RED TIGER SECURITY

Security Regulations and Standards for SCADA and Industrial Controls

Overview of NERC CIP and other Security Frameworks

Topics Covered

- Mapping of US Government Agency Oversight to each Critical Infrastructure Sector
- Provide a current status of various SCADA Security references for adaptation by International markets
- NERC CIP, ISA SP99, CFATS, API 1164, NIST 800-82, NIST 800-53 rev3, AGA 12, CSSP DHS Best Practice Guides, etc…
- Use NERC CIP as a sample security framework, and break down the compliance requirements
- Actual security Incidents involving SCADA and Industrial Control Systems

Sources

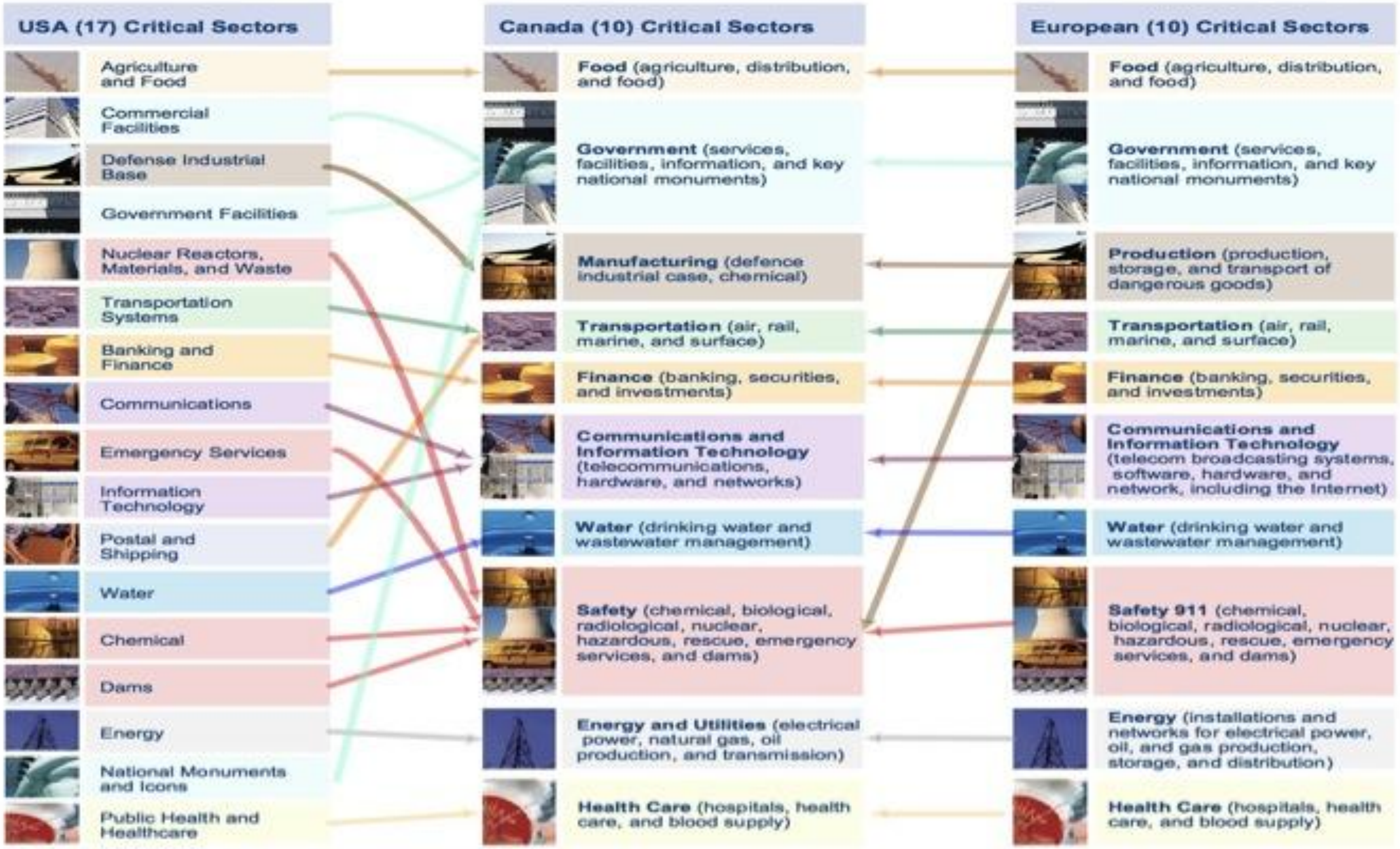
- www.dhs.gov/nipp
- Meetings with DHS
- Meetings with NERC / FERC
- NERC CIP Consulting and CFATS Compliance Projects
- NERC CIP Standards (CIP-002 through CIP-009) http://www.nerc.com/~filez/standards/Cyber-Security-Permanent.html
- NERC Cyber Security Standards Education Workshop (Workbook provided at training workshops)
- ISO / IEC 17799 and 270001
- ISA SP99 Volunteer Draft Development & Review
- Experience with over 100 assessments of Critical Infrastructure facilities over past seven years

What is the NIPP

- DHS was commissioned under the Homeland Security act of 2002 to develop one single approach or plan for protecting all 17 critical infrastructure sectors

- DHS developed the National Infrastructure Protection Plan (NIPP) to unify what was previously done in multiple various agencies to reduce redundancy and focus on one centralized approach.

- NIPP Mission
  - Build a safer, more secure, and resilient America by enhancing protection of the Nation’s CI/KR (Critical Infrastructures / Key Resources) to prevent, deter, neutralize, or mitigate the effects of deliberate by terrorists to destroy, incapacitate, or exploit them, and to strengthen national preparedness, timely response, and rapid recovery in the event of an attack, natural disaster, or other emergency



USA (17) Critical Sectors

- Agriculture and Food
- Commercial Facilities
- Defense Industrial Base
- Government Facilities
- Nuclear Reactors, Materials, and Waste
- Transportation Systems
- Banking and Finance
- Communications
- Emergency Services
- Information Technology
- Postal and Shipping
- Water
- Chemical
- Dams
- Energy
- National Monuments and Icons
- Public Health and Healthcare

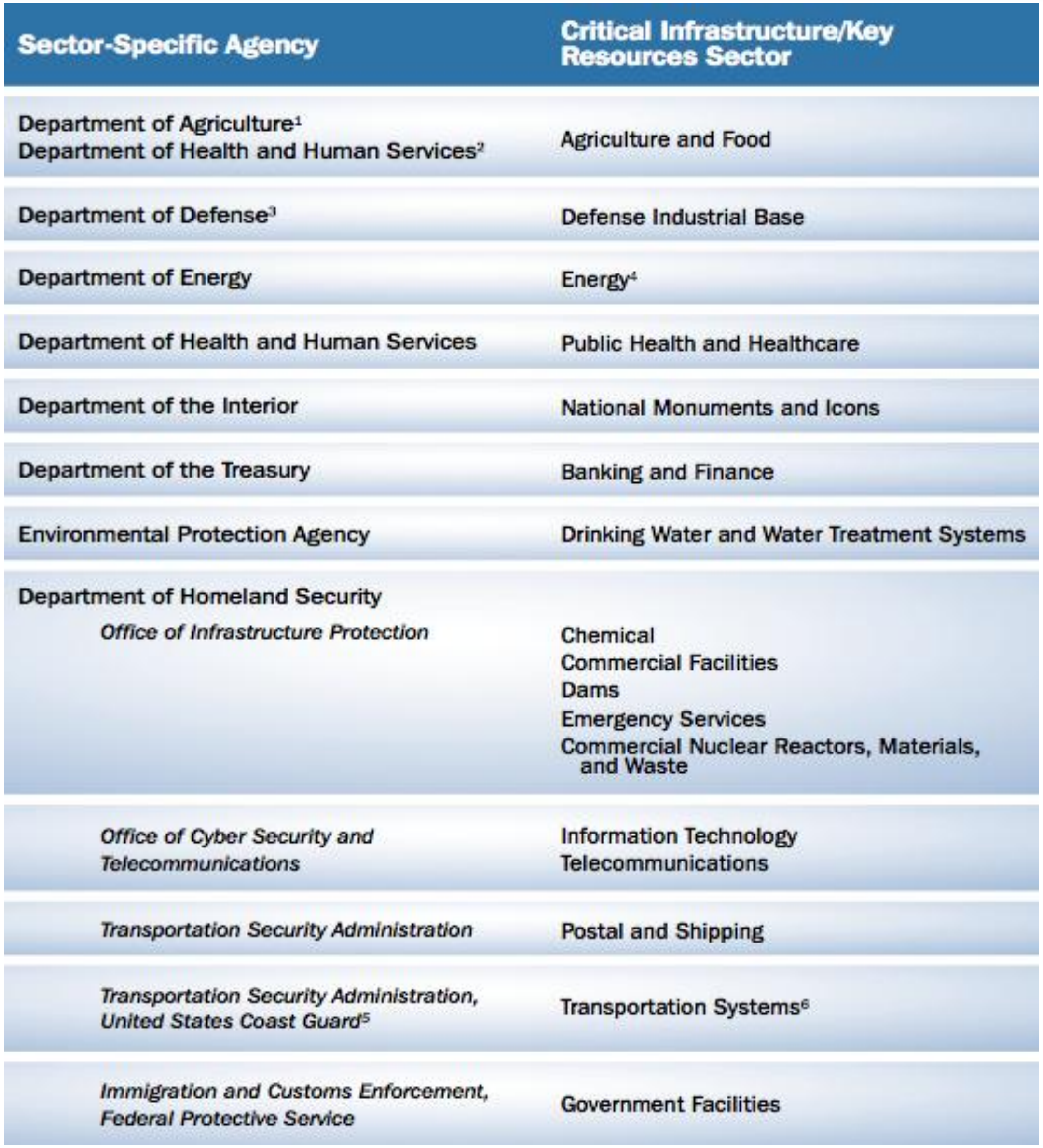
Canada (10) Critical Sectors

- **Food** (agriculture, distribution, and food)
- **Government** (services, facilities, information, and key national monuments)
- **Manufacturing** (defence industrial case, chemical)
- **Transportation** (air, rail, marine, and surface)
- **Finance** (banking, securities, and investments)
- **Communications and Information Technology** (telecommunications, hardware, and networks)
- **Water** (drinking water and wastewater management)
- **Safety** (chemical, biological, radiological, nuclear, hazardous, rescue, emergency services, and dams)
- **Energy and Utilities** (electrical power, natural gas, oil production, and transmission)
- **Health Care** (hospitals, health care, and blood supply)

European (10) Critical Sectors

- **Food** (agriculture, distribution, and food)
- **Government** (services, facilities, information, and key national monuments)
- **Production** (production, storage, and transport of dangerous goods)
- **Transportation** (air, rail, marine, and surface)
- **Finance** (banking, securities, and investments)
- **Communications and Information Technology** (telecom broadcasting systems, software, hardware, and network, including the Internet)
- **Water** (drinking water and wastewater management)
- **Safety 911** (chemical, biological, radiological, nuclear, hazardous, rescue, emergency services, and dams)
- **Energy** (installations and networks for electrical power, oil, and gas production, storage, and distribution)
- **Health Care** (hospitals, health care, and blood supply)

Map GOV Agencies to each CI Sector



Sector-Specific Agency	Critical Infrastructure/Key Resources Sector
Department of Agriculture[1] Department of Health and Human Services[2]	Agriculture and Food
Department of Defense[3]	Defense Industrial Base
Department of Energy	Energy[4]
Department of Health and Human Services	Public Health and Healthcare
Department of the Interior	National Monuments and Icons
Department of the Treasury	Banking and Finance
Environmental Protection Agency	Drinking Water and Water Treatment Systems
Department of Homeland Security *Office of Infrastructure Protection*	Chemical Commercial Facilities Dams Emergency Services Commercial Nuclear Reactors, Materials, and Waste
Office of Cyber Security and Telecommunications	Information Technology Telecommunications
Transportation Security Administration	Postal and Shipping
Transportation Security Administration, United States Coast Guard[5]	Transportation Systems[6]
Immigration and Customs Enforcement, Federal Protective Service	Government Facilities

Example: Energy Sector

- Energy Policy Act of 2005 (EPACT) called for the office and function of an ERO (Energy Reliability Organization) to develop and enforce a set of minimum physical and cyber security standards for the Bulk Electric System (BEP)
- FERC recognized NERC as the ERO in June 2006, and granted the right to levy financial fines and penalties for non-compliance
- NERC CIP standards become law in Jan 2007, and mandatory compliance begins in 2009 with financial penalties and audits beginning in 2010.
- Up to $1,000,000 per day per occurrence for non-compliance.
- Energy companies maintain all compliance proof at their facilities, do not submit anything to NERC. Compliance is audited by NERC going to utilities offices.

