ESTCP

TECHNICAL REPORT

Improving ESTCP Demonstration Outcomes & Tech Transfer via Integration of Standardized Third-Party Technology Verification using ISO 14034

Tim Hansen
350Solutions, Inc.

November 2022

ESTCP Project EW20-5333

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
30-11-2022	ESTCP Technical Report	4/16/2020 - 12/31/2023

4. TITLE AND SUBTITLE
Improving ESTCP Demonstration Outcomes & Tech Transfer via Integration of Standardized Third-Party Technology Verification using ISO 14034

5a. CONTRACT NUMBER
20-C-0007

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Tim Hansen

5d. PROJECT NUMBER
EW20-5333

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
350Solutions, Inc.
1053 E. Whitaker Mill Rd.
Suite 115
Raleigh, NC 27604

8. PERFORMING ORGANIZATION REPORT NUMBER
EW20-5333

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Security Technology Certification Program
4800 Mark Center Drive, Suite 16F16
Alexandria, VA 22350-3605

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
EW20-5333

12. DISTRIBUTION / AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This project examines how to integrate the ISO 14034 – Environmental Technology Verification (ETV) standard into existing ESTCP processes and projects. It aims to provide an example of how the ISO standard implementation can work, how it can integrate with existing ESTCP processes, and its potential benefits in supporting technology transition. The project will apply the ISO 14034/17020 framework for ETV, establish its relevance to demonstration projects within ESTCP via a gap analysis and case study implementation for two current projects, and disseminate the results to end users, purchasers, regulators and funders (including 3rd party finance mechanisms) within the DoD.

15. SUBJECT TERMS
Tech Transfer, Implementation of Standardized Third-Party Technology Verification, ISO 14034

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Tim Hansen
UNCLASS	UNCLASS	UNCLASS	UNCLASS	31	**19b. TELEPHONE NUMBER** *(include area code)* 919-675-6432

Table of Contents

Acronyms

Acronym	Definition
ANAB	ANSI National Accreditation Board
ANSI	American National Standards Institute
DoD	United States Department of Defense
ESTCP	U.S. Department of Defense Environmental Security Technology Certification Program
ETV	Environmental Technology Verification
FAR	Federal Acquisition Regulation
ISO	International Standards Organization
NIST	National Institute of Standards and Technology
QA/QC	Quality Assurance / Quality Control
QMS	Quality Management Systems
SERDP	Strategic Environmental Research and Development Program

1.0 INTRODUCTION

DoD's Environmental Security Technology Certification Program (ESTCP) was established to promote the transfer of innovative technologies that have successfully established proof of concept to field or production use [1]. ESTCP demonstrations collect cost and performance data to overcome the barriers to employ an innovative technology because of concerns regarding technical or programmatic risk, the so-called "Valley of Death". The Program's goal is to identify and demonstrate the most promising innovative and cost-effective technologies and methods that address DoD's high-priority environmental requirements. Projects conduct formal demonstrations at DoD facilities and sites in operational settings to document and validate improved performance and cost savings. To ensure the demonstrated technologies have a real impact, ESTCP collaborates with end-users and regulators throughout the development and execution of each demonstration. Transition challenges are overcome with rigorous and well-documented demonstrations that provide the information needed by all stakeholders for acceptance of the technology. However, the transfer of technologies and market uptake is still limited, and challenges remain. In many markets, including the Department of Defense, transfer of knowledge to end users, purchasers, regulators, and others is often done in an ad hoc, inconsistent manner, which can result in critical stakeholders having to try to repeatedly compare options, review barriers, assess performance, and estimate impact on their own, relying on information from various disparate resources.

One approach to reducing barriers to entry and reducing risk associated with implementation of innovative technologies is to provide credible, consistent, high quality data that directly addresses stakeholder information needs. This approach to technology demonstration and validation has been standardized via ISO Standard 14034: Environmental Technology Verification [2] – establishing a scalable, unified framework for technology validation and incorporating qualification requirements for independent verifiers as well as data quality assurance requirements for test and calibration labs and data providers.

This project examines how to integrate the ISO 14034 – Environmental Technology Verification (ETV) standard into existing ESTCP processes and projects. It aims to provide an example of how the ISO standard implementation can work, how it can integrate with existing ESTCP processes, and its potential benefits in supporting technology transition. The project will apply the ISO 14034/17020 framework for ETV, establish its relevance to demonstration projects within ESTCP via a gap analysis and case study implementation for two current projects, and disseminate the results to end users, purchasers, regulators and funders (including 3rd party finance mechanisms) within the DoD.

The primary objective of the project is to demonstration how integration of ISO standards into the ESTCP process can enable more rapid technology demonstration and tech transfer, and ultimately technology deployment through the following programmatic benefits:

- Identification of potential unified consensus testing and demonstration approaches for specific technology categories that can be applied to all future projects in those areas;
- Determination of stakeholder needs and input in the overall ESTCP Energy & Water program to ensure needed data and information is obtained during demonstrations for each technology type;
- Implementation of third-party verification of demonstration data and information to ensure high data quality, credibility, and consistency across demonstration programs;
- Potentially more rapid acceptance of technologies due to the inclusion of interested parties needs, standard protocols and improved data quality;

- Development of outreach materials and guideline documents to train users and enable implementation of ISO 14034.

The overall objectives and supporting tasks for this project in Table 1.

Table 1. Proposed Project Goals and Approaches

Project Goal	Approach
Complete Gap Analysis for ESTCP processes vs. ISO 14034	Compare ESTCP existing project guidance and requirements vs. ISO 14034. Identify gaps and develop modified guidance and requirements.
Establish connection of tech developers to stakeholders to ensure data needs are met	Establish stakeholder groups and processes for two technologies to obtain input on info needs
Establish relevant verification metrics	Utilize stakeholder approach to identify metrics for two specific technology types
Complete technology verifications	Work with demonstration project teams to ensure consistent verification approach is followed and complete independent verification of results in accordance with ISO 14034
Complete case studies for two tech verifications	Evaluate impact of verification on technology adoption in market – identify additional barriers to implementation and tech transfer
Modify ESTCP Dem-Val Requirements based on ISO 14034 integration and case study outputs	Work with ESTCP Program Managers to develop universal approach to incorporating an ISO ETV requirement for specific types of demonstrations based on this project's outcomes

Since ESTCP already has significant existing processes and requirements in place for demonstration-validation programs, it is important to identify where existing requirements meet the ISO 14034 guidelines, and where there are gaps. In Task 1 of the project, 350Solutions (350) will reviewed relevant current ESTCP guidelines and requirements and identified potential gaps that must be filled to meet the ISO 14034 requirements. Findings of this analysis will be used to drive this pilot study and modify ESTCP guidance to incorporate any additional requirements or needs associated with the ISO 14034 and related standards.

This interim report summarizes the findings of the Task 1 ESTCP Processes vs. ISO 14034 Audit and Gap Analysis.

2.0 ESTCP-ETV GAP ANALYSIS

2.1 Gap Analysis Approach

To identify, summarize, and evaluate gaps between the existing ESTCP demonstration process and the requirements of the ISO standard, the project reviewed relevant existing ESTCP processes and guidance and compare it to the ISO 14034, 17020, and 17025 requirements as depicted in Figure 1.

