Control Systems Security Standards
Accomplishments & Impacts

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Abstract

The National SCADA Test Bed (NSTB) Control Systems Security Standards Team (CS³T) has been actively participating in select Control System security-related standards groups with an emphasis on the acceleration of field-proven best practices and baseline standards for control systems. This project has utilized the expertise and capabilities of the United States Department of Energy (DOE) National Laboratories, through the support of the NSTB, to provide consistent guidance and assistance to security-related standards groups in the development of new and improved standards specifically focused on the cyber-security of energy sector control systems. The CS³T defined three goals for the team that would lead to the needed improvements.

This report describes the accomplishments and impacts of the standards team towards achieving these three goals and describes the follow-on efforts that need to be made toward meeting the priority strategies defined in the DOE/DHS Roadmap to Secure Control Systems in the Energy Sector.
Acknowledgements

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Executive Summary

The Control Systems Security Standards Team (CS³T) has been actively participating in select Control System (CS) security-related standards groups with an emphasis on the acceleration of field-proven best practices and baseline standards for control systems. This project has utilized the expertise and capabilities of the United States Department of Energy (DOE) National Laboratories through the support of the National SCADA Test Bed (NSTB), to provide consistent guidance and assistance to security related standards groups in the development of new and improved standards specifically focused on the cyber-security of energy sector control systems.

The improvement and implementation of standards addresses three of the priority strategies described in The Roadmap to Secure Control Systems in the Energy Sector: (1) Measure and Assess Security Posture, (2) Develop and Integrate Protective Measures, and (3) Sustain Security Improvements.

In response to the strategies under the Roadmap, the first goal of the CS Security Standards project has focused on the National Laboratories’ participation in Control System related standards development activities and organizations that have the potential of impacting the security posture of energy infrastructure systems. The second goal has been to continue DOE and National Laboratory efforts to understand the CS security standards-related needs of the energy sector industry. The third goal has been to incorporate lessons learned from NSTB assessments and analyses, combined with best practices and expertise, in recommendations to the appropriate standards groups. Such efforts assist in providing a common cyber-security architectural foundation for the assurance of safeguarding energy systems and the survivability of the U.S. critical infrastructures.

The efforts of the CS³T have fostered an increased awareness and understanding of the significance of increased security for control systems. These efforts have also moved the energy sector partners closer to meeting the goals and milestones defined in the strategies of the Roadmap. The industrial partners have, for the most part, shown a positive approach to a working relationship with the CS³T. Future efforts should focus on the need for continuing to involve the energy sector stakeholders in developing and implementing cyber security standards in design and operation of control systems. If standards are to be accepted and implemented by operators, they must be practical, straightforward, and applicable to specific industry sector CS and SCADA operations.

This report describes (1) the accomplishments and impacts the standards team has had to date toward achieving these three goals and (2) what follow-on efforts need to be made toward meeting the goals defined in the Roadmap. Additional work remains in achieving the goals outlined and gaining a better understanding of the barriers, gaps, and weaknesses that exist in the implementation of CS security standards by the standards groups and industry asset owners. Once these shortfalls are determined, the NSTB CS³T can agree on how best to assist these groups in overcoming existing problems in meeting the strategies of the Roadmap.

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1 Introduction

This section provides a brief background description of the need for the United States Department of Energy (DOE) National SCADA Test Bed (NSTB) to provide assistance to energy sector industry standards groups and asset owners in the definition and development of control system cyber-security standards specifically addressing the needs of those groups to meet the strategies and milestones defined in the Roadmap to Secure Control Systems in the Energy Sector [1]. Included in this section is a description of the purpose and goals of the Control Systems (CS) Security Standards Task and the benefits to be realized through these efforts.

1.1 Background

1.1.1 Description
This project has utilized the expertise and capabilities of the United States Department of Energy (DOE) National Laboratories (SNL, ANL, INL, & PNNL), through the support of the National SCADA Test Bed (NSTB), to provide consistent guidance and assistance to security-related standards groups in the development of new and improved standards specifically focused on the cyber-security of energy sector control systems.

1.1.2 Historical Information
The National Labs have been providing a unique role as an independent body to identify inconsistencies and common areas of coverage in current and emerging cyber-security standards for control systems.

1.1.3 Significance
Various programs and initiatives involving the National Laboratories within both the Department of Energy (DOE) and the Department of Homeland Security (DHS) are focusing on improving industry-wide control system cyber-security through involvement in industry-driven standards organizations. There are other related government supported efforts such as with the National Institute of Standards & Technology (NIST), Process Control Systems Forum (PCSF), and the Institute for Information Infrastructure Protection (I3P). Coordination between DOE and DHS is needed to ensure standards efforts are not being duplicated and to facilitate the sharing of products, contacts, and knowledge between the teams supporting these efforts.

1.1.4 Literature review
See Appendix E, “Cyber and Control System Security Standards”, in this document for a description of the standards considered during the work described herein.
1.2 Purpose
The purpose of this task has been to utilize the expertise and capabilities of the DOE National Laboratories (SNL, PNNL, ANL, and INL), through the support of the NSTB, to provide consistent guidance and assistance to security related standards groups in the development of new and improved standards specifically focused on the cyber-security of energy sector control systems.

1.2.1 Reasons for Investigation
With many national and international groups/organizations working on control systems security standards, coordination of these efforts is both essential and at the same time difficult. Inconsistencies in standards generated from these various groups often confuse industry and asset owners.

