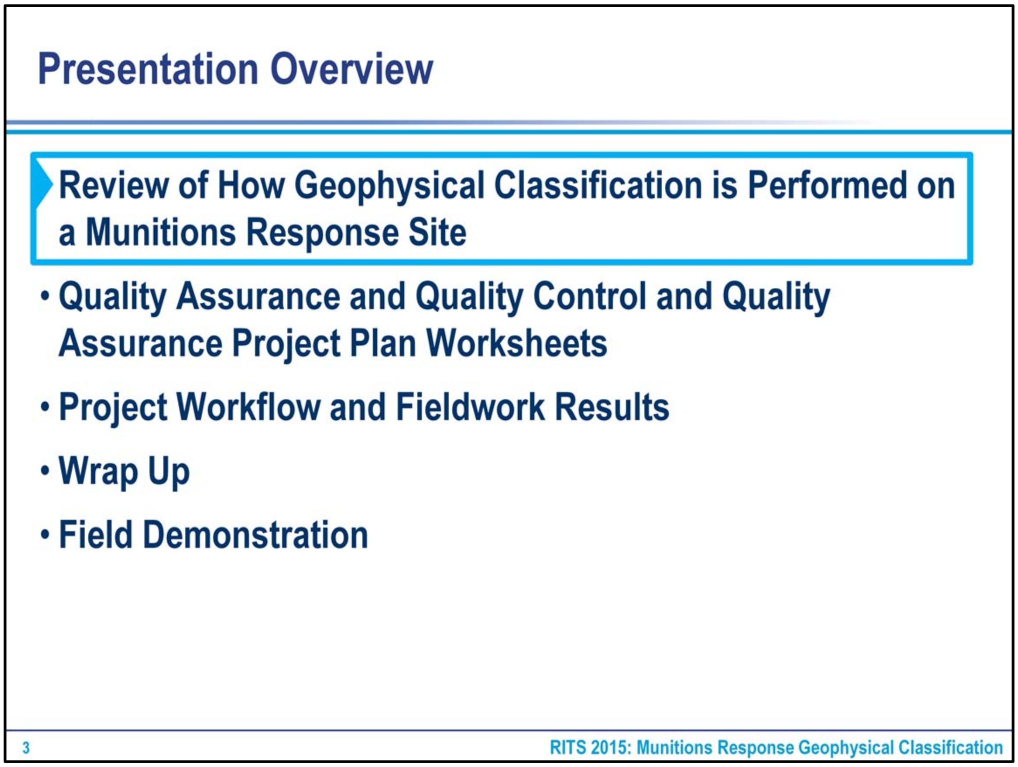


- Introduce self and experience
- Highlight that we have an explosive topic and a process to remove the explosive hazard while leaving the non-hazardous metal behind
- Also briefly discuss the development of QA/QC procedures, the workflow process and that this RITS will have a Field Demo of the TEMTADS unit
- Discuss how this presentation builds upon last year’s RITS on classification

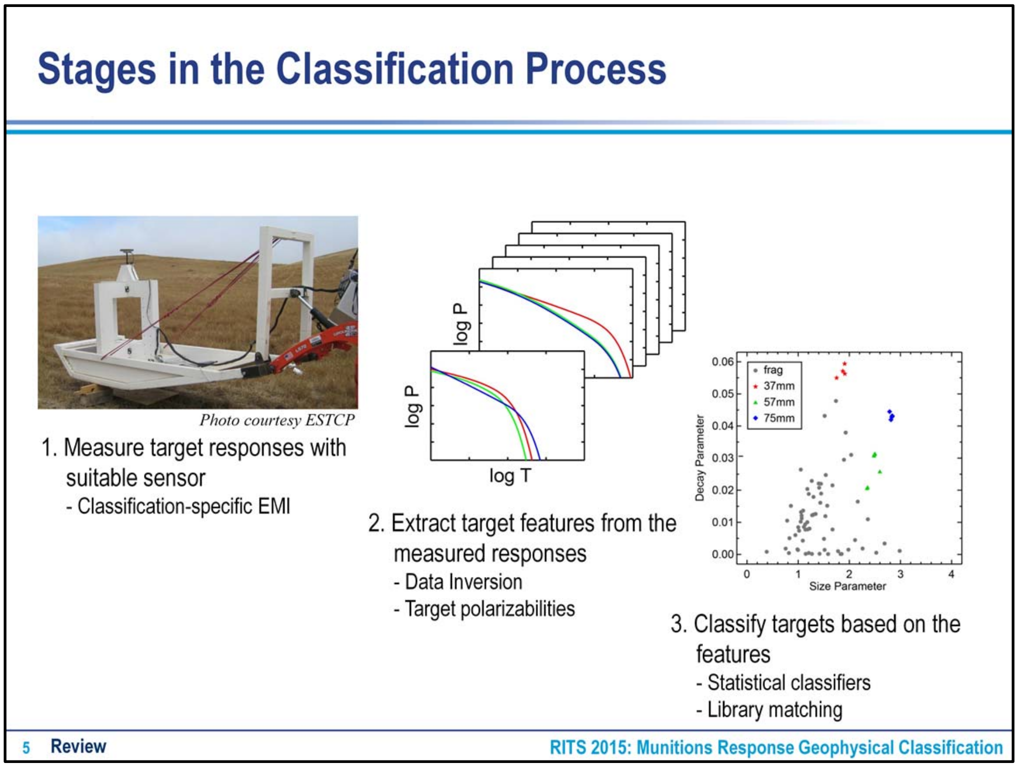


- These are some of the reasons why an RPM or Contractor should pay attention to this presentation

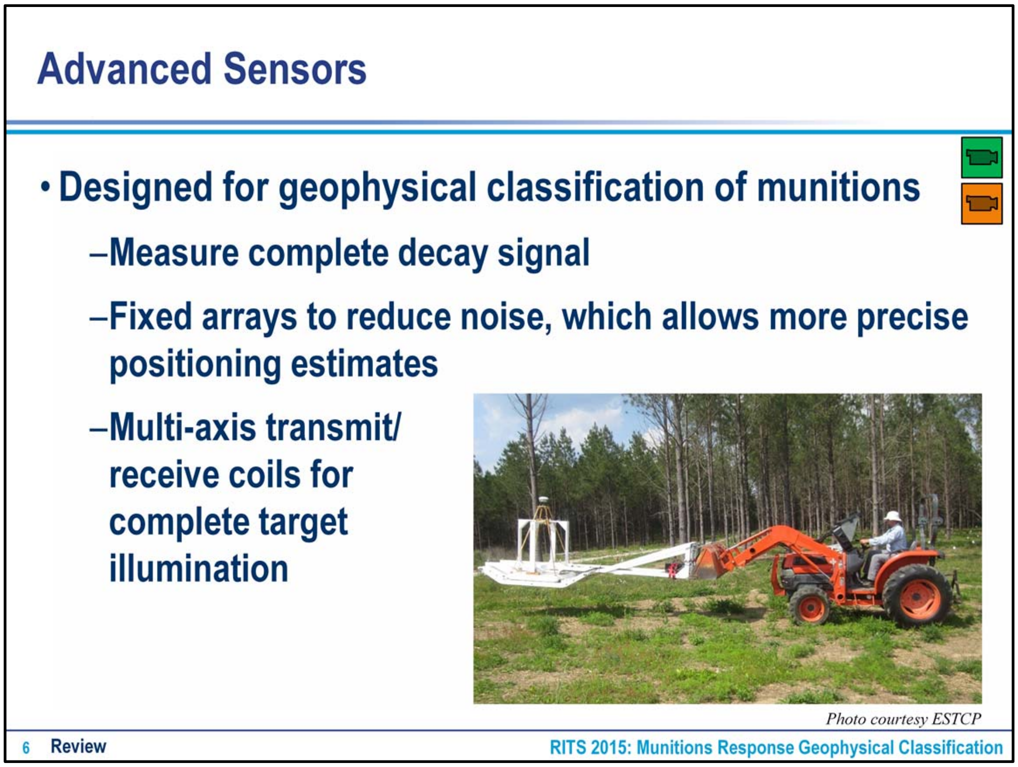


- Here is an outline of the topics we will cover today

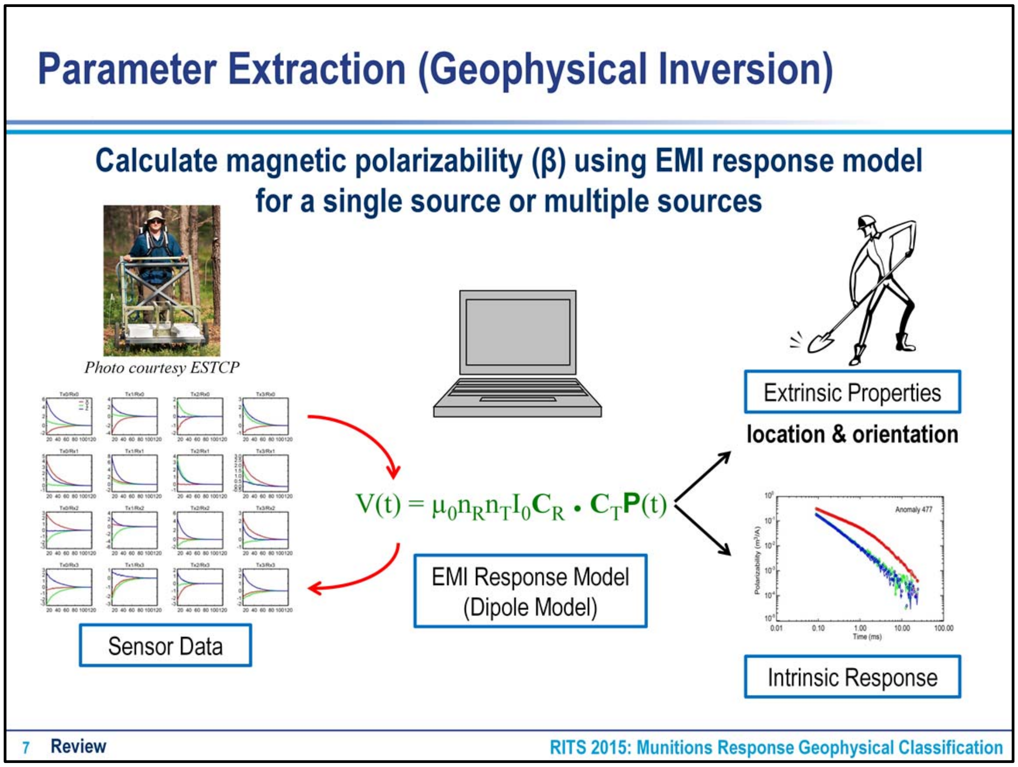
- To recap, the goal is to sort the buried metal objects into two classes (hence the name Classification)
- This is easy if they are on the surface but, since the objects are buried, we have to rely on what we can glean from the advanced sensors to help us sort the objects
- How this works is the subject of the next module in the presentation
- Show the props of a shell fragment, a munition and ISO



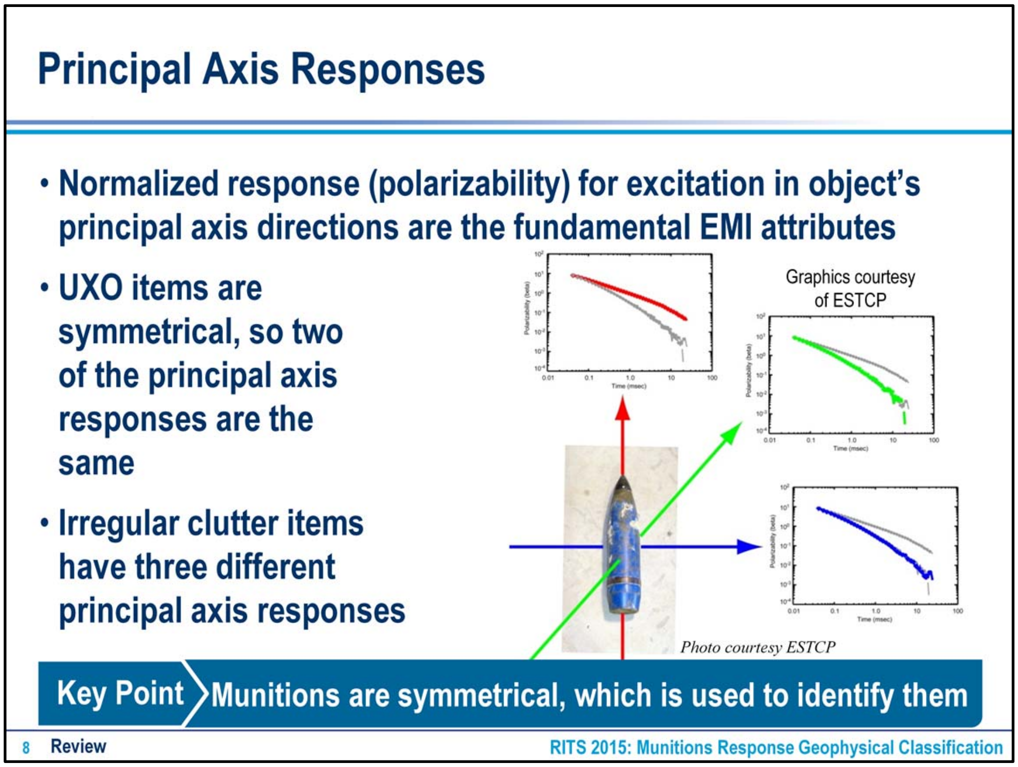
- There are really three steps in the Classification process – collect some data over the buried object using an advanced EMI sensor, use those data to extract some information about the object (often called parameters or features), and then use that information to make a decision about the object
- We'll go through these three steps one by one



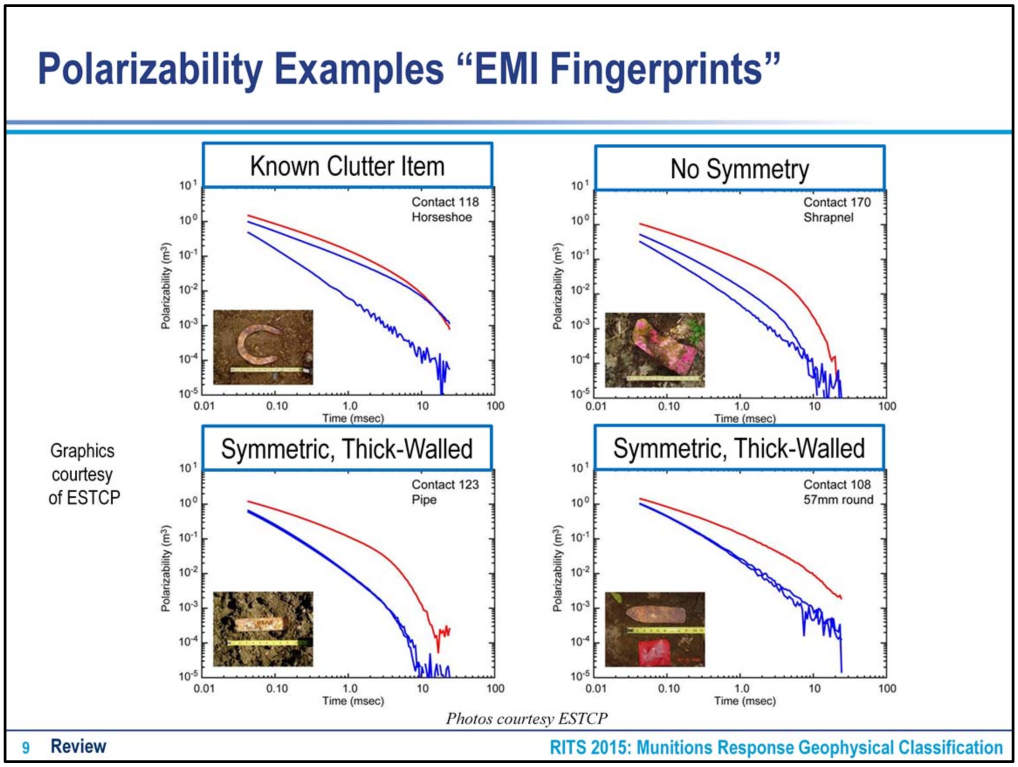
- To efficiently acquire the data required for classification we use multi-axis, multi-coil sensors designed for this purpose
- The videos illustrate the difference between the EM61 and the Metal Mapper sensor’s operation and ability to acquire much higher fidelity data (spatial resolution data)
- The sensors took over ten years to develop and field



- After acquiring data, target parameters are estimated using an iterative process called geophysical inversion
- An initial guess is made for these parameters, the signal that would result is calculated, and this calculated signal is compared to the measured data
- If they do not match the parameters are adjusted slightly and the cycle repeats
- After thousands of cycles (easy for a computer) we achieve a good match between the calculated and measured signals and we can be confident we have the target parameters
- As mentioned before, we recover the object's polarizability decay curves (parameters intrinsic to the object) which can be used for Classification and the object's location and orientation (extrinsic properties) that are not useful for Classification but are handy to guide the intrusive crew
- Show the props again in different orientations and separation distances to illustrate the single source and multiple source solutions that can now be obtained



- Since intact MEC items are symmetrical, advanced geophysical sensors measure the response in the three planes (axis) shown and use this information to determine if the subsurface item is symmetrical or not
- The graphs depict decay curves (in three dimensions) for a symmetrical item
- Show the prop to illustrate the different axes



- Here are other examples of decay curves
- Note how the different (relative to each other) response curves are a function of the shape and thickness of the items
- These are somewhat analogous to "fingerprints", albeit "EMI fingerprints"

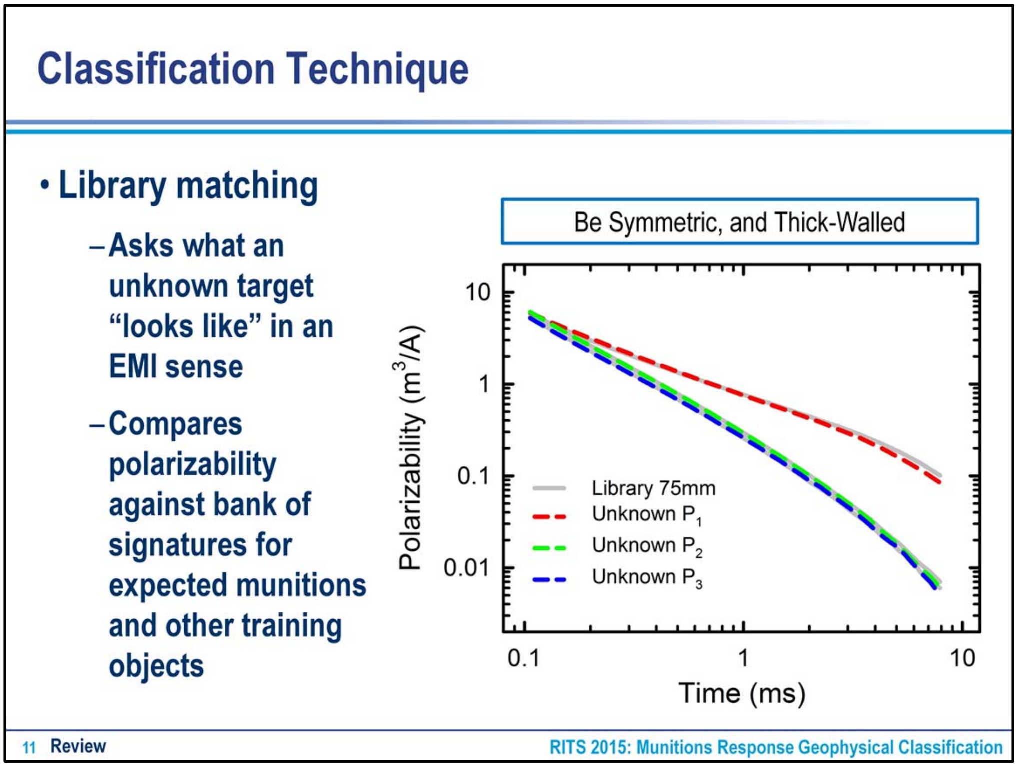
Polarizability Relationships

- **Basic relationship between properties of the polarizabilities and the source object**

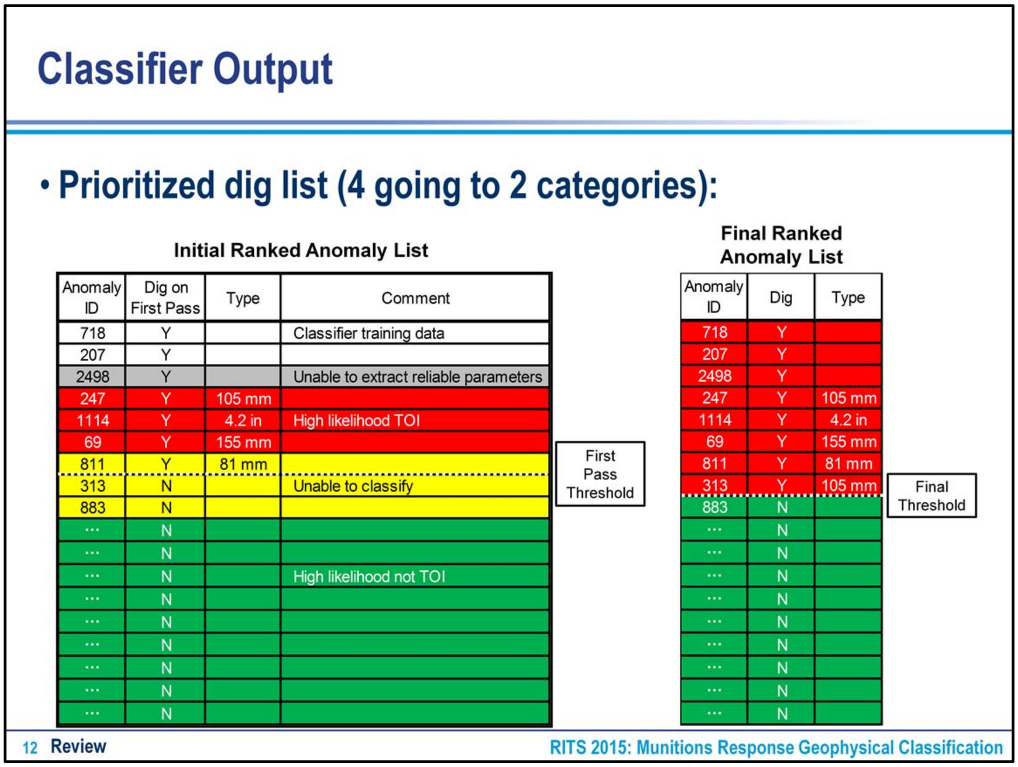
Polarizability Property	Target Property
Decay rate	Wall thickness
Relative magnitude	Shape
Total magnitude	Size (volume)

10 Review RITS 2015: Munitions Response Geophysical Classification

- Shown here are the basic relationships between the properties of the polarizabilities and the subsurface target property



- There are a number of ways to use the polarizabilities to classify
- The most common in munitions work is library matching methods
- It uses the polarizability curves to find matches



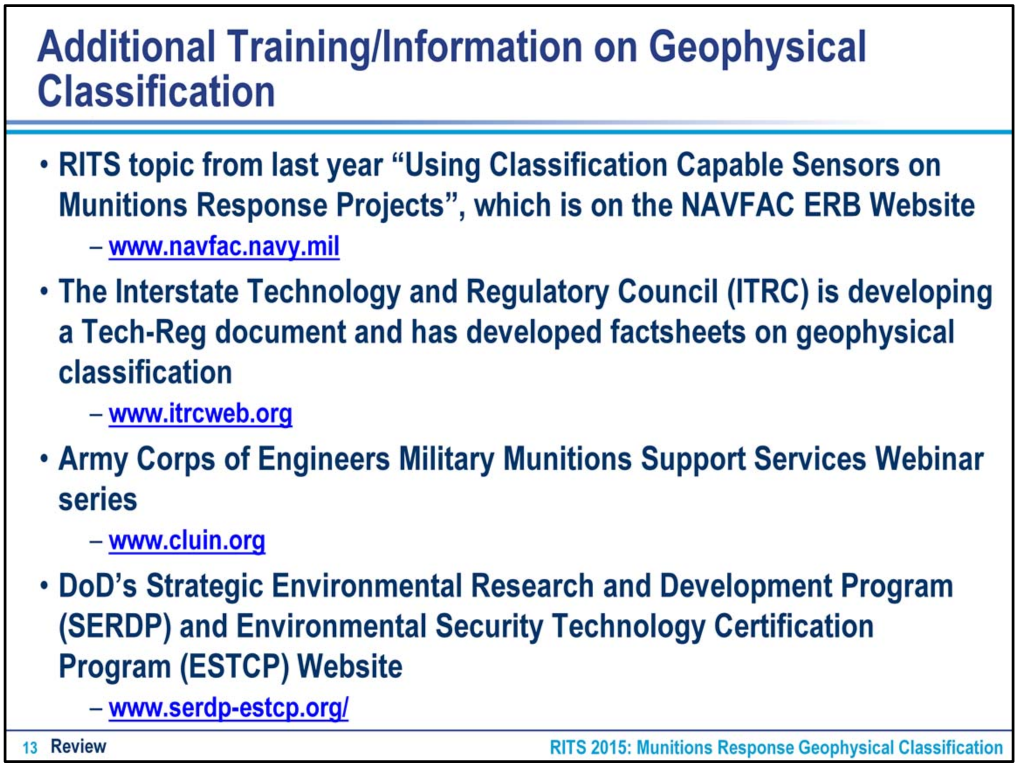
Initial Ranked Anomaly List

Anomaly ID	Dig on First Pass	Type	Comment
718	Y		Classifier training data
207	Y		
2498	Y		Unable to extract reliable parameters
247	Y	105 mm	
1114	Y	4.2 in	High likelihood TOI
69	Y	155 mm	
811	Y	81 mm	
313	N		Unable to classify
883	N		
···	N		
···	N		
···	N		High likelihood not TOI
···	N		
···	N		
···	N		
···	N		
···	N		
···	N		

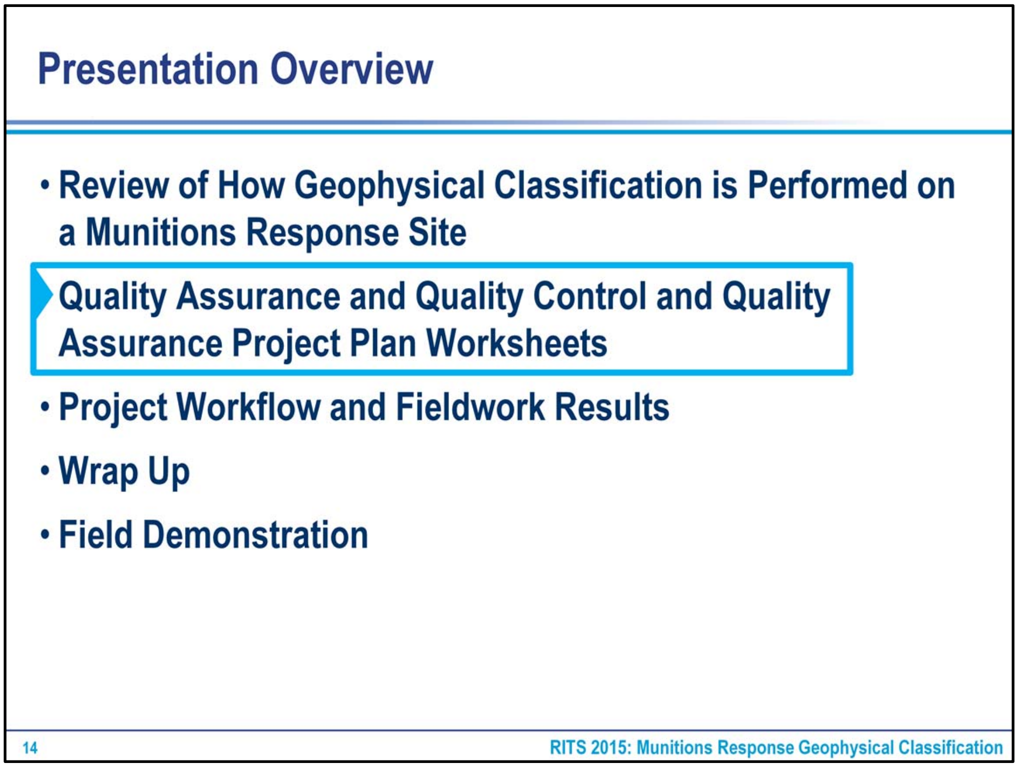
Final Ranked Anomaly List

Anomaly ID	Dig	Type
718	Y	
207	Y	
2498	Y	
247	Y	105 mm
1114	Y	4.2 in
69	Y	155 mm
811	Y	81 mm
313	Y	105 mm
883	N	
···	N	
···	N	
···	N	
···	N	
···	N	
···	N	
···	N	
···	N	
···	N	

