Department of Defense Quality System Requirements for Advanced Geophysical Classification (DoD QSR)

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Department of Defense Quality System Requirements for Advanced Geophysical Classification

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DoD Requirements, Clarifications, and Guidance [Note: This DoD Quality Systems Requirements (QSR) document supplements, and is intended for use in conjunction with, the International Standardization Organization/International Electrotechnical Commission (ISO/IEC) Standard 17025:2017, "General requirements for the competence of testing and calibration laboratories".]

3. TERMS AND DEFINITIONS

Clarifications: Additional abbreviations and acronyms used in this standard:

- A: Ampere
- AB: Accreditation Body
- AGC: Advanced Geophysical Classification
- ASQ: American Society for Quality
- BG: Background
- CA: Corrective action
- CAR: Corrective action request
- cm: centimeter
- DFW: Definable feature of work
- DGM: Digital geophysical mapping
- DOC: Demonstration of capability
- DOP: Dilution of precision
- DQO: Data quality objective
- DUA: Data usability assessment
- EDQW-MR: Environmental Data Quality Workgroup Munitions Response Subgroup
- ESTCP: Environmental Security Technology Certification Program
- GCMR-QAPP: Geophysical Classification for Munitions Response – Quality Assurance Project Plan
- GCO: Geophysical classification organization
- GIS: Geographical information system
- GPS: Global positioning system
- ISO: Industry standard object
- ISO/IEC: International Organization for Standardization/International Electrotechnical Commission
- ITRC: Interstate Technology Research Council
- IVS: Instrument verification strip
- m: meter
- mV: millivolt
- MPC: Measurement performance criteria
- MQO: Measurement quality objective
- MR: Munitions Response
- N/A: Not applicable
- pdf: Portable document format
- QAM: Quality assurance manager
- QC: Quality control
- RCA: Root cause analysis
- RTK: Real-time kinematic
- Rx: Receive
- SERDP: Strategic Environmental Research Demonstration Protocol
- SI: International System of Units
- SOP: Standard Operating Procedure
- SNR: Signal to noise ratio

- Tx: Transmit
- UXO: Unexploded ordnance

Clarifications: Additional terms used in this standard:

- Advanced geophysical classification: The use of data from a geophysical sensor system to make a decision about the likely source of a signal; specifically, to determine whether the source is potentially a hazardous munition that shall be removed or other non-hazardous item(s) that can be left in the ground. Advanced geophysical classification requires three essential components: 1) a geophysical sensor system, 2) a model to estimate intrinsic properties of a buried item based on its electromagnetic induction (EMI) fingerprint, and 3) classification algorithms to assign likelihood that the buried item is a target of interest.
- Accreditation Body: Authoritative body that performs accreditation.
- Classification validation: A qualitative assessment of the EMI fingerprints predicted from geophysical inversions used to evaluate overall investigation performance. This is achieved by making one or more predictions about the size or general shape of selected non-TOI items, followed by excavation of the items and comparison of actual intrinsic characteristics to predicted characteristics. It may also include a comparison of actual to predicted extrinsic properties such as location and depth of the item.
- Customer: The DoD client
- Data Quality Objectives (DQOs): Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data. They provide the statistical framework for planning and managing environmental data operations consistent with the user's needs.
- DoD (or Government) Quality Assurance Manager (QAM): The DoD representative providing quality assurance oversight throughout the life cycle of a munitions response project.
- EMI fingerprint: A set of three magnetic polarizabilities which express how an object responds following electromagnetic excitation along each of its three principal axis directions. These intrinsic properties of the object are determined by geophysical inversion of multi-axis EMI sensor data.
- Geophysical inversion: A process that uses geophysical data and a physics-based model to iteratively estimate intrinsic properties of a buried item.
- Industry standard object (ISO): An object, constructed from steel pipe manufactured to ASTM specifications, used as a munitions surrogate for the purpose of quality assurance or quality control. More information is available in the Geophysical System Verification (GSV): A Physics-Based Alternative to Geophysical Prove-Outs for Munitions Response document found on the SERDP-ESTCP webpage.
- Instrument verification strip: A constructed series of buried inert munitions or industry standard objects used to verify proper functioning of the geophysical and geodetic sensors.
- Management system (quality system): The means by which an organization ensures the quality of the products or services it provides and includes a variety of management, technical, and administrative elements such as policies and objectives, procedures and practices, organizational authority, responsibilities, and accountability.
- Nonconformity: Deviation from a specification or standard.

- Polarizabilities: Three principal axis responses returned by the inversion process, which relate directly to the physical attributes of the object under investigation. Information inferred from the responses (e.g. size, shape, aspect ratio and wall thickness) is the basis for classification decisions.
- Source selection (AGC): The process of using data from geophysical sensors (primarily electromagnetic induction sensors) to determine the location and orientation (extrinsic properties) and size and wall thickness (intrinsic properties) of buried metal objects (sources). Sources that are too small or thin-walled to be TOI can be eliminated from further consideration.
- Standard method: A method for performing advanced geophysical classification that has been successfully performed in an Environmental Security Technology Certification Program (ESTCP) demonstration and is capable of meeting the minimum specifications contained in Appendix A of this document.
- Target of interest (TOI): Any item that shall be removed from a munitions response site. Common TOI include UXO, other inert munitions that shall be excavated to be identified as inert, QC and validation seeds, and substantial components of munitions that are selected for removal.
- Validation seed: Industry standard object or inert target of interest buried at a recorded location, depth, and general declination and orientation, by, or on behalf of, the government, which is used to evaluate overall contractor performance on advanced geophysical classification. The identity, location, and depth, declination, and orientation of the seed item are blind to the contractor.