1.2.2 Roadmap challenges
The *Roadmap to Secure Control Systems in the Energy Sector* [1] identifies specific strategies, goals, challenges, and priorities with defined milestones for achieving secure CS for critical applications. Among them is the specific mandate that “mandatory security standards and interoperability protocols must be established and implemented to guide continuous development of … control system technology and software … Standards should be defined across the full life cycle of the control system to facilitate technology transition.”

This Standards Task seeks to support the recommendations of the *Roadmap* for clearly defined cyber security standards by working with industry and stakeholders to develop consistent and effective standards.

1.2.3 Audience
The audience for this work is made up of the bodies that formulate these standards and the asset owners, industry bodies, and energy sector stakeholders to whom the standards are relevant.

1.2.4 Desired Response
New and emerging standards will produce benefits to asset owners, industry, and stakeholders within the energy sector (1) through the establishment and development of best practices in cyber security toward the protection of control systems from cyber-related events and (2) by providing a common cyber-security architectural foundation for the assurance of safeguarding energy systems and the survivability of the U.S. critical infrastructures.

Encompassed within the purpose described in Section 1.2, specific benefits realized through the implementation of this task are: (1) increased standardization of control system cyber security requirements for energy sector industries, (2) more consistent recommendations to energy sector standards organizations regarding secured practices, and (3) assistance with the implementation of these emerging standards.
1.3 Scope

1.3.1 Extent and limits of investigation
Each Laboratory participating on this task has identified standard organizations and/or vendor user/groups (see Section 3.1, Control system security standards industry partners) to develop a strategic working relationship. The team has provided standards recommendations and encouraged consistent application of cyber security standards. Specific accomplishments and impacts of the CS³T are detailed later in this report (Sections 3.2 and 3.3).

This task involves an on-going effort to ensure that the DOE and DHS standards-specific programs remain integrated and leverage any work, products, contacts, and knowledge gained in the DOE/NSTB and the DHS/CSS Programs. Weekly teleconference meeting of all CS³T members have assured the coordination necessary for this effort. Face-to-face team meetings were planned to coincide with occurrences of those standards group meetings that would normally be attended by members in support of such groups. Participation in these standards activities has provided visibility for the support of the DOE NSTB program and national laboratory standards efforts. Whenever possible, interactions with other government supported security standards efforts such as NIST and PCSF has been attained.

1.3.2 Goals
The NSTB Control Systems Security Standards Team (CS³T) has been working to assist asset owners in maneuvering through existing cyber security standards and encouraging the development of consistent control systems cyber security standards across all critical infrastructure sectors, including the energy sector.

1.3.3 Objectives
The primary objectives of this effort have been to (1) identify ways the National Laboratories (SNL, INL, PNNL, ANL) will support standards development activities, (2) provide appropriate assistance to standards development efforts, (3) inform the standards bodies of efforts of the NSTB standards team, and (4) assist standards groups and industry to overcome barriers, gaps, and weaknesses in the implementation of CS security standards.

The first goal of the CS Security Standards task has focused on the National Laboratories’ participation in Control System related standards development activities and organizations that have the potential of impacting the security posture of energy infrastructure systems.

The second goal has been to continue DOE and National Laboratory efforts to understand the CS security standards-related needs of the energy sector industry.

The third goal has been to incorporate lessons learned from NSTB assessments and analysis, combined with best practices and expertise, in recommendations to the appropriate standards groups.
2 Approach

2.1 Methods
The CS$^3$T is composed of staff members from the DOE National Laboratories: Sandia National Laboratories (SNL), Idaho National Laboratory (INL), Pacific Northwest National Laboratory (PNNL), and Argonne National Laboratory (ANL). Using their expertise and experience in process control systems within the energy sector and cyber-security requirements necessary for the protection of these industrial assets, this team works to partner with security related standards and key industry groups of the energy sector.

The technical approach taken by this team has been to actively participate in select CS security related standards groups. A list of the meetings attended by the CS$^3$T to accomplish this is provided in Appendix A. The primary objectives of this effort have been to (1) identify ways the National Laboratories (SNL, INL, PNNL, ANL) will support standards development activities, (2) provide appropriate assistance to standards development efforts, (3) inform the standards bodies of efforts of the NSTB standards team, and (4) assist standards groups and industry to overcome barriers, gaps, and weaknesses in the implementation of CS security standards.

2.2 Assumptions
There were no overt assumptions made in carrying out the work described in this report.

2.3 Procedures
The CS$^3$T attended many invitation-only meetings of relevant standards working groups in order to become recognized as possessing relevant security expertise required to safeguard the nation’s control systems and to achieve partner status. In coordination with standards groups, working sub-groups, and proposed working sub-groups, the CS$^3$T provided presentations on the goals and strategies of the Roadmap and on the various NSTB tasks that support the efforts of improved security for the energy sector. The team has also conducted training courses on self-assessments of current security posture and security awareness. These efforts have resulted in participation in several standards efforts, which the CS$^3$T has used to advance Roadmap goals in the area of control systems standards.
3 Results and discussion

3.1 Control system security standards industry partners

Table 1 defines the organizations partnered with the CS Security Standards Team during this past year. This table also summarizes the current role of the standards groups, working sub-groups, or proposed working sub-groups activities and responsibilities. In coordination with these groups, the CS3T provided presentations on the goals and strategies of the Roadmap and on the various NSTB tasks that support the efforts of improved security for the energy sector. The team has also conducted training courses on self-assessments of current security posture and security awareness.

Through these presentations and discussions, the CS3T has been able to also be in contact with industry asset owners and their current corporate efforts to establish cyber-security measures within their individual organizations.