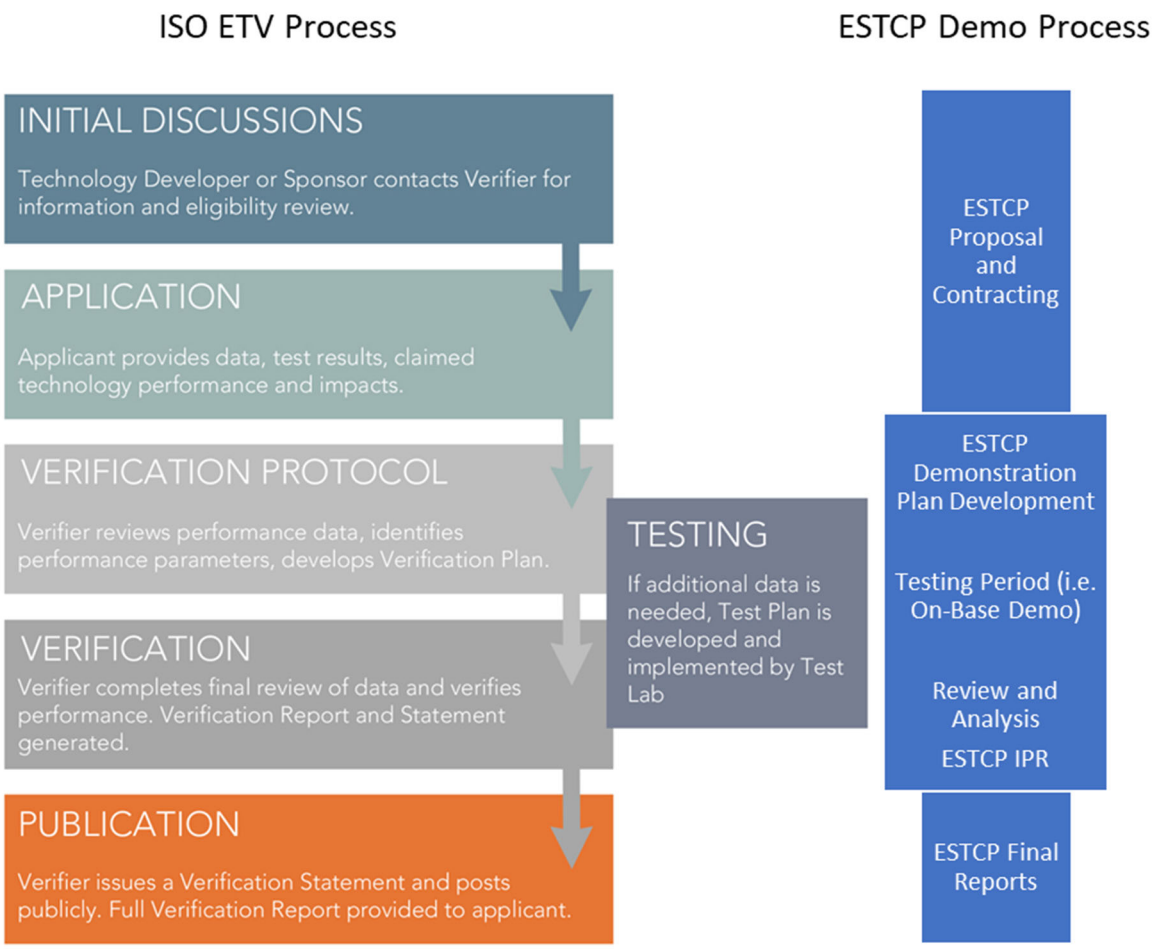

Figure 1. the ISO 14034 ETV Process & ESTCP Process Comparison

The analysis addressed specific ESTCP procedural and guidance items such as: Demonstration Plan Guidelines, Demonstration and Cost and Performance Report Guidelines, programmatic project review and selection process, technical panel input processes, and any other stakeholder input processes utilized by ESTCP. In subsequent tasks under this project, the project will review capabilities of entities working with and outside of ESTCP to identify potentially qualified independent demonstrators or verifiers that could support ESTCP under the revised ETV approach. These potential supporters may include national laboratories, DoD laboratories and research centers, university-based researchers, or private entities with suitable accreditation or credentials. For support entities without current ISO 14034/17020 accreditations, a similar gap type analysis can be conducted to identify the processes or competencies needed to demonstrate suitability to ESTCP demonstration/verification support.

2.1.1 ESTCP Processes and Policies Reviewed.

The following ESTCP processes and documents were reviewed to support the gap analysis:

- **Relevant proposal requirements** [Reference documents: *PROGRAM ANNOUNCEMENT FOR FY 2020 ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM (ESTCP), BAA Pre-Proposal Submittal Instructions, Reference: Broad Agency Announcement*

(BAA) January 8, 2019; ESTCP Installation Energy Open Broad Agency Announcement (BAA), Full Proposal Submittal Instructions, BAA CY19]

Demonstration Plan Guidance documents: SERDP and ESTCP manage projects in five program areas and issue guidance for the requirements of Demonstration Plans.

- Installation Energy and Water [*Reference document: ESTCP Demonstration Plan Guidance: Installation Energy and Water Projects, March 2018*]
- Environmental Restoration [*Reference document: ESTCP Demonstration Plan Guidance: Environmental Restoration Projects, November 2017*]
- Munitions Response **[***Reference document: ESTCP Demonstration Plan Guidance: Munitions Response Projects, November 2017***]**
- Resource Conservation and Resiliency **[***Reference document: ESTCP Demonstration Plan Guidance: Resource Conservation and Resiliency Projects, November 2017***]**
- Weapons Systems and Platforms **[***Reference document: ESTCP Demonstration Plan Guidance: Weapons Systems and Platforms Projects, November 2017***]**

- **Cost and Performance Report Guidance [***Reference documents: ESTCP Final Report Guidance, Energy and Water, Environmental Restoration, and Resource Conservation and Resiliency Projects, May 2018***].**
- **ESTCP Contractual Guidance [***Reference document: Example Contract W912HQ19P0012, January 2019***].** An example ESTCP contract was reviewed to determine which, if any, contractual terms and conditions are relevant toward conformance with the standards.

2.1.2 ISO ETV Standards

The ESTCP programmatic requirements and guides were reviewed and summarized for comparison to the provisions of the ETV requirements of the ISO 14034 standard.

- ***ISO 14034:2016 Environmental Management – Environmental Technology Verification (ETV [2]), specifies principles, procedures, and requirements for environmental technology verification.*** [https://www.iso.org/standard/43256.html].

ISO 14034 integrates with two additional important standards:

- ***ISO 17020: Conformity assessment [3] - Requirements for the operation of various types of bodies performing inspection,*** which establishes qualifications for independent entities to perform verification work. [https://www.iso.org/standard/52994.html].
- ***ISO 17025: General Requirements for the Competence of Testing and Calibration Laboratories [4]*** **-** to ensure data used in evaluation of new technologies meets consistent standards and is provided by qualified entities. [https://www.iso.org/standard/66912.html].

Findings of the gap analysis, summarized in Section 2.2 below, will guide the remainder of this project through application of ETV in accordance with the standard on at least two select ESTCP demonstrations.

2.2 Gap Analysis Findings

Detailed findings of the gap analysis are organized by requirements of the three relevant standards and provided in Appendix A, which summarizes the main principles of the group of ISO standards and where individual ESTCP processes, policies, or documents address the requirements, demonstrating some level of compliance with the requirements of the standard. Table 2 below summarizes the most critical findings with respect to gaps between the requirements of the standards and the current ESTCP demonstration process.

2.2.1 ISO 14034 Compliant ESTCP Processes & Principles

As shown in the detailed analysis in Appendix A and Table 2, many of the requirements of the standards are addressed in the guidance and procedural processes summarized in 2.1 above and, as such, much of the current ESTCP program processes are conformant with these standards. In some cases, opportunities for improvement are identified where additional requirements within ESTCP processes could improve consistency, quality, and demonstration outcomes via improved compliance with the ISO standards. There are also requirements in the standards that are not particularly relevant to ESTCP, or are merely stating definitions, references, or other administrative information.

Table 2. ISO 14034 Compliant ESTCP Processes

ISO 14034 Standard Section	Principle Requirement of ISO Standards	Relevant ESTCP Process or Requirement Demonstrating Compliance
1. **Scope**	Focus on the evaluation of innovative environmental technologies, including their benefits and performance	ESTCP Program focus on innovative environmental technologies as applied to Defense Installations
2, 3. References and Definitions	NA	NA
4. General Principles & Requirements	General principles of credible, impartial evaluation, Factual approach, Sustainability, Transparency and Credibility, Flexibility.	All principles are, in general, adhered to via ESTCP programs, except for requirement for third party verification. Opportunities for improvement exist regarding independent or impartial evaluation, input of stakeholders, and improved data quality standards.
5. Application Requirements & Review	Requirements for technology details, justification of its impact and performance claims, and initial approach for verification	ESTCP Proposal process requires significant technology details and justification, as well as supporting information for performance and impact claims. ESTCP Technical review and proposal selection evaluates most relevant information to ensure technologies are beneficial and ready for demonstration.