3.1 Impartiality

3.2 Complaint

3.3 Interlaboratory comparison

3.4 Intralaboratory comparison

3.5 Proficiency testing

3.6 Laboratory

Clarification: For the purposes of this standard, the term “laboratory” refers to the organization (i.e., the geophysical classification organization (GCO)) performing advanced geophysical classification.

3.7 Decision rule

3.8 Verification

3.9 Validation

4. GENERAL REQUIREMENTS
4.1 Impartiality
4.1.1
4.1.2
4.1.3
4.1.4
4.1.5
4.2 Confidentiality
4.2.1
4.2.2
4.2.3
4.2.4
5. STRUCTURAL REQUIREMENTS
5.1
5.2 <u>Requirement:</u> The GCO shall identify the following management personnel, however named: • Corporate Manager: i.e., the person having 1) overall responsibility and accountability for conforming with these requirements and 2) authority to commit resources on behalf of the GCO. • Technical Manager: i.e., the person responsible and accountable for managing all technical operations of the GCO. • Quality Assurance Manager: i.e., the person responsible for monitoring and implementing the GCO's management system. • Project Geophysicist: i.e., the person responsible and accountable for implementing and overseeing project-specific technical operations for a specific client and contract • Quality Control Geophysicist: i.e., the person responsible and accountable for implementing and overseeing project-specific quality systems at a given Munitions Response Site. The GCO shall maintain current job descriptions defining roles and responsibilities for management personnel. With appropriate training and qualifications, personnel may fill more than one role; however, if management personnel have technical responsibilities, they may not perform oversight of their own work.
5.3
5.4

5.5
a)
b) <u>Requirement:</u> The GCO shall identify personnel responsible for the following: • Reviewing and responding to all requests, tenders, and contracts • Ensuring all personnel (internal and external) are appropriately qualified and trained before performing any work under the scope of this accreditation • Participating in project-planning activities, i.e., the development of DQOs • Reviewing and agreeing to implement project-specific Quality Assurance Project Plans (QAPPs) • Reviewing and approving all GCO-supplied standard operating procedures (SOPs) • Verifying the selection of appropriately qualified external personnel • Verifying the selection of appropriate technology • Performing data review • Performing project-specific oversight • Notifying the DoD client of all non-conformances • Developing corrective action (CA) plans • Implementing and monitoring CA • Reporting inappropriate practices to the AB
c)
5.6
a)
b)
c)
d)
e)
5.7
a)
b)

6. RESOURCE REQUIREMENTS

6.1 General

6.2 Personnel

6.2.1 Requirement: All personnel shall be trained in accordance with this standard and all personnel performing testing or data analysis shall complete internal demonstration of capability (DOC). If the GCO uses external personnel as either temporary or permanent extensions of its own staff, external personnel shall operate under the GCO's management system. The GCO shall maintain records documenting the training and competency, including internal DOC, for all external personnel, and these records shall be available for review and provided to assessors upon request. The DoD customer shall provide written approval for the use of external personnel (prior to field work).

6.2.2 Requirement: The GCO shall identify essential personnel, which includes any person whose absence or departure could influence the results of advanced geophysical classification and the GCO's ability to comply with these requirements. In addition to documenting competence requirements, the GCO shall describe the unique capabilities for essential personnel and the specific activities for which they are responsible. The GCO shall notify the AB of any changes in essential personnel.

6.2.3 Requirement: Training procedures shall address both ISO/IEC 17025 and the supplemental DoD management system requirements contained in this document, including prohibited practices identified in Appendix C.

The GCO shall have SOPs for conducting individual (internal) DOC. [Note: The internal DOC is not the same as the corporate DOC that shall be performed as part of the accreditation process.] Internal DOC shall be performed under direct supervision by personnel who have successfully performed an internal DOC for the same activity. SOPs shall describe the circumstances under which the internal DOC shall be repeated. All internal DOC, whether successful or unsuccessful, shall be documented.

For field personnel, the internal DOC shall demonstrate the following minimum skills:

- Instrument assembly and operation
- Continuous operation within specifications
- Dynamic operation
- Cued operation

For personnel performing data processing and analysis, the internal DOC shall demonstrate the following minimum skills:

- Quality control checks of field data (unknown targets and background)
- Background correction
- Source selection (dynamic survey only)
- Parameter extraction
- Appropriate use of parameters
- Classification

The internal DOC for the project geophysicist shall demonstrate all of the above. In addition, the project geophysicist shall have documented experience in the following:

- Geophysical survey design and management
- Data usability assessment

The quality control (QC) geophysicist shall have general familiarity with the skills listed above, but an internal DOC is not required. The GCO shall maintain records demonstrating the QC geophysicist's experience in the following:

- Design and placement of the Instrument Verification Strip (IVS) and QC seeds
- Data processing and analysis
- Data validation and verification
- Approving corrective action

Requirement: The effectiveness of training actions shall be documented prior to authorizing personnel to perform testing. Personnel competence for each type of equipment used that affects the data quality shall be documented. The Project Geophysicist shall sign records documenting satisfactory completion of the internal DOC by field personnel and personnel performing data processing and analysis. The Technical Manager shall sign records documenting satisfactory completion of the internal DOC by the Project Geophysicist(s). Electronic signatures are acceptable.