Table 1. Control System Security Standards Industry Partners

<table>
<thead>
<tr>
<th>Organization</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGA – American Gas Association</td>
<td>CS security standards group; development of standards for the natural gas industry in cyber security, protocols, and encryption</td>
</tr>
<tr>
<td>API – American Petroleum Institute</td>
<td>CS security standards group; cybernetics committee evaluating security standards</td>
</tr>
<tr>
<td>GTI – Gas Technology Institute</td>
<td>CS standards group; research, development, &amp; training for natural gas industry</td>
</tr>
<tr>
<td>IEC – International Electrotechnical Commission</td>
<td>CS security standards group; responsible for two of the primary protocols used in electric industry</td>
</tr>
<tr>
<td>IEEE – Institute of Electrical and Electronics Engineers</td>
<td>CS security standards group; preparation of standards for power substations intelligent electronic device cyber security</td>
</tr>
<tr>
<td>INGAA – Interstate Natural Gas Association of America</td>
<td>The North American association represents interstate and inter-provincial natural gas pipeline companies and speaks for the companies that own and operate those lines. The INGAA is forming a working group focused on CS security issues.</td>
</tr>
<tr>
<td>ISA – Instrumentation, Systems, &amp; Automation Society</td>
<td>CS security standards group; preparing a multipart standard for CS cyber security and wireless systems for automation</td>
</tr>
<tr>
<td>NERC – North American Electric Reliability Council</td>
<td>CS security standards group; development of CIP standards</td>
</tr>
<tr>
<td>NIST – National Institute of Standards and Technology</td>
<td>CS security standards group; preparing or modifying several CS standards documents</td>
</tr>
<tr>
<td>PCSF – Process Control Systems Forum</td>
<td>CS security standards group; coordination of PCS security efforts and transition to industry</td>
</tr>
</tbody>
</table>


3.2 Results of contacts and meetings

The following sections describe the accomplishments of the CS³T resulting from partnering and working with the energy sector standards and industry groups described in Table 1. These accomplishments are described in terms of contacts made with the energy sector industrial standards groups and specific industry asset owners. More importantly, these sections describe the results of the contacts and meetings that progress the efforts toward meeting the goals and strategies of the Roadmap.

3.2.1 Contact responsibilities with CS standards organizations

One of the first tasks of the team was to determine the contact responsibilities with the possible energy sector industrial standards organizations. This approach was taken to avoid overlap of efforts, to best utilize the strengths and expertise of the team members, and to assure that all of the organizations identified were contacted. Primary assignments indicate the primary responsibility for contact, while secondary assignments indicate both backup to the primary tasking and to assist in the contact and workload effort. In some instances, for particular meetings or discussions, other Lab members would be included.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Responsible Lab</th>
<th>Secondary Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Gas Association (AGA)</td>
<td>ANL</td>
<td>PNNL</td>
</tr>
<tr>
<td>American Petroleum Institute (API)</td>
<td>ANL</td>
<td>SNL</td>
</tr>
<tr>
<td>Gas Technology Institute (GTI)</td>
<td>ANL</td>
<td>SNL</td>
</tr>
<tr>
<td>International Electrotechnical Commission (IEC)</td>
<td>PNNL</td>
<td>SNL</td>
</tr>
<tr>
<td>Interstate Natural Gas Association of America (INGAA)</td>
<td>ANL</td>
<td>SNL</td>
</tr>
<tr>
<td>Instrumentation, Systems, &amp; Automation Society (ISA)</td>
<td>INL</td>
<td>PNNL</td>
</tr>
<tr>
<td>Institute for Electrical and Electronics Engineers (IEEE)</td>
<td>PNNL</td>
<td>SNL</td>
</tr>
<tr>
<td>National Institute of Standards and Technology (NIST)</td>
<td>All Labs</td>
<td>All Labs</td>
</tr>
<tr>
<td>North American Electric Reliability Council (NERC)</td>
<td>PNNL</td>
<td>SNL</td>
</tr>
<tr>
<td>Process Control Systems Forum (PCSF)</td>
<td>SNL</td>
<td>All Labs</td>
</tr>
</tbody>
</table>

3.2.2 Results of meetings and contacts with industry partners

The CS³T has had great success over the past year in meeting and working with the industry partners identified in Tables 1 and 2. In some instances, meetings of the different groups have occurred at or nearly the same time, and in other instances, meetings have occurred simultaneous with conferences hosted or sponsored by I3P, PCSF, ISA, ASME, SANS, and KEMA. Multiple contact responsibilities have allowed the team to participate and respond to the meetings of all these organizations in a timely manner. It is important to note that attendance at the meetings of these industry organizations is by invitation only, since the groups are specifically established to meet the needs of the industrial asset owners and stakeholders and are often closed to non-members. Often, attendance by team members will occur only during a part of the overall organization meeting.
Accomplishments by the CS$^3$T and the impacts made on the energy sector industrial standards groups and asset owners are detailed in Section 3.3. The CS$^3$T has achieved recognition by the security standards working groups and committees within these organizations and is viewed as a critical partner for the security expertise required to safeguard their systems.

A template was created for the NSTB Standards Team members to report on any industry standards meetings attended (list of meetings attended are provided in Appendix B). The template described in Appendix C was used to collect the information and data pertinent to such meetings. Included in the information being collected are short-term and long-term needs of the standards groups and recommendations for the NSTB standards team based upon what is heard/discussed during those meetings. A Standards Meeting Report is created soon after a meeting has occurred so information is fresh and does not rely on memory months after the meeting occurred.