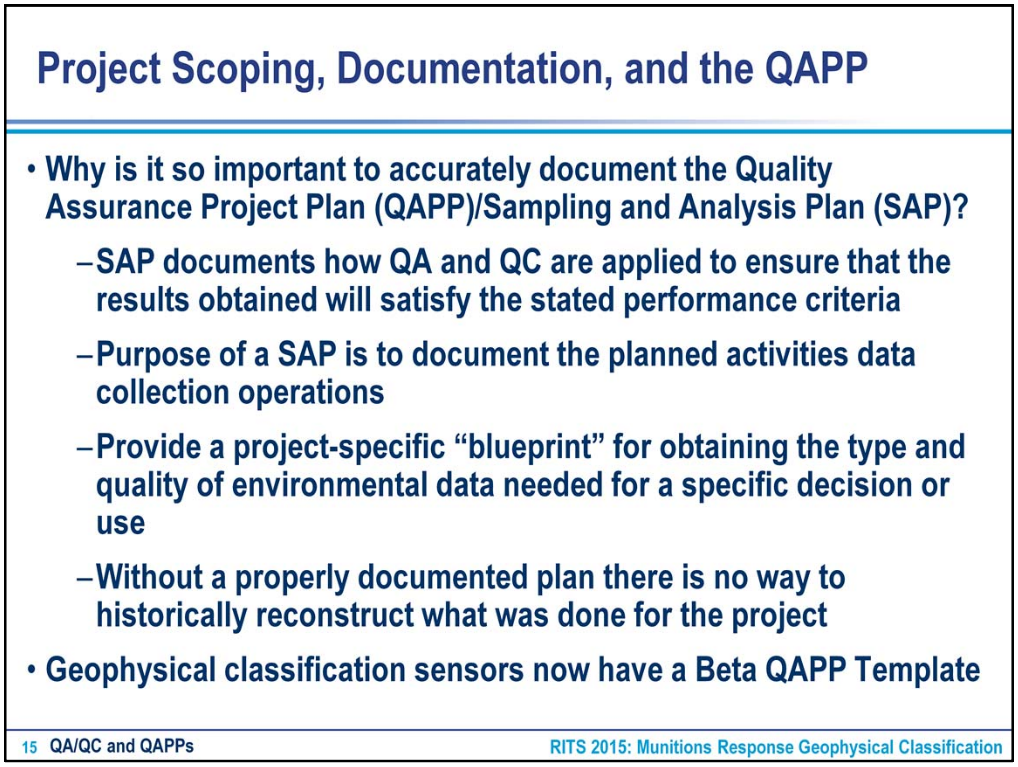
- The final output of the classifier is a ranked anomaly list constructed as shown here
- There are always a few targets for which the data are bad or there was some analysis problem
- Since we can say nothing useful about these targets, they have to be dug
- We show them here in gray
- Next come the items we are confident are munitions (remember the projectiles from a few slides back)
- These also must be dug
- There may or may not be some clusters that we can’t decide about based on our current information
- The only things we can leave in the ground are the targets we are confident are not munitions
- These are shown in green on the list
- The items in red on the final list are dug



- Here are some additional resources that can provide more information on geophysical classification
- Discuss the level of detail/intended audience for each of the bullet items



- Now we are going to discuss QA/QC and QAPPs, probably the most exciting topic on the planet



- Here is a reminder of why documenting the project specific SAP/QAPP is important for all the reasons above
- A good QAPP helps to get buy in from regulators/stakeholders on the project team to leave non-hazardous metal in the ground
- This is a big change from the past of digging it all, where quality was not such a large issue
- Fortunately, a Beta QAPP Template is available now for project teams to use on their sites

QAPP Worksheets Included (1)

Number	Title
1 & 2	Title and Approval Page
3 & 5	Project Organization and QAPP Distribution
4 , 7 & 8	Personnel Qualifications and Sign-off Sheet
6	Communication Pathways and Procedures
9	Project Planning Session Summary
10	Conceptual Site Model
11	Project/Data Quality Objectives
12	Measurement Performance Criteria
13	Secondary Data Uses and Limitations

16 QA/QC and QAPPs RITS 2015: Munitions Response Geophysical Classification

- Here are the worksheets that are included in the Beta QAPP Template for Geophysical Classification
- Note that we are more streamlined than a traditional chemical SAP because we don’t have all the Lab QA/QC worksheets
- We are only going to discuss a few worksheets from the template
- There will be an upcoming OER2 webinar on this template later this year that will go into the details on more of these worksheets

QAPP Worksheets Included (2)

Number	Title
14 & 16	Project Tasks & Schedule
17	Survey Design and Project Work Flow
22	Equipment Testing, Inspection, and Quality Control
29	Data Management, Project Documents and Records
31, 32 & 33	Assessments and Corrective Action
34	Data Verification, Validation, and Usability Inputs
35	Data Verification and Validation Procedures
36	Geophysical Classification Process Validation
37	Data Usability Assessment

17 QA/QC and QAPPs RITS 2015: Munitions Response Geophysical Classification

- Here are more worksheets that are included in the Beta QAPP Template for Geophysical Classification

QAPP Worksheets Not Included

Number	Title
15	Project Action Limits and Laboratory-Specific Detection / Quantitation Limits
18	Sampling Locations and Methods
19 & 30	Sample Containers, Preservation, and Hold Times
20	Field QC
21	Field SOPs
23	Analytical SOPs
24	Analytical Instrument Calibration
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection
26 & 27	Sample Handling, Custody, and Disposal
28	Analytical Quality Control and Corrective Action

18 QA/QC and QAPPs RITS 2015: Munitions Response Geophysical Classification

- These worksheets were not included because they covered laboratory procedures or in the case of the field procedures were all covered in WS#22

Worksheet #12 (1)
Measurement Performance Criteria

Measurement Performance Activity (or DFW*)	Data Quality Indicator (DQI)	Specification	Activity Used to Assess Performance
QC Seeding	Representa-tiveness	[Insert number] blind QC seeds will be placed at the site. Blind QC seeds must be detectable as defined by the DQOs and located throughout the horizontal and vertical survey boundaries defined in the DQOs. [Describe and justify the types of QC seeds that will be used.] Blind QC seeds will be distributed such that the field team can be expected to encounter between one and three seeds per day per team.	Review of blind seed plan
Detection Survey	Completeness	100% of the site is sampled.	Verification of conformance to MQOs^ for in-line spacing and cross-line spacing

*DFW = Definable Feature of Work
^MQOs = Measurement Quality Objectives

19 QA/QC and QAPPs — RITS 2015: Munitions Response Geophysical Classification

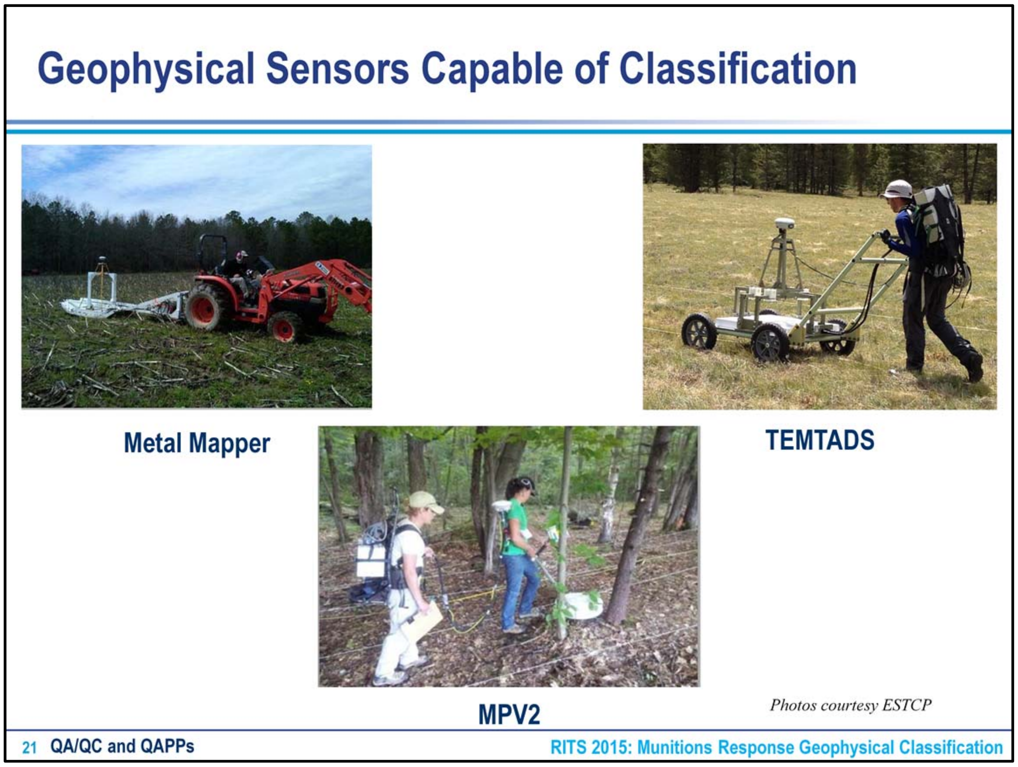
- Discuss MPCs (overall project quality objectives/requirements) and define verification (QC) and validation (QA)
- Discuss the requirements of blind seeding identified above and making sure the detection survey is complete

Worksheet #12 (2)
Measurement Performance Criteria

Measurement Performance Activity (or DFW)	Data Quality Indicator (DQI)	Specification	Activity Used to Assess Performance
Detection survey	Sensitivity	This worksheet must describe the project-specific detection threshold. (Example) A detection threshold of ≥1.7 mV/A and SNR ≥5 is required to detect a [37 mm projectile] lying horizontally at a depth of [0.3 m].	• Initial and ongoing IVS surveys • Blind seed detection • Analysis of background variability across the site
Detection survey	Accuracy/ Complete-ness	100% of validation seeds must be detected.	Review of validation seed detection results per survey unit
Classification survey	Complete-ness	All detected anomalies classified as: 1. TOI 2. Non-TOI 3. Inconclusive	Data verification
Intrusive Investigation	Accuracy/ Complete-ness	Cued survey must correctly classify 100% of all validation seeds.	Review of validation seed classification results

20 QA/QC and QAPPs RITS 2015: Munitions Response Geophysical Classification

- Discuss each of the specifications for the surveys and the intrusive investigation



- Shown above are the sensors that are capable of geophysical classification
- Discuss the availability of the sensors and the type of site you would use the different sensors on (farm fields, wooded undulating terrain, etc.)
- The TEMTADS has also been used on rougher ground in a litter-carried deployment
- Note that each will have some slightly different QC procedures that we will discuss next
- The Metal Mapper costs $60,000 and rents for $500 a day

Worksheet #22 (1)
Equipment Testing, Inspection, and QC

Measurement Quality Objective (MQO)	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	As specified in SOP-1, Assembly checklist	CA: Make necessary adjustments, and re-verify
Initial dynamic positioning accuracy (IVS)	Once prior to start of dynamic data acquisition	Project Geophysicist/ IVS Memorandum/QC Geophysicist	Derived positions of IVS target(s) are within 25 cm of the ground truth locations	CA: Make necessary adjustments, and re-verify
Initial dynamic detection response amplitudes (IVS)	Once prior to start of dynamic data acquisition	Project Geophysicist/ IVS Memorandum/ QC Geophysicist	Response amplitudes within 25% of predicted amplitudes	CA: Make necessary adjustments, and re-verify

CA = Corrective Action

22 QA/QC and QAPPs RITS 2015: Munitions Response Geophysical Classification

- Discuss the acceptance criteria for each MQO

Worksheet #22 (2)
Equipment Testing, Inspection, and QC

Measurement Quality Objective (MQO)	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
In-line measurement spacing (TEMTADS)	Verified for each survey unit using existing UX Detect tools based upon monostatic Z coil data positions	Project Geophysicist/ running QC summary/QC Geophysicist	100% ≤0.20m between successive measurements	RCA/CA CA assumption: data set fails, (recollect portions that fail)
In-line measurement spacing (Metal Mapper)	Verified for each survey unit using existing UX Detect tools based upon monostatic Z coil data positions	Project Geophysicist/ running QC summary/QC Geophysicist	100% ≤0.25m between successive measurements	RCA/CA CA assumption: data set fails, (recollect portions that fail)

RCA = Root Cause Analysis

23 QA/QC and QAPPs RITS 2015: Munitions Response Geophysical Classification

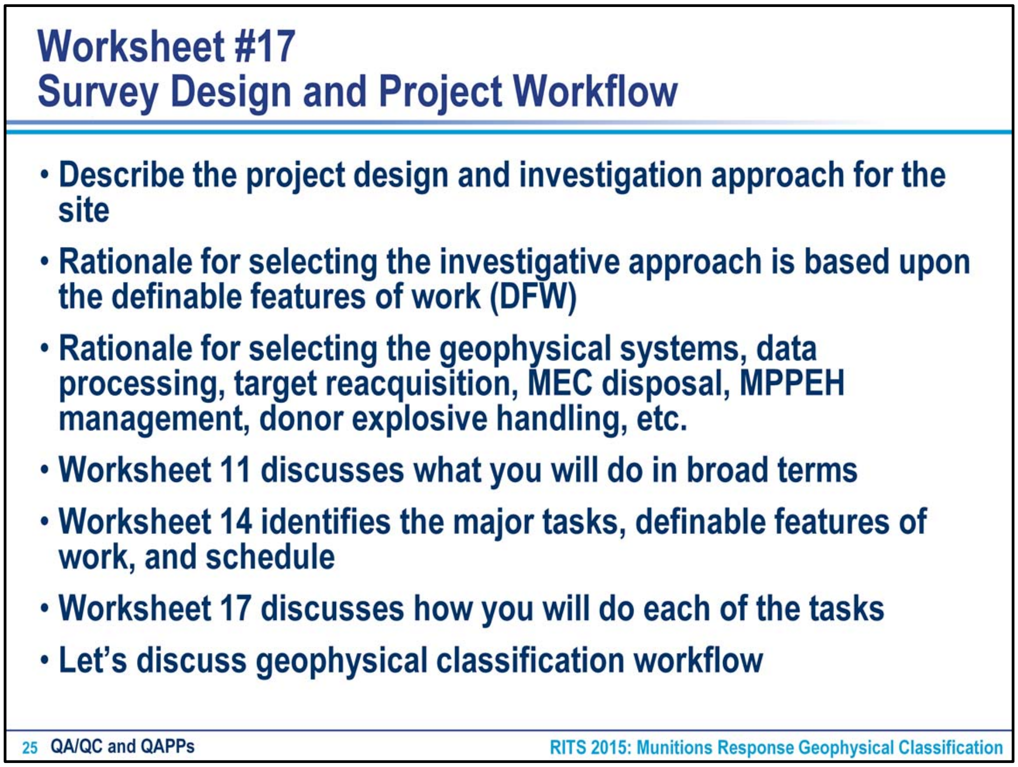
- Note the difference in the acceptance criteria for the in-line measurement spacing due to the slightly different size of the equipment (1m MM vs 0.8mTEMTADS)

Worksheet #22 (3)
Equipment Testing, Inspection, and QC

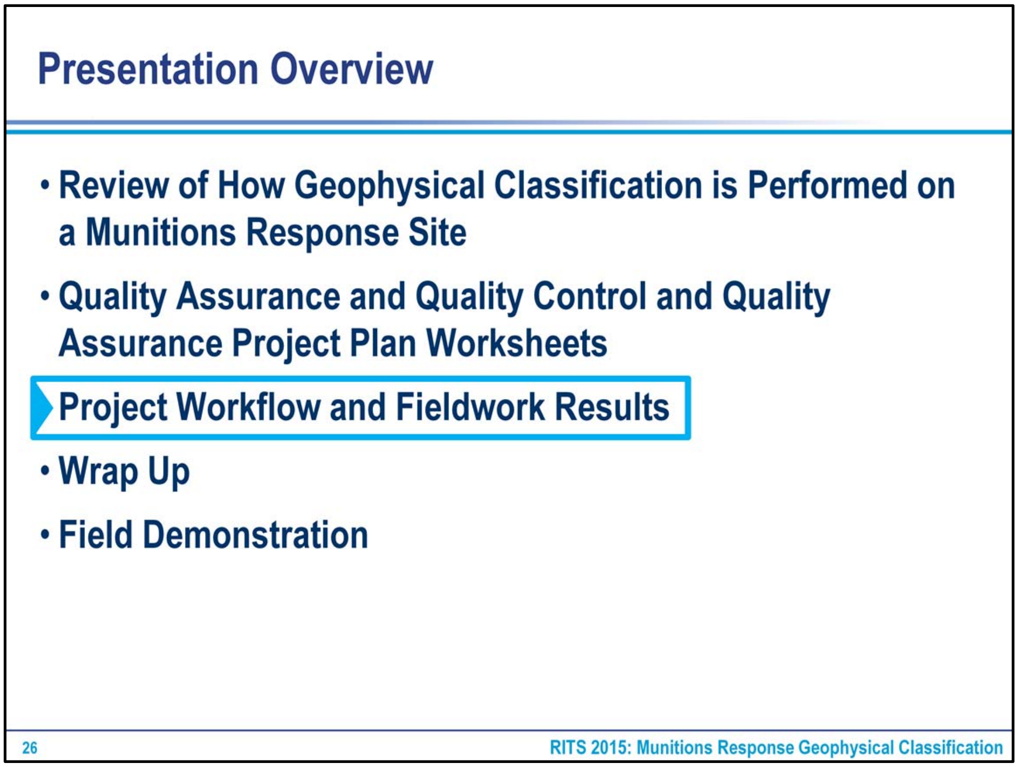
Measurement Quality Objective (MQO)	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Sensor TX current (TEMTADS)	Per measurement	Field Team Leader/running QC summary/Project Geophysicist	Current must be ≥5.5A	CA: out of spec data rejected
Sensor TX current (Metal Mapper)	Per measurement	Field Team Leader/running QC summary/Project Geophysicist	Current must be ≥4.0A	CA: out of spec data rejected

24 QA/QC and QAPPs RITS 2015: Munitions Response Geophysical Classification

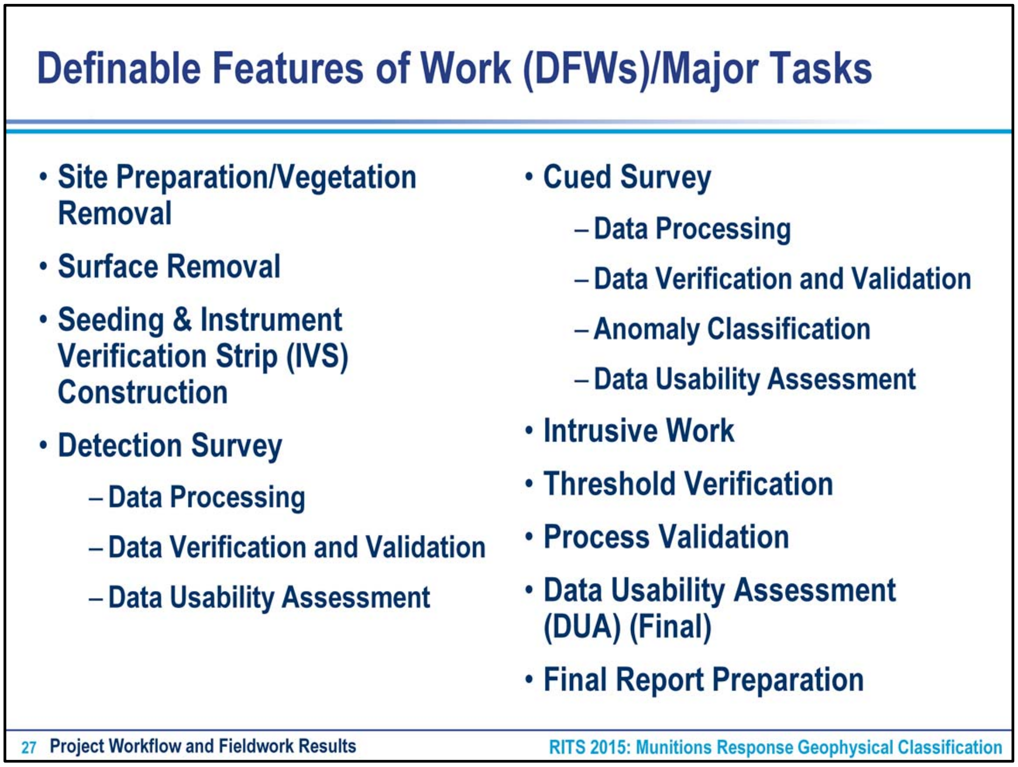
- Since the instruments have different coils, the acceptable transmit current is different for each sensor
- These are just some of the criteria, the QAPP Template has several pages of MQOs and their acceptance criteria



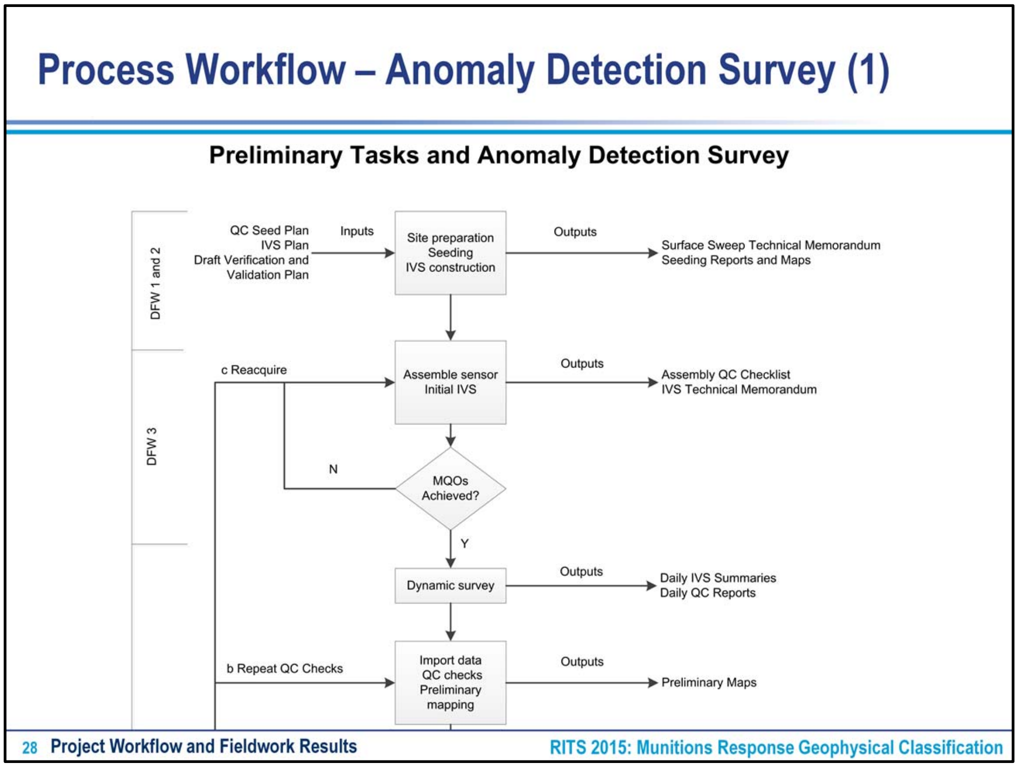
- Another important WS is #17
- Here is what worksheet 17 should describe and what rationale it should provide
- The intent of WS17 is different than some of the other WS's listed
- WS17 really should discuss how each of the tasks will be performed and how the work will be accomplished (workflow)



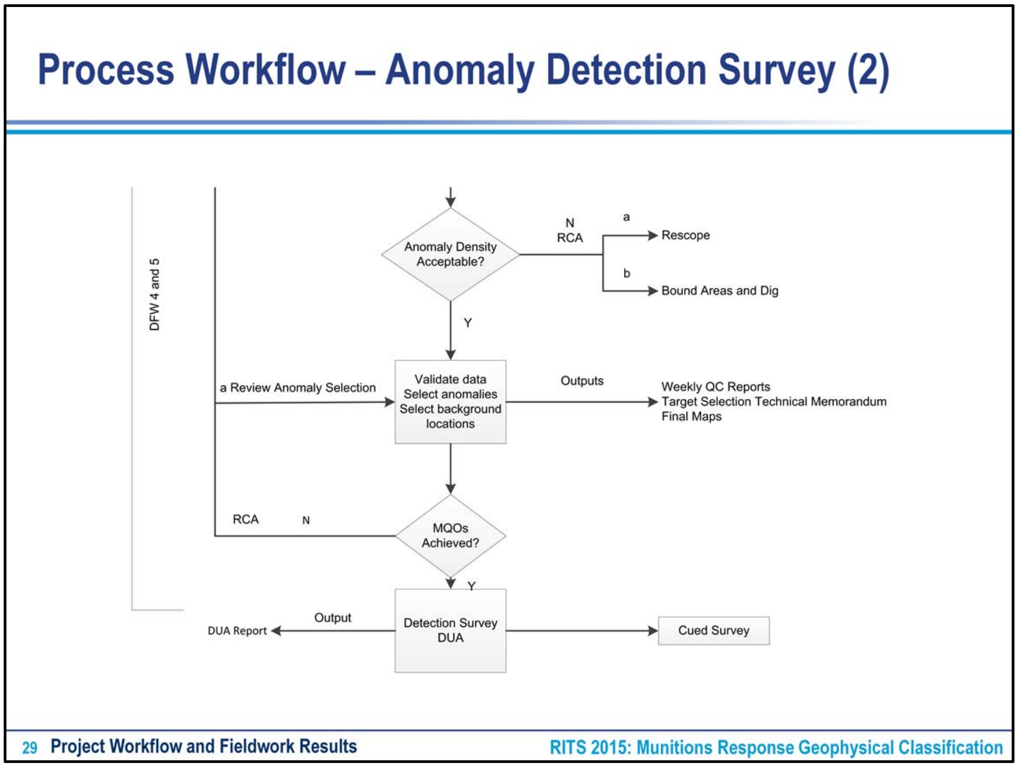
- Let’s now discuss how work is accomplished on a MRS using geophysical classification and some of the quality considerations for the work



- Here are the major DFWs/Tasks on a MR project
- Discuss each of the DFWs/Tasks and provide examples of the type of work performed in each
- Walk around during the detection survey and stand stationary for the cued survey to help illustrate the difference between the surveys



- This graphic shows the process workflow for the anomaly detection survey
- In the student handbook is a full page printout of this workflow
- Show the students where this is and why they don’t have to stare at the eyechart up on the screen
- In the following slides we will be discussing and highlighting some of the sections of this workflow that are important in performing geophysical classification



