Security Controls for Industrial Control Systems

EEI/AGA Security Committee Fall Meetings

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NIST Responsibilities for Industrial Control Systems (ICS) Security

- **In general**
  - **NIST promotes the U.S. economy and public welfare**
  - **NIST develops mandatory standards and guidelines for use by federal agencies (except national security systems)**
  - **Standards and guidelines may also be voluntarily used by nongovernmental organizations**
- **Specifically concerning ICS**
  - **Special Publication (SP) 800-53 *Recommended Security Controls for Federal Information Systems* requires that federal agencies implement minimum security controls for their organizational information systems**
    - **ICS have many unique characteristics differentiating them from traditional information systems**

NIST ICS Security Project Objectives

- **Work cooperatively with federal stakeholders and industry to interpret SP 800-53 security controls* for ICSs**
- **Publish SP 800-82 *Guide to Supervisory Control and Data Acquisition (SCADA) and Industrial Control System Security* initial public draft - September 2006**
- **Improve the security of public and private sector ICSs**
  - **Work with the many on-going industry standards activities**
    - **Standards for the ICS industry, if widely implemented, will raise the level of control systems security**
    - **Foster convergence**
  - **Use open public process in developing candidate set of security requirements**

*Control has two different uses: (1) An adjective of "system" (e.g., control system, industrial control system) (2) A noun (e.g., security control)

NIST Publications

Security Standards and Guidelines

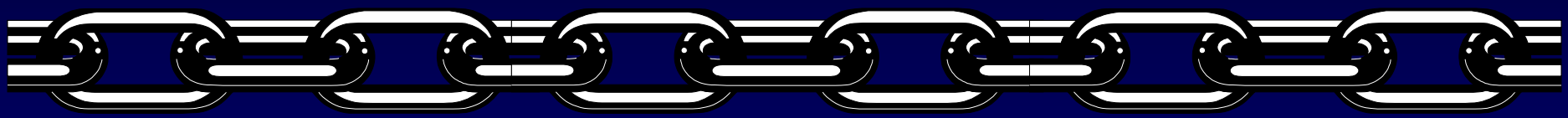
- Federal Information Processing Standards (FIPS)
  - Developed by NIST in accordance with FISMA.
  - Approved by the Secretary of Commerce.
  - Compulsory and binding for federal agencies; not waiverable.
- NIST Guidance (Special Publication 800-Series)
  - OMB Memorandum M-05-15, *FY 2005 Reporting Instructions for the Federal Information Security Management Act and Agency Privacy Management* states that for other than national security programs and systems, agencies must follow NIST guidance.
- Other security-related publications
  - NIST Interagency and Internal Reports and Information Technology Laboratory Bulletins provide technical information about NIST's activities.
  - Mandatory only when so specified by OMB.

Key Standards and Guidelines

- FIPS Publication 199 (Security Categorization)
- FIPS Publication 200 (Minimum Security Requirements)
- NIST Special Publication 800-18 (Security Planning)
- NIST Special Publication 800-30 (Risk Management)
- NIST Special Publication 800-37 (Certification & Accreditation)
- NIST Special Publication 800-53 (Recommended Security Controls)
- NIST Special Publication 800-53A (Security Control Assessment)
- NIST Special Publication 800-59 (National Security Systems)
- NIST Special Publication 800-60 (Security Category Mapping)

Many other FIPS and NIST Special Publications provide security standards and guidance supporting the FISMA legislation…

Information Security Program



Links in the Security Chain: Management, Operational, and Technical Controls

- ✓ Risk assessment
- ✓ Security planning
- ✓ Security policies and procedures
- ✓ Contingency planning
- ✓ Incident response planning
- ✓ Security awareness and training
- ✓ Physical security
- ✓ Personnel security
- ✓ Certification, accreditation, and security assessments
- ✓ Access control mechanisms
- ✓ Identification & authentication mechanisms (Biometrics, tokens, passwords)
- ✓ Audit mechanisms
- ✓ Encryption mechanisms
- ✓ Firewalls and network security mechanisms
- ✓ Intrusion detection systems
- ✓ Security configuration settings
- ✓ Anti-viral software
- ✓ Smart cards

Adversaries attack the weakest link…where is yours?