Presentations by team members on the role of the NSTB and CSSP programs and the key tenets, goals, and strategies of the Roadmap have been given during meetings with ISA, IEEE, NERC, IEC, AGA, API, INGAA, ASME, and PCSF. Specific contacts and discussions held during the past year with each of the industry organizations are shown in Table 3.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Established Contacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGA – American Gas Association</td>
<td>AGA 12: Kimberly Denbow and Dr. Bill Rush (formerly GTI)</td>
</tr>
<tr>
<td>API – American Petroleum Institute</td>
<td>Cybernetics Committee: Tom Frobase and Karen Simons</td>
</tr>
<tr>
<td>GTI – Gas Technology Institute</td>
<td>Dr. Bill Rush (formerly GTI)</td>
</tr>
<tr>
<td>IEC – International Electrotechnical Commission</td>
<td>TC 57 WG 15: Herb Falk, Grant Gilchrist, and Stan Klein</td>
</tr>
<tr>
<td>TC 65 WG 10: Tom Phinney &amp; Hans Daniel</td>
<td></td>
</tr>
<tr>
<td>IEEE – Institute of Electrical and Electronics Engineers</td>
<td>Samuel Sciacca</td>
</tr>
<tr>
<td>INGAA – Interstate Natural Gas Association of America</td>
<td>SCADA Committee: Terry Boss and Page Clark</td>
</tr>
<tr>
<td>ISA – Instrumentation, Systems, &amp; Automation Society</td>
<td>SP 99 and SP100: Brian Singer, Richard Sanders, and Dan Sexton</td>
</tr>
<tr>
<td>NERC – North American Electric Reliability Council</td>
<td>Tom Flowers</td>
</tr>
<tr>
<td>CSSWG: Marty Sidor and Linda Nappier</td>
<td></td>
</tr>
<tr>
<td>NIST – National Institute of Standards and Technology</td>
<td>Keith Stouffer and Dr. Joe Falco</td>
</tr>
<tr>
<td>PCSF - Process Control Systems Forum</td>
<td>David Norton and Dr. Bill Rush</td>
</tr>
</tbody>
</table>

Detailed interactions and accomplishments with each of these groups are summarized in the following paragraphs. In these paragraphs, only the identifiers of the standards are used; the full titles of all standards are provided in Appendix C.
AGA: Continued interaction to support the AGA 12 standards and the development of cryptographic devices with vendors. AGA (Kimberly Denbow) was provided a copy of A Summary of Control System Security Standards Activities in the Energy Sector [2]. Ms. Denbow has expressed an interest in seeking assistance from the CS3T with the preparation of AGA Report No. 12, Part 3, “Cryptographic Protection of SCADA Communications: Protection of Network Systems”, and AGA Report No. 12, Part 4, “Cryptographic Protection of SCADA Communications: Protection Embedded in SCADA Components.” However, this has not been a formal written request to date (see additional note in Section 3.2.3, Future planning and contacts with industry partners).

API: Active in communications with the API Cybernetics Committee. By attending the API Pipeline Conference and Cybernetics Symposium in April 2006, the CS3T established future opportunities for CS3T collaboration with API and build on their interest in the DOE NSTB programs and developments. Extending from these contacts, ANL hosted a meeting with the API Cybernetics Committee in September 2006 to elaborate on the efforts of the DOE NSTB and the work of the CS3T. Finally, API provided reviewers for the DOE NSTB Peer Review program in October 2006. The CS3T was requested to perform a comparison/mapping of ISA TR99-00-04 to the API 1164 requirements.

IEC: Ongoing support with Working Group (WG) 15 of the Technical Committee (TC) 57 for standards and document reviews and security training. Initialized support with TC 65 WG 10 on the development of a new standard 62443. Requests have been made by the IEC for assistance in using the NSTB test bed.


INGAA: Long-term contacts and efforts for collaboration came to fruition in a meeting held jointly with members of the CS3T in February 2007. Furthermore, tours of several asset-owner facilities (El Paso NG and Panhandle Energy NG) were arranged for the CS3T. Between these two companies and their subsidiaries, nearly 74000 miles of NG pipelines, related compressor stations, interconnects, etc. are controlled. CS self-assessments and consistent methodology are the key issues with the INGAA members.


NERC: Continued contact with NERC for standards review and security training. The CS3T provided NERC mitigation strategies to address new vulnerabilities identified by NERC members (see the NERC report Top 10 Vulnerabilities of Control Systems and their Associated Mitigations [4].)

NIST: The CS3T (SAT) attended a NIST workshop in April 2006 to discuss NIST SP 800-53 and SP 800-82 standards documents and their applicability to control systems. From this workshop, an effort by the DHS CSSP developed a Catalog of Control System Security Requirements [3].

PCSF: The CS3T attended the PCSF/PCSRF/I3P meetings in June 2006. A joint collaborative DHS CSSP and CS3T meeting was held at the conclusion of these meetings.
3.2.3 Future planning and contacts with industry partners

AGA: The CS³T plans to attend the AGA Operations Conference & Biennial Exhibition Operating Section Spring Committee Meetings to be held on April 22-26, 2007 in Grapevine (Dallas) Texas. There is a possibility of an opportunity to present information on the DOE NSTB and DHS CSSP programs and industry/multiple-laboratory collaboration in these programs. As noted in Section 3.2.2, the AGA expressed an interest in CS³T assistance with AGA Report No. 12, Parts 3 & 4. If formally requested, this effort will only proceed pursuant to the availability of funds and the approval of the DOE NSTB Program Manager.