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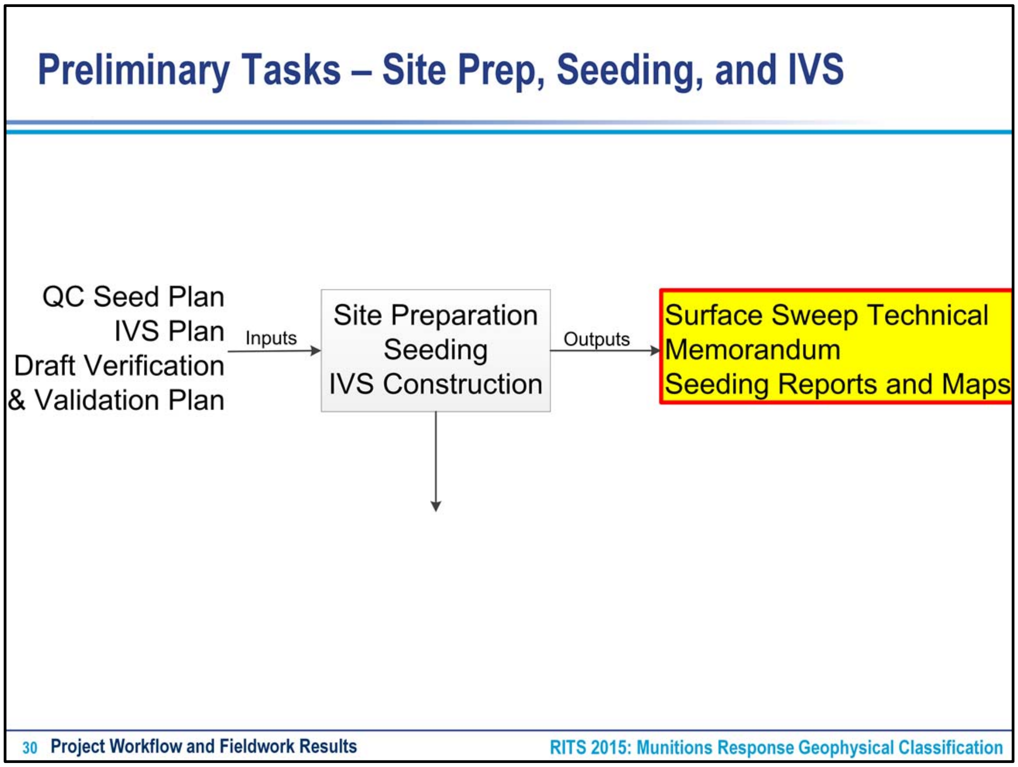
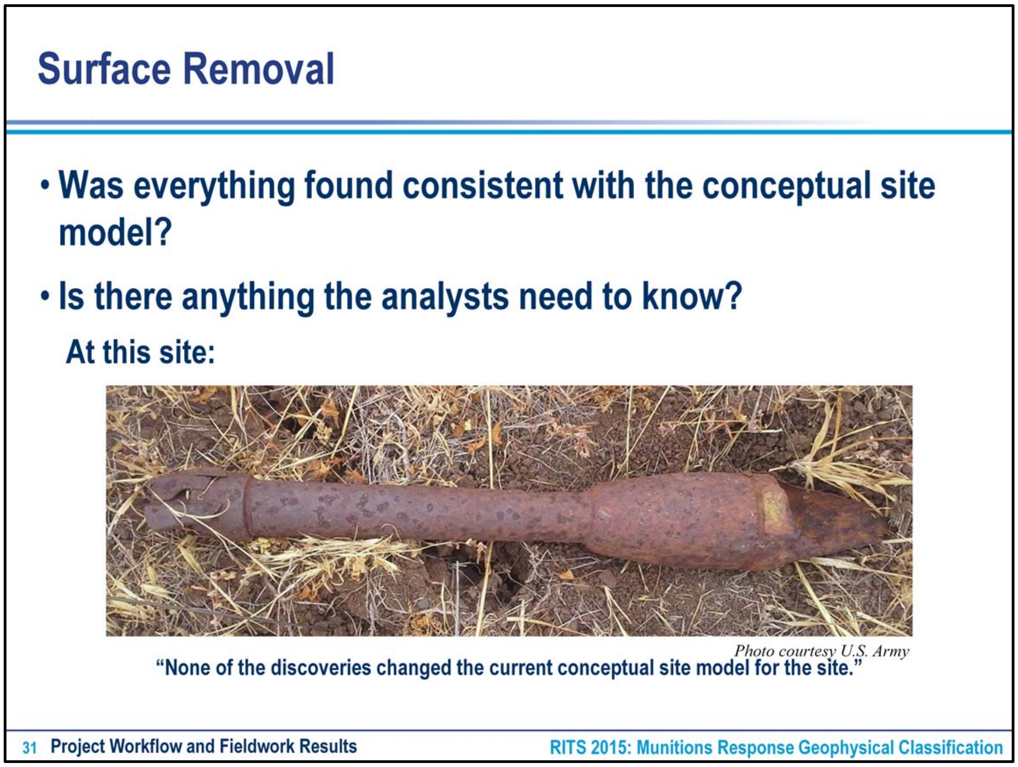


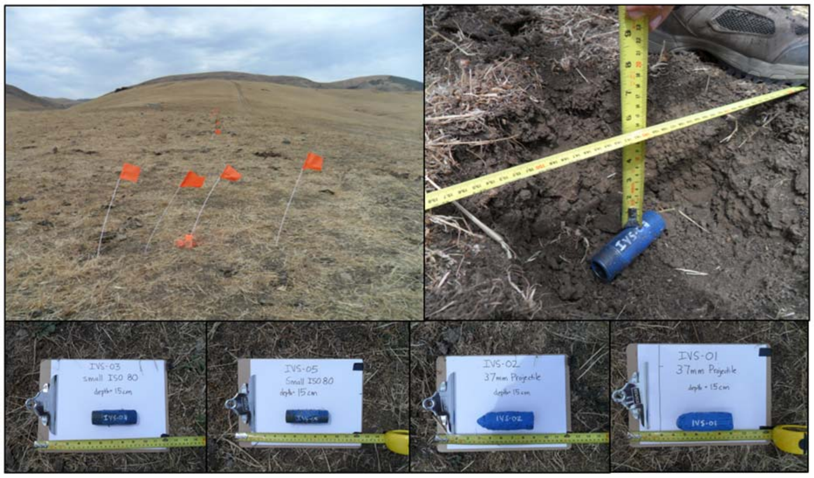
- Throughout the rest of this presentation we are going to highlight some of the key points in the workflow
- Site preparation, seeding and IVS construction are important preliminary tasks
- The outputs from these tasks include the results from the surface sweep, and seeding reports which are firewalled from the production crews



- Discuss the importance of the CSM and how it identifies the munitions used on the site
- If the surface removal were to find munitions that had not been previously identified, this could change the investigation or remediation
- For example, a different projectile may have a different tactical range
- This could then call into question whether the firing point has been identified for that type of projectile
- Luckily on this site, none of the discoveries changed the CSM

- Here is an example of the QC seeds placed out at a site
- Note that they were placed at different depths and orientations throughout the production area to verify the contractor's work
- Discuss how orientation of the seed affects the sensor's response and thus it's ability to detect the item

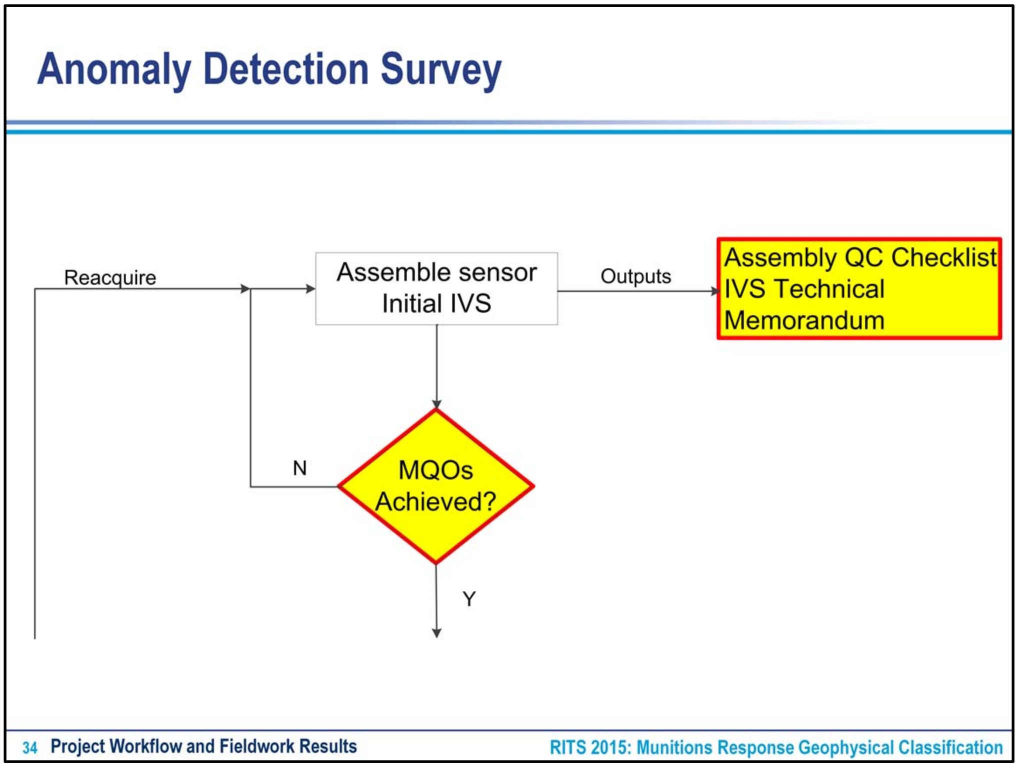
IVS Construction



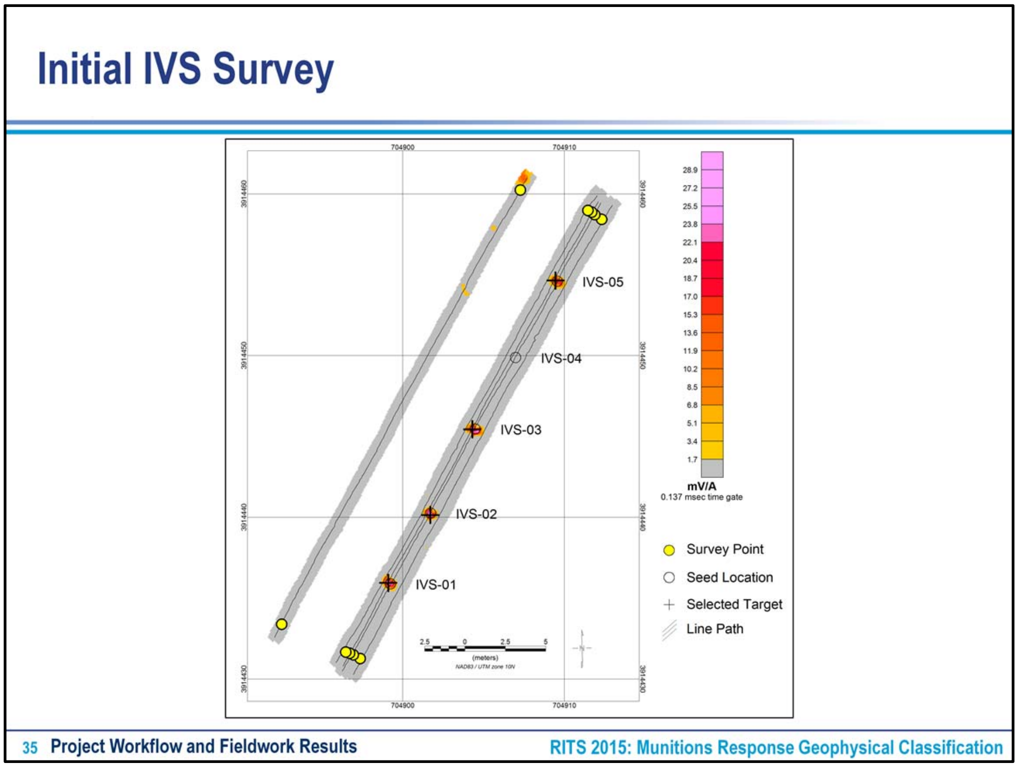
Photos courtesy U.S. Army

33 **Project Workflow and Fieldwork Results** **RITS 2015: Munitions Response Geophysical Classification**

- Here are the four items emplaced in the IVS and the view of the IVS strip
- Note the depth measurement and orientation



- The next portion of our workflow involves assembling the sensor and making sure it's functioning correctly by taking measurements in the IVS to verify that it can meet Measurement Quality Objectives
- The following slides discuss the MQOs associated with this phase of work



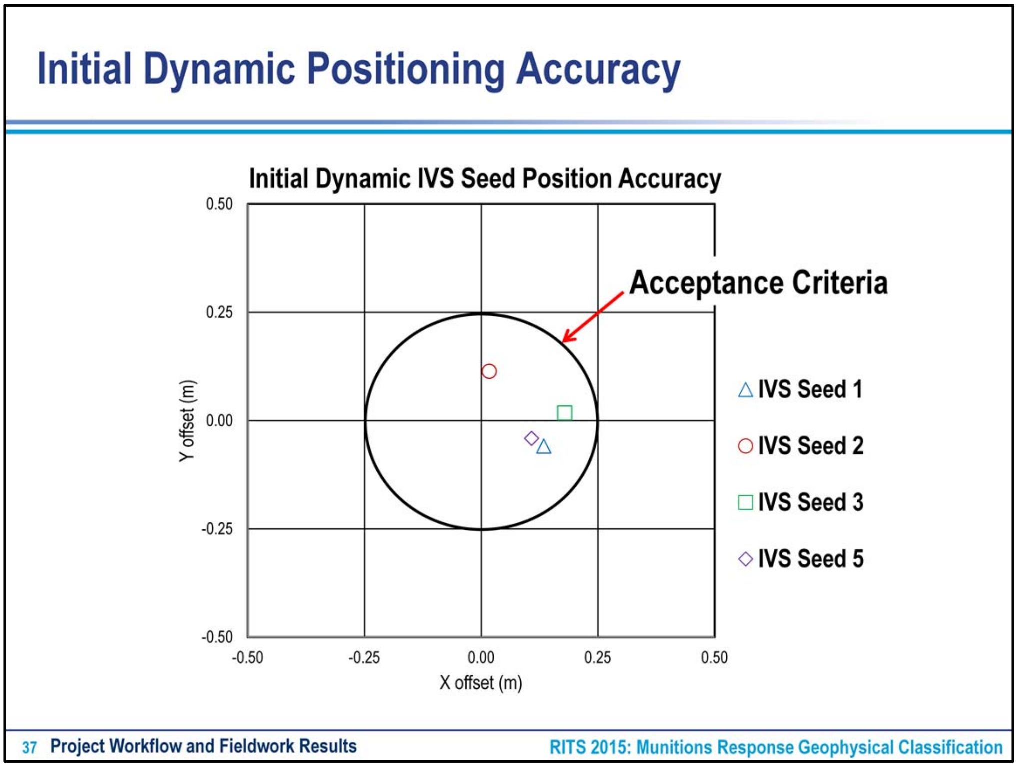
- Here are the responses that are measured by the sensor at each seed location in the IVS, the blank spot in the IVS, and the noise strip
- This looks good, point out the red responses for the items and the lack of response in the noise strip

Initial IVS – Is the Sensor Functioning Properly and Ready to Collect Data?

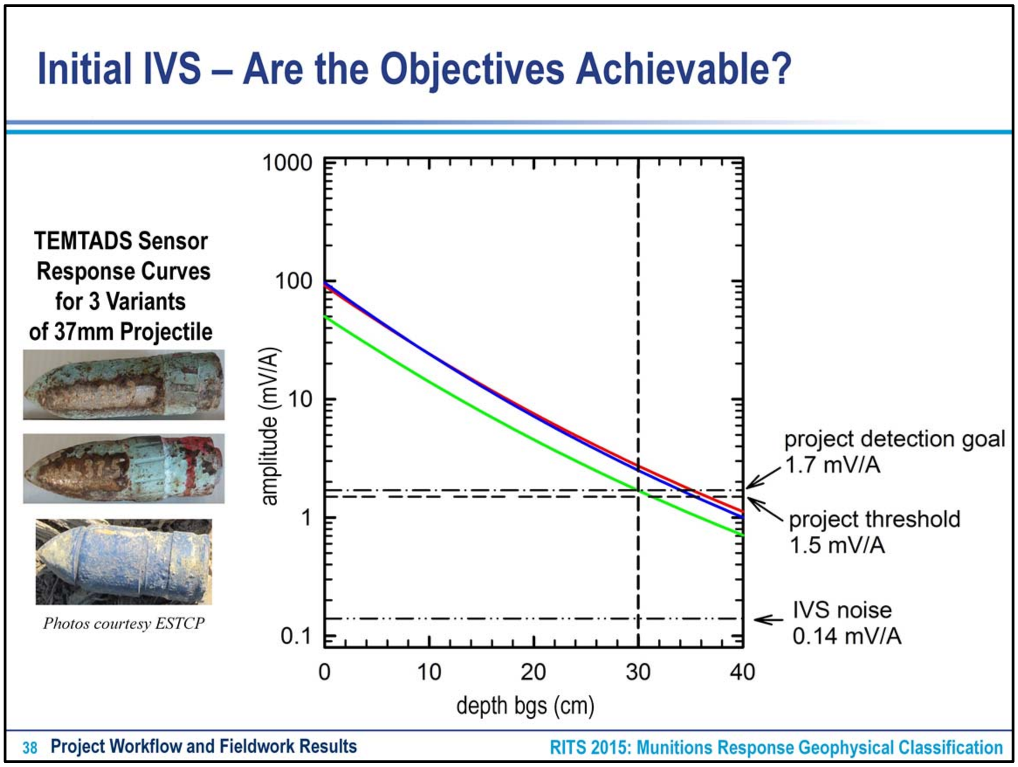
TEMTADS Measurement Quality Objectives

MQO	Acceptance Criteria	Results
Initial Dynamic positioning accuracy (IVS)	Derived positions of IVS target(s) are within 0.25m of the ground truth locations	Pass: average position offset = 0.14 m, maximum position offset = 0.18 m
Initial Dynamic detection response amplitudes (IVS)	Response amplitudes within 25% of predicted amplitudes	Pass: response items were within 25% of predicted amplitudes
Instrument Function test	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	Pass: real-time pass/fail indicated at time of tests

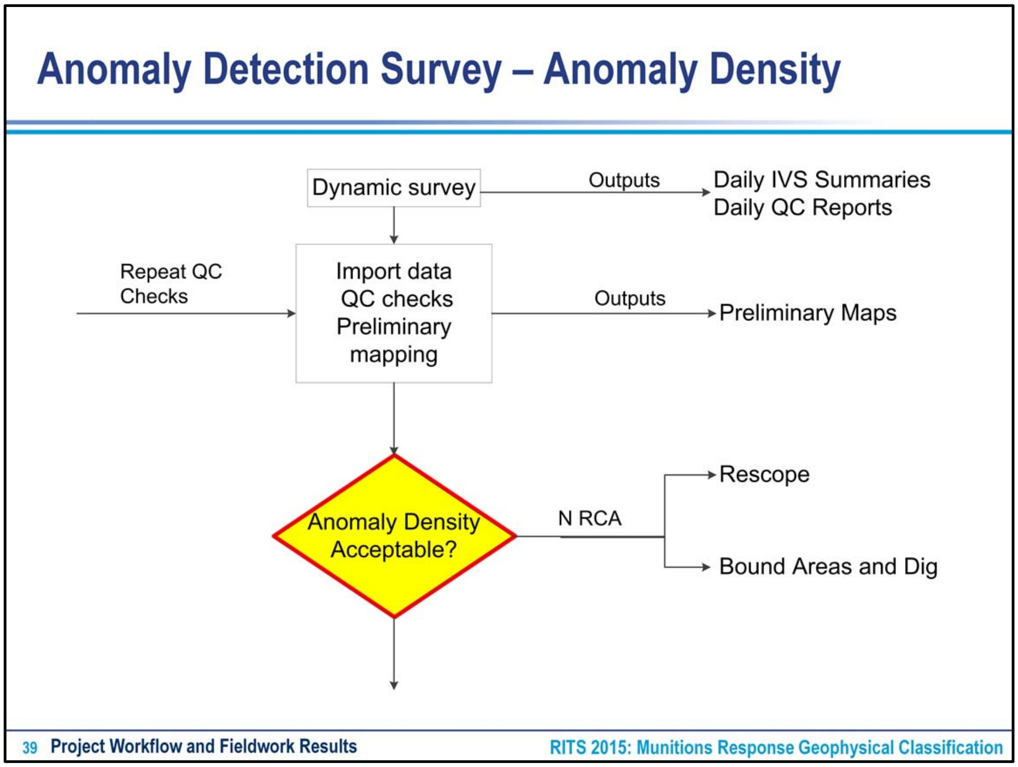
- We have acceptance criteria for the initial IVS to make sure the sensor is functioning correctly, which includes positioning accuracy, response amplitudes, and making sure all the responses “agree” with each other



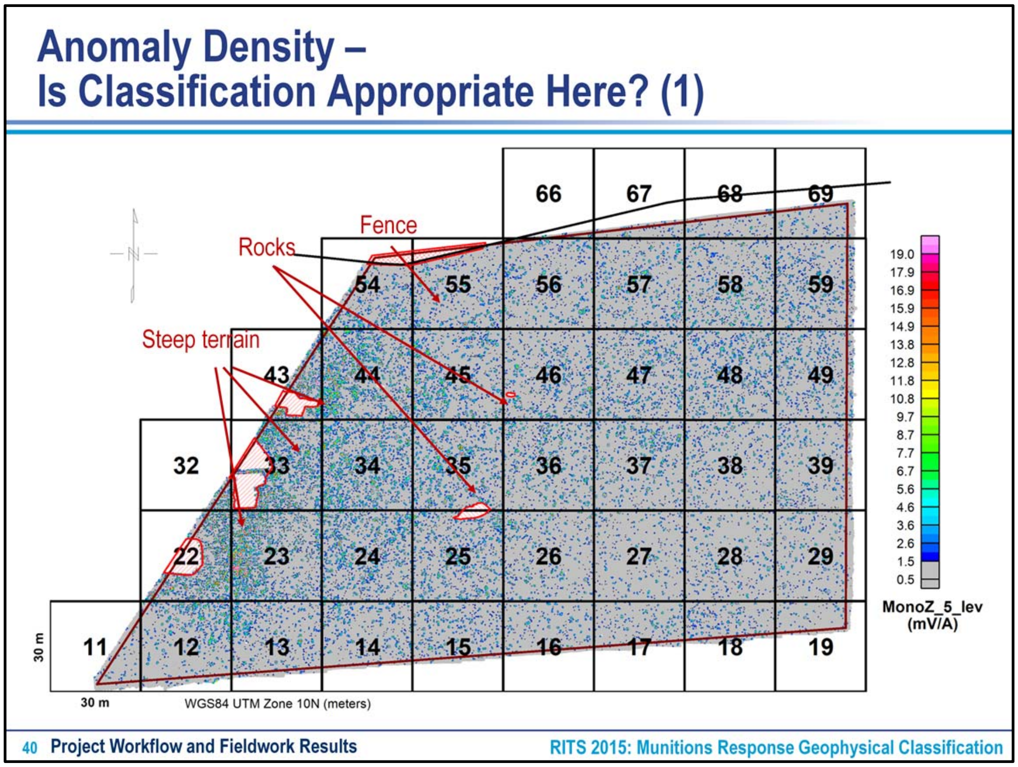
- Here is a graphic showing the four emplaced items and their reported positions
- The measurements have met the 0.25m acceptance criteria



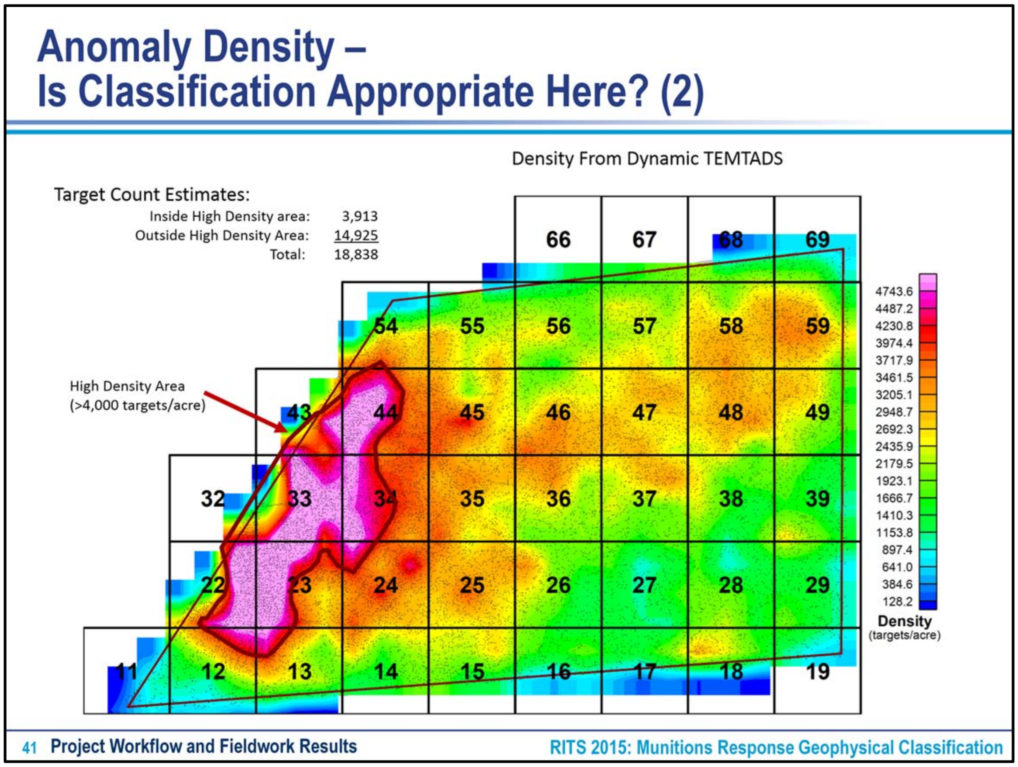
- This graphic shows the responses of 3 variants of 37mm projectile
- The lowest response (green) is still more than 10 times the threshold at the detection goal of 30cm
- Thus are objectives are achievable



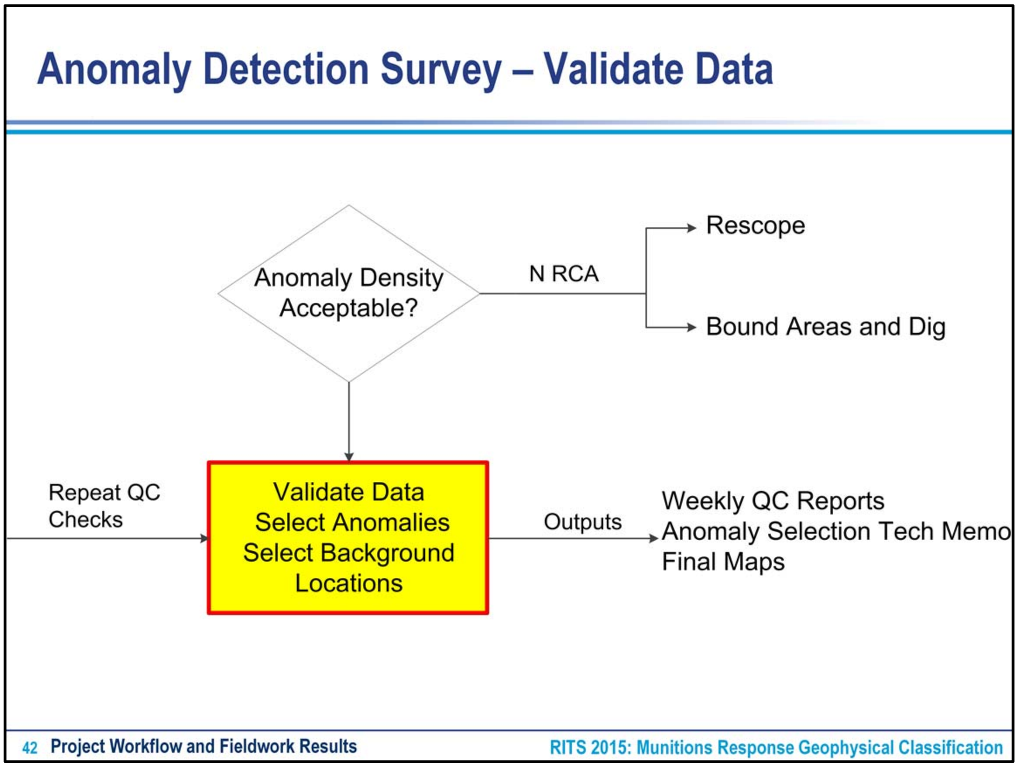
- After verifying the sensor is functioning properly, the dynamic survey is performed
- The data from the survey must be evaluated to determine if the anomaly density is acceptable to perform geophysical classification
- Geophysical maps help us evaluate the anomaly density to determine if areas have too high an anomaly density to reliably perform classification



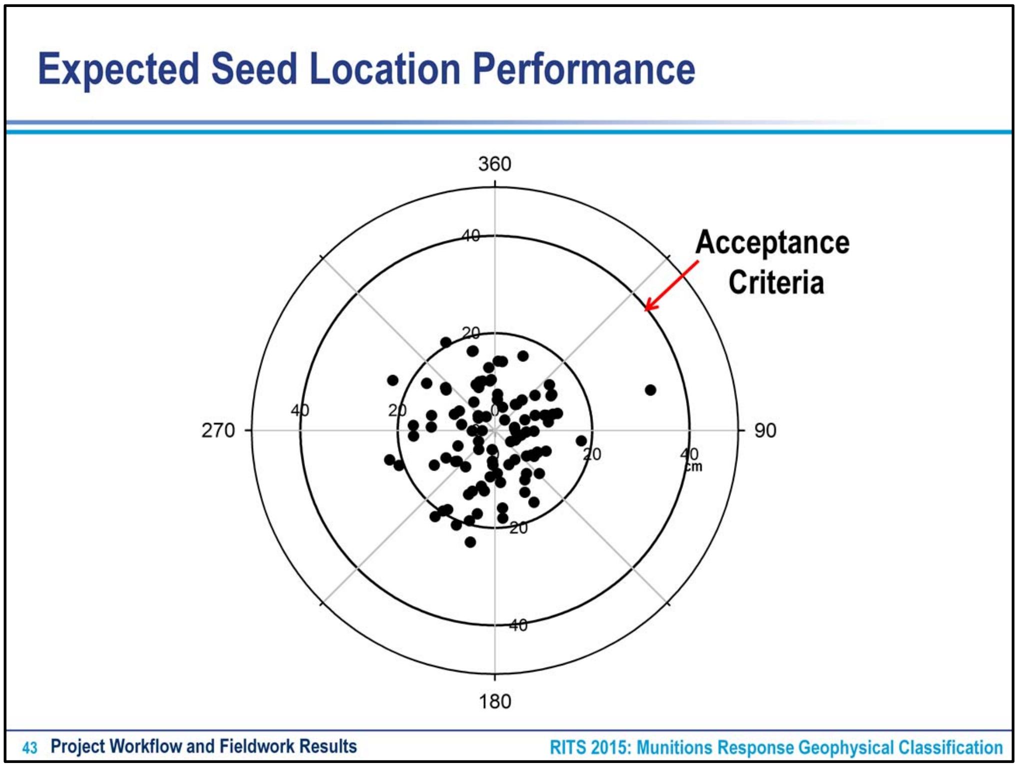
- Here is a geophysical map with varying monostatic Z coil responses
- Some areas may not be accessible to survey due to terrain (30 percent slope rule)
- Point these out to the audience
- Also note the actual target area for this site was just off the map near grids 32 and 43