The NIST Risk Framework

Starting Point

FIPS 199 / SP 800-60

Security Categorization

Define criticality /sensitivity of information system according to potential impact of loss

FIPS 200 / SP 800-53

Security Control Selection

Select minimum (baseline) security controls to protect the information system; apply tailoring guidance as appropriate

FIPS 200 / SP 800-53 / SP 800-30

Security Control Refinement

Use risk assessment results to supplement the tailored security control baseline as needed to ensure adequate security and due diligence

SP 800-18

Security Control Documentation

Document in the security plan, the security requirements for the information system and the security controls planned or in place

SP 800-70

Security Control Implementation

Implement security controls; apply security configuration settings

SP 800-53A

Security Control Assessment

Determine security control effectiveness (i.e., controls implemented correctly, operating as intended, meeting security requirements)

SP 800-37

System Authorization

Determine risk to agency operations, agency assets, or individuals and, if acceptable, authorize information system operation

SP 800-37 / SP 8800-53A

Security Control Monitoring

Continuously track changes to the information system that may affect security controls and reassess control effectiveness

ICSs and Information Systems

- **ICSs are information systems**
  - **Historically, little resemblance to typical information systems**
    - **Originally, isolated systems running proprietary control protocols**
    - **More stringent safety, performance and reliability requirements**
    - **Used special purpose operating systems and applications**
  - **Today, ICSs resemble corporate information systems**
    - **Connected to corporate information systems**
    - **Increased connectivity, remote access capabilities, Internet protocols**
- **ICS cyber security implications**
  - **Significantly less isolation**
  - **More vulnerable to compromise or takeover**
  - **Greater need to secure these systems**

Applying Security Controls to ICS

- **ICSs have many special characteristics compared to typical information systems**
  - **Reliability and availability are key drivers**
  - **Different risks and priorities**
  - **Significant risk to the health and safety of human lives**
  - **Serious damage to the environment**
  - **Serious financial risks such as production losses**
  - **Negative impact to a nation's economy**
- **Goals of safety and security sometimes conflict with the operational requirements of ICSs**
- **ICS failures can result in serious disruptions to critical national infrastructures**

Applying SP 800-53 to ICS

- **SP 800-53 provides a rich set of security controls**
  - **Consistent & complement other security standards**
  - **Compliance can demonstrate due diligence**
- **Research/study**
  - **Bi-directional mappings & analysis of SP 800-53 ⇔ NERC CIPs**
    - **Generally, meeting SP 800-53 meets NERC CIPs**
    - **Meeting NERC CIPS does not automatically meet SP 800-53**
  - **U.S. Government (USG) stake holder working group**
    - **Get USG stake holder's inputs/experience**
    - **Evolve SP 800-53 in cooperation with USG stake holders**

Invitational USG ICS Workshop

- Workshop April 19-20, 2006 at NIST to discuss the development of security requirements and baseline security controls for federally owned/operated industrial/process control systems based on NIST SP 800-53
- Attended by Federal agency stakeholders
- Results
  - Some incorporated SP 800-53, Rev 1
  - Continuing work to be reflected in future revisions to SP 800-53

ICS Workshop Activities

- Develop draft material for an Appendix and/or Supplemental Guidance material that addresses the application of SP 800-53 to ICS
- Review the SP 800-53 controls to
  - Determine which controls are causing challenges when applied to ICS
  - Discuss why a specific control is causing a challenge
  - Develop guidance on the application (or non application) of that control to ICS
  - Determine if there are any compensating controls that could be applied to address the specific control that can't technically be met