6.2.4

6.2.5
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b)
c)
d)
e)
f)
6.2.6
a)
b)
c)
6.3 Facilities and Environmental Conditions
6.3.1
6.3.2
6.3.3 Requirement: Procedures for monitoring environmental conditions shall require that a qualitative assessment of moisture and any potential sources of interferences (e.g., power lines and electrical fences) be recorded in the field notes, whether electronic or hard copy. Guidance: Examples of environmental conditions that may influence the validity of test results include the following: • Rapid (over the course of an hour) changes in soil moisture levels. This could result from heavy rains or thunderstorms, or heavy dew that dries up during the first hour of testing. Depending on the magnitude of the change, it could make the background variation too severe to compensate for. • Interferences from overhead high-voltage lines. To assess this interference, two background measurements should be collected closely in time. • Interference from intermittent radar sources or other high-power microwave sources (this would most likely occur at or near airports or other similar sites).
6.3.4
a)
b)
c)
6.3.5

6.4 Equipment
6.4.1
6.4.2
6.4.3
6.4.4 Requirement: Appendix A provides minimum required equipment inspection, maintenance, and QC checks.
6.4.5 Requirement: Equipment shall be validated by the DoD Environmental Data Quality Workgroup (EDQW).
6.4.6 Clarification: GCOs do not perform calibration activities in the course of performing Advanced Geophysical Classification (AGC).
6.4.7
6.4.8
6.4.9
6.4.10 Requirement: Appendix A describes minimum required intermediate checks to ensure that equipment remains in proper working order. These include the ongoing function tests and ongoing operation at the IVS.
6.4.11
6.4.12
6.4.13
a)
b)
c)
d)
e)
f)
g)
h)
6.5 Metrological Traceability
6.5.1
6.5.2

a)
b)
c)
6.5.3 Clarification: Traceability of measurements to the International System of Units (SI) is not possible or relevant. Traceability in measurements is achieved through the use of the DoD TOI Library and serially numbered objects provided with the advanced geophysical sensors. Requirement: The GCO shall use the DoD TOI Library as the source of polarizabilities for munitions used in classification decisions.
a)
b)
6.6 Externally Provided Products and Services
6.6.1
a)
b)
c)
6.6.2
a) Guidance: Examples of externally provided products that affect the quality of tests include QC seeds (e.g., ISO and inert munitions) and equipment (e.g. geophysical sensors and global positioning systems), whether purchased or rented. Examples of externally provided services include registered surveyors and intrusive investigation teams.
b)
c)
d)
6.6.3
a)
b)
c)
d)

7. PROCESS REQUIREMENTS
7.1 Review of Requests, Tenders and Contracts
7.1.1 Requirement: Either the Project Geophysicist or the QC Geophysicist shall participate in this review.
a)
b)
c) Requirement: In cases where more than one accredited GCO provide services in support of a specific project (i.e., specific client and contract), the contract and project-specific QAPP shall define one QC Geophysicist with overall responsibility/accountability for the project, and identify one management system under which all work shall be performed. The DoD customer shall provide written approval of the arrangement prior to field work.
d)
7.1.2
7.1.3 Clarification: The classification decision of TOI vs. non-TOI is considered a statement of conformity.
7.1.4
7.1.5
7.1.6
7.1.7
7.1.8
7.2 Selection, Verification and Validation of Methods
7.2.1 Selection and Verification of Methods
7.2.1.1
7.2.1.2 Requirement: The GCO shall maintain SOPs that include the minimum QC requirements contained in Appendix A as well as any contract-specific requirements. (Project-specific amendments to SOPs are permitted, with justification, based on project-specific DQOs.) Any instructions provided by the manufacturer shall be attached to SOPs and made available as noted above. SOPs shall be made available to personnel at all times, at all sites where they are used. Requirement: Technical SOPs shall be provided to the DoD customer upon request, to be included in the project-specific QAPP.
7.2.1.3

7.2.1.4 Requirement: For the purposes of this document, a standard method is one that a) has been successfully demonstrated during an ESTCP demonstration and b) is capable of meeting all minimum recommended specifications contained in Appendix A. Any other method is considered to be a non-standard method. The use of any non-standard methods shall be approved by the DoD EDQW. Clarification: The use of library-matching has been successfully demonstrated under the ESTCP and is capable of meeting requirements contained in Appendix A; therefore, it is considered to be a standard method.
7.2.1.5
7.2.1.6
7.2.1.7
7.2.2 Validation of Methods
7.2.2.1 Requirement: When methods referred to in this paragraph are used on a project-specific basis, both the corporate QAM and DoD QAM shall provide written approval before the procedure is considered validated. When methods referred to in this paragraph are intended to be used on a DoD-wide basis, both the corporate QAM and the EDQW shall provide written approval before the procedure is considered validated.
7.2.2.2
7.2.2.3
7.2.2.4
a)
b)
c)
d)
e)
7.3 Sampling
7.3.1 Clarification: The selection of non-TOI used in classification validation is considered to be a sampling activity.
7.3.2
a)
b)

c) Clarification: For the purposes of advanced geophysical classification accreditation, this section is not applicable.
7.3.3
a)
b)
c)
d)
e)
f)
g)
h)
7.4 Handling of Test or Calibration Items Clarification: For the purposes of advanced geophysical classification accreditation, this section is not applicable.
7.4.1
7.4.2
7.4.3
7.4.4
7.5 Technical Records
7.5.1
7.5.2
7.6 Evaluation of Measurement Uncertainty
7.6.1 Guidance: Appendix E: Factors Affecting Measurement Uncertainty provides guidance on potential sources of measurement uncertainty.
7.6.2
7.6.3

7.7 Ensuring the Validity of Results
7.7.1 Requirement: The organization shall monitor its ongoing performance on quality control procedures for the purpose of identifying trends in performance so that preventive actions can be taken where practicable. At a minimum, GCOs shall monitor ongoing performance on the IVS, QC seeds, and validation seeds. Guidance: The regular and routine analysis of quality control data can often permit trends to be spotted before a nonconformity occurs. There are several tools available for analyzing quality control data including check sheets, control charts, and histograms. The American Society for Quality (ASQ) provides information and links to resources addressing the analysis of quality control data on its webpage.
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
7.7.2
a)
b)
7.7.3 Requirement: Appendix A provides minimum required QC procedures, data quality acceptance criteria, and corrective action processes.