Security Standards end up being Regulated by Government when industry can not be accountable to be “Self Regulated”

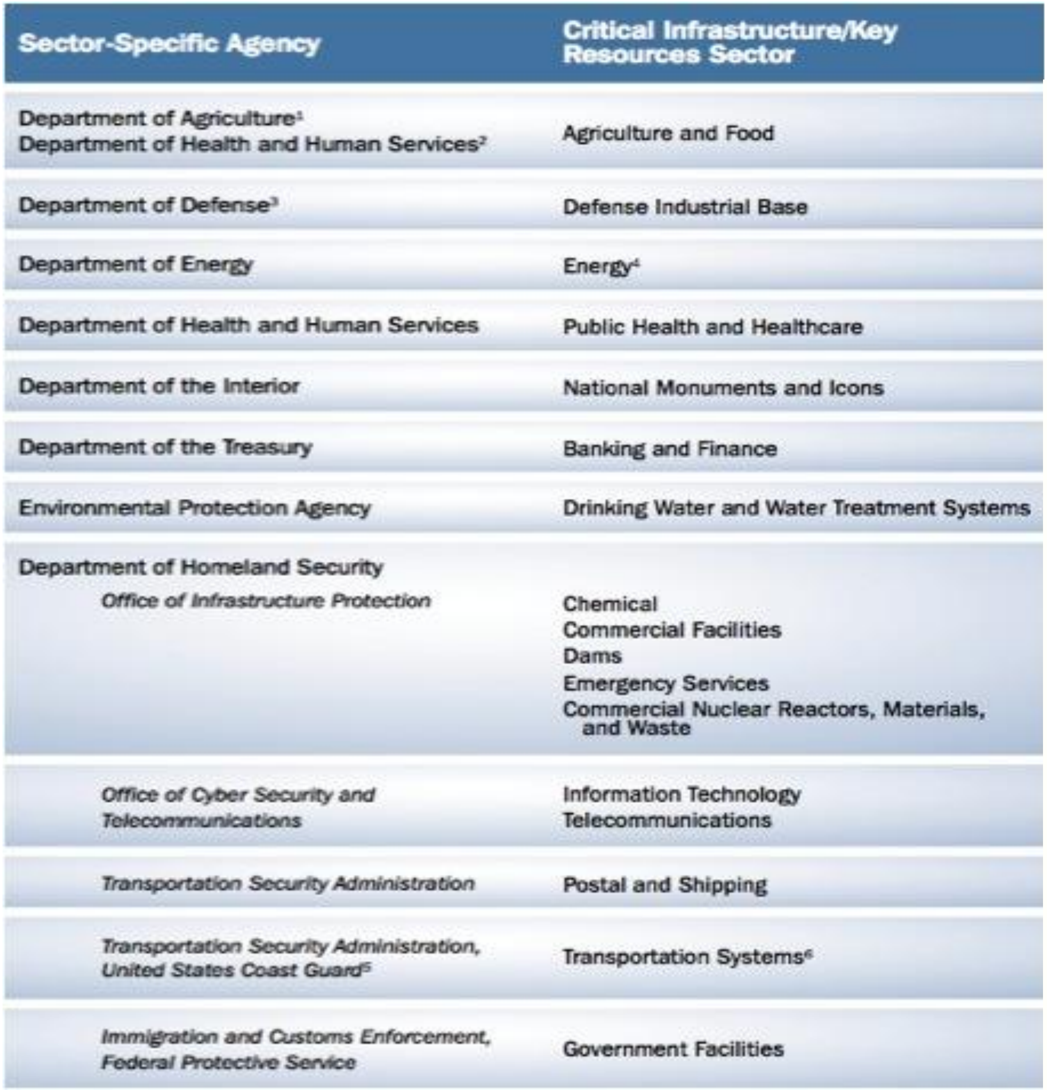
"You should check your e-mails more often. I fired you over three weeks ago."

Example: Chemicals Sector

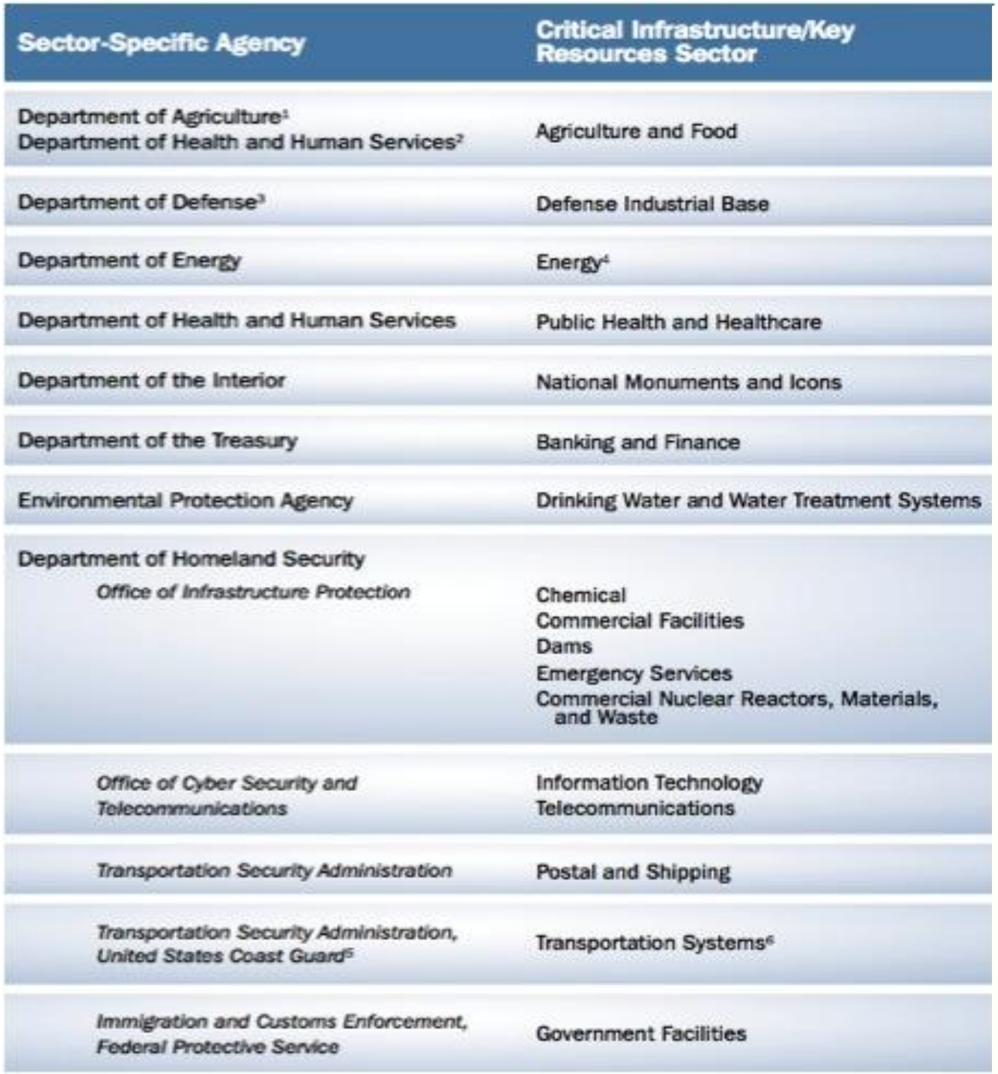
- DHS has direct authority over the Chemical sector and developed the CFATS (Chemical Facilities Anti-Terrorism Standards) to ensure that any organizations that manufacture, store, or transport hazardous chemicals have a baseline or minimum physical and cyber security measures in place.
- CFATS has specific steps and timeline for compliance
- DHS has the right to audit for non-compliance at any time, and can send agents into the facilities
- Non-compliance can result in "Cease to Operate" action taken by DHS to shut down the chemical operations
- Chemical organizations must submit documentation and inventories to a central DHS application called Top Screen

Government / Military Sectors: NIST 800-53

- All Federal systems must pass accreditation and certification processes based on NIST 800-53
- Control Systems and SCADA Systems in use at Federal installations could not pass certification testing due to their unique differences
- NIST 800-82 written as a best practice guide for securing SCADA systems
- NIST 800-53 updated to NIST 800-53a and SCADA specific language added. The current standard is NIST 800-53 rev3.
- The underlining technical systems can not be commissioned and put into operational use if they are not compliant – no current financial penalties for non-compliance



Sector-Specific Agency	Critical Infrastructure/Key Resources Sector	Security Standard
Department of Agriculture[1] Department of Health and Human Services[2]	Agriculture and Food	TBD
Department of Defense[3]	Defense Industrial Base	FIPS, FISMA, NIST 800-53 rev3
Department of Energy	Energy[4]	NERC CIP
Department of Health and Human Services	Public Health and Healthcare	FIPS, FISMA, NIST 800-53 rev3, HIPPA
Department of the Interior	National Monuments and Icons	TBD
Department of the Treasury	Banking and Finance	PCI, NIST 800-53 rev3
Environmental Protection Agency	Drinking Water and Water Treatment Systems	AWWA >> CFATS
Department of Homeland Security *Office of Infrastructure Protection*	Chemical Commercial Facilities Dams Emergency Services Commercial Nuclear Reactors, Materials, and Waste	CFATS, NEI-0404, NIST 800-53 rev3
Office of Cyber Security and Telecommunications	Information Technology Telecommunications	FIPS, FISMA, NIST 800-53 rev3
Transportation Security Administration	Postal and Shipping	FIPS, FISMA, NIST 800-53 rev3
Transportation Security Administration, United States Coast Guard[5]	Transportation Systems[6]	TBD
Immigration and Customs Enforcement, Federal Protective Service	Government Facilities	FIPS, FISMA, NIST 800-53 rev3



Sector-Specific Agency	Critical Infrastructure/Key Resources Sector	Security Standard
Department of Agriculture[1] Department of Health and Human Services[2]	Agriculture and Food	TBD >> **NIST 800-53 rev3**
Department of Defense[3]	Defense Industrial Base	FIPS, FISMA, **NIST 800-53 rev3**
Department of Energy	Energy[4]	NERC CIP >> **NIST 800-53 rev3**
Department of Health and Human Services	Public Health and Healthcare	FIPS, FISMA, **NIST 800-53 rev3**, HIPPA
Department of the Interior	National Monuments and Icons	TBD >> **NIST 800-53 rev3**
Department of the Treasury	Banking and Finance	PCI, **NIST 800-53 rev3**
Environmental Protection Agency	Drinking Water and Water Treatment Systems	AWWA >> CFATS >> **NIST 800-53 rev3**
Department of Homeland Security *Office of Infrastructure Protection*	Chemical Commercial Facilities Dams Emergency Services Commercial Nuclear Reactors, Materials, and Waste	CFATS, NEI-0404, **NIST 800-53 rev3**
Office of Cyber Security and Telecommunications	Information Technology Telecommunications	FIPS, FISMA, **NIST 800-53 rev3**
Transportation Security Administration	Postal and Shipping	FIPS, FISMA, **NIST 800-53 rev3**
Transportation Security Administration, United States Coast Guard[5]	Transportation Systems[6]	TBD >> **NIST 800-53 rev3**
Immigration and Customs Enforcement, Federal Protective Service	Government Facilities	FIPS, FISMA, **NIST 800-53 rev3**