API: Additional discussions and collaborations in support of API 1164 standard review are being considered. There is a possibility of applying the Catalog [3] to revisit the API 1164 SCADA Security Standards and any impact to the recent release of API 1165. API 1165 is a new standard that focuses on the design and implementation of displays used for the display, monitoring, and control of information on pipeline SCADA.

GTI: Efforts are underway to establish new contacts with GTI (due to the departure of Dr. William Rush from GTI) and direct dialogue with GTI and a possible meeting during the second quarter of 2007. The goal is to determine if GTI will continue to support the AGA standards efforts.

IEC: The CS³T will continue support to TC57/WG15. Based upon experiences with the authenticator, PNNL will provide processor requirements for various key update algorithms for multiple computing platforms. The CS³T will also provide support to the TC65/WG10 on IEC 62443.

IEEE: The CS³T will provide continued support, interaction, and technical feedback with the C1 Application of Computer-Based Systems WG in the development of IEEE P1686.

INGAA: Long-term relationships and partnering with INGAA appear positive. Possible assistance with self-assessments and reviews of vendor systems/applications and information on the Catalog [3] in standards development applicable to the interstate natural gas transmission pipeline are possible tasks in 2007.

ISA: The CS³T will provide continued support and interaction with the Standards and Practices group (SP 99). It is anticipated members from the CS³T will attend the ISA Expo 2007 Technical Conference, October 23-24 2007 in Houston, Texas.

NERC: The CS3T will provide continued support and interaction with NERC as standards reviewers and annual updates to the Top 10 Vulnerabilities [4] by the Control System Security WG (CSSWG).

NIST: Continued cooperation and collaboration between NIST and the CS³T is anticipated. Attendance is planned by the CS³T members at a workshop to review the Catalog [3], SP800-53 Revision 1, and NERC CIP comparison with SP800-53 study by MITRE. This workshop will be held on March 27-28, 2007 at the NIST facility in Gaithersburg, Maryland.

PCSF: Attendance by the CS³T at the PCSF 2007 Annual Meeting, March 2007 in Atlanta, Georgia.
3.3 Impacts on energy sector industrial standards groups & asset owners

As described in the preceding sections of this report, the CS$^3$T has been working closely with many of the energy sector industrial standards groups. Through these efforts there has been a natural relationship of cooperation developed with many asset owners and representatives from the industry companies. This section describes additional accomplishments not already described in earlier sections, but also the impacts that have been achieved toward the goals and milestones of the Roadmap [1].

3.3.1 Accomplishments and impact with CS industry partners

The CS$^3$T has been actively participating in meetings with the technical committees, working groups, special interest groups, and cyber-security groups of the organizations listed in Table 1. Through these efforts the NSTB Standards program has been proactive in providing information on the NSTB program, the Roadmap efforts, and assisting these groups to define and approve standards relevant to each of the particular areas of application.

One of the greatest impacts delivered to the energy sector organizations and asset owners belonging to these organizations has been to help these groups to understand the multi-laboratory efforts and role in the DOE NSTB program and project efforts to secure control systems in the energy sector. Furthermore, the NSTB Standards team has made a concerted effort to help these organizations understand the goals and strategies of the Roadmap.

Some noteworthy indicators of impact realized through these efforts are:

1. Assisted in the completion of ISA TR 99-1 Revision 1, ISA 99.00.01, and ISA 99.00.02 drafts through the process of reviews and comments on the revisions to these drafts,
2. Negotiated with API to provide support in reviewing and providing input to the amendments associated with API 1164 and API 1165 standards and to provide recommendations of how best to implement these standards,
3. Provided active participation and collaboration with INGAA as this group begins to make decisions about standards applicable to their particular part of the energy sector,
4. Provided active participation and collaboration with IEC TC65/WG10 as this group develops the international standard IEC 62443,
5. Participated in the development of IEEE P1686, and
6. Continued the process of developing new contacts within each of the sector organizations.

The security standards working groups and committees within the organizations identified in Table 1 have all indicated a desire to continue working with the NSTB standards team. These groups understand the critical nature of developing security standards that will be applicable to their control systems and make a definite difference in safeguarding their systems. The DOE NSTB Standards team is viewed as a critical partner for the security expertise required.
3.3.2 Status of Security Standards

The current cyber and control system security standards are listed in Appendix C. The 2005 Summary [2] provided a status review of all the standards listed. Rather than repeat the information contained in that report, this report will concentrate on changes in those standards that have occurred since the release of the 2005 Summary.

AGA Report No. 12, Part 1, was issued March 14, 2006.

AGA Report No. 12, Part 2, is near completed and is pending decision from the new development SCADA Task Group for final proceedings.

IEC 62443 is a three-part international development with two standards sections and a third section to be used as a set of recommended guidelines.

ISA 99.00.01 anticipated for approval and release as a standard in 2nd quarter of 2007.

ISA 99.00.02 anticipated balloting by membership also in 2nd quarter of 2007.

NERC 1200 was put into place as an “urgent action” standard intended strictly as a temporary standard to be replaced by a permanent standard. This was not a mandatory standard but strictly voluntary.

NERC 1300 was intended to be the permanent replacement standard for NERC 1300, but as work began it was determined that a more comprehensive set of standards to be developed as a series of standards was needed, known collectively as the Critical Infrastructure Protection (CIP) standards.