7.8 Reporting of Results
7.8.1 General
7.8.1.1 Requirement: The organization shall have SOPs that describe responsibilities and procedures for performing internal data review before data are transmitted to the client. Personnel performing internal data review shall be independent of the activity generating the data. The SOP shall describe who performs internal review, how it is performed, and how it is documented.
7.8.1.2
7.8.1.3
7.8.2 Common Requirements for Reports (Test, Calibration or Sampling)
7.8.2.1 Requirement: The organization shall have an SOP for determining and specifying the format and contents of all test reports including databases and electronic deliverables. Appendix D provides minimum requirements for test reports. Requirement: Project-specific reporting requirements will be specified in contract documents and the project-specific QAPP.
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
l)
m)
n)
o)
p)

7.8.2.2
7.8.3 Specific Requirements for Test Reports
7.8.3.1
a)
b)
c) Clarification: [As noted in QSR Section 7.6.3, Appendix E provides guidance on factors affecting measurement uncertainty.]
d)
e) Requirement: The QC Geophysicist or Project Geophysicist, in accordance with an established procedure, shall make a qualitative evaluation of the match between the predicted and actual properties of every item that is excavated. This comparison shall be reported.
7.8.3.2
7.8.4 Specific Requirements for Calibration Certificates
7.8.4.1
a)
b)
c)
d)
e)
f)
7.8.4.2
7.8.4.3
7.8.5 Reporting Sampling – Specific Requirements
a)
b)
c)
d)
e)
f)

7.8.6 Reporting Statements of Conformity
7.8.6.1 Clarification: The prioritized dig list is a statement of conformity regarding the TOI vs. non-TOI decision.
7.8.6.2
a)
b)
c)
7.8.7 Reporting Opinions and Interpretations
7.8.7.1
7.8.7.2
7.8.7.3
7.8.8 Amendments to Reports
7.8.8.1
7.8.8.2
7.8.8.3
7.9 Complaints
7.9.1
7.9.2
7.9.3
a)
b)
c)
7.9.4
7.9.5
7.9.6
7.9.7
7.10 Nonconforming Work
7.10.1

a)
b) Requirement: Appendix A: Equipment, Inspection, and Quality Control includes minimum required specifications, criteria, and procedures for controlling non-conforming work.
c)
d)
e) Requirement: Any nonconforming work that impacts the quality of the AGC process, other than a missed validation seed, shall be reported by the GCO to the DoD customer within 7 calendar days. [See Appendix B: Requirements for Monitoring and Reporting Ongoing Performance on Validation Seeds]. The GCO shall notify the DoD customer and the AB within 7 calendar days if it discovers that any inappropriate practice(s) have taken place. [See appendix C: Prohibited Practices.] Clarification: Either the DoD customer or the GCO may determine when it is necessary to recall work.
f)
7.10.2
7.10.3
7.11 Control of Data and Information Management
7.11.1
7.11.2 Clarification: A list of validated software is available for reference on the DENIX DAGCAP webpage.
7.11.3
a)
b)
c)
d)
e)
7.11.4
7.11.5
7.11.6 Requirement: Formulas (e.g., those used in spreadsheets developed and used by GCOs) require validation.

8. MANAGEMENT REQUIREMENTS
8.1 Options
8.1.1 General Requirement: For the purpose of DAGCAP, the management system shall meet all requirements of option A.
8.1.2 Option A
8.1.3 Option B
8.2 Management System Documentation
8.2.1 Clarification: The GCO (if part of a parent organization) is permitted to have its own management system as long as roles and responsibilities for management personnel in the parent organization are included.
8.2.2 Requirement: If management personnel have technical responsibilities, they may not perform oversight of their own work.
8.2.3
8.2.4
8.2.5
8.3 Control of Management System Documents
8.3.1
8.3.2
a) Requirement: the corporate QAM and the technical manager shall approve all technical SOPs prior to issue.
b) Requirement: Technical SOPs shall be reviewed at least every year. All other management system documents shall be reviewed at least every two years.
c) Requirement: Pen and ink amendments to documents that form part of the management system are not permitted. (As noted in ISO/IEC 17025 Section 8.3.1, these documents include regulations, standards, other normative documents, test methods, drawings, software, specifications, instructions and manuals.) Any amendments to management system documents shall be issued in the form of a written notice signed by the QAM and showing the date of issuance and the effective date of the amendment. Electronic signatures are acceptable. Project-specific (one-time) amendments to management system documents (e.g. technical SOPs) shall also provide justification for the amendment. The corporate QAM shall notify all affected personnel of amendments to quality system documents.