Workshop Result
SP 800-53 Appendix I

- **Industrial Control Systems: Interim Guidance on the Application of Security Controls**
- **Provides initial recommendations for organizations that own and operate industrial control systems:**
  - **Use Section 3.3 of SP 800-53, *Tailoring the Initial Baseline*, to modify or adjust the recommended security control baselines when certain conditions exist that require that flexibility.**
  - **Develop appropriate rationale and justification as described in the compensating control section of SP 800-53 to meet the intent of a control that can't technically be met.**

http://csrc.nist.gov/publications/drafts.html#sp800-53-Rev1

Comparing SP 800-53 Controls and NERC CIP Standards

- Comparing control sets from different organizations/ frameworks is difficult and subject to interpretation
- NERC CIP standards generally correspond to controls in one or more of the SP 800-53 control families
  - Most NERC CIP requirements* correspond to controls in SP 800-53.
  - NERC CIP measures* correspond to assessments of the security controls in SP 800-53 described in SP 800-53A *Guide for Assessing the Security Controls in Federal Information Systems*.
  - NERC CIP compliance* best corresponds to SP 800-37 *Guide for the Security Certification and Accreditation of Federal Information Systems*

* *Requirements*, *measures*, and *compliance* are reserved words defined in the NERC CIP

Mapping Table Extract

			CIP-002				CIP-003						CIP-004				CIP-005					CIP-006						CIP-007									CIP-008		CIP-009				
			R1. Critical Asset Identification	R2. Critical Asset Identification	R3. Critical Cyber Asset Identification	R4. Annual Approval	R1. Cyber Security Policy	R2. Leadership	R3. Exceptions	R4. Information Protection	R5. Access Control	R6. Change Control and Confgn Mgmt	R1. Awareness	R2. Training	R3. Personnel Risk Assessment	R4. Access	R1. Electronic Security Perimeter	R2. Electronic Access Controls	R3. Monitoring Electronic Access	R4. Cyber Vulnerability Assessment	R5. Documentation Review and	R1. Physical Security Plan	R2. Physical Access Controls	R3. Monitoring Physical Access	R4.Logging Physical Access	R5. Access Log Retention	R6. Maintenance and Testing	R1. Test Procedures	R2. Ports and Services	R3. Security Patch Management	R4. Malicious Software Prevention	R5. Account Management	R6. Security Status Monitoring	R7. Disposal or Redeployment	R8. Cyber Vulnerability Assessment	R9. Documentation Review and	R1. Cyber Security Incident Response	R2. Cyber Security Incident	R1. Recovery Plans	R2. Exercises	R3. Change Control	R4. Backup and Restore	R5. Testing Backup Media
NERC CIP FINAL											2,								18			12								19 ,2		21	21					22		23				
Other - Notes						2	3	2	11	2	7	2					2																										
SP 800-53 Rev. 1 Controls		Count	0	0	0	0	1	0	0	0	2	0	0	0	0	2	2	5	3	0	0	1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Access Control																																											
AC-1	Access Control P & P	4					8				8							13				13																					
AC-2	Account Management	3									13					17																13										
AC-3	Access Enforcement	0																																								
AC-4	Information Flow Enforcement	0																																								
AC-5	Separation of Duties	0																																								
AC-6	Least Privilege	3														17												13			13										
AC-7	Unsuccessful Logon Attempts	0																																								
AC-8	System Use Notification	1																8																								
AC-9	Previous Logon Notification	0																																								
AC-10	Concurrent Session Control	0																																								
AC-11	Session Lock	0																																								
AC-12	Session Termination	0																																								
AC-13	Supervision and Review—A C	0																																								
AC-14	Permitted Actions without I or A	0																																								
AC-15	Automated Marking	0																																								
AC-16	Automated Labeling	0																																								
AC-17	Remote Access	3															12	9	8																							
AC-18	Wireless Access Restrictions	3															7	17	17																							
AC-19	Access Control for Portable and Mobile Systems	2																17	17																							
AC-20	Personally Owned Information Systems	0																																								