5. Verification Planning	Specification of Verification Parameters, test methods, operating conditions, for verification. Input of interested stakeholders is obtained. Consistent evaluation approaches across similar technologies are used. Data quality specifications are established.	ESTCP Demonstration Planning requires significant aspects of ISO verification planning, including specification of performance parameters, site conditions, operation. However, Demonstration plans do not require input of outside stakeholders, uniform approaches for similar techs, specific data quality requirements. Independent verification not required.
5. Verification Reporting & Publication	Requires specific information to be included regarding the technology and verified data. Verification information must be published.	ESTCP reporting requirements are thorough and match well with ISO requirements, except for the reporting being completed or verified by an independent entity.

It should be noted that the key difference between existing ESTCP guidance and policies is the utilization of a qualified independent verifier to evaluate and verify the performance data and results provided by the technology developer. This is a key requirement that adds credibility and ensures quality of results. In some ways, the ESTCP Technical Review Panel, and the outputs of the In-Progress Review (IPR) meetings can partially serve the role of independent verifier. But, to be compliant with the ISO standards, a more detailed process would need to be established, or qualified verifier participate.

The remainder of this report focuses on the major gaps between the ESTCP processes and the ISO standards – particularly with respect to impartial performance assessment of technologies, competence of demonstration performers, and requirements of the standards that can improve data quality.

Key findings of the gap analysis summarized in Table 3 are discussed below and organized by applicable standard. Although the standards are comprehensive in nature and include detailed requirements for technology verification that accredited verifiers must demonstrate conformance, modifications to the ESTCP demonstration processes proposed here are limited to the primary functional gaps between the existing processes and the standards. There are many minor adjustments to ESTCP procedures and requirements that can address minor gaps, which are also described in Appendix A.

Detailed discussion of the fundamental gaps is provided following Table 3.

Table 3. Summarized ESTCP/ISO 14034 Gap Analysis

ISO Standard non-conformities	Requirement	Potential Implementation Strategies	Potential Benefits	Potential Barriers to Implementation
Fundamental gaps in ESTCP processes vs. ISO 14034, 17020, and 17025				
Impartial or independent verification of performance	ISO 14034: 4.1.1 - provide a credible and impartial account of the performance of environmental technologies. ISO 17020: 4.1.1 - Inspection activities shall be undertaken impartially.	Require demonstrations be conducted or audited (verified) by qualified third party testing or verification bodies	Reduces risk of bias with respect to verification of technology performance	Additional demonstration costs. Acceptance by applicants and performers (confidentiality concerns)
Transparency and Credibility	ISO 14034: 4.1.4 – ETV is based on reliable test results and robust procedures. The process is facilitated such that, to the greatest extent possible, methods and data are fully disclosed and reports are clear, complete, objective and useful to the interested parties.	Development of technology category specific demonstration protocols with expert and stakeholder inputs	Increased credibility and technology transfer	Costs associated with protocol development
Use of existing performance data	ISO 14034: 5.4.2 - Acceptance of existing test data - Test data provided by the applicant that were generated prior to verification shall be accepted for the verification if they meet the certain requirements of the standard.	Allow use of independently verified existing performance data from relevant technology applications toward performance at DoD installations	Reduced demonstration costs and timelines	DoD stakeholder acceptance of performance data generated at non-DoD applications (risk of being non-representative)
Technical Review	ISO 14034: 5.2.2.2 - the performance claim for the intended application of the technology addresses the needs of the interested parties	Expanded and focused technical review panels	Increased relevance, credibility, and outreach	Availability and interest of specialized peer reviewers
Demonstrator/verifier competency	ISO 17020: 6.1.3 - The personnel responsible for inspection shall have appropriate qualifications, training, experience, and a satisfactory knowledge of the requirements of the	Demonstration Plan requirements for inclusion of independent verifier and documentation of	Increased demonstration relevance and quality, increased data quality,	Additional demonstration costs, acceptance by

	inspections to be carried out. They shall also have relevant knowledge of the technology under demonstration.	competencies for those conducting ESTCP sponsored demonstrations or verifications	broader acceptance of reported performance	applicants and performers
Metrological traceability of demonstration measurements	ISO 17020: 6.2.6 – 6.2.10 - The overall program of calibration of equipment shall be designed and operated so as to ensure that, wherever applicable, measurements made by the verification body are traceable to national or international standards of measurement, where available. Where traceability to national or international standards of measurement is not applicable, the inspection body shall maintain evidence of correlation or accuracy of inspection results. Where relevant, equipment shall be subjected to in-service checks between regular recalibrations. Reference materials shall, where possible, be traceable to national or international reference materials, where they exist.	Demonstration Plan requirements for documentation of data quality, measurement equipment calibration plans, and traceability to reference standards	Increased demonstration relevance and quality, increased data quality, broader acceptance of reported performance	Additional demonstration costs, acceptance by applicants and performers
General requirements for the competence of testing and calibration laboratories	ISO 17025: Entire standard - Specifies the general requirements for the competence, impartiality, and consistent operation of laboratories (organizations performing or supporting demonstrations) as defined in the standard. These include laboratories with different levels of independence and organizations where laboratory activities form part of demonstration, verification, inspection, or product certification. This also applies to field measurements and those selecting, installing, and operating in-field measurements and instrumentation	Demonstration Plan requirements for documentation of data quality, measurement equipment calibration plans, and traceability to reference standards	Increased demonstration relevance and quality, increased data quality, broader acceptance of reported performance	Additional demonstration costs, acceptance by applicants and performers

Secondary gaps in ESTCP processes vs. ISO 14034, 17020, and 17025				
Subcontractor competency	ISO 17020: 6.3.1 - Where an inspection body subcontracts any part of the inspection, it shall ensure and be able to demonstrate that the subcontractor is competent to perform the activities in question and, where applicable, complies with the relevant requirements stipulated in this International Standard or in other relevant conformity assessment standards.	Demonstration Plan requirements for documentation of competencies for organizations conducting or supporting ESTCP sponsored demonstrations or verifications	Increased demonstration relevance and quality, increased data quality, broader acceptance of reported performance, increased technology transfer	Availability of qualified performers
Standard conformant performer management systems	ISO 17020: 8 - The inspection body shall establish and maintain a management system that is capable of achieving the consistent fulfilment of the requirements of the International Standard (general requirements of ISO 9001 including control of records and documents)			Minimal. Partial conformance through contracting processes, and most credible performers will meet requirements of standard.

2.2.2 ISO Standard 14034

Impartial Verification of Technology Performance

A fundamental requirement of ISO 14034 is that verification of test (or performance demonstration) be conducted by independent and impartial (third) parties. The purpose of ETV is to provide a credible and impartial account of the performance and as such, ETV is based on a number of principles to ensure that verifications are performed and reported accurately, clearly, unambiguously and objectively. By modifying the ESTCP demonstration processes such that demonstrations, or verification of demonstration findings, are conducted by independent and impartial parties.

It is noted that current ESTCP processes include front end technical reviews through proposal reviews, as well as in-progress project reviews by an impartial Technical Review Panel. These reviews add to the process a level of impartial review and stakeholder input. The process does not however, include impartial verification of demonstration activities and generation of technology performance data needed to conform to the ISO requirements.

Application of this requirement under the ESTCP program can result in increased demonstration credibility and reduce risks to impartiality of the data generated during demonstrations. Increased performance credibility has the potential to significantly improve technology transfer and acceptance across DoD.