NERC CIP became the official series of standards for the NERC; there are a total of nine standards currently underway CIP-001 through CIP-009. In 2006, NERC was approved as the Electric Reliability Organization (ERO).
4 Conclusions

There have been very positive changes in the development of cyber-security standards specifically focused on the control systems within the energy industrial sector. Over the past year, asset owners and the industry standards groups have come to understand the differences of reliability and safety standards for their control systems and the need for additional security incorporated into the computers, networks, controllers, and communications elements that make up the front design of these systems.

As described in the preceding sections of this report, the NSTB CS³T efforts have moved the energy sector partners closer to meeting the goals and milestones defined in the strategies of the Roadmap [1]. For the most part, industrial standards groups and asset owners have been open to the development of partnerships and working with the DOE NSTB Program. However, such partnerships and cooperative teaming take time to build the trust necessary for these partnerships to work well.

Additional work remains in gaining a better understanding of the barriers, gaps, and weaknesses that exist in the implementation of CS security standards by the standards groups and industry asset owners. Once these shortfalls are determined, the NSTB CS³T can agree on how best to assist these groups in overcoming existing problems in meeting the strategies of the Roadmap.
5 Recommendations

The CS$^3$T recommends that the following tasks be funded in FY07:

1. Better understanding is needed of the barriers, gaps, and weaknesses that exist in the implementation of CS security standards by the standards groups and industry asset owners. Once determined, the DOE NSTB CS Security Standards team can then determine how best to assist these groups to overcome these existing problems in meeting goals and milestones of the *Roadmap* [1]. Such efforts will assist in providing a common cyber-security architectural foundation for the assurance of safeguarding energy systems and the survivability of the U.S. critical infrastructures.

2. Continued support of the CS$^3$T for active participation in select Control System (CS) security-related standards groups with an emphasis on the acceleration of field-proven best practices and baseline standards for control systems. Focus the CS$^3$T efforts in Control System related standards development activities and organizations that have the potential of impacting the security posture of energy infrastructure systems.

3. Using the NSTB Metrics Taxonomy developed in FY06, perform a cross-walk of one selected industry control system standard to identify what metrics might be applied to each defined standard that would provide traceability from the standards definition to the implementation of elements expected to deliver protection and security. This effort would demonstrate to asset owners a means of quantifying the success of meeting security and operational goals as defined in the *Roadmap*. 
Appendix A: References


Appendix B: Acronyms

AGA American Gas Association
AHWG06 Ad hoc working group 06
ANL Argonne National Laboratory
ANSI American National Standards Institute
API American Petroleum Institute
ASME American Society of Mechanical Engineers
CIGRE International Council on Large Energy Systems
CIP Critical Infrastructure Protection
CISSWG Critical Infrastructure Security Standards Working Group
CS Control System
CSSP Control System Security Program
CS' ST Control Systems Security Standards Team for the DOE NSTB
DCS Distributed Control Systems
DHS United States Department of Homeland Security
DOE United States Department of Energy
ERO Electric Reliability Organization
FERC Federal Energy Regulatory Commission
GRI Gas Research Institute
GTI Gas Technology Institute
HV High Voltage
I3P Institute for Information Infrastructure Protection
ICS Industrial Control Systems
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronic Engineers
IETF Internet Engineering Task Force
IGT Institute of Gas Technology
INEEL Idaho National Engineering and Environmental Laboratory
INGAA Interstate Natural Gas Association of America
INL Idaho National Laboratory
ISA Instrumentation, Systems, and Automation Society
ISO International Organization for Standardization
IT Information Technology
MMS ISO/IEC 9506 - Manufacturing Message Specification
NERC North American Electric Reliability Council
NG Natural Gas
NIST National Institute of Standards and Technology
NSTB National SCADA Test Bed
OE Office of Electricity Delivery and Energy Reliability (within DOE)
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tr>
<td>PCS</td>
<td>Process Control System</td>
</tr>
<tr>
<td>PCSF</td>
<td>Process Control Security Forum</td>
</tr>
<tr>
<td>PCSRF</td>
<td>Process Control Security Requirements Forum</td>
</tr>
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<td>PNNL</td>
<td>Pacific Northwest National Laboratory</td>
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<td>PSRC</td>
<td>Power Systems Relay Committee</td>
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<td>SAT</td>
<td>Standards Awareness Team</td>
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<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
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<td>SNL</td>
<td>Sandia National Laboratories</td>
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<td>SSEMP</td>
<td>Security Standards for Electric Market Parties</td>
</tr>
<tr>
<td>SP</td>
<td>Special Product</td>
</tr>
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<td>TASE.2</td>
<td>Telecontrol Application Service Element Two</td>
</tr>
<tr>
<td>TC</td>
<td>Technical Committee</td>
</tr>
<tr>
<td>TC 57</td>
<td>Technical Committee 57 on Power System Control and Associated Communications</td>
</tr>
<tr>
<td>TCP/IP</td>
<td>Transmission Control Protocol/Internet Protocol</td>
</tr>
<tr>
<td>TR</td>
<td>Technical Report</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide Area Network</td>
</tr>
<tr>
<td>WG</td>
<td>Working Group</td>
</tr>
<tr>
<td>WG 15</td>
<td>Working Group 15 on Data and Communications Security</td>
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</table>
## Appendix C: Meetings Attended by CS³T