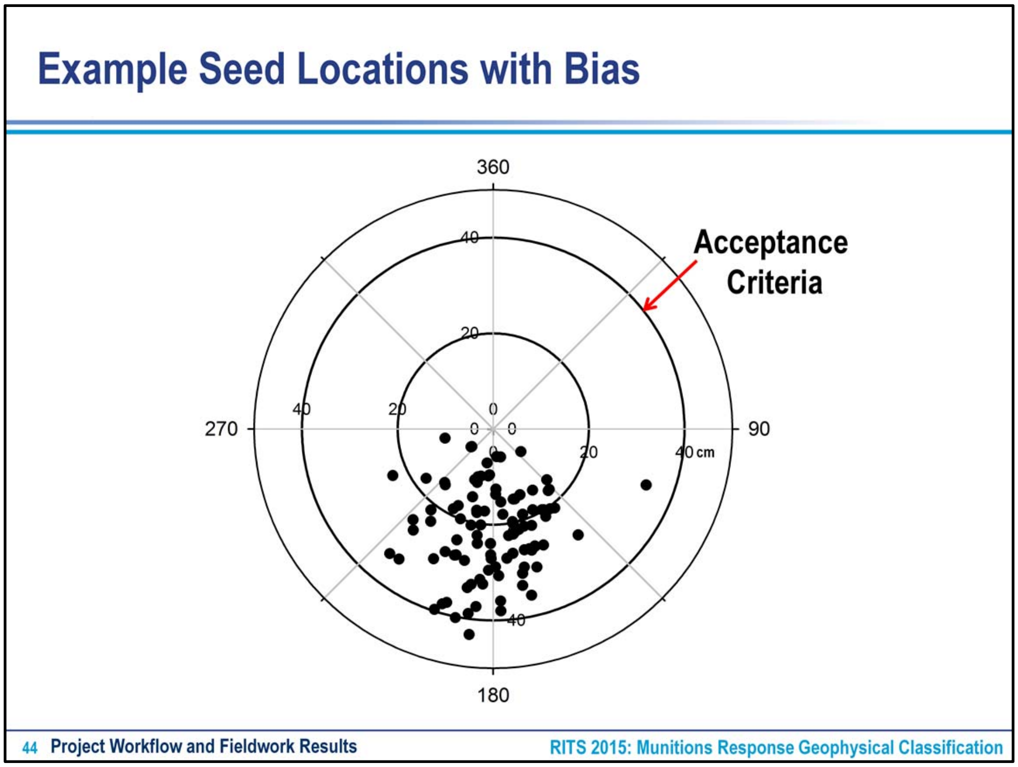
- At some point the sensor cannot resolve individual anomalies due to signal saturation of the sensor
- This processed geophysical map provides the density (targets/acre)
- The rough "rules of thumb" are 5 large anomalies under sensor or more than ~4,200 anomalies per acre
- The red line indicates the area where classification will not work
- In this case, this is very close to the actual target area which is just off the map
- A large percentage of the area is amenable to classification



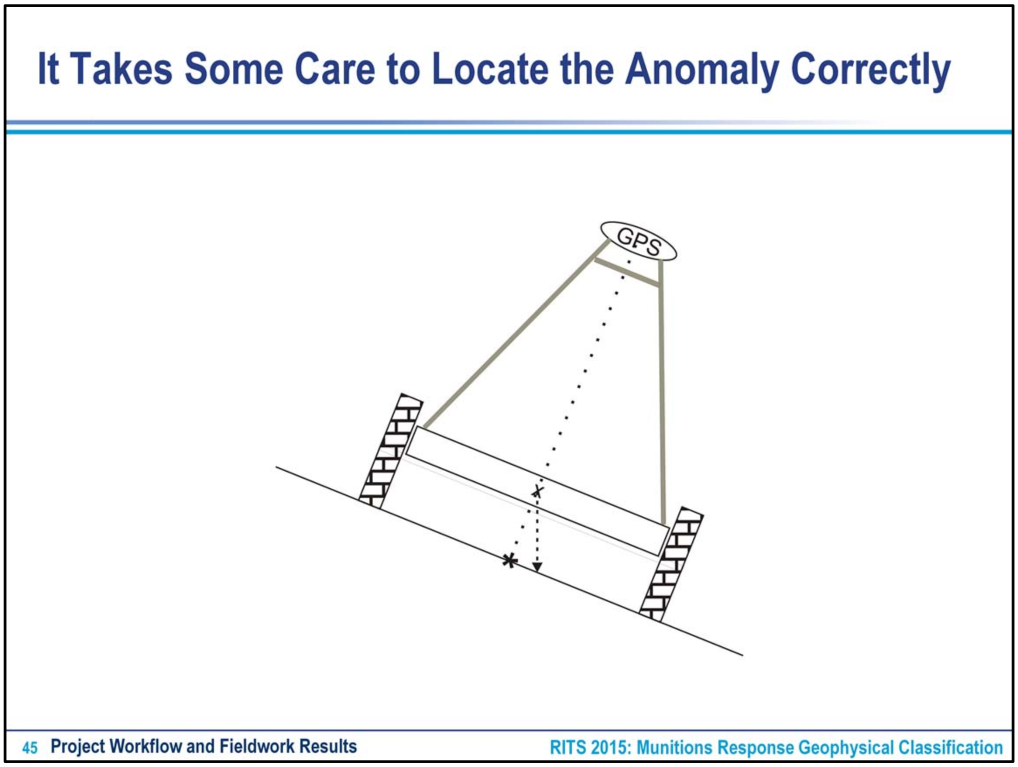
- Validating the data, selecting the anomalies, and selecting background locations is the next step performed in the process workflow
- We will go over in the following slides some of the criteria to validate the data



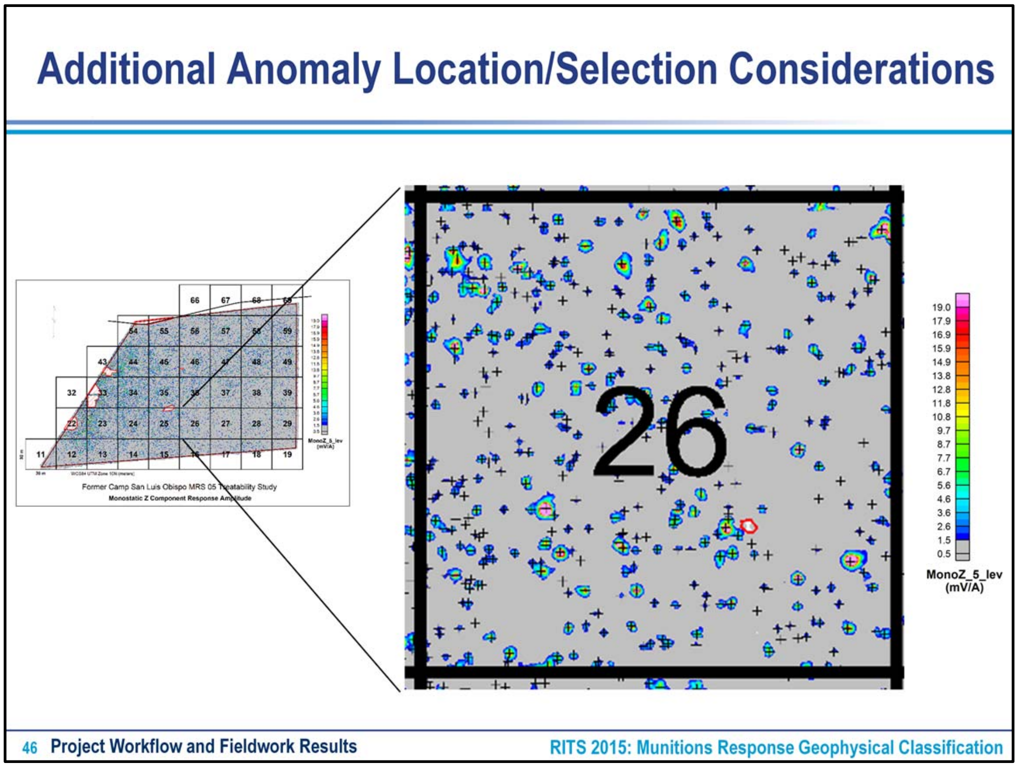
- The seeds that are placed in the production area have quality criteria associated with them as well
- In this case, their reported position from the survey must be within 40cm of their emplaced position
- This is a example of what “good” data look like
- Note that the acceptance criteria is larger for the seeds than for the IVS (25cm)
- This because we aren’t purposely driving right over the top of the seeds, unlike the items in the IVS



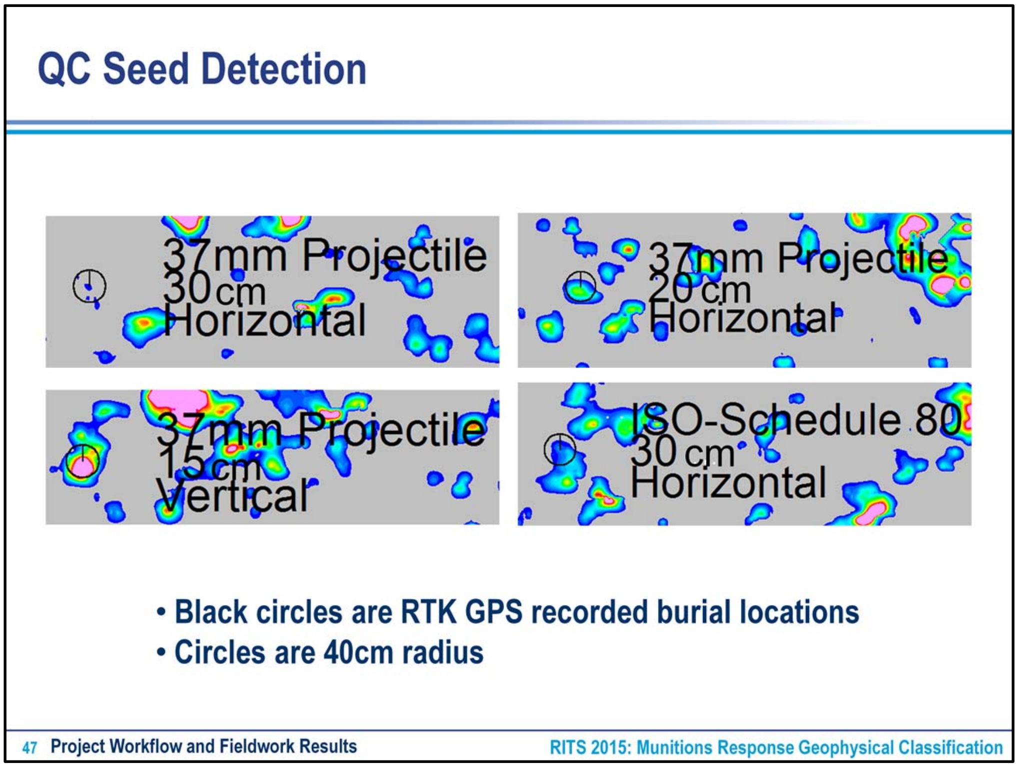
- Here is an example of a bias in the data
- This is analogous to a gunner with his sights off!
- Clearly the data need to be checked to determine why it is biased



- And here is the reason for the bias
- Note how the sensor reports its position with respect to its frame, which is tilted due to the slope of the hill (the bias)
- The true position is just the x,y and needs to be accounted for when reporting the data
- This should be in the next update to Oasis Montaj software to account for this potential error, which can be corrected for using the sensor's inertial measurement unit (IMU)

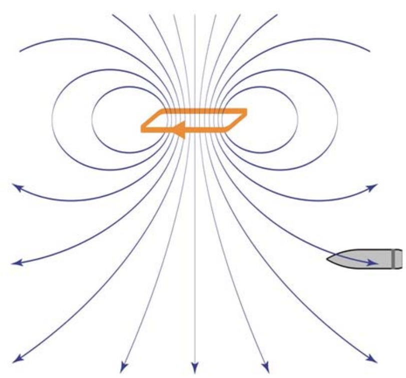


- There are additional anomaly location/selection considerations that we will discuss on the next several slides
- These criteria need to be applied to each grid of the data



- First, all the seeds need to be detected and placed on the anomaly selection list (Tech Memo)
- For each grid, the seeds that were emplaced at different depths and orientations need to be identified and checked to make sure they're on the list

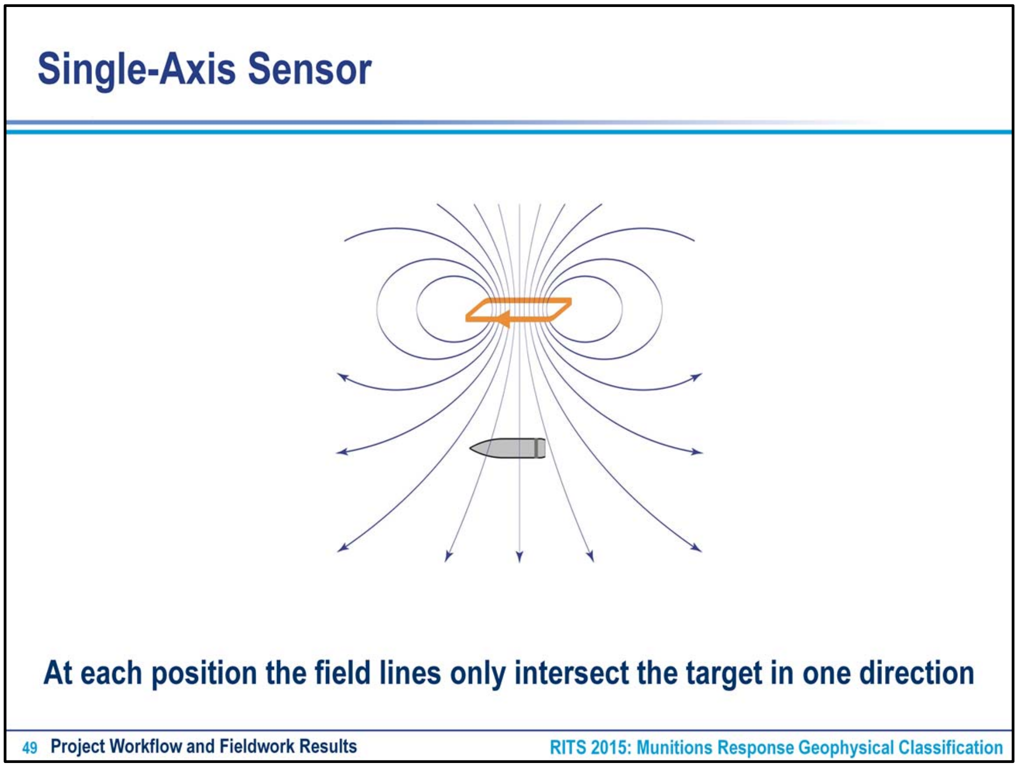
Single-Axis Sensor



At each position the field lines only intersect the target in one direction

48 Project Workflow and Fieldwork Results RITS 2015: Munitions Response Geophysical Classification

- One of the big problems using single-axis sensors like the EM61 to characterize buried munitions is illustrated in the next three slides
- As you can see, at any position of the sensor over the object, the field lines only intersect the object in a single direction



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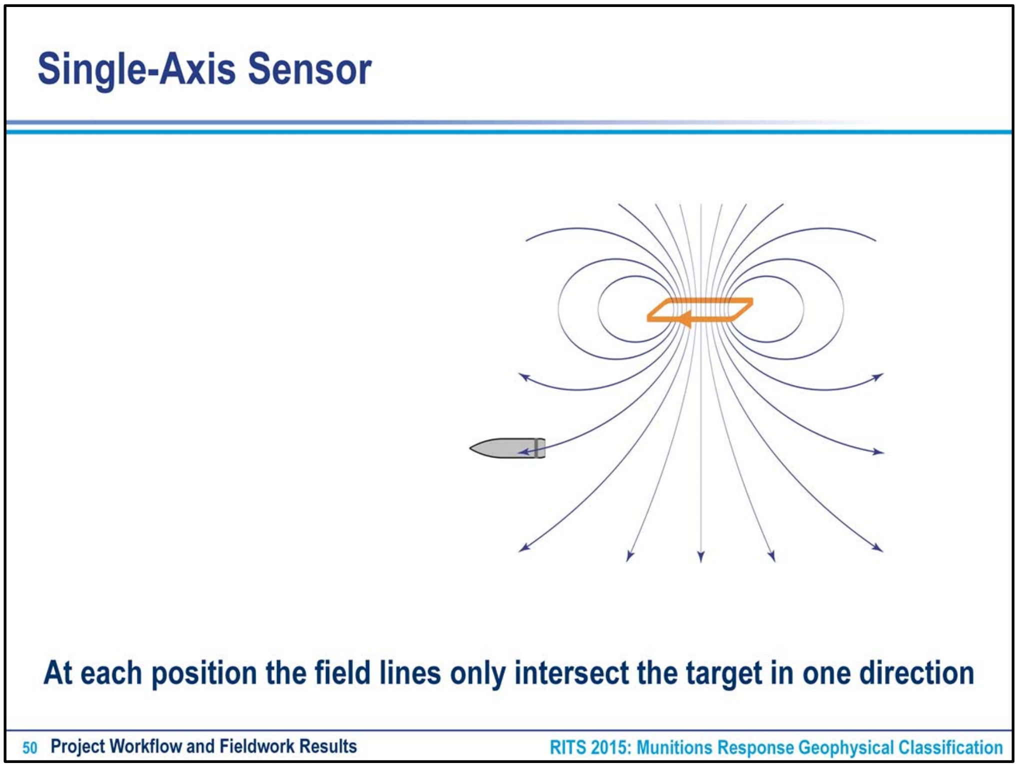

- One of the big problems using single-axis sensors like the EM61 to characterize buried munitions is illustrated in the next three slides
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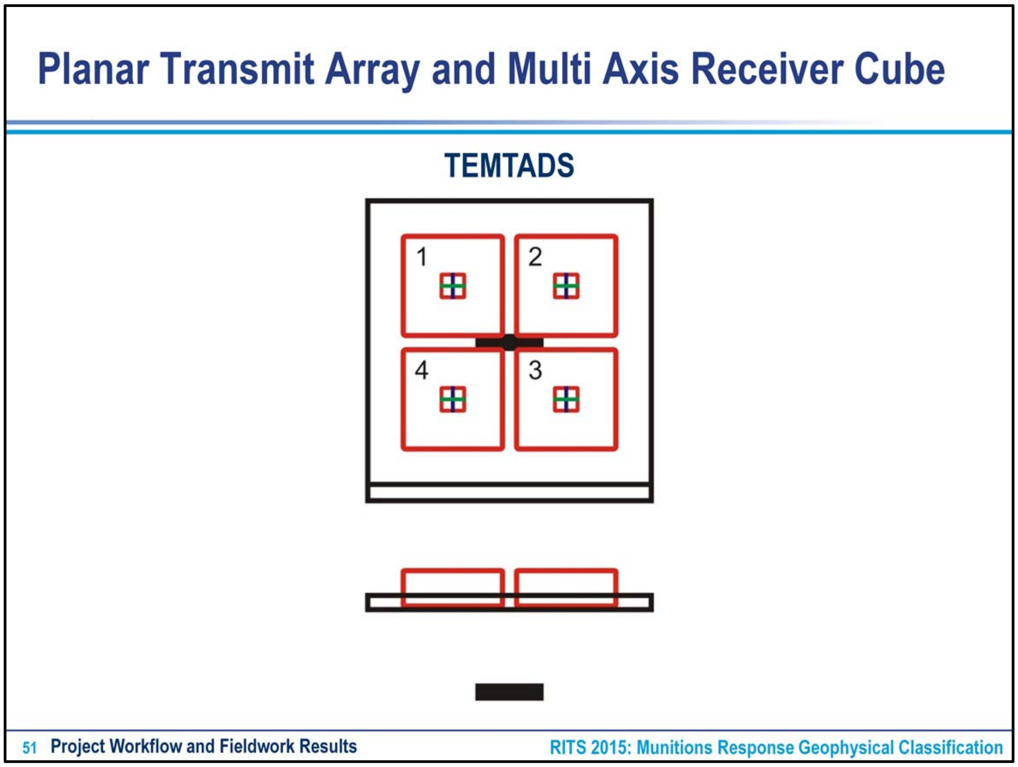
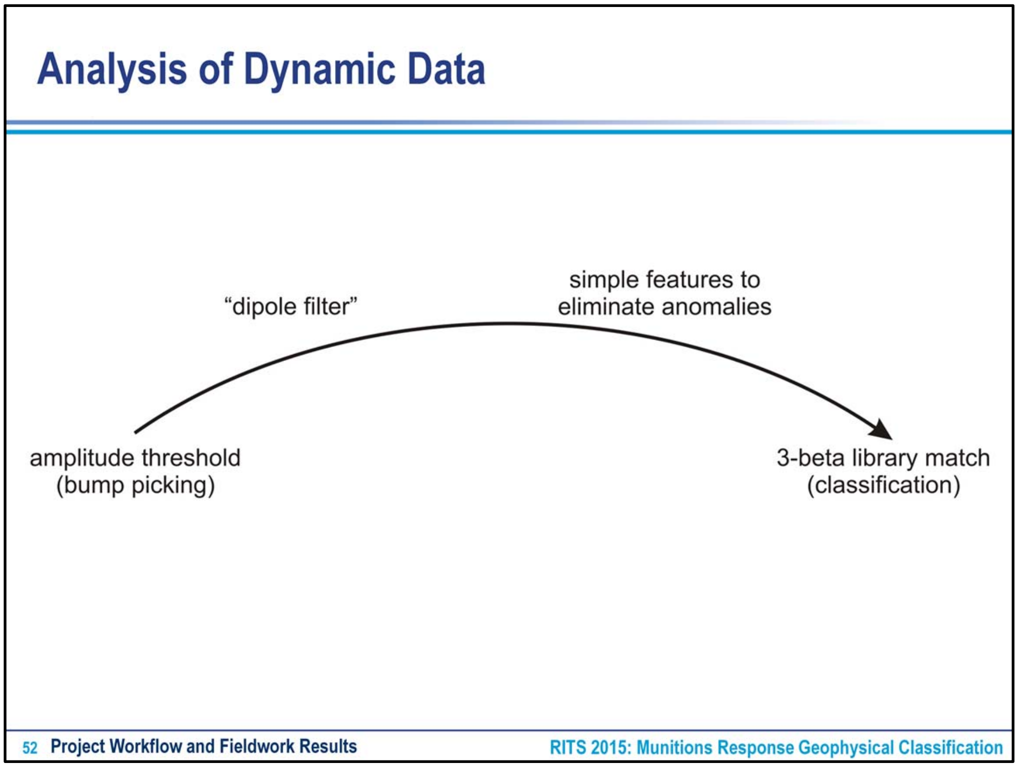
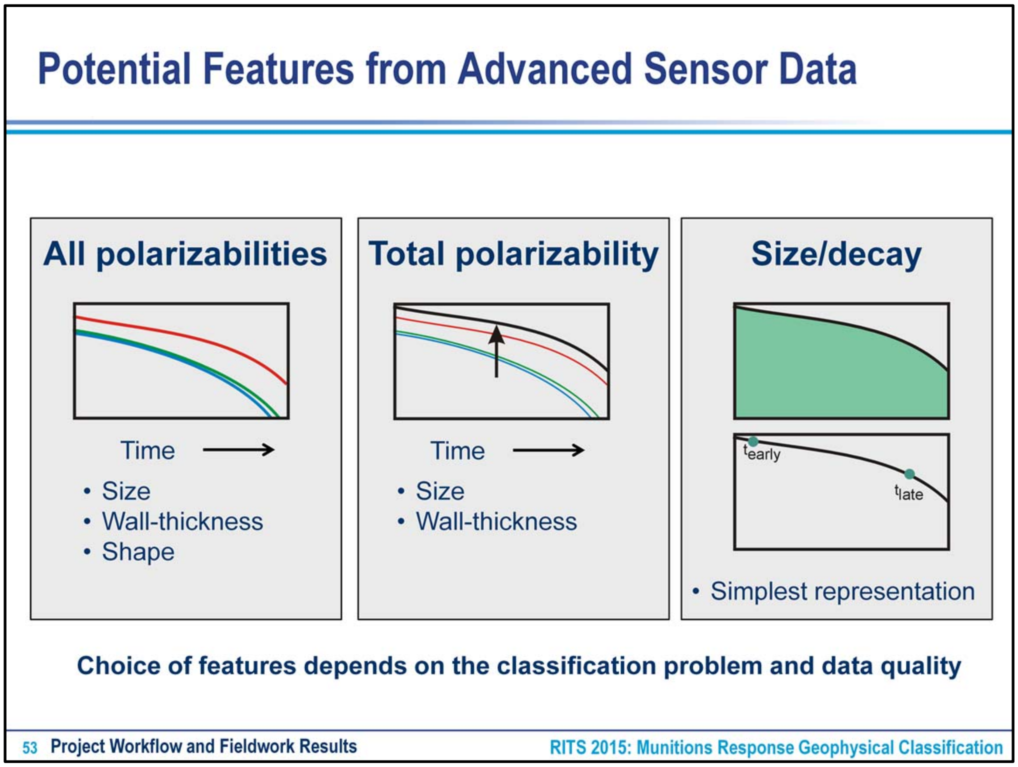


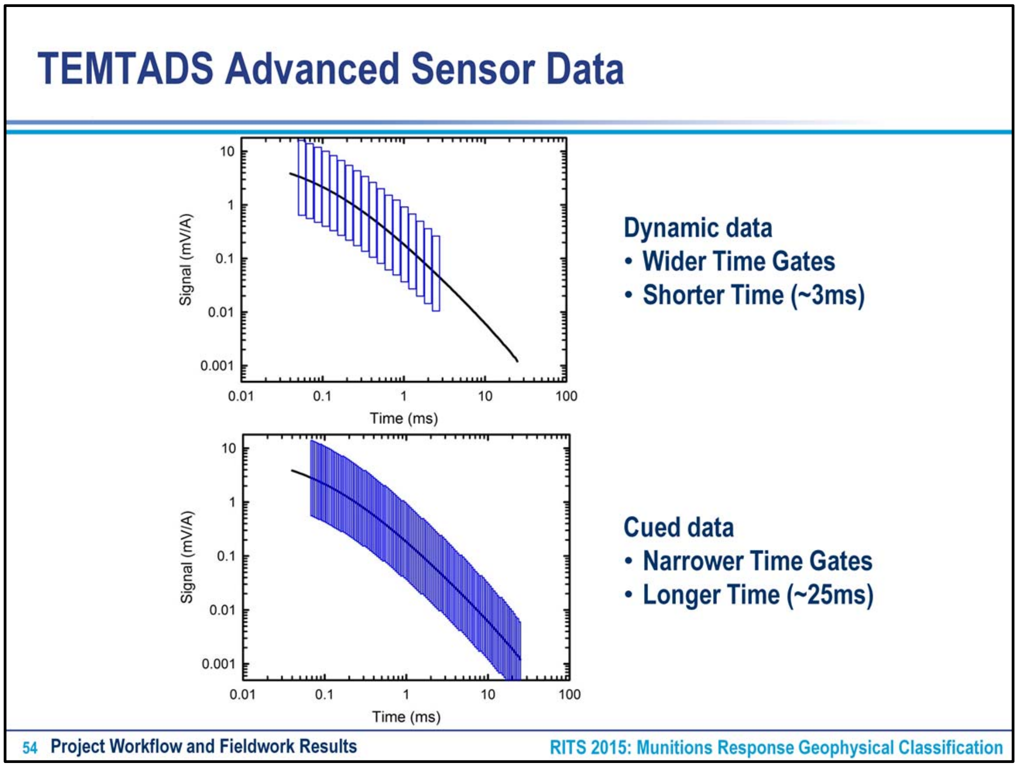
- The TEMTADS overcomes this issue with its many transmit and receiver combinations
- It illuminates the target with 4 different transmit coils and receives on 4 different receiver cubes (x,y,z)
- The net result of this is improved spatial data, allowing better definition of the anomaly and its position on the geophysical maps
- Point out the firing sequence, the location of the cubes, and why an object that is in the center is illuminated from all transmitters and good responses are received on all the receivers