A potential implementation strategy to address this gap could be modification of the demonstration guidance and requirements that requires demonstrations be conducted or verified by impartial parties (that is, parties without vested interest or other conflicts with respect to promotion of the technology under demonstration). The costs associated with third party demonstrations can be largely offset by reducing the internal demonstration costs borne by demonstration applicants/performers. Alternately, short term independent verifications of demonstration activities conducted by applicants can be conducted by qualified and competent verification bodies, although it is assumed the cost of such third party verifications will be borne by the ESTCP program (that is, built into the overall demonstration costs).

Utilization of Existing Performance Data

The standard allows for use of existing technology data to demonstrate performance potential. The standard provides specific existing data criteria with respect to relevance toward potential DoD applications and quality of data. Although a fundamental aspect of the ESTCP program is that demonstrations be conducted in relevant and broadly applicable DoD facilities, it is likely that there may be cases where existing technology performance data that are representative of DoD applications is available. In such cases, significant cost savings could be realized through independent verification of existing data as it applies to certain DoD applications.

This gap could be addressed by allowing the use of existing data that is relevant to DoD installations, of sufficient quality, and transferrable to broad applicability to DoD. In the interest of cost and efficiency, it is likely that the burden of assessment of existing data with respect to those characterizations could be placed on the applicants during the demonstration proposal and selection process.

Input of Interested Parties

The 14034 standard includes a technical review requirement that the performance claim for the intended application of the technology addresses the needs of the interested parties. Although current ESTCP processes include proposal and in-progress project reviews by an impartial Technical Review Panel, expanded use of reviewers and stakeholders could enhance the program and better conform to the standard. Development and implementation of broader stakeholder groups with expertise and interests

specifically relevant to technological categories could improve the process and tech transfer. A broader group could involve more expertise in specific technology categories as well as purchasers, and participants with expertise in UFC regulation and technology finance, etc.

Technology Specific Demonstration Protocols

In cases where ESTCP has sponsored demonstration of multiple technologies within a technology category (e.g., energy storage or cybersecurity technologies) development and use of standardized approaches for demonstration and performance assessment should be implemented according to standard requirements (ISO 14034 4.1.4). Implementation of this process into ESTCP would facilitate standardization of the approach, the performance parameters required, the data quality, and demonstration conditions that would enhance stakeholder ability to assess and compare technology relevance and performance. More details regarding implementation of a standardized technology demonstration approach is provided in Section 3.1.2.

2.2.3 ISO Standard 17020

Competencies

The ESTCP proposal and project selection processes address the qualifications of potential demonstration performers. However, this standard for verification bodies and ISO 17025 for laboratories, requires demonstration of specific qualifications, competencies, and procedures that are relevant to the technology under demonstration. Application of the competency and procedural requirements within this standard to the ESTCP process can significantly improve the quality of data generated, demonstration credibility, and broad acceptance of demonstration results. Requirements for demonstration of performer competencies with respect to the standards can be applied to primary demonstration performers, their subcontractors, supporting analytical laboratories, and/or independent verification bodies during the proposal and selection process. Conformance with those requirements could then be further documented during the demonstration processes (in the Demonstration Plan and Technical Reports).

It is likely that competency requirements may increase demonstration costs by requiring ESTCP applicants to utilize third parties to either conduct or at least independently verify demonstration activities. Availability of qualified demonstration performers or verifiers may also complicate the overall process. The benefits to the program of competency requirements however can be expected to increase acceptance and transferability of demonstration results.

Metrological Traceability

Under the current ESTCP guidance, performers are required to generally describe their approaches to and plans for data quality, and to quantify uncertainty in results for key performance parameters. A greater level of data quality, demonstration credibility, and acceptance of findings can be promoted by applying the metrological traceability requirements of the standard to ESTCP demonstrations. Further, the requirement of traceability to international reference standards, as verified by impartial performers or verifiers, can “level the field” of data quality for demonstrations of technologies within technological categories, adding value to the demonstrations from the perspective of stakeholders and decision makers. Adherence to the traceability requirements of the standard should be able to be applied at minimal or no additional significant costs to the program. More details about data quality recommendations with respect to measurement traceability and verifiability are provided in Appendix B.

Requirements of metrological traceability of critical measurements supporting a demonstration are not expected to add significant costs to demonstrations. It can generally be assumed that organizations applying for demonstration funding in efforts toward wide technology acceptance will inherently have

data quality and critical measurement standards in place. That said, it can be expected that implementation of traceability requirements can significantly improve the credibility and transferability of demonstration results, particularly with respect to Section 6 of ISO 17020:

6.2.6 *Where appropriate, measurement equipment having a significant influence on the results of the inspection shall be calibrated before being put into service, and thereafter calibrated according to an established program.*

6.2.7 *The overall program of calibration of equipment shall be designed and operated so as to ensure that, wherever applicable, measurements made by the inspection body are traceable to national or international standards of measurement, where available. Where traceability to national or international standards of measurement is not applicable, the inspection body shall maintain evidence of correlation or accuracy of inspection results.*

Quality Management Systems

Section 8 of ISO 17020 provides the requirements for Quality Management Systems (QMS) of performers (demonstrators, verifiers, or supporting test and laboratory bodies). Generally, accreditation under ISO 17020 requires that performers be either accredited under ISO 9001 "Quality Management Systems" or can demonstrate conformance with the requirements of that standard which include:

- management system documentation (e.g. manual, policies, definition of responsibilities);
- control of documents;
- control of records;
- management review processes;
- internal auditing processes;
- corrective and preventive actions; and
- complaints and appeals processes.

These requirements are relevant to improvement of ESTCP demonstration data quality and credibility. For key QMS requirements of the standard, much of the required control of documents and records will be covered in the ESTCP contract – Federal Acquisition Regulation (FAR) systems, Clauses Incorporated by Reference.

Implementation of this requirement under the ESTCP program is expected to be difficult and could lead to a lack of qualified performers that are either accredited or meet all the standard requirements. A more acceptable implementation approach may be to require conformance to the requirements of ISO 17025 for laboratories and test bodies generating demonstration data, and then require independent review of demonstration activities under ISO 17020 where feasible or viable.

2.2.4 ISO Standard 17025

General requirements for the competence of testing and calibration laboratories

The ISO 17025 Standard specifies the general requirements for the competence, impartiality, and consistent operation of laboratories (which can include organizations performing or supporting demonstrations). Under ESTCP this standard can apply to organizations where field testing or analytical activities form part of demonstration, verification, inspection, or reporting of technology performance.

By requiring conformance with this standard for critical technology performance objectives under the ESTCP program, demonstrations can document increased relevance and quality, increased data quality, broader acceptance of reported performance, and greater technology transfer. Many credible laboratories used to support ESTCP demonstrations are either accredited under ISO 17025, or conform to most

relevant requirements of the standard. Since there is wide acceptance of the standard globally and no shortage of laboratories that conform to the standard, a requirement for conformance to this standard should be a relatively simple implementation under ESTCP.

3.0 FOLLOW UP TASKS FOR IMPLEMENTATION

Under this project, two ESTCP demonstrations will be selected for ISO 14034 implementation as a pilot study to demonstrate efficacy. For select demonstrations, the project will modify existing ESTCP process and procedure documentation, and develop additional required documentation drafts, if needed, that will ensure the ESTCP processes and projects operating under these processes can operate in accordance with the ISO 14034 and associated standards. The following project tasks will further address the findings of this gap analysis and begin recommendations and processes for implementation strategies that will close the fundamental gaps.

3.1 Gap Analysis Relevant Project Tasks

The remaining tasks of this pilot study project will be used to further steer and guide the successful application of ETV to the selected demonstrations, with a goal of developing recommendations and guidance for broader ETV implementation across SERDP/ESTCP demonstration programs.