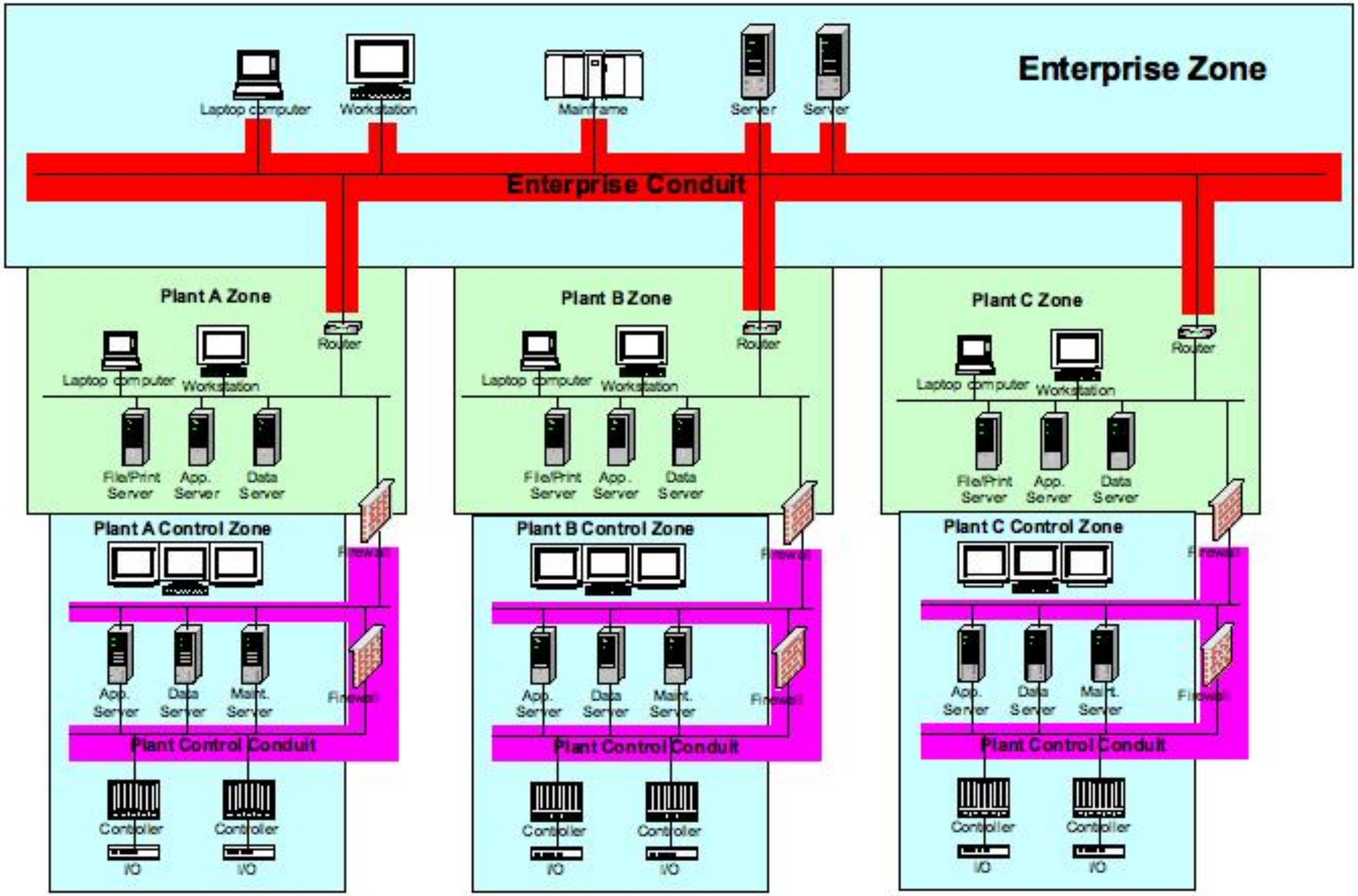
Standards and Regulations can be overwhelming at times. Seek professional advice if you believe your business may be impacted….

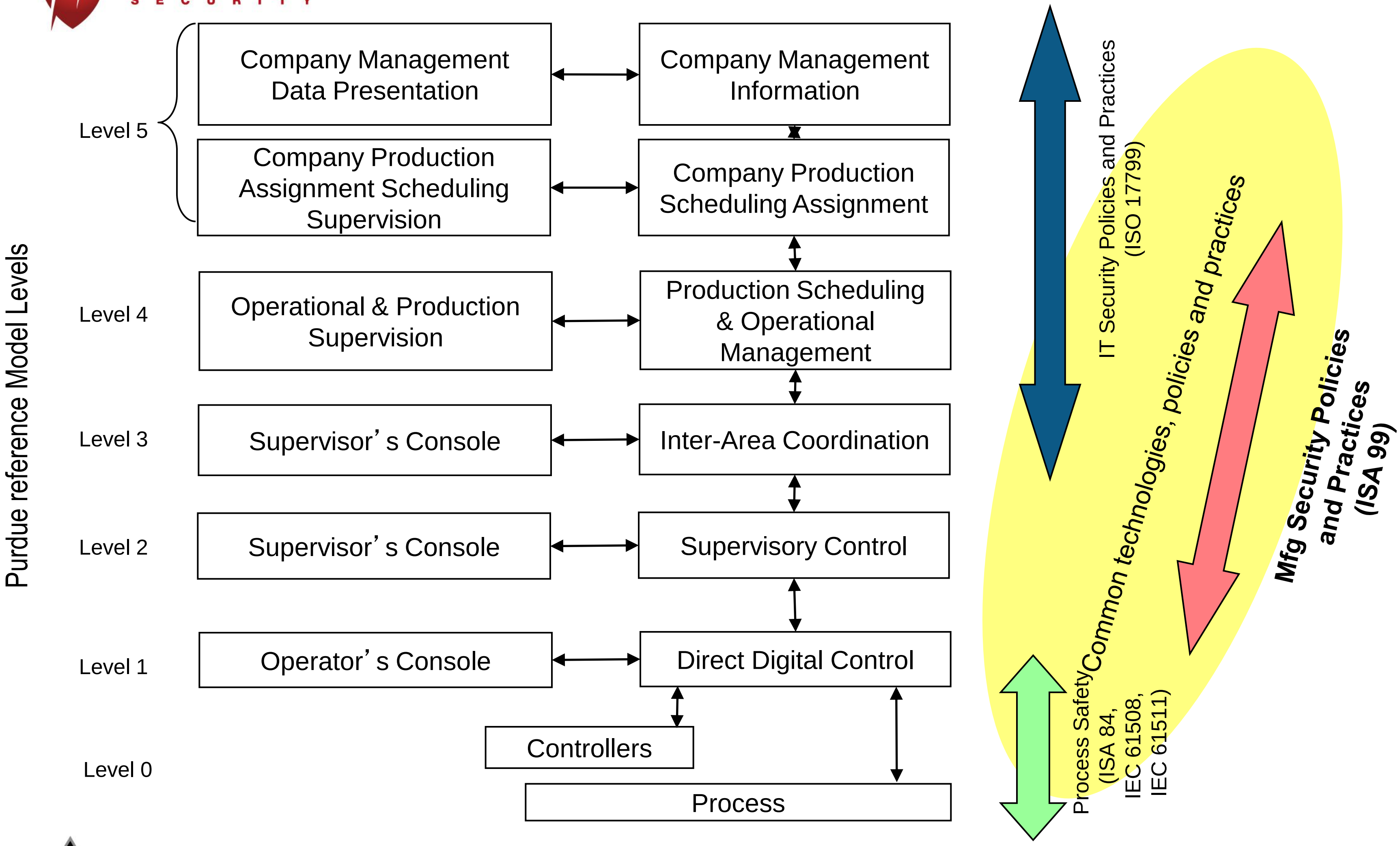
"Nurse, get on the internet, go to SURGERY.COM, scroll down and click on the 'Are you totally lost?' icon."

ISA S99 (now referenced in NIST 800-53)

- Four Part Standard
  - ISA S99.00.01 – Models, Definitions, and Terminology
  - ISA S99.00.02 - Establishing a Manufacturing and Control System Security Program
  - ISA S99.00.03 – Operating a Manufacturing and Control Systems Security Program
  - ISA S99.00.04 - Specific Security Requirements for Manufacturing and Control Systems
  - (more documents and work products being released soon)

Source: http://www.isa.org/MSTemplate.cfm?MicrositeID=988&CommitteeID=6821


Enterprise Zone
Laptop computer
Workstation
Mainframe
Server
Server
Enterprise Conduit
Plant A Zone
Router
Laptop computer
Workstation
File/Print Server
App. Server
Data Server
Plant A Control Zone
Firewall
App. Server
Data Server
Maint. Server
Firewall
Plant Control Conduit
Controller
I/O
Controller
I/O
Plant B Zone
Router
Laptop computer
Workstation
File/Print Server
App. Server
Data Server
Plant B Control Zone
Firewall
App. Server
Data Server
Maint. Server
Firewall
Plant Control Conduit
Controller
I/O
Controller
I/O
Plant C Zone
Router
Laptop computer
Workstation
File/Print Server
App. Server
Data Server
Plant C Control Zone
Firewall
App. Server
Data Server
Maint. Server
Firewall
Plant Control Conduit
Controller
I/O
Controller
I/O



Purdue reference Model Levels

Level 5

Company Management Data Presentation

Company Management Information

Company Production Assignment Scheduling Supervision

Company Production Scheduling Assignment

Level 4

Operational & Production Supervision

Production Scheduling & Operational Management

Level 3

Supervisor’s Console

Inter-Area Coordination

Level 2

Supervisor’s Console

Supervisory Control

Level 1

Operator’s Console

Direct Digital Control

Level 0

Controllers

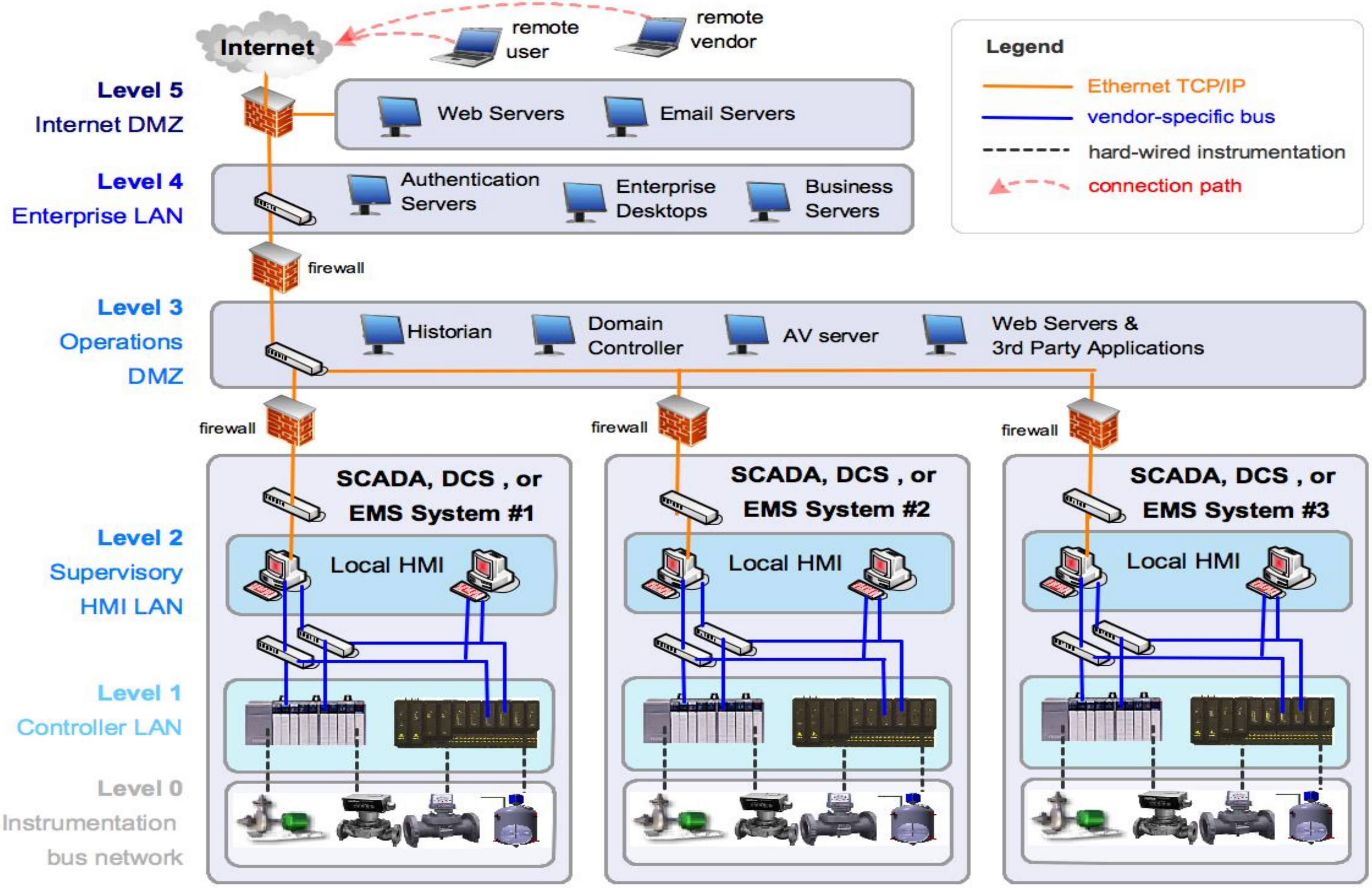
Process

IT Security Policies and Practices (ISO 17799)