d) Requirement: Management system documents describing detailed procedures for performing work in the field (e.g., technical SOPs) shall be available to all personnel performing work in the field. The use of electronic copies of SOPs is permitted.
e)
f)
8.4 Control of Records
8.4.1 Clarification: Technical records include hard-copy and electronic documentation of work as it is performed (e.g., raw data and results) and reports.
8.4.2 Requirement: Organizations shall retain all quality and technical records for a minimum of five years.
8.5 Actions to Address Risks and Opportunities
8.5.1 Guidance: As specified in 7.8.3 (e), the QC Geophysicist shall make a qualitative evaluation of the match between predicted and actual properties of every item that is excavated. Monitoring the GCOs ongoing performance on its ability to predict the properties of excavated items can be an important part of addressing risks and opportunities. This evaluation could be conducted by the corporate QAM during management reviews.
a)
b)
c)
d)
8.5.2
a)
b)
8.5.3
8.6 Improvement
8.6.1
8.6.2
8.7 Corrective Actions
8.7.1
a)
b)

c)
d)
e)
f)
8.7.2
8.7.3
a)
b)
8.8 Internal Audits
8.8.1 Clarification: Internal audits and management reviews are separate activities. Requirements: Internal audits shall be performed by, or under the direction of, the corporate QAM. Internal audits shall be performed at least once every two years and include on-site audits of technical activities. Internal audits may be conducted in phases.
a)
b)
8.8.2
a)
b)
c)
d)
e)
8.9 Management Review
8.9.1 Requirement: Management reviews shall be conducted at least once every year. Management reviews shall include evaluation of ongoing performance on validation seeds. Management reviews may be conducted in phases. Requirement: Appendix B provides requirements for monitoring and reporting performance validation seeds.
8.9.2
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b)

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d)
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o)
8.9.3
a)
b)
c)
d)

Appendix A: Equipment Inspection, Maintenance, and Quality Control[1]

This table documents minimum procedures and acceptance criteria for performing testing, inspections and quality control. Where appropriate, the failure response column prescribes a corrective action (CA); otherwise a root cause analysis (RCA) shall be conducted to determine the appropriate CA. For the purpose of accreditation, the organization shall demonstrate the ability to comply with all minimum specifications.

Table A-1: **Dynamic Survey**

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
1	Verify correct assembly		Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	As specified in Assembly checklist	CA: Make necessary adjustments, and re-verify
2	Initial Instrument Function Test MetalMapper 2x2 (Instrument response amplitudes)		Once following assembly	Field Geophysicist/ Initial IVS Memorandum/Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: Make necessary adjustments, and re-verify

[1] For ease of reference, a list of abbreviations and acronyms used in this table is presented at the end of the table.

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
3	Initial Instrument Function Test MetalMapper		Once following assembly	Field Geophysicist/ Initial IVS Memorandum/Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response	CA: Make necessary adjustments, and re-verify
4	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 25cm of the ground truth locations	CA: Make necessary adjustments, and re-verify
5	Ongoing Instrument Function Test (Instrument response amplitudes) MetalMapper 2x2		Beginning and end of each day and each time instrument is turned on	Field Team Leader/ running QC summary (Excel/Geosoft)/ Project or QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: Make necessary repairs and re-verify
6	Ongoing Instrument Function Test (MetalMapper)		Beginning and end of each day and each time instrument is turned on	Field Team Leader/ running QC summary/Project or QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: Make necessary repairs and re-verify
7	Ongoing dynamic positioning precision (IVS)		Beginning and end of each day	Project Geophysicist/ running QC summary/QC Geophysicist	Derived positions of IVS target(s) within 25 cm of the average locations	RCA/CA

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
8	In-line measurement spacing (MetalMapper 2x2)		Verified for each survey unit using [describe tool to be used] 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, (re-collect portions that fail)
9	In-line measurement spacing (MetalMapper)		Verified for each survey unit using [describe tool to be used] based upon monostatic Z coil data positions	Project Geophysicist/ running QC summary/ QC Geophysicist	100% ≤0.25m between successive measurements	RCA/CA
10	Coverage (MetalMapper 2x2)		Verified for each survey unit using [describe tool to be used] based upon monostatic Z coil data	Project Geophysicist/running QC summary and survey unit validation report/QC Geophysicist	100% at ≤0.7m cross-track measurement spacing (excluding site specific access limitations, e.g., obstacles, unsafe terrain)	RCA/CA
11	Coverage (MetalMapper)		Verified for each survey unit using [describe tool to be used] based upon monostatic Z coil data	Project Geophysicist/running QC summary and survey unit validation report/QC Geophysicist	100% at ≤0.7m cross-track measurement spacing (excluding site specific access limitations, e.g., obstacles, unsafe terrain)	RCA/CA

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
12	Sensor Tx current (MetalMapper, MetalMapper 2x2 and MPV)		Per measurement	Field Team Leader/running QC summary/Project Geophysicist	MetalMapper current shall be ≥3.5A MetalMapper 2x2 current shall be ≥6A MPV current shall be ≥4A	CA: out of spec data rejected
13	Dynamic detection performance		Evaluated by survey unit	QC Geophysicist/ survey unit validation report/lead agency QA Geophysicist	All blind seeds shall be detected and positioned within 40 cm radius of ground truth	RCA/CA
14	Valid position data (1)		Per measurement	Field Team Leader/running QC summary/Project Geophysicist	GPS status flag indicates RTK fix	Out-of-spec data rejected
15	Valid orientation data (2)		Per measurement	Field Team Leader/running QC summary/Project Geophysicist	Orientation data reviewed and appear reasonable within bounds appropriate to site	Unreasonable data rejected
16	Size and decay rate threshold verification (when advanced anomaly selection is used)		Collect cued data from an additional 200 anomalies excluded on the basis of advanced anomaly selection		Cued data analysis confirms 100% of excluded anomalies are non-TOI	RCA/CA
17	Confirm reacquisition precision		Daily	UXO tech or field tech/Daily QC Report/Project Geophysicist	Benchmark positions repeatable to within 10cm	RCA/CA

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
18	Confirm adequate spacing between units (MetalMapper 2x2)		Per measurement	Field Team Leader/ Field Logbook/Project Geophysicist	Minimum separation of 50m	CA: Recollect all coincident measurements
19	Confirm adequate spacing between units (MetalMapper)		Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/Project Geophysicist	Minimum separation 25m	CA: Recollect all coincident measurements