LEGEND

- High baseline (no shading)
- Moderate baseline (12.5% grey shading)
- Low baseline (25% grey shading)
- Not in baseline (50% grey shading)

Codes

8 NERC req ≅ SP 800-53 controls

9 NERC more specific than SP 800-53 control

13 NERC ⊂ SP 800-53 control

17 NERC less specific than SP 800-53 control

Research Findings (1 of 2)

- **Conforming to moderate baseline in SP 800-53 generally complies with the management, operational and technical security requirements of the NERC CIPs; the converse is not true.**
- **NERC contains requirements that fall into the category of business risk reduction**
  - **High level business-oriented requirements**
  - **Demonstrate that enterprise is practicing due diligence**
  - **SP 800-53 does not contain analogues to these types of requirements as SP 800-53 focuses on information security controls (i.e., management, operational, and technical) at the information system level.**

Research Findings (2 of 2)

- NERC approach is to define critical assets first and their cyber components second
  - No criteria for criticality
  - Non-critical assets barely mentioned
- FIPS 199 specifies procedure, applied to all information and information systems for identifying the security categories based on potential impact
  - Confidentiality, availability, and integrity evaluated separately
  - Possible outcomes are low, moderate, and high
  - Highest outcome applies to system
- Documentation requirements differ; more study required

NIST Plans

- Anticipated FY07 Products
  - White paper on ICS cyber security in the FISMA paradigm
  - Annotated SP 800-53 addressing conformance to NERC CIP
  - Annotated NERC CIP showing correspondence to FISMA paradigm
  - Input to revision 2 of SP 800-53
- Continue working with the federal ICS stakeholders
  - Including FERC, Department of Homeland Security (DHS), Department of Energy (DOE), the national laboratories, and federal agencies that own, operate, and maintain ICSs
  - To develop an interpretation of SP 800-53 for ICSs that permits real/practical improvements to the security of ICSs and, to the extent possible, ensures compliance with the management, operational, and technical requirements in the NERC CIP standards

NIST SP 800-82

- **Guide to Supervisory Control and Data Acquisition (SCADA) and Industrial Control System Security**
- Purpose
  - Provide guidance for establishing secure SCADA and ICS, including the security of legacy systems
- Content
  - Overview of ICS
  - ICS Vulnerabilities and Threats
  - ICS Security Program Development and Deployment
  - Network Architecture
  - ICS in the Federal Information Security Management Act (FISMA) Paradigm
  - ICS Security Controls
- Initial public draft - September 2006

http://csrc.nist.gov/publications/drafts.html

SP 800-82 Audience

- Control engineers, integrators and architects when designing and implementing secure SCADA and/or ICS
- System administrators, engineers and other IT professionals when administering, patching, securing SCADA and/or ICS
- Security consultants when performing security assessments of SCADA and/or ICS
- Managers responsible for SCADA and/or ICS
- Researchers and analysts who are trying to understand the unique security needs of SCADA and/or ICS
- Vendors developing products that will be deployed in SCADA and/or ICS

NIST ICS Security Project Summary

- **Issue ICS security guidance**
  - **Evolve SP 800-53 *Recommended Security Controls for Federal Information Systems* security controls* to better address ICSs**
  - **Publish SP 800-82 *Guide to Supervisory Control and Data Acquisition (SCADA) and Industrial Control System Security* initial public draft - September 2006**
- **Improve the security of public and private sector ICSs**
  - **Raise the level of control system security**
    - **R&D and testing**
  - **Work with on-going industry standards activities**
    - **Assist in standards and guideline development**
    - **Foster convergence**

NIST ICS Security Project Contact Information

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Web Pages

Federal Information Security Management Act (FISMA) Implementation Project

http://csrc.nist.gov/sec-cert

NIST ICS Security Project

http://csrc.nist.gov/sec-cert/ics