Common technologies, policies and practices

Mfg Security Policies and Practices (ISA 99)

Process Safety (ISA 84, IEC 61508, IEC 61511)


Internet
remote user
remote vendor
Legend
Ethernet TCP/IP
vendor-specific bus
hard-wired instrumentation
connection path
Level 5
Internet DMZ
Web Servers
Email Servers
Level 4
Enterprise LAN
Authentication Servers
Enterprise Desktops
Business Servers
firewall
Level 3
Operations DMZ
Historian
Domain Controller
AV server
Web Servers & 3rd Party Applications
firewall
firewall
firewall
SCADA, DCS , or EMS System #1
SCADA, DCS , or EMS System #2
SCADA, DCS , or EMS System #3
Level 2
Supervisory HMI LAN
Local HMI
Local HMI
Local HMI
Level 1
Controller LAN
Level 0
Instrumentation bus network

ISA S99 Committee Work Products List

ISA Number	IEC Number (proposed)	Work Product Subject	Status
ISA-99.01.01	IEC 62443-1-1	Terminology, Concepts And Models	Released
ISA-TR99.01.02	IEC/TR 62443-1-2	Master Glossary of Terms and Abbreviations	Draft
ISA-99.01.03	IEC 62443-1-3	Security Compliance Metrics	Draft
ISA-99.02.01	IEC 62443-2-1	Establishing an IACS Security Program	Released
ISA-99.02.02	IEC 62443-2-2	Operating an IACS Security Program	Proposed
ISA-TR99.02.03	IEC/TR 62443-2-3	Patch Management in the IACS Environment	Proposed

ISA S99 Work Products List continued…

ISA Number	IEC Number (proposed)	Work Product Subject	Status
ISA-TR99.03.01	IEC/TR 62443-3-1	Security Technologies for Industrial Automation and Control Systems	Released
ISA-99.03.02	IEC 62443-3-2	Target Security Assurance Levels for Zones and Conduits	Draft
ISA-99.03.03	IEC 62443-3-3	System Security Requirements and Security Assurance Levels	Draft
ISA-99.03.04	IEC 62443-3-4	Product Development Requirements	Proposed
ISA-99.04.01	IEC 62443-4-1	Embedded Devices	Proposed
ISA-99.04.02	IEC 62443-4-2	Host Devices	Proposed
ISA-99.04.03	IEC 62443-4-3	Network Devices	Proposed
ISA-99.04.04	IEC 62443-4-4	Applications, Data and Functions	Proposed

ISA99 Common	**ISA-99.01.01** Terminology, Concepts And Models	**ISA-TR99.01.02** Master Glossary of Terms and Abbreviations	**ISA-99.01.03** System Security Compliance Metrics was ISA-99.03.03	
Security Program	**ISA-99.02.01** Establishing an IACS Security Program	**ISA-99.02.02** Operating an IACS Security Program	**ISA-TR99.02.03** Patch Management in the IACS Environment	
Technical - System	**ISA-TR99.03.01** Security Technologies for Industrial Automation and Control Systems was ISA-TR99.00.01-2007	**ISA-99.03.02** Target Security Assurance Levels for Zones and Conduits was Target Security Levels	**ISA-99.03.03** System Security Requirements and Security Assurance Levels was Foundational Requirements was ISA-99.01.03	**ISA-99.03.04** Product Development Requirements
Technical - Derived	**ISA-99.04.01** Embedded Devices	**ISA-99.04.02** Host Devices	**ISA-99.04.03** Network Devices	**ISA-99.04.04** Applications, Data And Functions

Sample Security Framework - NERC CIP

- Provide a quick overview of the NERC CIP standards
- Allow time for a NERC CIP update at the end

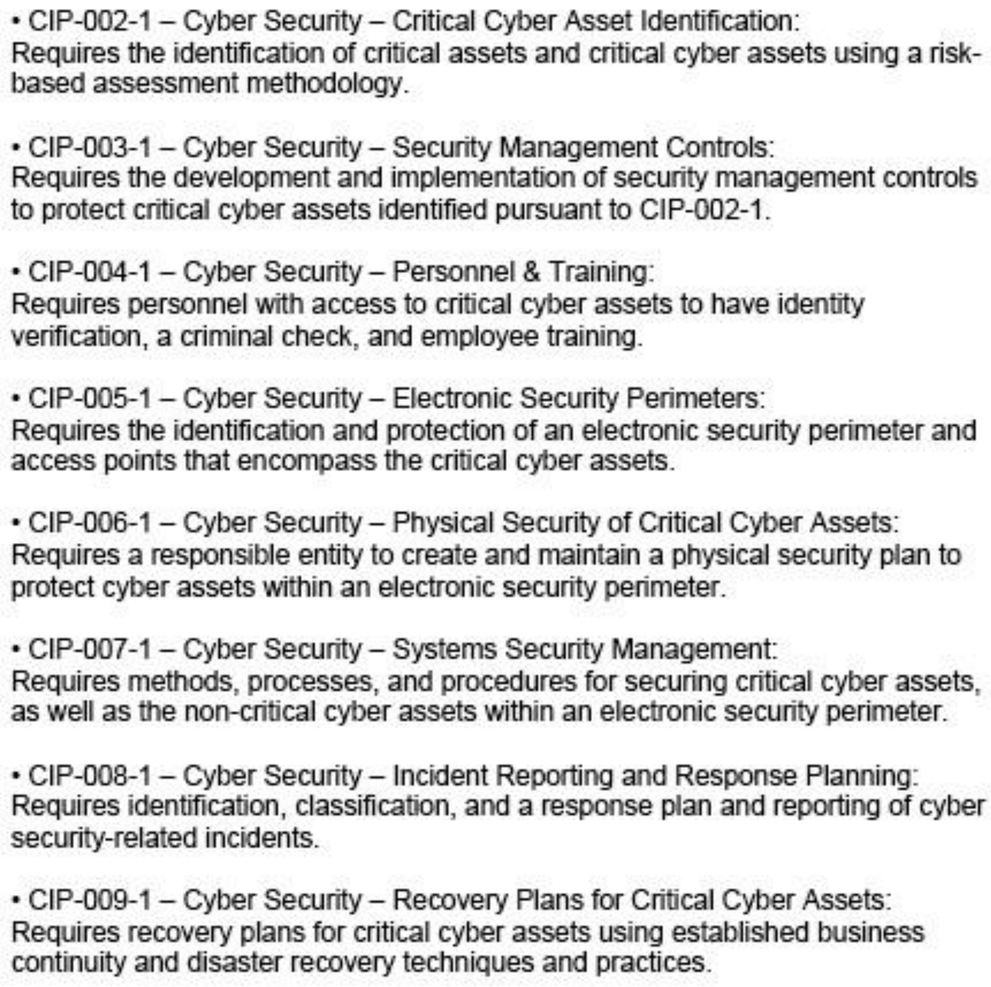
Major Functional Areas	NERC CIP Standards	ISO/IEC 17799	API 1164	NIST Publications
Risk Assessment / Asset Identification	CIP-002	5	B.1, 4.1, 4.1.5	800-30
Network Management	CIP-005	8.5	3.1,6.1	800-12
Change Management	CIP-006	10.5.1	B.3.1	800-12
Access Controls	CIP-003, CIP-004, CIP-005, CIP-006, and CIP-007	9	2, B.3.6.2	800-14
Governance	CIP-003	4	B.5	800-14
Incidence Response	CIP-008	6.3	7.2	800-12, 800-14, 800-61
Information Classification & Handling	CIP-003	5.2.2	4.1.5	800-14
HR and Personal Risk Assessment	CIP-004	6.1.2	4.1.4,5.1.1	800-14
Physical Security	CIP-006	7	5	800-12, 800-14
Recovery Operations	CIP-009	8.4.1	B.3.5.1	800-92
Systems Management	CIP-007	8	3	800-12, 800-14
Testing	CIP-007	11.1.5,11.1.5.1-11.1.5.2	B.2.3.5	800-12, 800-14, 800-42
Training	CIP-004	6.2.1	7.1, B.5.2, B. 5.2.4	800-12, 800-14, 800-50
Vulnerability Assessment	CIP-005, CIP-007	7.1.1, 7.1.5, 7.2.5, 7.2.6	2.1, 5.1.1-2, B.2	800-12, 800-26, 800-42

Framework for Understanding the NERC CIP Standard

All areas of the NERC CIP Standard can be mapped into 14 “Functional Areas”

> Risk Assessment / Asset Identification
> Network Management
> Change Management
> Access Controls
> Governance
> Incidence Response
> Information Classification & Handling
> HR and Personal Risk Assessment
> Physical Security
> Recovery Operations
> Systems Management
> Testing
> Training
> Vulnerability Assessment

NERC CIP Standards Overview



- CIP-002-1 – Cyber Security – Critical Cyber Asset Identification: Requires the identification of critical assets and critical cyber assets using a risk-based assessment methodology.

- CIP-003-1 – Cyber Security – Security Management Controls: Requires the development and implementation of security management controls to protect critical cyber assets identified pursuant to CIP-002-1.

- CIP-004-1 – Cyber Security – Personnel & Training: Requires personnel with access to critical cyber assets to have identity verification, a criminal check, and employee training.

- CIP-005-1 – Cyber Security – Electronic Security Perimeters: Requires the identification and protection of an electronic security perimeter and access points that encompass the critical cyber assets.

- CIP-006-1 – Cyber Security – Physical Security of Critical Cyber Assets: Requires a responsible entity to create and maintain a physical security plan to protect cyber assets within an electronic security perimeter.

- CIP-007-1 – Cyber Security – Systems Security Management: Requires methods, processes, and procedures for securing critical cyber assets, as well as the non-critical cyber assets within an electronic security perimeter.

- CIP-008-1 – Cyber Security – Incident Reporting and Response Planning: Requires identification, classification, and a response plan and reporting of cyber security-related incidents.

- CIP-009-1 – Cyber Security – Recovery Plans for Critical Cyber Assets: Requires recovery plans for critical cyber assets using established business continuity and disaster recovery techniques and practices.

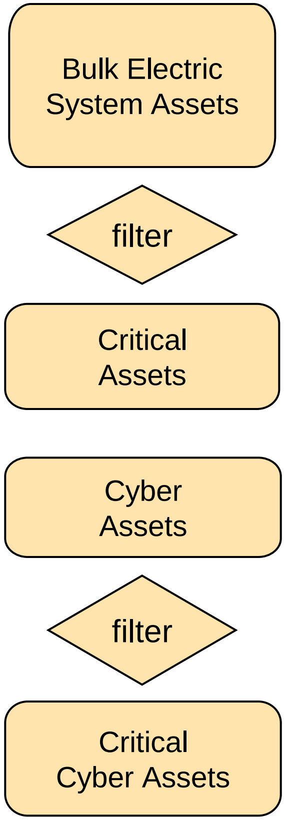
Risk Assessment / Asset Identification (CIP-002)

Step 1 - Gather information regarding generation resources, substations, control centers, system restoration processes, load shedding, and protection processes to build a list of **ASSETS**

Step 2 - Select a Risk Based Assessment process and document that process *(required documentation)*. Use that process to filter this large list down to a list of only those that are **CRITICAL ASSETS** *(also required documentation)*

Step 3 - Identify the **CYBER ASSETS** that support the functions of those critical assets, then filter only those cyber assets that are *essential to the operations of the critical assets.*

Step 4 - Generate the list of **CRITICAL CYBER ASSETS** *(required documentation)*
NOTE: Keep in mind that non-critical cyber assets inside the electronic perimeter must be treated as critical cyber assets.