Table A-2: **Cued Survey**

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
20	Verify correct assembly		Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	As specified in instrument assembly checklist	CA: Make necessary adjustments, and re-verify
21	Initial sensor function test (MetalMapper 2x2)		Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: make necessary repairs/ adjustments and re-verify
22	Initial system functionality test (MetalMapper) (Five measurements over a small ISO80 target, 1 each directly under each coil and 1 directly under center of array). Derived polarizabilities for each measurement are compared to the library using UX-Analyze		Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	Library match metric ≥0.95 for each of the five sets of inverted polarizabilities	CA: make necessary repairs/ adjustments and re-verify

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
23	Initial IVS background measurement (five background measurements, one centered at the flag and one offset at least 35cm in each cardinal direction)		Once during initial system IVS test	Field Team Leader/ Initial IVS memorandum/Project Geophysicist	Receiving a pass from the UX-Analyze Background Validation Tool or validated equivalent.	CA: reject/replace BG location
24	Initial derived polarizabilities accuracy (IVS)		Once during initial system IVS test	Project Geophysicist/ Initial IVS memorandum/ QC Geophysicist	Library Match metric ≥0.9 for each set of inverted polarizabilities	RCA/CA
25	Derived target position accuracy (IVS)		Once during initial system IVS test	Project Geophysicist/ Initial IVS Memorandum/ QC Geophysicist	All IVS item fit locations within 0.25m of ground truth locations	RCA/CA
26	Ongoing IVS background measurements		Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/ QC Geophysicist	Receiving a pass from the UX-Analyze Background Validation Tool or validated equivalent.	RCA/CA CA assumption: rejection of BG measurement (unless RCA indicates system failure)
27	Ongoing derived polarizabilities precision (IVS)		Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/ QC Geophysicist	Library Match to initial polarizabilities metric ≥0.9 for each set of three inverted polarizabilities	RCA/CA
28	Ongoing derived target position precision (IVS)		Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/ QC Geophysicist	All IVS items fit locations within 0.25m of average of derived fit locations	RCA/CA

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
29	Initial measurement of production area background locations (five background measurements: one centered at the flag and one offset at least 35cm in each cardinal direction)		Once per background location	Field Team Leader/ background location report/Project Geophysicist	Receiving a pass from the UX-Analyze Background Validation Tool or validated equivalent.	CA: reject BG location and find alternate
30	Ongoing production area background measurements		Background data collected a minimum of every two hours during production	Field Team Leader/failures noted in field log and tracking summary/Project Geophysicist	Receiving a pass from the UX-Analyze Background Validation Tool or validated equivalent.	CA: BG measurement rejected and re-collected
31	Ongoing instrument function test (MetalMapper 2x2)		Each time instrument is restarted	Field Team Leader/ tracking summary/ Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: make necessary repairs and re-verify
32	Ongoing instrument function test (MetalMapper)		Each time instrument is restarted	Field Team Leader/ tracking summary/ Project Geophysicist	Response within 20% of predicted response	CA: Make necessary repairs and re-verify
33	Valid position data		Per measurement	Field Team Leader/running QC summary/Project Geophysicist	GPS status flag indicates RTK fix	Out-of-spec data rejected

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
34	Valid orientation data		Per measurement	Field Team Leader/running QC summary/Project Geophysicist	Orientation data reviewed and appear reasonable within bounds appropriate to site	Unreasonable data rejected
35	Transmit current levels (MetalMapper 2x2)		Evaluated for each sensor measurement	Field Team Leader/ tracking summary/ Project Geophysicist	Peak transmit current between 6 and 9A	CA: stop data acquisition activities until condition corrected
36	Transmit current levels (MetalMapper)		Evaluated for each sensor measurement	Field Team Leader/ tracking summary/ Project Geophysicist	Peak transmit current between 4.0 and 4.5A	CA: stop data acquisition activities until condition corrected
37	Transmit current levels (MPV)		Evaluated for each sensor measurement	Field Team Leader/ tracking summary/ Project Geophysicist	Peak transmit current between 4 and 6A	CA: stop data acquisition activities until condition corrected
38	Confirm adequate spacing between units (MetalMapper 2x2)		Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	Minimum separation of 50m	CA: Recollect all coincident measurements
39	Confirm adequate spacing between units (MetalMapper)		Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	Minimum separation 25m	CA: Recollect all coincident measurements
40	Confirm inversion model supports classification (1 of 3)		Evaluated for all models derived from a measurement (i.e. single item and multi-item models)	Project Geophysicist/ Measurement QC summary/ QC Geophysicist	Derived model response shall fit the observed data with a fit coherence ≥0.8*	Follow procedure in SOP or RCA/CA

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
41	Confirm inversion model supports classification (2 of 3)		Evaluated for derived target	Project Geophysicist/ Measurement QC summary/ QC Geophysicist	Fit location estimate of item ≤0.4m from center of sensor	Follow procedure in SOP or RCA/CA
42	Confirm inversion model supports classification (3 of 3)		Evaluated for all seeds	QC Geophysicist/ Measurement Inversion model QC summary/ lead agency QA Geophysicist	100% of predicted seed positions ≤0.25m from known position (x, y, z).	RCA/CA
43	Confirm reacquisition GPS precision		Daily	UXO tech or field tech/ Daily QC Report/ Project Geophysicist	Benchmark positions repeatable to within 10cm	RCA/CA
44	Classification performance		Evaluated for all seeds	QC Geophysicist; USACE QA Geophysicist/ Ranked dig list/ USACE QA Geophysicist	100% of QC and validation seeds placed on dig list	RCA/CA