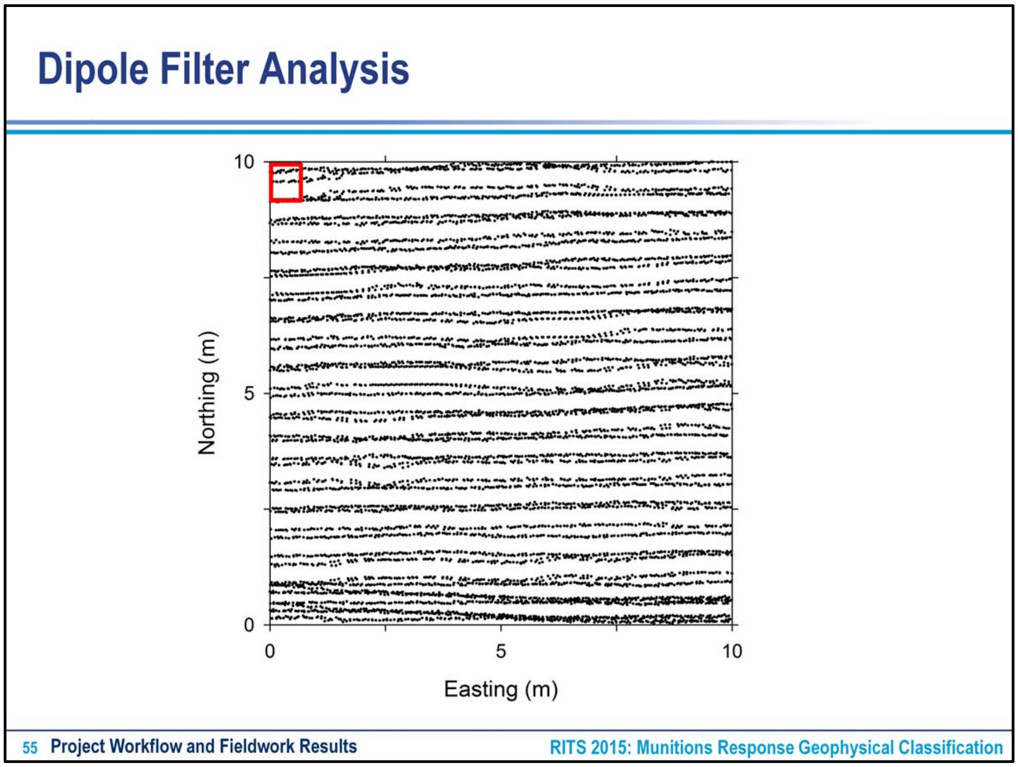
- The analysis of dynamic data spans the range from simple bump picking (amplitude and spatial extent to remove any data spikes), all the way to using library match techniques on the data
- In between are some techniques like diploe filtering, which makes sure the signal is from a dipole (metal object) and using simple features like size/decay to help determine if an item should be selected as an anomaly or not
- These processes can be used to "filter out" or "screen" the anomalies to reduce the number of anomalies requiring a cued survey



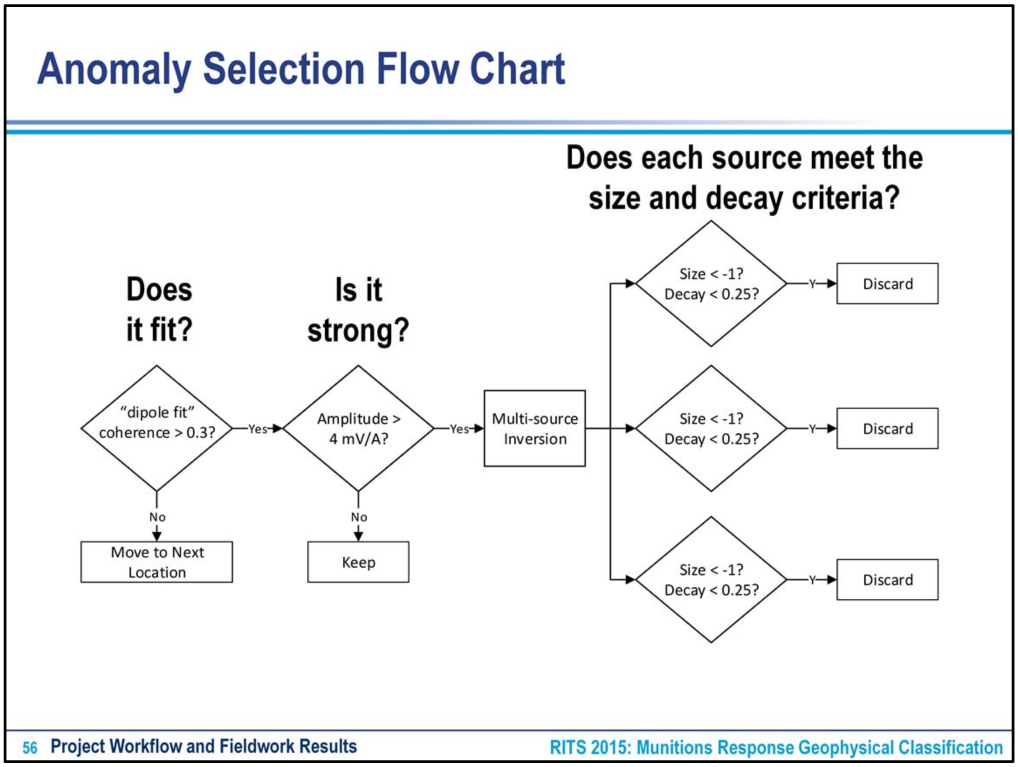
- Here are the potential features from advanced sensor data ordered from best to most simple that can be used to make a decision about the geophysical data
- The choice of features depends on the classification problem and data quality



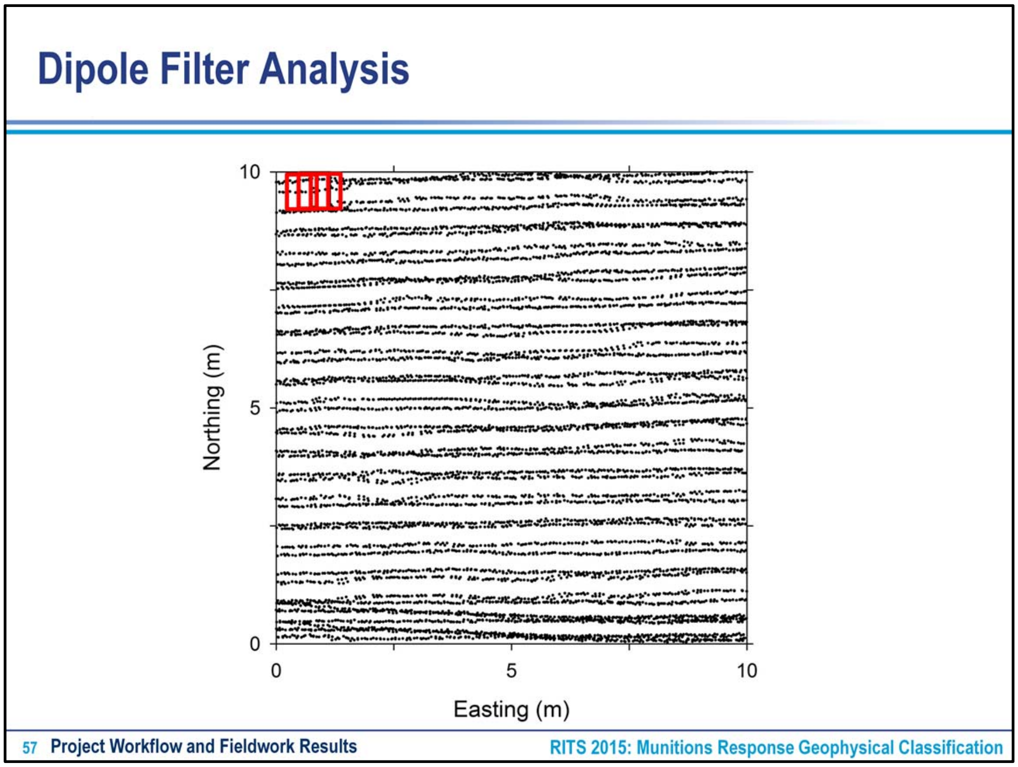
- This slide shows the difference between the dynamic data and cued data for the TEMTADS
- If the data is good enough with the shorter time and wider time gate to make determination about the anomaly then this data will be used, otherwise it will be cued to make the determination



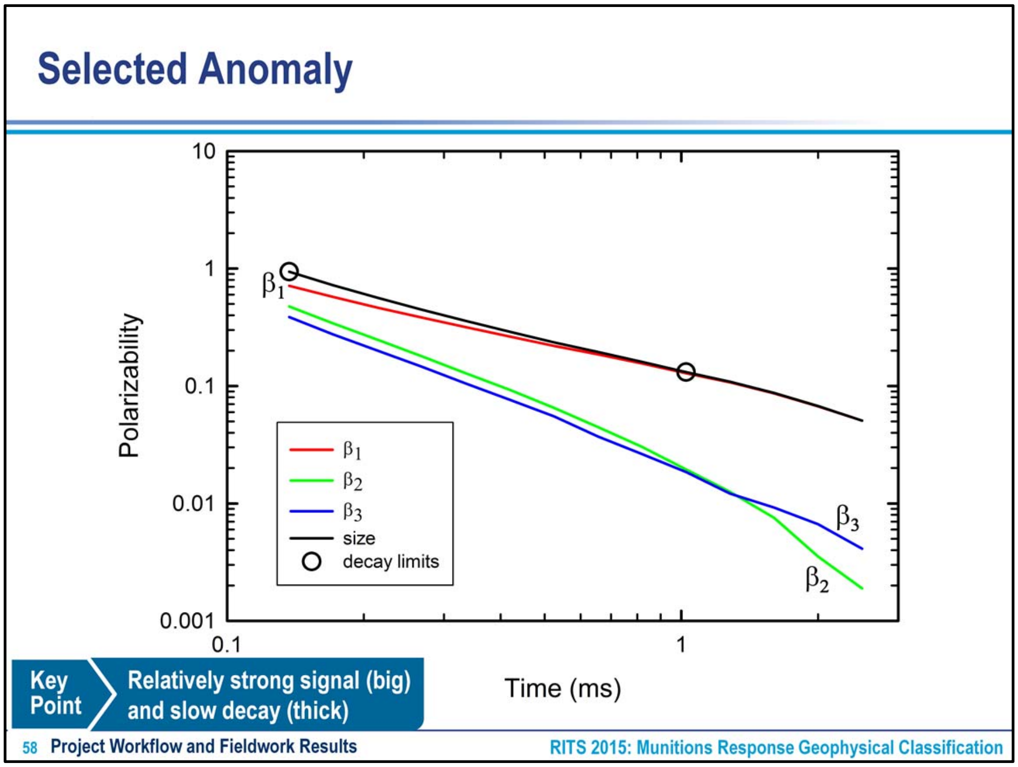
- One of the methods mentioned previously is the dipole filter analysis
- This method processes a “window” of dynamic data to make sure the source of the anomaly is a metal
- The next slide provides more details on the criteria that is used to filter the data



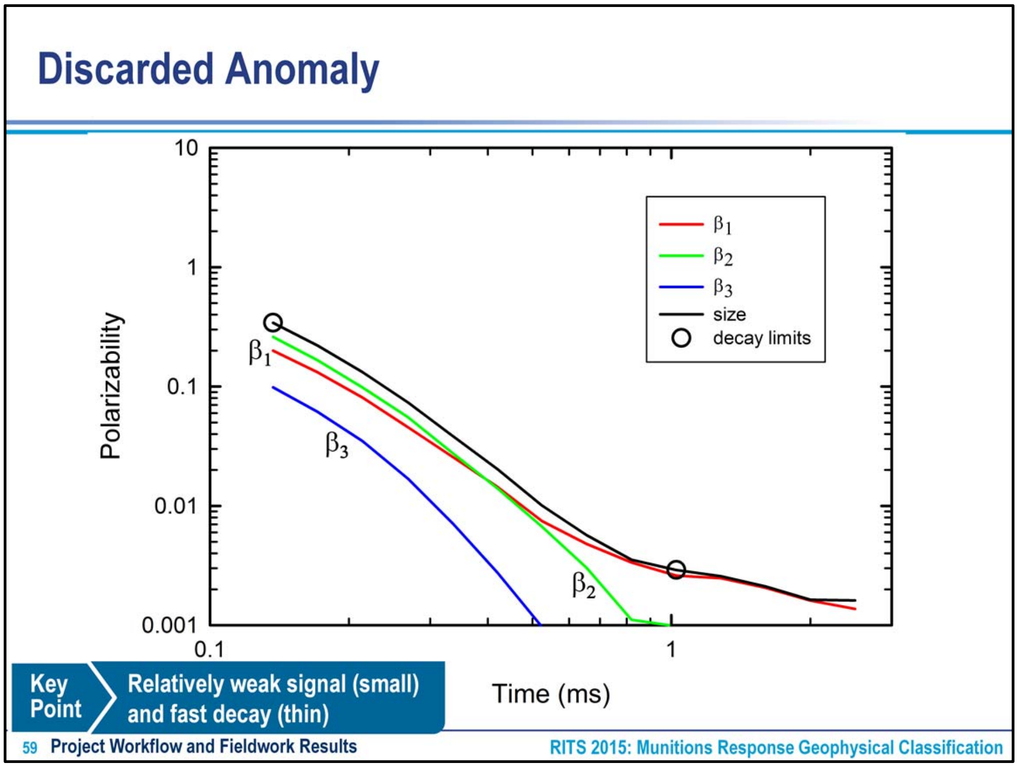
- Walk through the flowchart to discuss the different selection criteria, dipole fit, strength, and if there are multiple anomalies under the sensor, do they meet the size decay criteria



- The “window” is then moved on to process another area of somewhat overlapping data



- Here is an example of an anomaly that has been selected because its has a slow decay (thick walled) and it’s relatively strong (big)
- Point out the two circles on the total polarizability curve that help illustrate this point



- Here is an example of an anomaly that has been discarded because its has a quick decay (thin walled) and it's relatively weak (small)
- Point out the two circles on the total polarizability curve that help illustrate this point
- Compare and contrast with the previous slide

Seed Detection

QC Seeds Offset Results

	Average (cm)	Std Dev (cm)
Fit location offset from recovery measurement	5.5	4.0

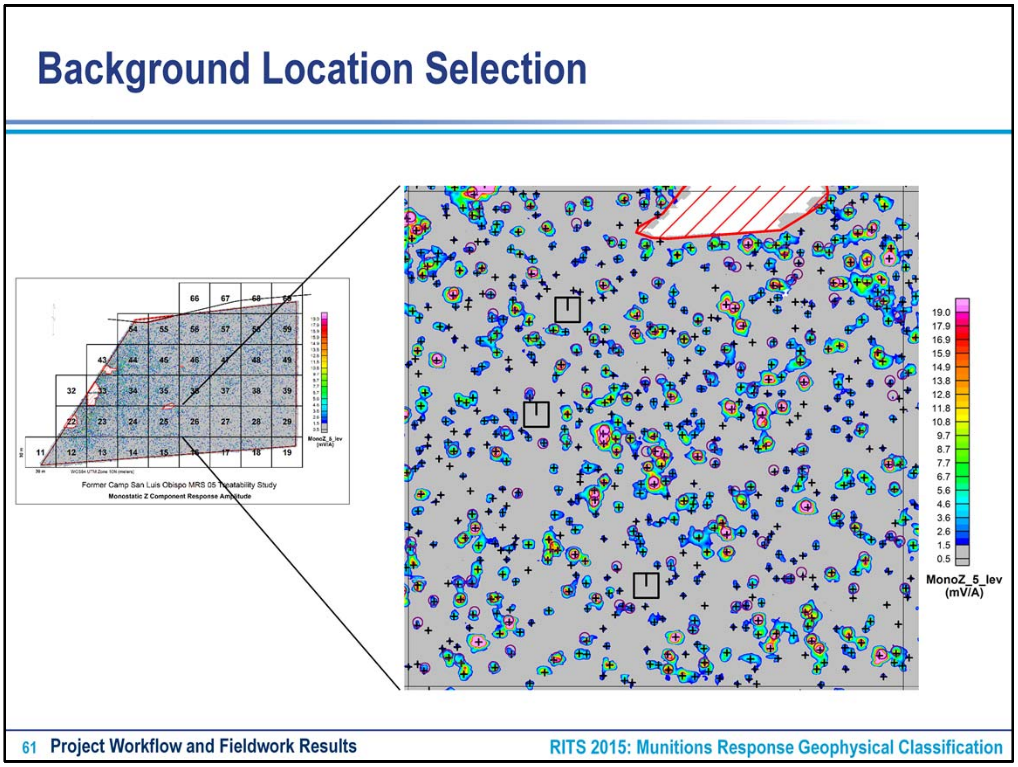
Validation Seeds Offset Results

	Average (cm)	Std Dev (cm)
Fit location offset from emplacement measurement	11.8	9.1
Recovered location offset from emplacement measurement	9.4	6.4

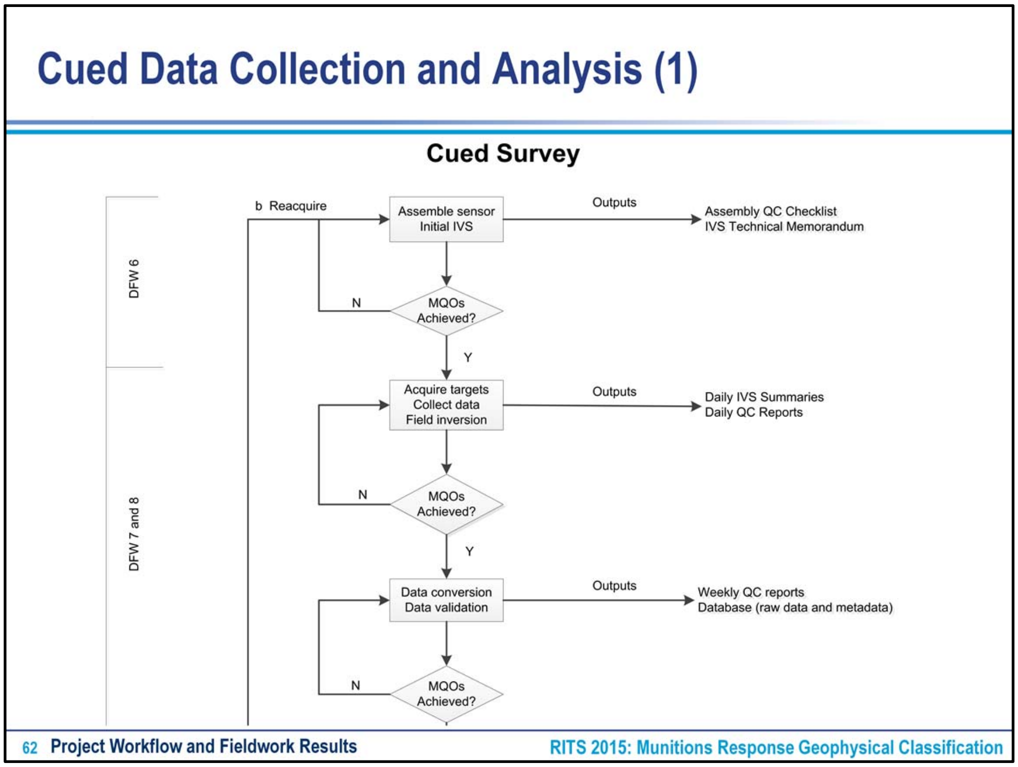
100% Validation Seeds Detected/Identified as TOI or on Cued Survey List

60 Project Workflow and Fieldwork Results RITS 2015: Munitions Response Geophysical Classification

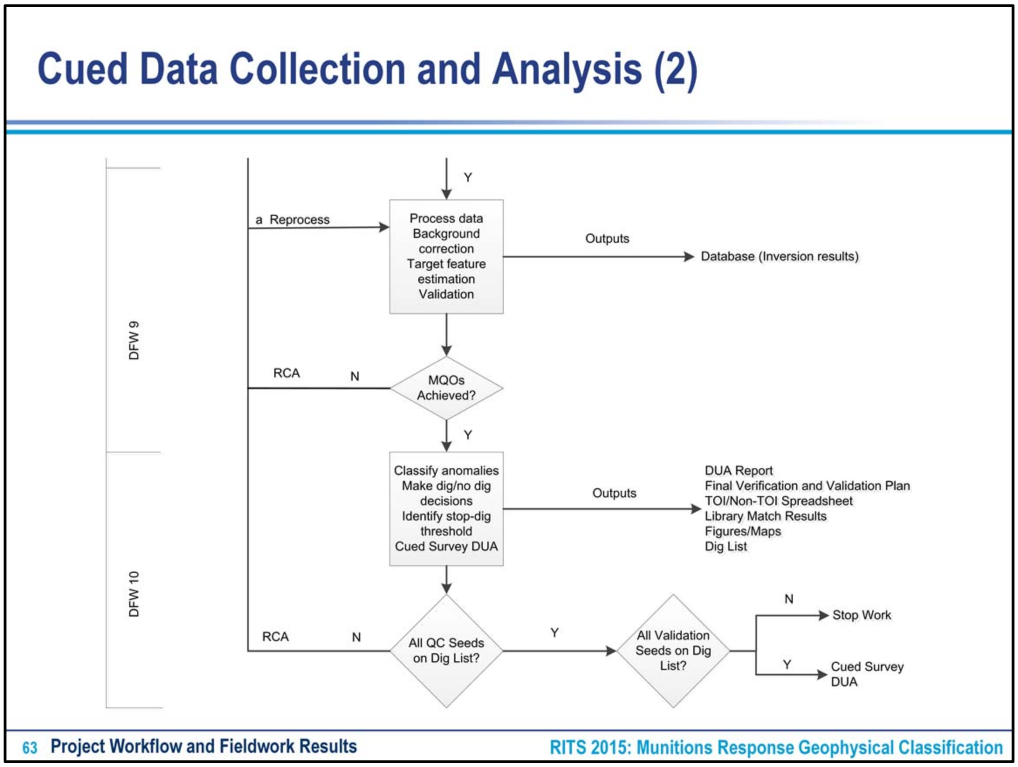
- In the end, all of the seeds should be detected and their offsets measured to ensure they meet the acceptance criteria
- Also, 100% of the validation seeds must be detected/identified as TOI or placed on the cued survey list before preceding to the cued survey



- From the dynamic data, background locations must also be selected
- These background locations will be used in the processing of the cued survey data
- Point out square areas which look like good locations for background readings



- Which brings us to the cued survey and the process to collect the data and analyze it
- Note that this eyechart is also a handout



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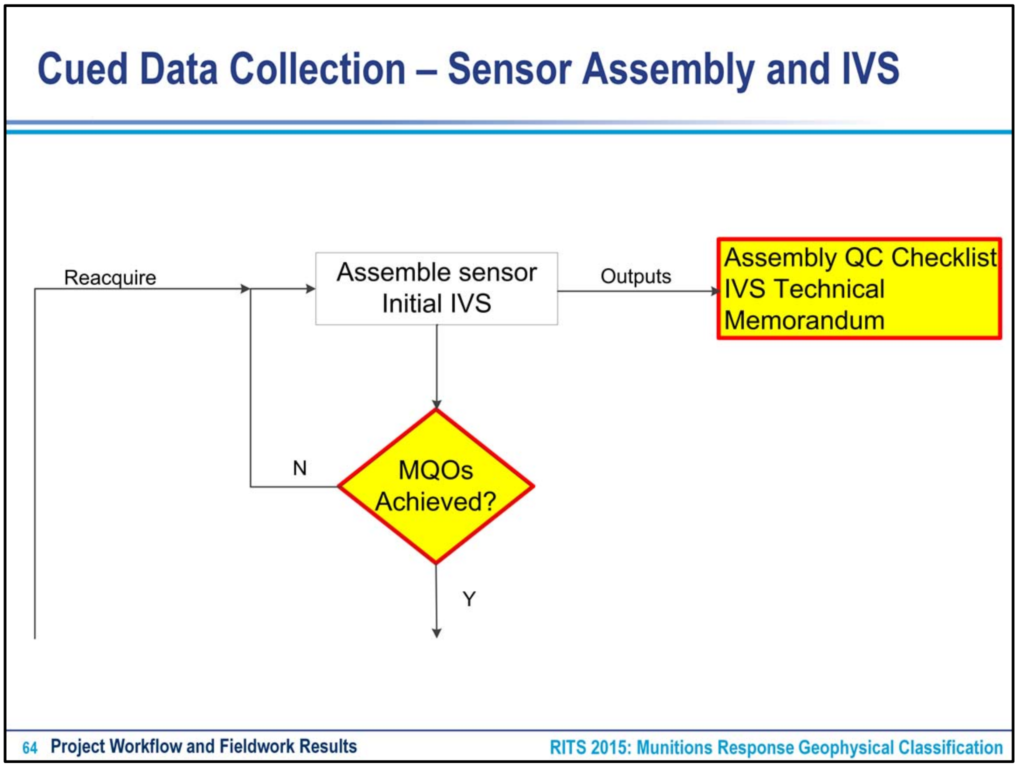
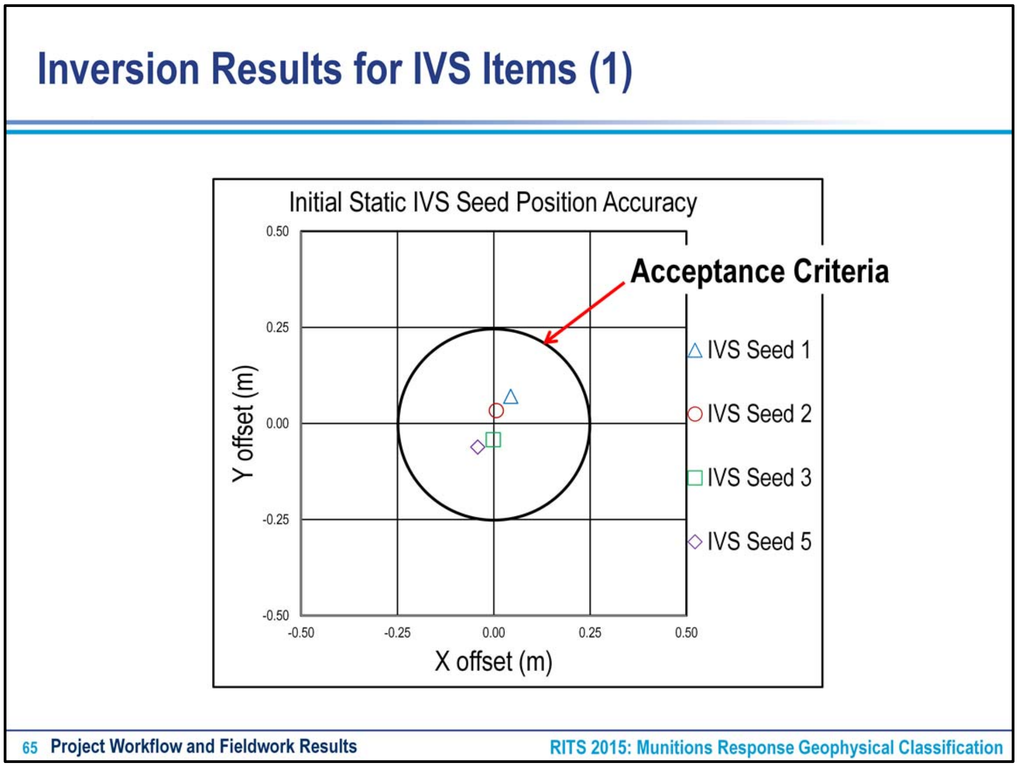
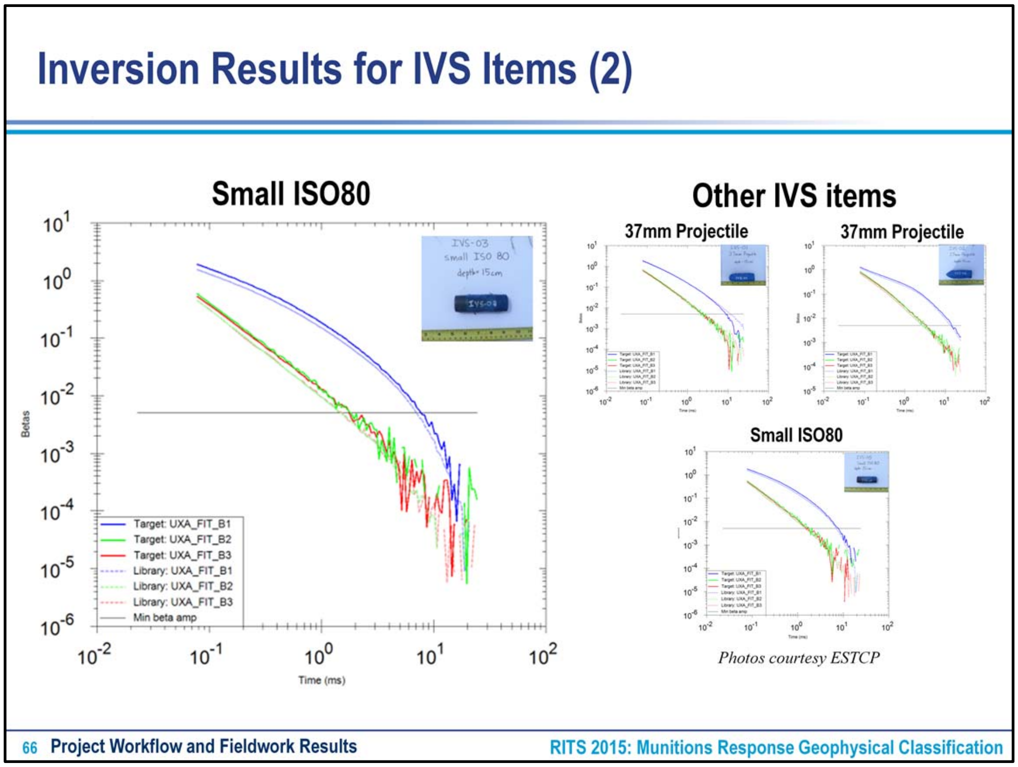