Network Management (CIP-002/5)

- Step 1 - Identify and document the ELECTRONIC SECURITY PERIMETER (ESP)
- Step 2 - Identify and document all ACCESS POINTS (AP) in and out
- Step 3 - Identify and document all CRITICAL and NON-CRITICAL CYBER ASSETS within the Electronic Perimeter
  - Comments:
    > Don't forget about DIAL-UP connections
    > Links between perimeters are not considered part of the ESP
    > End points for these links are also considered APs.
- Why is the ESP important?
  - Determines scope for access controls, monitoring, physical protection, and training
  - Drives documentation and log retention requirements
- ESP and all Corresponding Documentation Must be Reviewed Annually

Change Management (CIP-003)

- Most are familiar with Change Management from Corporate requirements, SOX, or other requirements for change management
- Examples of how it is required for NERC CIP Compliance includes:
  - List of Assets, Critical Assets, and Critical Cyber Assets must be documented as changes are made
  - Documented testing required prior to changes made to production systems
  - Patch Management
  - Any changes to the ESP must be put through Change Management
  - Any changes to the Physical Security Perimeter (PSP) must also be documented
  - Any change to the known services/ports allowed on hosts and through access points must also go through Change Management
  - Any change to personnel that have physical access to critical cyber assets

Change Management (CIP-003)

- What Documentation is Required for Change Management (How do you do it?)
  - **Document the Process**
    - Types of change to be made
    - Who will initiate the change
    - Who approves the change
    - Who tests the change
    - Who implements the change
  - **Document the Results**
    - Performance of system after change
    - Any incidents or emergencies caused by the change

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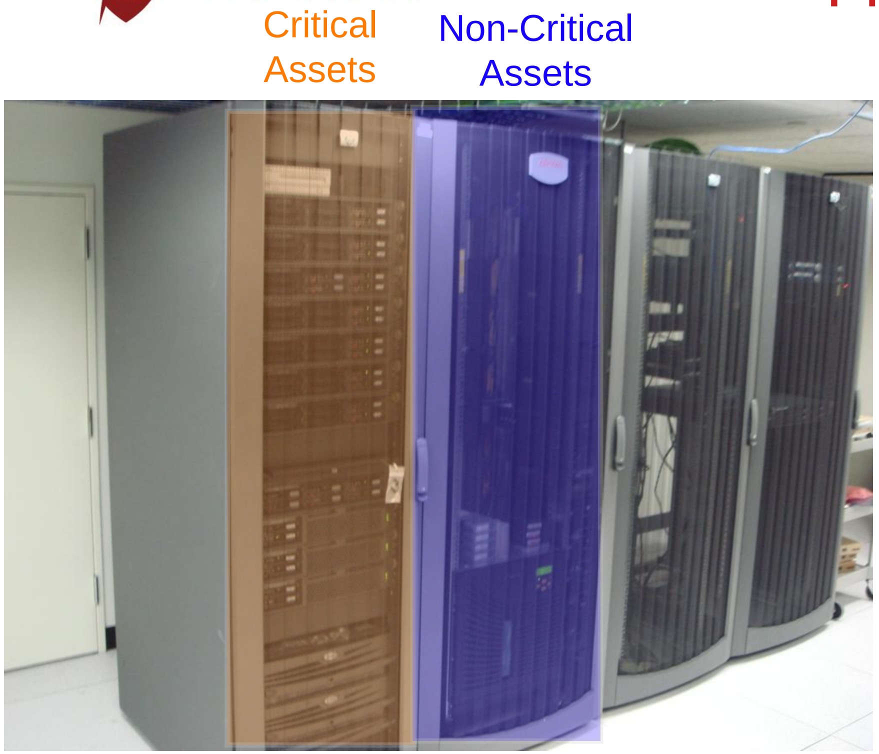
Change Management (Tip)

- What if changes are made by outside resources out of my control?
  - **1. Vendor / System Integrator**
    - Document the Change Management process
    - Create a “cheat sheet” one-page version for vendors with access to the system
    - Require service provider to follow the process
    - Periodically test to ensure that process is being followed
  - **2. Enterprise IT Group Responsible for Some Assets**
    - They should be following a corporate policy
    - Check to make sure that this corporate policy fulfills NERC requirements
    - Request periodic supporting documentation that Change Management is followed
  - **3. Outsourced MSS (Managed Security Services)**
    - Outsourced entity can do this for you as a service

Access Controls (5 out of the 8 standards cover this)

- CIP-003, CIP-004, CIP-005, CIP-006, and CIP-007
- Process must be in place to provide access controls to Critical Cyber Assets **and** any information relating to Critical Cyber Assets
- Management Controls must be reviewed annually
- Documentation must be kept up to date on who has authorized, unescorted, physical access to Critical Cyber Assets
- Hint:
  - Scope can be reduced by limiting assets within the Physical and Electronic Security Perimeters
  - Move non-essential applications and systems out of the ESP and PSP
  - Consider installing Critical Cyber Assets in small locked cages or locked cabinets...entire room does not need to be within the PSP (cage creates 6 walls)

Physical Security Perimeters



Cages and fencing can create the required “6-walls” within the existing Data Center, if Enterprise IT and SCADA/EMS systems are currently in the same room.

Access Controls (Personnel and Remote Access)

- Personnel Implications
  - List of authorized personnel reviewed quarterly
  - Any change to list must be documented within 7 days
  - Change of personnel
  - Change of access rights (initiating or revoking)
  - Personnel Terminated for cause must be documented in 24 hours
  - NOTE: includes Contractors and/or Vendors
- Don't Forget about Remote Access (included under Electronic Access Controls)
  - Provide challenge/response for any access requested into the ESP
  - Log all attempts (successful and unsuccessful) into the ESP
  - Must be setup as Deny-By-Default...include Appropriate Use Banners where possible
  - Logs to be retained for 90 days / User accounts reviewed annually

Access Controls (Systems Management) – NERC CIP-003

- Requirements for Systems Management should already be in place
  - If not already done so, limit access to and use of Administrator accounts by:
    - Identifying those with access to Administrator and Shared Accounts
    - Limiting access to only those with authorization
    - Require Administrators to log on with their own unique login, not the Administrator account
    - Document the process for changing access levels upon personnel change
    - Always "enable" auditing and logging of any activity performed by Administrator, accounts with Admin privileges, or shared accounts
    - Remove, disable, or rename Administrator accounts wherever possible
    - Change Administrator passwords routinely - especially after personnel or contractor change

Access Controls (Password Management) – NERC CIP-003

- Because of Operational Considerations, Passwords Requirements by NERC CIP will typically be lower than requirements by corporate IT policies
  - Wherever technically feasible, passwords must:
    - Have a minimum of 6 characters
    - Contain a combination of alpha, numeric, and “special” characters
    - Should be changed at LEAST annually, however, should be changed more often based on risk
- Hints:
  - Use of Domain Controllers within the environments supporting Critical Cyber Assets allow for easier system management
  - Changes can be “pushed” out to multiple workstations, once tested
  - All logs can be centrally managed (technology can reduce human labor)

Governance (CIP-003)

- Identifying the “Responsible Entity”
  - Should also extend into identifying the Internal CIP Compliance Team, but documentation of the team is not required, only the “Responsible Entity
  - Documentation required within 30 days of any change in the “Responsible Entity”
  - Most areas can be delegated, but annual review of the security policy can not be delegated to anyone else
- Cyber Security Policy
  - Policy must address all areas of CIP-002 through CIP-009
  - Can be made up of a group of security policies, but must be able to prove that all areas of NERC CIP compliance is covered across all policies
  - Exceptions to policy can be granted based on emergency conditions
  - Security Policies must be made available publicly

Incidence Response (CIP-008)

- Need to document which types of incidents are classified as a "Cyber Security Incident"
  - Malicious or suspicious events require following the IR plan
  - Normal operational failures not in scope

- Response Plan should include:
  - What events trigger the IR plan
  - Tasks and checklists required to updating
  - Roles and responsibilities required to update the plan
  - Timing and requirements

Trojans infect SCADA system

Problem

A manufacturing company in the U.S. set up a direct link with one of their trading partners. The link bypassed the standard security, and allowed a Trojan onto the plant floor. The Trojan modified existing code on the SCADA system, making cleanup efforts very difficult.

Consequences

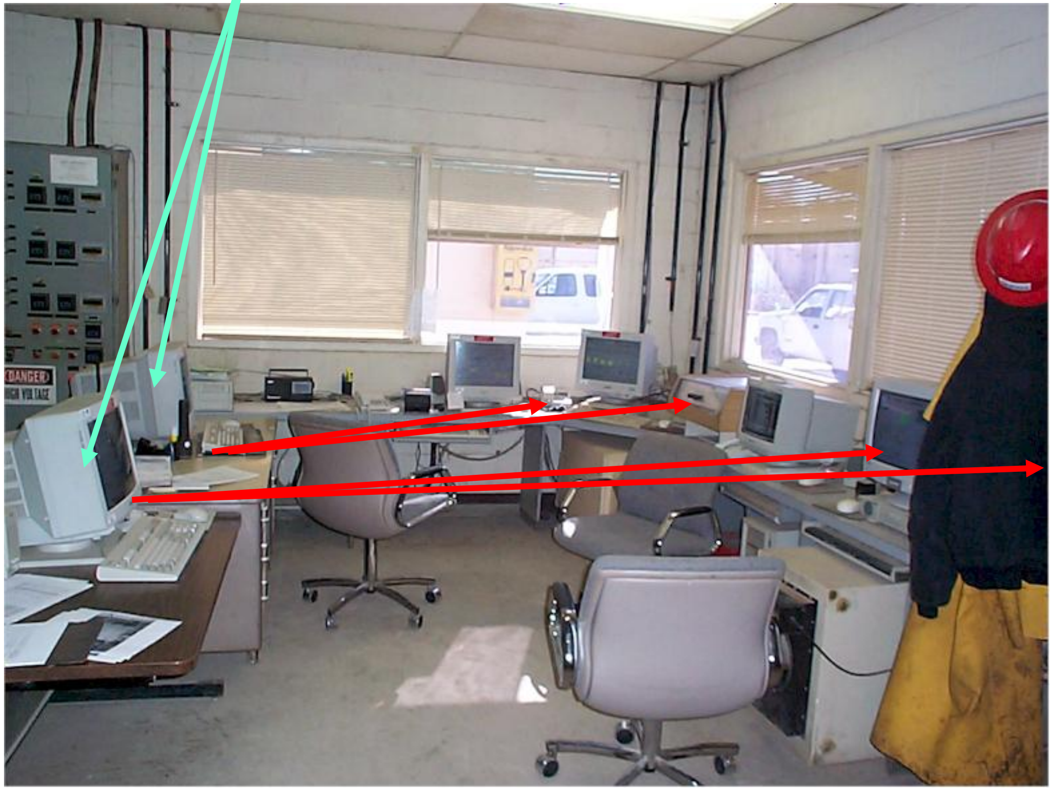
Cleanup efforts took two weeks with associated production productivity loss. All code became suspect, requiring reinstalling OS with the potential loss of customizations, configurations, the difficulty of locating original media, replicating original build, and retesting.

Key Control System Recommendations

Technology: Tighter firewall configuration rules, IDS, and IPS/Network Antivirus perimeter protection

Policy: Up to date recovery procedures and media

Computers on Corporate Network compromised, and used to plant Trojans on SCADA Computers awaiting control Commands from hacker.



An email was sent with a Trojan to a PC near the SCADA/DCS Systems, and then the Trojan was remotely controlled from anywhere in the world.

SCADA/DCS systems lacked virus protection software, and this case, the antivirus software was not maintained up to date.

Most SCADA computers we have observed do not have proper security patches installed.

Worm Crashes Offshore Oil/Gas SCADA System Causing $1.2 Million in Loses

Problem

In 2004, two major Oil and Gas Companies both had connections to an offshore production platform to monitor and control 4 large down hole wells. The operator of the platform had very tight strong cyber security, but the other royalty owner was also connected to the platform to get real-time data. The SQL Slammer worm crawled through the royalty owner’s corporate IT network, and onto the platform, and in less than a minute, all operator workstations and SCADA Servers were blue-screened and would not restart after reboot. It took 8 hours to restore the SCADA system and restart production.

Consequences

Immediate loss of monitoring the down-hole wells forced an ESD condition, and loss of production for all 4 major wells. Hard losses in production and pipeline fees totaled over $1.2 million before production was finally restored.