3.1.1 Establish Connection of Technology Developers and Stakeholders

The project will seek to establish a broad stakeholder group including interested DoD users and decision makers, along with technology developers, to inform the project team on information and data needs with respect to applying the ISO Standard to ESTCP demonstrations and outcomes. The goal is broad integration of stakeholder inputs that can help ensure that needed info is obtained and distributed, is of required quality, and addresses critical barriers to technology implementation at DoD installations. The stakeholder involvement process will help establish ETV Process Credibility in ESTCP applications. To ensure potential DoD users of the ETV process under ISO 14034/17020 are identified and made aware of the ETV approach, and to establish program credibility, the project will lead market research and outreach efforts to entail direct contact and consultation with numerous stakeholders regarding input on data needs and verification program structure, implementation of strategies to address the gaps between the ISO standards and current ESTCP processes summarized here, and integration within ESTCP and DoD programs.

3.1.2 Identify Opportunities to Establish Standard and Relevant Verification Metrics

The development of standardized, consensus, technology-specific Verification Protocols for ESTCP projects is an important consideration. For this project, the team, with ESTCP's input, has selected two existing projects to complete case-study implementations of the ISO 14034 standard. Because these are existing projects for which data collection has been completed, new protocols with standard and relevant verification parameters and metrics cannot be developed for implementation by the project. However, the review and verification process for these projects will consider the potential requirements of a consensus demonstration protocol, that could include verification parameters and data quality specifications important to stakeholders for these specific categories of technology. Use of standardized metrics and parameters can facilitate consistent evaluation approaches and data quality for technology categories important to DoD.

Identification of technology category performance requirements and test methods will include:

- Standardized performance objectives for technology categories;
- Integration of ISO standards into the ESTCP process;
- Reference to other applicable testing standards (i.e. ASTM, ASHRAE, etc.)
- Integration of stakeholder needs and input in the protocols to ensure needed data and information is obtained during demonstrations for each specific technology type.

3.1.3 Modify ESTCP Demonstration Requirements for ISO 14034 Integration

The project will provide a modified ESTCP demonstration project process that incorporates ISO 14034 requirements, associated ISO 17020 and 17025 conformances, and ensures project implementation meets requirements and provides consistency. Once completed, the team will develop outreach tools, including a webinar, blog posts, case study documents, a Guideline for ISO 14034 Implementation. These documents and activities will be aimed at ESTCP programmatic staff, stakeholders in the community, such as energy and facility managers, purchasers/procurement officers, third party financers, regulators, testing labs, researchers, and others. The goal of the outreach is to ensure broader awareness of the standards, their implementation requirements, the value, and, ultimately, to enable broad implementation of the ISO ETV process and acceptance of ISO 14034 verified technologies;

REFERENCES

[1]. Environmental Security Technology Certification Program (ESTCP), Alexandria, VA 22350-3605. https://www.serdp-estcp.org/About-SERDP-and-ESTCP/About-ESTCP.

[2]. ISO 14034:2016 Environmental Management – Environmental Technology Verification (ETV), International Organization for Standardization. November 2016. [https://www.iso.org/standard/43256.html].

[3] ISO 17020 :2012 Conformity Assessment – Requirements for the Operation of Various Types of Bodies Performing Inspection, International Organization for Standardization. March 2012. [https://www.iso.org/standard/52994.html].

[4] ISO/IEC 17025:2017 – General Requirements for the Competence of Testing and Calibration Laboratories. International Organization for Standardization. March 2018. [https://www.iso.org/standard/66912.html].

APPENDIX A: ESTCP/ISO 14034, 17020, and 17025 Gap Analyses

ESTCP ISO 14034 Gap analysis		ESTCP conformance					
ISO 14034 Citations	**Requirement**	**Not Applicable**	**Conforms**	**Partial conformance**	**Non conformance (gaps)**	**Comments**	**Potential Implementation Strategy**
1 - Scope	This document specifies principles, procedures and requirements for environmental technology verification (ETV).	X					
2 - Normative references	ISO/IEC 17020:2012, Conformity assessment — Requirements for the operation of various types of bodies performing inspection				Impartial verification not required	See also ISO 17020 gap analysis	
	ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories				ISO conformant testing (demonstrated competence) not required	See also ISO 17025 gap analysis	conducted by or crosschecked (audited) by separate test body either accredited under 17025, or following the requirements
3 - Definitions	Terms and Definitions	X					
4 - General Principles and Requirements							
4.1.1 - General	Provide a credible and impartial account of the performance of environmental technologies. ETV is based on a number of principles to ensure that verifications are performed and reported accurately, clearly, unambiguously and objectively.			ESTCP demonstrations based on presentation of credible and relevant evidence of performance. Impartial verification of results and findings not required			Demonstrations could require independent and impartial test bodies to conduct the field measurements and data analysis, or require impartial verification of demonstration design, execution, and data quality and analysis.
4.1.2 - Factual approach	Verification statements are based on factual and relevant evidence confirming objectively the performance of environmental technologies.						
4.1.3 - Sustainability	Environmental technology verification is a tool that supports sustainability by providing credible information on the performance of environmental technologies	X					
4.1.4 - Transparency and credibility	Demonstration is based on reliable test results and robust procedures. The process is facilitated such that, to the greatest extent possible, methods and data are fully disclosed and reports are clear, complete, objective and useful to the interested parties.			Plan Guidance: 1.3 Objectives, 5.1 Test design; no impartial verification requirement			
4.1.5 - Flexibility	To maximize the utility of results, demonstration allows for flexibility in the specification of the performance parameters and test methods. This is achieved through a dialogue between the applicant, verifier and interested parties.			Minimal stakeholder input on demonstration plan, ESTCP technical panel review			
4.2 - Requirements	When verifying the performance of environmental technologies, the requirements of this document and ISO/IEC 17020:2012 shall be applied and demonstrated.				Not fully ISO conformant (impartiality and compentence not required)		Develop competency requirements for demonstrators or verifiers
5 - Environmental Technology Verification							
5.1 - General	This clause outlines key procedures of the environmental technology verification	X					
5.2.1 - Application requirements	Information about the technology vendor/developer, including its name and address(es) of its physical location(s).		Plan Guidance: 2.1 Technology overview, 2.2 Advantages and limitations			Consideration of the rigorous ESTCP proposal and selection process, committee (stakeholder) driven, technology details presented in proposal stage which include: technical objectives, technology description and maturity, technical approach for demonstration, technical risks, expected benefit (definition of baseline operation). All information however, is provided by applicant and not independently verified.	
	Description of the technology						
	Information about the intended application of the technology						
	Operation and performance of the technology						
	Development status of the technology proposed for verification and its readiness for market						
	Information on relevant alternative of the technology; including its relevant performance and environmental impacts		Plan Guidance: 5.2 Baseline characterization				
	Information on significant environmental impacts of the technology proposed for verification and its environmental added value		Plan Guidance: Section 2.0				
	Performance claim including a proposed set of performance parameters and their numerical values to be verified		Plan Guidance: 4.0 Performance Objectives, 5.1 Test Design, 6.0 Performance Assessment			Recommend generic protocols for technology categories to implement consistent operational and performance objectives across demonstrations	
	Installation and operating requirements and conditions		Plan Guidance: 5.4 Operational Testing				
	Service and maintenance requirements		Plan Guidance: 2.0 Technology Description, and 4.0 Performance Objectives				
	Expected length of time for which a technology functions under normal operating conditions						
	Any applicable health and safety requirements and considerations						
	Relevant existing test data and methods for acquiring the data that were applied to support the performance claim				Not currently considered for demonstration		Develop guidance for verification and utilization of existing technology performance data with DoD relevance