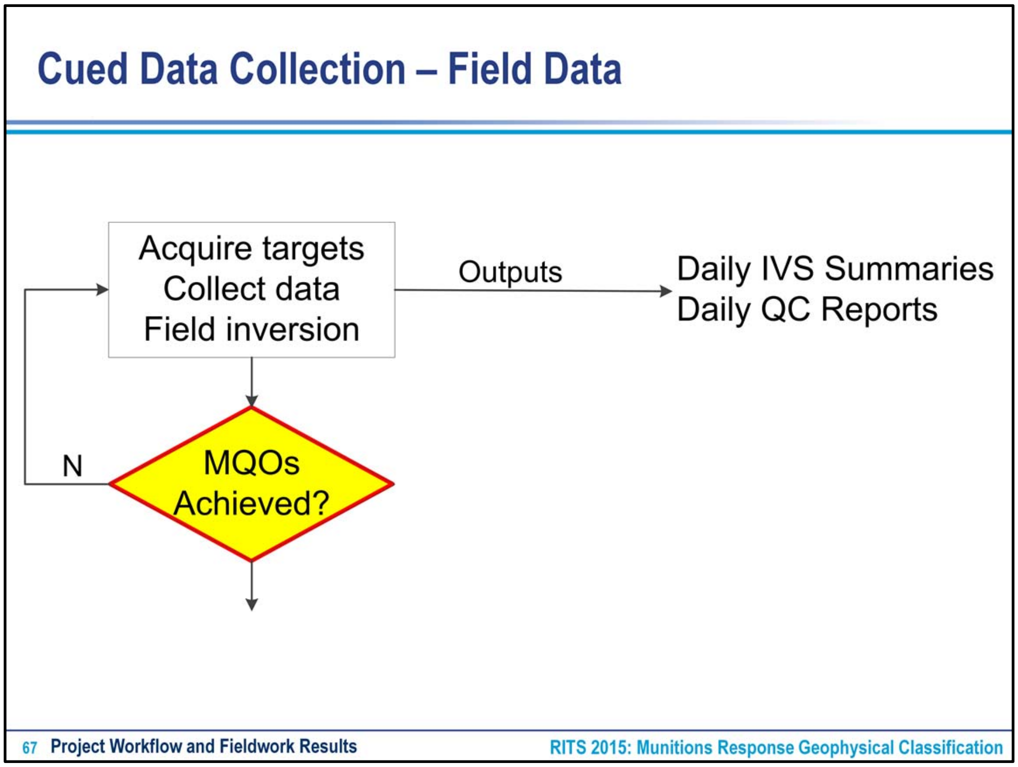
- The cued data collection also involves assembling the sensor and making sure it's functioning correctly by taking measurements in the IVS to verify that it can meet Measurement Quality Objectives
- The following slides discuss the MQOs associated with this phase of work



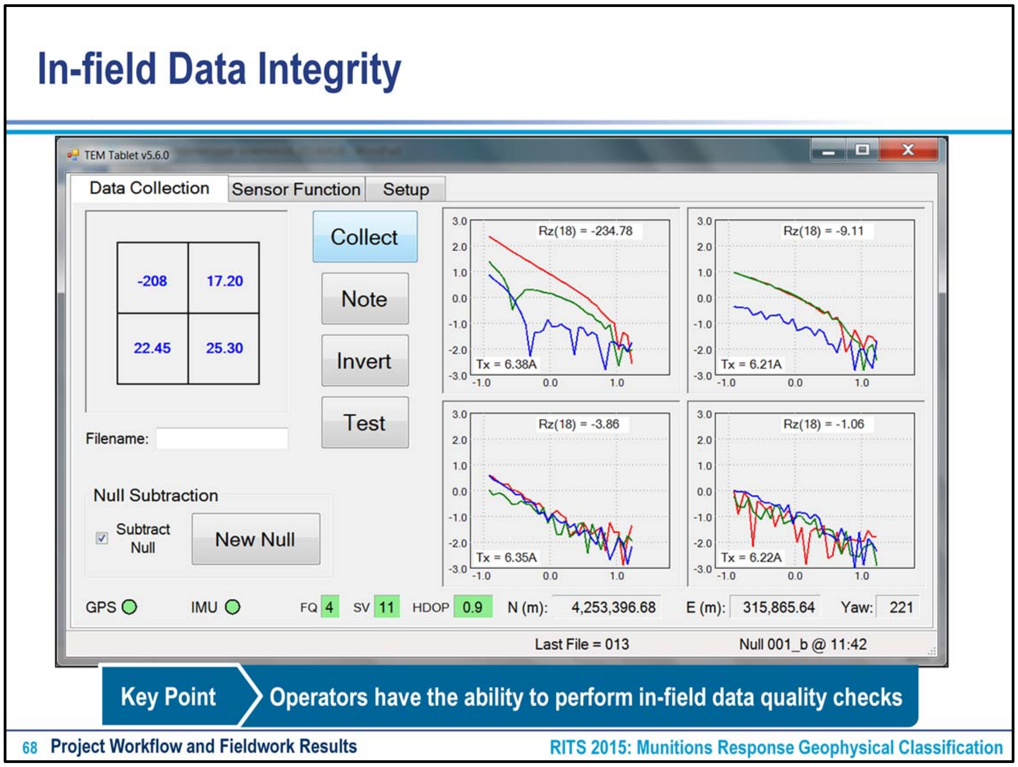
- The cued data reported position after inversion must meet the acceptance criteria, which is the same as for the dynamic data (0.25m)



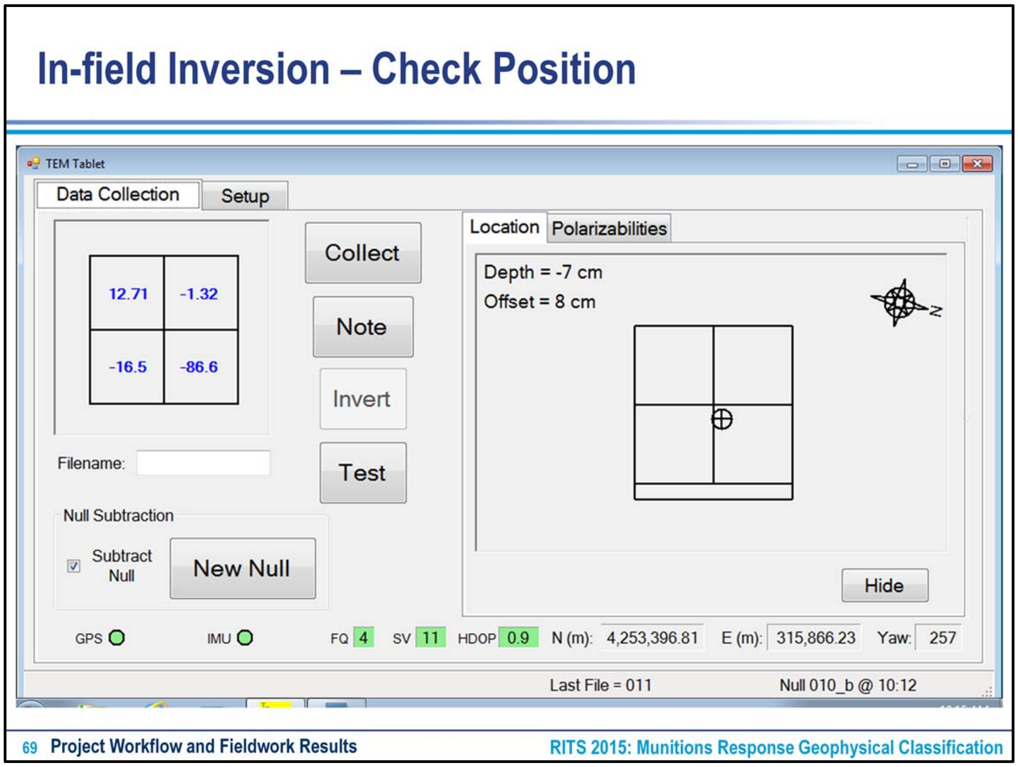
- In addition the inversion results must match their applicable signature "EMI fingerprint" in the library
- Shown above are the inversions and the library data, which are in good agreement (point out how close the blue betas are on the large graphic) and meet the acceptance criteria (0.9)



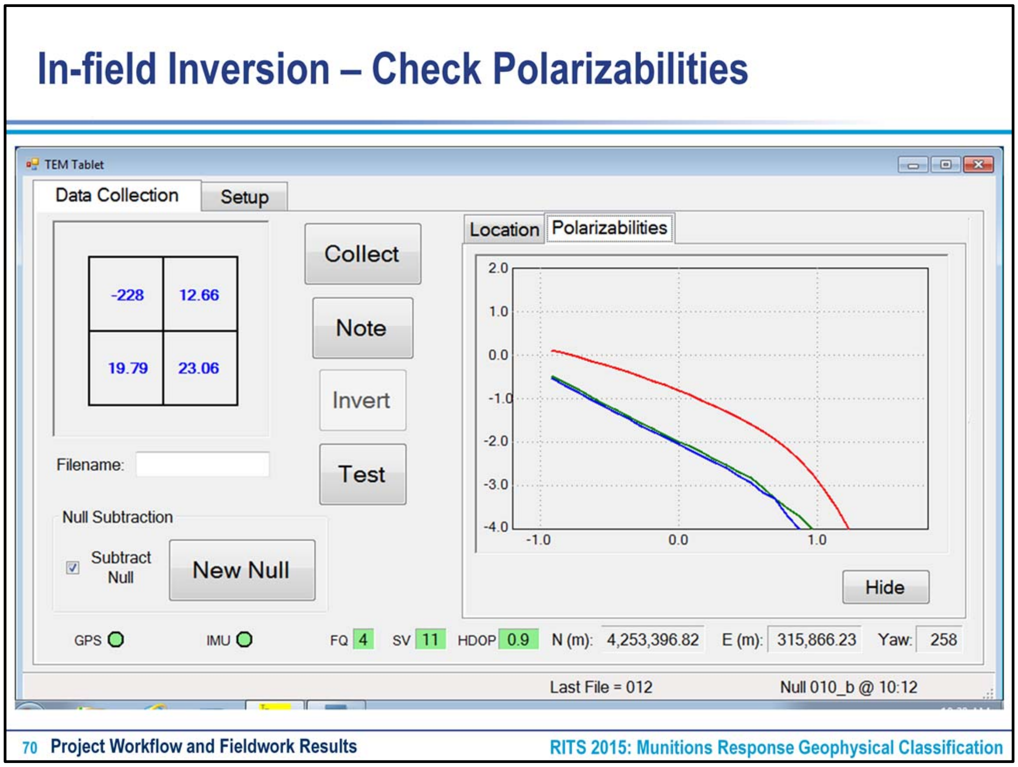
- The cued data collection also involves some QC procedures that can be performed in the field
- The following slides show some of these QC procedures/checks performed on the data to insure that it will meet the MQOs



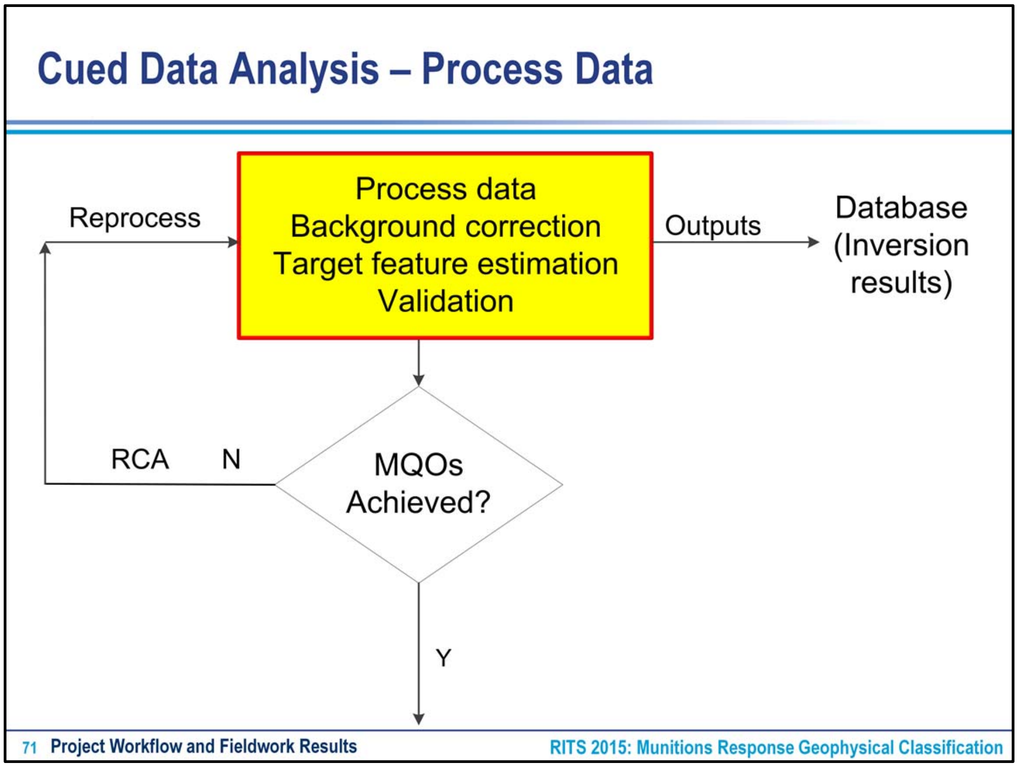
- When collecting the data there are some things to pay attention to, first green is good, red is bad
- So for the GPS and IMU, the system is saying that the GPS and IMU are working (good)
- The GPS fix quality, number of satellites in view, and the HDOP (which is a measure of the position precision) are all within spec as denoted by the green background in the boxes
- Also note the transmit current met our acceptance criteria of greater than 5.5A
- The raw data receiver responses are shown in the traces on the right
- The sample of the decays collected show that there is good signal in the two upper receivers



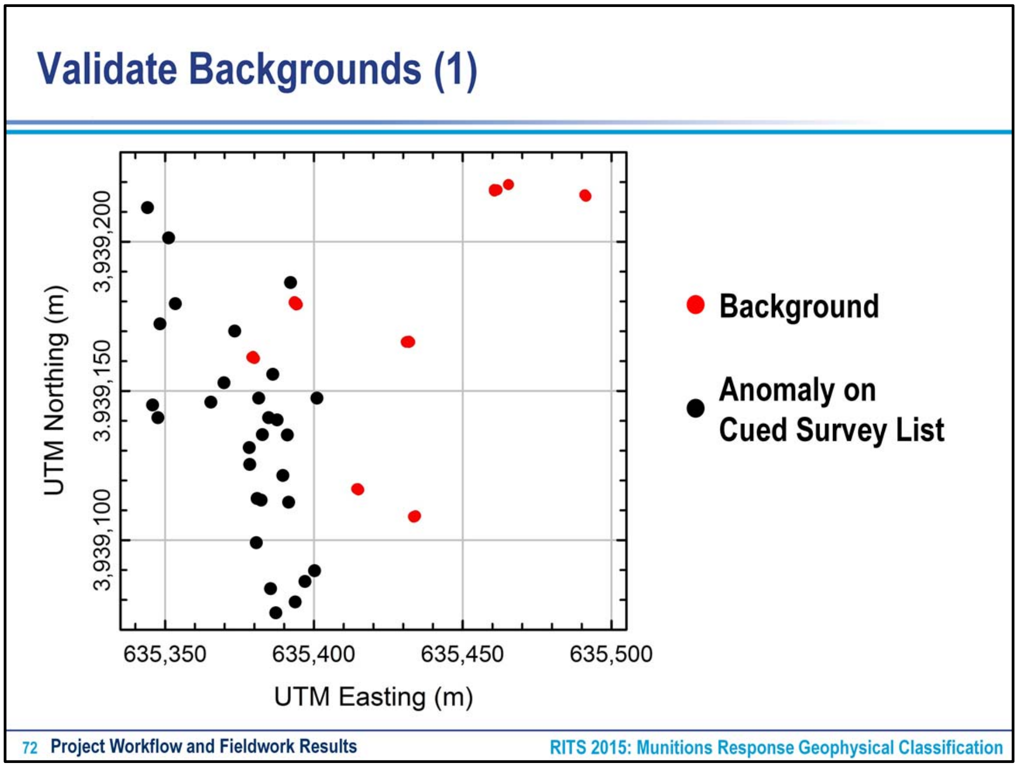
- This screen shows that the predicted in field inversion position of the buried metal object is ~8 cm from the center of the sensor (well within the acceptance criteria of 40 cm)
- If the offset was out of spec, the field team could move the sensor and take another measurement right away
- The reported depth is -7cm (negative because it was only a test above ground)



- The other part of the in-field inversion analysis is to look at the predicted polarizability decay curves
- Here we see that they are not noisy, look a lot like a munition (one large and two small curves) and an experienced operator will see that they represent something about the size of a 37-mm projectile

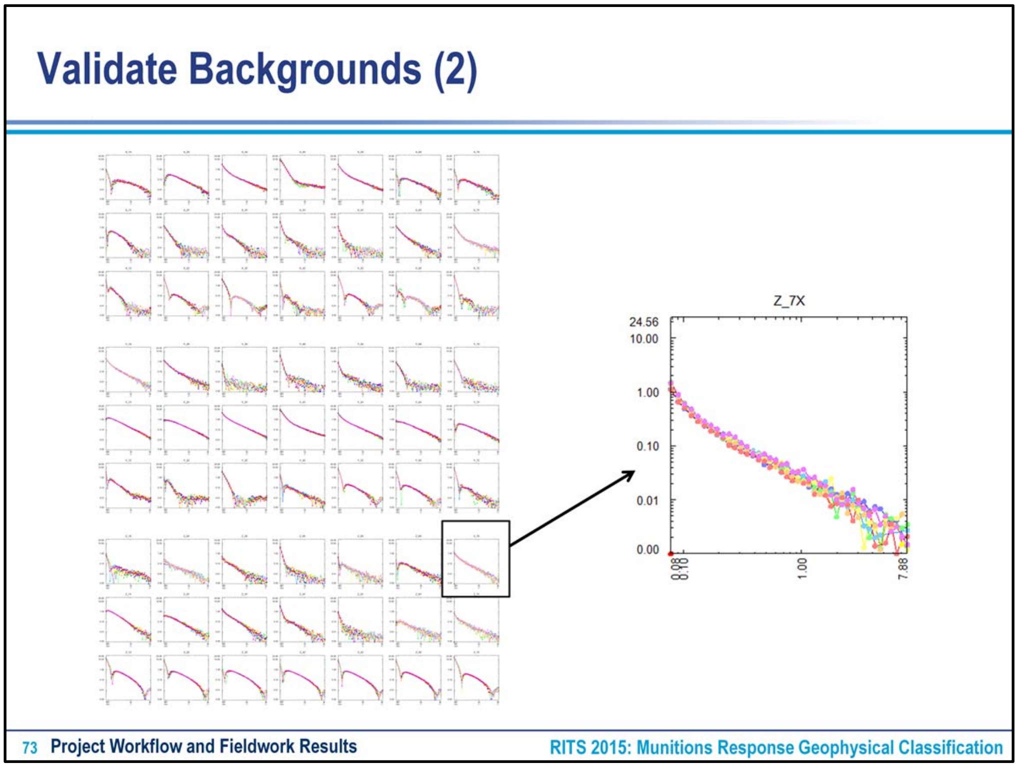


- Next we are going to focus on background correction, making sure we have a good signal to noise ratio, and inversion results



- This slide shows how backgrounds are acquired during a cued survey
- A number of clean spots (believed to be free of metallic objects) are identified from the detection survey and marked (either with flags or an entry in a list of locations for the GPS)
- Each day, the field crew returns to the background location every two hours for background measurements
- Sensor data acquired over these areas are subtracted to remove sensor drift, biases, and ground response

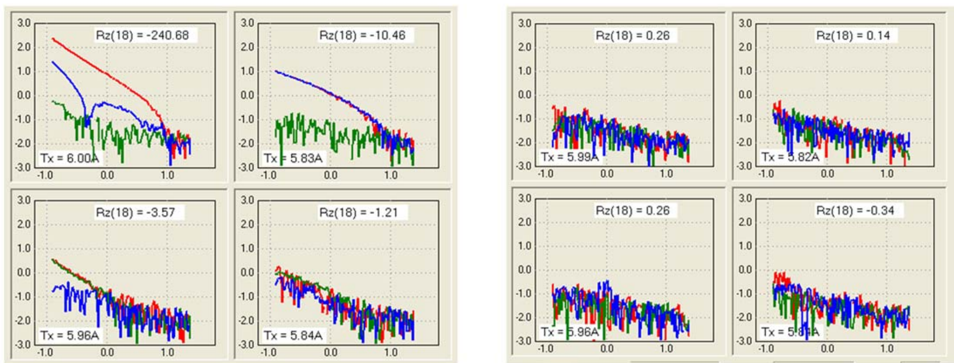
- The reason for taking backgrounds is to remove any effects due to soil response and amplifier drift so that the analysis is only on the signal from the buried metal at our anomaly location
- This requires periodically recording “background” measurements in a spot free of metal and subtract that background from all our measurements
- It is important to make sure the locations are, in fact, backgrounds and not contaminated by unknown metal or geologically active soil



- Here is a plot of each of the measured decays (Z coil) on top of each other
- The consistent and low response validates that these background locations are suitable to remove sensor drift, biases, and ground response
- If plotting revealed significant variations, then care must be taken as to which background will be used to remove sensor drift, biases and ground response
- The allowable background levels are project specific and will vary due to geology (Fe bearing conductive soils), moisture, and temperature

Is SNR High Enough to Process? (1)

Good Signal on Two Receivers | **Nothing to Invert**



74 **Project Workflow and Fieldwork Results** | **RITS 2015: Munitions Response Geophysical Classification**

- Shown here on the left array are the raw data showing a good signal on two of the receivers (above our signal to noise threshold)
- On the right is the response with no target under the sensor

Is SNR High Enough to Process? (2)

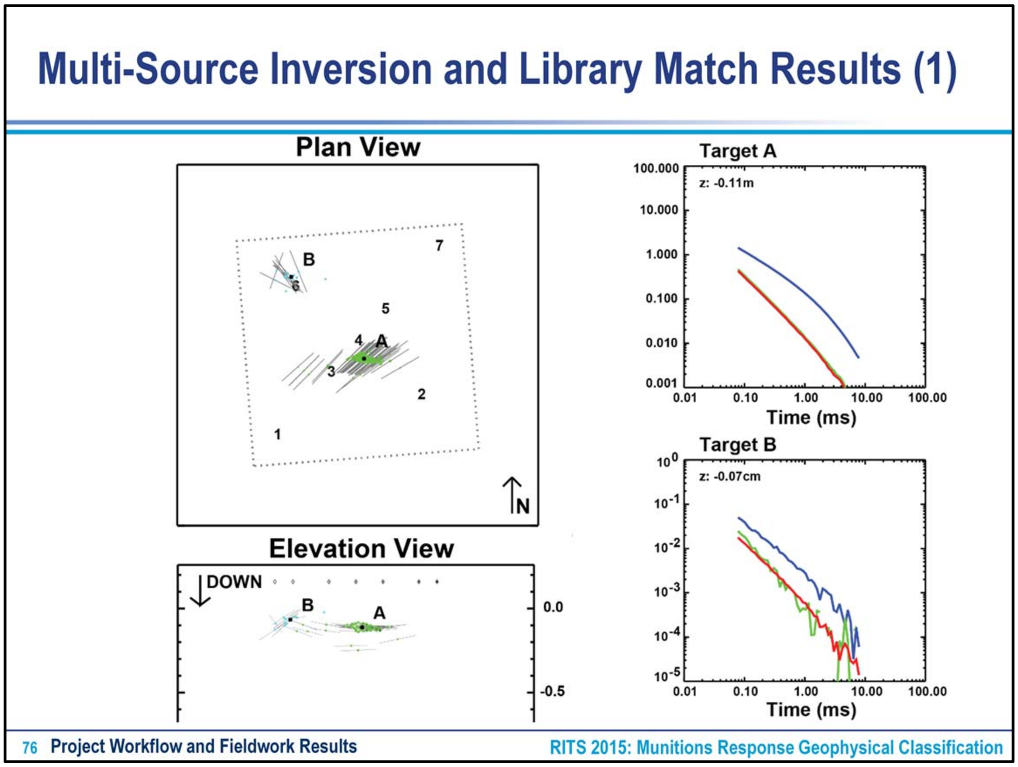
target.gdb

single	X	Y	UXA_TARGET_ID	UXA_rank	UXA_Category	A_decision_statist	UXA_SIG_AMPLITUDE	UXA_FIT_COH[8]
0.0	635380.02	3939075.24	1506_001_01	*	*	*	39.92	0.9920
1.0	635387.16	3939075.54	1507_001_01	*	*	*	43.23	0.9857
2.0	635393.61	3939079.24	1515_001_01	*	*	*	51.59	0.9981
3.0	635385.53	3939083.72	1524_001_01	*	*	*	11.94	0.8733
4.0	635397.03	3939086.10	1528_001_01	*	*	*	32.40	0.9818
5.0	635400.27	3939089.47	1532_001_01	*	*	*	32.26	0.9905
6.0	635380.79	3939098.96	1551_001_01	*	*	*	36.71	0.9056
7.0	635391.73	3939112.56	1573_001_01	*	*	*	54.20	0.9888
8.0	635382.41	3939113.23	1574_001_01	*	*	*	15.64	0.9757
9.0	635381.08	3939113.99	1576_001_01	*	*	*	57.33	0.9984
10.0	635389.73	3939121.65	1595_001_01	*	*	*	30.96	0.9913
11.0	635378.69	3939125.31	1606_001_01	*	*	*	56.64	0.9986
12.0	635378.40	3939130.96	1619_001_01	*	*	*	53.12	0.9986
13.0	635391.04	3939135.15	1624_001_01	*	*	*	17.99	0.9359
14.0	635382.68	3939135.28	1626_001_01	*	*	*	157.14	0.9986
15.0	635387.56	3939140.30	1635_001_01	*	*	*	46.57	0.6056
16.0	635347.73	3939141.07	1636_001_01	*	*	*	121.93	0.9978
17.0	635384.88	3939141.05	1638_001_01	*	*	*	63.64	0.9988
18.0	635365.38	3939146.12	1655_001_01	*	*	*	8.77	0.9951
19.0	635401.00	3939147.55	1659_001_01	*	*	*	20.06	0.7653
20.0	635386.30	3939155.51	1676_001_01	*	*	*	24.05	0.9050
21.0	635373.44	3939169.98	1716_001_01	*	*	*	31.50	0.9944
22.0	635348.38	3939172.27	1725_001_01	*	*	*	36.30	0.9990
23.0	635392.33	3939186.04	1758_001_01	*	*	*	44.68	0.9969
24.0	635343.96	3939211.19	1780_001_01	*	*	*	33.03	0.9988
25.0	635351.14	3939200.98	1793_001_01	*	*	*	17.33	0.9970
26.0	635353.41	3939179.00	1796_001_01	*	*	*	38.84	0.9522
27.0	635345.82	3939145.30	1811_001_01	*	*	*	12.30	0.9972
28.0	635381.40	3939147.41	1867_001_01	*	*	*	14.78	0.9955
29.0	635369.88	3939152.62	1868_001_01	*	*	*	21.45	0.9955