**Funded fully or in part by NSTB**

**March 1, 2006 – March 28, 2007**

<table>
<thead>
<tr>
<th>Meeting Name</th>
<th>Date of Meeting</th>
<th>Meeting Location</th>
<th>Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standards Awareness Team &amp; CISSWG Planning Meeting</td>
<td>February 27-28, March 1, 2006</td>
<td>Albuquerque, NM</td>
<td>Baca, Dagle, Hadley, Hammond, Robbins, Shamsuddin, Young,</td>
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<tr>
<td>NIST First FISMA CS Workshop</td>
<td>April 18-20, 2006</td>
<td>Gaithersburg, MD</td>
<td>Evans, Young</td>
</tr>
<tr>
<td>Instrumentation, Systems, &amp; Automation Society (ISA) Meeting</td>
<td>May 7-11, 2006</td>
<td>Cleveland, OH</td>
<td>Evans</td>
</tr>
<tr>
<td>Gas Institute of Technology (GTI) Meeting</td>
<td>May 16, 2006</td>
<td>Chicago, IL</td>
<td>Hadley</td>
</tr>
<tr>
<td>North American Electric Reliability Council (NERC) Cyber Security Standards Education Team Meeting</td>
<td>May 18-19, 2006</td>
<td>Las Vegas, NV</td>
<td>Hadley</td>
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<tr>
<td>Platts 4th Annual Cyber Security Conference</td>
<td>May 22-24, 2006</td>
<td>Houston, TX</td>
<td>Shamsuddin</td>
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<tr>
<td>Process Controls Systems Forum (PCSF) and I3P Meeting</td>
<td>June 5-10, 2006</td>
<td>La Jolla, CA</td>
<td>Evans, Dagle, Hadley, Hammond, Young, Shamsuddin</td>
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<tr>
<td>KEMA Cyber Security – Control Systems Conference</td>
<td>August 7-9, 2006</td>
<td>Portland, OR</td>
<td>Dagle, Hadley, McBride</td>
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<tr>
<td>Standards Awareness Team Meeting</td>
<td>August 9, 2006</td>
<td>Portland, OR</td>
<td>Evans, Dagle, Hadley, Halbgewachs, Hill, Hammond, Shamsuddin</td>
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<tr>
<td>International Control Systems Security &amp; Standards Coordination Workshop</td>
<td>August 10-11, 2006</td>
<td>Portland, OR</td>
<td>Evans, Dagle, Hadley, Halbgewachs</td>
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<tr>
<td>American Petroleum Institute (API) Cybernetics Meeting</td>
<td>September 13, 2006</td>
<td>Argonne, IL</td>
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<tr>
<td>Standards Awareness Team Meeting</td>
<td>September 14, 2006</td>
<td>Argonne, IL</td>
<td>Hadley, Halbgewachs, Hammond</td>
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<tr>
<td>SANS Cyber Security Meeting</td>
<td>September 27, 2006</td>
<td>Las Vegas, NV</td>
<td>Halbgewachs, McBride</td>
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<tr>
<td>International Electrotechnical Commission (IEC) Technical Committee Working Group 57</td>
<td>October 10, 2006</td>
<td>Silver Spring, MD</td>
<td>McBride</td>
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<tr>
<td>NERC Control System Security WG (CSSWG)</td>
<td>October 12, 2006</td>
<td>St. Louis, MO</td>
<td>Dagle, Hadley</td>
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<tr>
<td>ISA SP 99 Meeting</td>
<td>October 15-19, 2006</td>
<td>Houston, TX</td>
<td>Evans</td>
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<tr>
<td>NSTB Peer Review Meeting</td>
<td>October 17-19, 2006</td>
<td>Arlington, VA</td>
<td>Hammond, Halbgewachs</td>
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<tr>
<td>Event</td>
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<td>Location</td>
<td>Attendees</td>
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<tr>
<td>North American Electric Reliability Council (NERC) Control System</td>
<td>October 10, 2006</td>
<td>St. Louis, MO</td>
<td>Dagle, Hadley</td>
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<tr>
<td>Security WG (CSSWG)</td>
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<td>Network Information Technology R&amp;D – Beyond SCADA</td>
<td>November 8-9, 2006</td>
<td>Pittsburgh, PA</td>
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<tr>
<td>American Society of Mechanical Engineers (ASME)</td>
<td>November 10, 2006</td>
<td>Chicago, IL</td>
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<td>ISA SP 100 Workshop Meeting</td>
<td>February 12-15, 2007</td>
<td>Phoenix, AZ</td>
<td>Hammond</td>
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<td>Interstate Natural Gas Association of American (INGAA) Security</td>
<td>February 13, 2007</td>
<td>Houston, TX</td>
<td>Halbgewachs, Hill, Shamsuddin</td>
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<tr>
<td>Meeting</td>
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<tr>
<td>Institute for Information Infrastructure Protection (I3P) Meeting</td>
<td>February 14-15, 2007</td>
<td>Houston, TX</td>
<td>Hill, Shamsuddin</td>
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<tr>
<td>PCSF 2007 Annual Meeting</td>
<td>March 6-8, 2007</td>
<td>Atlanta, GA</td>
<td>Halbgewachs</td>
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<td>IEC TC 65/WG 10 – Standard 62443</td>
<td>March 5 &amp; 8-9, 2007</td>
<td>Atlanta, GA</td>
<td>Halbgewachs</td>
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<tr>
<td>NIST Second FISMA CS Workshop</td>
<td>March 27-28, 2007</td>
<td>Gaithersburg, MD</td>
<td>Hadley, Halbgewachs, Shamsuddin</td>
</tr>
</tbody>
</table>

Note: Others from the CS³T may have also attended some of these meetings, but utilized funding sources other than NSTB.