Key Control System Recommendations

Policy :	Did not implement a Network Connection Policy for 3rd Parties
	Restoration Media and Recovery Process Not Tested
Technology:	Missing a Defense-in-Depth Approach, no Antivirus at the perimeter, no IDS, no Antivirus on the Host Computers

Information Classification & Handling (CIP-003)

- **Identify Information that should be protected…examples include:**
  > Operational procedures
  > Lists required for CIP-002
  > Network Topologies
  > Floor plans of computing centers that contain Critical Cyber Assets
  > Equipment layouts of Critical Cyber Assets
  > Disaster Recovery Plans
  > Incident Response Plans

- **Information can be in multiple formats:**
  > Physical Documents
  > Electronic documents
  > Backup media
  > Mobile media (USB keys, CDs, DVDs, disks…)

- **Select a classification system…examples include:**
  > Government - Unclassified, Protected, Confidential, Secret, Top Secret
  > Industry - Public, Internal-only, Confidential, Restricted
  > Use a system that matches the organizations needs

Quick Check - What have we covered so far...

- All areas of the NERC CIP Standard can be mapped into 14 "Functional Areas"
  > Risk Assessment / Asset Identification
  > Network Management
  > Change Management
  > Access Controls
  > Governance
  > Incidence Response
  > Information Classification & Handling
  > HR and Personal Risk Assessment
  > Physical Security
  > Recovery Operations
  > Systems Management
  > Testing
  > Training
  > Vulnerability Assessment

HR and Personal Risk Assessment (CIP-004)

- Required Checks:
  - Identity verification
    - Form I-9 for the US
    - Canada developing similar verification
  - Seven year criminal check
    - Includes local, county, state, federal, and sex offenders registration
  - Can conduct more detailed reviews
    - (Employment history, education, credit checks...)
  - Criminal Check Considerations:
    - Responsible Entity should predefine what actions are considered “adverse”
    - Describe and list company liabilities for actions based on adverse information
    - Existing employee process vs. New hire process

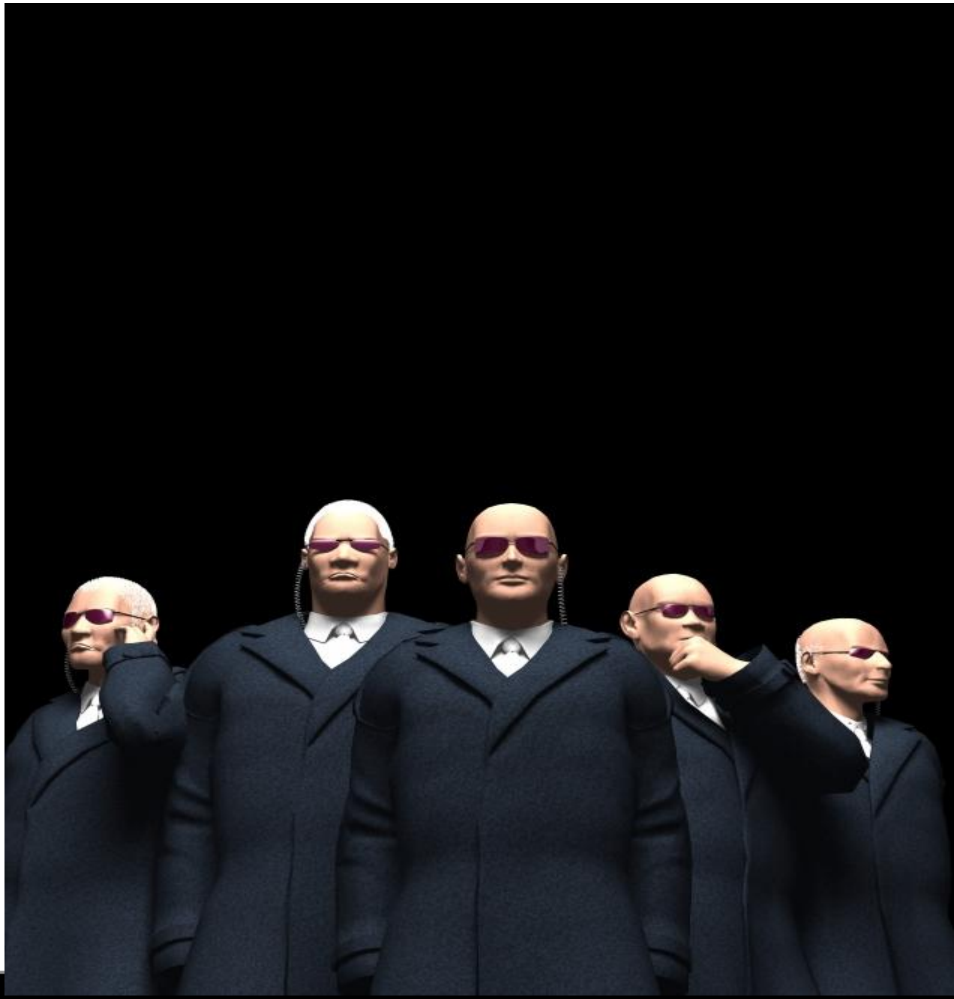
HR and Personal Risk Assessment (CIP-004)

- Rinse and Repeat
  - Update each personnel risk assessment at least every seven years or for cause
  - Company should provide managers with parameters to a “for cause” check
  - Supporting documentation must also be keep for “contractor and service vendor personnel”

- HINTS:
  - Make sure to include representation from HR when setting policy that impact personnel privacy
  - There may be implications when represented workers are involved

Physical Security (CIP-006)

- Physical Security Plan
- Physical Access Control
- Monitoring Physical Access
- Logging Physical Access
- Access Log Retention
- Maintenance and Testing



Physical Security (CIP-006)

- Starts with having and documenting a Physical Security Plan
- Similarities to Cyber
- Know your Perimeter (Hint: Remember small cages can still create the required “6-walls”)
- Know your Access Points (must manage access into PSP with 24x7 coverage)
- Know your Procedures (access rights, escorted / unescorted access, termination)
- Know your Controls (see list below, some include multi-factor authentication)

Card Key	Card Key: A means of electronic access where the access rights of the card holder are predefined in a computer database. Access rights may differ from one perimeter to another.
Special Locks	Special Locks: These include, but are not limited to, locks with “restricted key” systems, magnetic locks that can be operated remotely, and “man-trap” systems.
Security Personnel	Security Personnel: Personnel responsible for controlling physical access who may reside on-site or at a monitoring station.
Other Authentication Devices	Other Authentication Devices: Biometric, keypad, token, or other equivalent devices that control physical access to the Critical Cyber Assets.

Physical Security - Monitoring / Logging (CIP-006)

Just like Cyber, Physical Access Monitoring is also Important

Computerized Logging

Computerized Logging: Electronic logs produced by the Responsible Entity's selected access control and monitoring method.

Video Recording

Video Recording: Electronic capture of video images of sufficient quality to determine identity.

Manual Logging

Manual Logging: A log book or sign-in sheet, or other record of physical access maintained by security or other personnel authorized to control and monitor physical access as specified in Requirement R2.3.

Access Log Retention - 90 Days

Access Log Retention — The responsible entity shall retain physical access logs for at least ninety calendar days. Logs related to reportable incidents shall be kept in accordance with the requirements of Standard CIP-008.

Maintenance and Testing

Maintenance and Testing — The Responsible Entity shall implement a maintenance and testing program to ensure that all physical security systems under Requirements R2, R3, and R4 function properly. The program must include, at a minimum, the following:

Recovery Operations (CIP-009)

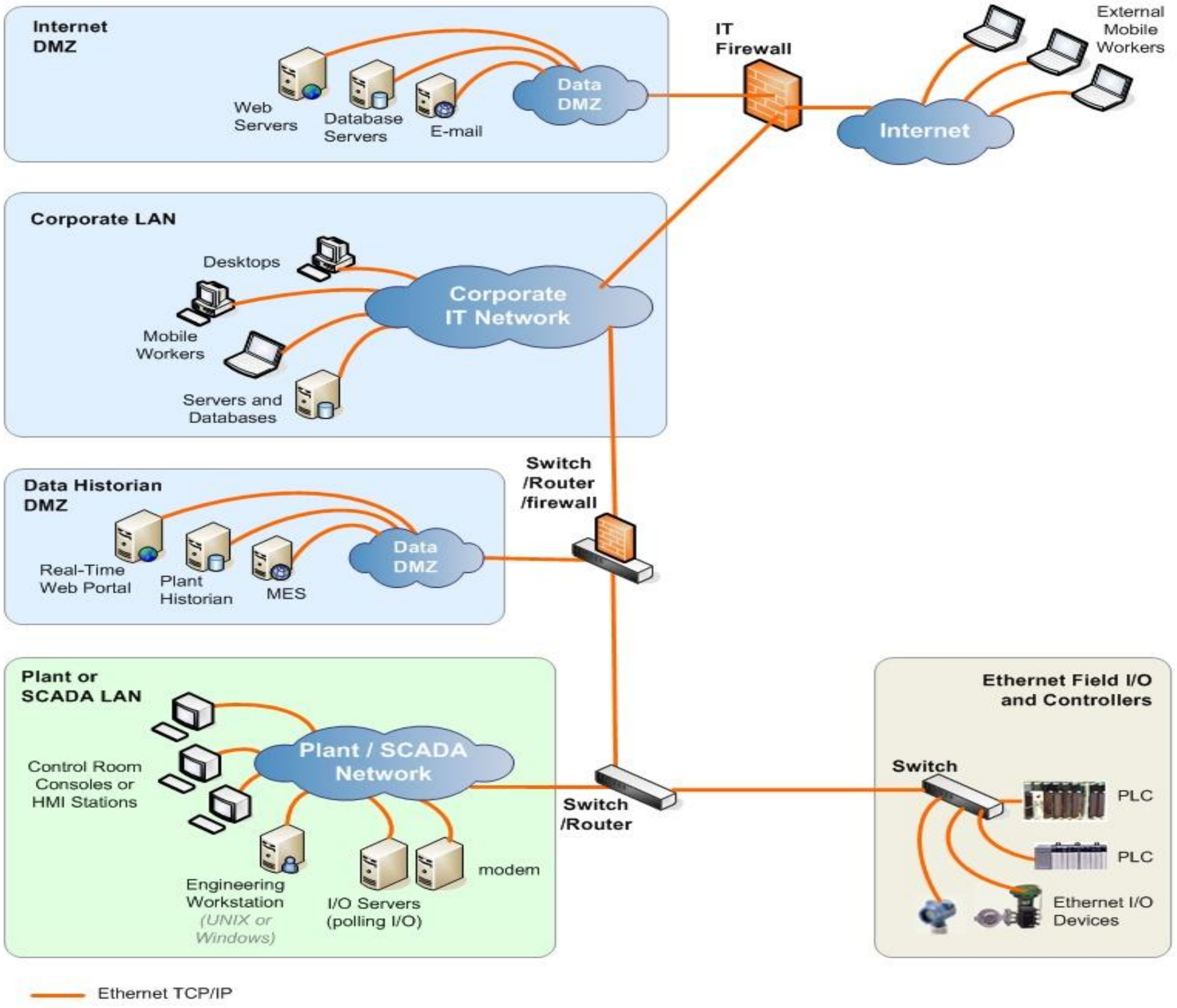
- Standard CIP-009 ensures that recovery plan(s) are put in place for Critical Cyber Assets and that these plans follow established business continuity and disaster recovery techniques and practices.
  - First Step? - Establish your Recovery Plan
  - Procedure to specify actions in response to event/conditions that would activate the plan
  - Definition of responder roles and responsibilities
  - Annual recovery plan exercise procedure
  - Recovery Plan change control procedure
  - Backup and Restore procedure
  - Backup media test procedure
  - Use a reliable tape rotation schedule, and routinely check for restore capability