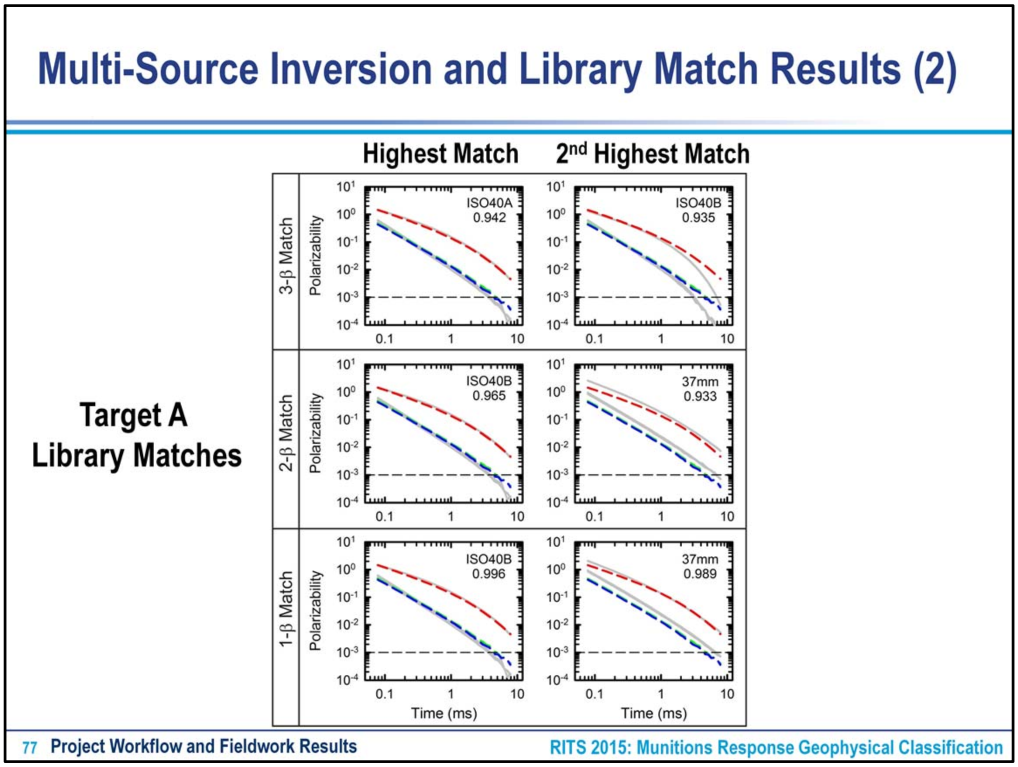
Line/Group

75 Project Workflow and Fieldwork Results RITS 2015: Munitions Response Geophysical Classification

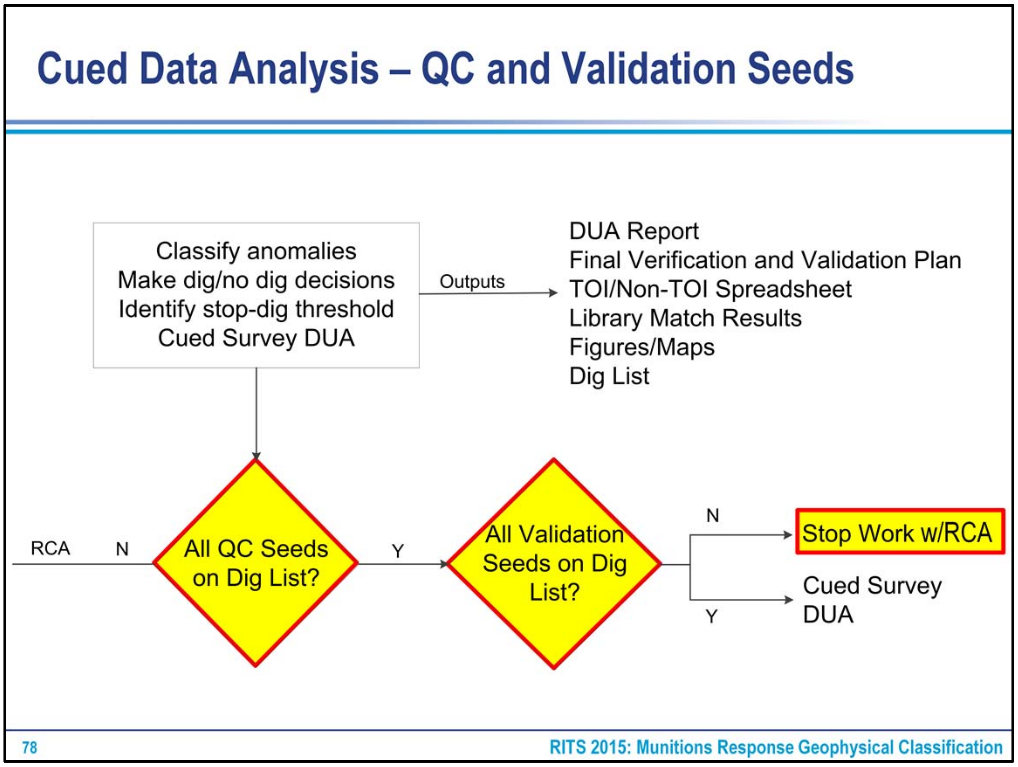
- Of course this process of checking whether the SNR is high enough is performed for every target in the database



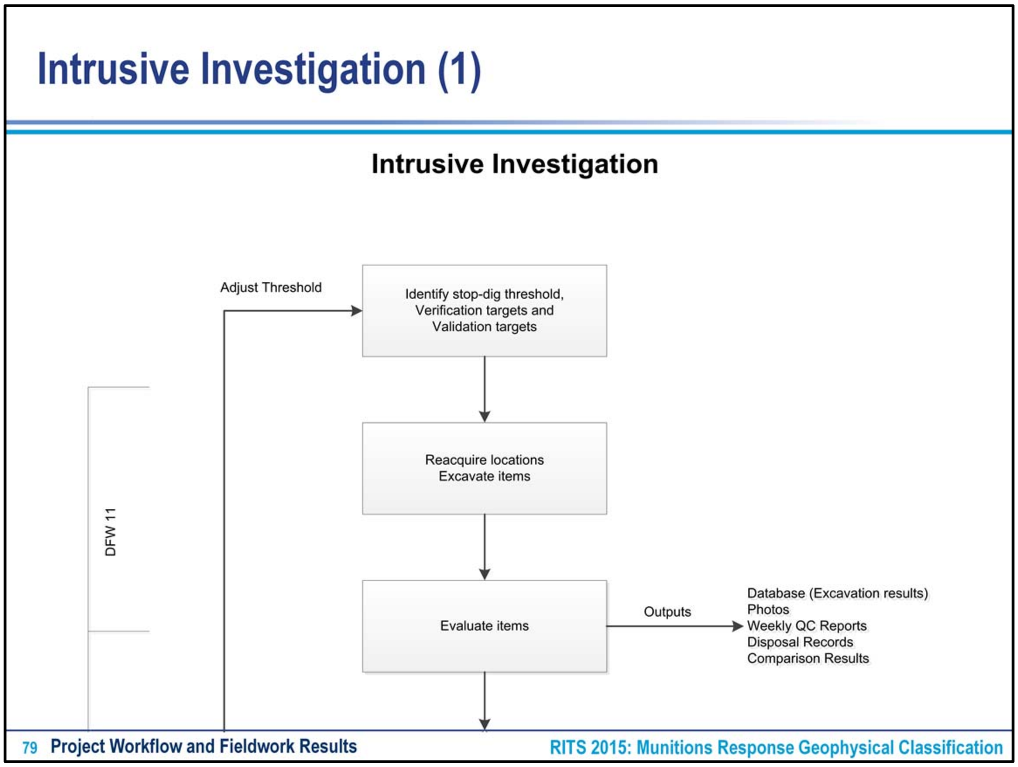
- This graphic shows two targets under the sensor (Metal Mapper), A and B and their depths below the ground
- Point out decay curves and why one is frag (too small) and the other is a TOI



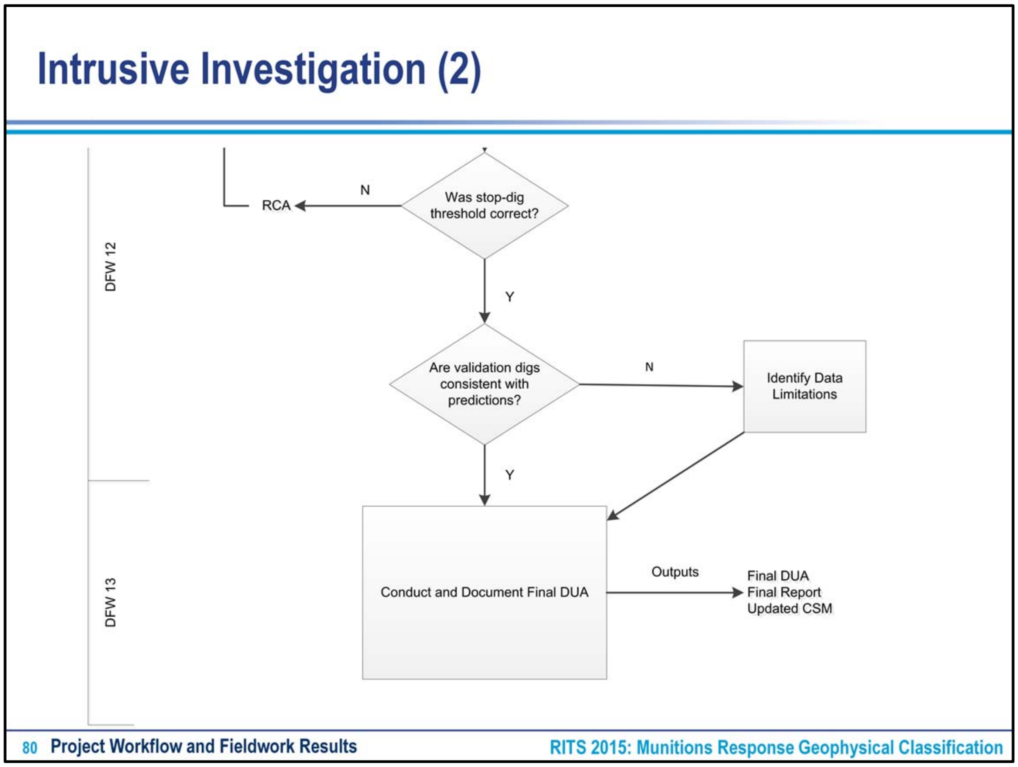
- This graphic shows the library matches to Target A using the matching criteria of one beta, two betas, and three betas
- The left column are the best matches, the right column are the second best matches
- Note that in the top row, both the matches were ISO40
- This is because there are a few ISO40s in the library and not everything that comes off the production line is the same
- The same type of thing can happen with munitions like the 37mm since there are different variants
- From the data above, we believe our TOI is an ISO40
- Library matches put you in the ballpark of what the item is, but they do not provide Mk or Mod level of detail due a number of issues (deformation, corrosion, etc.) even though the item in the library may have a Mk or Mod associated with it



- One of the major ways we are making sure that we have a quality process is by making sure all of the QC seeds are on the dig list and all of the validation seeds are also on the dig list
- If they are, we can proceed to the intrusive investigation
- If they aren’t, we must perform a root cause analysis (RCA)



- Here is the intrusive investigation workflow/eyechart
- We are now going to discuss the excavation of items and the comparison of the dig results with the measured responses for those items from our sensor



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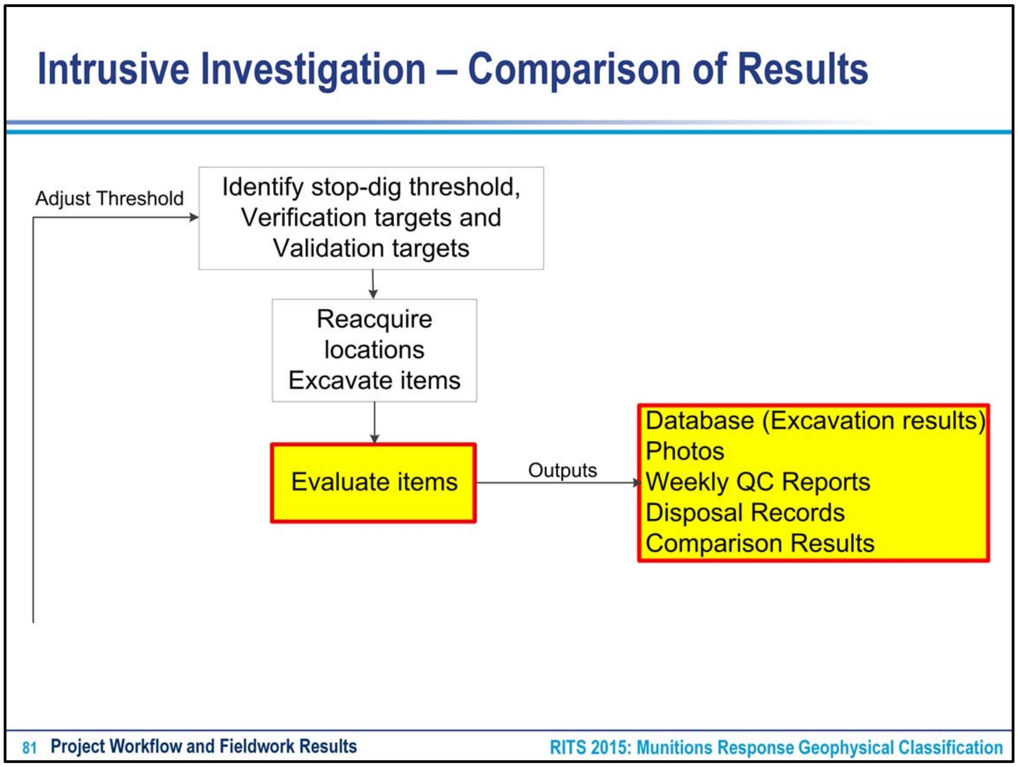

Intrusive Investigation – Comparison of Results
Adjust Threshold
Identify stop-dig threshold, Verification targets and Validation targets
Reacquire locations Excavate items
Evaluate items
Outputs
Database (Excavation results)
Photos
Weekly QC Reports
Disposal Records
Comparison Results
81 Project Workflow and Fieldwork Results
RITS 2015: Munitions Response Geophysical Classification

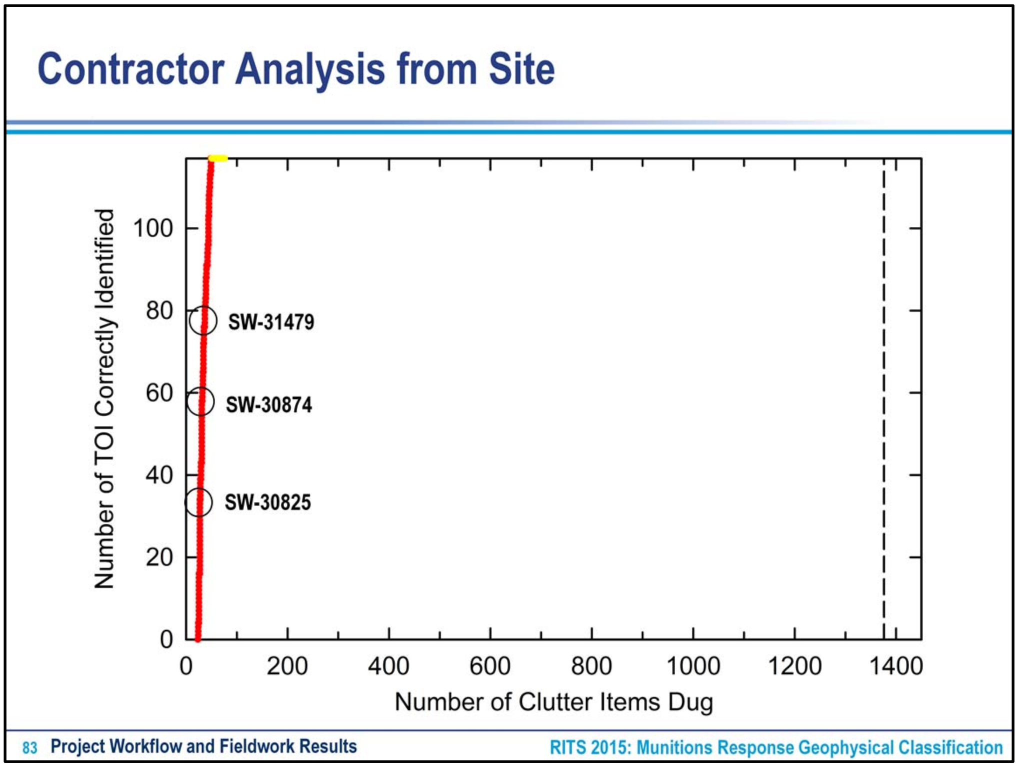
Intrusive Investigation

Anomaly	Photo No.	Depth (cm)	ID	Length (cm)	Type	N (predicted)	E (predicted)	N (measured)	E (measured)	Delta (m)	Date
10075	SW-10075a	40	105mm	32	MD	3743941.10	438737.77	3743941.18	438737.98	0.22	10/17/13
10075	SW-10075a	46	105mm	29	MD	3743941.10	438737.77	3743941.21	438737.91	0.17	10/17/13
10075	SW-10075	110	105mm	33	MD	3743941.10	438737.77	3743941.34	438737.89	0.27	10/17/13
10075	SW-10075	112	Frag	7	MD	3743941.10	438737.77	3743941.34	438737.88	0.26	10/17/13
10178	SW-10178	7	Frag	9	MD	3743942.80	438739.77	3743942.76	438739.77	0.05	10/17/13
10183	SW-10183	30	Frag	22	MD	3743934.06	438739.69	3743934.10	438739.79	0.11	10/17/13
10462	SW-10462	1	Frag	16	MD	3743930.71	438744.82	3743930.73	438744.89	0.07	10/17/13

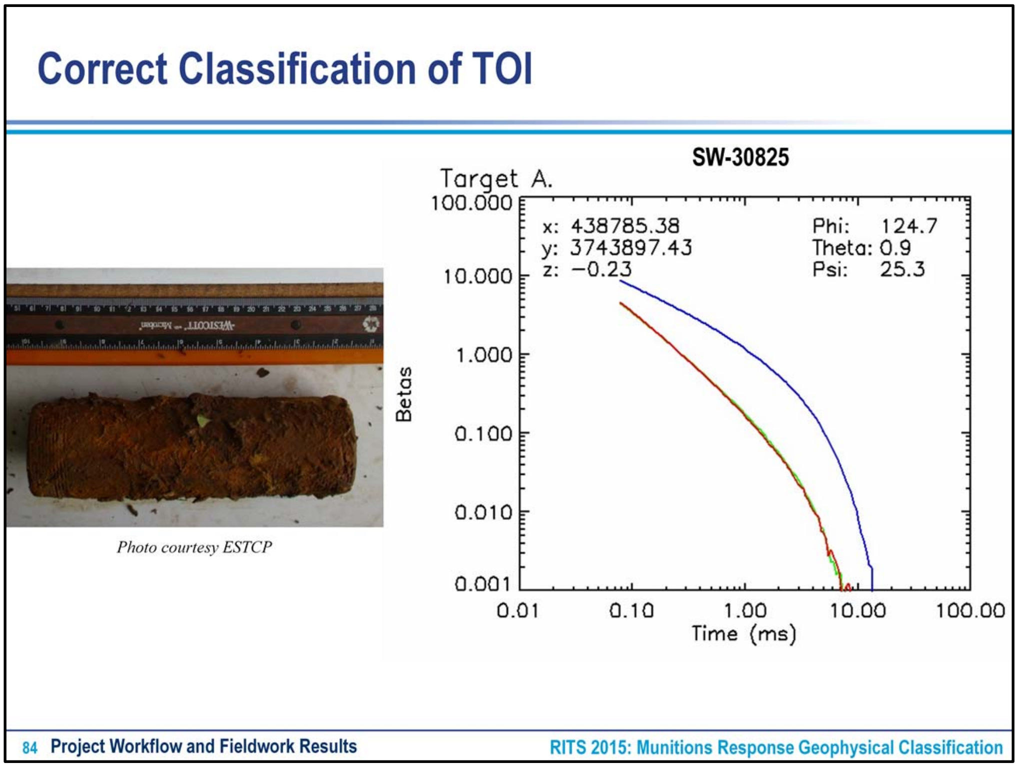
Photos courtesy ESTCP

82 **Project Workflow and Fieldwork Results** **RITS 2015: Munitions Response Geophysical Classification**

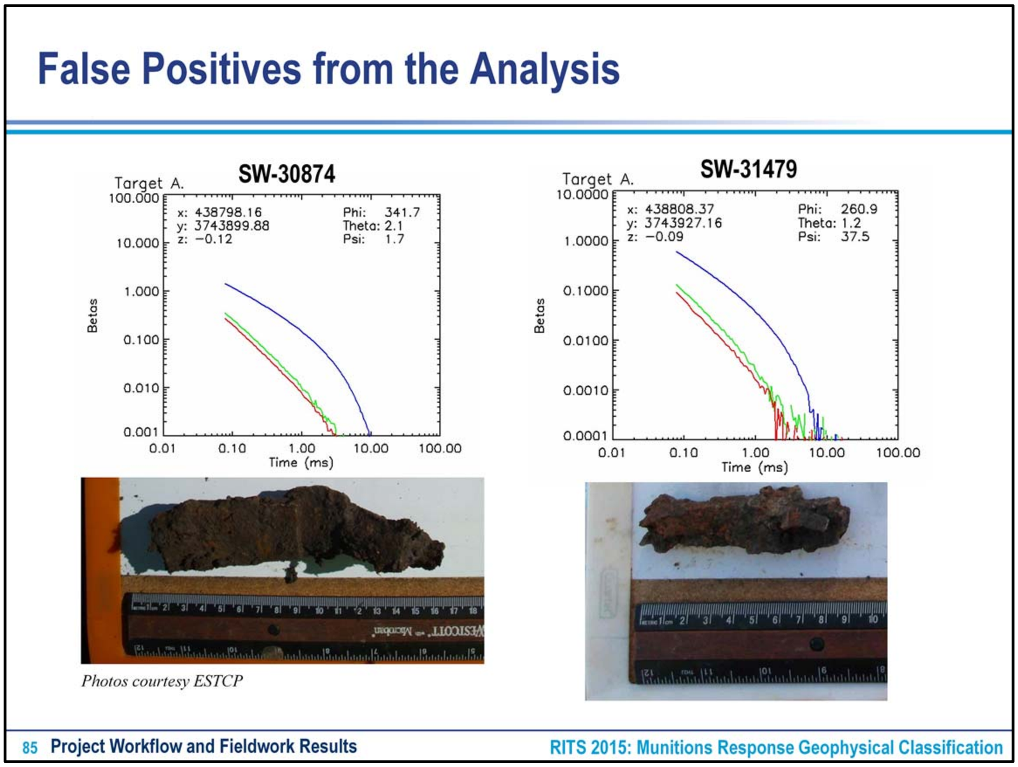
- The intrusive investigation must ensure that the correct anomaly is dug up that was placed on the dig list
- The Delta (location on dig list versus actual location from intrusive work) and what the dig team discovered are important in this process, as well as making sure the field crews follow proper hole clearing procedures which are defined in the SOP
- One nice feature that the new sensors provide is also an estimate of the depth of the item



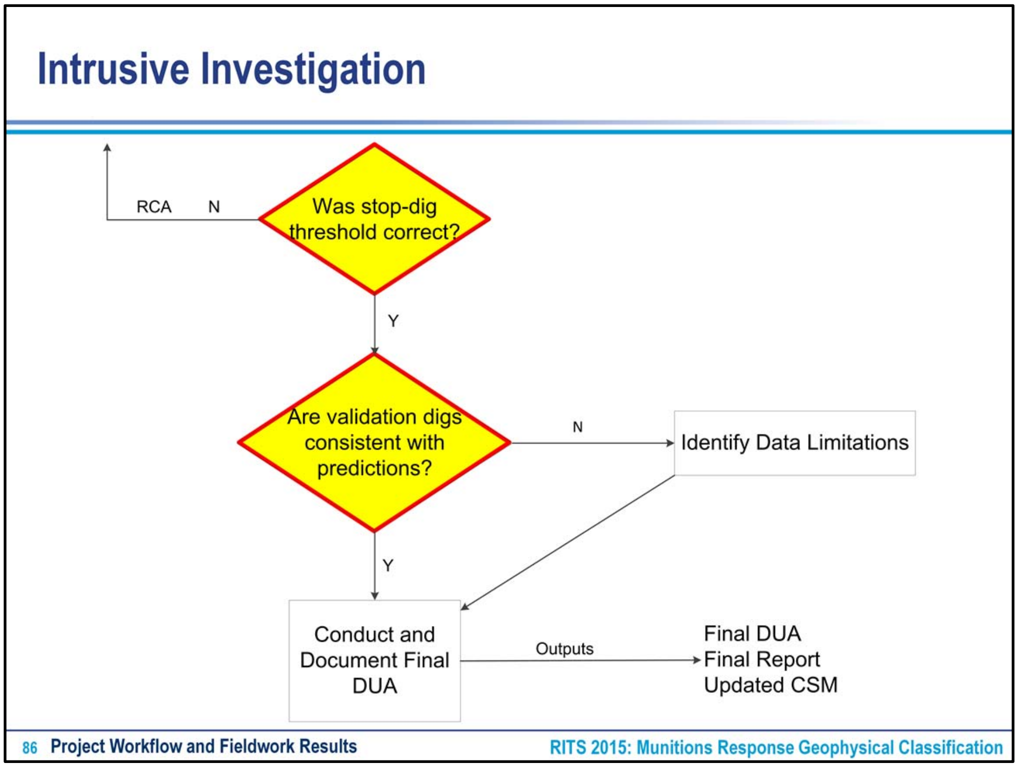
- Here is an example of a contractor's analysis from a site
- Explain how to read a Receiver Operating Characteristic (ROC) curve, and why this is a good ROC Curve
- This curve is constructed by digging each item on our prioritized anomaly dig list in turn
- If the item turns out to be a munition we go up on the plot, if it is clutter we go to the right
- The example here is a very good ROC curve
- Almost all the things we called high-confidence munitions (colored red like the anomaly list) were, in fact, munitions
- Some, but not much, clutter was also dug



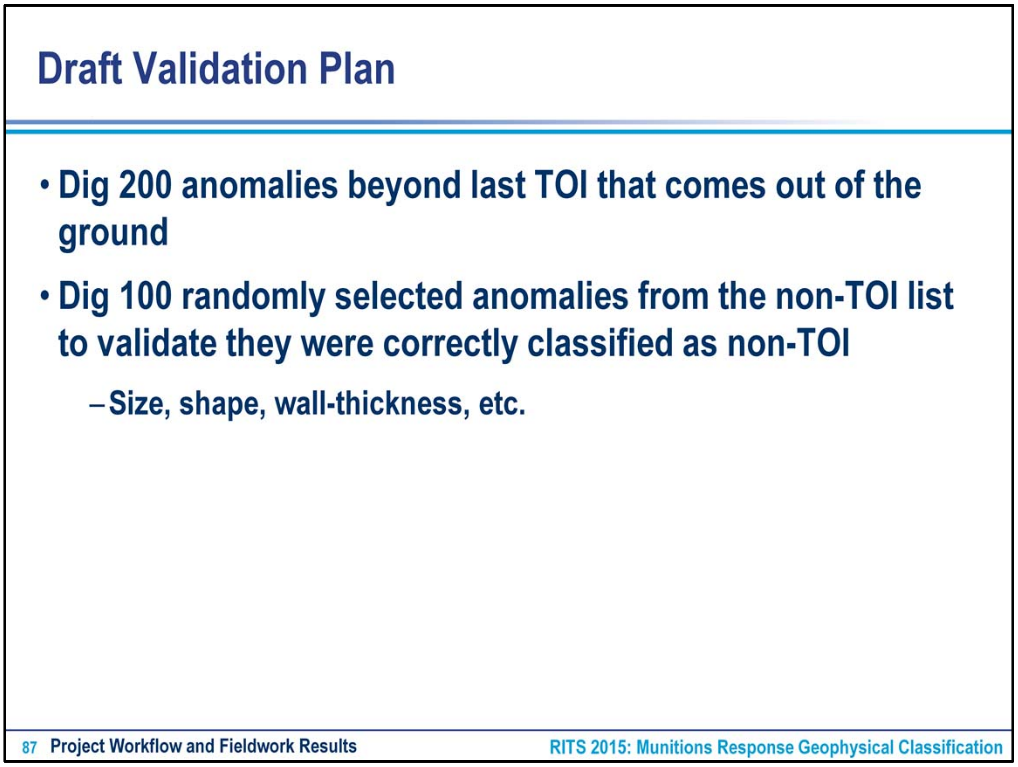
- Ask the audience if this is the type of polarizability curve for an anomaly that should be placed on the dig list and if they want to guess what it is
- Point out the strength of the response over time and the shape of the polarizability curves
- From the polarizability curves, this is an item that should be dug
- The intrusive team recovered a large pipe nipple, exactly the kind of the thing we should find with our classification process