**NSTB CS³T Members:**
Ronald Halbgewachs – SNL – Team Lead
Michael Baca – SNL
Kevin Robbins – SNL
Mary Young – SNL
Jeffery Dagle – PNNL
Mark Hadley – PNNL
Justin McBride – PNNL
James Shaw – PNNL
Virgil Hammond – ANL
Shabbir Shamsuddin – ANL
Robert Evans – INL
Robert Hill – INL
Appendix D:

NSTB Standards Meeting Report Template

This template is used by the NSTB Standards Team members to report on any industry standards group meetings attended. The intent of this form is to collect the information and data pertinent to that meeting. Included in the information being collected are short-term and long-term needs of the standards groups and recommendations for the standards team based upon what is heard/discussed during those meetings. The Standards Meeting Report is to be created soon after the meeting occurred so information is fresh and does not rely on memory months after the meeting occurred.

The Standards Meeting Report is also a means of identifying issues, problems, and barriers to implementation of standards that will affect an accelerated development and implementation of consistent standards to better secure control systems in the energy sector.

Completing the template is relatively straightforward as information is transferred from notes that one would normally take at these meetings. The formatted template is simply a means of standardizing the information reported. Guidance to the Standards Team is to also include any notes to be added that do not seem to fit into any of the template categories of information.
Meeting Report
Title of Meeting

Author(s)
Name of Laboratory
Dates of Meeting
Locations of Meetings
Outline of the Report:

NSTB Standards Meeting Report ........................................................................................... 36
Title Of This Meeting ............................................................................................................. 36
  Date of meeting .................................................................................................................. 36
  Location of the meeting .................................................................................................... 36
The Near Term:..................................................................................................................... 36
  What was the purpose or goal attending this meeting? ............................................ 36
  Who was in attendance? ........................................................................................... 36
  What are the key outcomes? ..................................................................................... 36
  What key issues did this uncover? ............................................................................ 36
  What action items resulted from the meeting? ......................................................... 36
  What suggestions do you have for follow-up? ......................................................... 36
The Longer Term: ................................................................................................................... 37
  Any new insights into standards group/stakeholder needs? ................................... 37
  Any new insights about technology trends or applications? .................................. 37
  Any new insights about standards efforts? ............................................................... 37
  Any new ideas for future standards or task development? ...................................... 37
TITLE OF THIS MEETING

Date of meeting

Location of the meeting

The Near Term:

5.1.1 What was the purpose or goal attending this meeting?

5.1.2 Who was in attendance?

5.1.3 What are the key outcomes?

5.1.4 What key issues did this uncover?

5.1.5 What action items resulted from the meeting?

<table>
<thead>
<tr>
<th>ACTION</th>
<th>OWNER</th>
<th>DUE DATE</th>
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<tbody>
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</tbody>
</table>

5.1.6 What suggestions do you have for follow-up?

(repeat this page as necessary for multiple meetings on same trip)
THE LONGER TERM:

Any new insights into standards group/stakeholder needs?

•

Any new insights about technology trends or applications?

•

Any new insights about standards efforts?

•

Any new ideas for future standards or task development?

•
Appendix E:
Cyber and Control System Security Standards

The following standards and guidelines deal with cyber or control system security. In many cases, guidelines published by an organization are considered comparable in significance to published standards and so those guidelines are also included in this list. There are recognized differences in standards aimed at the manufacturing section, as opposed to those for energy distribution. There are also differences between technical and operating standards, and most of the cyber security standards fall into the operating standards category. Most good standards are based on best practices developed by asset owners/operators. This is not an exhaustive list of the standards, but it is believed to include those that are most relevant to energy sector control system security. These standards are listed by sector.

**Electric Power**


IEEE P1686  *Substation Intelligent Electronic Device Cyber Security Standards* (draft proposed).


IEC 61850-SER  *Communication Networks and Systems in Substations.*


NERC CIP  *Cyber Security*, also known as CIP-001-1 through CIP-009-1, June 2006.


FERC SSEMP  *Security Standards for Electric Market Participants (SSEMP).*

**Oil and Gas**


API Guideline


API SVA


AGA Report No. 12 Part 1

Cryptographic Protection of SCADA Communications Background, Policies & Test Plan

AGA Report No. 12 Part 2

Cryptographic Protection of SCADA Communications: Retrofit Link Encryption for Asynchronous Serial Communications

AGA Report No. 12 Part 3

Cryptographic Protection of SCADA Communications: Protection of Networked Systems

AGA Report No. 12 Part 4

Cryptographic Protection of SCADA Communications: Protection Embedded in SCADA Components.

Cross-Cut Organizations

ISA SP99.00.01


ISA SP99.00.02


ISA TR99.00.01-2004


ISA TR99.00.01 Rev.1


ISA TR99.00.02-2004


ISO 15408


ISO 17799


ISO 27001


NIST PCSRF

Security Capabilities Profile for Industrial Control Systems.

NIST SPP


NIST SP 800-53, Rev.1

Recommended Security Controls for Federal Information Systems, (Rev.1 specific to Control Systems), December 2006.

NIST SP 800-82

Guide to Supervisory Control and Data Acquisition (SCADA) and Industrial Control System Security (draft).
Distribution:

1  MS 1368  Jennifer Depoy, 5628
1  MS 0671  Robert Pollock, 5633
1  MS 1235  Ronald Halbgewachs, 5633
1  MS 0899 Technical Library, 9536  (electronic copy)