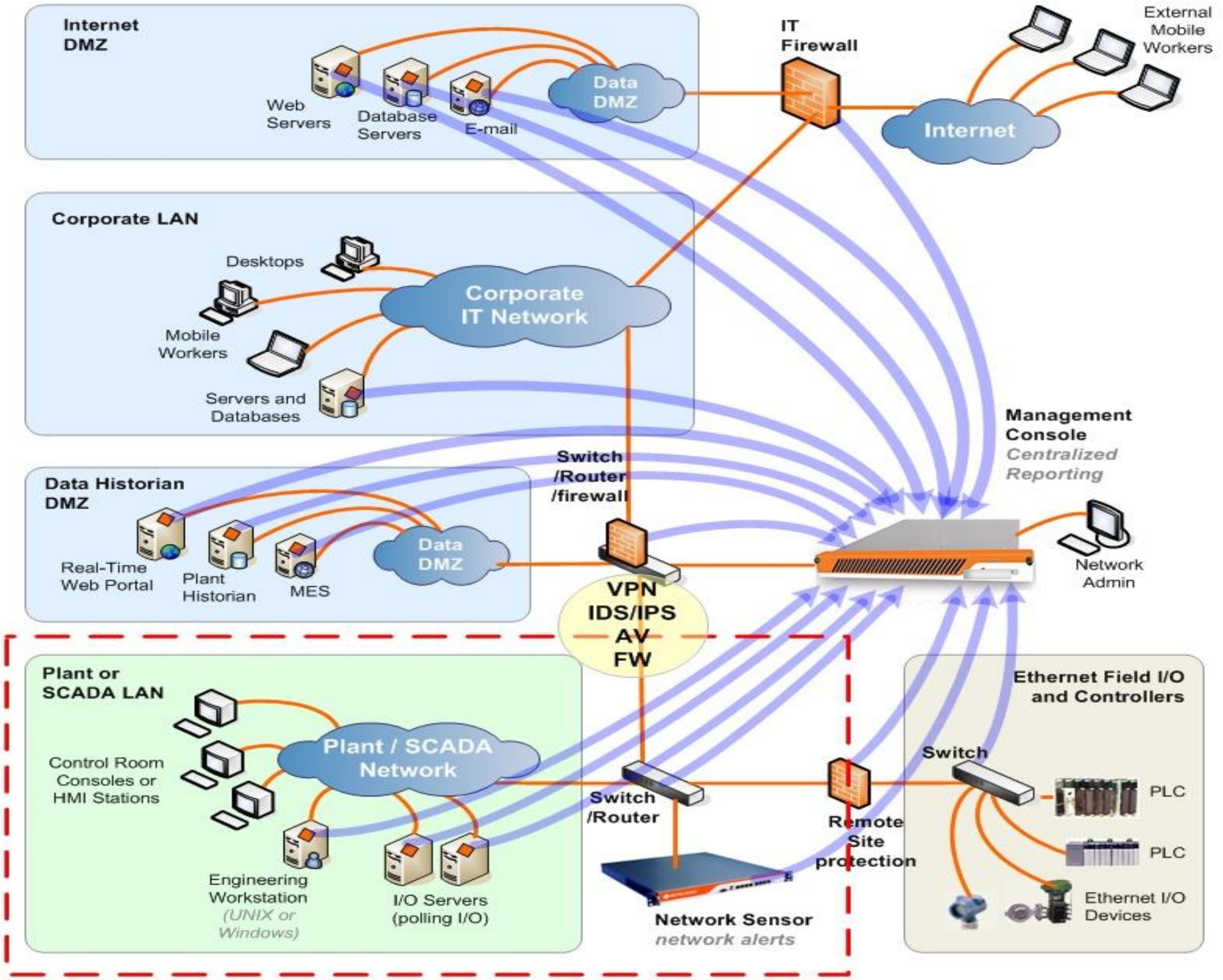
Systems Management (CIP-007)

- Ports and Services
  - Document known ports and services and only enable those required for normal and emergency operations
  - Disable unused ports and services
  - NOTE: It helps to capture traffic for 10 to 15 minutes first to see what the typical ports and setting are in use
- Security Patch Management
  - Track with security patches for Critical Cyber Assets have been released
  - Evaluate if their are compelling reasons not to patch and document them
  - Test the patches on development systems first
  - Document the implementation of security patches

Systems Management (CIP-007)

- Malicious Software Prevention
  - The responsible party shall use anti-virus software and other malware prevention tools to detect, prevent, deter, or mitigate the exposure to propagation of malware
  - HINT: It is easier to deploy and maintain antivirus-on-the-wire at the perimeter than on the systems within the perimeter
- Security Status Monitoring
  - Security monitoring controls shall issue automated or manual alerts when they detect something out of the norm
  - Processes for enabling ports on hosts, routers, and firewalls
  - Alerts generated by the monitoring solution should be logged
  - Logs must be maintained for a minimum of 90 days
  - Documentation / reporting requirements
  - HINT: Security Monitoring, Alert Correlation, Central Log Retention, and reporting can all be automated using technology - goal is to reduce human labor


Internet DMZ
Web Servers
Database Servers
E-mail
Data DMZ
IT Firewall
External Mobile Workers
Internet
Corporate LAN
Desktops
Mobile Workers
Servers and Databases
Corporate IT Network
Switch /Router /firewall
Data Historian DMZ
Real-Time Web Portal
Plant Historian
MES
Data DMZ
Plant or SCADA LAN
Control Room Consoles or HMI Stations
Plant / SCADA Network
Engineering Workstation (UNIX or Windows)
I/O Servers (polling I/O)
modem
Switch /Router
Ethernet Field I/O and Controllers
Switch
PLC
PLC
Ethernet I/O Devices
Ethernet TCP/IP



— Ethernet TCP/IP

⇒ Alert / Log Collection & Device Management

◆ Host-based Agents Reporting Statistics & Logs

Testing (CIP-007)

- Do you have procedures for TESTING your systems?

- A significant change shall, at a minimum, include implementation of security patches, cumulative service packs, vendor releases, and version upgrades of operating systems, applications, database platforms, or other third-party software or firmware.
    - Step 1 - Create the procedures
    - Step 2 - Test the procedures to ensure they are being followed
    - Step 3 - Document the rests from testing the procedures

- Document the test results
  > Perform "port scans" to identify open/available services
  > Check the file integrity to identify change in certain files
  > Review technical documentation for solutions to determine security features

- Testing should be integrated into the change management process

- Just like SOX, results from the testing of security controls must be documented

Training - General Security Awareness (CIP-004)

- Security Awareness Training is less rigorous, less detailed, and the content is left up to the utility
  > Examples include:
    > Password usage, management, shoulder surfing, tailgating, etc..
    > Unknown emails, attachments, spam, phishing
    > Social engineering techniques
    > Incident response
    > Access controls

- Training can be delivered through:
  > Direct Methods - Emails, Memos, Computer-based training
  > Indirect Methods - Posters, Intranet, Brochures
  > Management support and reinforcement - presentations and staff meetings

- Awareness training should be reinforced on a quarterly basis

- Most utilities should already be doing this

Training - Specific Training Courses (CIP-004)

- Unlike general security awareness training, this training content is specified and must be more detailed, and based on access to critical cyber assets

- Required content should include:
  > Proper use of Critical Cyber Assets
  > Concept of the Physical and Electronic Security Perimeter(s)
  > Proper handling of Critical Cyber Asset information
  > Action plans and procedures to recover Critical Cyber Assets and access following a Cyber Security Incident

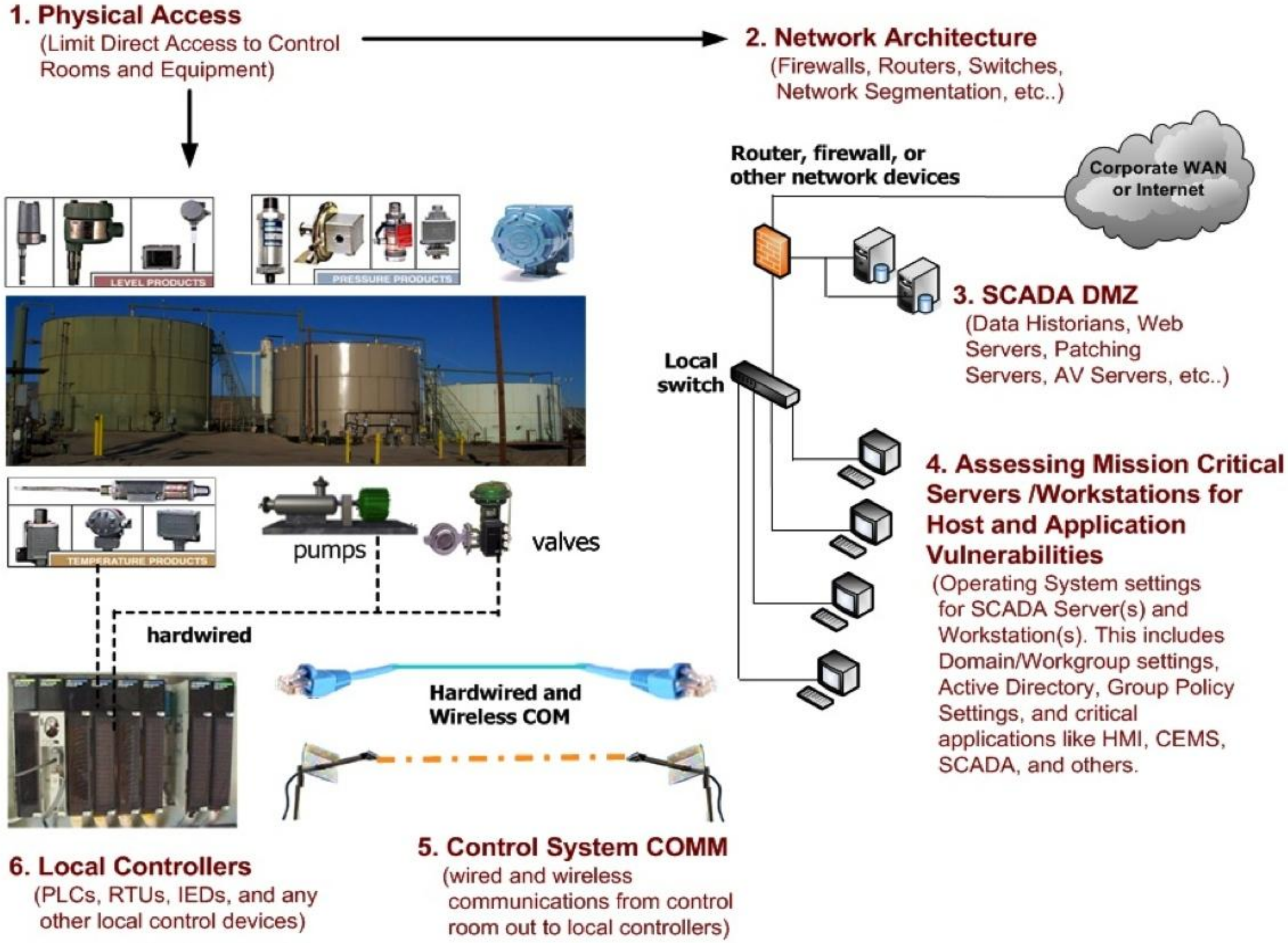
- NOTE: Having the training materials is the only proof required for the awareness training program

- NOTE: The job-specific training courses have greater requirements to show proof
  > Attendance records
  > Date when training was provided
  > Proof training was conducted at least annually
  > Documented training materials

Vulnerability Assessment (CIP-005, CIP-007)

- **Assessment process should include:**
  - Access into the Electronic Security Perimeter through Access Points (Perimeter)
  - Vulnerability Assessment of Cyber Assets within the perimeter (internal systems)
- **VA process should include:**
  - Documentation of the assessment methodology for:
    - Access points to the Electronic Security Perimeter (Perimeter)
    - The cyber assets inside the perimeter
  - At a minimum, this process / methodology should include:
    - Only those ports and services required for system operations are enabled
    - Required open ports may need additional security if services are vulnerable
    - Discovery of all access points
    - Review of the access controls, passwords, and network management
    - Methodical process for covering all cyber assets from the perimeter down to the lowest component in the system

Security Mapped to 6 Functional Areas



1. Physical Access
(Limit Direct Access to Control Rooms and Equipment)

2. Network Architecture
(Firewalls, Routers, Switches, Network Segmentation, etc..)

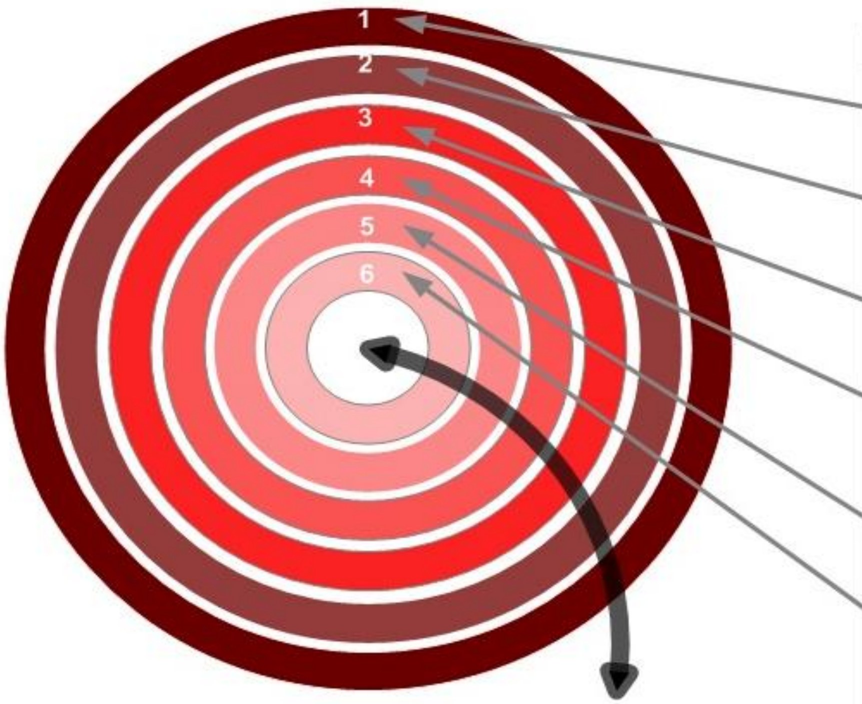
3. SCADA DMZ
(Data Historians, Web Servers, Patching Servers, AV Servers, etc..)