ESTCP ISO 14034 Gap analysis (continued)		ESTCP conformance					
ISO 14034 Citations	**Requirement**	**Not Applicable**	**Conforms**	**Partial conformance**	**Non conformance (gaps)**	**Comments**	**Potential Implementation Strategy**
5.2.2 - Application review	Administrative and technical review criteria		Proposal evaluation and selection processes				
5.3.1 - Specification of performance claims	Are relevant and sufficient for the verification of the performance of the environmental technology, and its environmental added value		Plan Guidance: 2.0 Technology Description, and 4.0 Performance Objectives			Also addressed in pre-proposal and full proposal selection process, although unverified.	
	Correspond in full to the needs of the interested parties						
	Can be quantitatively verified through testing		Plan Guidance: 5.0 Test Design and 6.0 Performance Assessment				
	Can be verified under set operating conditions						
5.3.2 - Verification planning	The verification plan shall detail the verification procedure specific to the technology and the performance to be verified.						
5.4.1 - General	Verification organization - acceptance of existing data, need for additional data, confirmation of performance			Plan Guidance: 5.0 Test Design, use of existing data not currently considered			
5.4.2 - Acceptance of existing test data	Relevant for the performance to be verified				Not currently considered for demonstration		Develop guidance for verification and utilization of existing technology performance data with DoD relevance
	Produced and reported according to the requirements of ISO/IEC 17025						
	Meet the requirements specified in the demonstration plan						
5.5 - Verification Report and Statement	A verification report shall be developed. It shall adhere to the verification plan and shall include at a minimum the list of required elements in standard.			Detailed and public Final Technical Report required. Impartial verification reporting not required			
5.6.1 - Publication	At a minimum, the verification statement shall be made publicly available. The publication shall be included in a publicly available directory (e.g. website).		Program requirement: Final Technical and Cost and Performance Reports available at SERDP/ESTCP website				
5.6.2 - Validity of verification report/statement	The applicant shall: a) ensure that the technology for which performance has been verified is conforming to the conditions as per its verification, published verification statement and report, if relevant; b) inform the verifier, in writing, of any changes that have been made to the technology.			Impartial verification reporting not required, but Technical and Cost and Performance Reports subject to programmatic and peer reviews.			

ESTCP ISO 17020 Gap analysis		ESTCP conformance				
ISO 17020 Citations	**Requirement**	**Not Applicable**	**Conforms**	**Partial conformance**	**Non conformance (gaps)**	**Potential Implementation Strategy**
1 - Scope	Contains requirements for the competence of bodies performing inspection and for the impartiality and consistency of their inspection activities				Impartial verification not required	
2 - Normative references	ISO/IEC 17000, Conformity assessment — Vocabulary and general principles	X				
3 - Definitions	Terms and Definitions	X				
4 - General Requirements						
4.1 - General	Impartiality and independence				Impartial verification not required	Demonstrations could require independent and impartial test bodies to conduct the field measurements and data analysis, or require impartial verification of demonstration design, execution, and data quality and analysis.
4.1.1	Inspection activities shall be undertaken impartially					
4.1.2	Verification statements are based on factual and relevant evidence confirming objectively the performance of environmental technologies.					
5 - Structural Requirements		X				
6 - Resource Requirements						
6.1- Personnel	Verification body will employ, or have contracts with, a sufficient number of persons with the required competencies, including, where needed, the ability to make professional judgements, to perform the type, range and volume of its inspection activities				No competency or formal training/knowledge required for field demonstrations	Develop and implement competency requirements for demonstrators or verifiers
6.1.3	The personnel responsible for verification shall have appropriate qualifications, training, experience and a satisfactory knowledge of the requirements of the inspections to be carried out					
6.1.5	The inspection body shall have documented procedures for selecting, training, formally authorizing, and monitoring inspectors and other personnel involved in inspection activities.					
6.2.1 - Facilities and Equipment	The verification body shall have available, suitable and adequate facilities and equipment to permit all activities associated with the inspection activities to be carried out in a competent and safe manner.			Demonstration Plan guidance Section 5.6 - Equipment Calibration and Data Quality Issues, for ensurance that data collection is valid. Requires descriptions of equipment calibrations, quality assurance and sampling, and post processing statistical analyses planned for the demonstration. Impartial or independant verification of these approaches, methods, or data analyses not formally required.		
6.2.2	The verification body shall have rules for the access to, and the use of, specified facilities and equipment used to perform inspections.					
6.2.3	The verification body shall ensure the continued suitability of the facilities and the equipment mentioned in 6.2.1 for their intended use.					
6.2.4	All equipment having a significant influence on the results of the inspection shall be defined and, where appropriate, uniquely identified.					
6.2.5	All equipment (see 6.2.4) shall be maintained in accordance with documented procedures and instructions.					
6.2.6	Where appropriate, measurement equipment having a significant influence on the results of the verification shall be calibrated before being put into service, and thereafter calibrated according to an established program.					
6.2.7	The overall program of calibration of equipment shall be designed and operated so as to ensure that, wherever applicable, measurements made by the verification body are traceable to national or international standards of measurement, where available. Where traceability to national or international standards of measurement is not applicable, the inspection body shall maintain evidence of correlation or accuracy of inspection results				Metrological traceability to reference materials or standards for critical measurements not specified	Development and implementation of measurement traceability requirements for ESTCP demonstrations
6.2.8	Reference standards of measurement held by the inspection body shall be used for calibration only and for no other purpose. Reference standards of measurement shall be calibrated providing traceability to a national or international standard of measurement.					
6.2.9	Where relevant, equipment shall be subjected to in-service checks between regular recalibrations.					
6.2.10	Reference materials shall, where possible, be traceable to national or international reference materials, where they exist.					
6.3.1 - Subcontracting	The inspection body shall itself normally perform the inspections that it contracts to undertake. Where an inspection body subcontracts any part of the inspection, it shall ensure and be able to demonstrate that the subcontractor is competent to perform the activities in question and, where applicable, complies with the relevant requirements stipulated in this International Standard or in other relevant conformity assessment standards.				No competency requirements for outside resources supporting demonstrations (installation contractors, installers, equipment providers, analytical laboratories, etc.)	Develop and implement competency requirements for demonstrators or verifiers
7 - Process Requirements						
7.1 - Inspection (verification) methods	The inspection body shall use the methods and procedures for inspection which are defined in the requirements against which inspection is to be performed. Where these are not defined, the inspection body shall develop specific methods and procedures to be used (see 7.1.3).			Demonstration Plan guidance Section 5.5 - Sampling Protocol. The sampling protocol should result in the collection of relevant and sufficient data to validate the technology cost and performance under real-world conditions. Consider using a tabular format to convey the data sampling protocol. Requires identification of data collectors, descriptions of data generated and recording procedures, data storage and backup.		
7.2 - Inspection items and samples	Ensure items and samples to be inspected are uniquely identified in order to avoid confusion regarding the identity of such items and samples					
7.3 - Inspection (verification) records	The verification body shall maintain a record system to demonstrate the effective fulfilment of the verification procedures and to enable an evaluation of the verification.					
7.4	Inspection reports and certificates	X				
7.5	Complaints and appeals	X				
8 - Management System Requirements	The inspection body shall establish and maintain a management system that is capable of achieving the consistent fulfilment of the requirements of this International Standard in accordance with the requirements of ISO 9001 - Quality Systems Management.			Control of documents and records requirements partially addressed through normative contracting FAR requirements	Accreditation to or conformance with ISO Quality Management System procedures not required for organizations designing or executing demonstrations	