***** Fit coherence is defined as the square of the correlation coefficient between data and model

Table A-3: **Intrusive Investigation**

MQO #	Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
45	Confirm derived features match ground truth (1 of 2)		Evaluated for all recovered items	Project Geophysicist/ Measurement QC Summary or intrusive database/ QC Geophysicist	100% of recovered (excluding inconclusive category) item positions ≤0.25m from predicted position (x, y).	RCA/CA
46	Confirm derived features match ground truth (2 of 2)		Evaluated for all recovered items	UXO Dig Team/ Dig List and intrusive database/ Project or QC Geophysicist	100% of recovered object size estimates (excluding inconclusive category) qualitatively match predicted size	RCA/CA
47	Verification of TOI/non-TOI threshold		Dig 200 anomalies beyond last TOI on Dig List	Project Geophysicist/ Verification and Validation Report/ QC Geophysicist	100% of predicted non-TOI intrusively investigated are non-TOI	Adjust threshold
48	Classification validation		Each of the 200 non-TOI	Project Geophysicist/ Verification and Validation Report/ QC Geophysicist	100% of predicted non-TOI qualitatively matches predictions	Document in DUA

Abbreviations and acronyms:

A – ampere
BG – background
CA – corrective action
cm – centimeter
DOP – dilution of precision
DUA – data usability analysis
GCMR-QAPP – Geophysical Classification for Munitions Response Quality Assurance Project Plan
GPS – global positioning system
ISO – industry standard object
IVS – instrument verification strip
m – meter

Abbreviations and acronyms:

QA – quality assurance
QAPP – quality assurance project plan
QC – quality control
RCA – root cause analysis
RTK – real time kinematic
Rx – receive
SOP – standard operating procedure
TBD – to be determined
TOI – target of interest
Tx – transmit
UXO – unexploded ordnance

Appendix B: Requirements for Monitoring and Reporting Ongoing Performance on Validation Seeds

1. Geophysical classification organization (GCO) receives award or task order, and notifies Accreditation Body (AB) of upcoming project (site name, basic information, and approximate date for beginning site work).
2. GCO conducts detection survey, by survey unit.
3. Following data verification and validation, GCO reports detection survey results to DoD customer in accordance with the site-specific GCMR-QAPP.
4. DoD customer reports validation seed detection results to the GCO within 14 days of receiving detection survey results.
5. DoD customer reports validation seed failures to EDQW.
6. GCO reports validation seed failures to AB within 7 days.
7. If the GCO failed to detect any validation seeds, GCO shall issue a QA stand down, conduct RCA, and identify CA.
    a. GCO provides RCA/CA to DoD customer and AB.
    b. AB coordinates with EDQW.
    c. If the RCA reveals the failure resulted from a government error, the DoD customer implements CA, and work resumes.
    d. If the RCA reveals the failure resulted from an error on the part of the GCO), the GCO implements corrective action and the DoD customer implements contract remedies, if applicable.
8. Process is repeated for cued survey.
9. AB tracks and reports validation seed failures.

Appendix C: Prohibited Practices

The following is a list of practices that are inappropriate for the collection of environmental data, and are therefore prohibited. Inappropriate practices are deliberate activities undertaken with the objective of misrepresenting data, i.e., making it appear that all required specifications were followed or acceptance criteria achieved, when they were not. The major bullets identify categories of inappropriate practices. Sub-bullets provide examples.

- Fabrication, falsification, or misrepresentation of data.
    - Creating data for a field measurement that was not performed.
    - Using data from one field measurement to represent a measurement at another location (e.g. changing the measurement location coordinates of one data file to represent a measurement at another location).
    - Altering or deleting original (i.e. raw) field measurement data (i.e. the measured transients, also known as receiver decays) in any way.
    - Changing the time stamp of a field measurement in either the field data file or subsequent processing data file(s) or database(s).
    - Altering, changing or deleting the output of an inversion process or inversion routine (i.e. the betas or polarizabilities reported from the inversion process).
    - Renaming a data file.
    - Altering a file's creation date or a file's modification date.
- Improper clock setting or improper date and time recording.
    - Resetting the internal clock on an instrument or computer to make it appear that field measurements were taken within some given background measurement interval other than the true interval, or to make it appear that background measurements were taken at intervals other than those actually performed.
    - Changing the actual time or recording a false time to make it appear that a field measurement was taken at some time other that the true time it was taken.
- Altering library data or library information.
    - Altering in any manner the library signature (also known as betas or polarizabilities), the library transients (also known as receiver decays), or metadata of a Government-furnished library signature.
- Unwarranted manipulation of analyses, software, or firmware
    - Changing or altering the measurement instrument's operating or recording parameters without documenting the reasons for doing so in accordance with SOPs.
    - Changing or altering the inversion software in any manner without following the SOP for doing so.
    - Using inversion software or an inversion routine that has not been accepted by the Government in accordance with Sections 7.2.1.4 and 7.2.2.1 of this standard.

    - Changing or altering the inversion parameters without documenting the change following the standard operating procedure (SOP) for doing so.
    - Turning off, or otherwise disabling or manipulating, electronic or software-controlled audit or tracking functions.
- Misrepresenting or misreporting quality control (QC) information
    - Substituting previous instrument verification strip (IVS) results for non-compliant IVS results.
    - Repeating a quality control (QC) task multiple times until a specification is met (i.e., intentionally replacing non-compliant QC results with compliant QC results) without performing required corrective action.
    - Deleting or failing to record non-compliant QC data for any reason.
    - Tampering with QC data or QC results to make it appear they are compliant with project specifications.
- Misrepresenting or overstating personnel competencies or personnel experience or expertise.
    - Misrepresenting, overstating, or falsifying training records.
    - Misrepresenting, overstating, or falsifying work experience.
    - Misrepresenting, overstating, or falsifying education credentials.
- Concealing a known measurement or analysis problem.
- Concealing a known improper or unethical behavior or action.
- Failing to report the occurrence of a prohibited practice or known improper or unethical act to the appropriate contractor representative or to an appropriate government official.
- Sharing blind seed information in violation of the firewall.