4. Assessing Mission Critical Servers /Workstations for Host and Application Vulnerabilities
(Operating System settings for SCADA Server(s) and Workstation(s). This includes Domain/Workgroup settings, Active Directory, Group Policy Settings, and critical applications like HMI, CEMS, SCADA, and others.

5. Control System COMM
(wired and wireless communications from control room out to local controllers)

6. Local Controllers
(PLCs, RTUs, IEDs, and any other local control devices)

Router, firewall, or other network devices
Corporate WAN or Internet
Local switch
LEVEL PRODUCTS
PRESSURE PRODUCTS
TEMPERATURE PRODUCTS
pumps
valves
hardwired
Hardwired and Wireless COM



Technical Controls

1. **Physical Security**
   (Fencing, Surveillance, Guards, Gates, Locks)
2. **Network Infrastructure**
   (Switches, Routers, Firewalls, 3rd Party Connections, and Modems)
3. **Manufacturing IT DMZ**
   (Data Historians, Data Logging, Web Servers)
4. **Mission Critical DCS Servers, Workstations, and Operator Consoles**
   (Operating System Security, Application Security)
5. **Communications to Field Devices**
   (Profibus, Modbus, OPC, and other protocols...)
6. **Field Devices**
   (PLCs, RTUs, IEDs, Plant Equip.)

Procedural Controls

Across all **Six Layers** spans the need for procedural controls that include:
- Governance, Security Policies, Plans, Procedures, and System Ownership
- Asset Inventory, System Documentation, Management of Change, and Test / Development Systems
- Risk Management, Patch Management, Lifecycle Planning, and Routine Assessments
- Crisis Management, Emergency Planning, Safety, and Safe Shutdown Procedures, Backup and Recovery

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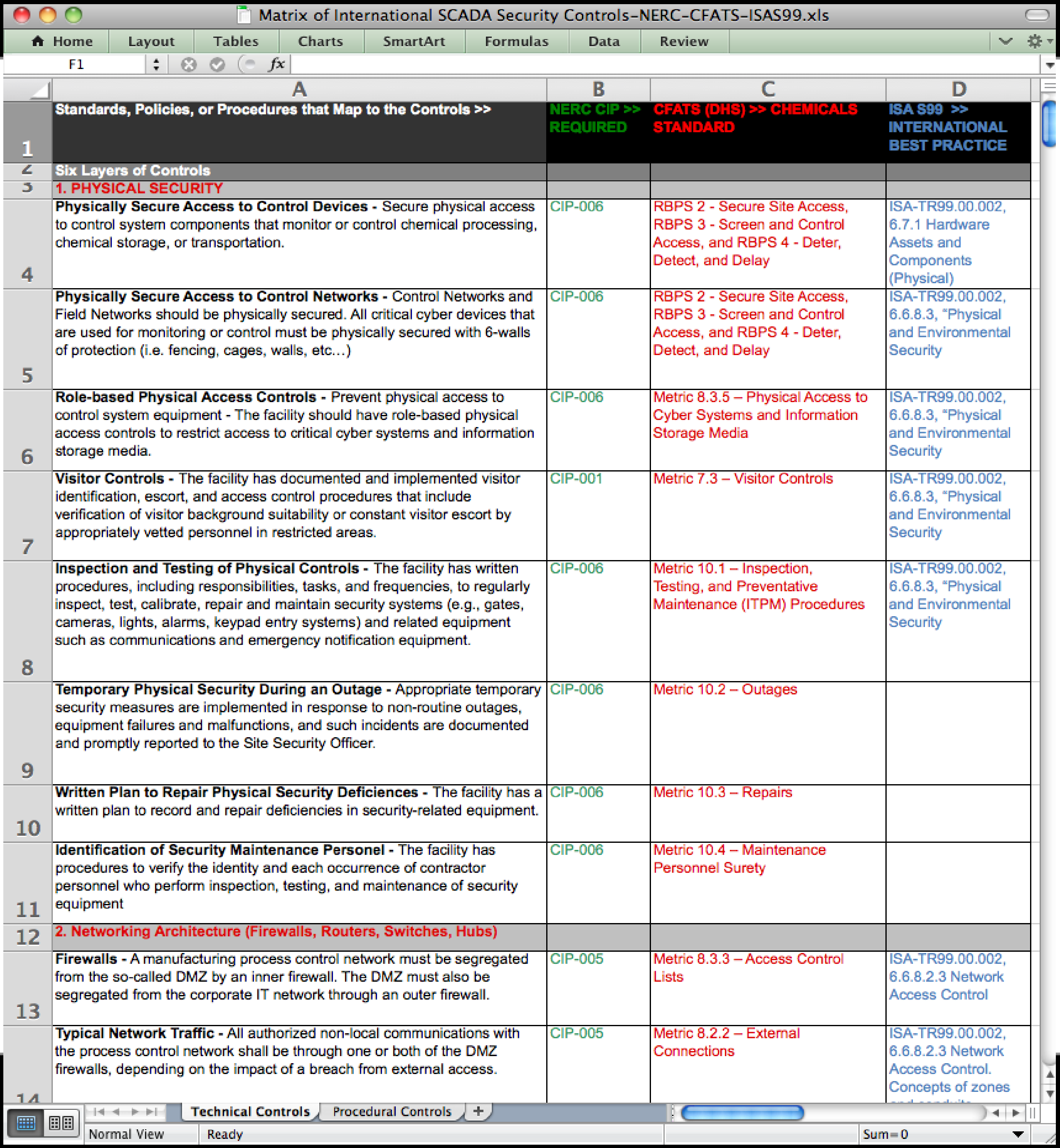
Security Controls by Functional Areas Mapped to NERC CIP, CFATS, and ISA S99 standards



Matrix of International SCADA Security Controls–NERC–CFATS–ISAS99.xls

	A	B	C	D
1	**Standards, Policies, or Procedures that Map to the Controls >>**	**NERC CIP >> REQUIRED**	**CFATS (DHS) >> CHEMICALS STANDARD**	**ISA S99 >> INTERNATIONAL BEST PRACTICE**
2	**Six Layers of Controls**			
3	**1. PHYSICAL SECURITY**			
4	**Physically Secure Access to Control Devices -** Secure physical access to control system components that monitor or control chemical processing, chemical storage, or transportation.	CIP-006	RBPS 2 - Secure Site Access, RBPS 3 - Screen and Control Access, and RBPS 4 - Deter, Detect, and Delay	ISA-TR99.00.002, 6.7.1 Hardware Assets and Components (Physical)
5	**Physically Secure Access to Control Networks -** Control Networks and Field Networks should be physically secured. All critical cyber devices that are used for monitoring or control must be physically secured with 6-walls of protection (i.e. fencing, cages, walls, etc…)	CIP-006	RBPS 2 - Secure Site Access, RBPS 3 - Screen and Control Access, and RBPS 4 - Deter, Detect, and Delay	ISA-TR99.00.002, 6.6.8.3, "Physical and Environmental Security
6	**Role-based Physical Access Controls -** Prevent physical access to control system equipment - The facility should have role-based physical access controls to restrict access to critical cyber systems and information storage media.	CIP-006	Metric 8.3.5 – Physical Access to Cyber Systems and Information Storage Media	ISA-TR99.00.002, 6.6.8.3, "Physical and Environmental Security
7	**Visitor Controls -** The facility has documented and implemented visitor identification, escort, and access control procedures that include verification of visitor background suitability or constant visitor escort by appropriately vetted personnel in restricted areas.	CIP-001	Metric 7.3 – Visitor Controls	ISA-TR99.00.002, 6.6.8.3, "Physical and Environmental Security
8	**Inspection and Testing of Physical Controls -** The facility has written procedures, including responsibilities, tasks, and frequencies, to regularly inspect, test, calibrate, repair and maintain security systems (e.g., gates, cameras, lights, alarms, keypad entry systems) and related equipment such as communications and emergency notification equipment.	CIP-006	Metric 10.1 – Inspection, Testing, and Preventative Maintenance (ITPM) Procedures	ISA-TR99.00.002, 6.6.8.3, "Physical and Environmental Security
9	**Temporary Physical Security During an Outage -** Appropriate temporary security measures are implemented in response to non-routine outages, equipment failures and malfunctions, and such incidents are documented and promptly reported to the Site Security Officer.	CIP-006	Metric 10.2 – Outages	
10	**Written Plan to Repair Physical Security Deficiences -** The facility has a written plan to record and repair deficiencies in security-related equipment.	CIP-006	Metric 10.3 – Repairs	
11	**Identification of Security Maintenance Personnel -** The facility has procedures to verify the identity and each occurrence of contractor personnel who perform inspection, testing, and maintenance of security equipment	CIP-006	Metric 10.4 – Maintenance Personnel Surety	
12	**2. Networking Architecture (Firewalls, Routers, Switches, Hubs)**			
13	**Firewalls -** A manufacturing process control network must be segregated from the so-called DMZ by an inner firewall. The DMZ must also be segregated from the corporate IT network through an outer firewall.	CIP-005	Metric 8.3.3 – Access Control Lists	ISA-TR99.00.002, 6.6.8.2.3 Network Access Control
14	**Typical Network Traffic -** All authorized non-local communications with the process control network shall be through one or both of the DMZ firewalls, depending on the impact of a breach from external access.	CIP-005	Metric 8.2.2 – External Connections	ISA-TR99.00.002, 6.6.8.2.3 Network Access Control. Concepts of zones

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Vulnerability Assessment Reporting

(CIP-005, CIP-007)

Find #: 2

Vulnerability	Severity Level
2. ICMP is not filtered at the Access Points	🟨🟨🟧🟧⬜

Description	Impact
The firewall device configurations showed that ICMP protocol is being allowed from the outside of the firewall.	While ICMP protocol is typically enabled to allow system administrators to "ping" devices for troubleshooting purposes, it also allows attackers to build covert tunnels that bypass firewall rules. Heavy amounts of ICMP packets has also been known to crash SCADA applications and embedded devices.

Systems Affected:	All firewall devices reviewed
Recommendations	Disable ICMP protocol from the public or outside interface of the firewalls. If a network monitoring application requires ICMP to work through the firewall, then limit the protocol to work only from a known documented source IP address.
Level of Effort:	Low

Response / Actions

Session Summary Points

- Provided an overview of the US NIPP (National Infrastructure Protection Plan)
- Mapped the US Government Agency Oversight to each Critical Infrastructure Sector
- Provided a current status of various SCADA Security references for adaptation by International markets
- NERC CIP, ISA SP99, CFATS, API 1164, NIST 800-82, NIST 800-53 rev3, AGA 12, CSSP DHS Best Practice Guides, etc…
- Used NERC CIP as a sample security framework to understand the compliance requirements for the Energy sector
- Looked at a few actual security Incidents involving SCADA and Industrial Control Systems
- Finished up with a review of the SCADA VA methodology taught earlier in the course, and how it satisfies the VA requirements in NERC CIP and CFATS