ESTCP ISO 17025 Gap analysis	Note: References to "laboratories" supporting ESTCP demonstrations are assumed to include any body performing measurements or analytical support of demonstrations	ESTCP conformance			
ISO 17025 Citations	**Requirement**	**Not Applicable**	**Conforms**	**Partial conformance**	**Non conformance (gaps)**
1 - Scope	Specifies the general requirements for the competence, impartiality and consistent operation of laboratories (test bodies) as defined in the standard				
2 - Normative references	ISO/IEC 17000, Conformity assessment — Vocabulary and general principles	X			
3 - Definitions	Terms and Definitions	X			
4 - General requirements					
4.1	Laboratory activities shall be undertaken impartially				
4.2	The laboratory shall ensure the protection of its customers' confidential information and proprietary rights, including protecting the electronic storage and transmission of results				
5 - Structural Requirements		X			
6 - Resource Requirements					
6.1 - General	Verification body will employ, or have contracts with, a sufficient number of persons with the required competencies, including, where needed, the ability to make professional judgements, to perform the type, range and volume of its inspection activities				
6.2 - Personnel	The laboratory shall manage the risk to impartiality arising from over-familiarity between its personnel and the customer.				
6.3 - Laboratory facilities	The facilities and environmental conditions shall be suitable to realize the laboratory activities and do not adversely affect the validity of results.				
6.4 - Equipment	6.4.1 The laboratory shall have access to all equipment required for the correct performance of the laboratory activities. Equipment shall include software, measurement standards, reference materials, reagents and consumables or auxiliary apparatus or combination thereof necessary to realize a measurement process and which may influence the measurement result.				In general terms, ESTCP demonstration and planning guidance across the range of programmatic technology categories requires descriptions of data quality approaches and analyses as well as equipment calibration planning (e.g., see Section 5.6 of Energy & Water Demonstration Plan Guidance). However, current ESTCP guidance does not explicity address or require the level of detail and quality assurance specified in relevant components of the ISO 17025 standard as summarized here.
	6.4.3. The laboratory shall have documented processes for appropriate handling, transport, storage, use and planned maintenance of equipment to ensure proper functioning and in order to prevent contamination or deterioration.				
	6.4.5. The laboratory shall identify equipment used for measurements and capable of achieving the accuracy required and complying with the specifications relevant to the laboratory activities concerned. It shall establish a documented calibration program for such equipment to ensure metrological traceability of the measurement results.				
	6.4.6. All equipment requiring calibration shall be labelled, coded or otherwise identified to allow the user of the equipment to readily identify the status of calibration				
	6.4.7. Records shall be maintained for equipment significant to the laboratory activities.				
	6.4.9. When intermediate checks are needed to maintain confidence in the performance of the equipment, these checks shall be carried out according to a defined procedure.				
	6.4.10. When calibration and reference material data include reference values or correction factors, the laboratory shall have procedures to ensure the correction factors and reference values are updated and implemented, as appropriate, to meet specified requirements.				
	6.4.11. Equipment shall be safeguarded from adjustments which would invalidate the test and calibration results.				
	6.4.12. The laboratory shall select and use reference materials that are fit for the specific purpose in the measurement process.				
6.5 - External Services		X			
6.6 - Metrological traceability	6.6.1. The laboratory shall establish and maintain metrological traceability of its measurement results by means of a documented unbroken chain of calibrations or comparisons each contributing to the measurement uncertainty, linking them to an appropriate reference.				
	6.6.2. Where it is technically possible, the laboratory shall demonstrate that the appropriate reference is a direct realization of, or traceable to the International System of Units (SI) (Système international d'unités). The link to SI units shall be achieved by comparison or reference to national or international measurement standards or certified reference materials with stated metrological traceability to the SI.				
	6.6.4. Metrological traceability of measurement results shall be assured through calibrations by laboratories that can demonstrate competence, measurement capability and traceability.				
7 - Process Requirements	7.1 Tenders and contracts	X			
	7.2.1.1 The laboratory shall use appropriate methods and procedures for all tests and/or calibrations. These include procedures for sampling, handling, transport, storage and preparation of items to be tested and/or calibrated, and, where appropriate, for evaluation of the measurement uncertainty as well as statistical techniques for analysis of test and/or calibration data				
	7.2.2.1 The laboratory shall use methods for laboratory activities which meet the needs of the customer and which are appropriate for the laboratory activities it undertakes. The laboratory shall ensure that it uses the latest valid edition of a standard unless it is not appropriate or possible to do so.				
	7.3.1 The sampling process shall address the factors to be controlled to ensure the validity of results. The laboratory shall have a sampling plan and procedures for sampling when it carries out sampling of substances, materials or products for subsequent testing or calibration. The sampling plan and procedures shall be available at the site where sampling is undertaken. Sampling plans shall, whenever reasonable, be based on appropriate statistical methods.				
	7.3.4 The laboratory shall have procedures for recording relevant data and operations relating to sampling that forms part of the testing or calibration that is undertaken.				
	7.4 Test or calibration items	X			
	7.5.1 The laboratory shall ensure that records for each laboratory activity contain the report or certificate and sufficient information to facilitate, if possible, identification of factors affecting the uncertainty and enable the laboratory activity to be repeated under conditions as close as possible to the original.				
	7.6.1 A laboratory performing calibrations, including of its own equipment, shall apply procedures to evaluate the uncertainty of measurement for all calibrations.				
	7.6.2 A laboratory performing testing activities shall apply procedures for evaluating uncertainty of measurement.				
	7.7 through 7.12 - Process requirements without relevant to ESTCP	X			
8 - Management Requirements	See ISO 17020 gap analysis				

APPENDIX B: Data Quality Recommendations

To increase acceptance and transferability of demonstration results, the data collected during the demonstration must be of documented and sufficient quality so that the results derived from that data will meet the decision-making needs of project stakeholders and other parties with an interest in the technology. Under the ETV standard, specific requirements for data quality, and the objectives that follow from these requirements, depend on the type of result reported as well as the end use of those results by decision makers.

Data Quality Assessment for Key Performance Objectives - The following sections discuss data quality for key demonstration objectives and describe the means by which verifiers measure, document and assess data quality to provide assurance that the results will be of documented quality sufficient to meet stakeholder needs.

During verifications and performance assessments, uncertainty calculations are estimated based on manufacturer sensor accuracy specifications and predicted system performance and using standard formulas for propagation of error. In these estimates, the covariance terms in the error propagation formulas can be neglected, although in most cases the values are in fact correlated. Sensor manufacturer accuracy figures are generally taken as 1-sigma values.

- Ancillary Data Quality - Ancillary data are those data that will be collected that do not directly support determination of demonstration objectives. As these data are not critical measurements and do not directly affect achievement of data quality objectives, the most stringent QA/QC requirements are unnecessary.

- Instrument Calibrations and Quality Checks - Calibration records and/or procedures for all monitoring instruments to be installed by verifiers or applicant will be reviewed and documented for measurement validation for at least the duration of the demonstration period. This includes any measurements or combination of measurements used to validate performance criteria or objectives.

  Where appropriate, measurement equipment having a significant influence on the results of the demonstration should be calibrated before being put into service, and thereafter calibrated according to an established program (NIST or suitable substitute attestation as determined by verifier using sound professional judgment). The overall program of calibration of equipment should be designed and operated so as to ensure that, wherever applicable, measurements made by the demonstration or verification body are traceable to national or international standards of measurement, where available. Where traceability to national or international standards of measurement is not applicable, the inspection body should maintain evidence of correlation or accuracy of inspection results. Reference standards of measurement held by the inspection body shall be used for calibration only and for no other purpose. Reference standards of measurement shall be calibrated providing traceability to a national or international standard of measurement.

- Data Quality Review and Validation - All data, generated by verifiers or demonstrators, that is used to validate or verify performance claims or performance objectives should be reviewed on a regular ongoing basis and classified as valid, incomplete, or invalid.

  Verifiers provide for internal and external independent review for all planning, data collection and analysis activities conducted as part of demonstration/verification projects. This review is

conducted by verifiers with demonstrated competencies that are not directly connected or involved with the project activities or by external reviewers as deemed necessary or appropriate.

- Data Management – As a critical component of traceability and verifiability, all field data generated during demonstrations should be collected, stored, and retrieved from technology demonstration data acquisition systems, in whichever form these systems may present (manual recordings, electronic files, etc.). Verifiers retrieve data through demonstrations at relevant intervals and frequencies that are specified in verification plans.

APPENDIX C: Comments Regarding Specific ESTCP Documents

The following ESTCP Program Documents and Processes were reviewed for compliance with the ISO 14034, 17020, and 17025 requirements. The following summarizes comments regarding each specific document and its provision of requirements that adhere to the ISO standards and areas where each documents could be improved.