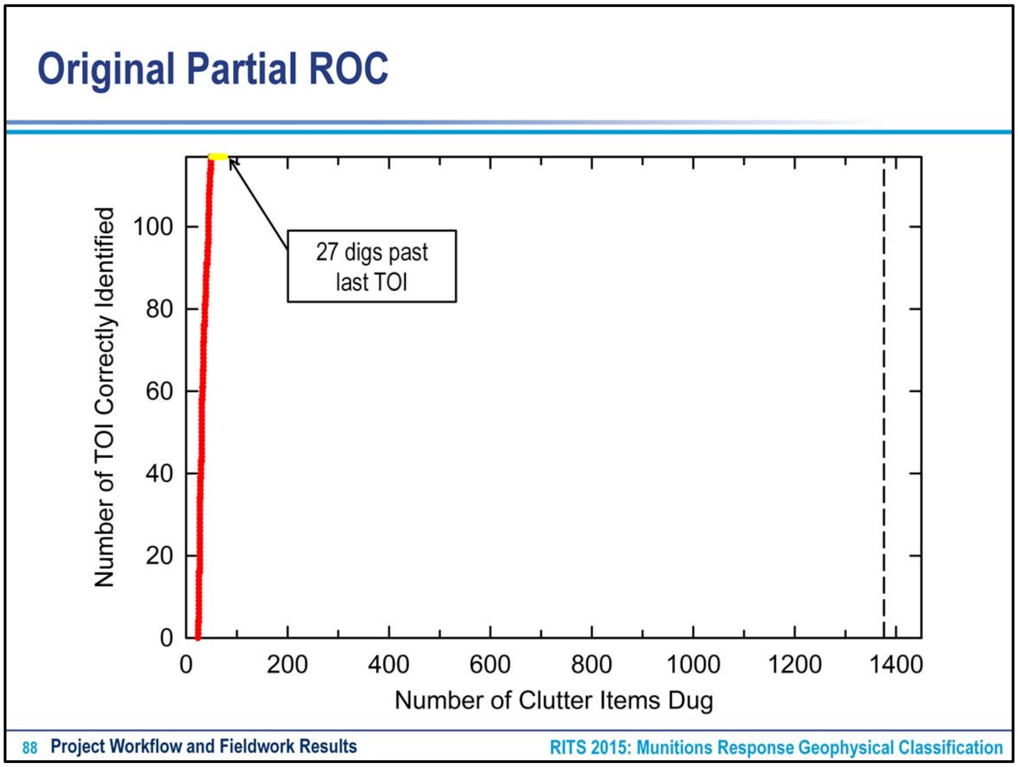
- Ask the audience if these are the type of polarizability curves for anomalies that should be placed on the dig list and if they want to guess what they are
- Point out the strength of the response over time and the shape of the polarizability curves, which are not quite as good as the previous example
- From the polarizability curves however, these items should be dug
- The intrusive team recovered two large pieces of frag that are fairly symmetric, the kind of the thing we should find with our classification process
- Note that the comparison to the dig results is qualitative and not quantitative



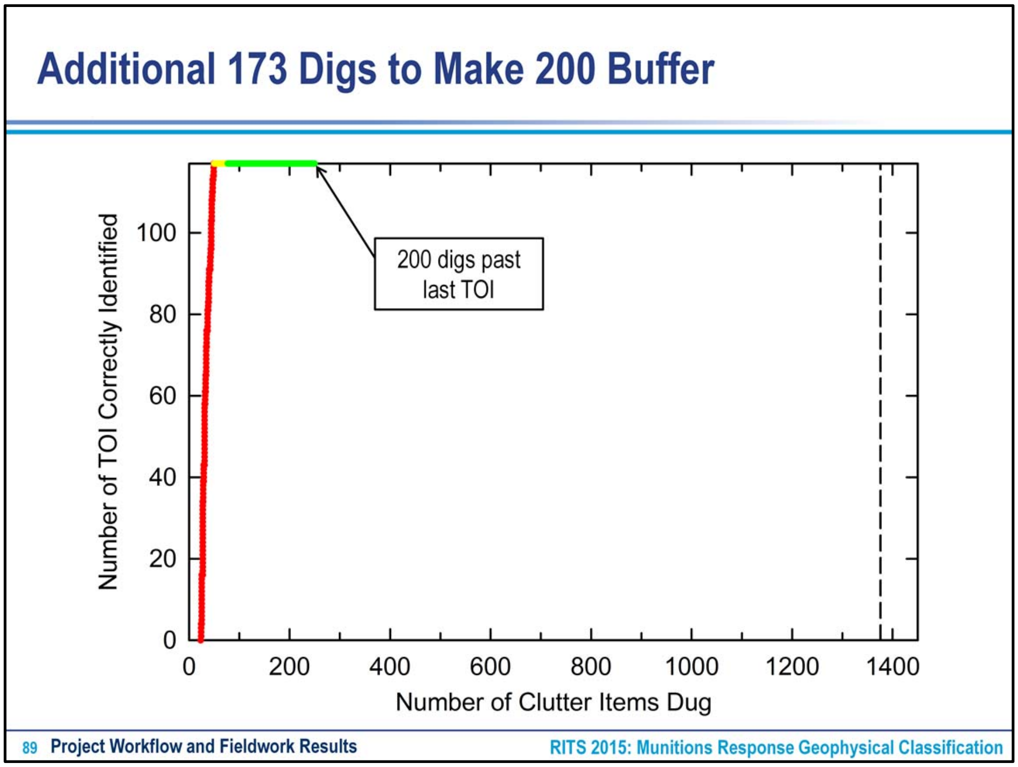
- We have to come up with a plan to validate our results, let's discuss some ways to validate our work



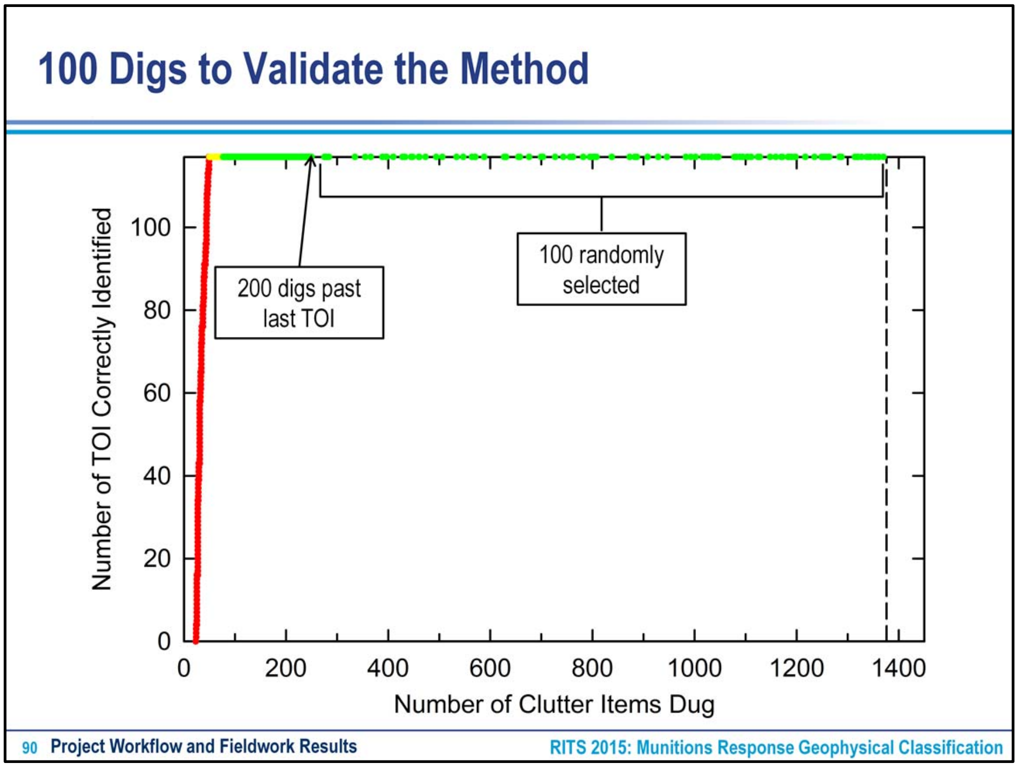
- The project team needs to come to agreement on how the process will be validated
- This is done through the development of a validation plan
- Some starting points for discussion among the project team are how many anomalies will be dug beyond the last TOI, and how many anomalies will be dug from the non-TOI list to validate that they were correctly classified as non-TOI
- The numbers provided (200, 100) can vary depending upon site size, so a treatability study would have less and a large site might have more



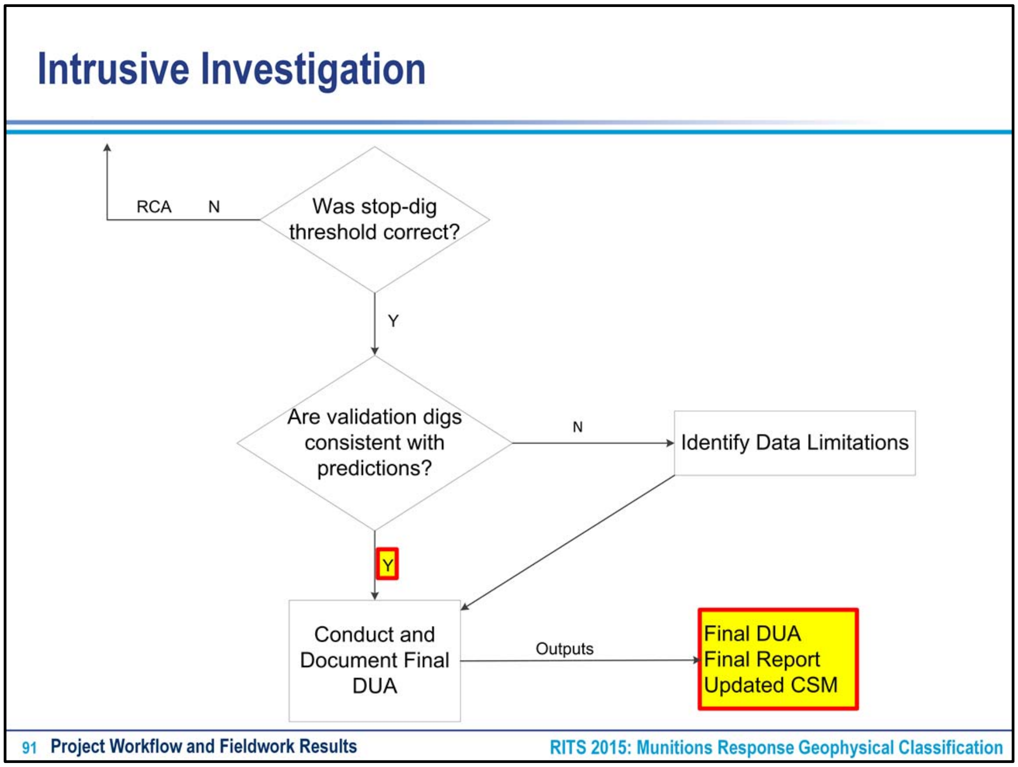
- In this example the contractor performed 27 digs past the last TOI



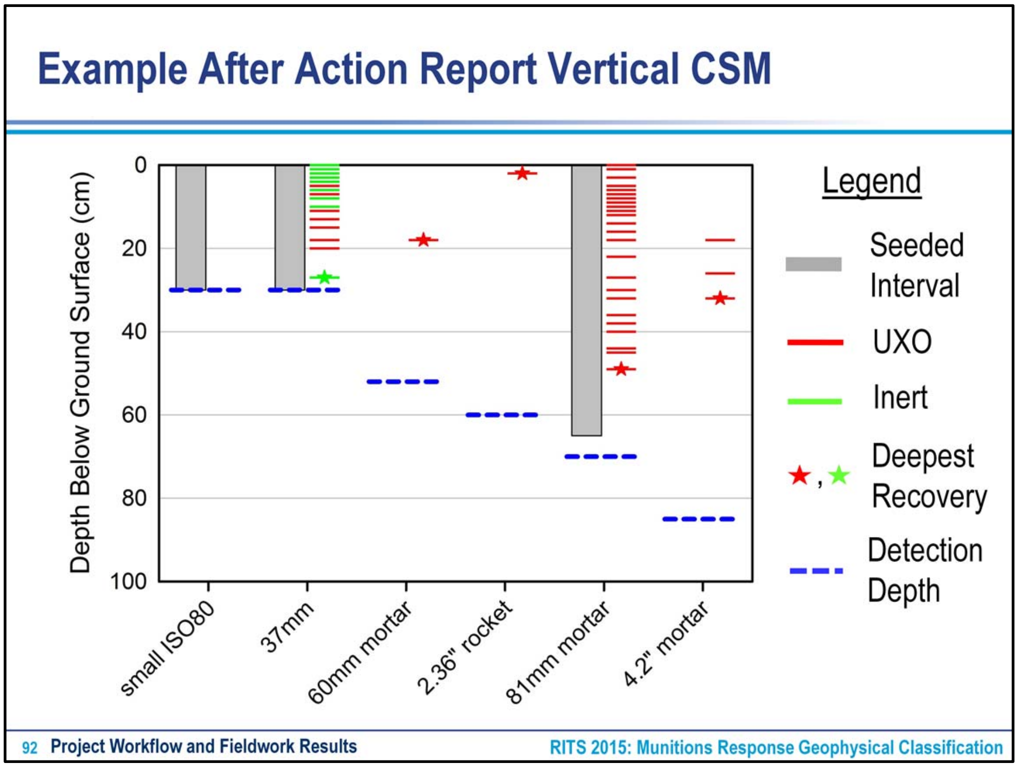
- In order to validate the decision, an additional 173 digs would have to be performed if the project team used the example of 200 digs beyond the last TOI
- Obviously, no TOI should be found in this “buffer”
- If a TOI is found, a RCA must be performed



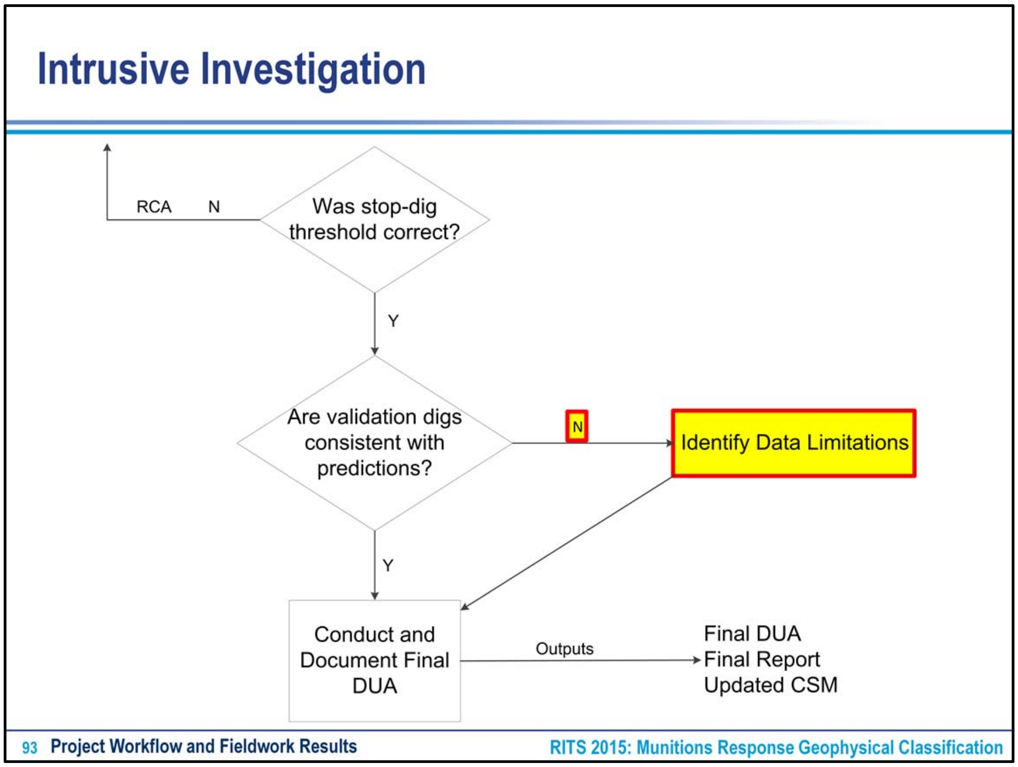
- The validation plan also includes making sure that some of clutter is properly characterized
- Again, this is a qualitative versus quantitative assessment
- The items dug should be clutter and the contractor's reason for leaving it behind may be something like "too small" or perhaps "polarizabilities indicated the item to be flatter or plate-like as opposed to symmetric"



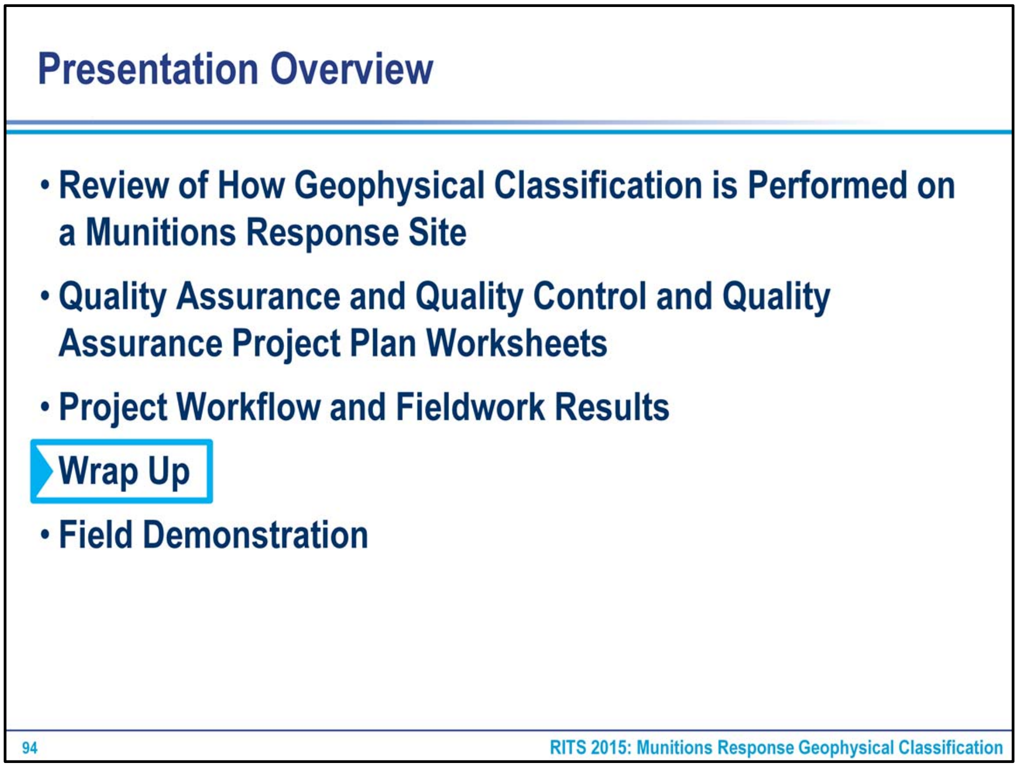
- We have to come up with a plan to validate our results, let’s discuss some ways to validate our work



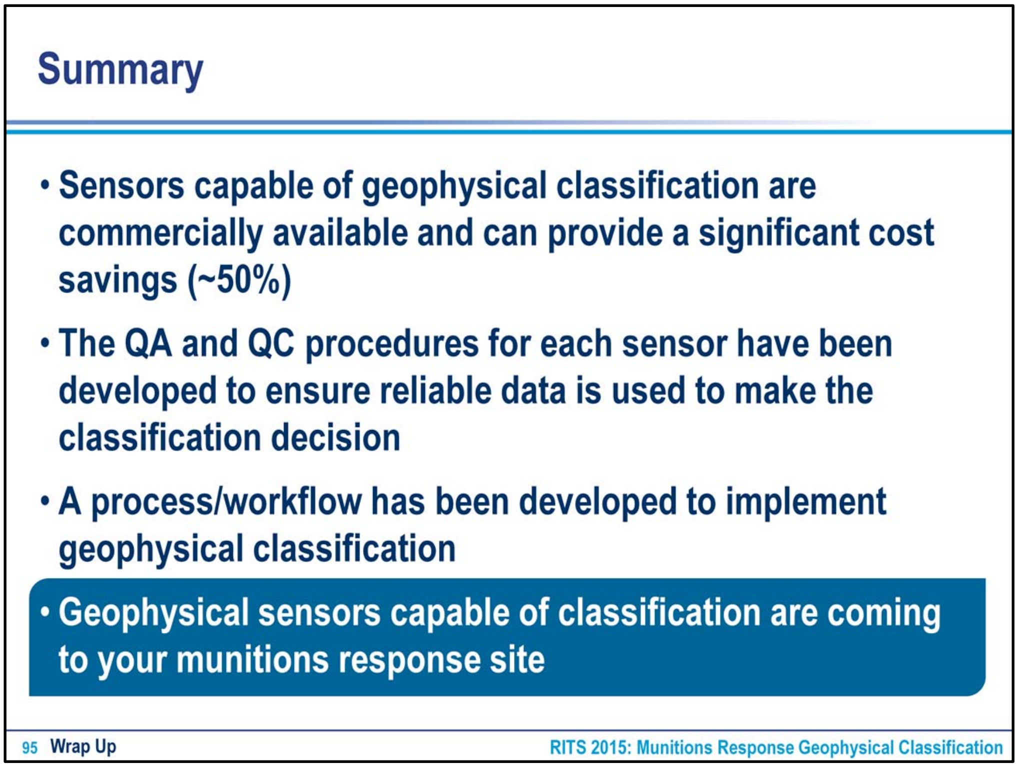
- Here is an example AAR Vertical CSM
- Explain the graphic by pointing out the Detection Depth (worst orientation), Seed Interval, and recovered distribution of UXO and Inert items
- If a project team had a CSM like this at the conclusion of the project, they would have confidence that their results (data) support the effective removal of 37mms to a depth of 30cm, etc.



- We have to come up with a plan to validate our results, let’s discuss some ways to validate our work



- Let’s wrap it up



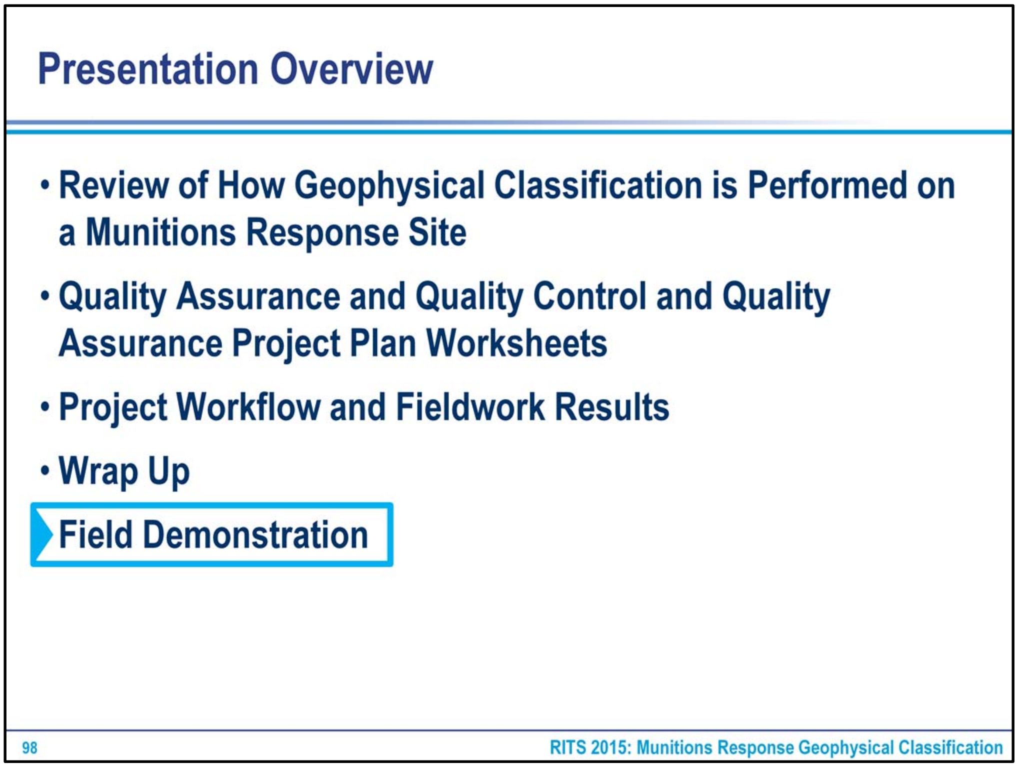
- Here is a summary of the presentation, the sensors are coming to your MRS

References

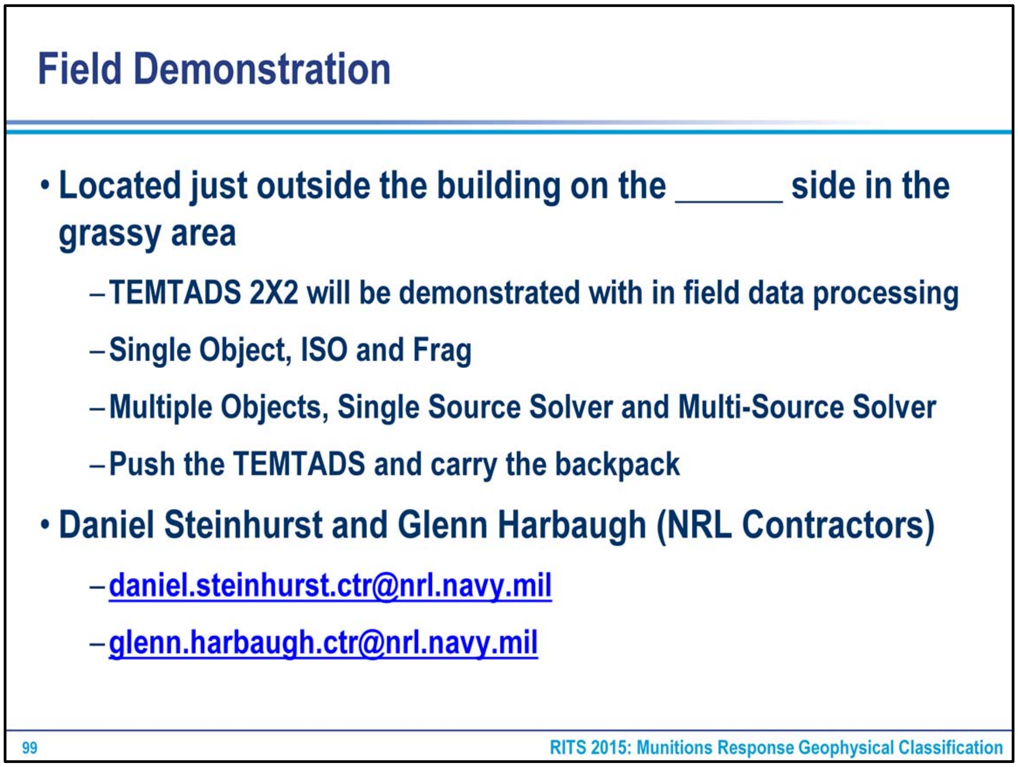
- RITS topic from last year "Using Classification Capable Sensors on Munitions Response Projects", which is on the NAVFAC ERB Website
  - www.navfac.navy.mil
- Interstate Technology Regulatory Council factsheets, guidance documents, and training on geophysical classification
  - www.itrcweb.org
- Beta Uniform Federal Policy for Quality Assurance Project Plan Template on Geophysical Classification for Munitions Response
- Army Corps of Engineers Military Munitions Support Services Webinar series
  - www.cluin.org
- DoD's Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) Website
  - www.serdp-estcp.org/

96 Wrap Up RITS 2015: Munitions Response Geophysical Classification

- Here are some references



- The last portion of the MR Topic provides an actual field demo of the TEMTADS



- We are going to take a break, and when we return Dan Steinhurst will give a short introduction to the TEMTADS here on the computer
- We will then go outside and Glenn Harbaugh will demonstrate the TEMTADS unit
- After that we will come back inside and look at the data that was taken outside