Appendix D: Data Management, Project Documents, and Records

This appendix is based on the GCMR-QAPP template, Worksheet #29, and it is subject to updates as the GCMR-QAPP is updated. This appendix presents data management specifications and lists minimum required documents and records for geophysical investigations. Where applicable, specific versions or dates of software used shall be documented.

Part 1: Data Management Specifications

Computer Files and Digital Data: All final document files, including reports, figures, and tables, will be submitted in electronic format on CD/DVD-ROM or as specified by the DoD client. Data management and backup shall be performed in accordance with the organization's documented quality system.

TOI Library: The project-specific QAPP shall document the version (date) of the DoD Target of Interest (TOI) library used and describe or reference procedures to be used to update the library. The TOI libraries used shall be included in data deliverables.

Part 2: Control of Documents, Records, and Databases

[Organizations should complete this table for use in their quality system and project-specific QAPPs.]

Minimum Required Documents and Records			
Document/Record	**Purpose**	**Completion/ Update Frequency**	**Format/ Storage Location/ Archive Requirements**
Site Manager Log			
Quality Control (QC) Seed Plan			
QC Firewall Plan			
Daily Status Reports			
Daily QC Reports			
Weekly Geophysical QC Report			
Team Leader Log(s)			
Field Change Request Form			
Root Cause Analysis			
Photograph Log			
Production Area QC Seeding Report			
Surface Sweep Technical Memorandum			
Land Survey/Control Point Data Report			
Instrument Verification Strip (IVS) Technical Memorandum			
SOP Checklists			
Seed Tracking Log			
Data Usability Assessments (dynamic survey, cued survey and final DUA)			

Minimum Required Documents and Records			
Document/Record	**Purpose**	**Completion/ Update Frequency**	**Format/ Storage Location/ Archive Requirements**
Target Selection Technical Memorandum			
Final Ranked Dig List			
Reacquisition Results			
Intrusive Investigation Results			
Anomaly Resolution Results			
Digital Geophysical Mapping (DGM) Data Deliverable			
DGM QC Deliverable			
Supporting Classification Images			

Appendix E: Factors Affecting Measurement Uncertainty

[Note: This appendix provides guidance for implementing ISO/IEC 17025, Section 7.6.1. It discusses examples of factors affecting measurement uncertainty, but it is not an exhaustive list.]

The primary decision in Advanced Geophysical Classification is the decision to dig, or not dig, a detected item. Because of this, the uncertainties of most concern are uncertainties in the estimated polarizabilities for the unknown item which are the basis for the decision. Of lesser concern are uncertainties in positioning which impact the time required for excavation and the likelihood of recovering the correct item.

Recovered Polarizabilities: Analyses starting with a high signal-to-noise measurement routinely yield precise polarizabilities. As the signal-to-noise ratio degrades, the uncertainties in the recovered polarizabilities increase until the results are too poor to use as inputs to classification. In this limit, the item is marked for excavation. The two contributors to low signal-to-noise ratio are incorrect background subtraction and weak or contaminated signal from the unknown item, as discussed below.

Background Uncertainties: For large targets with high amplitude signals, minor variations in background are negligible. For the smallest targets of interest at their deepest depths of concern however, signal amplitudes are low and minor variations in background result in large variation in the input to the geophysical inversion routine that is used to estimate polarizabilities. Common causes of background variation in decreasing importance include:

- short spatial scale variability in the soil response such that a nearby background measurement is not representative of the soil response at the site of the unknown measurement
- the presence of small pieces of metal at the site of the background measurement resulting in a background that is the sum of the soil response and the signal from the metal contamination
- rapid change in soil conductivity due to moisture changes associated with dew burn off or a passing rainstorm
- long spatial scale variability in soil response making a background collected on one side of the field unsuitable for use correcting an unknown measurement on the other side of the field.

Weak or Contaminated Signal: Selecting anomalies too deeply into the noise in an attempt to stretch the detection depth of the instruments can lead to measured data with insufficient amplitude for analysis. Even for stronger signals, external noise sources such as nearby radars and transmission towers, high-power overhead transmission lines, and even faulty electric fences can add noise to the measurement and compromise the SNR. Even those sources in very different frequency bands (radar and radio) can leak sufficient energy into the measurement band to impact the SNR.

The best diagnosis of uncertainty in recovered polarizabilities is to compare the results for the QC and validation seeds. If a large number of the seeds are identical items (Industry Standard Objects for example) the measured variation in the recovered polarizabilities will be a direct measure of the uncertainties in polarizabilities.

Location Uncertainties: In areas with good sky view cm-level GPS can be used for sensor geolocation. This, coupled with an affordable orientation measurement, results in a location estimate uncertainty that is negligible for the purposes of classification. There is a continuing check of this result from comparison of the derived position of the blind seeds against their known emplaced positions.

For other positioning systems such as robotic total stations or fiducial methods that shall be employed in GPS-compromised environments, the location uncertainties can be large (decimeters to meters) which can impact the ability of the intrusive team to efficiently return to the intended excavation target and even to the recovery of incorrect items. These uncertainties will have to be evaluated on a case-by-case basis depending on the particular conditions encountered at the site.