- **Relevant proposal requirements** [Reference documents: *PROGRAM ANNOUNCEMENT FOR FY 2020 ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM (ESTCP), BAA Pre-Proposal Submittal Instructions, Reference: Broad Agency Announcement (BAA) January 8, 2019; ESTCP Installation Energy Open Broad Agency Announcement (BAA), Full Proposal Submittal Instructions, BAA CY19*]
    - Pre-proposal:
        - Current emphasis: The pre-proposal guidance outlines need for technical objectives, technology description and maturity, technical approach overview, technical risks.
        - Recommended modifications: Refer to specific guidance regarding instrumentation and data quality; specify need to include access to data and site for 3rd party verifier; Refer to specific (planned) ESTCP test protocols OR to specfici sets of required testing standards that apply (i.e. ASTM / ASHRAE)
    - Full proposal:
        - Current emphasis: Requires a more detailed description of the technology and demonstration test design. Refers proposers to the ESTCP Demonstration Plan guidance for design of data requirements with respect to metrics and data quality, sufficient to address technology performance objectives.
        - Recommended Modifications: Same as for pre-proposal. Also include budget guidelines for 3rd party verifier. Draft Full proposal guidelines have been prepared that incorporate ISO 14034 requirements.

- **Demonstration Plan Guidance documents:** SERDP and ESTCP manage projects in five program areas and issue guidance for the requirements of Demonstration Plans. With respect to alignment with the ISO standard for ETV, demonstration guidance for each of the technology categories all include requirements for:
    - descriptions of the technology under demonstration,
    - specific performance objectives,
    - general demonstration approaches,
    - experimental design, and
    - performance assessment.

  With respect to verification of performance and data quality, current requirements of demonstration plan content vary by technology category and are summarized as follows:

  - Installation Energy and Water [*Reference document: ESTCP Demonstration Plan Guidance: Installation Energy and Water Projects, March 2018*]
      - Section 5.5 – Sampling Protocol: The sampling protocol should result in the collection of relevant and sufficient data to validate the technology cost and performance under real-world conditions.
      - Section 5.6 – Equipment Calibration and Data Quality:
          - Equipment Calibration: Indicate which equipment requires calibration and who will ensure the calibration occurs.

        - Quality Assurance Sampling: Describe the activities associated with data collection to ensure data quality, such as duplicate sampling or optimization of sampling frequency.
        - Post-Processing Statistical Analysis: Describe any statistical data analysis to ensure reasonableness of collected data and to identify possible discrepancies, such as incorrect readings or faulty measurement equipment.

- Environmental Restoration [*Reference document: ESTCP Demonstration Plan Guidance: Environmental Restoration Projects, November 2017*]
    - Section 5.5 - Calibration of Analytical Equipment, Quality Assurance Sampling, Sample Documentation
    - Section 5.6 - Data Analyses - a detailed description of the data analyses that will be conducted to determine whether the success criteria for the performance objectives have been met. This section should include a description of the statistical analyses to be conducted.

- Munitions Response **[***Reference document: ESTCP Demonstration Plan Guidance: Munitions Response Projects, November 2017***]**
    - Section 5.4 – Calibration Activities: Describe the methods that will be used to confirm that equipment is operating properly, and that meaningful data will be collected.
    - Section 5.5 – Data Collection Procedures: The data collection plan should provide detailed information on how the data will be collected, recorded, and stored.
    - Section 6.0 - Data Analysis Plan: Indicate the steps that will be involved in transforming the raw data streams to the data product that will ultimately be used for analysis.

- Resource Conservation and Resiliency **[***Reference document: ESTCP Demonstration Plan Guidance: Resource Conservation and Resiliency Projects, November 2017***]**
    - Section 5.5 – Sampling Protocol: The sampling protocol should result in the collection of relevant and sufficient data to validate the technology or methodology performance under real-world conditions and enable regulatory agencies and managers to evaluate the innovative technology or methodology.
    - Section 5.6 – Equipment Calibration and Data Quality:
        - Equipment Calibration: Provide a description of the calibration procedures for any equipment that will be utilized as part of the project, except for equipment operated by a contract laboratory.
        - Quality Assurance Sampling: Provide a description of the quality assurance (QA) samples that will be collected, such as field duplicates, equipment blanks, trip blanks, and field blanks.
        - Sample Documentation: Describe the components of the sample documentation program, including sample labels, custody seals, field logbooks, photographs, chain-of-custody forms, and laboratory logbooks.

- Weapons Systems and Platforms **[***Reference document: ESTCP Demonstration Plan Guidance: Weapons Systems and Platforms Projects, November 2017***]**
    - Section 5.5 – Measurement/monitoring Plan: This plan should result in sufficient data to validate the technology performance under real-world conditions and allow stakeholders to evaluate the innovative technology. Provide a description of exactly what will be measured or monitored during each phase of the field testing.

    - Section 5.6 – Laboratory Material Testing: This section should describe all laboratory tests of material produced or collected during the demonstration required by stakeholders for qualification of the alternative technology.
- Recommended improvements to all Demonstration Plan guidance includes the following:
    - Indicating instrumentation specifications and requirements, such as:
        - Minimum accuracy specifications
        - NIST traceable instrument calibrations
        - Calibration frequency and requirements during demonstration period
    - Requiring and specifying procedures for data validation, such as specifying operating conditions for valid data, identifying procedures to use for evaluation of outliers, and procedures for data filling, if instrumentation failures result in data gaps;
    - Identifying (typically in standard protocols, if available) specific reference standards for test procedures or demonstration requirements. Potentially, a list of applicable standards that must be met or used in testing could be provided for each technology type
    - Requirements for incorporating uncertainty analyses in all demonstrations
    - Requirements to utilize independent labs whenever possible that meet the ISO 17025 requirements or are accredited for any analytical measurements.

- **Cost and Performance Report Guidance [***Reference documents: ESTCP Final Report Guidance, Energy and Water, Environmental Restoration, and Resource Conservation and Resiliency Projects, May 2018***].** Similar to Demonstration Plan guidance, ESTCP report guidance includes requirements for basic demonstration components relevant to ETV including descriptions of the technology demonstrated, defined performance objectives, general demonstration approaches, experimental design, and performance assessment and results. Additionally, report guidance includes requirements for reporting of documentation of data generated and data quality:
    - Section 5.5 – Sampling Protocol: Provide a description of the samples collected during each phase of the project and summarize the number and type of samples collected in a table. In addition, provide a brief description of each method required.
        - *Calibration of equipment*. Provide a description of the calibration procedures for any equipment that was utilized as part of the project, except for equipment operated by a contract laboratory. If calibration procedures follow manufacturer guidelines, it is not necessary to repeat the procedure in this report; instead, a reference can be provided.
        - *Quality assurance sampling*. Provide a description of the quality assurance (QA) samples that were collected, such as duplicates, spiked samples, and blanks.
    - Section 5.6 – Sampling Results: Provide a detailed summary of all sampling results in terms of both temporal and spatial dependence as appropriate. The Final Report serves as the archived document for all data gathered during the demonstration.
    - Section 6.0 – Performance Assessment: A summary of all data analysis conducted in support of the assessment of performance objectives should be provided in this section. At a minimum, provide a subsection for each performance objective. Substantive analyses of data obtained during the demonstration that supports the conclusions summarized in the report should be provided. Describe the statistical procedures/tests applied for analyzing the data and determining statistical significance, especially when comparisons with data from current or alternative technologies are needed or comparisons to success criteria are sensitive to variances in the data and sample size.
    - Generally, with the exception of including a 3rd party verification and their report, the report guidance provides all of the information required by the ISO standards.

Consideration should also be given to developing a standard Verification Statement template that verifiers can issue that summarizes the results of the demonstration succinctly, and certifies that a 3rd party verifier has reviewed and verified the results.

- **ESTCP Contractual Guidance [***Reference document: Example Contract W912HQ19P0012, January 2019***].** An example ESTCP contract was reviewed to determine which, if any, contractual terms and conditions are relevant toward conformance with the standards. In particular, Section 8 of ISO 17020 (Quality Management System requirements), includes requirements for control of records and documents that are likely addressed in ESTCP contractual requirements within Federal Acquisition Regulation (FAR) System requirements.